Table of Contents

Merged compilation — fisheries & aquaculture data-collection reference documents

Collection Methodologies (NIMRD Romania – Black Sea sampling) 3

- Collecting Biological Variables 3
- Collecting Traversal Variables 23
- Collecting Economic Variables 27
- Collecting Social Variables 31

Methodological Report – Economic and Social Data Collection for Aquaculture and Fish-Processing Industry in Romania 34

Socio-Economic Data Collection Methodology – Aquaculture Sector Census (Romania) 95

Socio-Economic Data Collection Methodology – Fish Processing Sector Census (Romania) 111

Methodology for Bottom Trawl Survey in the Romanian Black Sea Area 121

Guidance Document for the Aquaculture Sector (PGECON) 133

Guidance Document for the Fishing Fleet (PGECON) 144

Guidance Document for the Fish Processing Sector (PGECON) 153

Guidance Document for the Social Variables (PGECON) 167

GFCM Data Collection Reference Framework (DCRF) 172

- Part 1 – Structure of the Data Collection 181
- Part 2 – Common Practices in Data Collection 225
- Appendices 260

Handbook for Data Collection on Recreational Fisheries in the Mediterranean and the Black Sea (FAO) 300

- Background 314
- 1. Introduction 316
- 2. Data Collection 320
- 3. Methodology 334
- 4. Data Analysis 350
- 5. Stakeholder Engagement 360
- References 362
- Annexes 368

Incidental Catch of Vulnerable Species in Mediterranean and Black Sea Fisheries: A Review (FAO) 386

- Seabirds 410
- Sea Turtles 452
- Elasmobranchs 516
- Marine Mammals 604
- Macrobenthic Invertebrates 664

Glossary 719

International Bottom Trawl Survey in the Mediterranean – Instruction Manual (MEDITS), Version 9 739

Introduction 747
[1] Specifications of the Sampling Gear 749
[2] Sampling Methodology 752
[3] Treatment of the Catches 756
[4] Inter-calibration of the Work at Sea 760
[5] Data Exchange Formats 761
[6] Gear Standardization and Monitoring 762
[7] Protocol for Monitoring Marine Litter 763
[8] Other Aspects (MEDITS Rules) 764
[9] Annexes 772

Monitoring the Incidental Catch of Vulnerable Species in Mediterranean and Black Sea Fisheries – Methodology for Data Collection 845

Introduction 867
Vulnerable Species 869
Data Sources 875
Sampling Scheme 883
Incidental Catch Estimation 891
Benthic Species 893
Marine Litter 897
References 899
Annexes 907

Technical Guidelines for Scientific Surveys in the Mediterranean and the Black Sea (FAO) 951

1. Demersal Bottom Trawl Surveys 967
2. Pelagic Acoustic Surveys 983
3. Demersal Beam Trawl Surveys 991
4. Ecosystem Data 1001
5. Data Policy 1007
References 1009
Annexes 1013

EU Legislation on Fisheries and Aquaculture Data Collection 1059

Commission Implementing Decision (EU) 2019/909 1059
Commission Delegated Decision (EU) 2019/910 1065
Commission Implementing Decision (EU) 2016/1251 1123

GFCM Recommendations and Resolutions 1188

REC.DIR-GFCM/40/2016/2 – Progressive Implementation of Data Submission (DCRF) 1188
Recommendation GFCM/41/2017/6 – Submission of Data on Fishing Activities 1207
RES-GFCM/40/2016/3 – Sustainable Small-Scale Fisheries 1227

COLLECTION METHODOLOGIES

COLLECTING BIOLOGICAL VARIABLES

Methods of sampling and storage

1. *Sampling of ichthyoplankton*

The qualitative and quantitative composition of the ichthyoplankton is determined by analyzing the samples taken from fixed stations, located on a part of the Romanian platform (up to the 70 m isobath), the methodology for collecting and processing the samples being the one unanimously accepted for the Black Sea basin (Radu E and Maximov V., 2006). The collection is usually done with the Bongo fillet with a diameter of 60 cm, with a mesh of 505 mm, equipped with a flow meter for recording the distance traveled, through oblique trajectories, for 5 minutes, at the speed of the ship of 1.5 -2 Nd (Fig. 1). For each station, the following data are recorded: the station, the date of the sample, the geographical coordinates of the station, the water depth (m), the horizon until the fill (m) was launched, the umber of rotations recorded by the flow meter.

Fig. 1 Bongo fillet for collecting ichthyoplankton samples

The ichthyoplankton samples are stored in 4% formol, and the processing is carried out in the laboratory. The laboratory analysis consists in the complete sorting under stereomicroscope of each sample taken, establishing the qualitative and quantitative structure. Once these elements are established, based on the aforementioned parameters, the density (specimens/m^2) is determined, for each species separately, making distribution maps (E. Radu, V. Maximov, 2006). The data obtained are used to calculate the abundance of the eggs, thus determining the intensity of reproduction, as a first element in characterizing the state of the population of a species of fish.

Determining the qualitative structure of ichthyoplankton and fish brood

The qualitative structure of the ichthyoplankton is determined taking into account the main distinguishing features of the pelagic ichra: the shape and the diameter of the ichel, the presence or absence of the drop of fat, the diameter and appearance of the drop of fat, the segmentation or homogeneity of the vitellus, the size of the perivitelin space (fig. 2). To determine the pelagic larvae were considered: meristic characteristics, morphometrics, pigmentation and body shape, shape of the vitelline sac, position of the anal orifice (fig. 3). The characteristics of ichthyoplankton communities are expressed through analytical ecological indicators (abundance, constancy and dominance) and synthetic ecological indicators (ecological significance indices, diversity) (Pârvu, 1999).

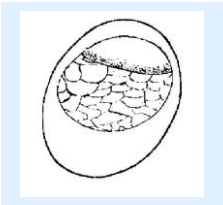
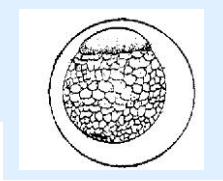
a)  b) 

Fig. 2 Types of eggs (a = anchovy; b = sprat)

a)

b)

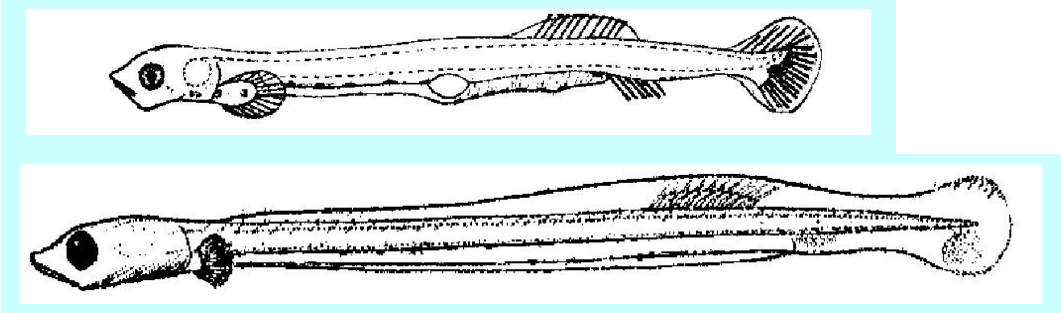


Fig. 3 Types of fish larvae (a = anchovy; b = sprat)

2. ***Collecting biological samples of juveniles/brood***

Fig. 4 Pelagic fish brood trawl

For fish brood, sampling is performed with pelagic trawl for brood, type Danielevski (Fig. 4), elaborated within the NIMRD by specialists in the field, for coastal trawler vessels of 570 hp (Nicolaev, 1988). The optimum value of the driving speed is in the range 1-1.5 Nd (Anton, 2006). Fish brood samples are analyzed qualitatively and quantitatively after each trawl or are stored in 4-5% formol and analyzed in the laboratory. The results are expressed in number of copies / m^2.

3. Sampling of biological samples for catch sampling

For the study of fish populations, the method of studying randomly extracted samples is used, which is part of the whole population, but which provides sufficient information to characterize the entire population. The catches of the industrial fishery constitute the main source of material for establishing the qualitative and quantitative structure of the fish populations, of the biological parameters, by extrapolating the results obtained to the whole population from which the analyzed specimens come. Although fisheries are already being sorted out by a fishing population, due to the selectivity of the fishing gear, however, industrial fisheries catches represent a useful source of information for population studies, as they are of particular interest to industrially exploited populations. In the Romanian marine area, commercial fishing is carried out with two types of tools: passive tools, located at depths of 5-12 m (Fig. 5) and active trawl-like tools, drawn by a ship and provided with a reinforcement system (pelagic beam, beam trawl / Fig. 6).

Fig. 5 Stationary gear (pound net)

Fig. 6 Pelagic trawl

Biological data sources

Sampling at landing/market places (fishery-dependent data);
Sampling on commercial vessel (fishery-dependent data);
Self-sampling (fishery-dependent data);
Sampling on research vessel for experimental or/and scientific survey (fishery-independent data).

a. ***Sampling at landing/market places***

During sampling, it may be possible to collect a variety of information, including fishing location and depth, type and amount of gear used, species identification and biological samples (i.e. length and weight). At the landing place, fish may be found in several different ways, as a bulk of mixed species, or separated by species (in boxes), or even by size categories. In all cases, when the total landing of a given species, or a fraction of a given species (e.g. juveniles or small size fish), is too abundant, it seems reasonable to make a sufficiently representative subsample (Gulland, 1966; Cochran, 1977; Baird, 1983; Pauly, 1983; Galluci et al., 1996). To get data on the length composition of individuals in the landing, a subsample should be selected randomly from each fishing day per target species, also recording the total weight of the catch of that particular species. All the size categories of a given species should be represented in the sample (it is important not to collect biological parameters for only small or large individuals). These measurements can either be taken directly at the landing place, or the sample can be purchased in order to collect additional biological parameters, such as age, individual weight, sex and maturity stages, and assess them later in the laboratory.

Sampling mixed species – When faced with a mix of species for sampling, the first basic task is to estimate the proportions of each one in the bulk load. In this case, it will probably be necessary to take larger subsamples of fish from each location in the bulk. Each subsample should be of approximately similar size. There is no guarantee that a large load of fish will be homogeneously mixed. Ideally, sampling would give each fish in the load an equal chance of inclusion in the sample, but this is seldom achievable in practice, given restricted physical access, time and other difficulties. Therefore, to maximize the accuracy of the mean of the sample, the sample should be made up of subsamples of the species taken, for example, from several boxes. If this is impractical, collection of data should try to devise other practical ways to minimize the influence over the choice of individual species, so that all possible classes are present in the sample in roughly the same proportions as they are in the bulk. To improve accuracy further, the number of species collected in a sample should be large, but only if the species are selected independently.

Sampling single species – For species divided into size categories, following market demand, a sample should be collected from each size category. To maximize accuracy in this case, the sample should be a composite from subsamples of individuals taken from several size categories. It is essential to record the total weight of landing for that species and, if present, for each size category.

b. ***Sampling on board commercial vessel***

At sea, ideally fishery observations should make a more precise record of the weight and/or number of individuals by species and per fishing hauls. Sampling on a boat poses many difficulties, apart from those associated with working on an unstable platform. On board commercial vessels, the data collectors must work in a way that will cause the least possible interference with the normal work of the crew and often, they will have a very limited time in which to obtain their samples. If it is not feasible to sample the entire fishing trip, some hauls should be taken randomly. There is no predefined list of hauls upon which one can base a random sample. The idea could be to make a kind of systematic sampling, spreading the samples equally during fishing day(s). On board, catches are often split into categories and subcategories depending on commercial values. For each main commercial species, the total weight should be collected.

c. *Self-sampling*

Self-sampling occurs when fishers themselves collect, and sometimes process, biological samples and report on these. It is a tool that has been developed recently to obtain data in an affordable manner, often producing a higher rate of coverage (in time and space). At-sea sampling of commercial fishery catches by observers could result in a relatively expensive exercise, in terms of cost and human resources. From this perspective, sampling by fishers may offer an alternative, since a larger number of trips can be sampled at a lower cost. However, a major problem with the self-sampling approach is that some scientists and/or managers consider that the data provided by fishers may not have been collected in a sufficiently rigorous manner, and they may be biased as a result (Hoare *et al*., 2011). To avoid these problems, regular and accountable training sessions for fishers can be conducted to guarantee the accuracy and reliability of data collection. In the event of self-sampling activities, countries should ensure that:

- fishers are trained;
- protocols are well developed;
- results are scrutinized for flaws, and controlled for bias.

d. *Sampling on research vessel for experimental or/and scientific survey*

Fig. 7 The research vessel „Steaua de Mare”

Besides commercial fisheries' statistics, another source of information for biological data is fishery-independent data collected by scientific survey at sea, is carried out during the research expeditions by the NIMRD "*Grigore Antipa*", specialists with the research vessel "*Steaua de Mare* 1" (Fig. 7).
Surveys provide accurate indices of species/stock abundance and distribution, though the major problem is cost.

Surveys require fishing with a standard vessel using standard fishing gear at predetermined fishing stations, selected according to a fixed-grid, fixed-site or stratified random sampling design. Such surveys provide an estimate of average fish density (e.g. per area swept by a trawl net; as fish encounters with longlines or gillnets; number of nautical miles for acoustic survey etc.) over the entire spatial range where the species might be found. It also provides mapping of the spatial distribution of density over the entire range.

Information to be collected during each sampling day at landing/market places or on board commercial vessels:

* fleet segment sampled;
* area (GSA) and time period;
* gear used;
* name of selected target species;
* length of all individuals contained in at least one sample (e.g. a single box) of the total commercial landing of that species;
* sample weight;
* total landed quantity (by weight) of the species selected for sampling;
* discarded fraction of the target species;
* total weight of all landed species.
* Incidental catch of vulnerable species

e. *Selection of species*

Usually, due to restricted funds and personnel, it is not possible to collect data (e.g. biological data,

effort data etc.) from all species of commercial interest. A limited number of species (namely priority species) should be selected as representative of the entire living resources. The concept of priority species represents a key factor for the management of fisheries resources (Barone *et al*., 2006; AdriaMed, 2007; Ungaro *et al*., 2008). In the context of data collection, priority species are those for which the most complete set of data are required. Their identification has to be based on criteria relevant to the objectives of the GFCM: development, conservation and management.

According to these criteria, three different groups have been established, whereby species are listed at subregional level (GFCM subregions):

* the first group concerns the **frequency of assessments** (i.e. species that are regularly assessed);
* the second one concerns the **fishery's importance** (i.e. landing, catch and/or economic value);
* the third group is based on **conservation criteria** (i.e. endangered species) or impact of them presence on the ecosystem (i.e. non-indigenous species).

It is known that ichthyology deals with the study of fish from a morphological, systematic, physiological and ecological point of view. In systematic zoology, the fundamental element is the species, that is, the group of related individuals, with similar and stable morpho-physiological, biochemical, ecological and genetic features. Sometimes the species comprises smaller groups, subspecies, which differ in non-essential characters. Several species form a larger unit, the genus. The classification continues so that more genres form a family, and more families an order, they are grouped more into a class. Species determination is based on morphological characteristics of the collected species, using determination keys for each systematic unit. The identification of the species implies the knowledge of the morpho-anatomical particularities of the individual: shape, color, number of swimmers, number and type of radii, presence (and number) or absence of scales on the lateral line, various relationships between biometric parameters, presence of particular excrescences, such as spines gills, etc. According to Dehnic (1979), the Black Sea fishery comprises 165 species and subspecies, of which 119 are exclusively marine, 24 are anadromous or semi-marine and 22 are freshwater species. Some of the other 15 species are rarely found. According to other authors, the Ihtiofauna of the Black Sea comprises 140 species, species classified according to the systematic adopted in 19 orders, 48 families and 93 genres.

4. *Collecting material to determine length and weight*

a. length

The samples that are taken for the study of the qualitative and quantitative composition consist of several kilograms of fish taken at random from the talian catch, from the points near the institute headquarters and from the other fishery points on the coast. Also, samples are collected from the surveys carried out with industrial fishing vessels, on which research personnel activate. The samples taken for the study of the fish populations will consist of a number of 200 specimens, collected at random, from at least four lots of 50 copies from four different places of a minimum catch of 100 kg - in passive fishing and 500 kg - in active fishing. The length frequency samples will be collected and analyzed whenever the appearance of a species is changed, in terms of length, but not less than one sample for each of the main species of a catch (E. Radu and V. Maximov , 2006).

Examination of the samples involves counting, biometric measurements, gravimetry (weighing), sampling of otoliths, scales or other hard structures used at a later stage (determining age), determining the sex and degree of maturation of the gonads, determining the degree of stomach filling and fattening degree, determining the degree of infestation with parasites, etc. The characters determined by biometric studies are: plastic characters (length, mass, thickness) and meristic characters, which involve the counting of radii, scales, branchial spines. Within these analyzes, the elements necessary for the estimation of the growth parameters are pursued, firstly:

- structure by classes of lengths and ages;
- weight / weight by length and age classes;
- the sex ratio.

For the elaboration of the variation of the total length variation (Lt), the measurements are made

with the ihtiometer (Fig. 8), from the end of the muzzle, to the end of the longest radius of the caudal (sprat, anchovy, whiting), or bifurcation (horse mackerel). Sometimes both lengths (total and fork) are measured to establish correlations. The ihtiometer consists of a wooden or plastic panel, graded along the longitudinal axis, with a vertical wall at the left end. The fish is placed with its longitudinal axis parallel to the axis of the ichthyometer and the muzzle (closed mouth) slightly pressed by the vertical wall. The roulette is used to measure large fish.

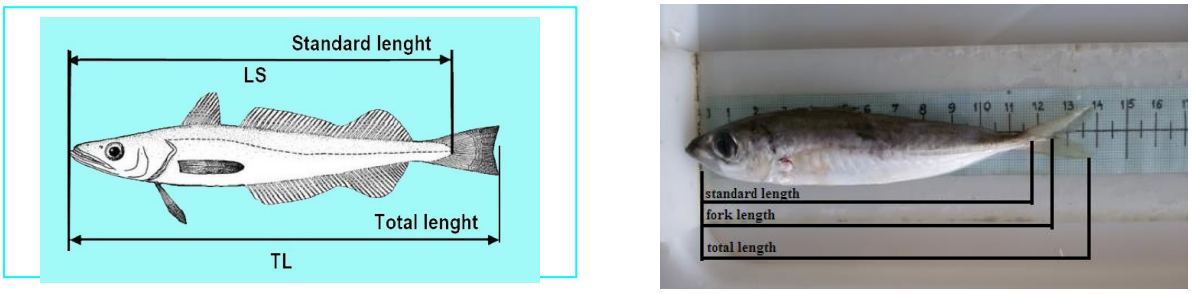


Fig. 8 Determination of length for small fish species

The main biometric measurements and the external morphology of different fish (bones, sharks, rajidae and flat fish) are presented in the following Figures 9, 10 and 11.

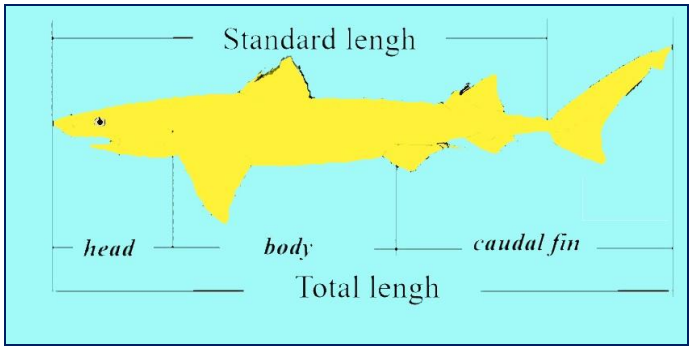


Fig. 9 Determination of length for picked dogfish species

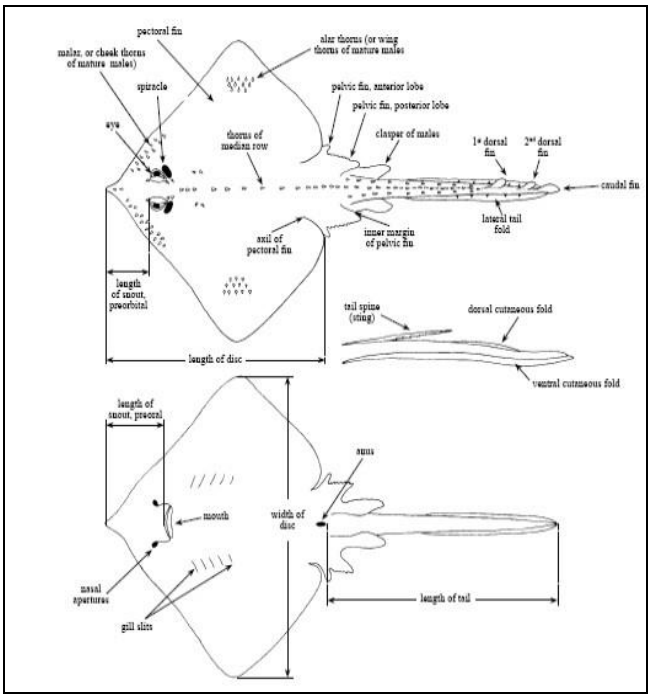


Fig. 10 Main technical terms and measurements in Rajidae

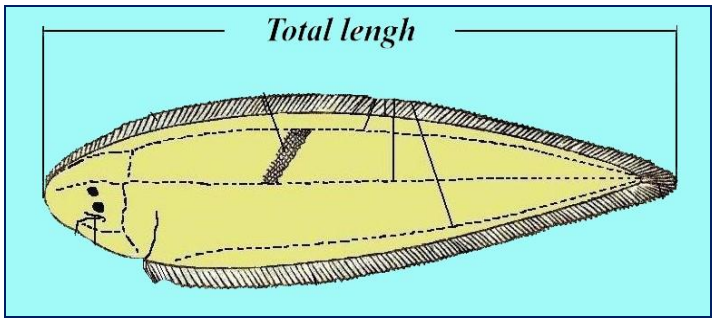


Fig. 11 The main measurements for flat fish

Marine decapods are a group of organisms of even ecological importance in some places. They serve both as direct food for many fish, locally and for humans, and indirectly through their planktonic larvae, which are the basic food for many planktonic fish. Regarding the Romanian Black Sea coast, among the most common decapods encountered here, we mention: sand shrimp, grass shrimp, stone guinea pig and grass crab. Figures 12 and 13 show the main measurements and the main morphological elements in the crustacean (Băcescu, 1967).

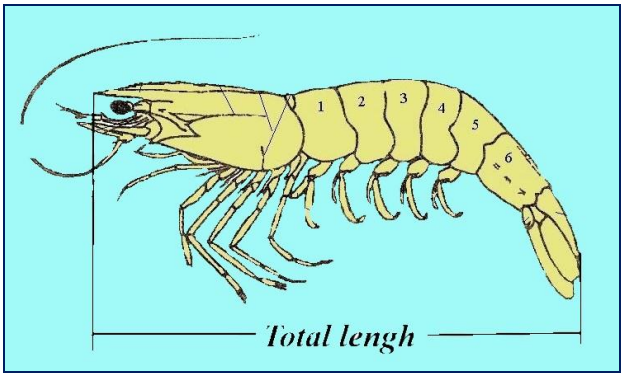


Fig. 12 Technical terms used in the description of a shrimp's body

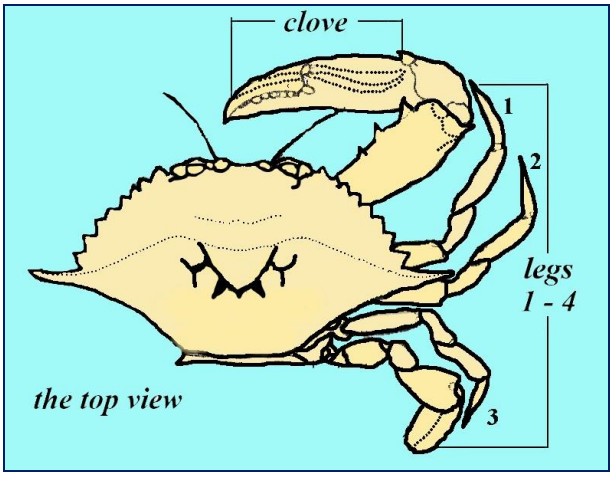
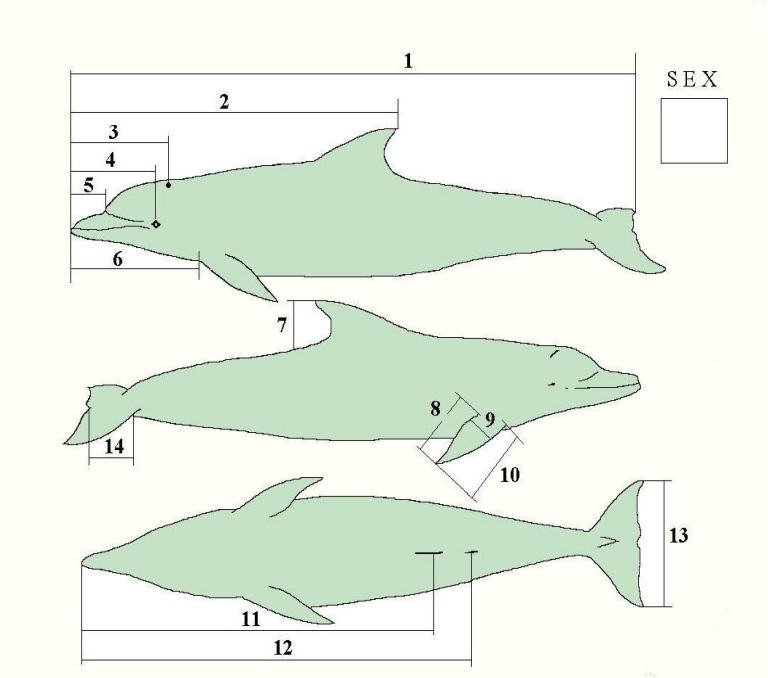


Fig. 13 Technical terms and main measurements in crabs

Cetaceans are vertebrates with a long life cycle, representing the highest part of the trophic chain, and they are also indicators of the health status of marine ecosystems. Marine mammals play a major role in the ecological balance of marine ecosystems, being very sensitive to ecological environmental conditions and in direct competition with human activities. In the Black Sea live three species belonging to the Cetaceans. The three species of dolphins in the Black Sea are: *Delphinus delphis ponticus*, the common dolphin, *Tursiops truncatus ponticus* - aphid, glass-mouthed dolphin or big-mouthed dolphin, and *Phocoena phocoena* relicta, popularly known as phoenix, sea pig or martin. The main biometric measurements of dolphins are shown in figure 14.

The total length is measured for all fish species from the Romanian coast.

For species with bilobate flow rate, it is recommended to measure the **fork length** - defined as the distance measured along the longitudinal axis of the body, from the tip of the muzzle to the tip of the "V" formed by the lobes of the bifurcated flow. It is also mandatory to measure the commercial length (**standard length**), which represents the distance from the tip of the muzzle to the completion of the solzos shell; if the fish is nude or there are small scales on the flow, the reference point is the base of the middle radii of the flow (Fig. 7.9, 7.10 and 7.11). In fish, measurements will generally be recorded at the nearest centimeter and sometimes, depending on requirements, at the lower centimeter. Often it is necessary to measure both lengths (total and fork) and both methods (at the nearest centimeter, or at the bottom centimeter) to establish correlations. These situations will be set out expressly through the work program.



1. The total length.
2. Distance from the tip of the upper jaw to the posterior edge of the dorsal fin tip.
3. Distance from the tip of the upper jaw to the center of the breathing hole.
4. Distance from the tip of the upper jaw to the center of the eye.
5. The distance from the top jaw to the front of the melon.
6. Distance from the tip of the upper jaw to the front of the base of the pectoral fin.
7. Height of the dorsal fin.
8. The posterior length of the pectoral fin.
9. The width of the chest at the base.
10. Anterior length of the pectoral.
11. The distance from the tip of the lower jaw to the center of the genital orifice.
12. Distance from the tip of the lower jaw to the center of the anal hole.
13. The distance between the tips of the lobes of the caudal fin.

Fig. 7.14 The main biometric measurements in dolphins

In the Romanian marine sector, the measurements made on fish will be recorded at the bottom centimeter.

The range between the length classes is 0.5 cm for small species: *Sprattus spratust* (sprat), *Merlangius merlangus euxinus* (whiting), *Engraulis encrasicolus* (anchovy), *Trachurus mediterraneus ponticus* (horse mackerel), *Atherina boyeri* (atherina), *Alosa caspia nordmanni* (alosa), *Clupeonella cultriventris*, *Gobiidae* (gobies) and 3 cm for large ones: *Psetta maxima maeotica* (turbot), *Squalus acanthias* (picked dogfish), *Platichthys flesus luscus* (flounder), *Acepenseridae* (sturgeons spp.)(E. Radu și V. Maximov, 2006).

The crustacean measures the length of the body from the tip of the rostrum (practically from the front of the eye) to the completion of the telson (tail). The interval between two classes of length is 0.5 cm and the recording is made at a lower centimeter (Gomoiu & Skolka, 2001). Typically, for fish whose size is greater than 30 cm, the class range of 1 cm in length is chosen, and for those under this size, an interval of 0.5 cm can be chosen (Table 1). According to this method, all lengths between 36.0 and 36.9 cm are reported to 36 cm, when using the 1 cm range. When measured in 0.5 cm units, fish between 26.0 and 26.49 cm are reported at 26 cm, and fish between 26.5 and 26.99 cm at 26.5 cm. Samples made of large specimens are analyzed by measuring each specimen, subtracting the elements required for analysis and then performing the frequency range of the lengths.

At 3-5 samples, for the frequency of the lengths, a sample for the frequency of the ages is provided, calculated, according to the stratified method, that is, by providing for each length class a constant

number of age material (otoliths or scales) - about 10 copies (per as many as 5 females and 5 males).

b. *weight*

Individual weight is important biological information, although the weighing of individuals may prove to be more complex depending on prevailing conditions in the workplace. It is essential to establish length-weight relationships for all target species, because at some stage in stock assessments, lengths of fish have to be converted to weights of fish.

The choice of weighing device (electronic balance) depends on the size of the sampling and working conditions. For fish, elasmobranch and cephalopod species, the total weight of each individual could be reported to the nearest 1 g, using an electronic balance. In the case of crustaceans, the weight should be recorded to the nearest 0.1 g. The length-weight relationship for single species requires a large set of data in order to obtain good representation of the entire "*size ranges*" of a species: from the smaller individuals to the larger ones. This will help to increase the accuracy of estimates. It is also important to stress that the length-weight relationship may vary seasonally, and between each sex.

The average mass of the specimens per each class of length is determined by the global weighting of all the specimens of a class of length, the recording of the value determined in the form, to be obtained by calculation based on all the samples. Large specimens are weighed individually. The unit of measure is the gram. Care shall be taken to remove the weighing errors by placing the scales along the axis of the ship, which balances less and adjusts whenever its horizontal conditions change. For weighing smaller fish, the analytical balance is used, the weighing being done in the laboratory. It is important to establish length-weight relationships for all species where we want to determine the status of stocks, for which we must convert lengths to weight. Equally it is recommended to establish the length-to-mass relationships seasonally because the weight of the fish may be greater during the breeding season than outside the season.

c. *Data quality*

The quality of fisheries data is related to the precision and accuracy of measurements made on fisheries variables. It is subject to many factors, including data type, nature of fisheries and economic, social or ecological values of fisheries (Cochran 1977; FAO, 1999; Kolding & Ubal Giordano, 2002; Pennington *et al*., 2002; Vigneau & Mahevas, 2004; ICES, 2008, 2010e). All collected data contain some level of bias and random variation. Improvements needed in precision and accuracy often require greater relative expenditures on sampling and analysis.

Data quality must be ensured in all data collection phases: survey design, field and laboratory methods, data processing and transmission.
Errors deriving from different sources have different statistical characteristics: errors linked to direct measurement of fishery variables (e.g. length, weight), or to well-designed sampling programmes, are likely to be random and small. In some cases, errors associated with fisheries data can be non-random and biased, a characteristic of low-quality data.

Quality indicators such as statistical dispersion parameters are needed to perform quality controls. In the region, the definition of such indicators is in progress and needs to be agreed upon by all CPCs in order to establish control routines.

Generally, a routine quality validation/control should be performed at both internal (e.g. country) and external level (e.g. GFCM Secretariat) to quantify the accuracy and precision level and, if problems are identified, they must be solved before datasets are assembled.

Table 1

Important species fished in the Black Sea
with the indication of the samples to be collected

Scientific name	Common name	Observations		Length class (cm)	Total length	Aeging		
		optional	mandatory			scales	otoliths	
0	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*
Acipenser gueldenstaedti colchicus Marti, 1940	Danube sturgeon	+		3	+			
Acipenser stellatus Pallas, 1771	Starry sturgeon		+	3	+		+	
Alosa caspia nordmanni Antipa, 1906	Caspian shad		+	0,5	+	+		
Alosa fallax nilotica (Geoffroy, 1808)	alosa	+		1	+	+		
Alosa maeotica maeotica (Grimm, 1901)	Pontic shad		+	0,5	+	+		
Alosa pontica pontica (Eichwald, 1838)	Danube shad		+	1	+	+		
Anguilla anguilla (L., 1758)	European eel	+		3	+		+	
Atherina (Hepsetia) boyeri (Risso, 1810)	Sand smelt		+	0,5	+		+	
Belone belone euxini (Günther, 1866)	garfish	+		1	+			
Blennius sp.	blennies	+		0,5	+			
Boops boops (L., 1758)	bogue	+		0,5	+			
Caspiosoma caspium (Kessler, 1877)	gobies	+		0,5	+			
Chelon labrosus (Risso, 1826)	Grey mullet	+		0,5	+			
Clupeonella cultriventris (Nordmann, 1840)	kilka		+	0,5	+		+	
Conger conger (L., 1758)	European conger	+		3	+			
Coryphoblennius galerita (L., 1758)	blennies	+		0,5	+			
Dasyatis pastinaca (L., 1758)	Common stingray	+		3	+			
Dicentrarchus labrax (L., 1758)	European seabass	+		3	+			
Diplodus sp.	Annular seabream	+		0,5	+			
Engraulis encrasicolus (L., 1758)	anchovy		+	0,5	+	+	+	
Gaidropsarus mediterraneus (L., 1758)	Shore rockling	+		0,5	+			
Gasterosteus aculeatus L., 1758	stickleback	+		0,5	+			
Gobius sp.	gobies		+	0,5	+			
Gymnammodytes cicerellus (Rafinesque, 1810)	Sand eel	+		0,5	+			
Hippocampus guttulatus (Cuvier, 1829)	Sea horse	+		0,5	+			
Huso huso (L., 1758)	Beluga		+	3	+			
Labrus viridis L., 1758	Green wrasse	+		0,5	+			
Lithognathus mormyrus (L., 1758)	Striped seabream	+		0,5	+			
Liza sp.	Grey mullet	+		1	+			
Merlangius merlangus (Nordmann, 1840)	whiting		+	0,5	+		+	
Mesogobius batrachocephalus (Pallas, 1811)	goby		+	0,5	+		+	
Mugil cephalus (L., 1758)	Flathead mullet		+	1	+		+	
Mugil so-iuy (Basilewsky, 1855)	Mullet so-iuy		+	0,5	+		+	

0	1	2	3	4	5	6	7	8
Mullus barbatus ponticus (Essipov, 1927)	Red mullet		+	0,5	+		+	
Neogobius melanostomus (Pallas, 1811)	Round goby		+	0,5	+		+	
Neogobius sp.	goby	+		0,5	+		+	
Nerophis ophidion (L., 1758)	Pipefish	+		0,5	+			
Oblada melanura (L., 1758)	Saddled sea bream	+		0,5	+			
Ophidion rochei (Müller, 1845)	cuskeel	+		0,5	+			
Parablennius sp.	Rusty blenny	+		0,5	+			
Platichthys flesus luscus (Pallas, 1811)	European flounder		+	1	+		+	
Pomatomus saltatrix (L., 1766)	bluefish		+	1	+		+	
Psetta maxima maeotica (Pallas, 1811)	turbot		+	3	+		+	
Raja clavata (L., 1758)	Thornback ray		+	3	+		+	
Salmo trutta labrax (Pallas, 1811)	Sea trout		+	1	+		+	
Sarda sarda (Bloch, 1793)	Atlantic bnito		+	1	+		+	
Sardina pilchardus (Walbaum, 1792)	European pilchard		+	1	+	+	+	
Sarpa salpa (L., 1758)	salema	+		1	+			
Sciaena umbra (L., 1758)	Brown meagre	+		1	+			
Scomber japonicus (Houttuyn, 1780)	Spanfish mackerel	+		1	+			
Scophthalmus rhombus (L., 1758)	brill		+	1				
Scomber scombrus (L., 1758)	Atlantic mackerel		+	1	+		+	
Scorpaena sp.	Black scorpionfish	+		0,5	+			
Solea nasuta (Pallas, 1811)	Common sole		+	0,5	+		+	
Sparus aurata (L., 1758)	Gilthead seabream	+		0,5	+			
Spicara sp.	picarel	+		0,5	+			
Sprattus sprattus (L., 1758)	sprat		+	0,5	+		+	
Squalus acanthias (L., 1758)	Dog fish		+	3	+		+	
Symphodus (Crenilabrus) sp.	Grey wrasse	+		0,5	+			
Syngnathus abaster (Risso, 1826)	pipefish	+		0,5	+			
Syngnathus sp.	Great pipefsh	+		0,5	+			
Trachinus draco (L., 1758)	Greater weever	+		0,5	+			
Trachurus mediterraneus ponticus (Aleev, 1956)	Horse mackerel		+	0,5	+		+	
Trigla lucerna (L., 1758)	Tub gurnard	+		0,5	+			
Tripterygion tripteronotus (Risso, 1810)	Black Sea blenny	+		0,5	+			
Umbrina cirrosa (L., 1758)	Shi drum	+		1	+			
Uranoscopus scaber (L., 1758)	stargazer	+		0,5	+			

d. *Internal validation*

The design and implementation of statistical sampling schemes is placed under the responsibility of the each country. In order to meet fisheries data requirements in existing GFCM decisions, it may be necessary to improve, standardize and possibly modify current national data collection systems. A more efficient use of sampling resources may require the definition of best practices for sampling design and data analysis, with the aim to obtain accurate variable estimates with minimum bias and uncertainty levels.

It is fundamental that field collection, laboratory techniques and data processing be applied consistently and correctly. The integrity of the data should be also maintained and documented, from sample collection to entry in the data record. Countries are expected to keep, at the national level, standard data quality documentation as follows:

* *A standard operating procedure* which should include:
  - the quantitative goals of the monitoring programme;
  - the methodological details of all steps performed (e.g. fields and laboratory aspects);
  - details of the procedure related to the analysis and archiving of data.

* *A quality manual* which should describe:
  - the quality assurance system in place;
  - the frequency at which different aspects of quality assurance should be reviewed;
  - the standards that should be met;
  - the actions needed if the standards are not met.

Precision, accuracy, representativeness, completeness, and comparability are all components of the quality that should be taken into account.

Precision	Measure of the proportion of agreement among replicate measurements
Accuracy	The degree to which a recorded measurement varies from a true or expected value
Representativeness	The extent to which measurements represents the true value in the population
Completeness	The proportion of valid data collected with regards the total expected
Comparability	The extent to which data from different sources can be comparable

e. External validation

This validation is performed by the JRC / GFCM Secretariat to assess the quality of data transmitted by countries. The will check:

- check the completeness of data collected;
- identify deficiencies in the data transmissions;
- check differences between countries;
- check problems connected with the quality of existing data, their completeness and the level of comparability;
- check comparability with other sources of information/reference;
- identify significant discontinuities in time of collected data;
- identify significant outcomes.

5. *Collecting material to determine age*

Determining age in fish is an important element that contributes to the study of the population dynamics of a species. It is an important parameter that helps to analyze the growth, mortality, recruitment, fundamental population parameters. In most fish species the age can be determined by

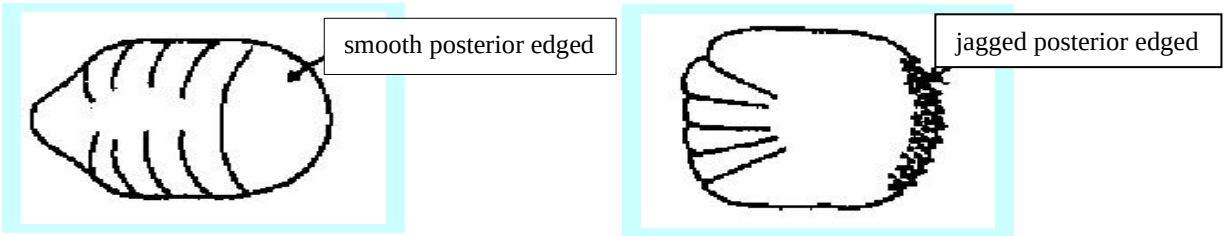
analyzing the discontinuities that form in the skeletal structure. These discontinuities may occur in the skeletal structure either due to changes in the living environment (eg. temperature changes) or changes in fish physiology (eg. changes in the reproduction process). However, as in some fish specimens, living in a constant living environment, skeletal discontinuities are not visibly formed, then the age assessment for these individuals will be performed indirectly.

A knowledge of the anatomy of the vestibular apparatus and the morphology of the otoliths is important in effectively collecting the otoliths. Depending on where they are located in the inner ear, the otoliths may be: utricular, sagittal and lagenar (Stevenson & Campana, 1992). In most species of fish used in determining the age is the sagittal otolith, which is located in the sacculus component of the inner ear.

Scheme of the process of determining the age at fish by analyzing the bone structures

The samples for the determination of age will be collected according to the stratified method, ie by providing for each length class a constant number of age material - 10 copies (as many as 5 males and 5 females) in the sample for studying the frequency at length and outside. of him (chair and from other trainings until the number of 10 copies at each length class is completed). For 5 - 10 samples, a sample for the frequency of the ages should be provided for the length frequency. In this interval you can complete the number of 10 copies in each length class. The material used to determine the age in order to obtain the age frequency in the analyzed samples consists mainly of scales (Fig. 15) and otoliths (Fig. 16), being specific to each species.

The scales are collected from certain areas of the body, in order not to collect scales just formed, with the degeneration of the central part or from the lateral line, which can give rise to errors, or are ineligible. In most species, scales are collected from the area near the middle of the body, below the front of the dorsal fin. If there are a few dorsal fins, the scales are taken from under the first one, placed closer to the head. At the same time, the scales must be taken above the lateral line, but not far from it. If the fish does not have a lateral line (Clupeidae) the scales are collected from the middle of the coast, also under the dorsal fin. Quite often the first row below the side line is used. Before scraping the surface of the body with a scalpel, or knife, it is recommended to clean the collection site with a cloth and with the back of the knife to remove any foreign scales and mucus. The scales resulting from scraping are put for storage in the scales of scales, so numbered so that it can be recognized, when reading the age, the meristic elements of the collected specimen.



a. b.

Fig. 15 Types of scales (a = cycloid; b = ctenoid)

Otoliths - are collected from the inner ear of the fish, located at the base of the skull. As a general rule, otoliths should be collected from fresh fish. They can be reached by an oblique sectioning of the head through the dorsal part, starting above the eye, at the base of the brain, or after removing the branchial arches by breaking with the tweezers of the bone base of the brain, just before the first vertebra. From the inner ear the otoliths are easily removed, without being crushed with the tweezers and placed in a drop of water on the back of the left hand to clean the blood and the transparent membrane surrounding them. The otoliths thus collected are kept in small glass tubes, envelopes, or notebooks using the same numbering system as for scales. After otoliths one can

easily determine the age of anchovies, sprats, squid, gadids, pleuronectids, gobiids.

Fig. 16 Otolith of anchovy (*Engraulis encrasicolus* /*photo* by NIMRD Constanta)

The age of the fish can also be determined by the thorny radii of the fins, on the membrane whose annual layers are seen and after the opercules or preopercles, etc.

Cartilaginous fish **-** unlike age determination methods in bony fish, which have otoliths and scales, age determination methods in cartilaginous fish are more complex (Campana, 2014). Thus, structures suitable for reading age are vertebrae and spines.

The vertebrae are taken from the thoracic (central) area; For each sampled individual, a section of at least ten vertebrae should be extracted and then stored in the freezer (-18°C). The vertebrae contain concentric pairs of opaque and translucent bands; the pairs of bands are counted as the growth rings of a tree. In order to obtain a thin section suitable for reading, the central vertebra must be incorporated into the epoxy resin. It should then be immersed in distilled water for 30 to 45 minutes and then dried to remove excess moisture.

The cleaned central vertebra should be photographed with a stereomicroscope in the reflected light using an integrated camera. A reference should be included in the image. The main measures of the vertebrae should be recorded in the form: radius (RV, in mm) and length (LV, in mm). It can be analyzed after sectioning. To enhance the image, dye will be used.

The correct interpretation of the growth strips is of fundamental importance in estimating the age of the analyzed sample. Reading should be done along the corpus calcareum, starting with the first year after the birthmark (BM), which is sometimes associated with a variation of the corpus calcareum angle (Sulikowski et al., 2003).

The dorsal spine has growth bands, so the best approach is to capture a digital image; The growth bands are usually the clearest if the spine is held with the convex side of the curve facing upward, but slightly offset from the vertical. On the Romanian Black Sea coast, among the cartilaginous fish species is the dog fish (*Squalus acanthias*). Thus, as a method for determining age, the backbone is used, which is removed, the meat removed by boiling and then skimmed (Irvine et al., 2006).

Mollusks / **Gastropods** – bivalves from natural populations can be analyzed by identifying the growth bands on the shell, formed at regular intervals of time. This also allows the study of the abiotic and biotic environmental factors (temperature, salinity, physical disorders) on the development of the individual (Doris et al. 2009). Also, the age of the bivalves can be identified by analyzing the growth bands on the sectioned shell. The usual age-reading procedure for Rapa welk is based on the analysis of the deposition strips that form on the shell. These bands can be counted in two ways:

* counting these strips directly from the shell surface (Fig. 17);
* counting the strips on the sectioned surface of the shell (Fig. 7.18).

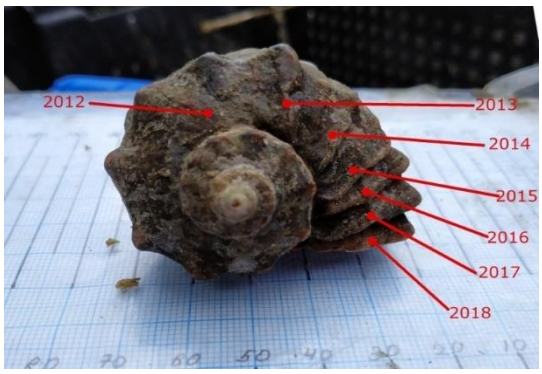


Fig. 17 Strips identification on Rapa welk shell (*photo* by Bohdan Hulak - Center YugNIRO)

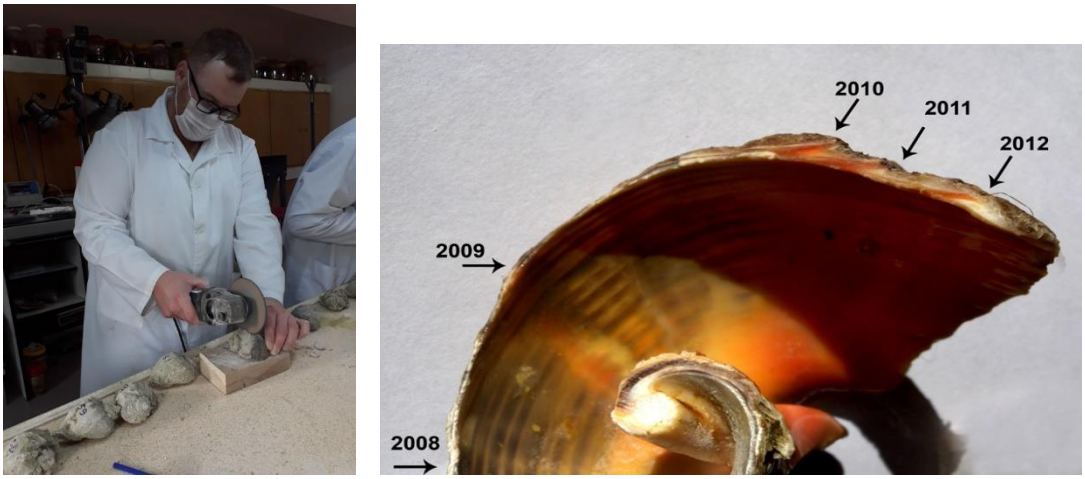


Fig. 18 Identification of strips on a Rapa welk sectioned shell (*photo* by dr. Oleg Kovtun, Center YugNIRO)

a. ***Method of collecting the otoliths***

The best method for removing otolith depends on the morphology of the hearing capsule, the size of the fish and how the individual was kept. The method by which the cut is made on the head of the individual for sampling is also done according to the preference of the one who takes it. To access the cavities in which the otoliths are closed, different cutting methods can be used:

* rear section ("open hatch" method),
* cross section (guillotine method),
* longitudinal section ("right between eyes" method).

In general, the first two methods are used in demersal species. The cutting and cutting tools vary depending on the size and strength of the skull, but generally consist of razor blades, scissors and knives. The section should be done carefully to avoid damage to the inner ear or otolith (Carbonara and Pollesa, 2019). After proper cutting, the otoliths can be removed with a stainless-steel tweezers.

Fig. 19 Otoliths sampling from anchovy (photo NIMRD, Constanţa)

b. ***Method of cleaning the otoliths***

After extraction, the otoliths should be cleaned of any residual organic tissue, then washed with alcohol and dried on paper. The analysis of *scales* to determine age is also a commonly used method. Scales differ in shape and size depending on the area where they are inserted. For the age analysis, those from the upper dorsal part are used, in the area between the head and the dorsal fin. After cleaning them with alcohol, the scales are placed between two glass slides and can be analyzed in binoculars. The age is determined by counting the annual growth circles.

c. ***Method of storing the otoliths***

It is recommended to be stored in plastic tubes, these having the advantage of being rigid enough to protect them from damage due to handling. Also, when analysing a sample from which the otoliths are taken for estimating age, it is important to label the vial with other information, such as date of sampling, station, species, length and weight.

d. ***Interpretation of age***

For the interpretation process it is recommended that the otoliths be immersed in glycerin to make the rings more visible under the reflected light using a binocular (Fig. 20).

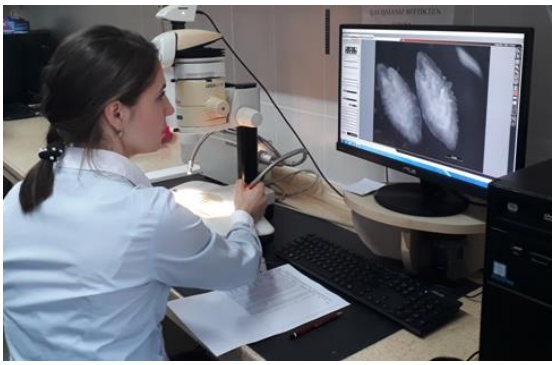


Fig. 20 Otoliths analysis on binocular with attached camera (*photo* by NIMRD)

These marks of annual deposit are formed by the growth stops at the shell level and the thickening of its edges. Pigmentation in the thickness of the shell changes during the breeding period. The first mark of deposit in the reproduction process is formed at the age of 2 years. The complete age of individuals can be determined according to dr. Chuhchin's formula:

$$(n + 2) +$$ where, n = the number of marks.

e. Accuracy of interpretations

In order to minimize the risk of systematic errors due to preconditioning, readings / interpretations of calcified structures should be performed by at least two independent operators, without sample information (eg. size, gender, etc.). Moreover, the readings must be made at least twice by each reader, at an interval of 10-15 days. When readings disagree, calcified structures need to be re-analyzed (Goldman, 2005). You can also analyze the percentage of agreement (PA), calculated according to the formula:

$$PA = (\text{no agreement}) / (\text{no disagreement}) \times 100$$

Regarding the PA, the value can be considered acceptable when reaching an agreement of at least 80% with expert readers.

6. Harvesting of material to establish the gonosomatic ratio and fertility

In parallel with the usual biometric measurements, the gonads are weighed, both in males and females. It is labeled: the date, the number of the trawl, the number of the specimen in the sample from which it was taken. Formolizes in gauze bags.

a. ***Sex, stage of maturation of the gonads and fertility***

Determining sex and sexual maturity are essential in fishery biology, through their knowledge of fish stock reproduction. Equally, the information that results from these analyzes can be used to determine the age and size at which the fish reach sexual maturity, the time and place of reproduction and the duration of the cycle from the beginning of ovarian development to the spawning emission. Normally determining sex is not a difficulty. Work on samples with an established number (depending on the species, 50-60 specimens to have 40-50 specimens with gonads in stage IV-V), measuring the length and weighing each individual. An abdominal incision is made noting the sex. The gonads that are examined according to the classical criteria are taken: superficial vascularization, color, transparency of the ovary shell, consistency, volume. Knowing the proportion of the two sexes within a population allows a correct ecological characterization, constituting the expression of genetic polymorphism. The sex ratio indicates the state of the population under this aspect at one point and remains relatively stable or changes over time.

In some fish species, sex is determined by the color of the gonads, for example, atherin, the gonads in males are dark gray to black. The number of females is usually higher than that of males, though not always. Sometimes the sex ratio varies with age, in most species it is about 1:1.
The term "maturation stage" has a special meaning, but is generally accepted in fishery biology. It is used to signify the maturity of a fish's ovaries and testes. During one year the gonads go through several successive phases: the premature phase, the actual maturation phase, the tip (reproduction) phase and the atresia phase. At the same time, the term "first maturity" is used to describe a fish that breeds for the first time.

Sexual maturity in fish is of great practical importance, regardless of whether the fish becomes mature in the 2nd or 3rd year, or only in the 16th. A fish that breeds late cannot be fished intensively without its number decreasing. Generally, fish are considered to be mature when they reach half their maximum size. The slower a fish grows, the later it becomes sexually mature and vice versa. The maturity of the genital products is also related to the matabolism of the lipid substances and from this point of view we distinguish fatty and weak fish.

Fig. 21 Anchovies (*Engraulis encrasicolus*) mature sexually (female and male) photo, NIMRD

The procedure used in the NIMRD admits that, for every 10 copies analyzed to determine the frequency of ages, the sex and the degree of maturation of the gonads should be studied, in order to determine the reproduction period of the analyzed populations and the gender ratio. In order to determine the sex and degree of maturation of the gonads, the specimens taken in the study are dissected and the observations made in the age frequency form are recorded.
In order to facilitate the analysis of the biological material regarding the course of sexualmaturity and for the delimitation of the different stages of the sexual cycle, numerous maturation scales have been elaborated, applicable to different fish species. The NIMRD uses the six-stage visual appreciation scale of Nikolski (1962):

sex (I/imature, F/female, M/male)	**The reproductive apparatus aspect**	**Maturation stage** (maturation state)
I	Sex cannot be determined with the naked eye. The gonads are very small and translucent, almost transparent.	**0** (undetermined)

F	The ovary is small, rosy and translucent and shorter than ⅓ in the body cavity. Eggs are not visible to the naked eye.	**1** (immature)
M	Thin and whitish testis are shorter than ⅓ in the body cavity.	
F	The ovary is reddish pink / reddish orange, translucent and is about ½ of the body cavity. Blood vessels are visible. Eggs begin to be visible to the naked eye.	**2** (beginning of ripening)
M	The testis are whitish / pink, are more or less symmetrical and have a length of about ½ of the body cavity.	
F	The ovary is pink-yellow and has a granular appearance and a length of approximately ⅔ in the body cavity. The eggs are large, transparent, easily visible.	**3** (mature, reproductive)
M	Testiculul este alb-cremos și moale, cu o lungime de aproximativ ⅔ până la toată lungimea cavității corpului.	
F	The ovary is reddish with obvious superficial vessels, measuring from ⅔ to the full length of the body cavity. Eggs are large, transparent, clearly visible and could be expelled under a little pressure. In more advanced conditions, the eggs can be released freely.	**4** (in full reproduction activity, breeder)
M	The testicle is white and under light pressure, the spermatic material can be expelled.	
F	The reddish ovary is reduced to about ½ of the length of the body cavity. The walls of the ovary are flaccid; the ovary may contain remnants of desintegrating opaque and / or translucent eggs.	**5** (end of reproduction, spent)
M	The testis are pinkish-red and occupy up to about ½ of the length of the body cavity.	
F	The ovary is rosy and translucent, measuring approximately ⅓ length from the body cavity. Eggs begin to form but are not visible to the naked eye.	**6** (resting, recovering)
M	The testicle is whitish / pinkish, more or less symmetrical, with a length approximately ⅓ of the body cavity.	

Descriptive maturity stages on crustace:

Females:

Stage I - Telicum is undeveloped, or incompletely developed. The ovary is very small, the oocytes being small, of equal size.

Stage II - The telicum is completely formed, red. They usually carry spermatophores. The oocytes are about the same size, but larger than at stage I.

Stage III - The telicum bears spermatophores. In the center of the ovary are groups of large, opaque oocytes. Their nuclei are seen in a transparent, light-colored disc form.

Stage IV - The telomum with spermatophores, has all the large oocytes, except the marginal ones. In the central part of the ovary the oocytes are non-transparent. The nuclei of these oocytes are not seen at all.

Stage V - Telicum with spermatophores, has all opaque oocytes, their nuclei are not seen. The carapace is hollowed out.

Stage VI - Spermatophores may be missing from the telicum. The carapace is hollow but empty. The ovary is small, virtually devoid of large mate oocytes.

Males:

Stage I - Petazma is incompletely developed. Sex can only be determined upon dissection.

Stage II - Petazma does not reach the end of the internal appendix. The sperm pouch is round. The cavity is relatively large. There are no spermatophores in the semen removal vessels.

Stage III - Petazma exceeds in length the internal appendix, is weakly chitinized. The proximal branch of the internal lobe is not flattened. The spermatophore pouch is long and carries several secretions of thickened sperm. The cavity is quite small. There are no spermatophores in the sperm elimination vessels, and if they are very small.

Stage IV - Petazma is fully developed, chitinized. The proximal branch of the internal lobe is flattened. The sperm pouch is very large. The cavities are not large. Spermatophores drain easily under pressure.

To confirm the maturing stage macroscopically, a histological analysis can be performed. From the fresh gonad is taken, a piece from its central part. A methodology used for the histological analysis it can be the one described by Mazzi (1997) and by Cerri & Sasso-Cerri (2003):

- is fixed in 5% buffered formaldehyde (0.1 M, pH 7.4) for a maximum period of 48 hours and stored in 70% ethanol;
- it is dehydrated by a progressive series of alcohol concentrations (70-100%);
- it is incorporated into a synthetic resin (GMA, Technovit 7100, Bio-Optica);
- cut at 3.5 μm with a rotary microtome (LKB, Historange);
- it is covered with a different technique; to analyze the histological structure of the ovaries and oviduct glands, Gill or Carazzi hematoxylin and alcoholic eosin (H and E). Masson trichrome (MT) or toluene blue and eosin (TB and E) can be used.
- quickly dehydrated in graded ethanol (95-100%), cleaned in Histolemon and mounted in resinous environment (Eukitt).
- can be observed using an optical microscope equipped with a camera, at different magnifications.

Depending on the degree of maturation of the ovaries, the relative weight of the ovary varies during a sexual cycle. This relative weight is called a gonosomatic ratio and is used to establish prolificity. The gonosomatic ratio can be expressed by the ratio between the weight of the ovaries and the weight of the fish after the removal of the ovaries, according to Schaefer's formula (1954):

$$RGS = g \times 100 / G$$ where, g = weight of the ovaries and G = weight of the fish.

Knowing the fecundity of a species is an important factor in the rational exploitation of the fish stock and is also used in the analysis of the breeding and survival potential of the stock.

The absolute fertility can be expressed by the ratio of the weight of the fish multiplied with the gonosomatic ratio and the average weight of an egg, multiplied by 100, according to Williams's formula (1997):

$$N = p \times F / m \times 100$$ where, N = fertility;
p = gonosomatic ratio;
F = body weight (g);
m = average weight of an egg.

The installation of sexual maturity is very different depending on the species; In some cases, it is conditioned by the individual reaching certain dimensions, sometimes by environmental conditions (food, temperature). The determination of the sex ratio and of the sequence of changes in maturity stage during the year are of considerable importance in building a thorough knowledge of the general biology of an exploited stock.

Identification of sex and sexual maturity stages find their primary application in providing basic knowledge of the reproductive biology of a stock. The information derived from these analyses can be used in ascertaining the age and size at which fish attain sexual maturity, the time and place of spawning and the duration of the cycle from the beginning of the development of the ovary to the final release of eggs. Together with fecundity estimates this information can be used to calculate the size of a stock and its reproductive potential.

7. Harvesting material for the study of food

Methods of on fish are diverse but must be critically evaluated in order to properly use them to determine the importance of food. An objective analysis is one that highlights both quantitative and qualitative aspects of food. Thus, a simple way of recording data by analyzing stomach contents is

to record the number of stomachs that contain one or more individuals in each food category, the number can be expressed as a percentage of the total stomachs analyzed (Hyslop, 1980).

Sikora et al. (1972) determined average dry weight in predatory species and expressed this as "biomass units". Variation in the average total weight of stomach contents relative to the size of the fish is commonly used in determining the daily rate of food behavior (Staples, 1975 Changes in the average weight of the annual gastric content indicate differences in feeding intensity. Values that incorporate body weight are probably much more useful because they are a measure of food consumption relative to the size of the fish.

a. Stages of analysis of stomach contents in fish:

- individuals of small size will be taken and placed completely in formaldehyde (4% solution) and then analyzed in the laboratory;
- from large individuals the stomach will be collected; with the help of the scissors the digestive tract will be cut to its extreme parts and then the ends will be connected and then it will be introduced into formaldehyde (4% solution);
- the meristic characteristics of the analyzed individuals, the date and the sampling station will be noted;
- the organisms present in the stomach will be identified up to the group level and, where possible up to the family level;
- depending on purpose different indicators will be calculated (frequency of occurrence, dominance, feeding coefficient, relative importance index (IRI), etc.).

Fig. 22 Stomach content analysis in turbot (INCDM photo)

Stomach content research has been an important area of activity in fisheries biology. Fish food studies cannot be treated in isolation, as they must be discussed in correlation with the whole marine environment in which fish are mere elements. For the laboratory study of the stomach contents, the establishment of trophic relations, it is necessary to collect the digestive tract. The proper collection consists in the cutting with the scissors of the digestive tube at its extreme points, the introduction at one end of a note, the number of which will indicate the meristic characteristics of the fish in the age frequency form. The digestive tubes collected and thus labeled are attached to both ends with thread, placed in a gauze bag and placed in formaldehide (4% solution) as soon as possible, to reduce as much as possible the alteration of the stomach contents.

Quantitative analysis is done by weighing method. The whole stomach content is weighed on the analytical balance as well as each element separately. In order to link these data with the individual to whom they belong, the stomach filling coefficient is calculated or as the fish feeding coefficient is also called.

Two methods are used for the determination, namely: qualitative and quantitative. The qualitative analysis consists in the complete identification of the food components present in the stomach of the fish. The quantitative method consists of numerical analysis (frequency of occurrence, dominance) and gravimetric analysis (feeding coefficient, index of relative importance (IRI). The frequency of occurrence and the numerical percentage of food components are generally calculated to characterize stomach contents (Hyslop, 1980). The frequency of occurrence (FO%) is expressed as the percentage of the total number of stomachs in which the respective species appears:

$$FO\% = FOi / FOt \times 100$$ where, FOi = number of stomachs in which species I appears;

FOt = total number of stomachs

A first evaluation can be determined by determining the filling coefficient of the digestive tract or the weighting coefficient. With the help of an electric scales, the stomach and the individual are weighed before and after the stomach is taken. Regarding the calculation formula regarding the filling coefficient of the stomach (of the digestive tract) there are several variants of calculation.

A first evaluation can be determined by determining the filling coefficient of the digestive tract or the weighting coefficient. With the help of an electric balance, the stomach and the individual are weighed before and after sampling.

Regarding the formula for calculating the coefficient of filling of the stomach (digestive tract) are more alternatives:

* Schreck et al., 1990 propose the following formula:

CU = <Cs/(Gt-Cs)> x 1000 where, CU = the filling coefficient;
Cs = weight content stomach; Gt = total weight of the fish

* Porumb I., 1961, carrying out studies on the biology of horse mackerel, proposes the following calculation formula for the filling coefficient of the stomach:

CU = ms x 10000 / mp where, CU = the coefficient of filling of the digestive tract in fish;
ms - mass of stomach contents;
mp - total mass of the fish.

* Smyly (1952) working with only a small amount of stomach content calculated the average weight of the whole content:

total stomach content / total weight of fish x 100

However, a realistic assessment is based on combining several values. One such indicator is the " index of relative importance " (IRI) in the formula Pinkas et al, 1971 Prince 1975:

IRI = (%N + % V) x %F

where, N% = number in percent,
V = volume;
F = frequency of occurrence.

This index is an integration of the measurement of the number, volume and frequency of occurrence to help evaluate the relationship between the different types of food identified in the stomach.

a. Index of relative importance (IRI)

This index is an integration of the measurement of the number, volume and frequency of occurrence to help evaluate the relationship between the different types of food found in the stomach. It is calculated by summing the numerical and volumetric percentage values and multiplying by the frequency of the occurrence percentage (Pinkas et al., 1971).

IRIi = (% Ni +% Vi) *% FOi

If Ni, Vi and FOi represent percentages of the number, volume and frequency of occurrence of the species, to estimate comparisons between species, the IRI was standardized to% IRI (Cortés, 1997).

COLLECTING TRAVERSAL VARIABLES

Given that the long-term sustainable use of fishery resources is the main object of conservation and management, the authorities involved in fisheries management must take measures based on competent scientific data, which will allow:

* avoiding the establishment of excess fishing capacity;
* preventing excessive fishing situations with unfavorable implications by sizing the fishing

effort and ensuring the selective nature of the fishing based on the assessment of the allowable catches;

* the development and use of cost-effective selective-non-destructive fishing gear and techniques that respect the environment and protect living marine resources.

In this sense, in order to ensure an efficient conservation and protection of the living marine resources from the Romanian coast, it was necessary to develop a system of monitoring and control of the catches of targeted and unvisited species, of the fishing capacities and effort.

1. ***Catch***

Knowledge of the biomass removed from the ecosystem by fishing operations is fundamental so as to monitor the status of stocks, as well as the impact of fishing on fish populations.

Landing data - the total amount of landing. The total amount of all landed species, in weight (tonnes) by fleet segment, together with the total number of active fishing vessels, should be reported by country and area (GSA). Total landing figures can be obtained from different sources (e.g. logbooks, sales notes, sampling and interviews).

Catch data per species - the main commercial species, identified at national level, information on the total catches by area and fleet segment. Total catch should be considered as the weight of the total annual catches, including the retained catches (landings) and the discarded fraction (discardes).

**** Incidental catch of vulnerable species*** - refers to the specific reporting of incidental catch of seabirds, sea turtles, seals, cetaceans, sharks and ray's species. It is important to collect existing data and identify additional / alternative sources of information to guide any possible revision of monitoring schemes. Data on the number of individuals taken, as well as fleet segments and gear types (if available) should be reported. Appropriate methods for recording by-catches include, for example, on-board observers and / or automatic sampling.

2. ***Fishing fleet***

The general objective is to provide information on the fleet operating, in order to compile reliable statisctics on fishing capacity for regional and sub-regional management purposes. Information will be collected on all vessels, boats, vessels or other national vessels that are equipped and used for commercial fishing purposes in the fishing area. Special attention should be paid to small-scale vessels.

3. ***Fishing effort***

Fishing effort is a measure of the amount of fishing activity deployed. It can be calculated through a combination of inputs related to capacity, gear and time. Effort information is needed to analyse changes in the amount of catch and it is crucial for developing multiannual management plans. Usually, fishing effort is calculated by multiplying the fishing capacity deployed (i.e. total GT or power, number of hooks in longlines) by the period of time (number of hours or days spent fishing) and can be obtained through various sources (logbooks, sampling, census, port surveys, etc.). Also, effort is combined with catch to estimate the rate of catch per unit effort. The catch per unit of fishing effort (CPUE) is a relative measure of fish stock abundance and can be used to estimate absolute abundance; it could be an indicator of fishing efficiency, both in terms of abundance and economic value. In its basic form, the CPUE could be expressed as the captured biomass for each unit of effort applied to species/stock (e.g. total catch of a species divided by the total fishing: kg/number of fish per longline hook days). Declining trends of this estimator could indicate overexploitation, while unchanging value could indicate sustainable fishing.

a. The structure of the data to be collected

In order to obtain the information regarding the situation of fishing capacities and effort, of the total catch and landed in tonnes respectively the value of the catch landed in euros, it is necessary to collect the following tranversal variables:

* *Number of vessels;*
* *GT, kW, Vessel Age;*
* *Days at sea;*
* *Hours at sea:*
* *Fishing days;*
* *Hours fished;*
* *kW - Fishing Days;*
* *GT - Fishing days;*
* *Number of trips;*
* *Number of fishing operations;*
* *Number of fishing tools;*
* *Live Weight of landings*
* *Value of landings total and per commercial species*
* *Prices by commercial species.*

The variables mentioned above are in line with those required in table 4 of Decision (EU) 1251/2016 and their analysis is performed according to the level of the requirements set out in tables 1A, 2, 5B and 5C (the existence of a strict correlation between catches and the effort of area fishing, vessel length classes, gears and fishing techniques). The Romanian fishing vessels operate only in a single superregion / region, in accordance with Table 5C of the Union's multiannual program [Decision (EU) 2016/1251] - Mediterranean and Black Sea. In the case of Romania, the ships are segmented on 5 length classes:

- < 6 m;
- 6 - <12 m;
- 12 - <18 m;
- 18 - <24 m;
- 24 - <40 m.

The fishing gear used on board the vessels are: OTM, TBB, GNS, FPO, LHP, LLS, SB. Depending on the fishing gear used, the ship segments are grouped on 2 fishing techniques:

* PG (length classes 0 - <6 m; 6 - <12 m);
* PMP (length classes 6 - <12 m; 12 - <18 m; 18 - <24 m; 24 - <40 m).

b. ***Data collection sources***

The main sources of collection of the transversal variables are the following documents: the questionnaire, the Black Sea fishing journal and of the coastal areas, the fleet register, the sales notes and the transport notes.

a. The questionnaire is the source of information on fishing capacities (vessel name, registration number, GT, kW, length and age) [according to the requirements of table 4 of Decision (EU) 1251/2016]. The elaboration of the content of the Questionnaire is carried out by the research staff of INCDM "Grigore Antipa" in collaboration with the ANPA staff, with strict compliance with all the data requirements (tranversal, economic and social variables) required in Decision (EU) 1251/2016. After elaborating the final form of the questionnaire, it is distributed to each economic agent who has the obligation to complete all the available data, depending on the complexity of the activities carried out (according to Chapter 10 of the Emergency Ordinance no. 23/2008 on fisheries and aquaculture).

b. The Black Sea and coastal areas fishing log is the source of information on fishing effort (no sea trips, fishing days, sea days, fishing and sea hours, no. of fishermen, no. of fishing operations). fishing, the duration of fishing operations, number of gears and their type respectively the value of catches per species in kg (total / landed / discharged) per vessel (according to the requirements of Table 4 of Decision (EU) 1251/2016).

c. The Fishing Fleet Register is a document that contains information on the technical characteristics of each fishing vessel (active or inactive) (vessel name, registration no., GT, kW, length and age) [according to the requirements in Table 4 of the Decision (EU) 1251/2016].

d. The sales notes are the documents that contains data on the catch landed per species in kg, respectively the price per species landed.

In addition to the ones mentioned above, the collection activity also includes: field surveys through the network of data collectors used in sample surveys, interviews with fishermen, cross-checking with information reported in logbooks, data recorded by the Monitoring System Vessels (VMS), respectively comparisons with previous fleet structures. The basic and periodic checks are implemented during the fishing operations on all types of gear used, respectively species caught and landed.

Also, the VMS information regarding the geographical location of the fishing vessel are well established, so, in addition to providing effort distribution information, they are used as a control tool for each activity, by intersecting with the statements of the marine and coastal fishing logs, respectively probation surveys. They can also provide information about the tools used by ships during their activities.

c. Method of data collection

The data is collected monthly, with the support of NAFA, from all economic operators, from the sources mentioned above. Also, the economic agents are regularly checked during the fishing activities, the landing points and the first sale centers. The collection method in this case is exhaustive and provides 100% coverage of the population, respectively the highest level of quality. The essential advantage of the census collection method is that estimates are known with certainty.

d. The quality of data collected

In order to verify the correctness of the fishing capacities and of the effort, it is possible to cross-validate the capacity and effort data mentioned in the questionnaires, respectively the Journals of marine and coastal fishing by each economic agent (according to the provisions of the origin and the results of the activities carried out), with the existing ones in RFP and registered by VMS (Ship Monitoring System).

Regarding the verification of the accuracy of the data regarding the landing situations, there is the possibility to re-validate the data sheets with the sales notes and the transport notes. The estimation of the average price for each commercial species is made by calculating the weighted average based on the prices recorded in the sales notes issued by the first sale centers for each landing made by the economic agents.

Periodic presence of research personnel on board vessels, tracking of fishing activities with all types of gear, recording the duration of fishing operations performed both in the case of trailed and fixed fishing gear under different conditions (hydro-meteorological conditions, water depth, vessel type, level of mechanization, type of fishing gear, stc.) allowed to obtain norms regarding the level of fishing effort for different situations encountered in the fishing process, which can be taken as a comparative unit in cross-checking the data quality.

After a thorough verification, the data is centralized and processed according to the requirements of the external users and uploaded to their platforms, in the requested formats, according to the chedules.

COLLECTING ECONOMIC VARIABLES

The objective of this task is to collect information in order to monitor the economic status of the fishing sector. Data collected under this task is needed to develop appropriate policies and strategies, especially in relation to promoting the long-term sustainability of resources and fleets. Economic data can help to explain fisher behavior and the overexploitation of fisheries resources. The species that fishers target, the level of exploitation, and the gear that they use are all influenced by the benefits they receive (i.e. the revenue) and the costs they incur.

The systematic collection of economic data is necessary so as to assess the economic consequences of different management options on the varying groups, based on the incentives that these create. Economics provide a framework for the optimal allocation of marine resources for the benefit of society. It provides an approach to valuing the different activities, allowing trade-offs between activities to be assessed and impacts to be measured in a consistent manner.

Economic information should be collected by area (GSA) and by fleet segment. Economic and social data are generally collected through sampling surveys using questionnaires, but for some fleet segments and some variables, other data sources could be used (e.g. administrative records, auction sales, and census).

Data collected under this task will help to obtain:

* trends in economic performance indicators;
* time series analysis of average annual prices for commercial species;
* analysis of the profitability of fleets (income, gross value added, operating cash flow);
* an accurate source of statistical data for landing values and prices;
* a better knowledge of fleet costs and their breakdown in different categories;
* a complete picture of regional, subregional and national employment in the fishery sector.

In order to highlight the level of efficiency of a fishing fleet, it is necessary to have the basic calculation elements (economic variables) that through a detailed analysis / processing will reveal whether the activity of the fishing fleet or a segment of a fleet is profitable or not.

a. *The structure of the data to be collected*

In order to obtain information on the diversity of economic indicators, such as: income, expenditure, subsidies, investments, labor, etc., it is necessary to collect the following economic variables (table 2):

* Gross value of landings;
* Income from leasing out quota or other fishing rights;
* Other income;
* Personnel costs;
* Value of unpaid labour;
* Energy costs;
* Repair and maintenance costs;
* Variable costs;
* Non-variable costs;
* Lease/rental payments for quota or other fishing rights;
* Operating subsidies;
* Subsidies on investments;
* Consumption of fixed capital;
* Value of physical capital;
* Value of quota and other fishing rights;

* Investments in tangible assets, net;
* Long / short Debt;
* Total assets;
* Engaged crew;
* Unpaid labour;
* Total hours worked per year;
* Number of fishing enterprises/units;
* Value of landings per species.

Table 2 Socio-economics: Economic and social data; Operating costs; Species value; Other economic aspects - Mandatory data (on annual basis)

FIELDS	*DEFINITION OF VARIABLES*
Fleet segment	*The fleet segment code or the code corresponding to the merged fleet segments*
Number of vessels	*The corresponding number of all active fishing vessels (by GSA) operating in the identified fleet segment, during the reference year*
Valută	*The currency (Euro or US dollar) in which the total value of landing is reported*
Valoare	*The total value of landing of all active fishing vessels belonging to that fleet segment*
Personnel costs	*Crew wages, including social security costs and imputed value of unpaid labour (for example, the vessel owner's own labour)*
Capacity (gross tonnage)	*The total capacity, expressed as gross tonnage (GT), of all active fishing vessels18 belonging to that fleet segment*
Capacity (engine power)	*The total capacity, expressed as engine power (kW), of all active fishing vessels14 belonging to that fleet segment*
Consum de combustibil	*Consumption in litres of fuel (regardless of fuel type)*
Fuel consumption	*Average price of fuel in the reference year (regardless of fuel type) in local currency per liter*
Total fuel cost	*Total amount paid for fuel in local currency. These data should be transmitted if no data for "Fuel consumption" or "Fuel price" are available*
Repair and maintenance costs	*Costs for maintenance and repairs of fishing equipment, gear and vessel parts*
Commercial costs	*Costs related to sales of vessel output. This includes fish market or wholesaler's fees, transportation of production, purchasing of ice, boxes and packaging*
Other variable costs	*All purchased inputs (good and services) related directly or indirectly to fishing effort (for example, bait, food consumed during the fishing operation) plus the purchase of components of assets (gear or vessel), but only if these do not improve the lifetime of the asset itself (consumed within the given year)*
Capital costs	*Depreciation costs plus Opportunity costs. Depreciation costs: consumption of fixed capital; this represents the reduction in value of the fixed assets used in production during the accounting period resulting from physical deterioration, normal obsolescence or normal accidental damage. Opportunity costs: the capital value is related to the opportunity cost of capital, or the required rate of return that is the rate of return that a company would otherwise be able to earn at the same risk level as the investment that has been selected. The opportunity cost of production is the value of the firm's best alternative use of its resources.*
Value of physical capital	*Value of the vessel, i.e., the hull, engine, all on board equipment and gear. The capital stock must be valued at the prices of the current year and should be depreciated*

Fixed costs	*The costs not directly connected with the operational activities (i.e. effort and catch/landing), which could include bookkeeping, vessel insurance, legal and/or bank expenses, annual quota for fishers' associations, dock expenses, renewal of fishing licences, etc.*
Employment	*The number of persons working on the active fishing vessels, both on a part-time and full-time basis*
Currency	*The currency (Euro or US dollar) in which the operating costs are reported*
Species	*The 3-alpha code identifying the species*
Total landing volume	*The total landing (tonnes) of the species mentioned for that fleet segment*
Total landing value	*The total value of the landing (currency unit, for example, euro), for the species mentioned, of all active fishing vessels belonging to that fleet segment*
Prices by commercial species	*The average value of species' prices during the reference year*
Operating subsidies	*Includes direct payments, e.g. compensation for halting fishing, refunds of fuel duty or similar lump sum compensation payments. Excludes social benefit payments, indirect subsidies, e.g. reduced duty on inputs such as fuel, investment subsidies*
Investments in physical capital Improvements	*Improvements to existing vessel/gear during the given year. These investments aim to improve the lifetime of the assets and are not consumed within the given year*
Other income	*Includes other income from use of the vessel, e.g. recreational fishing, tourism, oil rig duty, etc. Also, insurance payments for damage/loss of gear/vessel*

The variables mentioned above are in line with those required in table 5A of Decision (EU) 1251/2016 and their analysis is performed according to the level of the requirements set out in tables 1A, 2, 4, 5B and 5C (the existence of a close correlation between economic indicators, catches made on each class of vessel lengths, fishing effort by area, fishing gear and techniques, etc.). The Romanian fishing vessels operate only in a single superregion / region, in accordance with Table 5C of the Union's multiannual program [Decision (EU) 2016 / 1251- Mediterranean and Black Sea.

As with the transversal variables, the analysis of the economic variables is performed on the same segmentation of the ships (lengths 0- <6 m; 6- <12 m; 12- <18 m; 18- <24 m; 24- <40 m), fishing gear (OTM, TBB, GNS, FPO, LHP, LLS, SB) and fishing techniques [PG (length classes 0- <6 m; 6- <12 m) and PMP (length classes 6 - <12 m; 12- <18 m; 18- <24 m; 24- <40 m)].

b. ***Data collection sources***

As in the previous case, the main sources of collection of economic variables are the following documents: the questionnaire, the Black Sea fishing journal and of the coastal areas, the fleet register, the sales notes and the transport notes, respectively information from the economic agents' balance

sheet. on the website of the Ministry of Public Finance.

a. The questionnaire is the source of information about all groups of variables (Income, Labor costs, Energy costs, Repair and maintenance costs, Other operating expenses, Subsidies, Capital costs, Capital value, Investments, Financial position, Employment, Fleet, Effort, Number of enterprises / units in fisheries, Production value by species) [according to the requirements of table 5A of Decision (EU) 910/2019].

   As mentioned above, the elaboration of the Content of the Questionnaire is carried out by the INCDM research staff "Grigore Antipa" in collaboration with the ANPA staff, with strict compliance with all the economic data requirements required in Decision (EU) 910/2019.

After elaborating the final form of the questionnaire, it is distributed to each economic agent who has the obligation to complete, after the balance sheet, all the available data, depending on the complexity of the activities carried out (according to Chapter 10 of the "Emergency Ordinance no. 23/2008 regarding fishing and aquaculture").

b. The Fishing Journal of the Black Sea and coastal source that provides information on fishing effort (no. days at sea), number of enterprises / unit's fisheries employment (no. fisherman total hours worked per year). [according to the requirements of table 5A of Decision (EU) 910/2019].

c. The Fishing Fleet Register (RFP) is a document that contains information on the number of fishing companies, respectively the technical characteristics for each fishing vessel (active or inactive) (vessel name, registration no., GT, kW, length and age). [according to the requirements of Table 5 of Decision (EU) 910/2019]. For the active vessels, all the economic variables mentioned in point 1 will be collected and for the inactive vessels only the value of the physical capital and the consumption of fixed capital.

d. The sales notes are the documents that contain data on the catch landed per species in kg, respectively the price per species landed (according to the requirements of table 5A of Decision (EU) 910/2019).

e. The Ministry of Public Finance website is a source from which information can be obtained from the balance sheets submitted by the economic agents that carry out fishing activities in the Romanian Black Sea sector.

c. *Method of data collection*

The economic data is collected annually, with the support of NAFA, from all economic operators, from the sources mentioned above. Completion of the questionnaires is carried out by the accountants in the case of the companies that file the balance sheet or by the administrators of the income statements, expenses, etc., in the case of the Individual Companies and the Authorized Individuals who carry out fishing activities on vessels of 0- <6 m; and 6- <12 m.

Preventive, the accountants and the administrators of the economic agents are information, in advance, about what economic indicators they must provide for the economic analysis of the fishing activity of the companies they represent.

In accordance with the obligations regarding different data that should be reported to other bodies in the EC, e.g. Eurostat (the annual methodological report on data collection and management of statistics on national fisheries), will apply the exhaustive method covering 100% of the vessels registered in the FRF for all segments of the fleet.

d. *Quality of data collected*

The questionnaires completed with the requested economic data are analyzed by the INCDM specialists, by groups of variables, reporting from a percentage point of view the expenses at the level of the income obtained by each economic agent, respectively their comparative reporting at the level of the expense / income ratio obtained in the previous years with the strict observance of the correlation of the economic variables in table 5A by ship segments and fishing techniques, fishing effort, etc.

Thus, the process of controlling the primary data will consist of the following stages: identification of the extreme values from the absolute values; identification of extreme values from average values; cost structure evaluation and comparison with baseline data.

The primary economic data provided by the economic operators through questionnaires can be cross-checked with other sources of activity-related data, VMS, balance sheet data or balance sheet data submitted by them on the website of the Ministry of Public Finance.

In the event that there are any uncertainties regarding the value of some economic indicators, the

data providers (accountants or administrators of the economic agents) are contacted in order to make clarifications or corrections if necessary.

Regarding the verification of the accuracy of the data regarding the landing situations, there is the possibility to re-validate the data sheets with the sales notes and the transport notes.

The estimation of the average price for each commercial species is made by calculating the weighted average based on the prices recorded in the sales notes issued by the first sale centers for each landing made by the economic agents.

After a thorough verification, the data is centralized and processed according to the requirements of the external users and uploaded on their platforms, in the requested formats, according to the schedules.

COLLECTING SOCIAL VARIABLES

The objective of this task is to collect information in order to monitor the social status of the fishing sector. Data collected under this task is needed to develop appropriate policies and strategies, especially in relation to promoting the long-term sustainability of resources and fleets. Social data can help to explain fisher behaviour and the overexploitation of fisheries resources. The species that fishers target, the level of exploitation, and the gear that they use are all influenced by the benefits they receive (i.e. the revenue) and the costs they incur.

The systematic collection of socio data is necessary so as to assess the social consequences of different management options on the varying groups, based on the incentives that these create. Social provide a framework for the optimal allocation of marine resources for the benefit of society. It provides an approach to valuing the different activities, allowing trade-offs between activities to be assessed and impacts to be measured in a consistent manner.

Social information should be collected by area (GSA) and by fleet segment. Social data are generally collected through sampling surveys using questionnaires, but for some fleet segments and some variables, other data sources could be used (e.g. administrative records, auction sales, and census).

Data collected under this task will help to obtain:

* trends in economic performance and social indicators;
* time series analysis of average annual prices for commercial species;
* analysis of the profitability of fleets (income, gross value added, operating cash flow);
* an accurate source of statistical data for landing values and prices;
* a better knowledge of fleet costs and their breakdown in different categories;
* a complete picture of regional, subregional and national employment in the fishery sector.

Social indicators are instruments that allow the measurement of social performance for the purpose of quantitative and qualitative knowledge of social phenomena and processes, making time comparability possible by referring to the concept of quality. For these reasons, collecting these data will facilitate the assessment of the level of social progress in fishing activities, the sustainable management of natural resources and the quality of life.

a. *The structure of the data to be collected*

In order to obtain information regarding the structure of the workforce divided by sex, age, level of education, nationality and professional status, respectively equivalent to full time (FTE) by sex and national level, it is necessary to collect the following social variables (Table 3):

* Employment by gender

* FTE by gender.
* Unpaid labour by gender.
* Employment by age.
* Employment by education level.
* Employment by nationality.
* Employment by employment status
* FTE National.

Table 3 Socio-economics: social data; Other economic aspects - Mandatory data (on annual basis)

FIELDS	*DEFINITION OF VARIABLES*
Personnel costs	Crew wages, including social security costs and imputed value of unpaid labour (for example, the vessel owner's own labour)
Employment	*The number of persons working on the active fishing vessels, both on a part-time and full-time basis*
Full-time equivalent (FTE)	*Full-time equivalent employment, which equals the number of full-time equivalent jobs, is defined as total hours worked divided by the average annual number of hours worked in full-time jobs*
Number of persons in the crew < 25 years-old	*For that fleet segment, the total number of persons in the crew who are younger than 25*
Number of persons in the crew 25-40 years-old	*For that fleet segment, the total number of persons in the crew who are between 25 and 40 years-old*
Number of persons in the crew > 40 years-old	*For that fleet segment, the total number of persons in the crew who are older than 40*
Currency	*The currency (Euro or US dollar) in which these economic aspects are reported*

The variables mentioned above are in line with those required in table 6 of Decision (EU) 910/2019 and their analysis is performed according to the level of the requirements set out in tables 2, 5B and 5C [the existence of a strict correlation between the personnel engaged in fishing activities, ship segments, fishing techniques (PG and PMP) and fishing effort (fishing hours)]. The Romanian fishing vessels operate only in a single superregion / region, in accordance with Table 5C of the Union's multiannual program [Decision (EU) 2019/910] - Mediterranean and Black Sea.

And in this case, the analysis of the social variables is performed on the same segmentation of the ships (lengths 0- <6 m; 6- <12 m; 12- <18 m; 18- <24 m; 24- <40 m), tools fishing (OTM, TBB, GNS, FPO, LHP, LLS, SB) and fishing techniques [PG (length classes 0- <6 m; 6- <12 m) and PMP (length classes 6- <12 m; 12- <18 m; 18- <24 m; 24- <40 m)].

b. *Data collection sources*

As with economic variables, the main sources for collecting social variables are the following documents: the questionnaire, the Black Sea fishing log and of the coastal areas and fishing

authorizations. The questionnaire is the source of information on all the social variables (employment broken down by gender, FTE broken down by gender, unpaid work broken down by gender, employment broken down by age, employment broken down by level of studies, employment broken down by nationality, employment broken down by professional status, national FTE) according to the requirements of table 6 of Decision (EU) 910//2019.

a. The content of the questionnaire was elaborated by the research staff of INCDM "*Grigore Antipa*" in collaboration with the NAFA staff, with strict compliance with all the requirements regarding the complexity of the social indicators provided in Decision (EU) 910/2019. After

completing the final form of the questionnaire, it was distributed by the NAFA inspectors to each economic agent who had the task of completing all the available data, depending on the complexity of the activities carried out after the preparation of the balance sheet (according to Chapter 10 of the “Emergency Ordinance no. 23/2008 on fisheries and aquaculture”).

b. The Black Sea fishing and coastal areas are the source of information on the number of crew members, number of hours spent in fishing activities or at sea (according to the requirements of table 6 of Decision (EU) 910/2019).

c. The fishing authorization is a document containing information about the number of fishermen engaged in fishing activities (according to the requirements of table 6 of Decision (EU) 910/2019).

d. Periodic field surveys

c. *Method of data collection*

The economic data is collected annually, with the support of NAFA, from all economic operators, from the sources mentioned above.

In addition, data and information are also obtained through periodic field surveys through the network of collectors (registration of fishermen at fishing points in the case of stationary or on board vessels in the case of expeditionary fishing), interviews with fishermen, basic and periodic checks are carried out during fishing operations on all types of gear used, respectively during landing. In both individual and group interviews, the interviewer's role is to moderate the discussion and to create a framework in which participants feel encouraged to participate in the discussion.

In accordance with the obligations regarding different data that should be reported to other bodies in the EC, e.g. Eurostat (the annual methodological report on data collection and management of statistics on national fisheries), will apply the exhaustive method covering 100% of the vessels registered in the FRF for all segments of the fleet.

d. *Quality of data collected*

After completing the questionnaires by each economic operator, they are taken over with the support of NAFA by NIMRD "*Grigore Antipa*" who after a thorough verification of the data [cross-comparison of the data from the questionnaire with those from other sources of collection / information such as the logs of coastal and marine fisheries, fishing authorizations, interviews with fishermen on the ground (fishing points or in fishing areas)], proceed to the next stage of analysis / processing with strict observance of the correlation of each social variable by segment of vessel and fishing techniques.

If questions arise about the value of social indicators are contact data providers (administrators economic) in view of clarifications or corrections if necessary.

After a thorough verification, the data is centralized and processed according to the requirements of the external users and uploaded on their platforms, in the requested formats, according to the schedules.

METHODOLOGICAL REPORT – ECONOMIC AND SOCIAL DATA COLLECTION FOR AQUACULTURE AND PROCESSING INDUSTRY IN ROMANIA

Galați

CONTENTS

CHAPTER 1 - INTRODUCTORY ELEMENTS 3
1.1 Purpose and scope..... 3
1.2 Reference documents 4

CHAPTER 2 - MONITORING DIRECTIONS 4

Chapter 3 - WORKING METHODOLOGIES 5
3.1 The methodology used to select different data sources 6
3.2 Methodology used for choosing how to collect data 10
3.3 Methodology used to choose the sampling framework and allocation scheme 15
3.4 Methodology used to choose data estimation 16
3.5 Methodology used for data quality for the aquaculture and processing sector 16
3.6 Methodology used to ensure data quality for the aquaculture and processing sector 17
3.7 Management and use of data from the aquaculture and processing sector 19

CHAPTER 1
INTRODUCTORY ELEMENTS

1.1 Purpose and scope

There is a framework program in the EU for collection and management of data concerning fishing practices. This program was last reformed in 2008, resulting in a Data Collection Framework (DCF). In this context, RO collects, manages and makes available a wide range of data on the fisheries, aquaculture and fish processing sector.

Data is collected on the basis of a national program in which each Member State, including RO, indicates what data is collected, the resources it allocates for collection and how data is collected. RO must report annually on the program implementation and the Scientific, Technical and Economic Committee for Fisheries (STECF) evaluates the report.

Some of the data collected by RO is uploaded to databases managed by the JRC in response to data calls issued by DG MARE. These data are analysed by STECF experts and form the basis for scientific opinions and recommendations made in STECF reports. The resulting scientific advice is used as a basis for establishing The Common Fisheries Policy.

The purpose of this manual is to ensure a coherent and unitary framework for creating and implementing the National Program for Data Collection (PNCD) in the Romanian fisheries sector.

Data quantity, quality and collection methods, have a direct influence on economic agents with main activity in aquaculture (NACE code 0322), as well as on the management of fish, fish products and other aquatic creatures processing sector, in Romania, in accordance with NACE code 1020 - Processing and preserving of fish, crustaceans and molluscs.

1.2 Reference documents

The methods of data collection, verification, processing and analysis are in line with the EU Commission requirements.

The reference documents, on which the implementation of this data collection and management program in the aquaculture and processing sector is based, are the following:

Regulation no. 1004/2017 on establishing a Union framework for the collection, management and use of data in the fisheries sector and supporting scientific consultancy on the Common Fisheries Policy and repealing Council Regulation no. 199/2008 (revised).

EU Delegated Decision no. 910/2019 of 13 March 2019 establishing the Union multiannual program for collection and management of biological, environmental, technical and socio-economic data in fisheries and aquaculture sectors.

Implementing **Decision (EU) no. 909/2019** establishing a list of compulsory research campaigns and thresholds for the Union's multiannual program for data collection and management in fisheries and aquaculture sectors.

Implementing **Decision (EU) no. 2016/1251 of 12 July 2016** adopting a multiannual Union program for collection, management and use of data from fisheries and aquaculture sectors for the 2017-2019 period.

CHAPTER 2
MONITORING DIRECTIONS

The structure of collected data was established in accordance with Article 21 of Regulation (EU) no. 508/2014.

- **Economic data for the aquaculture and processing sector**
  - **Economic data for the <u>aquaculture sector</u> are the economic variables (revenues and expenditures) according to Table 7 of Commission Implementing Decision (EU) no. 2016/1251. These data can be found in section IV of the questionnaire used to collect data from the aquaculture sector.**
  - **Economic data for the processing sector are the economic variables (revenues and expenditures) according to Table 11 of Commission Implementing Decision (EU) no. 2016/1251. These data can be found in section III of the questionnaire used to collect data from the processing sector.**
- **Social data aims at defining / characterizing employees in the aquaculture and processing industry sectors according to level of education, age, gender and nationality. These data can be found in section IV of the questionnaire for the aquaculture sector and in section III of the questionnaire for the processing sector.**
- **Environmental data for the aquaculture sector represents the collection, analysis and interpretation of environmental data for aquaculture, regarding the type and quantity of drugs or treatments administered for prevention and control of diseases in Romanian aquaculture sector and mortality recorded in aquaculture units. These data can be found in section V of the questionnaire for the aquaculture sector.**

In addition to data presented above, the following types of data are also collected:

- **Unit identification data (unit name, NACE code, ownership, unit address, contact person). These data can be found in section I of the questionnaire for both aquaculture and processing sectors.**
- **Production data (technical data)**

- **Technical data from the aquaculture sector refers to: area, unit category (breeding station, nursery, rearing, combined), age of the biological material (embryonated eggs, summer I brood, summer II brood, fish for consumption, breeders), type of breeding technologies applied (directed, artificial or combined), type of breeding technology and category of technological system (extensive system, semi-intensive system, intensive system, in earthen ponds, in concrete ponds, in cages or pens, in recirculating system, floats, ropes, seabed, other enclosures), number of persons employed, by gender. These data can be found in sections I, II and III of the questionnaire.**
- **Technical data on the processing unit activity refer to raw material processed within the unit (quantities, values, species, origin) and to assortments obtained after processing (quantity and value for each assortment and whether it is marketed on the internal or external market). These data can be found in section II of the questionnaire.**

Chapter 3
WORKING METHODOLOGIES

The data collection methods and their quality must be appropriate to the purposes defined in Article 25 of Regulation (EU) no. 1380/2013 and must comply with the best practices and methodologies in accordance with the opinions of the relevant scientific bodies.

Romania's national data collection program for the aquaculture and fish processing sector is revised as often as necessary in accordance with the regulation requirements for the current year and for its improvement.

The collection of technical and economic data from economic agents in aquaculture is done in two ways: by questionnaire and by interview at the level of aquaculture units throughout the country. The sector-specific questionnaires collect annual technical and economic data for the entire contract duration. The interview role is to complete and verify the data accuracy entered in the questionnaire.

The model questionnaire is sent and distributed to all units, by experts involved in the implementation team together with the ANPA representatives assigned to the regional branches. Data collection is also carried out by a team of experts involved, together with ANPA inspectors, through questionnaires sent to producer associations, companies, individuals or entities authorized to carry out aquaculture and / or processing activities.

Interviews are conducted at aquaculture economic units assigned to the ANPA regional branches: Moldova, Muntenia, Oltenia, Transylvania, and the

Maritime Directorate - Constanța Department, as well as the Danube Delta Inspection Service.

The thoroughly researched processing units are in one of the following situations:

- **units with juridical personality regardless of the form of ownership (state, private, public institutions, other (specified);**
- **units with main activity in aquaculture or processing, included in the segments required by EC Implementing Decision (EU) 2016/1251.**

Data are collected from the following types of processing units:

- **units whose main activity is - Processing and preserving of fish, crustaceans and molluscs, classified according to EUROSTAT with NACE code 10.20;**
- **units whose secondary activity is - Processing and preserving of fish, crustaceans and molluscs, classified according to EUROSTAT with NACE code 10.20.**

The methodology of data processing provided by economic agents through questionnaires and interviews was entirely subordinated to the generation of specific data provided in tables 3B, 3C, 5B, 6A National Data Collection Plan, and are found in the European Commission Decision no. 1701/2016.

The processing of data specific to the two sectors, involved in a first stage, their ordering according to locality, county, form of organization, cultivated species, processed species and their introduction in the database.

In the second stage, the data analysis took place in order to evaluate the aquaculture sector and the fisheries processing industry.

In the third stage, data management and use were performed.

3.1 The methodology used to select different data sources

Aquaculture sector

For the aquaculture sector, the data collected consists in identifying the economic agent, by consulting the Register of Aquaculture Units - RUA, from the ANPA statistical data. The data collected are of an economic, social and technological nature.

The source of technical and economic data is represented by values entered in the questionnaires completed by economic agents with main activity in aquaculture (NACE code 0322), as well as by the information collected through interviews. These data are verified / completed, in order to ensure the validation of the primary data processed within the program.

The questionnaires are revised annually, for the purpose of tabular production reporting, keeping the structure of four basic sections:

- **Section I - Unit identification data (name of the unit, NACE Code, form of ownership, address of the unit, contact person).**
- **Section II - Technical data on the unit, relating to:**

– **aquaculture: area, unit category (breeding station, nursery, rearing, combined), age of the biological material (embryonated eggs, fingerlings, summer I brood, summer II brood, fish for consumption, breeders, fish eggs for human consumption), type of breeding technologies applied (directed, artificial or combined), type of breeding technology and category of technological system (extensive system, semi-intensive system, intensive system, in earthen ponds, in concrete ponds, in cages or pens, in recirculating system, floats, ropes, seabed, other enclosures), number of persons employed, by gender.**

Data acquisition for the aquaculture sector will be made in accordance with European Commission Decision no. 1251/2016 and its annex in accordance with EU legislation (table 1).

Economic variables for the aquaculture sector are defined and collected according to Table no. 7 of the annex of the European Commission Decision no. 1251/2016.

Table no. 1 - Source of economic variables collected for the aquaculture sector

Variable group	*Variable*	*Data Sources*
Income	Gross sales per species	Questionnaire
	Other income	Questionnaire
Personnel costs	Personnel costs	Questionnaire
	Value of unpaid labour	Questionnaire
Energy costs	Energy costs	Questionnaire
Raw material costs	Livestock costs	Questionnaire
	Feed costs	Questionnaire
Repair and maintenance	Repair and maintenance	Questionnaire
Other operational costs	Other operational costs	Questionnaire
Subsidies	Operating subsidies	Questionnaire
	Subsidies on investments	Questionnaire
Capital costs	Consumption of fixed capital	Questionnaire
Capital value	Total value of assets	Questionnaire
Financial results	Financial income	Questionnaire
	Financial expenditures	Questionnaire
Investments	Net investments	Questionnaire
Debt	Debt	Questionnaire
Raw material weight	Livestock used	Questionnaire
	Fish Feed used	Questionnaire

Weight of sales	Weight of sales per species	Questionnaire
Employment	Number of persons employed	Questionnaire
	Unpaid labour	Questionnaire
	Number of hours worked by employees and unpaid workers	Questionnaire
Number of enterprises	Number of enterprises (by category on the number of persons employed)	Questionnaire

Social data expected to be obtained, aim at defining/characterizing employees from the aquaculture sectors according to level of education, age, gender and nationality and national FTE. Social variables will be collected according to Table 6 of the annex of the European Commission Decision no. 1251/2016 (table 2).

Table no. 2 - Source of social variables collected for the aquaculture sector

Variable	*Data Sources*
Employment by gender	Questionnaire
FTE by gender	Questionnaire
Unpaid labour by gender	Questionnaire
Employment by age	Questionnaire
Employment by education level	Questionnaire
Employment by nationality	Questionnaire
Employment by employment status	Questionnaire
FTE National	Questionnaire

Processing sector

The source of economic, social and technical (production) data for the processing segment is the questionnaire. The telephone or personal interview at the unit's headquarters has the role of verifying data correctness and their correlation.

The questionnaires are structured in three sections:

- Section I - Unit identification data (name of the unit, NACE code, ownership, unit address, contact person).
- Section II - Data on the processing unit activity (raw materials, assortments, types, quantity, value).
- Section III - Economic and social data according to Table 11 - Commission Implementing Decision (EU) 2016/1251.

If the companies will not allow access to this information or if data is incomplete, figures registered and declared to the authorities of the fiscal body will be used, respectively the website of the Ministry of Public Finance

(information from the balance report of economic agents that process fish as their main or secondary activity).

The source of the economic variables for the processing sector are presented below in table no. 3.

Table no. 3 - Source of economic variables collected for the processing sector

Variable group	*Variable*	*Data Sources*
Income	Turnover	Questionnaire
	Other income	Questionnaire
Personnel costs	Personnel costs	Questionnaire
	Value of unpaid labour	Questionnaire
	Payment for external agency workers (optional)	Questionnaire
Energy costs	Energy costs	Questionnaire
Raw material costs	Purchase of fish and other raw material for production	Questionnaire
Other operational costs	Other operational costs	Questionnaire
Subsidies	Operating subsidies	Questionnaire
	Subsidies on investments	Questionnaire
Capital costs	Consumption of fixed capital	Questionnaire
Capital value	Total value of assets	Questionnaire
Financial results	Financial income	Questionnaire
	Financial expenditures	Questionnaire
Investments	Net investments	Questionnaire
Debt	Debt	Questionnaire
Employment	Number of persons employed	Questionnaire
	FTE National	Questionnaire
	Unpaid labour	Questionnaire
	Number of hours worked by employees and unpaid workers	Questionnaire
Number of enterprises	Number of enterprises	NAFA
Weight of raw material (optional)	Weight of raw material per species and origin (optional)	Questionnaire

The source of social variables for the processing sector are presented in table no. 4.

Table no. 4 - Source of social variables collected for the processing sector

Social variable	*Data Sources*
Employment by gender	Questionnaire
Employment by age	Questionnaire
Employment by education level	Questionnaire

The production data source for the processing sector can be found in table no.5.

Table no. 5 - Source of production data for the processing sector

Production variables	*Data Sources*
Origin of raw material	Questionnaire
Processed species of fish or other aquatic life	Questionnaire
Quantity of processed raw material	Questionnaire
Cost of processed raw material	Questionnaire
Type of assortment obtained	Questionnaire
Quantity of assortment obtained	Questionnaire
Cost of assortment obtained	Questionnaire
Destination of the obtained products	Questionnaire

The data source is clearly mentioned for each variable in the data source box in Table 3C: Population segments for collection of economic and social data for the processing industry, which accompanies the annual report.

3.2. Methodology used for choosing how to collect data

Aquaculture sector

Data collected from economic agents, common to the aquaculture sector will have an economic character (presented above) and a technological character: number of units, number of employees, equivalent working time (national and European) and productions.

The characteristic segments of aquaculture sector are: species and breeding technologies, yields by types of units and culture.

The method of data collecting from the aquaculture sector will be exhaustive, namely the census, and questionnaires will be sent to all registered units. Thus, the samples size is equal to the total number of aquaculture units in the year in which the study is carried out, respectively to the framework population, proposing to obtain a response rate of 100%.

The last phase of the study will be the collected data analysis and interpretation, the testing of research tools and protocols effectiveness and the statistical parameters estimation for further analysis.

The target population is represented by units in the aquaculture sector and processing industry.

Aquaculture units will be classified in one of the size classes, depending on the number of employees, as follows:

A - units ≤ 5 employees

B - units with 6-10 employees

C - units ≥ 10 employees.

Segmentation of the aquaculture sector will be carried out in accordance with Table no. 9 of the annex (Segmentation to be applied in order to collect data from the aquaculture sector) of the European Commission Decision no. 1251 of 2016.

The main segments of Romanian aquaculture, by species that predominate in culture, will be:

(a) salmon farming;

(b) cypriniculture, a segment that includes rearing of other freshwater species, in polyculture with cyprinids, such as predatory species;

(c) other species of fish (salmon, sea perch, sea bream, tuna, eel);

(d) sturioniculture;

(e) other species of freshwater and marine fish;

(f) the rearing of other aquatic creatures, namely bivalves, crustaceans, algae.

As in the case of economic variables, the main sources for collecting social variables are the following documents: questionnaire, interview and data from the Ministry of Public Finance website, a source from which information can be taken from balance sheets submitted by economic agents that carry out aquaculture activities in the Romanian sector.

The questionnaire is the source where information can be found on all social variables *(employment broken down by gender, FTE broken down by gender, unpaid work broken down by gender, employment broken down by age, employment broken down by level of education, employment broken down by nationality, employment broken down by professional status, national FTE)* as required by Decision (EU) 1251/2016.

The social data expected to be obtained aim at defining / characterizing the employees in the aquaculture sector according to the level of education, age, gender and nationality and national FTE.

Processing sector

Economic, social and production data are collected annually, with the support of ANPA, from all economic operators identified as having their main and secondary activity - Processing and preserving of fish, crustaceans and molluscs, according to NACE 1020.

Data collection is performed by region and depends on the number of employees per unit.

The method of data collection is exhaustive, namely the census, the questionnaires being distributed to all companies active in the current monitored year.

The collection method ensures a 100% coverage of the population.
The essential advantage of this type of collection (census) is that it makes it possible to know the entire processing sector.

For enterprises whose main activity is fish processing, data on economic variables are collected for reporting according to the table below:

Variable group	***Variable***	***Methodology***
Income	**Turnover**	**For all units whose main activity is fish processing, data collection and reporting is performed by segments according to the number of employees as follows:** • **≤ 10** • **11-49** • **50-249** • **≥ 250**
	Subsidies	**For all units whose main activity is fish processing, data collection is performed by segments according to the number of employees as follows:** • **≤ 10** • **11-49** • **50-249** • **≥ 250.** **Data reporting is performed for all segments.**
	Other Income	**For all units whose main activity is fish processing, data collection is performed by segments according to the number of employees as follows:** • **≤ 10** • **11-49** • **50-249** • **≥ 250.** **Data reporting is performed for all segments.**
Personnal Costs	**Wages and salaries of staff**	**For all units whose main activity is fish processing, data collection and reporting is performed by segments according to the number of employees as follows:** • **≤ 10** • **11-49** • **50-249** • **≥ 250**

	Imputed value of unpaid labour	**For all units whose main activity is fish processing, data collection and reporting is performed by segments according to the number of employees as follows:** • **≤ 10** • **11-49** • **50-249** • **≥ 250**
Energy Costs	**Energy Costs**	**For all units whose main activity is fish processing, data collection and reporting is performed by segments according to the number of employees as follows:** • **≤ 10** • **11-49** • **50-249** • **≥ 250**
Raw Material Costs	**Purchase of fish and other raw material for productio n**	**For all units whose main activity is fish processing, data collection is performed by segments according to the number of employees as follows:** • **≤ 10** • **11-49** • **50-249** • **≥ 250.** **Data reporting is performed for all segments.**
Other operational costs	**Other Operational Costs**	**For all units whose main activity is fish processing, data collection and reporting is performed by segments according to the number of employees as follows:** • **≤ 10** • **11-49** • **50-249** • **≥ 250**
Capital Costs	**Depreciatio n of capital**	**For all units whose main activity is fish processing, data collection and reporting is performed by segments according to the number of employees as follows:** • **≤ 10** • **11-49** • **50-249** • **≥ 250**
	Financial Costs, net	**For all units whose main activity is fish processing, data collection and reporting is performed by segments according to the number of employees as follows:** • **≤ 10** • **11-49**

		• 50-249 • ≥ 250
Extraordinary costs	**Extraordinary Costs, net**	**For all units whose main activity is fish processing, data collection and reporting is performed by segments according to the number of employees as follows:** • ≤10 • 11-49 • 50-249 • ≥ 250
Capital Value	**Total value of assets**	**For all units whose main activity is fish processing, data collection and reporting is performed by segments according to the number of employees as follows:** • ≤ 10 • 11-49 • 50-249 • ≥ 250
Net Investments	**Net Investments**	**For all units whose main activity is fish processing, data collection and reporting is performed by segments according to the number of employees as follows:** • ≤ 10 • 11-49 • 50-249 • ≥ 250
Debt	**Debt**	**For all units whose main activity is fish processing, data collection and reporting is performed by segments according to the number of employees as follows:** • ≤ 10 • 11-49 • 50-249 • ≥ 250
Employment	**Number of persons employed**	**For all units whose main activity is fish processing, data collection is performed by segments according to the number of employees as follows:** • ≤ 10 • 11-49 • 50-249 • ≥ 250. **Data reporting is performed for all segments.**
	FTE National	**For all units whose main activity is fish processing, data collection is performed by segments according to the number of employees as follows:** • ≤ 10

		• 11-49 • 50-249 • ≥ 250. Data reporting is performed for all segments.
Enterprises	Number of Enterprises	For all units whose main activity is fish processing, data collection is performed by segments according to the number of employees as follows: • ≤ 10 • 11-49 • 50-249 • ≥ 250. Data reporting is performed for all segments.

For enterprises whose secondary activity is fish processing, data on economic variables are collected for reporting according to the table below:

Variable group	*Variable*	*Methodology*
Number of enterprises	Number of enterprises	• Total (all enterprises)
Turnover attributed to fish processing	Turnover attributed to fish processing	

<u>Full-Time-Equivalent (FTE) for the aquaculture and processing sector</u>

The full-time equivalent (FTE) is a unit of measurement corresponding to the workload of a full-time employee.

This represents a value equal to the number of full-time employees of a company and is calculated by adding all the hours worked in a year by the staff, both part-time and full-time, and then dividing the result by the number of work hours of a full-time employee.

This determines the effort required to carry out a project expressed in FTE, regardless of the actual number of employees and changes in the work schedule in a given period.

Currently, seasonal and fixed-term workers are excluded from the FTE calculation.

Full-time equivalent (ENI) is collected and reported by gender.

$$\text{Full-Time-Equivalent (FTE)} = \frac{\text{no. total hours actually worked}}{\text{maximum number of hours in the reported period}}$$

3.3 Methodology used to choose the sampling framework and allocation scheme

The processing units with main activity according to NACE code 1020 were classified, according to the EU recommendations found in table 3C: Population segments for collection of economic and social time for the processing industry,

according to the number of employees, in 4 segments: companies ≤10 employees, companies with 11-49 employees, companies with 50-249 employees and companies ≥250 employees.

RO is one of the Member States that has decided to follow the extended program through which data are transmitted following the segmentation by size category provided for in Commission Decision 2010/93 / EU.

From the processing units with secondary activity the data collection and reporting is not performed by segments.

3.4 Methodology used to choose data estimation

Data processing from the aquaculture and processing sector, provided by economic operators through questionnaires, is entirely subjected to the generation of specific data, the correspondent of which can be found in Appendix XII of Commission Decision 93 of 2010.

If an economic, social or production variable has not been reported by a unit, it will be estimated by calculating the results from unit reports of the same type (from the same segment) and size. The type of error is biased, and the statistical calculation will be performed in accordance with the methodological provisions suggested by STECF - SGECA 10-03, namely the calculation of the response rate (RR) according to the following formula:

$$RR\ (\%) = \frac{Achieved\ number}{\text{frame population number}}\ x\ 100$$

3.5 Methodology used for data quality for the aquaculture and processing sector

The primary data obtained from respondents will be recorded, calculated according to the DCF recommendations, statistically processed and entered in the official documents of the Program.

The data obtained will also be presented in comparison with what was planned in the initial proposal. Any deviation from the initial proposal of the National Program regarding the methods used for data source selection, data collection type, sampling framework and allocation scheme, as well as the estimation procedures, will be explained.

The control process of the primary data will consist in going through the following stages:

- identification of extreme values from average values;
- evaluation of the cost structure and comparison with reference data from the previous year;

- correlation of the quantity and value of raw material with the quantity and value of assortments obtained and marketed.

Primary production, economic and social data provided by the economic operators through questionnaires are cross-checked with other data sources related to the processing activity, such as data from the balance sheet submitted by them on the website of the Ministry of Public Finance.

If there are any ambiguities regarding economic or production indicators, the data providers (accountants or administrators of the economic agents) are contacted in order to make clarifications or corrections if necessary.

If an economic, social or production variable has not been reported by a unit, it will be estimated by calculating the average resulting from the reporting of units of the same type (from the same segment) and size.

After a thorough verification, the data is centralized and processed according to the requirements of external users and uploaded on their platforms, in the required formats, as planned.

3.6 Methodology used to ensure data quality for the aquaculture and processing sector

The quality of data collected by RO for the processing sector is ensured taking into account the following recommendations which are detailed below.

Type of data collection is A: census

Definition and presentation of <u>accuracy indicators</u>

For the processing sector, the response rate calculation (RR) is performed as follows:

- for units with main activity, the analysed sample is represented by each segment of employees (≤ 10, 11-49, 50-249, ≥ 250);
- for units with secondary activity, the analysed sample is represented by all data of the variable taken into account.

<u>*The response rate (RR)*</u> is reported as a percentage and is calculated according to the following formula:

$$RR\ (\%) = \frac{Achieved\ number}{\text{frame population number}}\ x\ 100$$

Where:

Achieved Number is the number of respondents who supplied data in response to the census.

<u>*Coefficient of variation (CV) for the aquaculture and processing sector*</u>

The CV is required for the census when response rate is low (CV <70%), and it must be treated as if it were a Non-Probability Sample survey.

The coefficient of variation (CV) is an indicator of accuracy and is preferred when appropriate.

Coefficient of variation (CV) - is a relative measure of data dispersion. CV represents the evaluation of standard deviation in relation to the arithmetic mean.

CV is independent of the measurement units and intervenes in the study of homogeneity of some populations as follows:

- **if CV < 20% the population is relatively homogeneous;**
- **if 20% < CV < 30% the population is relatively heterogeneous;**
- **if 30% < CV the population is heterogeneous.**

Coefficient of variation = (standard deviation / mean value) * 100. With symbols:

$$CV = (SD / \overline{X}) * 100$$

The following formula applied for the frame population or for a sample (segment) is used to calculate the CV.

CV calculated for the frame population:

$$CV\ (\%) = \sigma / \mu * 100$$

CV calculated for a sample (segment):

$$CV\ (\%) = S / \overline{X} * 100$$

– **σ is the standard deviation for a population, which is the same as "S" for the sample.**

– **μ is the mean for a population, which is the same as $\overline{X}$ in the sample.**

<u>Standard deviation</u>

The standard deviation is calculated according to the formula:

$$S = \sqrt{\frac{1}{N-1} * \sum \left(D[n] - M_D\right)^2} = \sqrt{S^2}$$

Where:

N = {1, ..., N-1, N}

M_D = average value of data set D

S^2 = variance value

Given the definition for the variance of a data set D, it follows that the standard deviation is the square root of the variance value.

The standard deviation in Excel is calculated very simply using the STDEV statistical function for a given set of values.

Arithmetic mean is the central value measure of the data set around which data fluctuates in the set.

In statistics, the arithmetic mean of a set of variables is their sum divided by their number according to the formula:

$$\overline{X} = \frac{x1+x2+\cdots+xn}{n}$$

The arithmetic mean is influenced by extreme values, and the sum of differences between individual values of the series and the mean is always zero.

After calculating the coefficient of variation, the value shall be included in the corresponding level of accuracy as follows:

Depending on the CV value, the following levels of precision are established for the studied variables:

Level 0:	coefficient of variation (CV) is higher than 20%
Level 1:	coefficient of variation (CV) is between 12.5% and 20%;
Level 2:	coefficient of variation (CV) is between 2.5% and 12.5%;
Level 3:	coefficient of variation (CV) is less than 2.5%.
Level 4:	exhaustive data collection.

3.7 Management and use of data from the aquaculture and processing sector

I.C.D.E.A.P.A. Galați complies with Regulation 199/2008 (art. 17-20) regarding the sending and availability of data.

Primary data collected will be available to the supplier, deliverable under PNCD - INCDM Constanța and ANPA for transmission to international scientific organizations and relevant scientific bodies within the regional fisheries management organizations (GFCM) in accordance with the international obligations of the EU and Member States.

Detailed and compiled data will be transmitted in secure electronic format.

Where detailed and compiled data are required for specific scientific analysis, it is ensured that the data will be provided to end-users.

Given Romania's reporting obligations to: FAO, GFCM, EC-DGMARE / JRC main data requesters, EUROSTAT, INS, MADR, etc., it is necessary that basic, aggregated and meta-data can be used / accessed from a single source in compliance with the requirements, the EU legislative provisions.

RA is provided in two physical documents, a file that contains the report text in a Microsoft Word document (a PDF file from the Word document that accompanies the presentation), and a file that contains the standard tables in Excel.

The annual reports are prepared by RO, reviewed by independent experts and evaluated by STECF in two dedicated annual meetings. On the basis of the STECF proposals, DG MARE approves the programs and reports.

Uploading data to the JRC server is done in accordance with data management procedures.

The use of data collected under the umbrella of the EU Data Collection Framework (DCF) is regulated by Regulation (EC) no. 199/2008 of the Council from 25 February 2008: Articles 18 and 20.

The use of data collected under the umbrella of the EU Data Collection Framework (EU-MAP) is regulated by Regulation (EC) no. 1004/2017.

1. Methodology for demersal research in the Romanian Black Sea waters

The methodology and techniques used for data collection, verification, processing and analysis for the general assessment of demersal stocks (turbot, whiting) are, generally, follow the methodology applied during previous data collection programs for the Romanian Black Sea area.

The submitted data were collected by standard techniques (bottom trawl) and methodology, which remained constant in the survey evaluation. The vessel's GPS system was connected to the NAFA satellite system for fishing vessel monitoring system (VMS) and the vessel's location was strictly controlled during trawling activities. The data analysis was performed by the "swept area method" and the results obtained can be reproduced and compared.

1.1 Information collected through bottom trawl activities:

* GPS coordinates from the start and of trawling;
* The depth measured with the vessel acoustic probe;
* The mean trawling speed (Nd);
* Time / trawling duration;
* The total catch;
* The abundance of the target species;
* Total catch weight;
* The absolute and standard length, individual weight;
* The otoliths extraction for age determination;
* The sex determination;
* The composition of by-catch species;
* The discharged catches;
* The stomach content (turbot).

The specimens with absolute length below the minimum, specified in the Ministerial Order no. 432/2008 regarding the minimum individual dimensions of living aquatic resources in the public domain of the state, by species, which can be captured from the aquatic environment (MADR 2008), (below 45 cm), are returned to the sea, after being measured.

All the data collected from demersal research expeditions were entered in the program developed by COISPA, Biondex Script (version 2.0) running in program R version 3.6.0, through fisheries data processing software, including statistical data processing, in accordance with the requirements of the European Commission Regulations. Before entering the data in the Biondex script, are organized in the format of MEDITS tables, being verified with the RoME script (version 1.4) to perform multiple data checks. The RoME package includes functions related to single checks for a total of 55 functions ("*facility functions*"), associated with a certain control in the tables TA, TB, TC, TD, TT, TE and TL.

The results obtained by running this script are saved in the OUTPUT folder, like JPEG, TIFF and CSV files and are presented like maps and tables that include data related to:

* the surface of the researched square (Km^2, m^2);
* the average mass per unit area (g/m^2, t/Km^2);
* the mass limits variation per unit area;
* the total biomass values (t);
* the abundance index (individuals/km^2).

Demersal expeditions for the assessment of turbot and dog fish agglomerations provide additional information for the calculation of the catch effort per unit CPUE (kg/hour) and of catch per unit area CPUA (kg/m^2) in the researched areas. The collected data are stored in the NIMRD database, as well as in a special module created within NAFA Romania.

The survey was conducted with the research vessel "*Steaua de Mare 1*" (ROU – P – 040254 CT), belonging to the National Institute for Marine Research and Development "*Grigore Antipa*" Constanța, having the following characteristics:

* Type of fishing vessel: B-410
* Total length: 25,71 m;
* Maximum width: 7,22 m
* Maximum
* The engine power: 420 kw (570 HP)
* Maximum tonnage: 134 t
* Net tonnage: 40 t
* The speed: 7-10 Nd
* The crew number: 7 people
* Researchers number: 6 people
* The year of construction: 1981

During the demersal expeditions, the bottom trawl 22 / 27-34 was used, with a horizontal opening of 13 m, the average speed of the vessel was 1.8-2.1 Nd in the spring season expedition and 1.9-2.2 Nd in the autumn expedition, the trawling time being standardized at 60 minutes.

2. Methodology for pelagic research in the Romanian Black Sea waters

The methodology and techniques used for data collection, verification, processing and analysis for the general assessment of pelagic stocks (*sprat, picked dogfish, jellyfish*) are, generally, follow the methodology applied during previous data collection programs for the Romanian Black Sea area.

The submitted data were collected by standard techniques (*pelagic trawl*) and methodology, which remained constant by sampling. The vessel's GPS system was connected to the NAFA satellite system for fishing vessel monitoring system (VMS) and the vessel's location was strictly controlled during trawling activities. The data analysis was performed by the "*swept area method*" and the results obtained can be reproduced and compared.

2.1 Information collected through pelagic trawl activities:

* GPS coordinates from the start and of trawling;
* The depth measured with the vessel acoustic probe;
* The mean trawling speed (Nd);
* Time / trawling duration;
* The total catch;
* The abundance of the target species;
* Total catch weight;
* The absolute and standard length, individual weight;
* The otoliths extraction for age determination;
* The sex determination;
* The composition of by-catch species;
* The discharged catches.

During the pelagic expeditions, the pelagic trawl 50 / 357-74 was used, with a horizontal opening of 22 m, the average speed of the vessel was 2.2-2.5 Nd in the spring season expedition and 2.1-2.4 Nd in the autumn expedition, the trawling time being standardized at 30 minutes.

Pelagic expeditions for the assessment of sprat agglomerations provide additional information for the calculation of the catch effort per unit CPUE (kg/hour) and of catch per unit area CPUA (kg/m2) in the researched areas. The collected data are stored in the NIMRD database, as well as in a special module created within NAFA Romania.

For the calculations of pelagic species biomass, catch per unit effort (CPUE) (kg/h) and catch per unit area (CPUA) (kg/km^2) data were used.

The results obtained are presented like maps and tables include data on:

* the surface of the researched square (Km^2, m^2);
* average mass per unit area (g/m^2, t/Km^2);
* mass limits variation per unit area;
* total biomass values (t).

The survey was conducted with the research vessel "Steaua de Mare 1" (ROU – P – 040254 CT), belonging to the National Institute for Marine Research and Development "*Grigore Antipa*" Constanța.

3. *The sampling scheme*

In order to establish the abundance and biomass of pelagic and demersal species, at the Romanian Black Sea coast, the standard methodology for stratified sampling was applied (Gulland, 1966; Sparre, Venema, 1998; Sabatella, Franquesa, 2004).

The analyzed area at Romanian Black Sea coast was divided into four layers, depending on the depth: *Stratum* 1 (0-30 m), *Stratum* 2 (30-50 m) and *Stratum* 3 (50-75 m). Also, to assess the abundance and biomass of pelagic and demersal species, the analyzed area was divided into 57 squares, each with sides of 10 x 10 Mm, surface of 100 Nm^2 (or 2000 – 2500 Mm^2).

On board of the vessel, the absolute and standard length, as well as the individual weight, were measured to determine the size and weight structure of the turbot stock and to estimate the share of specimens with a length below that allowed in the fisheries legislation.

4. Laboratory analysis

After collecting the samples on shipboard, the age, maturity of the reproductive system, stomach food composition, and fillet chemical composition were determined in laboratory.

The turbot age was established by otoliths reading under binocular microscope.

To identify the composition of the food stomachs were collected. The stomach content analysis included identification of the taxonomic composition and total number of food components, weight and frequency of occurrence of each food component. The index of relative importance (IRI) was used to determine the significance of food components in the trophic spectrum (Pinkas et.al., 1971):

$$IRI = (C_N + C_W) * F$$

C_N - percentage share of the food item i in total number;
C_W - percentage share of the food item i in the total weight;
F – frequency of occurrence.

IRI expressed as a percentage was calculated by the equation (Cortes, 1997):

$$\% \, IRI \, i = -\frac{100 * IRI}{\sum_i^n IRI \, i}$$

n – total number of the taxonomic categories at a given taxonomic level.

Statistical method

4.1 Swept areas method

To determine the relative biomass of the reference species, the "*swept area method*" was applied. According to this method, trawl sweeps a well-defined path, the area of which is the length of the path times the width of the trawl, called the "*swept area*" or the "effective path swept", thus the swept area can be estimated from equation:

a = D * hr * X2,

D = V * t

V is the velocity of the trawl over the ground when trawling,

t is the time spent trawling,

hr is the length of the head-rope.

X2 is that fraction of the head-rope length, hr, which is equal to the width of the path swept by the trawl, the "wing spread", hr*X2,

D - distance covered.

To calculate turbot biomass, the catch per unit area (CPUA) was used:

$$\frac{C\,w/t}{a/t} = \frac{Cw}{a}\ kg/Km^2$$

$C_{w\,/\,t}$ – cath in units of weight per trawling hour;

a / t – area swept per trawling hour

The biomass for each stratum was obtained from equation:

$$B = \left(C_{w\,/a}\right) * A$$

$C_{w\,/\,a}$ – men cath per unit of area for all trawl sweeps in the stratum,

A – stratum area

The variance of biomass estimated for each stratum is:

$$VAR(B) = A * \frac{1}{n} * \frac{1}{n-1} * \sum_{n=1}^{n}[Ca(i) - Ca]$$

The total area of the surveyed region is equal to the sum of the areas of every stratum:

A = A1 + A2 + A3

The mean catch for the entire survey area was obtained from equation:

$$Ca(A) = \frac{Ca1 * A1 + Ca2 * A2 + Ca3 * A3}{A}$$

Ca1- catch per unit area in stratum 1;

A1 – stratum 1 area,

A2 – stratum 2 area;

A3 – stratum 3 area; ….. etc.;

A – total water area.

The total biomass in the survey area is estimated by equation:

$$B = Ca\,(A) * A$$

Ca (A) - mean weighted catch for the entire surveyed water area;

A – total area surveyed

4.2 Maximum sustainable yield

Gulland's formula for virgin stock is:

$$MSY = 0.5 * M * Bv$$

M – coefficient of natural mortality;

Bv - biomass of virgin stock.

A generalized version of Gulland was proposed by Cadima (in Troadec, 1971) for exploited fish stocks for which only limited data are available for stock assessment:

$$MSY = 0.5 * Z * \bar{B}$$

$\bar{B}$ - mean annual biomass;

Z – total mortality.

Because

$$Z = F + M$$

and

$$Y = F * \bar{B},$$

Cadima suggested that in the absence of data for Z, the equation can be rewritten:

$$MSY = 0.5 * (y + M * \bar{B})$$

$\bar{y}$ – total catch in one year,

$\bar{B}$ - mean biomass in the same year.

4.3 Age and growth

For the estimation of turbot growth rate, the von Bertalanffy growth function (1938) was used, (per Sparre, Venema, 1998):

$$L_t = L_\infty \{1 - e^{[-k(t - t_0)]}\}$$

$$W_t = W_\infty \{1 - e^{[-k(t - t_0)]}\}^n$$

L_t, W_t are the length or weight of the fish at age **t** years;

L_∞, W_∞ - asymptotic length or weight;

k – curvature parameter;

to - the initial condition parameter.

The length – weight relationship is obtained by the following equation:

$$W_t = q\, L_t^{\,n}$$

q – constant in length-weight relationship;

n – constant in length-weight relationship.

4.4 Natural mortality (M)

Pauly's empirical formula (1979, 1980) was applied:

$$\log M = -0.0066 - 0.279 * \log L_\infty + 0.6543 * \log k + 0.4634 * \log T^oC$$

$$\log M = -0.2107 - 0.0824 * \log W_\infty + 0.6757 * \log k + 0.4687 * \log T^oC$$

$$\ln M = -0.0152 - 0.279 * \ln L_\infty + 0.6543 * \ln k + 0.463 * \ln T^0$$

L_∞, W_∞ and k – parameters in von Bertalanffy's equation;

TºC - the annual average temperature of the seawater in the horizons of habitation and reproduction of the species.

Method of Richter - Efanov (1976)

$$M = \frac{1.521}{(t\ mat\ 50\%)^{0.720}} - 0.155$$

t_{mat} – age at first maturation;

Method of Lukashev (1970)

$$M = 1 - \left[\frac{1 - e^{-k(t-to)}}{1 - e^{-k(t-t0)}}\right]^{3}$$

t = age of mature fish

Methodologies for the socio-economic data described in EU MAP

Ad hoc contract Commitment No. SI2 725 694

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29 June 2016

Introduction 2
Objectives 2
Approach used and critical issues 3
Main results 4
Methodological report and guidelines on statistical sampling 5
Specific issues on aquaculture 6
Specific issues on processing sector 7
Identification of methodologies 7
Suggestions from PGECON 7
Table 1 Economic variables for the fleet 9
Table 2 Economic variables for the aquaculture sector 18
Table 3 Economic variables for fish processing sector 21
Annex 1 – Presentation of the preliminary draft, PGECON 2016 27

Introduction

The common fisheries policy (Reg. EU n. 1380/13, article 25(2)) sets out the key principles for data collection:

- accuracy
- reliability and timeliness
- avoidance of duplication through improved coordination
- safe storage in database systems
- improved availability of data
- compliance with laws on personal data protection
- access for the European Commission, enabling it to check the availability and quality of data and the methodology used to collect them.

Another basic principle is that the methodologies by which data are obtained have to be made available to bodies with a research or management interest in the scientific analysis of data in the fisheries sector and to any interested parties.

The legislative framwork that is under implemetation takes into account these principles and also considers the need to have an appropriate degree of flexibility to address evolving needs of end-users over time. In particular, the system should allow for modifications to methodologies to be used.

One of the key changes considered through the revision of the DCF is that methodological aspects should no longer be specified in EU legislation, as it is in the present framework, but should be left to coordination between Member States through the EU Coordination Group for socio-economic (PGECON).

Methodological requirements shall be described in Member States' work plans to be approved by the Commission, following best practices and common methodologies.

The use of common methodologies will improve the collection, quality and comparability of the different variables among MS. However, despite of extensive discussion on the definitions in relevant experts groups (DCF, PGECON, STECF) and references from the European tatistical System (ESS, EUROSTAT, SBS), there are still no clear guidelines and recommendations on the methodologies for each of the socio-economic variables belonging to the fleet, aquaculture and fish processing modules of EU data collection.

PGECON (Zagreb, Maj 2016) was asked to provide a clear and detailed description of the data collection methods. To achieve this task, a specific ad hoc contract was issued by DGMARE.

The present document is the final outcome of the ad-hoc contract.

Objectives

The Terms of reference of the ad hoc contract are the following:

- The work will deal with methodologies on how to collect variables under the DCF socio-economic modules for the fleet, aquaculture and fish processing.
- For each variable, a methodology should be proposed. This might be an already agreed methodology (for certain cases) or, in the case of several possible methodologies, the expert should propose only one methodology, based on its simplicity, relevance, accuracy and consistency. For those variables where no methodology exists, the expert should propose a methodology, keeping consistency with international and EU definitions and statistics.

The preliminary input from this ad hoc contract have been discussed in the 2016 DCF expert sub-group on economic issues (Planning Group in Economic Issues). Annex 1 reports the presentation done during the PGECON.

Proposals and suggestions discussed during the above meeting heve been included in the present final version.

Approach used and critical issues

The basic principle followed in this work has been the compilation of all the methodologies already suggested in previous STECF reports, PGECON reports and in DCF workshops. In addition, NPs and ARs have been scrutinized to look for "best practices" already applied by some MS for some variables.

The complete list of reports considered is the following:

- 08-01_SG-ECA 08-01 - Economic Variables DCF. 21-25 January 2008, Lisbon - Report of the Working Group on the evaluation of Economic variables to be collected for the fishing industry, the processing and aquaculture sectors under the new EC Data Collection Regulation
- 09-05_SG-ECA 09-02 - Economic Data. 11-14 May 2009, Barcelona - Quality aspects of the collection of economic data, methods of calculation of the indicators and sampling strategies
- 10-09_SG-ECA 10-03 - Economic Data. 20-24 September 2010, Salerno, Italy - Review of economic data collected in relation to the Data Collection Framework (DCF), harmonisation of sampling strategies
- 2011-12_STECF 11-19 Review of economic data in relation to DCF. 7th to 11th, 2011 in Brussels, Belgium - Review of economic data collected in relation to the DCF and harmonisation of sampling strategies
- PGECON final reports 2012, 2013, 2014 and 2015
- Workshop on calculating capital value using PIM and definition of DCF variables Naples, Italy, 13th- 17th, June 2011
- DCF Workshop "Using fishing activity levels in economic data collection" The Hague, The Netherlands 13 17 October 2014
- DCF Workshop on statistical issues and thresholds, Helsinki, Finland 9.-13.12.2013
- Workshop on Aquaculture Data Collection 15 -19 June 2015 Gdynia, Poland
- JRC, 2015 - Analysis of socio-economic variables for fisheries, aquaculture and fish processing sectors in support of the revision of the EU Data Collection Framework

The present work presents important two critical issues.

The first one is represented by the fact that the EUMAP is still under discussion. The present work is based on the version of EUMAP circulated by DGMARE at the end of April (2016-463). Therefore, the final list of economic and social variables for which define a methodology is not yet available.

(Rec. 1) It is considered essential to review the work after the adoption of the EUMAP.

Another critical point is the estimation of capital value and capital costs. The estimation of these variables is crucial for calculation of profitability indicators which have important impact on management decisions. According to the definition of Capital Value included in the DCF (Commission Decision 2010/93/EU, Appendix VI), the capital value should represent the depreciated replacement value of the physical capital. This should be estimated through the PIM methodology as proposed in the study FISH/2005/03: 'Irepa Onlus Coordinator, 2006'.

The application of the PIM methodology allows a highly standardised calculation. However, it imples a wide range of possible input data (interest rates, depreciation times and methods) which lead to some degree of uncertanity and lack of harmonisation.

After the "Workshop on calculating capital value using PIM and definition of DCF variables" (Naples, (Italy, 13th- 17th, June 2011), the PGECON 2012 and DCF working group on 'Evaluation of Data Collection connected to fishing rights and capital costs' (Gothenburg, 18/22 November 2013), the application of the PIM Method and corresponding results are still questionable and not comparable between MSs. This is mainly due to the input parameters of the PIM Method which are difficult to be determined and varies from one year to another, as well as various assumptions that MSs have to make in the application of the PIM method which are not listed in the above mentioned study of 2006 such as the age classes of vessels to be included in the calculation, i.e. which age classes are considered a vintage classes and therefore replacement value is not applicable.

(Rec. 2) As the application of the PIM method affects the value of other variables such as the capital costs and investments, PGECON (Zagreb, 2016) observes the need of a new study or working group to review the calculation of the capital value and eventually update the underlying assumptions. Such study should also involve other experts from related fields such as agriculture and also academic researchers.

One approach that may result from this study or workshop is a pyramidal style code of practice. The ideal survey method, the census is at the top with sample survey methods, indirect methods etc below. The member state aims for the ideal survey method but due to its particular circumstance, resources, population structure etc, may choose a lower less ideal methodology but with justification.

Main results

Economic variables can either be:

1. obtained directly from survey or
2. estimated through indirect surveys or derived from other surveyed variables.

An example of the second case is personnel costs which can either be collected directly from survey or derived from the crew share based calculation. In the latter, the surveyed variables could be revenues, costs and crew share.

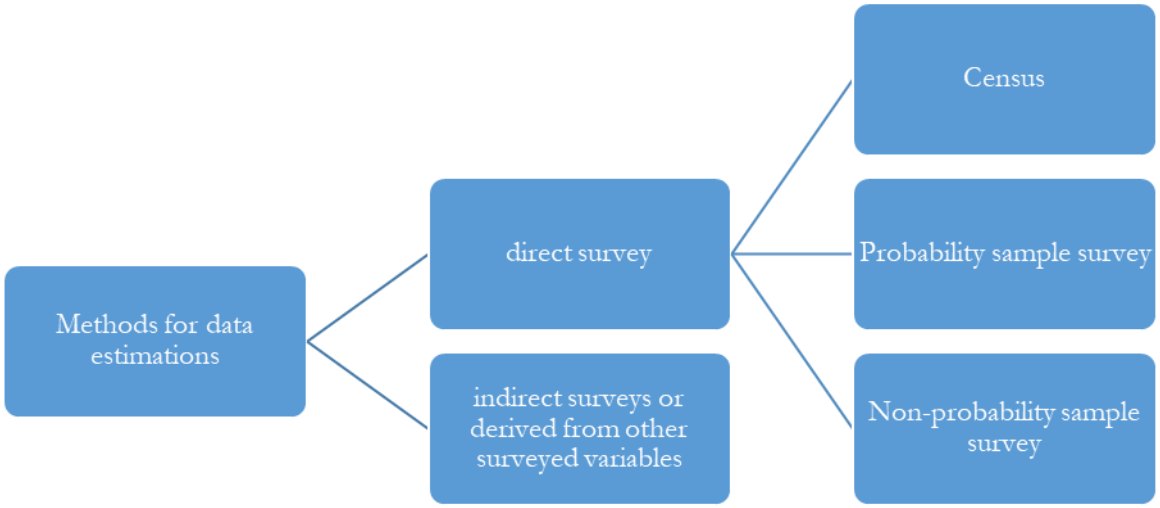
(Rec. 3) It is considered not appropriate to define only one methodology for each variable. In fact, as discussed in the workshop in the DCF WS on statistical issue (Helsinki, 2013) and in the STECF SGECA 2010 and as considered during the last PGECON (Zagreb, 2016), MS try to choose the best data collection approach available and most suitable for the country specific needs and conditions. The best method to use depends on which economic variables and other information is available at Member State level.

In case data are estimated through indirect surveys or derived from other surveyed variables (point 1), MS should be obliged to follow best practices and methods identified at European level and approved by PGECON.

In case data are obtained directly from survey (point 2) and in accordance to the guidelines for the submission of the Annual Reports on the National Data Collection Programmes under Council Regulation (EC) 199/2008, Commission Regulation (EC) 665/2008 and Commission Decision 2010/93/EU (January 2016), three types of data collection scheme are available:

- Census survey
- Probability sample survey
- Non-probability sample survey

MSs design their surveys based on the chosen method.



The DCF WS on statistical issue (Helsinki, 2013) compiled a summary on the specific data collection and estimation procedures implemented in each MS.

Resultes confirm that there are mainly three different approaches in the data collection:

1. census based data collection (for instance in Lithuania, Latvia, Poland, Romania, Slovenia). This data collection method is mainly enabled by the national legislative processes where for example issuing of fishing licenses is connected with the obligation to provide the financial statements data;
2. statistcal sample survey. Probability Proportional to Size (PPS) sampling, and random sampling are used in these cases (for instance Italy, France, Ireland, Greece);
3. regression estimation using sample data and registry data (for instance Finland, Germany).

The application of different type of survey is explained by the fact that MS tried to choose the best data collection approach available and most suitable for the country specific needs and conditions.

Methodological report and guidelines on statistical sampling

STECF 09-05 already considered that MS should include in their National Programs a "methodological report" in order to obtain methodology descriptions of a comparable standard among Member States.

This reccomendation was considered in the preparation of guidelines for NP presentation (2011-2013).

In the draft of guidelines for National Work Plans (NWP), to be used by MS in preparation of the workplane 2017-2019, it is reported that:

Where survey work is being undertaken, concise details should be given about:

- *Data sources*
- *Type of data collection*
- *Target and frame population*
- *Sampling frame and allocation scheme*
- *Estimation procedures*

- *Data quality*

PGECON (Zagreb 2016) continued to consider important this issue and recommended **(Rec. 4)** that each MS prepares a methodological report that describes in detail the data collection process. The report should contain the following points:

- Survey planning
- Survey strategy
- Overall survey design
- Sampling design
  - sample selection and estimation
- Estimation design
  - statistical models and use of auxiliary information
  - treatment of nonresponse
- Quality assessment of estimates
  - estimation methods for quality indicators

Methodological report should be a self-standing document that would be available on the data collection repository.

Methodological reports should describe the methods and procedures on which the surveys, results and analyses of economic data collection are based. They aim to ensure transparency and to promote collaboration MS data collection institutes and and researchers. Methodological reports also focus on the development and evaluation of new methods with a view to future application.

In case of direct survey, the DCF WS on statistical issue (Helsinki, 2013) considered useful to provide MS with statistical guidenlines. LM 2014 endorsed the conclusion from this WS stating that it would be very useful in improvement of future data collection and WS to prepare a handbook on guidelines of best practices in sampling design and estimation methods. The aim of the handbook shuld be to give clear guidance how to technically implement the principles in the data processing and analysis in individual MS.

However, it has to be considered that STECF 10-09 already provided guidelines to illustrate statistical techniques in case of simple and stratified random sampling. These guidelines provide information and reference for the following steps in the survey design and implementation:

- Simple random sampling
- Stratified random sampling
- The estimation of sample size and allocation across strata
- Estimation of parameters
- Sources of error in surveys
- Effects of non-response

Specific issues on aquaculture

The WS on aquaculture data collection (Gdynia, 2015) followed the request by the Planning Group on Economic Issues (PGECON) to provide technical advice to improve the methods for aquaculture data collection and harmonize data collection methods across MS.

The main outcomes in terms of methodologies for aquaculture data collection were:

- national implememting methods should be shared under the PGECON shared point and hosted by JRC. The aim of this exercise is to improve quality of data

- MSs presented their methods for allocating enterprises into DCF segments in cases when few different techniques are used and/or different fish species are produced. In such cases it is recommended to apply one of two methods:
    - either use production unit/establishment level to allocate the data instead of enterprise level
    - or create a new polyvalent segment where enterprises without a dominant production segment could be allocated.
- The WS evaluated the possibility to collect data for Eurostat and DCF through the same data collection system and questionnaire allowing for the gradual alignment of the Eurostat and DCF data collection systems. The conclusion from the WS was that most MSs are currently avoiding duplication of data collection. In a minority MSs, Eurostat and DCF data are collected by two different institutions and contain different information which is available at different periods of the year; therefore it is not feasible to combine data collection into one single questionnaire.

Specific issues on processing sector

The collection and provision of data on processing industry will be considered optional in the EUMAP (not approved yet).

In order to avoid duplication of data collection activities, STECF 16-07 suggested that work plans shall clearly identify the variables and the part of the population covered through Regulation (EC) No 295/2008 concerning structural business statistics and the variables and the part of the population that have to be covered through additional data collection methods.

Under this ambiguity, it is difficult to draft a document with methodologies for each variable. Legal requirements for MS should be clearly identified before approving a final proposal on methodologies.

Identification of methodologies

The methods available to calculate the economic variables for each sector (fleet, aquaculture and processing) have been identified. Where it was possible, the preferred method for such calculations was highlighted. Results are presented in the following tables:

- Table 1 Economic variables for the fleet
- Table 2 Economic variables for aquaculture
- Table 3 Economic variables for fish processing sector

Suggestions from PGECON

PGECON (Zagreb 2016) considered that it is not feasible to obtain a complete and fully defined document on methodologies for calculation and collection of each economic variable through a (short) ad hoc contract.

Therefore, PGECON suggested to implement the following procedure:

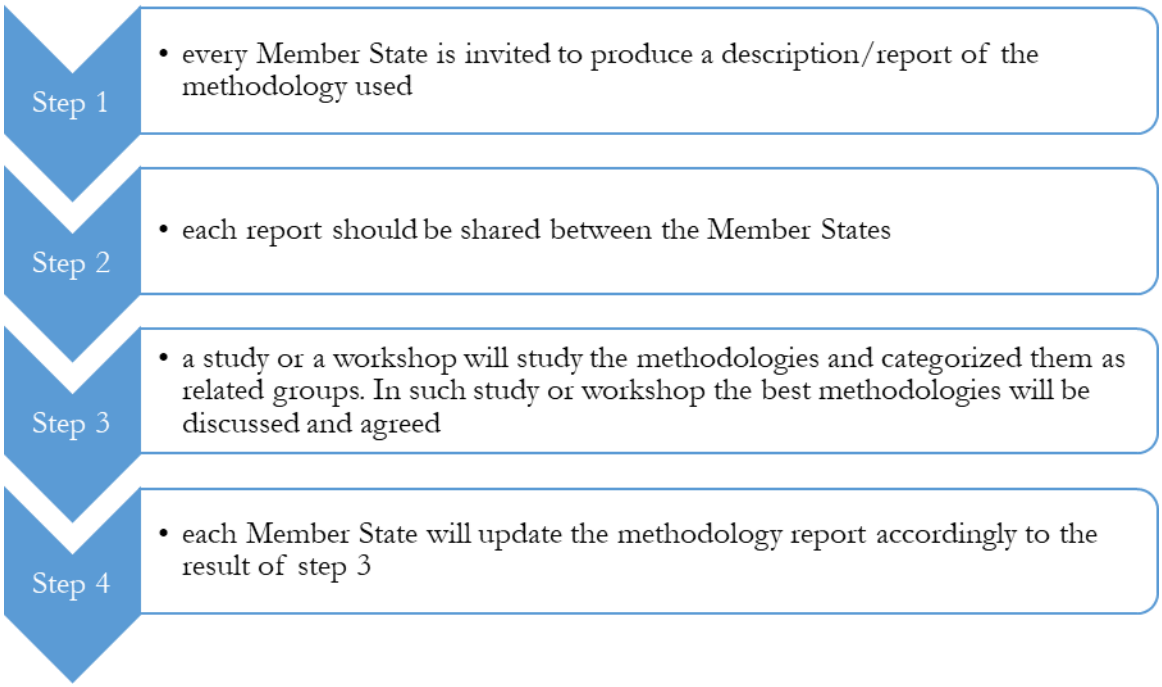

Step 1
• every Member State is invited to produce a description/report of the methodology used
Step 2
• each report should be shared between the Member States
Step 3
• a study or a workshop will study the methodologies and categorized them as related groups. In such study or workshop the best methodologies will be discussed and agreed
Step 4
• each Member State will update the methodology report accordingly to the result of step 3

Table 1 Economic variables for the fleet

Variable group	Variable	PGECON advice	Methodology
Income	Gross value of landings	Control data (logbooks and sales notes) should be used in case they are available and reliable, otherwise sample surveys might be used.	**1. Obtained directly from survey** **2. Derived from administrative sources or other surveyed variables.** The data source is the official national statistics on landings
	Income from leasing out quota or other fishing rights	Two methods might be used	**1. Obtained directly from survey.** **2. Derived from other surveyed variables.** In case the trade (lease) information in terms of fishing rights is available from the official sources this information together with the average lease price might be used to calculate the variable. The average lease price would be collected through the survey.
	Other income	No comments	**1. Obtained directly from survey.**
Labour costs	Personnel costs	Two methods are appropriate to be used. It is advised that MS takes into account how crew share is defined in the fishery at a national level, in case crew share based calculations are used.	**1. Obtained directly from survey** **2. Derived from other surveyed variables.** In several fisheries crew members are remunerated through crew share systems, rather than fixed salaries. In this case, personnel costs can be calculated as % of revenues, or as % of revenues-costs. To correctly apply this method, it is necessary to define, for each fleet segment: • what is the approach used to calculate the share: as percentage on total revenues or as percentage of revenues – costs • what are the costs actually included to calculate the share • what is the percentage that goes to the crew
	Value of unpaid labour	PGECON discussed the two methods used by MS deriving unpaid labor costs and agreed that method A should take	**Derived from other surveyed variables.** The estimation of the imputed value of unpaid labour represented one of the issue discussed during the Workshop on calculating capital value using PIM and definition of DCF variables that was held in Napoli, Italy, from 13th to 17th June 2011. The discussion held during that workshop

Variable group	Variable	PGECON advice	Methodology
		preference over method B. MS using other than method A, should justify and periodically review their alternative.	focused on the definition and methodology of estimation of the unpaid labour both for the fleet and for the processing sector. Taking into account difficulties encountered by MS in estimating this variable (recognized by SGECA 10-03 and STECF EWG 11-03), a specific ToR of the workshop was to reply to the need of having clear definitions and best practices for MS. The group agreed that the variable "imputed value of unpaid labour" should include the labour costs of all persons delivering unpaid labour. and, in general, in estimating labour costs people working only on shore should be excluded. On the basis of the results of this workshop and comparing different experiences by MSs (as reported in NPs and ARs), it is suggested that value of unpaid labour can be estimated through the following methodologies: A. FTE method (WS, Naples, 2009), that includes the following steps: • estimation of paid and unpaid FTE; • definition of an average remuneration per paid FTE (e.g. average wage by fleet segment/company, national average wage, minimum national wage, etc…); • calculation of imputed value of unpaid labour =: unpaid FTE * (average remuneration per paid FTE). B. SIZE method (Italian AR, UK AR); this one has to be preferred when no estimation of data about the number of not paid workers is available. The method is the following: • For vessels over 10m (12 m in the Med) imputed value of labour is zero because we assume all vessels pay the skipper / owner via the crew share system, or with a fixed wage. • For vessels between 8m and 10m (6m and 12 m in the Med) we assume that the top 25% (by revenues) of vessels pay skippers a crew share as part of the expenses of the business and that the lower 75% (by revenues) of vessels do not, but rather pay "owner's drawings" from the profits. Therefore, for the lower 75% of vessels in this size category, there is a positive imputed value of labour. Considering that many smaller vessels operate on a part-time basis, it is not appropriate to assume an average full-time wage for all owner-skippers of these vessels. Instead, each MS should estimate the market value of a skipper's full-time labour at national level (MKS, market value skipper). For vessels with profit less than or equal to MKS, we assume that 100% of profit is the imputed value of unpaid labour. If profit is over MKS, we assume it as the imputed value of labour. The remainder of the profits can be considered as return on investment or return on management skill.

Variable group	Variable	PGECON advice	Methodology
			• For vessels less than 8m (6m in the Med), we assume that skipper's wages are not included in fishing expenses as part of the crew share, but in every case, are taken from the profits. Therefore, each vessel in this segment must have an imputed value of labour. For vessels with profit less than or equal to MKS, we assume that 100% of profit is the imputed value of unpaid labour. If profit is over MKS, we assume MKS as the imputed value of labour
Energy costs	Energy costs	No comments	**1. Obtained directly from survey** **2. Derived from other surveyed variables.** Fuel cost could be calculated by multiplying the fuel consumption by the average fuel price, if fuel consumption is available
Repair and maintenance costs	Repair and maintenance costs	No comments	**Obtained directly from survey**
Other operating costs	Variable costs	No comments	**Obtained directly from survey**
	Non-variable costs	No comments	**Obtained directly from survey**
	Lease/rental payments for quota or other fishing rights	No comments	**1. Obtained directly from survey** **2. Derived from other surveyed variables.** In case the trade (lease) information in terms of fishing rights is available from the official sources this information together with the average lease price might be used to calculate the variable. The average lease price would be collected through the survey.
Subsidies	Operating subsidies	Administrative sources, if available, are more precise and therefore are preferable.	**1. Obtained directly from survey** **2. Obtained from administrative sources (e.g. paying Agency, Local authority).** The compilation of data on subsidies is based on the official lists provided by national and regional administrations. These lists should be further elaborate to consider only payments that can be classified as operating subsidies (see definition). Each payment has to associated with one vessel. This link allows to report operating subsidies in fleet segments.

Variable group	Variable	PGECON advice	Methodology
	Subsidies on investments	Administrative sources, if available, are more precise and therefore are preferable.	**1. Obtained directly from survey** **2. Obtained from administrative sources (e.g. paying Agency, Local authority).** Investment subsidies refer to permanent cessation or to fleet modernization. They should not be included in income (PGECON 2013). The compilation of data on subsidies is based on the official lists provided by national and regional administrations. These lists should be further elaborate to consider only payments that can be classified as subsidies on investments (see definition). Each payment has to associated with one vessel. This link allows to report operating subsidies in fleet segments. In case of subsidies for permanent cessation of fishing activities of those fleets which have become inactive during the year, it has to be decided if they can be classified in the segment of inactive vessel.
Capital costs	Consumption of fixed capital	No comments	**1. Obtained directly from survey** **2. Derived from other surveyed variables.** Consumption of fixed capital (Depreciation) represents the reduction in the value of the fixed assets used in production during the accounting period resulting from physical deterioration, normal obsolescence or normal accidental damage (EC study No. FISH/2005/03). According to DCF legislation (2010/93/EU) depreciation should be calculated using the degressive depreciation scheme based on capital values estimated using replacement values (STECF 11-19, page 6) and included in the template model developed by EC study No. FISH/2005/03. The general assumptions proposed in the template model applies a degressive depreciation function and it assumes that engine is renovated every 10 years, electronics every 5 years, other equipment every 7 years and hull never. The share of each asset item in the total vessel price is 60% for hull, 20% for the engine and 10% for both electronics and other equipment. The rentals expected in future periods are discounting using a discount rate, which is the interest rate on long terms bond. However, as for the estimation of the Capital value based on the PIM method, the assumptions made in the template model represent only a general scheme that should be calibrated to the national situations. For the same reason the DCF Working Group Evaluation of data collection

Variable group	Variable	PGECON advice	Methodology
			connected to Fishing Rights and Capital Costs (18 - 22 November, 2013, Gothenburg) suggested to use alternative approaches if accounting data (e.g. market value, book values) are available and can be easily derived by balance sheets.
Capital value	Value of physical capital	No comments	**1. Obtained directly from survey** **2. Derived from other surveyed variables.** The application of the Perpetual Inventory Method (PIM) performed through a template model developed by EC study No. FISH/2005/03 proposes to determine the aggregate value of the physical capital in the current year by aggregation of active fleets by age or vintage classes. Once the value of the capital goods in a given benchmark year has been determined, the capital value of each subsequent year is calculated by adding investments of that year (gross capital formation), revaluing the existing stock and subtracting value of capital goods taken out of operation (Depreciation). As the aggregation is based on current prices, this method gives an estimate of the depreciation replacement capital value. However, the calculation of capital stock according to PIM is based on several assumptions, which are also closely linked to several variables such as investment, depreciation, capital cost, opportunity cost. The required input parameters and major assumptions are: • Depreciation rates • Share of capital components (hull, engine, electronics, other equipments) in total value • Life time of each asset • Price per unit The determination of the PCU has probably the highest impact on the results. For this reason, in order to make results more harmonized in the Workshop on calculating capital value using PIM and definition of DCF variables (Naples, 2011) it was suggested a hierarchical order of preference for possible prices/values of a ship: 1. Price of new constructed vessels; 2. 2nd hand prices or insurance values of the current year; 3. Book value; 4. Scrapping value; 5. Other values (e.g. specific surveys to ask for an estimate of the current value of a vessel with certain characteristics in case previous indicators cannot be observed). The assumptions made in the study No. FISH/2005/03 represent in fact only a general scheme in order to provide a calculation tool. This general scheme should be changed and calibrated according to the specific needs of each country and to other empirical information, for example collected from Company accounts, Statistical surveys, Expert advice, European System of Integrated Economic Accounts (ESA).

Variable group	Variable	PGECON advice	Methodology
			Taking into account that the input parameters of the PIM method are difficult to be determined and could vary over time, the DCF Working Group on Evaluation of data collection connected to Fishing Rights and Capital Costs (18 - 22 November, 2013, Gothenburg) recommended to make use of alternative methods for the estimation of capital value of vessels when accounting data are available. However, STECF 10-09 also considered that the use of book value in order to estimate capital value and capital costs will limit the use of data to a fiscal accounting analysis more than to an economic valuation.
	Value of quota and other fishing rights	No comments	**1. Obtained directly from survey** **2. Derived from other surveyed variables.** Until now, capital valuation in fisheries focused primarily on the vessel and its equipment. Methodology for estimation of the capital value developed within the EC study No. FISH/2005/03 allows estimating the value of tangible assets. In case intangibles are part of the asset value, the suggested method requires separating them from the tangibles so that the determined value per capacity unit refers exclusively to physical assets. The EC study No. FISH/2005/03 proposed to apply the approach established by FADN, i.e. tradable intangibles should be valued at current market price (or a multi-year average), independently of the question whether they have or have not been acquired or whether they are or are not linked to specific tangible (e.g. vessel). However, attaching value to the intangible assets faces several conceptual as well as practical problems: - Ideally the value of assets should include all assets of the company including the intangible assets, especially the value of fishing rights. And tangible assets should be separated from intangibles. However, there should be common methodology to separate and value these assets. - Even when intangibles are freely tradable, observation of their prices in the market might be difficult because the number of transactions is small and the value might not be recorded. - When the intangibles are attached to vessel, direct observation of the price is impossible. The value has to be estimated. - In many cases, the fishing companies have not yet acquired any intangibles, but simply hold the rights which they have received free of charge from the government, when they were introduced. In that case it is not clear if these rights should be valued as an asset,

Variable group	Variable	PGECON advice	Methodology
			increasing substantially the total asset value of the company, or not. Results of the WS on valuation of fishing rights should be used for this purpose. *Specific study / review of methods applied is needed.*
Investments	Investments in tangible assets, net	PGECON suggests to use variables directly from survey. In case PIM method is used investment should be estimated from PIM method in order to ensure consistency with other variables.	**1. Obtained directly from survey** **2. Estimated from PIM method (we are not sure if anyone is using it, but it should be available from there)**
Financial position	Long/short Debt	No comments	**Obtained directly from survey.** Balance sheets are considered the most reliable source of data for debts (MSs that derived the value of debts from questionnaires experienced a very poor quality of responses). Critical points: - how to split company values in case of more than vessel or in case of more activities - how to estimate this variable for SSF or in general when balance sheets are not available
	Total assets	No comments	**Obtained directly from survey.** Balance sheets are considered the most reliable source of data for total assets (MSs that derived the value of debts from questionnaires experienced a very poor quality of responses). Critical points: - how to split company values in case of more than vessel or in case of more activities - how to estimate this variable for SSF or in general when balance sheets are not available
Employment	Engaged crew	No comments. As some MS might include unpaid labour in the definition of the engaged crew it has to be separated in the future EUMAP.	**Obtained directly from survey**
	Unpaid labour	New variable	**1. Obtained directly from survey**

Variable group	Variable	PGECON advice	Methodology
			2. Derived from other surveyed variables
	FTE National	No comments	**Derived from other surveyed variables** FTE definition: unit expressing the number of employees into full-time workers (usually defined in the national law). Appendix VI of the current regulation refers, in note 17 and 18 to the study "Calculation of labour including full-time equivalent (FTE) in fisheries" (FISH/2005/14, 'LEI WAGENINGENUR Coordinator, 2006), financed by EU in order to harmonise the definition and the estimation of employment variables under the data collection system. According to that study the estimation of the FTE should be done by using a threshold representing the total number of hours worked, on a standard and yearly basis, by a full-time worker in the fishery sector. Actually the study was based on the estimation of the engaged crew and of the FTE at métier level in order to trace the reality of labour input in fishing as closely as possible. This approach was mainly based on the fact that: • at the time of the study there were discussion, inside the STECF, about the possibilities to collect, under the revised DCR, economic data at métiers level; • "different fisheries may be characterised by different labour intensities and consequently by different levels of labour productivity. This is an important aspect of economic analysis; • using métiers in general improves the analytical understanding of the operation of the various fleets". Actually the concept of metier has been not introduced in the collection of economic data but the general approach on the definition of FTE, in particular on the definition of the yearly threshold (time-based approach), has been largely applied under the DCF. According to the study, a person working more than the threshold (holding one or more jobs) is still counted as one FTE only. A person working less than the threshold represents a certain percentage of a FTE. FTE national should be calculated using a threshold defined according to the features of the fishery sector in each MSs. If the annual working hours per crew member exceed the reference level, the FTE equals 1 per crew member. • if annual working hours>national threshold FTE national =1 If not, the FTE equals the ratio between the hours worked and the reference level.

Variable group	Variable	PGECON advice	Methodology
			• if annual working hours<national threshold FTE national = $\frac{annual\ working\ hours}{national\ threshold}$
	Total hours worked per year	New variable	**1. Obtained directly from survey** 2. **Derived from other surveyed variables** Calculated based on effort, number of vessels and average crew number.
Number of fishing enterprises/units	Number of fishing enterprises/units	No comments	**Obtained directly from Fleet Register**
Fuel consumption	Fuel consumption	PGECON could not define preferred method as it depends on the national context.	**1. Obtained directly from survey.** **2. Obtained from administrative sources (e.g. in case tax exemptions are used in the country).** **3. Derived from other surveyed variables.** Regression models could be used by some MS (regression models using 'engine power', 'days at sea' and 'coefficient of fuel consumption by engine power')

Table 2 Economic variables for the aquaculture sector

Variable group	Variable	PGECON advice	Methodology
Income	Gross sales per species	MS should avoid duplication of data collection.	**1. Obtained directly from survey** (from enterprise, or producer organisation). **2. Derived from other surveyed variables.** Production data collected for EUROSTAT should be used. Calculated as weight of sales multiplied by unit price and summed to observation unit.
	Other income	No comments	**Obtained directly from survey**
Labour costs	Personnel costs	No comments	**Obtained directly from survey**
	Value of unpaid labour	No comments	**Derived from other surveyed variables** FTE method (WS, Naples, 2009), that includes the following steps: • estimation of paid and unpaid FTE; • definition of an average remuneration per paid FTE (e.g. average wage by fleet segment/company, national average wage, minimum national wage, etc…); • calculation of imputed value of unpaid labour =: unpaid FTE * (average remuneration per paid FTE).
Energy costs	Energy costs	No comments	**Obtained directly from survey**
Repair and maintenance costs	Repair and maintenance costs	No comments	**Obtained directly from survey**
Other operating costs	Other operating costs	No comments	**Obtained directly from survey**
Raw material costs	Livestock costs	No comments	**Obtained directly from survey** **Derived from other surveyed variables** Could be derived from number of stock and unit price of seed/juveniles, etc.
	Feed costs	No comments	**Obtained directly from survey** **Derived from other surveyed variables** Could be derived from feed consumption per unit of production and feed price.

Variable group	Variable	PGECON advice	Methodology
Subsidies	Operating subsidies	Administrative sources, if available, are more precise and therefore are preferable.	**Obtained directly from survey** **Obtained from administrative sources (e.g. paying Agency, Local authority, grants, etc.)** The compilation of data on subsidies is based on the official lists provided by national and regional administrations. These lists should be further elaborate to consider only payments that can be classified as operating subsidies (see definition). Each payment has to be associated with aquaculture enterprise. This link allows to report operating subsidies aquaculture.
	Subsidies on investments	Administrative sources, if available, are more precise and therefore are preferable.	**Obtained directly from survey.** **Obtained from administrative sources (e.g. paying Agency, Local authority, grants, etc.)** Investment subsidies refer to modernization of existing and construction of new facilities (see more in definitions). The compilation of data on subsidies is based on the official lists provided by national and regional administrations. These lists should be further elaborate to consider only payments that can be classified as subsidies on investments (see definition). Each payment has to associated with aquaculture enterprise. This link allows to report operating subsidies by aquaculture segment.
Capital costs	Consumption of fixed capital	No comments	**Obtained directly from survey**
Capital value	Total value of assets	No comments	**Obtained directly from survey**
Financial results	Financial income	No comments	**Obtained directly from survey**
	Financial expenditures	No comments	**Obtained directly from survey**
Investments	Investments in tangible assets, net	No comments	**Obtained directly from survey**
Debt	Debt	No comments	**Obtained directly from survey**
Raw material weight	Livestock used	No comments	**Obtained directly from survey** **Derived from other surveyed variables** Could be derived from total production weight/numbers and estimates of mortalities.
	Fish Feed used	No comments	**Obtained directly from survey** **Derived from other surveyed variables**

Variable group	Variable	PGECON advice	Methodology
			Could be derived from technical guides and total livestock number.
Weight of sales	Weight of sales per species	No comments	**Obtained directly from production survey**
Employment	Number of persons employed	No comments	**Obtained directly from survey**
	Unpaid labour	New variable	**Obtained directly from survey** **Derived from other surveyed variables**
	FTE National	No comments	**Derived from other surveyed variables** FTE national should be calculated using a threshold defined according to the features of the sector in each MSs. If the annual working hours per employee exceed the reference level, the FTE equals 1 per employee. • if annual working hours>national threshold FTE national =1 If not, the FTE equals the ratio between the hours worked and the reference level. • if annual working hours<national threshold FTE national = $\frac{annual\ working\ hours}{national\ threshold}$
	Total hours worked per year	New variable	**Obtained directly from survey** **Derived from other surveyed variables** Could be estimated from days/weeks/months worked, or other variables
Number of enterprises	Number of enterprises (by category on the number of persons employed)	No comments	**Obtained directly from Business Register or other Administrative sources** (license list if exists)

Table 3 Economic variables for fish processing sector

Variable group	Variable	PGECON advice	Methodology
Income	Turnover	Two surveys have to be used for different parts of population	For the part of population covered by SBS • **directly obtained from SBS survey.** For the part of population not covered by SBS • **directly obtained from DCF survey;** • **obtained directly from administrative sources**
	Other income	Two surveys have to be used for different parts of population	For the part of population covered by SBS • **derived from other SBS variables.** Turnover in SBS includes turnover from principal activity, other incomes and subsidies. Therefore, other income should be calculated as following: Other income = Turnover – turnover from principal activity – subsidies. Other income also includes financial income, which is a separate variable in DCF. Therefore, a method for disseminating other income from financial income should be defined. • **Directly obtained from additional DCF survey**. For the part of population not covered by SBS • **directly obtained from DCF survey**
Personnel Costs	Personnel costs	Two surveys have to be used for different parts of population.	For the part of population covered by SBS: • **directly obtained from SBS survey**. For the part of population not covered by SBS: 1. **directly obtained from DCF survey**

Variable group	Variable	PGECON advice	Methodology
			2. Derived from other surveyed variables (e.g. costs structure).
	Value of unpaid labor	No comments	For the part of population covered by SBS the unpaid labour costs are equal to 0 as it is legally binding to employ all persons working in the bigger enterprises. For the part of the population not covered by SBS, unpaid labour costs would be d**erived from other surveyed variables.** FTE method (WS, Naples, 2009), includes the following steps: • estimation of paid and unpaid FTE; • definition of an average remuneration per paid FTE (e.g. average wage by company, national average wage, minimum national wage, etc…); • calculation of imputed value of unpaid labour =: unpaid FTE * (average remuneration per paid FTE). • Other methods based on number of enterprises?
	Payment for external agency workers (optional)	No comments	For the part of population covered by SBS **directly obtained from SBS survey** (optional). For the part of population not covered by SBS: • **directly obtained from DCF survey,** • **derived from other surveyed variables**.
Energy costs	Energy costs		For the part of population covered by SBS, **directly obtained from SBS survey** (optional). For the part of population not covered by SBS: • **directly obtained from DCF survey,** • **derived from other surveyed variables**.
Raw material costs	Purchase of fish and other raw material for production	SBS data should be preferred, but in case dissemination methods are not possible, data from surveys should be used for all processing	For the part of population covered by SBS: • **directly obtained from SBS survey**. However, these costs in SBS are combined under "Total purchases of goods and services", including financial and extraordinary costs. Therefore, a dissemination method should be applied for calculating raw material and other operating costs: (Raw material + Other operational costs) = Total purchases of goods and services – Financial costs – extraordinary costs; Because all of these Variables are also included in DCF, dissemination
Other operating costs	Other operational costs		

Variable group	Variable	PGECON advice	Methodology
		enterprises.	is very problematic. • **directly obtained from additional DCF survey** For the part of population not covered by SBS: • **directly obtained from DCF survey,** • **derived from other surveyed variables**.
Subsidies	Operating subsidies Subsidies on investments	Subsidies could be derived from SBS by disseminating Turnover, however because of a complex structure of SBS turnover, data from national and regional administrations for the whole processing sector, should be used, in preference to direct survey. This in turn will help to derive turnover and other income more precisely.	For the part of population covered by SBS: • **directly obtained from SBS survey**. However, data is aggregated under Turnover, complete with turnover from principal activities, other income, and financial income. Therefore, it should be disseminated. • **directly obtained from additional DCF survey** ; • **obtained directly from administrative sources** For the part of population not covered by SBS: • **directly obtained from DCF survey,** • **derived from other surveyed variables**. • **obtained directly from administrative sources**
Capital costs	Consumption of fixed capital	No comment	There is no data on capital costs or capital value in SBS. For all processing enterprises capital cost and capital value could be obtained: • **directly obtained from DCF survey;** • **derived from other surveyed variables or from PIM calculations.** • **By calculating capital value and capital costs by PIM.**
Capital value	Total value of assets		
Financial results	Financial income	Two surveys have to be used for different parts of population.	For the part of population covered by SBS: • **directly obtained from SBS survey**. however financial income is combined under Turnover. Therefore to get data on financial income, a method of dissemination should be used:

Variable group	Variable	PGECON advice	Methodology
			Turnover – Turnover from main activity – subsidies – other income. However, dividing financial and other income could be a problem. • **directly obtained from additional DCF survey** ; • **derived from other surveyed variables**. For the part of population not covered by SBS: • **directly obtained from DCF survey,** **derived from other surveyed variables**.
	Financial expenditures		For the part of population covered by SBS: • **directly obtained from SBS survey**. However financial expenditures in SBS is under Total purchases of goods and services, which also includes raw material, other operational costs and extraordinary costs, therefore a method for discriminating financial expenditures should be devised; • **directly obtained from additional DCF survey** • **derived from other surveyed variables**. For the part of population not covered by SBS: • **directly obtained from DCF survey,** • **derived from other surveyed variables**.
Investments	Net Investments	Two surveys have to be used for different parts of population.	For the part of population covered by SBS: • **directly obtained from SBS survey**. By subtracting sales of tangible investments goods from Gross investments in tangible goods • **directly obtained from additional DCF survey**. For the part of population not covered by SBS: • **directly obtained from DCF survey,** • **derived from other surveyed variables**.
Debt	Debt	No data coverage on SBS	For all processing sector enterprises Debt could be: • **directly obtained from additional DCF survey**. • **derived from other surveyed variables**.

Variable group	Variable	PGECON advice	Methodology
Employment	Number of persons employed		For the part of population covered by SBS: • **directly obtained from SBS survey**. However, SBS are not discriminated according to the gender. • **directly obtained from DCF survey,** • **obtained directly from administrative sources** For the part of population not covered by SBS: • **directly obtained from DCF survey,** • **derived from other surveyed variables**.
	Unpaid labour		For all processing sector enterprises unpaid labour could be: • **directly obtained from DCF survey,** • **derived from other surveyed variables**.
	FTE National		For the part of population covered by SBS: **directly obtained from SBS survey**. **FTE far all processing sector:** FTE definition: unit expressing the total number of employees into the equivalent number of full-time workers (usually defined in the national law). Appendix VI of the current regulation refers, in note 17 and 18 to the study "Calculation of labour including full-time equivalent (FTE) in fisheries"(FISH/2005/14, 'LEI WAGENINGENUR Coordinator, 2006), financed by EU in order to harmonise the definition and the estimation of employment variables under the data collection system. General approach on the definition of FTE, in particular on the definition of the yearly threshold (time-based approach), has been largely applied under the DCF. According to the study, a person working more than the threshold (holding one or more jobs) is still counted as one FTE only. A person working less than the threshold represents a certain percentage of a FTE. FTE national should be calculated using a threshold defined according to the features of the processing sector in each MSs. If the annual working hours per person exceed the reference level, the FTE equals 1 per crew member. • if annual working hours>national threshold FTE national =1 If not, the FTE equals the ratio between the hours worked and the reference level. • if annual working hours<national threshold FTE national = $\frac{annual\ working\ hours}{national\ threshold}$

Variable group	Variable	PGECON advice	Methodology
	Number of hours worked by employees and unpaid workers		For the part of population covered by SBS: • **directly obtained from SBS survey**. However, SBS houses data of employed work force only, and it does not include unpaid labor. Therefore, additional estimation of number of hours worked by unpaid workers should be calculated. • **directly obtained from DCF survey,** • **derived from other surveyed variables.** For the part of population not covered by SBS: • **directly obtained from DCF survey,** • **derived from other surveyed variables**.
Number of enterprises	Number of enterprises (1)	No comment	For the part of population covered by SBS: • **directly obtained from SBS survey**. For the part of population not covered by SBS: • **directly obtained from DCF survey,** • **derived from other surveyed variables**. • **Through other governmental or administrational organizations**
weight of raw material (OPTIONAL)			For all enterprises: • **directly obtained from DCF survey,** • **derived from other surveyed variables**.

Annex 1 – Presentation of the preliminary draft, PGECON 2016

17/06/2016

Methodologies for the socio-economic data described in EU MAP (Summer STECF Plenary)

Preliminary input to be discussed in the 2016 DCF expert sub-group on economic issues (Planning Group in Economic Issues)

Sabatella Evelina Carmen

30 May 2016

Tasks to be completed

- For each variable, a methodology should be proposed. This might be an already agreed methodology (for certain cases) or, in the case of several possible methodologies, the expert should propose only one methodology, based on its simplicity, relevance, accuracy and consistency. For those variables where no methodology exists, the expert should propose a methodology, keeping consistency with international and EU definitions and statistics
- PGECON (preliminary discussion) → Final report → STECF plenary

17/06/2016

How

- The basic principle followed in this work has been the compilation of all the methodologies already suggested in:
- previous STECF reports,
- PGECON reports
- in DCF workshops.

In addition, NPs and ARs have been scrutinized to look for "best practices" already applied by some MS for some variables

Preliminary results

- The aim of this document is to present a set of methodologies that will help in "harmonizing sampling strategies".
- This concept was already discussed by STECF 11-19 and STECF interpreted the phrase "harmonization of sampling strategies" to mean: **making the sampling strategies such that the results of the surveys are comparable**

17/06/2016

SURVEY

- Other income
- Energy costs
- Repair and maintenance costs
- Variable costs
- Non-variable costs
- Lease/rental payments for quota or other fishing rights
- Income from leasing out quota or other fishing rights
- Investments in tangible assets, net
- Engaged crew
- Total hours worked per year

AD HOC METHODOLOGIES

- Personnel costs
- Value of unpaid labour
- Operating subsidies
- Subsidies on investments
- Consumption of fixed capital
- Value of physical capital
- Value of quota and other fishing rights
- Long/short Debt
- Total assets
- Unpaid labour
- FTE National
- Number of fishing enterprises/units

«transversal variables»

Production value per species
Effort
Fleet
Gross value of landings

Preliminary results

- Most of the variables have to be collected trough a survey approach. In this case, **it is considered not appropriate to define a unique statistical method**. In fact, as discussed in the workshop in the DCF WS on statistical issue (Helsinki, 2013) and in the STECF SGECA 2010, MS try to choose the best data collection approach available and most suitable for the country specific needs and conditions

17/06/2016

Preliminary results

- A part from variables that are estimated through specific surveys implemented by MS within the DCF, there is another set of variables that are usually estimated trough indirect surveys or that are derived from other variables (such as for instance FTE).
- For these variables, the document present already available approaches. The PGECON is asked to review them and try to find an agreement on the most appropriate ones.

Table for fleet economic variables: see document

Table 6A List of Economic variables for the fleet

Variable group	Variable	Methodology: preliminary proposal for discussion at PGECON
Income	Gross value of landings	The data source is the official national statistics on landings. Gross value of landings has to be available for each vessel in the survey used to estimate economic data.
	Income from leasing out quota or other fishing rights	Survey
	Other income	Survey
Labour costs	Personnel costs	Two possible methodologies: 1. Survey 2. Indirect survey In several fisheries crew members are remunerated through crew share systems, rather than fixed salaries. In this case, personnel costs can be calculated as % of revenues, or as % of revenues- costs. To correctly apply this method, it is necessary to define, for each fleet segment: • what is the approach used to calculate the share: as percentage on total revenues or as percentage of revenues – costs • what are the costs actually included to calculate the share • what is the percentage that goes to the crew
	Value of unpaid labour	The estimation of the imputed value of unpaid labour represented one of the issue discussed during the Workshop on calculating capital value using PIM and definition of DCF variables that was held in Napoli, Italy, from 13th to 17th June 2011. The discussion held during that workshop focused on the definition and methodology of estimation of the unpaid labour both for the fleet and for the processing sector. Taking into account difficulties encountered by MS in estimating this variable (recognized by SGECA 10-03 and STECF EWG 11-03), a specific ToR of the workshop was to reply to the need of having clear definitions and best practices for MS. The group agreed that the variable "imputed value of unpaid labour" should include the labour costs of all persons delivering unpaid labour. and, in general, in estimating labour costs people working only on shore should be excluded. On the basis of the results of this workshop and comparing different experiences by MSs (as reported in NPs and ARs), it is suggested that value of unpaid labour can be estimated through the following methodologies: A. FTE method (WS, Naples, 2009), that includes the following steps: • estimation of paid and unpaid FTE; • definition of an average remuneration per paid FTE (e.g. average wage by fleet segment/company, national average wage, minimum national wage, etc…); • calculation of imputed value of unpaid labour = unpaid FTE * (average remuneration per paid FTE). B. SIZE method (Italian AR, UK AR); this one has to be preferred when no estimation of data about the number of not paid workers is available. The method is the following:

17/06/2016

Critical issues

- the EUMAP for the period 2017-2020 is still under discussion. Therefore, the final list of economic and social variables is not yet available.

- Estimation of capital value and capital costs. The estimation of these variables is crucial for calculation of profitability indicators which have important impact on management decisions.

?PIM versus balance sheets?

Data collection methods and estimation procedures

There are mainly three different approaches in the data collection (DCF WS on statistical issue, Helsinki, 2013):

- census based data collection (for instance in Lithuania, Latvia, Poland, Romania, Slovenia);
- statistical sample survey. Probability Proportional to Size (PPS) sampling, and random sampling are used in these cases (for instance Italy, France, Ireland, Greece);
- regression estimation using sample data and registry data (for instance Finland, Germany).

17/06/2016

Guidelines on statistical sampling

- STECF 09-05 considered that MS should include in their National Programs a "methodological report" in order to obtain methodology descriptions of a comparable standard among Member States.

Ok in NWP template:

Where survey work is being undertaken, concise details should be given about:

- *Data sources*
- *Type of data collection*
- *Target and frame population*
- *Sampling frame and allocation scheme*
- *Estimation procedures*
- *Data quality*

Guidelines on statistical sampling

- STECF 10-09 provided **guidelines to illustrate statistical techniques in case of simple and stratified random sampling**. These guidelines provide information and reference for the following steps in the survey design and implementation:

- Simple random sampling
- Stratified random sampling
- The estimation of sample size and allocation across strata
- Estimation of parameters
- Sources of error in surveys
- Effects of non-response

17/06/2016

Guidelines on statistical sampling

- The issue of providing MS with statistical guidelines was also addressed by the DCF WS on statistical issue (Helsinki, 2013).
- LM 2014 endorsed the conclusion from this WS stating that it would be very useful in improvement of future data collection and WS to prepare a **handbook on guidelines of best practices in sampling design and estimation methods**. The aim of the handbook shuld be to give clear guidance how to technically implement the principles in the data processing and analysis in individual MS.

Specific issues on aquaculture

- The WS on aquaculture data collection (Gdynia, 2015) followed the request by the Planning Group on Economic Issues (PGECON) to provide technical advice to improve the methods for aquaculture data collection and harmonize data collection methods across MS: **MAIN RESULTS**
- In this preliminary draft a table for the methodology of each economic variable is not included. PGECON is kindly requested to check if the approach used for the fleet economic variables could be repeated for the aquaculture as well.

17/06/2016

Specific issues on processing sector

- DCF RECAST: to avoid duplication with other legal provisions.
- STECF 16-07 suggested that work plans shall clearly identify the variables and the part of the population covered through Regulation (EC) No 295/2008 concerning structural business statistics and the variables and the part of the population that have to be covered through additional data collection methods
- Present version of the EUMAP does not include this provision. In addition, it seems that a final agreement has not been reached even in the basic regulation (the so called DCF RECAST).
- Under this ambiguity, it is difficult to draft a document with methodologies for each variable. Legal requirements for MS should be clearly identified.

MINISTRY OF AGRICULTURE AND RURAL DEVELOPMENT

National Agency for Fisheries and Aquaculture

Description of the socio-economic data collection methodology of the aquaculture sector in Romania
Census

1. General information about Executive agency for fisheries and aquaculture as responsible authority for fisheries control and data collection 2

2. Schematic overview of systems in place for recording logbook for sale from aquaculture farms data, transport documents and sales notes 2

2.1. Paper logbook for sale from aquaculture farms: 2

2.2. Transport documents and sales notes: 2

3. Cross-checking of data 2

3.1 Description of the cross-checking of paper-based documents and the cross-checking of data provided electronically of logbook data, landing declarations, transport documents, take-over declarations and sales notes 2

3.2 Process for following up inconsistencies and errors identified by the cross-checking of data 3

4. Description of the data collection scheme and sampling method for economic and social variables for the aquaculture farms 4

4.1 Type of data collection scheme 4

4.2 Update the questionnaire to comply with the latest legislation and the needs of the data collection program in Bulgaria 4

4.3 Data validation procedure 4

4.4 Estimation procedures 4

5. Methodology used for collection of the variables 5

6. Data storage and Confidentiality 16

1. General information about Executive agency for fisheries and aquaculture as responsible authority for fisheries control and data collection.

The responsible authority for fisheries control in Romania is the ***National Agency for Fisheries and Aquaculture*** (NAFA). The Agency is organized by General administration (Accounting office, Human resources and Legal Services) and Specialized administration (Fisheries control, Structural Fisheries Funds and Management and monitoring of fish resources. The activities related to the fisheries and aquaculture control are carried out by Directorate "Fisheries and Control" which is divided by several units on geographical basis as follows:

2. Schematic overview of systems in place for recording logbook for sale from aquaculture farms data, transport documents and sales notes.

2.1. Paper logbook for sale from aquaculture farms:

It is applicable for all aquaculture farms. A copy of all declarations should be submitted to NAFA until the end of the month of the declarations. The data from declarations shall be recorded into EAFA informational-statistical system no later than the 10th of the month after receiving of declaration.

2.2. Transport documents and sales notes:

At the moment they are only in paper format. All these documents shall be presented to NAFA within 48 hours after the relevant activity is completed. The data from these documents are recorded into our informational-statistical system.

3. Cross-checking of data.

3.1 Description of the cross-checking of paper-based documents and the cross-checking of data provided electronically of logbook data, landing declarations, transport documents, take-over declarations and sales notes.

The Informational-statistical system is carrying out the following automatic cross-checks, by comparing data from different sources (logbook, landing declarations, sales notes, transport documents, takeover declarations, late submission of documents, lack of referent document etc.).

Data source	Referent data source	Verifications	Description
Logbook: date	Landing declaration: date of submission in NAFA office	Late submission of landing declaration	The landing declaration shall be submitted to EAFA not later than 48 hours after the landing. For the aquacultures this period is 30 days
Logbook: species and catches, kg	Take-over declaration: species and catches, kg	Discrepancy in the type and quantity of catches	
Logbook: species and catches	Landing declaration: species and catches	Difference for same species less than 10% of logbook weight	System error signal when the difference between the quantity taken and landed is > = 10%
Logbook: species and catches	First sale note: species and catches	Discrepancy in the type and quantity of catches	The system assumes that there may be several documents for the first sale, so the quantities are summing by comparing them with the logbook declaration
Logbook: species and catches	Transport document: species and catches	Discrepancy in the type and quantity of catches	The system assumes that there may be several transport documents, so the quantities are summing by comparing them with the logbook declaration
Take-over declaration: date	Take-over declaration: delivery date in the department of NAFA	Later delivered take-over declaration in the department of NAFA	Copy of the take-over declaration should be submitted in NAFA within 48 hours

Take-over declaration	Transport document	No reference document	No related documents for the entered document
Take-over declaration	First sale note	Discrepancy in the type and quantity of catches	
Take-over declaration	Landing declaration	No reference document	No related documents for the entered document
First sale note: date	First sale note: delivery date in the department of EAFA	Later delivered first sale note in the department of NAFA	Copy of the first sale note should be submitted in the department of NAFA within 48 hours
First sale note	Take-over declaration	No reference document	No related documents for the entered document
First sale note	Landing declaration	No reference document	No related documents for the entered document
First sale note	Transport document	No reference document	No related documents for the entered document
Transport document: date	Transport document: delivery date in the department of NAFA	Later delivered transport document in the department of NAFA	Copy of the transport document should be delivered in the department of NAFA within 48 hours
First sale note	Take-over declaration	No reference document	No related documents for the entered document
First sale note	Landing declaration	No reference document	No related documents for the entered document
First sale note	Transport document	No reference document	No related documents for the entered document
Transport document: date	Transport document: delivery date in the department of NAFA	Later delivered transport document in the department of NAFA	Copy of the transport document should be delivered in the department of NAFA within 48 hours

In the information-statistical system of the *National Agency for Fisheries and Aquaculture*, data verification is done by cross-checks, which are organized in a separate module. This "cross-checking" module correlate input data, such as the basic rules for checking are given in the table above. After detecting the error, the system generates a message that identifies the regional office, which entered the document in the system. The message indicates the type of error and assigns a unique number to it. The system allows immediately open the document, which has led to the generation of error

The system checks the input data every 24 hours and generates error messages. In case the missing data is filled in, the system automatically removes the error. The system keeps information for all detected errors and allows checking by error type, by regional inspectorate and by period at any time.

3.2 Process for following up inconsistencies and errors identified by the cross-checking of data.

When inconsistence is identified, the system shows information about the error, including unique ID, type of error, date of occurrence, regional office and reason. The errors are visible to the staff of the relevant office, which is in charge to fill the necessary information and the reason for this inconsistence (the purpose of the fish is confused etc.). After taking measures to eliminate the discrepancy and filling the explanations, the case can be closed

4. Description of the data collection scheme and sampling method for economic and social variables for the aquaculture farms.

The annual questionnaire for aquaculture enterprises consists of 2 parts – in the first page the owner should fill his name, phone number, name of the enterprise, unique number of the enterprise, detailed information about the production, sales from the enterprise and the fish that was not sold at the end of the year and the environmental data on aquaculture. In this page there is also special place for explanation notes, if the owner would like to explain something about the production of the fish. On the second page of the questionnaire the owner should fill the economic and social variables indicated in Table 10 and Table 9 from COMMISSION DELEGATED DECISION (EU) 2021/1167. The collection of all variables is compliant with relevant PGECON/RCG ECON recommendations.

4.1 Type of data collection scheme

The data collection scheme for the aquaculture sector in Bulgaria is **Census and the sampling unit is an aquaculture farm**. Based on our legislation, every owner of an aquaculture farm which is in the register of the aquaculture farms in NAFA, or his representative, is required at the beginning of each year (before January 31) to submit economic and social information for the previous year. The sampling method that we are using is to collect questionnaires for all the aquaculture farms.

4.2 Update the questionnaire to comply with the latest legislation and the needs of the data collection program in Romania.

Every year the President of NAFA affirms the content and the type of questionnaire, which is prepared by the relevant data collection experts. The questionnaire is completed manually by the owner of the enterprise, his representative /like accountant/ in the presence of an employee (someone from the administration) of the agency who is trained for this and is aware of the meaning of economic and social indicators. If necessary, the employee explains some of the variables. The filling of the questionnaire is completed after the owner and the employee of NAFA put their signatures and the questionnaire is entered in the electronic record-keeping system of the Agency.

4.3 Data validation procedure

The first quality checks of the questionnaire are made by the employee of NAFA who receives the questionnaire – this initial check is focused mainly on the amount of data filled in. The second check is done by the person who submits the data from the questionnaire in the database of NAFA. If at this stage of the processing of the questionnaire are detect any inconsistencies or value that is not logical, based on parameters of the enterprise, number of employees, reported production and sales or any other parameter, an employee of the agency contacts the owner of the enterprise and if he is not able to provide a logical explanation, he is obliged to come and edit the value.

4.4 Estimation procedures

Estimation procedures were made only for the previous years (before 2014), in which the questionnaire was not mandatory and there was missing information. Since now the collection of questionnaires is from all aquaculture farms, no estimation is needed, because they are required to submit all the data. If for some reason after 31st of January some of the owners had not reported data for the previous year, an employee of the agency contacts the owner and reminds him of this obligation. In addition, administrative sanction can be imposed to the owner for not fulfilling obligations to report socio-economic information.

5. Methodology used for collection of the variables

In order to improve the collection, quality and comparability of the different variables among MS the guidelines on socio-economic variables contain definitions and methodology for the variables requested under the EU MAP from 2022 are used. The guidelines are prepared by the experts from all MS in the regional coordination group on the economic issues (RCG ECON, former PGECON) and they are living documents.

VARIABLE GROUP	Variable	Definition	PGECON advice	Methodology used
INCOME	Gross sales per species	Value of output from aquaculture sold during the year = DCF Turnover	MS should avoid duplication of data collection. What does this mean exactly? If "juveniles" (i.e., fish from hatcheries) are sold to another company they should be accounted. So, if the buying company then sales them at a later stage, the fish shall be counted twice.	**Derived from administrative source** The data source is the official national statistics on sales – sales notes.
	Other income	Other operating income included in company accounts which are excluded from turnover; income coming from other activities than aquaculture, e.g. the licensing of ponds for recreational fishery purposes. Other income, not shown under other headings. Exclude extraordinary and financial incomes. = DCF Other income	More clarification needed on what Commission wants us to collect. Main activity companies/should we exclude other things than aquaculture	Obtained directly from survey "Other income" refers to other operating income included in company accounts which are excluded from turnover; income coming from other activities than aquaculture, e.g. the licensing of ponds for recreational fishery purposes. Other income, not shown under other headings. Extraordinary and financial income should be excluded.
LABOUR COSTS	Personnel costs	Personnel costs are defined as the total remuneration, in cash or in kind, payable by an employer to an employee (regular and temporary employees as well as home-workers) in return for work done by the latter during the reference period. Personnel costs also include taxes and employees' social security contributions retained by the unit as well as the employer's compulsory and voluntary social contributions. = DCF Wages and Salaries		Obtained directly from survey
	Value of unpaid labour	Unpaid labour = Work that produces goods or services but is unremunerated. = DCF Imputed value of unpaid labour	Still there is a broad range of options to determine the average wage. If the number of unpaid labour is collected, then the imputed wage per FTE would be sufficient to calculate the value of unpaid labour	Obtained directly from survey

VARIABLE GROUP	Variable	Definition	PGECON advice	Methodology used
ENERGY COSTS	Energy costs	Purchases of all energy products during the reference period should be included in this variable only if they are purchased to be used as fuel. Energy products purchased as a raw material or for resale without transformation should be excluded	The livestock costs should correspond to the variable livestock volume. In the Structural Business Statistics it is included inside 13 11 0 "Total purchases of goods and services".	Obtained directly from survey
REPAIR AND MAINTENANCE	Repair and maintenance	The regular maintenance and repair of fixed assets used in production (items not treated as gross capital formation)		Obtained directly from survey
OTHER OPERATING COSTS	Other operating costs	Other operating costs should comprise outsourcing costs, property or equipment rental charges, the cost of raw materials and supplies that cannot be held in the inventory and have not been already specified (i.e. water, small items of equipment, administrative supplies, etc.), insurance premiums, studies and research costs, external personnel charges, fees payable to intermediaries and professional expenses, advertising costs, transportation charges, travel expenses, the costs of meetings and receptions, postal charges, bank charges (but not interest on bank loans) and other items of expenditure. On the Structural Business Statistics is included inside 13 11 0 "Total purchases of goods and services".		**Obtained directly from survey**
RAW MATERIAL COSTS	Livestock costs	Costs of livestock during the year.		Obtained directly from survey
	Feed costs	Costs of feed used for aquaculture production during the year.		Obtained directly from survey
SUBSIDIES	Operating subsidies	Direct payments which general government or the institutions of the European Union make to resident producers. Excluding investment subsidies. = DCF Subsidies	Administrative sources, if available, are more precise and therefore are preferable.	Obtained directly from survey
	Subsidies on investments New	Direct payments which general government or the institutions of the European Union make to resident producers to finance all or part of the costs of their acquiring assets.	Administrative sources, if available, are more precise and therefore are preferable.	Obtained directly from survey Obtained from administrative sources

GROUP	Variable	Definition	PGECON advice	Methodology used
SUBSIDIES	Operating subsidies	Direct payments which general government or the institutions of the European Union make to resident producers. Excluding investment subsidies. = DCF Subsidies	Administrative sources, if available, are more precise and therefore are preferable.	Obtained directly from survey
	Subsidies on investments New	Direct payments which general government or the institutions of the European Union make to resident producers to finance all or part of the costs of their acquiring assets.	Administrative sources, if available, are more precise and therefore are preferable.	Obtained directly from survey Obtained from administrative sources
CAPITAL COSTS	Consumption of fixed capital	of normal wear and tear and obsolescence. The estimate of decline in value includes a provision for losses of fixed assets as a result of accidental damage which can be insured against. = DCF Depreciation of capital	It is not clear which is the benefit of switching from "depreciation" to "consumption of fixed capital" - the concepts are somewhat different (see 3.141)	Obtained directly from survey. Represents the reduction in the value of the fixed assets used in production during the accounting period resulting from physical deterioration, normal obsolescence or normal accidental damage (EC study No. FISH/2005/03).
FINANCIAL RESULTS	Financial income	Income from investments and loans forming part of the fixed assets, and other interest receivable. Financial costs, net = Financial expenditures – Financial income		Obtained directly from survey Consider: * Income from participating interests, with a separate indication of that derived from affiliated undertakings. * Income from other investments and loans forming part of the fixed assets, with a separate indication of that derived from affiliated undertakings. Other interest receivable and similar income, with a separate indication of that derived from affiliated undertakings.
	Financial expenditures	Interest payable and similar charges. Financial costs, net = Financial expenditures – Financial income		Obtained directly from survey Considers the Interest payable and similar charges, with a separate indication of those concerning affiliated undertakings.

GROUP	Variable	Definition	PGECON advice	Methodology used
INVESTMENTS	Investments in tangible assets	Net Investments "Purchase and sale of assets during the year" Gross investment in tangible and intangible goods minus sales of tangible and intangible investment goods.	Gross investments = Purchases minus sales Net should be removed from the variable name to avoid confusion with financial accounting net investments, which refers to investments minus depreciation. Investments here should not include depreciation Tangible goods defined in SBS 15 11 0 and intangible goods defined in SBS 15 42 0 and SBS 15 44 1, tangible investment goods defined in 15 210.	**Obtained directly from survey** "Purchase and sale of assets during the year" Investment during the reference period in all tangible goods. Included are new and existing tangible capital goods, whether bought from third parties, acquired under a financial lease contract (i.e. the right to use a durable good in exchange for rental payments over a predetermined and protracted term) or produced for own use (i.e. Capitalised production of tangible capital goods), having a useful life of more than one year including non-produced tangible goods such as land. The threshold for the useful life of a good that can be capitalised may be increased according to company accounting practices where these practices require a greater expected useful life than the 1 year threshold indicated above. All investments are valued prior to (i.e. gross of) value adjustments, and before the deduction of income from disposals. Purchased goods are valued at purchase price, i.e. transport and installation charges, fees, taxes and other costs of ownership transfer are included. The value of goods acquired via financial lease corresponds to the market value of the good if it had been

				purchased in the year of acquisition only. This value is in principle known in the contract or can be estimated by summing -up the part of the instalments that cover the capital reimbursement. The part of instalments corresponding to the interest payments are to be excluded. Own produced tangible goods are valued at production cost. Goods acquired through restructuration (such as mergers, take-overs, break-ups, split-off) are excluded. Purchases of small tools which are not capitalised are included under current expenditure. Sales of tangible goods includes the value of existing tangible capital goods, sold to third parties. Sales of tangible capital goods are valued at the price actually received (excluding VAT), and not at book value, after deducting any costs of ownership transfer incurred by the seller. Value adjustments and disposals other than by sale are excluded
FINANCIAL POSITION	Gross Debt	Amount of money borrowed to be used to finance activities of the aquaculture enterprise.		Obtained directly from survey
	Total assets	An economic asset is a store of value representing the benefits accruing to the economic owner by holding or using the entity over a period of time. It is a means of carrying forward value from one accounting period to another. = DCF Total value of assets		Obtained directly from survey
RAW MATERIAL WEIGHT	Fish Feed used	Quantities of feed used for fish and other aquatic species for aquaculture production. = DCF Raw material volume: Feed		Obtained directly from survey

	Livestock used	Weight of purchased livestock that is meant for production, includes purchase of breeding stocks. Livestock refers to all fish and aquatic species kept or reared in captivity mainly for aqua cultural purposes. = DCF Raw material volume: Livestock	Unclear whether this variable should include only the livestock purchased during the year. Suggestion to amend variable name to: Livestock purchased	Obtained directly from survey
Weight of sales per species		Volume of output from aquaculture sold during the year, including production from hatcheries and nurseries offered for sale = DCF Total sales volume		Derived from administrative source The data source is the official national statistics on sales – sales notes
EMPLOYMENT	Paid labour	Total number of persons who have worked in the enterprise, irrespective of the total number of hours. Total employees = Persons employed + unpaid labour	Propose to rename to Paid persons employed or Paid labour (as in Fleet)	Obtained directly from survey
	Unpaid labour (Number)	Number of persons who have worked for the enterprise that have not received compensation in the form of wages, salaries, fees, gratuities, piecework pay or remuneration in kind. Total employees = Persons employed + unpaid labour		Obtained directly from survey
	Persons employed (FTE)	Total FTE = Persons employed (FTE) + unpaid labour (FTE)		Obtained directly from survey
	Unpaid labour (FTE)	Number of persons who have worked for the enterprise that have not received compensation in the form of wages, salaries, fees, gratuities, piecework pay or remuneration in kind.		Obtained directly from survey
	Number of hours worked by employees and unpaid workers New	The aggregate number of hours worked (by total employees) during the reference period.		Obtained directly from survey
NUMBER OF ENTERPRISES	Number of enterprises (by category on the number of persons employed)	Number of aquaculture enterprises in each size category (in terms of number of persons employed). Number of enterprises (by category on the number of persons employed)	Variables should be renamed: "Number of enterprises by size category" Suggested categories: ≤5; 6-10 and >10 FTE	Derived from official Administrative sources (license list exist in NAFA)

VARIABLE GROUP	Variable	Definition	PGECON advice	Methodology used
SOCIAL VARIABLES	Employment by gender	Specification of the meaning of "employment" missing, if reference to all or full-time-part-time required (corresponds to engaged crew or Paid labour for fleet)	1. Data should be raised to the total population. 2. Employment data reported in the social data calls should be consistent with the data reported under the Fleet and Aquaculture data calls. 3. PGECON recommends to stratify employment data for the social data call related to the EU fleet by supra region, geo-indicator, fishing activity (SCF, LSF and DWF) and main fleet segments, when possible. It is suggested to follow main AER group definitions as close as possible. For the employment data for the social data call related to the EU aquaculture sector, it is recommended to follow the same segmentation as for the aquaculture data call when possible, or at least to disaggregate by marine (finfish), freshwater (finfish) and shellfish. 4. It needs to be further investigated the trade-offs of providing the data for a particular date in the year so that duplications are avoided (e.g. when fishers are moving from one vessel to another during the year) or cover the whole year to include seasonal patterns.	**Obtained directly from survey** PGECON recommends to follow Eurostat practice and separate social variable "Employment by gender" in the following groups: - "Male"; - "Female"; - "Unknown" (only if needed). Figures for the number of persons working less than the standard working time of a full-year full-time worker, should be converted into full time equivalents, with regard to the working time of a full-time full-year employee in the unit. It is the total hours worked divided by the average annual number of hours worked in full-time jobs within the economic territory. Since the length of a full-time job has changed through time and differs between industries, methods which establish the average proportion and average hours of less than full-time jobs in each job group have to be used. A normal full-time week must first be estimated in each job group. If possible, a job group can be defined, inside an industry, according to sex and (or) kind of work of people. Hours contractually agreed upon can constitute for employee jobs, the appropriate criteria for determining those figures. Full-

				time equivalent is calculated separately in each job group, then summed. Included in this category are people working less than a standard working day, less than the standard number of working days in the week, or less than the standard number of weeks/months in the year. The conversion should be carried out on the basis of the number of hours, days, weeks or months worked.
	Unpaid labour by gender	Number of engaged crew / workers that have not received compensation in the form of wages, salaries, fees, gratuities, piecework pay or remuneration in kind.		Obtained directly from survey . PGECON recommends to follow Eurostat practice and separate social variable "Employment by gender" in the following groups: - "Male"; - "Female"; - "Unknown" (only if needed).
	Employment by age	Specification of the meaning of "employment" missing, if reference to all or full-time-part-time required		Obtained directly from survey. Taking into account needs of EMMF for monitoring of employment by age classes and Eurostat practice, PGECON recommends to separate social variable "Employment by age" at least into the following age classes: - <=14; - 15-24; - 25-39; - 40-64; - >=65; - "Unknown"
	Employment by education level	Specification of the meaning of "employment" missing, if reference to all or full-time-part-time		Obtained directly from survey. PGECON recommends to use

		required		the International Standard Classification of Education (ISCED 2011), defining social variable “Employment by education level”. Data collected under EUMAP by MS should allow to provide data at least for the following groups at EU level: * “Low" for education levels 0-2 (ISCED2011 and ISCED1997); * “Medium" for education levels 3-4 (ISCED2011 and ISCED1997); * “High" for education levels 5-8 (ISCED2011), levels 5-6 (ISCED1997); - “Unknown”
	Employment by nationality	Specification of the meaning of "employment" missing, if reference to all or full-time-part-time required		Obtained directly from survey. Taking into account national needs and EU requirements it is recommended to separate social variable “Employment by nationality” to at least the following groups: - “National”; - “EU”; - “EEA”; - “Non-EU/EEA"; - “Unknown”
	Employment by employment status	Specification of the meaning of "employment" missing, if reference to all or full-time-part-time required		Obtained directly from survey PGECON recommends for data collection of social variable “Employment by employment status” to be reported at least by two categories: - “Owner” (vessel owner involved in vessel activity/operation); - “Employee” (all engaged

				workers on-board, excluding owners). - “Unknown”. Possible to disaggregate on a voluntary basis between full and part time employees.

6. Data storage and Confidentiality

All data from questionnaires is entered and stored in the electronic record-keeping system of the Agency.

The raw and disaggregated data is treated as confidential as well as all personal data according to REGULATION (EU) 2016/679 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 27 April 2016 on the protection of natural persons with regard to the processing of personal data and on the free movement of such data, and repealing Directive 95/46/EC (General Data Protection Regulation).

MINISTRY OF AGRICULTURE AND RURAL DEVELOPMENT

National Agency for Fisheries and Aquaculture

Description of the socio-economic data collection methodology of the fish processing sector in Romania

Census

1. **General information about Executive agency for fisheries and aquaculture as responsible authority for fisheries control and data collection** 2

2. **Description of the data collection scheme and sampling method for economic and social variables for the processing enterprises** 2

2.1 Type of data collection scheme .....

2.2 Update the questionnaire to comply with the latest legislation and the needs of the data collection program in Romania 2

2.3 Data validation procedure 2

2.4 Estimation procedures 3

3. Methodology used for collection of the variables 3

4. Data storage and Confidentiality 10

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The responsible authority for fisheries control in Romania is the National Agency for Fisheries and Aquaculture (NAFA). The Agency is organized by General administration (Accounting office, Human resources and Legal Services) and Specialized administration (Fisheries control, Structural Fisheries Funds and Management and monitoring of fish resources..

2. Description of the data collection scheme and sampling method for economic and social variables for the processing enterprises

Registration and control of processing plants are carried out by the Romanian Food Safety Agency (RFSA). In the beginning of each year an expert from NAFA, which is responsible for the data collection from fish processing enterprises is downloading the list of active processing plants from the official online registers available in the webpage of the RFSA. In regards to the Data Collection Framework, the Bulgarian legislation was adapted in order to collect socio-economic variables from EU MAP, and in 2016 the Fisheries and aquaculture Act was amended. As a responsible institution for the Data collection, NAFA was provided with the rights to collect data for the fish processing sector. The annual questionnaire for processing enterprises consists of 2 parts – in the first part the owner should fill his name, phone number, name of the enterprise, in the second part of the questionnaire the owner /or his representative/ should fill the economic and social variables from Table 10 from the Commission delegated decision (EU) 2019/910. The collection of all variables is compliant with relevant PGECON/RCG ECON recommendations.

2.1 Type of data collection scheme.

The data collection scheme for the processing enterprises in Bulgaria is **Census and the sampling unit is a fish processing plant**. Based on national legislation (Art. 27a from Fisheries and Aquaculture Act), every owner of processing plant which is in the register in the RFSA, or his representative, is required at the beginning of each year (before January 31) to submit economic and social information for the previous year. The sampling method that we are using is to collect questionnaires for all the enterprises with an active registration during the reference year.

2.2 Update the questionnaire to comply with the latest legislation and the needs of the data collection program in Bulgaria.

Every year the President of NAFA affirms the content and the type of questionnaire, which is prepared by the relevant data collection experts. The questionnaire is completed manually or electronically by the owner of the enterprise or his representative /like accountant/ and is accepted by an employee (someone from the administration) of the agency who is trained for this and is aware of the meaning of economic and social indicators. If necessary, the employee explains some of the variables. The filling of the questionnaire is completed after the owner and the employee of NAFA put their signatures and the questionnaire is entered in the electronic record-keeping system of the Agency.

2.3 Data validation procedure

The first quality checks of the questionnaire are made by the employee of NAFA who receives the questionnaire – this initial check is focused mainly on the amount of data filled in. The second check is done by the person who submits the data from the questionnaire in the database of NAFA. If at this stage of the processing of the questionnaire are detect any inconsistencies or value that is

not logical, based on parameters of the enterprise, number of employees, reported production and sales or any other parameter, an employee of the agency contacts the owner of the enterprise and if he is not able to provide a logical explanation, he is obliged to come and edit the value.

2.4 Estimation procedures

Estimation procedures were made only for the previous years, in which the questionnaire was not mandatory and there was missing information. Since now the collection of questionnaires is from all processing plants, no estimation is needed, because they are required to submit all the data. If for some reason after 31st of January some of the owners had not reported data for the previous year, an employee of the agency contacts the owner and reminds him of this obligation. In addition, administrative sanction can be imposed to the owner for not fulfilling obligations to report socio-economic information.

3. Methodology used for collection of the variables

In order to improve the collection, quality and comparability of the different variables among MS the guidelines on socio-economic variables contain definitions and methodology for the variables requested under the EU MAP from 2022 are used. The guidelines are prepared by the experts from all MS in the regional coordination group on the economic issues (RCG ECON, former PGECON) and they are living documents.

VARIABLE GROUP	Variable	Definition	PGECON advice	Methodology used
INCOME	Turnover	Turnover comprises the totals invoiced by the observation unit during the reference period, and this corresponds to market sales of goods or services supplied to third parties. Turnover includes all duties and taxes on the goods or services invoiced by the unit with the exception of the VAT invoiced by the unit vis-à-vis its customer and other similar deductible taxes directly linked to turnover. It also includes all other charges (transport, packaging, etc.) passed on to the customer, even if these charges are listed separately in the invoice. Reduction in prices, rebates and discounts as well as the value of returned packing must be deducted. For the segments with "main" fish processing activities, "Turnover" variable, should include only Turnover related to the principal fish processing activity. = DCF Turnover	Two surveys have to be used for different parts of population Not clear if this is the procedure for all MS (i.e., to use SBS data +complementary survey)	**Directly obtained from DCF survey** For the segments with "main" fish processing activities, "Turnover" variable, should include only Turnover related to the principal fish processing activity.
	Other income	Other operating income included in company accounts, which are excluded from turnover; income coming from other activities than fish processing. Other income, not shown under other headings. Exclude extraordinary and financial incomes. Under "Other income" all the other revenues from other activities apart from fish processing should be provided. = DCF Other income	Two surveys have to be used for different parts of population	**Directly obtained from additional DCF survey** Under "Other income" all the other revenues from other activities apart from fish processing should be provided.
Personnel Costs	Personnel costs	Total remuneration, in cash or in kind, payable by an employer to an employee (regular and temporary employees as well as home-workers) in return for work done by the latter during the reference period. Personnel costs also include taxes and employees' social security contributions retained by the unit as well as the employer's compulsory and voluntary social contributions = DCF Wages and salaries	Two surveys have to be used for different parts of population.	**Directly obtained from DCF survey**
	Value of unpaid labor	= DCF Imputed value of unpaid labour	Still there is a broad range of options to determine the average wage. If the number of unpaid labour is collected, then the imputed wage per FTE would be sufficent to calculate the value of unpiad labour	**Directly obtained from DCF survey**
	Payment for external agency workers (optional)	Included are payments to temporary employment agencies and similar organisations supplying workers to clients' businesses for limited periods of time to supplement or		**Directly obtained from DCF survey**

		temporarily replace the working force of the client, where the individuals provided are employees of the temporary help service unit. However, these agencies and organisations do not provide direct supervision of their employees at the clients' work sites. Only the payments for the provision of personnel which is not linked to the provision of a particular industrial or other non-industrial service is included.		
Energy costs	Energy costs	Purchases of all energy products during the reference period should be included in this variable only if they are purchased to be used as fuel. Energy products purchased as a raw material or for resale without transformation should be excluded. This figure should be given in value only.		**Directly obtained from DCF survey**
Raw material costs	Purchase of fish and other raw material for production	Total purchases of fish and other raw material for production. Purchases of fish and other raw material for production include the value of fish and other raw material for production purchased during the accounting period for resale or consumption in the production process, excluding capital goods the consumption of which is registered as consumption of fixed capital. The fish and other raw material concerned may be either resold with or without further transformation, completely used up in the production process or, finally, be stocked.	SBS data should be preferred, but in case dissemination methods are not possible, data from surveys should be used for all processing enterprises. Should be re-named "other operating costs" • Eurostat data do not cover the raw material used by the fish processing companies, which is a key to understand the linkages with the wild-capture fisheries, aquaculture and external trade.	**Directly obtained from DCF survey**
Other operating costs	Other operational costs	Total purchases of goods and services minus Purchase of fish and other raw material for production. Purchases of goods and services include the value of all goods and services purchased during the accounting period for resale or consumption in the production process, excluding capital goods the consumption of which is registered as consumption of fixed capital. The goods and services concerned may be either resold with or without further transformation, completely used up in the production process or, finally, be stocked.		
Subsidies	Operating subsidies	services purchased during the accounting period for resale or consumption in the production process, excluding capital goods the consumption of which is registered as consumption of fixed capital. The goods and services concerned may be either resold with or without further transformation, completely used up in the production	Subsidies could be derived from SBS by disseminating Turnover, however because of a complex structure of SBS turnover, data from national and regional administrations for the whole processing	**Directly obtained from DCF survey**

		process or, finally, be stocked.	sector, should be used, in preference to direct survey. This in turn will help to derive turnover and other income more precisely.	
	Subsidies on investments New	Direct payments which general government or the institutions of the European Union make to resident producers to finance all or part of the costs of their acquiring assets.		**Directly obtained from DCF survey**
Capital costs	Consumption of fixed capital	Decline in value of fixed assets, as a result of normal wear and tear and obsolescence. The estimate of decline in value includes a provision for losses of fixed assets as a result of accidental damage which can be insured against. =DCF Depreciation of capital	NOT COVERED BY EUROSTAT	**Directly obtained from DCF survey**
FINANCIAL POSITION	Total assets	An economic asset is a store of value representing the benefits accruing to the economic owner by holding or using the entity over a period of time. It is a means of carrying forward value from one accounting period to another.	NOT COVERED BY EUROSTAT	**Directly obtained from DCF survey**
	Debt	Amount of money borrowed to be used to finance activities of the processing enterprise.	No data coverage in SBS	**Directly obtained from DCF survey**
Financial results	Financial income	Income from investments and loans forming part of the fixed assets, and other interest receivable. Financial costs, net = Financial expenditures – Financial income	Two surveys have to be used for different parts of population.	**Directly obtained from DCF survey**
	Financial expenditures	Interest payable and similar charges. Financial costs, net = Financial expenditures – Financial income		**Directly obtained from DCF survey**
Investments	Gross Investments	Gross investment in tangible and intangible goods minus sales of tangible and intangible investment goods.	Two surveys have to be used for different parts of population. Tangible goods defined in SBS 15 11 0 and intangible goods defined in SBS 15 42 0 and SBS 15 44 1, tangible investment goods defined in 15 210. Rename to Gross investments = Purchases minus sales. Net should be removed from the variable name to avoid confusion with financial accounting net investments, which refers to investments minus depreciation.	**Directly obtained from DCF survey**
Employment	Number of persons employed	Total number of persons who have worked in the enterprise, irrespective of the total number of hours.	Does it include unpaid labour?	**Directly obtained from DCF survey**
	Unpaid labour	Number of persons who have worked for the enterprise that have not received compensation in the form of wages, salaries, fees, gratuities, piecework pay or remuneration in		**Directly obtained from DCF survey**

		kind.		
	FTE National	The number of employees converted into full time equivalent jobs (FTE).		**Directly obtained from DCF survey**
	Number of hours worked by employees and unpaid workers	The aggregate number of hours worked during the reference period.		**Directly obtained from DCF survey**
Number of enterprises	Number of enterprises (1)	Number of fish processing enterprises in each size category (in terms of number of persons employed).	What does (1) mean? Number of fish processing enterprises in each size category (in terms of number of persons employed). Rename to "Number of enterprises by size category" , Suggested categories: ≤5; 6-10 and >10 FTE	**Derived from administrative source** (license list exist in BFSA and is publicly available)
Weight of raw material (OPTIONAL)	Weight of raw material per species and origin (optional)	Weight of raw material originating from fisheries and aquaculture	PGECON 2020: Weight and value of raw material by: □ Species □ Production environment (Capture based fishery and aquaculture sector) □ Country of Origin (Domestic, other EU or non-EU) Type of processed material (fresh, frozen and semi processed materials) – if possible	**Directly obtained from DCF survey**

VARIABLE GROUP	*Variable*	*Definition*	*PGECON advice*	*Methodology used*
SOCIAL VARIABLES	**Employment by gender**	Specification of the meaning of "employment" missing, if reference to all or full-time-part-time required (corresponds to engaged crew or Paid labour for fleet)	1. Data should be raised to the total population. 2. Employment data reported in the social data calls should be consistent with the data reported under the Fleet and Aquaculture data calls. 3. PGECON recommends to stratify employment data for the social data call related to the EU fleet by supra region, geo-indicator, fishing activity (SCF, LSF and DWF) and main fleet segments, when possible. It is suggested to follow main AER group definitions as close as	**Obtained directly from survey** PGECON recommends to follow Eurostat practice and separate social variable "Employment by gender" in the following groups: - "Male"; - "Female"; - "Unknown" (only if needed). Figures for the number of persons working less than the standard working time of a full-year full-time worker, should be converted into full time equivalents, with regard to the working time of a full-time full-year employee in the unit. It is the total hours worked divided by the average annual
	FTE by gender	The number of employees converted into full time equivalent jobs (FTE). Fleet: People working only onshore and paid from vessels should be included if their activity has a direct link with the fishing operations. Employment on shore should include those activities, which directly related to small-scale fisheries and mostly carried out by fishers and their family members, but not entirely related to other economic sectors and specialties		

			possible. For the employment data for the social data call related to the EU aquaculture sector, it is recommended to follow the same segmentation as for the aquaculture data call when possible, or at least to disaggregate by marine (finfish), freshwater (finfish) and shellfish. 4. It needs to be further investigated the trade-offs of providing the data for a particular date in the year so that duplications are avoided (e.g. when fishers are moving from one vessel to another during the year) or cover the whole year to include seasonal patterns.	number of hours worked in full-time jobs within the economic territory. Since the length of a full-time job has changed through time and differs between industries, methods which establish the average proportion and average hours of less than full-time jobs in each job group have to be used. A normal full-time week must first be estimated in each job group. If possible, a job group can be defined, inside an industry, according to sex and (or) kind of work of people. Hours contractually agreed upon can constitute for employee jobs, the appropriate criteria for determining those figures. Full-time equivalent is calculated separately in each job group, then summed. Included in this category are people working less than a standard working day, less than the standard number of working days in the week, or less than the standard number of weeks/months in the year. The conversion should be carried out on the basis of the number of hours, days, weeks or months worked.
SOCIAL VARIABLES	**Unpaid labour by gender**	Number of engaged crew / workers that have not received compensation in the form of wages, salaries, fees, gratuities, piecework pay or remuneration in kind.		**Obtained directly from survey** PGECON recommends to follow Eurostat practice and separate social variable “Employment by gender” in the following groups: - “Male”; - “Female”; - “Unknown” (only if needed).
	Employment by age	Specification of the meaning of "employment" missing, if reference to all or full-time-part-time required		**Obtained directly from survey** Taking into account needs of EMMF for monitoring of employment by age classes and Eurostat practice, PGECON recommends to separate social variable “Employment by age” at least into the following age classes: - <=14; - 15-24;

				- 25-39; - 40-64; - >=65; - “Unknown”
SOCIAL VARIABLES	**Employment by education level**	Specification of the meaning of "employment" missing, if reference to all or full-time-part-time required		**Obtained directly from survey** PGECON recommends to use the International Standard Classification of Education (ISCED 2011), defining social variable “Employment by education level”. Data collected under EUMAP by MS should allow to provide data at least for the following groups at EU level: - “Low" for education levels 0-2 (ISCED2011 and ISCED1997); - “Medium" for education levels 3-4 (ISCED2011 and ISCED1997); - “High" for education levels 5-8 (ISCED2011), levels 5-6 (ISCED1997); - “Unknown”
	Employment by nationality	Specification of the meaning of "employment" missing, if reference to all or full-time-part-time required		**Obtained directly from survey** Taking into account national needs and EU requirements it is recommended to separate social variable “Employment by nationality” to at least the following groups: - “National”; - “EU”; - “EEA”; - “Non-EU/EEA"; - “Unknown”.
	Employment by employment status	Specification of the meaning of "employment" missing, if reference to all or full-time-part-time required		**Obtained directly from survey** PGECON recommends for data collection of social variable “Employment by employment status” to be reported at least by two categories: - “Owner” (vessel owner involved in vessel activity/operation); - “Employee” (all engaged workers on-board, excluding owners). - “Unknown”. Possible to disaggregate on a voluntary basis between full and part time employees.

4. Data storage and Confidentiality

All data from questionnaires is entered and stored in the electronic record-keeping system of the Agency.

The raw and disaggregated data is treated as confidential as well as all personal data according to REGULATION (EU) 2016/679 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 27 April 2016 on the protection of natural persons with regard to the processing of personal data and on the free movement of such data, and repealing Directive 95/46/EC (General Data Protection Regulation).

Methodology for Bottom trawl survey in the Romanian Black Sea area

1. Information collected through the bottom trawling 3

2. Sampling scheme 3

3. Laboratory analyses 3

4. Statistical methods 4

5. References 9

Introduction

The methodology and techniques used for data collection, verification, processing and analysis for the general assessment of demersal stocks (turbot, whiting) are, generally, follow the methodology applied during previous data collection programs for the Romanian Black Sea area.

The target species of the demersal survey was turbot (*Scophthalmus maximus*), and the by-catch species - the spiny dogfish (*Squalus acanthias),* the thornback ray (*Raja clavata*) and the European flounder (*Platichthys flesus*) were also measured and analysed.

The methodology and techniques, used for data collection, verification, processing and analysis and for complete turbot stock assessment were following the generally applied methodology in the Romanian Black Sea zone.

The field data were collected by standard techniques - bottom trawl that remained

constant through the surveys. The GPS system of the ship was connected to NAFA satellite system for monitoring of the fishing vessels (VMS) and the ship location was strictly controlled during the trawling.

All the data collected from demersal research expeditions were entered in the program developed by COISPA, **Biondex Script** (version 3.1) running in program RStudio Version 1.1.463, through fisheries data processing software, including statistical data processing, in accordance with the requirements of the European Commission Regulations. Before entering the data in the Biondex script, are organized in the format of MEDITS tables, being verified with the RoME script (version 0.2.01) to perform multiple data checks. The RoME package includes functions related to single checks for a total of 55 functions ("facility functions"), associated with a certain control in the tables TA, TB, TC, TD, TT, TE and TL. The results obtained by running this script are saved in the OUTPUT folder, like JPEG, TIFF and CSV files and are presented like maps and tables that include data related to:

* the surface of the researched square (Km2, m2);
* the average mass per unit area (g/m2, t/Km2);
* the mass limits variation per unit area;
* the total biomass values (t);
* the abundance index (individuals/km2).

Demersal expeditions for the assessment of turbot and dog fish agglomerations provide additional information for the calculation of the catch effort per unit CPUE (kg/hour) and of catch per unit area CPUA (kg/m2) in the researched areas. The collected data are stored in the NIRMD - Constanta database, as well as in the international database of GFCM – DCRF Platform, and the JRC database.

Information collected through the bottom trawling

* Depth - measured with the echo-sounder;
* GPS coordinates of the trawling - starting and end points;
* Trawling duration;
* Abundance of fish species in the trawl;
* Weight of the total catch in the trawl;
* Absolute and standard length; weight of collected specimens;
* Collection of otoliths for age determination;
* Sex identification;
* By-catch species composition;
* Turbot stomachs for stomach content analysis.

For turbot biomass calculations, data for catch per unit effort (CPUE) (kg /h) and catch per unit area (CPUA) (kg /km^2) were used.

The results are presented in the form of maps and tables that include data for:

* Survey area (km2);
* Catch per unit effort (kg /trawl)
* Catch per unit area (t/km2);
* Abundance index (individual/km2);
* Limits of variation of CPUA;
* Total biomass (t.);
* Abundance (ind);

During the studies, a fishing bottom trawl 22/27-34 was applied, with following functional and technical parameters:

* Trawl vertical opening - 2 m;
* Effective part of Headrope - 13 m;
* Effective part of Footrope - 15 m;
* Trawling speed - 1.8 - 2.1 Nd;
* Trawling duration - 60 min.
* Mesh size – 200 mm.

2. Sampling scheme

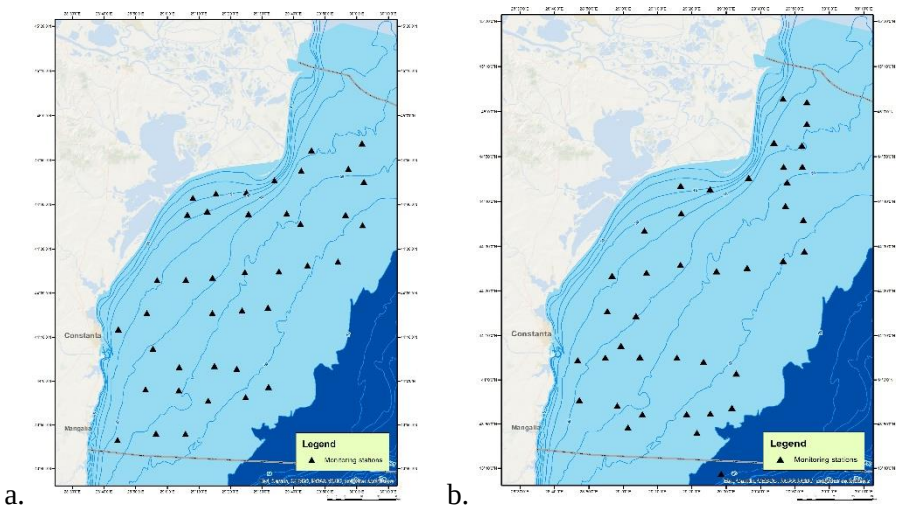
To establish the abundance and biomass of the reference species *S. maximus* off the Romanian Black Sea coast, a standard methodology for stratified sampling (Gulland,

1966; Sparre, Venema, 1998; Sabatella, Franquesa, 2004) was applied.

The surveyed region was divided into four strata, depending on the depth:

- Stratum 1 (15 - 35 m);
- Stratum 2 (35 - 50 m);
- Stratum 3 (50 - 75 m);
- Stratum 4 (75 - 100 m).

For assessment of turbot abundance and biomass, the surveyed territory was divided into 143 squares, each of them with sides 10 x 10 Nm, area 100 Nm^2 (Fig.1).



a. b.

Fig. 1 Bottom trawl planned distribution points (a – sprig season and b-autumn season)

The sampling was carried out at 40 randomly chosen fields (rectangles), situated at depth between 15 - 100 m. Each rectangle is with sides 10'Lat × 10'Long, while the total area is 125.16 km^2 (measured by GIS). Each field was marked with letters and digits for better distinction.

The seabed area covered during a single haul represents a basic measurement unit, considered representative, as turbots do not aggregate in dense assemblages.

The duration of each hauls was 60 min. At trawling speed of 1.8 - 2.2 knots.

On the ship board, the absolute and standard length, as well as the individual weight of each specimen were measured in order to determine the size and weight structure of the turbot stock and to estimate the share of specimens with length below the allowable fishing length in the catches.

3. Laboratory analyses

After collecting the samples on shipboard, the age, maturity of the reproductive system and stomach content composition were determined in laboratory.

The turbot age was established by otoliths reading under binocular microscope.

To identify the composition of the food stomachs were collected. The stomach content analysis included identification of the taxonomic composition and total

number of food components, weight and frequency of occurrence of each food component. The index of relative importance (IRI) was used to determine the si gnificance of each food component in the trophic spectrum (Pinkas et.al., 1971):

$$\mathbf{IRI = (CN + CW) *F,}$$

CN - percentage share of the food item i in total number;
CW - percentage share of the food item i in the total weight;
F – frequency of occurrence.

IRI expressed as a percentage was calculated by the equation (Cortes, 1997):

$$\%\mathbf{IRI_i} = \frac{100 * IRI\ i}{\sum_i^n IRI\ i}$$

n – total number of the taxonomic categories at a given taxonomic level

To determine the relative biomass of the reference species *S. maximus*, the “swept area method” was applied. According to this method, trawl sweeps a well-defined path, the area of which is the length of the path times the width of the trawl, called the " swept area" or the "effective path swept", thus the swept area can be estimated from equation:

$$\boldsymbol{a = D*hr*X2,\ D = V*t}$$

V - is the velocity of the trawl over the ground when trawling,

t - the time spent trawling,

hr - the length of the head-rope.

X2 is that fraction of the head-rope length, hr, which is equal to the width of the path swept by the trawl, the "wing spread", hr*X2,

D - distance covered.

To calculate turbot biomass, the catch per unit area (CPUA) was used:

$$\frac{Cw/t}{a/t} = \frac{Cw}{a}\ \mathbf{kg\ /\ km^2}$$

Cw/t – catch in units of weight per trawling hour;
a/t – area swept per trawling hour.

The biomass for each stratum was obtained from equation:

$$\boldsymbol{B} = (\boldsymbol{C}\,w\ /\ a\,) * \mathrm{A}$$

Cw / a - mean catch per unit of area for all trawl sweeps in the stratum,
A – stratum area.

The variance of biomass estimated for each stratum is:

$$VAR(B) = A^2 \frac{1}{n} * \frac{1}{n-1} * \sum_{i=1}^{n} [\ Ca(i) / Ca\ ]$$

The total area of the surveyed region is equal to the sum of the areas of every stratum:

$$A = A1+A2+A3$$

The mean catch for the entire survey area was obtained from equation:

$$Ca(A) = \frac{Ca1 * A1 + Ca2 * A2 + Ca3 * A3}{A}$$

Ca1- catch per unit area in stratum 1;

A1 – stratum 1 area, etc.;

A – total water area.

The total biomass in the survey area is estimated by equation:

$$B = Ca\ (A) * A$$

Ca (A) - *mean weighted catch for the entire surveyed water area,*
A - total area surveyed.

CPUE (*Catch per unit effort*) **-** is calculated by dividing the trawl catch by the fishing hours (kilograms/hour):

CPUE = yield/effort

Maximum sustainable yield

Gulland's formula for virgin stock is:

$$MSY = 0.5*M*Bv$$

M – coefficient of natural mortality,
Bv- biomass of virgin stock.

A generalized version of Gulland was proposed by Cadima (in Troadec, 1971) for exploited fish stocks for which only limited data are available for stock assessment :

$$MSY = 0.5 * Z * B$$

B - mean annual biomass;
Z – total mortality.

Because Z = F + M and Y = F * B , Cadima suggested that in the absence of data for Z, the equation can be rewritten:

$$MSY = 0.5 * (y + M * B)$$

y – total catch in one year;

B - mean biomass in the same year.

TAC - total allowable catch, Prediction models

Beverton and Holt yield per recruit model (1957):

$$Y/R = F*\exp[-M*(Tc-Tr)]*W_{\infty} * \left[\frac{1}{Z} - \frac{3S}{Z+K} + \frac{3S^2}{Z+2K} - \frac{S^3}{Z+3K}\right]$$

S = exp [-K (Tc – t0)],
K = von Bertalanffy growth parameter;
t_0 = von Bertalanffy growth parameter;
Tc = age at first capture;
Tr = age at recruitment;
W = asymptotic body weight;
F = fishing mortality;
M = natural mortality;
Z = F + M, total mortality.

To evaluate the exploitation ratio, the formulae of ***Pauly*** (1983) was used:

$$\mathbf{E = F / Z;}$$

E - exploitation ratio,
F - fishing mortality,
Z - total mortality;

Jones' Length - Based Cohort Analysis (1981)

Jones' length-based cohort analysis:

$$\exp\left(\frac{M}{2} * \Delta t\right) = \exp\left[\frac{M}{2} * \frac{1}{K} * \ln\left(\frac{L\infty - L1}{L\infty - L2}\right)\right] = \exp\left[\ln\left(\frac{L\infty - L1}{L\infty - L2}\right)^{M/2K}\right] = \left[\frac{L\infty - L1}{L\infty - L2}\right]^{M/2K}$$

Age and growth

For the estimation of turbot growth rate, the von Bertalanffy growth function (1938) was applied, (according to Sparre, Venema, 1998):

$$Lt = L_{\infty} \{1 - exp^{[-k\,(t + t0)]}\}$$
$$Wt = W_{\infty} \{1 - exp^{[-k\,(t + t0)]}\}^{n}$$

Wt are the length or weight of the fish at age t years;
L_{∞}, W_{∞} - asymptotic length or weight;
k – curvature parameter;
to - the initial condition parameter.

The length – weight relationship is obtained by the following equation:

$$\mathbf{Wt = q\ Lt}$$

q - constant in length-weight relationship;
n - constant in length-weight relationship.

Natural mortality (M)

Pauly's empirical formula (1979, 1980) was applied :

$$\log M = -0.0066 - 0.279 * \log L_\infty + 0.6543 * \log k + 0.4634 * \log T^\circ C$$
$$\log M = -0.2107 - 0.0824 * \log W_\infty + 0.6757 * \log k + 0.4687 * \log T^\circ C$$

L_∞, W_∞ and k – parameters in von Bertalanffy's equation;
TºC - the annual average temperature of the seawater in the horizons of habitation and reproduction of the species.

Method of Richter si Efanov (1976)

$$M = \frac{1.521}{tmat\ 50\%} + 1.521$$

t_{mat} – age at first maturation.

Stock exploitation (E)

is determined by Pauly (1983):

$$E = F / Z$$

where Z - total mortality,
F - fishing mortality.

D Q C & D Q A :

* Guidelines for DQA and DQC in Bulgaria: Ichthyological studies (2013);
* ICES (2015) Manual for the International Bottom Trawl Surveys ;
* Vitale, Worsøe, Chonchúir (2019).

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Methodology for fish stomach contents study (NIMRD "*Grigore Antipa*")

Methods of stomach contents analysis on fish are diverse but must be critically evaluated in order to properly use them to determine the importance of food. An objective analysis is one that highlights both quantitative and qualitative aspects of food. Thus, a simple way of recording data by analysing stomach contents is to record the number of stomachs that contain one or more individuals in each food category, the number can be expressed as a percentage of the total stomachs analysed (Hyslop, 1980).

Sikora et *al*. (1972) determined average dry weight in predatory species and expressed this as "biomass units". Variation in the average total weight of stomach contents relative to the size of the fish is commonly used in determining the daily rate of food behaviour (Staples, 1975 Changes in the average weight of the annual gastric content indicate differences in feeding intensity. Values that incorporate body weight are probably much more useful because they are a measure of food consumption relative to the size of the fish.

a. Stages of analysis of stomach contents in fish:

- individuals of small size will be taken and placed completely in formaldehyde (4% solution) and then analyzed in the laboratory;
- from large individuals the stomach will be collected; with the help of the scissors the digestive tract will be cut to its extreme parts and then the ends will be connected and then it will be introduced into formaldehyde (4% solution);
- the meristic characteristics of the analyzed individuals, the date and the sampling station will be noted;
- the organisms present in the stomach will be identified up to the group level and, where possible up to the family level;
- depending on purpose different indicators will be calculated (frequency of occurrence, dominance, feeding coefficient, relative importance index (IRI), etc.).

Stomach content analysis in turbot (NIMRD photo)

Stomach content research has been an important area of activity in fisheries biology. Fish food studies cannot be treated in isolation, as they must be discussed in correlation with the whole marine environment in which fish are mere elements. For the laboratory study of the stomach contents, the establishment of trophic relations, it is necessary to collect the digestive tract. The proper collection consists in the cutting with the scissors of the digestive tube at its extreme points, the introduction at one end of a note, the number of which will indicate the meristic characteristics of the fish in the age frequency form. The digestive tubes collected and thus labeled are attached to both ends with thread, placed in a gauze bag and placed in formaldehide (4% solution) as soon as possible, to reduce as much as possible the alteration of the stomach contents.

Quantitative analysis is done by weighing method. The whole stomach content is weighed on the analytical balance as well as each element separately. In order to link these data with the individual to whom they belong, the stomach filling coefficient is calculated or as the fish feeding coefficient is also called.

Two methods are used for the determination, namely: qualitative and quantitative. The qualitative analysis consists in the complete identification of the food components present in the stomach of the fish. The quantitative method consists of numerical analysis (frequency of occurrence, dominance) and gravimetric analysis (feeding coefficient, index of relative importance (IRI). The frequency of occurrence and the numerical percentage of food components are generally calculated to characterize stomach contents (Hyslop, 1980). The frequency of occurrence (FO%) is expressed as the percentage of the total number of stomachs in which the respective species appears:

FO% = FOi/ FOt x 100 where, FOi = number of stomachs in which species I appears;

FOt = total number of stomachs

A first evaluation can be determined by determining the filling coefficient of the digestive tract or the weighting coefficient. With the help of an electric scales, the stomach and the individual are weighed before and after the stomach is taken. Regarding the calculation formula regarding the filling coefficient of the stomach (of the digestive tract) there are several variants of calculation.

A first evaluation can be determined by determining the filling coefficient of the digestive tract or the weighting coefficient. With the help of an electric balance, the stomach and the individual are weighed before and after sampling.

Regarding the formula for calculating the coefficient of filling of the stomach (digestive tract) are more alternatives:

*Schreck et al., 1990 propose the following formula:

CU = <Cs/(Gt-Cs)> x 1000 where, CU = the filling coefficient;

Cs = weight content stomach; Gt = total weight of the fish

* Porumb I., 1961, carrying out studies on the biology of horse mackerel, proposes the following calculation formula for the filling coefficient of the stomach:

CU = ms x 10000 / mp where, CU = the coefficient of filling of the digestive tract in fish;

ms - mass of stomach contents;

mp - total mass of the fish.

* Smyly (1952) working with only a small amount of stomach content calculated the average weight of the whole content:

total stomach content / total weight of fish x 100

Relative importance index (IRI)

This index is an integration of the measurement of the number, volume and frequency of occurrence to help evaluate the relationship between the different types of food found in the stomach. It is calculated by summing the numerical and volumetric percentage values and multiplying by the frequency of the occurrence percentage (Pinkas et al., 1971):

IRI = (%N + % V) x %F

where, N% = number in percent,

V = volume;

F = frequency of occurrence

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GUIDANCE DOCUMENT FOR THE AQUACULTURE

Living document

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Updated by:
PGECON 2017
PGECON 2018
PGECON 2019
PGECON 2020

VARIABLE GROUP	Variable	Definition	PGECON advice	Methodology
INCOME	Gross sales per species	Value of output from aquaculture sold during the year = DCF Turnover	MS should avoid duplication of data collection. What does this mean exactly? If "juveniles" (i.e., fish from hatcheries) are sold to another company they should be accounted. So, if the buying company then sales them at a later stage, the fish shall be counted twice.	1. **Obtained directly from survey** (from enterprise, or producer organisation). 2. **Derived from other surveyed variables.** Production data collected for EUROSTAT should be used. Calculated as weight of sales multiplied by unit price and summed to observation unit.
	Other income	Other operating income included in company accounts which are excluded from turnover; income coming from other activities than aquaculture, e.g. the licensing of ponds for recreational fishery purposes. Other income, not shown under other headings. Exclude extraordinary and financial incomes. = DCF Other income	More clarification needed on what Commission wants us to collect. Main activity companies/should we exclude other things than aquaculture	1. **Obtained directly from survey** "Other income" refers to other operating income included in company accounts which are excluded from turnover; income coming from other activities than aquaculture, e.g. the licensing of ponds for recreational fishery purposes Other income, not shown under other headings. Extraordinary and financial income should be excluded.
~~**PERSONNEL COSTS**~~ **LABOUR COST**	Personnel costs	Personnel costs are defined as the total remuneration, in cash or in kind, payable by an employer to an employee (regular and temporary employees as well as home-workers) in return for work done by the latter during the reference period.		1. **Obtained directly from survey**

VARIABLE GROUP	Variable	Definition	PGECON advice	Methodology
		Personnel costs also include taxes and employees' social security contributions retained by the unit as well as the employer's compulsory and voluntary social contributions. = DCF Wages and Salaries		
	Value of unpaid labour	Unpaid labour = Work that produces goods or services but is unremunerated. = DCF Imputed value of unpaid labour	Still there is a broad range of options to determine the average wage. If the number of unpaid labour is collected, then the imputed wage per FTE would be sufficient to calculate the value of unpaid labour	**1. Derived from other surveyed variables** FTE method (WS, Naples, 2009), that includes the following steps: • estimation of paid and unpaid FTE; • definition of an average remuneration per paid FTE (e.g. average wage by fleet segment/company, national average wage, minimum national wage, etc…); • calculation of imputed value of unpaid labour = unpaid FTE * (average remuneration per paid FTE).
ENERGY COSTS	Energy costs	Purchases of all energy products during the reference period should be included in this variable only if they are purchased to be used as fuel. Energy products purchased as a raw material or for resale without transformation should be excluded	The livestock costs should correspond to the variable livestock volume. In the Structural Business Statistics it is included inside 13 11 0 "Total purchases of goods and services".	**1. Obtained directly from survey**

VARIABLE GROUP	Variable	Definition	PGECON advice	Methodology
REPAIR AND MAINTENANCE	Repair and maintenance	The regular maintenance and repair of fixed assets used in production (items not treated as gross capital formation)		1. **Obtained directly from survey**
OTHER OPERATING COSTS	Other operating costs	Other operating costs should comprise outsourcing costs, property or equipment rental charges, the cost of raw materials and supplies that cannot be held in the inventory and have not been already specified (i.e. water, small items of equipment, administrative supplies, etc.), insurance premiums, studies and research costs, external personnel charges, fees payable to intermediaries and professional expenses, advertising costs, transportation charges, travel expenses, the costs of meetings and receptions, postal charges, bank charges (but not interest on bank loans) and other items of expenditure. On the Structural Business Statistics is included inside 13 11 0 "Total purchases of goods and services".		1. **Obtained directly from survey**
RAW MATERIAL COSTS	Livestock costs	Costs of livestock during the year.		1. **Obtained directly from survey** 2. **Derived from other surveyed variables** Could be derived from number of stock and unit price of seed/juveniles, etc.

VARIABLE GROUP	Variable	Definition	PGECON advice	Methodology
	Feed costs	Costs of feed used for aquaculture production during the year.		1. **Obtained directly from survey** 2. **Derived from other surveyed variables** Could be derived from feed consumption per unit of production and feed price.
SUBSIDIES	Operating subsidies	Direct payments which general government or the institutions of the European Union make to resident producers. Excluding investment subsidies. = DCF Subsidies	Administrative sources, if available, are more precise and therefore are preferable.	1. **Obtained directly from survey** 2. **Obtained from administrative sources (e.g. paying Agency, Local authority, grants, etc.)** The compilation of data on subsidies is based on the official lists provided by national and regional administrations. These lists should be further elaborate to consider only payments that can be classified as operating subsidies (see definition). Each payment has to be associated with aquaculture enterprise. This link allows to report operating subsidies aquaculture.
	Subsidies on investments New	Direct payments which general government or the institutions of the European Union make to resident producers to finance all or part of the costs of their acquiring assets.	Administrative sources, if available, are more precise and therefore are preferable.	1. **Obtained directly from survey.** 2. **Obtained from administrative sources (e.g. paying Agency, Local authority, grants, etc.)** Investment subsidies refer to modernization of existing and construction of new facilities (see more in definitions). The compilation of data on subsidies is based on the official lists provided by national and regional administrations. These lists should be further elaborate to consider only payments that can be classified as subsidies on investments (see definition).

VARIABLE GROUP	Variable	Definition	PGECON advice	Methodology
				Each payment has to associated with aquaculture enterprise. This link allows to report operating subsidies by aquaculture segment.
CAPITAL COSTS	Consumption of fixed capital	Decline in value of fixed assets, as a result of normal wear and tear and obsolescence. The estimate of decline in value includes a provision for losses of fixed assets as a result of accidental damage which can be insured against. = DCF Depreciation of capital	It is not clear which is the benefit of switching from "depreciation" to "consumption of fixed capital" - the concepts are somewhat different (see 3.141)	**1. Obtained directly from survey** Represents the reduction in the value of the fixed assets used in production during the accounting period resulting from physical deterioration, normal obsolescence or normal accidental damage (EC study No. FISH/2005/03).
~~**CAPITAL VALUE**~~	~~Total value of assets~~	~~An economic asset is a store of value representing the benefits accruing to the economic owner by holding or using the entity over a period of time. It is a means of carrying forward value from one accounting period to another.~~ ~~= DCF Total value of assets~~	Moved under FINANCIAL POSITION	~~**1. Obtained directly from survey**~~
FINANCIAL RESULTS	Financial income	Income from investments and loans forming part of the fixed assets, and other interest receivable. Financial costs, net = Financial expenditures – Financial income		**1. Obtained directly from survey** Should consider: • Income from participating interests, with a separate indication of that derived from affiliated undertakings. • Income from other investments and loans forming part of the fixed assets,

VARIABLE GROUP	Variable	Definition	PGECON advice	Methodology
				with a separate indication of that derived from affiliated undertakings. Other interest receivable and similar income, with a separate indication of that derived from affiliated undertakings.
	Financial expenditures	Interest payable and similar charges. Financial costs, net = Financial expenditures – Financial income		**1. Obtained directly from survey** Considers the Interest payable and similar charges, with a separate indication of those concerning affiliated undertakings.
INVESTMENTS	~~Net~~ Investments in tangible assets	Net Investments "Purchase and sale of assets during the year" Gross investment in tangible and intangible goods minus sales of tangible and intangible investment goods.	Gross investments = Purchases minus sales Net should be removed from the variable name to avoid confusion with financial accounting net investments, which refers to investments minus depreciation. Investments here should not include depreciation Tangible goods defined in SBS 15 11 0 and intangible goods defined in SBS 15 42 0 and SBS 15 44 1, tangible investment goods defined in 15 210.	**1. Obtained directly from survey** "Purchase and sale of assets during the year" Investment during the reference period in all tangible goods. Included are new and existing tangible capital goods, whether bought from third parties, acquired under a financial lease contract (i.e. the right to use a durable good in exchange for rental payments over a predetermined and protracted term) or produced for own use (i.e. Capitalised production of tangible capital goods), having a useful life of more than one year including non-produced tangible goods such as land. The threshold for the useful life of a good that can be capitalised may be increased according to company accounting practices where these practices require a greater expected useful life than the 1 year threshold indicated above.

VARIABLE GROUP	Variable	Definition	PGECON advice	Methodology
				All investments are valued prior to (i.e. gross of) value adjustments, and before the deduction of income from disposals. Purchased goods are valued at purchase price, i.e. transport and installation charges, fees, taxes and other costs of ownership transfer are included. The value of goods acquired via financial lease corresponds to the market value of the good if it had been purchased in the year of acquisition only. This value is in principle known in the contract or can be estimated by summing-up the part of the instalments that cover the capital reimbursement. The part of instalments corresponding to the interest payments are to be excluded. Own produced tangible goods are valued at production cost. Goods acquired through restructuration (such as mergers, take-overs, break-ups, split-off) are excluded. Purchases of small tools which are not capitalised are included under current expenditure. Sales of tangible goods includes the value of existing tangible capital goods, sold to third parties. Sales of tangible capital goods are valued at the price actually received (excluding VAT), and not at book value, after deducting any costs of ownership transfer incurred by the seller. Value adjustments and disposals other than by sale are excluded

VARIABLE GROUP	Variable	Definition	PGECON advice	Methodology
~~**DEBT**~~ **FINANCIAL POSITION**	**Gross** Debt	Amount of money borrowed to be used to finance activities of the aquaculture enterprise.		**Obtained directly from survey**
	Total assets	An economic asset is a store of value representing the benefits accruing to the economic owner by holding or using the entity over a period of time. It is a means of carrying forward value from one accounting period to another. = DCF Total value of assets		**Obtained directly from survey**
RAW MATERIAL WEIGHT	Livestock used	Weight of purchased livestock that is meant for production, includes purchase of breeding stocks. Livestock refers to all fish and aquatic species kept or reared in captivity mainly for aqua cultural purposes. = DCF Raw material volume: Livestock	Unclear whether this variable should include only the livestock purchased during the year. Suggestion to amend variable name to: Livestock purchased	1. **Obtained directly from survey** 2. **Derived from other surveyed variables** Could be derived from total production weight/numbers and estimates of mortalities.
	Fish Feed used	Quantities of feed used for fish and other aquatic species for aquaculture production. = DCF Raw material volume: Feed		1. **Obtained directly from survey** 2. **Derived from other surveyed variables** Could be derived from technical guides and total livestock number.
Weight of sales per species		Volume of output from aquaculture sold during the year, including production from hatcheries and nurseries offered for sale = DCF Total sales volume		

VARIABLE GROUP	Variable	Definition	PGECON advice	Methodology
EMPLOYMENT	~~Number of persons employed~~ Paid labour	Total number of persons who have worked in the enterprise, irrespective of the total number of hours. Total employees = Persons employed + unpaid labour	Propose to rename to Paid persons employed or Paid labour (as in Fleet)	**1. Obtained directly from survey**
	Unpaid labour (Number)	Number of persons who have worked for the enterprise that have not received compensation in the form of wages, salaries, fees, gratuities, piecework pay or remuneration in kind. Total employees = Persons employed + unpaid labour		**1. Obtained directly from survey** **2. Derived from other surveyed variables**
	Persons employed (FTE)	Unit expressing the number of employees into full-time workers (usually defined in the national law) (definti Fleet) Total FTE = Persons employed (FTE) + unpaid labour (FTE)		**1. Derived from other surveyed variables** FTE national should be calculated using a threshold defined according to the features of the sector in each MSs (i.e., FTE national) If the annual working hours per employee exceed the reference level, the FTE equals 1 per employee. • if annual working hours>national threshold, then FTE national =1 If not, the FTE equals the ratio between the hours worked and the reference level. • if annual working hours<national threshold, then FTE national = $\frac{annual\ working\ hou}{national\ threshold}$

VARIABLE GROUP	Variable	Definition	PGECON advice	Methodology
	Unpaid labour (FTE)	Number of persons who have worked for the enterprise that have not received compensation in the form of wages, salaries, fees, gratuities, piecework pay or remuneration in kind.		1. **Obtained directly from survey** 2. **Derived from other surveyed variables** FTE = Persons employed (FTE) + unpaid labour (FTE)
	Number of hours worked by employees and unpaid workers New	The aggregate number of hours worked (by total employees) during the reference period.		1. **Obtained directly from survey** 2. **Derived from other surveyed variables** Could be estimated from days/weeks/months worked, or other variables
NUMBER OF ENTERPRISES	Number of enterprises (by category on the number of persons employed)	Number of aquaculture enterprises in each size category (in terms of number of persons employed). Number of enterprises (by category on the number of persons employed)	Variables should be renamed: "Number of enterprises by size category" Suggested categories: ≤5; 6-10 and >10 FTE	1. **Obtained directly from Business Register or** 2. **Derived from other Administrative sources** (license list if exists)

GUIDANCE DOCUMENT FOR THE FISHING FLEET

Living document

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PGECON 2019
PGECON Workshop on Capital Value estimations, Salerno 2019
PGECON 2020

VARIABLE GROUP	Variable	Definition	PGECON advice	Methodology
INCOME	**Gross value of landings**	Value of landings sold during the year	Control data (logbooks and sales notes) should be used where available and reliable; otherwise, sample surveys can be used.	**1. Obtained directly from survey** **2. Derived from administrative sources or other surveyed variables.** The data source is the official national statisticson landings
	Income from leasing out quota or other fishing rights	Totals invoiced during the reference period for leasing out quota or other fishing rights assigned to the related vessel and supplied to third parties	Two methods can be used	**1. Obtained directly from survey** **2. Derived from other surveyed variables** In case the trade (lease) information in terms of fishing rights is available from official sources, this information together with the average lease price can be used to calculate the variable. The average lease price would be collected through the survey.
	Other income	Totals invoiced during the reference period, corresponding to vessel activities other than fishing supplied to third parties. Insurance payment for damage/loss of gear/vessel should be included	Extraordinary and financial income should be **excluded**.	**1. Obtained directly from survey**
LABOUR COSTS	**Personnel costs**	Total remuneration, in cash or in kind, payable by an employer to an employee (regular and temporary employees as well as home-workers) in return for work done by the latter during the reference period. Personnel costs also include taxes and employees' social security contributions retained by the unit as well as the employer's compulsory and voluntary social contributions. People working only onshore and paid from vessels should be included if their activity has a direct link with the fishing operations. Employment on shore should include those activities, which directly related to small-scale fisheries and mostly carried out by fishers and their family members, but not entirely related to other economic sectors and specialties.	MS should take into account how crew share is defined in the fishery, in case crew share based calculations are used.	**1. Obtained directly from survey** **2. Derived from other surveyed variables** In several fisheries, crewmembers are remunerated through share systems rather than having a fixed salary. In this case, personnel costs can be calculated as a % of revenue, or as a % of revenues minus costs. To correctly apply this method, it is necessary to define, for each fleet segment: • what is the approach used to calculate the share: as percentage on total revenues or as percentage of revenues – costs • what are the costs actually included to calculate the share • what is the percentage that goes to the crew
	Value of unpaid labour	Imputed value of unpaid labour. Unpaid labour = Work that produces goods or services but is unremunerated (OECD Glossary of statistical terms). People working only on shore should be included only if their work is directly related to fishing activity.	The estimation of the imputed value of unpaid labour was discussed during the WS on calculating capital value using PIM and definition of DCF variables (Napoli, 13 -17 June 2011). Taking into account difficulties encountered by MS in estimating this variable (recognized by SGECA 10-03 and STECF EWG 11-03), a specific ToR was added to clarify definitions and best practices for MS. The group agreed that the variable "imputed value of unpaid labour" should include the labour costs of all persons delivering unpaid labour. On the basis of the results of this workshop and comparing different experiences by MS (as reported in NPs and ARs), it was suggested that the Value of unpaid labour can be estimated using the FTE method (method no.2)	**1. Derived from other surveyed variables** **2. FTE method** (based on WS Naples, 2011), that includes the following steps: • estimation of paid and unpaid FTE; • definition of an average remuneration per paid FTE (e.g. average wage by fleet segment/company, national average wage, minimum national wage, etc…); • calculation of imputed value of unpaid labour = unpaid FTE * (average remuneration per paid FTE).

VARIABLE GROUP	Variable	Definition	PGECON advice	Methodology
ENERGY COSTS	**Energy costs**	Purchases of all energy products during the reference period should be included in this variable only if they are purchased to be used as fuel. Energy products purchased as a raw material or for resale without transformation should be excluded. **Energy costs should be supplied as net costs, i.e. reduced by tax refunds**	Note: as in the DCF, excluding lubrication oil.	**1. Obtained directly from survey** **2. Derived from other surveyed variables** Fuel cost could be calculated by multiplying the fuel consumption by the average fuel price, if fuel consumption is available
REPAIR AND MAINTENANCE COSTS	**Repair and maintenance costs**	The regular maintenance and repair of fixed assets used in production (items not treated as gross capital formation). Should refer only to vessel incl. equipment		**1. Obtained directly from survey**
OTHER OPERATING COSTS	**Other variable costs**	All purchased inputs (goods and services) related to fishing effort and/or catch/landings excluding energy costs, personnel costs, repair and maintenance costs.	Change variable name to "**Other variable costs**" to distinguish from other discriminated variable costs, such as energy, repair and maintenance, personnel costs, etc.	**1. Obtained directly from survey**
	Other non-variable costs	Includes purchased inputs not related to the level of effort and/or catch/landings (including leased equipment).	Change variable name to "**Other non-variable costs**" to distinguish from other discriminated fixed costs	**1. Obtained directly from survey**
	Lease/rental payments for quota or other fishing rights	Total purchases of "Lease/rental payments for quota or other fishing rights"		**1. Obtained directly from survey** **2. Derived from other surveyed variables** In case the trade (lease) information in terms of fishing rights is available from official sources, this information together with the average lease price can be used to calculate the variable. The average lease price would be collected through the survey.
SUBSIDIES	**Operating subsidies**	Direct payments which general government or the institutions of the European Union make to resident producers. (ESA D.3). Refers to direct payments/transfers related to the vessel activity, **except for**: - Fuel tax refunds - Subsidies for permanent cessation of fishing activities - Investment subsidies (fleet modernization)	Administrative sources, if available, tend to be more precise and therefore are preferable. Corresponds to the homologous DCF variable Direct subsidies	**1. Obtained directly from survey** **2. Obtained from administrative sources** (e.g. paying Agency, Local authority). The compilation of data on subsidies is based on official lists provided by national and regional administrations. These lists should be further elaborated to consider only payments that can be classified as operating subsidies (see definition). Each payment should be associated to one vessel. This link allows to report operating subsidies in fleet segments.

VARIABLE GROUP	Variable	Definition	PGECON advice	Methodology
	Subsidies on investments (NEW)	Direct payments which general governments or the institutions of the European Union make to resident producers to finance all or part of the costs of their acquiring assets related to the vessel.	Administrative sources, if available, are more precise and therefore are preferable. Investment subsidies refer to permanent cessation or to fleet modernization. They should not be included in income (PGECON 2013). In case of subsidies for permanent cessation of fishing activities of those vessels which have become inactive during the year, it has to be decided if they can be classified in the segment of inactive vessel.	**1. Obtained directly from survey** **2. Obtained from administrative sources** (e.g. paying Agency, Local authority). The compilation of data on subsidies is based on official lists provided by national and regional administrations. These lists should be further elaborated to consider only payments that can be classified as operating subsidies (see definition). Each payment should be associated to one vessel.
CAPITAL COSTS	**Consumption of fixed capital**	Decline in value of vessel and equipment, as a result of normal wear and tear and obsolescence.	Consumption of fixed capital (=Depreciation) represents the reduction in the value of the fixed assets used in production during the accounting period resulting from physical deterioration, normal obsolescence or normal accidental damage (EC study No. FISH/2005/03). Corresponds to the homologous DCF variable Annual depreciation	The methodological framework for the estimation of consumption of fixed capital should be coherent with the one applied for the estimation on the value of physical capital. 1. Application of the perpetual inventory method (PIM, cross reference: https://stats.oecd.org/glossary/detail.asp?ID=2055). The key parameters to be considered in order to estimate the consumption of fixed capital within the PIM methodological framework are: the asset service life (that determine the economic depreciation rates), the retirement distribution and the depreciation function. The depreciation functions that can be applied in a PIM are: arithmetic (straight-line method) or geometric (degressive method). 2. Alternative methods based on company surveys. These alternative methods may be used if the derived estimates reflect the actual definition of net capital stock (depreciated replacement value of the vessel including on-board equipment with a useful lifetime of more than one year). In case the PIM is not used, MS should explain and justify the application of alternative methods in the WP and in the AR.
CAPITAL VALUE	**Value of physical capital**	Depreciated replacement value of the vessel including on-board equipment with a useful lifetime of more than one year.		1 Application of the perpetual inventory method (PIM, cross reference: https://stats.oecd.org/glossary/detail.asp?ID=2055) 2. Alternative methods based on company surveys. These alternative methods may be used if the derived estimates reflect the actual definition of net capital stock (depreciated replacement value of the vessel including on-board equipment with a useful lifetime of more than one year). In case the PIM is not used, MS should explain and justify the application of alternative methods in the WP and in the AR.

VARIABLE GROUP	Variable	Definition	PGECON advice	Methodology
	Value of quota and other fishing rights	The current value of the right to exploit fishing grounds over more than one year. To be collected only when fishing rights are tradable and thus data on the value of fishing rights are available.	PGECON 2020 concluded that optimally the value of intangibles should include the value of all fishing rights, but that in the current situation this is not possible as valuation of all rights needs additional data collection and methodological development to be carried out. Therefore, PGECON recommends a transition period in which MS explore the possibilities to apply the guidelines in their situation. During this transition period the obligation to gather information on the value of intangible assets should only include the transferable fishing rights. PGECON also recommends that in the meantime possibilities are sought to facilitate the sharing of experiences with the application of the guidelines in the various MS and the further development of the methodology	**1. Obtained directly from survey** **2. Derived from other surveyed variables** Tradable intangibles should be valued at current market price (or a multi-year average), independently of the question whether they have or have not been acquired or whether they are or are not linked to specific tangible (e.g. vessel).

VARIABLE GROUP	Variable	Definition	PGECON advice	Methodology
INVESTMENTS	**Investments in tangible assets**	Gross investment in vessel and onboard equipment minus sales of (vessel and) onboard equipment.	PGECON suggests to use variables directly from survey. In case PIM method is used investment should be estimated from PIM method in order to ensure consistency with other variables. Gross investments in tangible assets = Purchases minus sales Net should be removed from the variable name to avoid confusion with financial accounting net investments, which refers to investments minus depreciation. Investments here should not include depreciation PGECON to revise the guidelines (definition and methodology) based on the outcomes of the 2019_WS_Capital. Changes to be discussed and approved by the 2020 PGECON	**1. Obtained directly from survey** **2. Estimated from PIM method** (it is not clear if this is being used by any MS; if used, MS should specify in 'comments') **3. Obtained from administrative sources**
FINANCIAL POSITION	**~~Long/short~~ Gross debt (New)**	Amount of money borrowed to be used to finance ongoing vessel activities including value of quota and other fishing rights. Excludes finance obtained for land-based business activities.	Variable name is ambiguous and should be changed to Gross debt.	**1. Obtained directly from survey** Balance sheets are considered the most reliable source of data for debts (MSs that derived the value of debts from questionnaires experienced a very poor quality of responses). When balance sheets are available, value of long/short debts have to be split by vessel, according to the capital value of each vessel estimated trough the PIM which is used to "weigh" the share on the total value. On the other hand, to estimate this variable when balance sheets are not available, the methodology is: 1. To estimate the financial position as the ratio total debt/total value of assets 2. To use the value of capital (deriving from the PIM) as a proxy for total value of assets (it is important to bear in mind that the PIM value refers only to physical capital). 3. To derive the value of long/short term debts (sum) multiplying the financial position ratio (estimated in 1) by the value of assets (estimated in 2).
	Total assets (New)	"Balance sheet total", fixed assets and financial assets. It is essential that the two item of the ratio (debts and total asset) should be consistent. For example, if debts refer only to physical capital, the denominator (total asset) should refer to the physical capital as well. If debts comes from balance sheets and refer to the overall fishing activity, the total assets should be derived from balance sheets as well.		**1. Obtained directly from survey** Balance sheets are considered the most reliable source of data for total assets (MSs that derived the value of debts from questionnaires experienced a very poor quality of responses). To split the total (company) value of assets in case the company owns more than one vessel, the capital value of each vessel estimated trough the PIM could be used to "weight" the share on the total value. In case balance sheets are not available, estimation methodology of value of capital and value of debts have to be in line and derived from the PIM.

VARIABLE GROUP	Variable	Definition	PGECON advice	Methodology
EMPLOYMENT	~~Engaged crew~~ **Paid labour**	Total number of persons who have worked onboard the vessel, irrespective of the total number of hours. People working only onshore and paid from vessels should be included if their activity has a direct link with the fishing operations. Employment on shore should include those activities, which directly related to small-scale fisheries and mostly carried out by fishers and their family members, but not entirely related to other economic sectors and specialties.	Currently, includes unpaid labour as the term 'Engaged crew' implies. Propose to change variable to Paid Labour (and update definition to exclude unpaid labour) The total number of persons should be estimated as an annual average (consistent with the DCF). To be further discussed during PGECON 2020 meeting	**1. Obtained directly from survey**
	Unpaid labour (New)	Number of engaged crew that have not received compensation in the form of wages, salaries, fees, gratuities, piecework pay or remuneration in kind.		**1. Obtained directly from survey** **2. Derived from other surveyed variables**
	FTE National	The number of crew converted into full time equivalent jobs (FTE). People working only onshore and paid from vessels should be included if their activity has a direct link with the fishing operations. Employment on shore should include those activities, which directly related to small-scale fisheries and mostly carried out by fishers and their family members, but not entirely related to other economic sectors and specialties.	From 2017 onwards, FTE falls under social variables (EUMAP). PGECON recommends to keep it as an economic variable in the fleet data call to guarantee annual data (as in DCF).	**1. Derived from other surveyed variables** FTE definition: unit expressing the number of employees into full-time workers (usually defined in the national law). Appendix VI of the current regulation refers, in note 17 and 18 to the study "Calculation of labour including full-time equivalent (FTE) in fisheries" (FISH/2005/14, 'LEI WAGENINGENUR Coordinator, 2006), financed by EU in order to harmonise the definition and the estimation of employment variables under the data collection system. According to that study, the estimation of the FTE should be done by using a threshold representing the total number of hours worked, on a standard and yearly basis, by a full-time worker in the fishery sector. The study was based on the estimation of the engaged crew and of the FTE at métier level in order to trace the reality of labour input in fishing as closely as possible. This approach was mainly because: - at the time of the study, there were discussions at the STECF, about the possibilities to collect, under the revised DCR, economic data at métiers level; - "different fisheries may be characterized by different labour intensities and consequently by different levels of labour productivity. This is an important aspect of economic analysis; using métiers in general improves the analytical understanding of the operation of the various fleets". The concept of metier has been not introduced in the collection of economic data but the general approach on the definition of FTE, in particular on the definition of the yearly threshold (time-based approach), has been largely applied under the DCF. According to the study, a person working more than the threshold (holding one or more jobs) is still counted as one FTE only. A person working less than the threshold represents a certain percentage of a FTE. FTE national should be calculated using a threshold defined according to the features of the fishery sector in each MS. If the annual working hours per crewmember exceed the reference level, the FTE equals 1 per crewmember. - if annual working hours > national threshold, then FTE national

VARIABLE GROUP	Variable	Definition	PGECON advice	Methodology
				=1 If not, the FTE equals the ratio between the hours worked and the reference level. - if annual working hours < national threshold, then FTE national = annual working hours/(national threshold). In segments where this assumption (the annual working hours per crewmember exceed the reference level (the FTE equals 1 per crewmember) is not valid and an additional adjustment of the calculation may be required, if it can be expected that the result will be significantly affected (Study No FISH/2005/14).
	Total hours worked per year (New)	The aggregate number of hours worked by the engaged crew during the reference period. People working only onshore and paid from vessels should be included if their activity has a direct link with the fishing operations. Employment on shore should include those activities, which directly related to small-scale fisheries and mostly carried out by fishers and their family members, but not entirely related to other economic sectors and specialties.	Note that for Engaged crew, hours worked includes paid and unpaid labour as well as onshore labour with a direct link with the fishing operations. If engaged crew is changed to paid labour, specification needs to be updated (hours worked by paid and unpaid labour)	**1. Obtained directly from survey** **2. Derived from other surveyed variables** Calculated based on effort, number of vessels and average crew number.
FLEET	**Number of vessels**	Number of vessels in the EU Fishing Fleet Register on December 31st plus the number of vessels, which have been involved in any fishing activity during the year and have left the Fleet Register prior to year-end.		**1. Obtained from the Fleet register**
	Mean LOA of vessels	Average vessel length overall		**1. Obtained from the Fleet register**
	Total vessel tonnage	Sum of the tonnage of the vessels		**1. Obtained from the Fleet register**
	Total vessel power	Sum of the power of the main engines of the vessels		**1. Obtained from the Fleet register**
	Mean age of vessels	Average vessel age		**1. Obtained from the Fleet register**
EFFORT	**Days at sea**	To be aligned with the definition of the respective transversal variable.	For the small-scale fleet vessels less than 10 meters, it could be assumed that 1 Day at Sea is equivalent to 1 Fishing Day as far as no other data contradicts this hypothesis. Nevertheless, this assumption has to be assessed regionally by fishery, as significant differences can occur between them.	**1. Obtained from logbooks** **2. Obtained directly from survey**
	Energy consumption	Volume of vessel fuel consumed in litres	PGECON could not define preferred method as it depends on the national context.	**1. Obtained directly from survey** **2. Obtained from administrative sources** (e.g. in case tax exemptions are used in the country) **3. Derived from other surveyed variables** Regression models could be used by some MS (regression models using 'engine power', 'days at sea' and 'coefficient of fuel consumption by engine power')

VARIABLE GROUP	Variable	Definition	PGECON advice	Methodology
NUMBER OF FISHING ENTERPRISES /UNITS	**Number of fishing enterprises/units**	Number of fishing enterprises/units in ownership of the respective number of vessels. This refers to the fleet as a whole, not to fleet segments. By size category: - 1 owned vessel - 2-5 owned vessels - > 5 owned vessels Number of enterprises shall be collected on the level of the total fleet not fleet segment.		**1. Obtained from the Fleet register**
PRODUCTION VALUE PER SPECIES	**Value of landings per species**	Value of landings per species	To be aligned with the definition of the respective transversal variable.	
	Average price per species	Gross value of landings per kilogram live weight	To be aligned with the definition of the respective transversal variables. This variable can be derived from the weight and value of landings (as in the DCF) and therefore, no need to be requested. NOTE: EU-MAP calls for the variable Live weight of landings per species to be provided in **tonnes**.	

GUIDANCE DOCUMENT FOR THE FISH PROCESSING

Living document

Adapted from:
Ad hoc contract Commitment No. SI2 725 694
Ref. Ares (2016)2440332 - 26/05/2016 Sabatella Evelina Carmen, 29 June 2016

Updated by:
PGECON 2017
PGECON 2018
PGECON 2019
PGECON 2020

VARIABLE GROUP	Variable	Definition	PGECON advice	Methodology
INCOME	Turnover	Turnover comprises the totals invoiced by the observation unit during the reference period, and this corresponds to market sales of goods or services supplied to third parties. Turnover includes all duties and taxes on the goods or services invoiced by the unit with the exception of the VAT invoiced by the unit vis-à-vis its customer and other similar deductible taxes directly linked to turnover. It also includes all other charges (transport, packaging, etc.) passed on to the customer, even if these charges are listed separately in the invoice. Reduction in prices, rebates and discounts as well as the value of returned packing must be deducted. For the segments with "main" fish processing activities, "Turnover" variable, should include only Turnover related to the principal fish processing activity. = DCF Turnover	Two surveys have to be used for different parts of population Not clear if this is the procedure for all MS (i.e., to use SBS data +complementary survey)	For the segments with "main" fish processing activities, "Turnover" variable, should include only Turnover related to the principal fish processing activity. For the part of population covered by SBS 1. **directly obtained from SBS survey.** For the part of population not covered by SBS 2. **directly obtained from DCF survey;** 3. **obtained directly from administrative sources**

VARIABLE GROUP	Variable	Definition	PGECON advice	Methodology
	Other income	Other operating income included in company accounts, which are excluded from turnover; income coming from other activities than fish processing. Other income, not shown under other headings. Exclude extraordinary and financial incomes. Under "Other income" all the other revenues from other activities apart from fish processing should be provided. = DCF Other income	Two surveys have to be used for different parts of population	Under "Other income" all the other revenues from other activities apart from fish processing should be provided. For the part of population covered by SBS 1. **derived from other SBS variables.** Turnover in SBS includes turnover from principal activity, other incomes and subsidies. Therefore, other income should be calculated as following: Other income = Turnover – turnover from principal activity – subsidies. Other income also includes financial income, which is a separate variable in DCF. Therefore, a method for disseminating other income from financial income should be defined. 2. **Directly obtained from additional DCF survey**. For the part of population not covered by SBS 3. **directly obtained from DCF survey**
~~**Personnel Costs**~~ **LABOUR COSTS**	Personnel costs	Total remuneration, in cash or in kind, payable by an employer to an employee (regular and temporary employees as well as home-workers) in return for work done by the latter during the	Two surveys have to be used for different parts of population.	For the part of population covered by SBS: 1. **directly obtained from SBS survey**. For the part of population not covered by SBS: 2. **directly obtained from DCF survey** Derived from other surveyed variables (e.g. costs structure).

VARIABLE GROUP	Variable	Definition	PGECON advice	Methodology
		reference period. Personnel costs also include taxes and employees' social security contributions retained by the unit as well as the employer's compulsory and voluntary social contributions. = DCF Wages and salaries		
	Value of unpaid labor	= DCF Imputed value of unpaid labour	Still there is a broad range of options to determine the average wage. If the number of unpaid labour is collected, then the imputed wage per FTE would be sufficient to calculate the value of unpaid labour	For the part of population covered by SBS the unpaid labour costs are equal to 0 as it is legally binding to employ all persons working in the bigger enterprises. For the part of the population not covered by SBS: **1. derived from other surveyed variables.** FTE method (WS, Naples, 2009), includes the following steps: • estimation of paid and unpaid FTE; • definition of an average remuneration per paid FTE (e.g. average wage by company, national average wage, minimum national wage, etc…); • calculation of imputed value of unpaid labour =: unpaid FTE * (average remuneration per paid FTE). • Other methods based on number of enterprises?
	Payment for external agency workers (optional)	Included are payments to temporary employment agencies and similar organisations supplying workers to clients' businesses		For the part of population covered by SBS **directly obtained from SBS survey** (optional). For the part of population not covered by SBS: **1. directly obtained from DCF survey,** **2. derived from other surveyed variables**.

VARIABLE GROUP	Variable	Definition	PGECON advice	Methodology
		for limited periods of time to supplement or temporarily replace the working force of the client, where the individuals provided are employees of the temporary help service unit. However, these agencies and organisations do not provide direct supervision of their employees at the clients' work sites. Only the payments for the provision of personnel which is not linked to the provision of a particular industrial or other non-industrial service is included.		
Energy costs	Energy costs	Purchases of all energy products during the reference period should be included in this variable only if they are purchased to be used as fuel. Energy products purchased as a raw material or for resale without transformation should be excluded. This figure should be given in value only.		For the part of population covered by SBS, **directly obtained from SBS survey** (optional). For the part of population not covered by SBS: **1. directly obtained from DCF survey,** **2. derived from other surveyed variables**.

Raw material costs	Purchase of fish and other raw material for production	Total purchases of fish and other raw material for production. Purchases of fish and other raw material for production include the value of fish and other raw material for production purchased during the accounting period for resale or consumption in the production process, excluding capital goods the consumption of which is registered as consumption of fixed capital. The fish and other raw material concerned may be either resold with or without further transformation, completely used up in the production process or, finally, be stocked.	SBS data should be preferred, but in case dissemination methods are not possible, data from surveys should be used for all processing enterprises. Should be re-named "other operating costs" • Eurostat data do not cover the raw material used by the fish processing companies, which is a key to understand the linkages with the wild-capture fisheries, aquaculture and external trade.	For the part of population covered by SBS: 1. **directly obtained from SBS survey**. However, these costs in SBS are combined under "Total purchases of goods and services", including financial and extraordinary costs. Therefore, a dissemination method should be applied for calculating raw material and other operating costs: (Raw material + Other operational costs) = Total purchases of goods and services – Financial costs – extraordinary costs; Because all of these Variables are also included in DCF, dissemination is very problematic. 2. **directly obtained from additional DCF survey** For the part of population not covered by SBS: 3. **directly obtained from DCF survey,** 4. **derived from other surveyed variables**. Total purchases of goods and services minus Purchase of fish and other raw material for production. Purchases of goods and services include the value of all goods and services purchased during the accounting period for resale or consumption in the production process, excluding capital goods the consumption of which is registered as consumption of fixed capital. The goods and services concerned may be either resold with or without further transformation, completely used up in the production process or, finally, be stocked.

VARIABLE GROUP	Variable	Definition	PGECON advice	Methodology
Other operating ~~operational~~ costs	Other operational costs	Total purchases of goods and services minus Purchase of fish and other raw material for production. Purchases of goods and services include the value of all goods and services purchased during the accounting period for resale or consumption in the production process, excluding capital goods the consumption of which is registered as consumption of fixed capital. The goods and services concerned may be either resold with or without further transformation, completely used up in the production process or, finally, be stocked.		
Subsidies	Operating subsidies	Direct payments which general government or the institutions of the European Union make to resident producers. Excluding investment subsidies.	Subsidies could be derived from SBS by disseminating Turnover, however because of a complex structure of SBS turnover, data from national and regional administrations for the whole processing sector, should be used, in preference to direct survey. This in turn will help to derive turnover and other income more precisely.	For the part of population covered by SBS: 1. **directly obtained from SBS survey**. However, data is aggregated under Turnover, complete with turnover from principal activities, other income, and financial income. Therefore, it should be disseminated. 2. **directly obtained from additional DCF survey** ; 3. **obtained directly from administrative sources**

VARIABLE GROUP	Variable	Definition	PGECON advice	Methodology
				For the part of population not covered by SBS: **4. directly obtained from DCF survey,** **5. derived from other surveyed variables**. **6. obtained directly from administrative sources** Direct payments which general government or the institutions of the European Union make to resident producers to finance all or part of the costs of their acquiring assets.
	Subsidies on investments New	Direct payments which general government or the institutions of the European Union make to resident producers to finance all or part of the costs of their acquiring assets.		
Capital costs	Consumption of fixed capital	Decline in value of fixed assets, as a result of normal wear and tear and obsolescence. The estimate of decline in value includes a provision for losses of fixed assets as a result of accidental damage which can be insured against. =DCF Depreciation of capital	NOT COVERED BY EUROSTAT	There is no data on capital costs or capital value in SBS. For all processing enterprises capital cost and capital value could be obtained: **1. directly obtained from DCF survey;** **2. derived from other surveyed variables or from PIM calculations.** **3. By calculating capital value and capital costs by PIM.**
~~Capital value~~ FINANCIAL POSITION	Total ~~value of~~ assets	An economic asset is a store of value representing the benefits accruing to the economic owner by holding or using the entity over a period of time. It is a means of carrying forward value from	NOT COVERED BY EUROSTAT	

VARIABLE GROUP	Variable	Definition	PGECON advice	Methodology
		one accounting period to another.		
	Debt	Amount of money borrowed to be used to finance activities of the processing enterprise.	No data coverage in SBS	For all processing sector enterprises Debt could be: 1. **directly obtained from additional DCF survey**. **derived from other surveyed variables**.
Financial results	Financial income	Income from investments and loans forming part of the fixed assets, and other interest receivable. Financial costs, net = Financial expenditures – Financial income	Two surveys have to be used for different parts of population.	For the part of population covered by SBS: 1. **directly obtained from SBS survey**. however financial income is combined under Turnover. Therefore to get data on financial income, a method of dissemination should be used: Turnover – Turnover from main activity – subsidies – other income. However, dividing financial and other income could be a problem. 2. **directly obtained from additional DCF survey** ; 3. **derived from other surveyed variables**. For the part of population not covered by SBS: 4. **directly obtained from DCF survey,** 5. **derived from other surveyed variables**.
	Financial expenditures	Interest payable and similar charges.		For the part of population covered by SBS: 1. **directly obtained from SBS survey**. However financial expenditures in SBS is under Total purchases of goods and services, which also includes raw material,

VARIABLE GROUP	Variable	Definition	PGECON advice	Methodology
		Financial costs, net = Financial expenditures – Financial income		other operational costs and extraordinary costs, therefore a method for discriminating financial expenditures should be devised; **2. directly obtained from additional DCF survey** **3. derived from other surveyed variables**. For the part of population not covered by SBS: **4. directly obtained from DCF survey,** **5. derived from other surveyed variables**.
Investments	~~Net~~ Gross Investments	Gross investment in tangible and intangible goods minus sales of tangible and intangible investment goods.	Two surveys have to be used for different parts of population. Tangible goods defined in SBS 15 11 0 and intangible goods defined in SBS 15 42 0 and SBS 15 44 1, tangible investment goods defined in 15 210. Rename to Gross investments = Purchases minus sales Net should be removed from the variable name to avoid confusion with financial accounting net investments, which refers to investments minus depreciation.	For the part of population covered by SBS: **1. directly obtained from SBS survey**. By subtracting sales of tangible investments goods from Gross investments in tangible goods **2. directly obtained from additional DCF survey**. For the part of population not covered by SBS: **3. directly obtained from DCF survey, derived from other surveyed variables**.
~~**Debt**~~	~~Debt~~	~~Amount of money borrowed to be used to finance activities of the processing enterprise.~~	~~No data coverage in SBS~~	~~For all processing sector enterprises Debt could be:~~ ~~**2. directly obtained from additional DCF survey**.~~ ~~**3. derived from other surveyed variables**.~~

VARIABLE GROUP	Variable	Definition	PGECON advice	Methodology
Employment	Number of persons employed	Total number of persons who have worked in the enterprise, irrespective of the total number of hours.	Does it include unpaid labour?	For the part of population covered by SBS: 1. **directly obtained from SBS survey**. However, SBS are not discriminated according to the gender. 2. **directly obtained from DCF survey,** 3. **obtained directly from administrative sources** For the part of population not covered by SBS: 4. **directly obtained from DCF survey,** 5. **derived from other surveyed variables**.
	Unpaid labour	Number of persons who have worked for the enterprise that have not received compensation in the form of wages, salaries, fees, gratuities, piecework pay or remuneration in kind.		For all processing sector enterprises unpaid labour could be: 1. **directly obtained from DCF survey,** 2. **derived from other surveyed variables**.

VARIABLE GROUP	Variable	Definition	PGECON advice	Methodology
	FTE National	The number of employees converted into full time equivalent jobs (FTE).		For the part of population covered by SBS: 1. **directly obtained from SBS survey**. **FTE far all processing sector:** FTE definition: unit expressing the total number of employees into the equivalent number of full-time workers (usually defined in the national law). Appendix VI of the current regulation refers, in note 17 and 18 to the study "Calculation of labour including full-time equivalent (FTE) in fisheries"(FISH/2005/14, 'LEI WAGENINGENUR Coordinator, 2006), financed by EU in order to harmonise the definition and the estimation of employment variables under the data collection system. General approach on the definition of FTE, in particular on the definition of the yearly threshold (time-based approach), has been largely applied under the DCF. According to the study, a person working more than the threshold (holding one or more jobs) is still counted as one FTE only. A person working less than the threshold represents a certain percentage of a FTE. FTE national should be calculated using a threshold defined according to the features of the processing sector in each MSs. If the annual working hours per person exceed the reference level, the FTE equals 1 per crew member. • if annual working hours>national threshold FTE national =1 If not, the FTE equals the ratio between the hours worked and the reference level.

VARIABLE GROUP	Variable	Definition	PGECON advice	Methodology
				• if annual working hours<national threshold FTE national = $\frac{annual\ working\ hours}{national\ threshold}$
	Number of hours worked by employees and unpaid workers	The aggregate number of hours worked during the reference period.		For the part of population covered by SBS: 1. **directly obtained from SBS survey**. However, SBS houses data of employed work force only, and it does not include unpaid labor. Therefore, additional estimation of number of hours worked by unpaid workers should be calculated. 2. **directly obtained from DCF survey,** 3. **derived from other surveyed variables.** For the part of population not covered by SBS: 4. **directly obtained from DCF survey,** 5. **derived from other surveyed variables**.

VARIABLE GROUP	Variable	Definition	PGECON advice	Methodology
Number of enterprises	Number of enterprises (1)	Number of fish processing enterprises in each size category (in terms of number of persons employed).	What does (1) mean? Number of fish processing enterprises in each size category (in terms of number of persons employed). Rename to "Number of enterprises by size category" Suggested categories: ≤5; 6-10 and >10 FTE	For the part of population covered by SBS: 1. **directly obtained from SBS survey**. For the part of population not covered by SBS: 2. **directly obtained from DCF survey,** 3. **derived from other surveyed variables**. 4. **Through other governmental or administrational organizations**
~~weight of~~ Raw material (OPTIONAL)	Weight of raw material per species and origin (optional)	Weight of raw material originating from fisheries and aquaculture	PGECON 2020: Weight and value of raw material by: • Species • Production environment (Capture based fishery and aquaculture sector) • Country of Origin (Domestic, other EU or non-EU) Type of processed material (fresh, frozen and semi processed materials) – if possible	For all enterprises: 1. **directly obtained from DCF survey,** 2. **derived from other surveyed variables**.

GUIDANCE DOCUMENT FOR THE SOCIAL VARIABLES

Living document

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PGECON Workshop on social variables, Athens 2018
PGECON 2019
PGECON 2020

VARIABLE GROUP	Variable	Definition	PGECON advice	Methodology
SOCIAL VARIABLES	**Employment by gender**	Specification of the meaning of "employment" missing, if reference to all or full-time-part-time required (corresponds to engaged crew or Paid labour for fleet)	1. Data should be raised to the total population. 2. Employment data reported in the social data calls should be consistent with the data reported under the Fleet and Aquaculture data calls. 3. PGECON recommends to stratify employment data for the social data call related to the EU fleet by supra region, geo-indicator, fishing activity (SCF, LSF and DWF) and main fleet segments, when possible. It is suggested to follow main AER group definitions as close as possible. For the employment data for the social data call related to the EU aquaculture sector, it is recommended to follow the same segmentation as for the aquaculture data call when possible, or at least to disaggregate by marine (finfish), freshwater (finfish) and shellfish. 4. It needs to be further investigated the trade-offs of	PGECON recommends to follow Eurostat practice and separate social variable "Employment by gender" in the following groups: - "Male"; - "Female"; - "Unknown" (only if needed).
	FTE by gender	The number of employees converted into full time equivalent jobs (FTE). Fleet: People working only onshore and paid from vessels should be included if their activity has a direct link with the fishing operations. Employment on shore should include those activities, which directly related to small-scale fisheries and mostly carried out by fishers and their family members, but not entirely related to other economic sectors and specialties.		PGECON recommends to follow Eurostat practice and separate social variable "Employment by gender" in the following groups: - "Male"; - "Female"; - "Unknown" (only if needed). Figures for the number of persons working less than the standard working time of a full-year full-time worker, should be converted into full time equivalents, with regard to the working time of a full-time full-year employee in the unit. It is the total hours worked divided by the average annual number of hours worked in full-time jobs within the economic territory. Since the length of a full-time job has changed through time and differs between industries, methods which establish the average proportion and average hours of less than full-time jobs in each job group have to be used. A normal full-time week must first be estimated in each job group. If possible, a job group can be defined, inside an industry, according to sex and (or) kind of work of people. Hours

VARIABLE GROUP	Variable	Definition	PGECON advice	Methodology
			providing the data for a particular date in the year so that duplications are avoided (e.g. when fishers are moving from one vessel to another during the year) or cover the whole year to include seasonal patterns.	contractually agreed upon can constitute for employee jobs, the appropriate criteria for determining those figures. Full-time equivalent is calculated separately in each job group, then summed. Included in this category are people working less than a standard working day, less than the standard number of working days in the week, or less than the standard number of weeks/months in the year. The conversion should be carried out on the basis of the number of hours, days, weeks or months worked.
	Unpaid labour by gender	Number of engaged crew / workers that have not received compensation in the form of wages, salaries, fees, gratuities, piecework pay or remuneration in kind.		PGECON recommends to follow Eurostat practice and separate social variable "Employment by gender" in the following groups: - "Male"; - "Female"; - "Unknown" (only if needed).
	Employment by age	Specification of the meaning of "employment" missing, if reference to all or full-time-part-time required		Taking into account needs of EMMF for monitoring of employment by age classes and Eurostat practice, PGECON recommends to separate social variable "Employment by age" at least into the following age classes: - <=14; - 15-24; - 25-39; - 40-64; - >=65; - "Unknown"

VARIABLE GROUP	Variable	Definition	PGECON advice	Methodology
	Employment by education level	Specification of the meaning of "employment" missing, if reference to all or full-time-part-time required		PGECON recommends to use the International Standard Classification of Education (ISCED 2011), defining social variable "Employment by education level". Data collected under EUMAP by MS should allow to provide data at least for the following groups at EU level: - "Low" for education levels 0-2 (ISCED2011 and ISCED1997); - "Medium" for education levels 3-4 (ISCED2011 and ISCED1997); - "High" for education levels 5-8 (ISCED2011), levels 5-6 (ISCED1997); - "Unknown"
	Employment by nationality	Specification of the meaning of "employment" missing, if reference to all or full-time-part-time required		Taking into account national needs and EU requirements it is recommended to separate social variable "Employment by nationality" to at least the following groups: - "National"; - "EU"; - "EEA"; - "Non-EU/EEA"; - "Unknown".
	Employment by employment status	Specification of the meaning of "employment" missing, if reference to all or full-time-part-time required		PGECON recommends for data collection of social variable "Employment by employment status" to be reported at least by two categories: - "Owner" (vessel owner involved in vessel activity/operation); - "Employee" (all engaged workers on-board, excluding owners). - "Unknown".

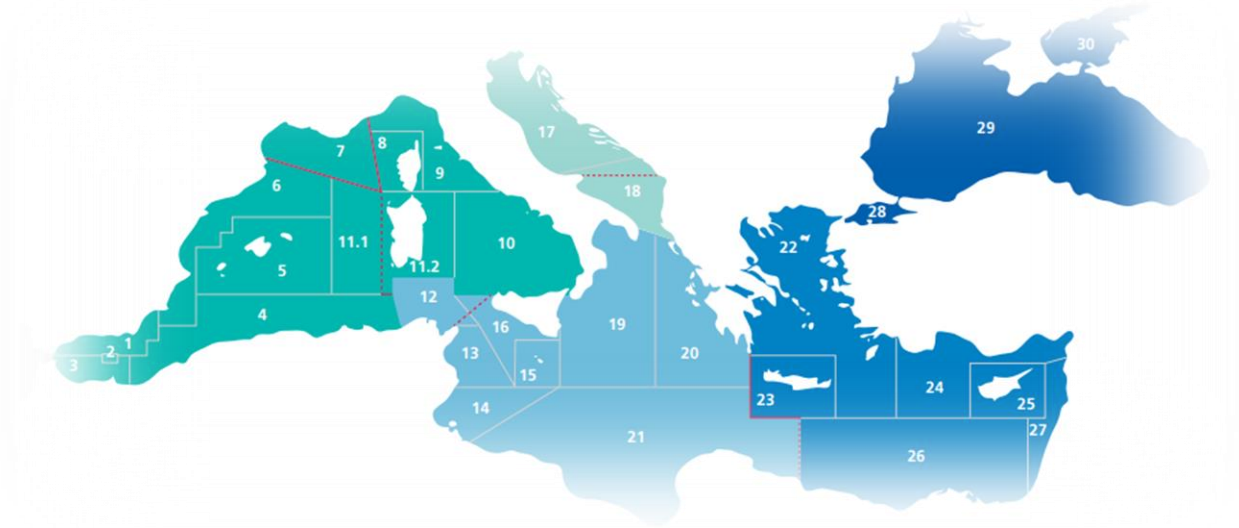
VARIABLE GROUP	Variable	Definition	PGECON advice	Methodology
				Possible to disaggregate on a voluntary basis between full and part time employees.

Food and Agriculture Organization of the United Nations

General Fisheries Commission for the Mediterranean
Commission générale des pêches pour la Méditerranée

GFCM DCRF

DATA COLLECTION REFERENCE FRAMEWORK



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Version: 21.1

GFCM - DCRF
DATA
COLLECTION
REFERENCE
FRAMEWORK

- PART 1 -

Structure of the data collection

- PART 2 -

Common practices in data collection

CONTENTS

Acronyms **4**

INTRODUCTION **5**

What is the GFCM Data Collection Reference Framework (DCRF)? 5

Historical background 5

The DCRF manual 6

Main characteristics 7

PART 1 - STRUCTURE OF THE DATA COLLECTION **8**

Chapter 1 - The need for a Data Collection Reference Framework (DCRF) **9**

Chapter 2 - Components of the DCRF **11**

2. Task I: Global figures of national fisheries 20

2.1 Task II: Catch 21

Subtask II.1 - Landing data 21

Subtask II.2 - Catch data per species 23

2.2 Task III: Incidental catch of vulnerable species 24

2.3 Task IV: Fishing fleet 26

2.4 Task V: Fishing effort 31

2.5 Task VI: Socio-economics 33

2.6 Task VII: Biological information 39

Subtask VII.1 - Stock assessment input data 39

Subtask VII.2 - Length data 40

Subtask VII.3 - Other biological data 42

Subtask VII.4 - Dolphin fish 45

Subtask VII.5 - Red coral 46

Subtask VII.6 - European eel 48

Subtask VII.7 - Ecosystem indicators 50

Part 2 - COMMON PRACTICES IN DATA COLLECTION **52**

Chapter 3 - Sampling overview **54**

Chapter 4 - Acquisition of landing and effort data **56**

Chapter 5 - Acquisition of socio-economic data **57**

5.1 Data on revenues, expenditures, employment, prices by species and investments 57

5.2 Capital value and capital costs 58

5.3 Full-time equivalent 58

Chapter 6 - Acquisition of biological data 59
6.1 Sampling from different data sources 59
6.2 Merging and selection of fleet segments 62
6.2.1 Merging procedures 62
6.2.2 Selection procedures 63
6.3 Selection of species 67
6.3.1 Length 68
6.3.2 Weight 71
6.3.3 Sex and maturity 71
6.3.4 Age 78
Chapter 7 - Shared stocks 81
Chapter 8 - Data quality 82
Chapter 9 - Data confidentiality and access policy 85
Chapter 10 - Data transmission 86

APPENDICES 87
Appendix A - Priority species (2021) 88
Appendix B - Fleet segments 94
Appendix C - Fisheries Restricted Areas (FRAs) 95
Appendix D - Fishing gear 96
Appendix E - Vulnerable species 98
Appendix F - Fishing effort measurement 103
Appendix G - Scales of maturity stages 106
Appendix H - European eel fishery 113
Appendix I - Shared stocks 114
Appendix L - Geographical subareas (GSA) and GFCM subregions 116
Appendix M - Geographic statistical grid for red coral 117
Appendix N - Templates for the selection of fleet segments and species (by GSA) 118
Appendix O - Data transmission calendar 119
References 121

Acronyms

- CPCs — Contracting parties and cooperating non-contracting parties
- CWP — Coordinating Working Party on Fishery Statistics
- DCRF — Data Collection Reference Framework
- FAO — Food and Agriculture Organization of the United Nations
- FMSY — Fishing mortality rate of maximum sustainable yield
- GFCM — General Fisheries Commission for the Mediterranean
- GSA — Geographical subarea
- ICES — International Council for the Exploration of the Sea
- IUCN — International Union for the Protection of Nature
- MPA — Marine protected area
- MSY — Maximum sustainable yield
- RFMO — Regional fisheries management organization
- SAC — Scientific Advisory Committee in Fisheries
- SC — Subcommittee
- SCSA — Subcommittee on Stock Assessment
- SCSE — Subcommittee on Economics and Social Sciences
- SRC — Subregional committee
- TAC — Total allowable catch
- WGBS — Working Group on the Black Sea

INTRODUCTION

What is the GFCM Data Collection Reference Framework (DCRF)?

The DCRF is the first GFCM comprehensive framework for the collection and transmission of the fisheries-related data that are requested as per existing GFCM Recommendations and are necessary for relevant GFCM subsidiary bodies to formulate advice in accordance with their mandate.

The DCRF is a GFCM instrument, developed by the technical subsidiary bodies responsible for scientific advice, as a concrete response to the need to strengthen the collection and processing of data on fisheries in the GFCM area of application (Mediterranean and Black Sea). It aims to be instrumental in achieving a more efficient data collection programme in the whole region, and to better integrate data collection and subregional multiannual management plans. The DCRF should be regularly reviewed by relevant GFCM subsidiary bodies in light of possible requirements emanating the Commission, including through new recommendations.

Historical background

Performance review and modernization of the GFCM

As all Regional Fisheries Management Organizations (RFMOs) and upon a call made by the United Nations General Assembly and the FAO Committee of Fisheries[1] to review and modernize their mandates, the GFCM undertook its performance review from 2009 to 2010. During the review, the Agreement for the establishment of the General Fisheries Commission for the Mediterranean (GFCM Agreement) was assessed along with the extent to which measures adopted by the GFCM had achieved the objectives of the Commission. A Task Force was established to build upon strengths and address weaknesses identified. Amongst the main topics to be addressed for enhancing a sound and scientifically based decision making process, the need to strengthen data collection systems in the region was prioritised.

Framework programme (FWP) and data collection activities

As an instrument to assist on the actions identified by the Task Force, the Commission established a platform to help strengthen intra-institutional coordination with FAO regional projects and other intergovernmental organizations through multiannual and multidonor arrangements. The GFCM Framework Program (2013-2018) was structured around five work programmes (WP): Governance (WP01), Data collection (WP02), Aquaculture (WP03), Small-scale fisheries (WP04), Subregional cooperation and Technical assistance (WP05).

The development of WP02 since 2013 has entailed a series of coordinated actions with the aim to strengthen data collection systems and to standardize the transmission process. The different national data programmes were assessed and their main characteristics and drawbacks analysed in four sub regional workshops held in 2013 and 2014 in the Mediterranean and Black sea[2 3 4 5].
The main gaps, difficulties, proposals and recommendations that emerged during these workshops were used as a basis to propose possible modifications and/or improvements to GFCM data and information requirements. Three main indications were of general agreement: i) to simplify data aggregation; ii) to clarify variables definitions and iii) to improve online procedures for data transmission by GFCM Contracting Parties and Cooperating non-Contracting Parties (CPCs).

[1] COFI Report on Strengthening regional fisheries management organizations and their performances including the outcomes of the 2007 tuna RFMOs meeting, twenty-seventh session (Rome, 5-9 March 2007)
[2] Report of the Workshop on fisheries data collection and management plans in the Adriatic Sea
[3] Report of the Subregional meeting on data collection for the western, central and eastern Mediterranean
[4] Report of the Workshop on fisheries data collection in the Black Sea
[5] Report of the Workshop on the implementation of the DCRF in the Mediterranean and the Black Sea

The DCRF manual

This manual outlines the DCRF principles by encompassing all the necessary indications for the collection of fisheries data by CPCs and its transmission to the GFCM in a standardized way, in order to empower the relevant GFCM subsidiary bodies with information needed for the formulation of advice.

Preparation

The DCRF manual has been prepared by the GFCM Secretariat under the umbrella of Scientific Advisory Committee on Fisheries (SAC) and taking into account the comments provided by the Working Group on the Black Sea (WGBS), in response to the mandate given by the thirty-eighth session of the Commission (May 2014). It considered GFCM binding decisions in force, as well as SAC and WGBS national reports, stock assessment forms, *ad hoc* questionnaires and other available sources[6].

The manual has been completed thanks to inputs provided by experts on the occasion of several technical meetings held during the intersessional period 2014-2015*:* Working Groups on Stock Assessments of demersal and small pelagic species (GFCM headquarters, November 2014); Workshop on the implementation of the DCRF in the Mediterranean and the Black Sea (Spain, December 2014); Subcommittee on Stock Assessments and Subcommittee on Social and Economic Sciences (GFCM headquarters, February 2015); Working Group on the Black Sea (Turkey, February 2014 and Georgia, March 2015).

The manual is composed of two main parts: *Structure of data collection* and *Common practices in data collection*. The first one was adopted by the sixteenth session of the SAC in March 2014 and was enriched with a practical section (second part) upon the request of the thirty-eighth session of the Commission (GFCM, 2014a).

The DCRF manual was endorsed by the Commission at its thirty-ninth session (Italy, May 2015).

The current version (2021.1) encompasses elements gathered by the GFCM Secretariat in the last years as follow:

- inputs from countries that participated on a voluntary basis in the DCRF pilot study (from October 2015 to October 2016), which was launched with a view to finalizing the online data transmission tools made available through the DCRF online platform;
- comments from the delegates of CPCs who participated in the meeting on GFCM fisheries data requirements (November 2016)[7];
- feedback from CPCs during the first official data transmissions in 2017 and the subsequent ones in 2018, 2019 and 2020 through the DCRF online platform;
- relevant elements from the 2018 and 2019 sessions of the SAC and WGBS.

The manual, and in particular its section dedicated to the biological information in support of the assessment of priority species as identified by GFCM subregions, has been aligned with the mid-term strategy (2017-2020) towards the sustainability of Mediterranean and Black Sea fisheries[8].

Part 1 of the manual has been enriched with relevant information about those GFCM fisheries data requirements implying annual submissions by CPCs which have been part of the so-called "DCRF harmonization process". In parallel, the dedicated Excel-based data-entry tools, including preliminary embedded quality checks, were progressively released and put at disposal to concerned CPCs on the DCRF online platform.

[6] CopeMed, 1999, 2002; Cingolani & Santojanni, 2003; Coppola, 2007; Council Regulation, 2008; Dimech *et al.*, 2012; Pinello & Dimech, 2013; FAO EastMed, 2014

[7] Report of the meeting on GFCM fisheries data requirements

[8] www.fao.org/gfcm/publications/brochures/midtermstrategy-2017-2020

Finally, the chapter on data quality has been then improved with elements deriving from the GFCM survey on fisheries data quality (launched by the GFCM Secretariat in April 2017 to assess the data quality control process carried out at the national level by CPCs) as well as from the application of quality checks to the data transmitted through the DCRF online platform for the reference years 2017 (feasibility phase), 2018 and 2019.

Main characteristics

The DCRF aims at optimizing the GFCM fisheries data collection through:

- clear identification of the main thematic areas of the data collection (defined as "tasks") together with the definition of their purposes in line with the objective of the GFCM[9];
- detailed description of all the data variables;
- simplified level of data aggregation for requested variables (in this regard, the concept of "operational units" has been superseded);
- more flexible and easier fleet segmentation scheme;
- simpler measures of fishing effort;
- new concept of priority species group whereby species are identified at the level of the five GFCM subregions (Western Mediterranean Sea, Central Mediterranean Sea, Adriatic Sea, Eastern Mediterranean Sea and Black Sea);
- well-defined data collection practices;
- improved online data transmission procedures.

[9] GFCM basic texts (Article 8 of the Amended Agreement for the establishment of the General Fisheries Commission for the Mediterranean, 24 May 2014)

PART 1

STRUCTURE OF THE DATA COLLECTION

Chapter 1 - The need for a Data Collection Reference Framework (DCRF)

The GFCM has the responsibility and authority to oversee the full process of fisheries management, undertake scientific evaluations and take decisions to ensure sustainability of fisheries resources in its area of application (Figure 1 and Appendix L). The collection of data required to achieve an appropriate management of fisheries is crucial and countries should therefore provide their best available information in terms of quality and comprehensiveness.

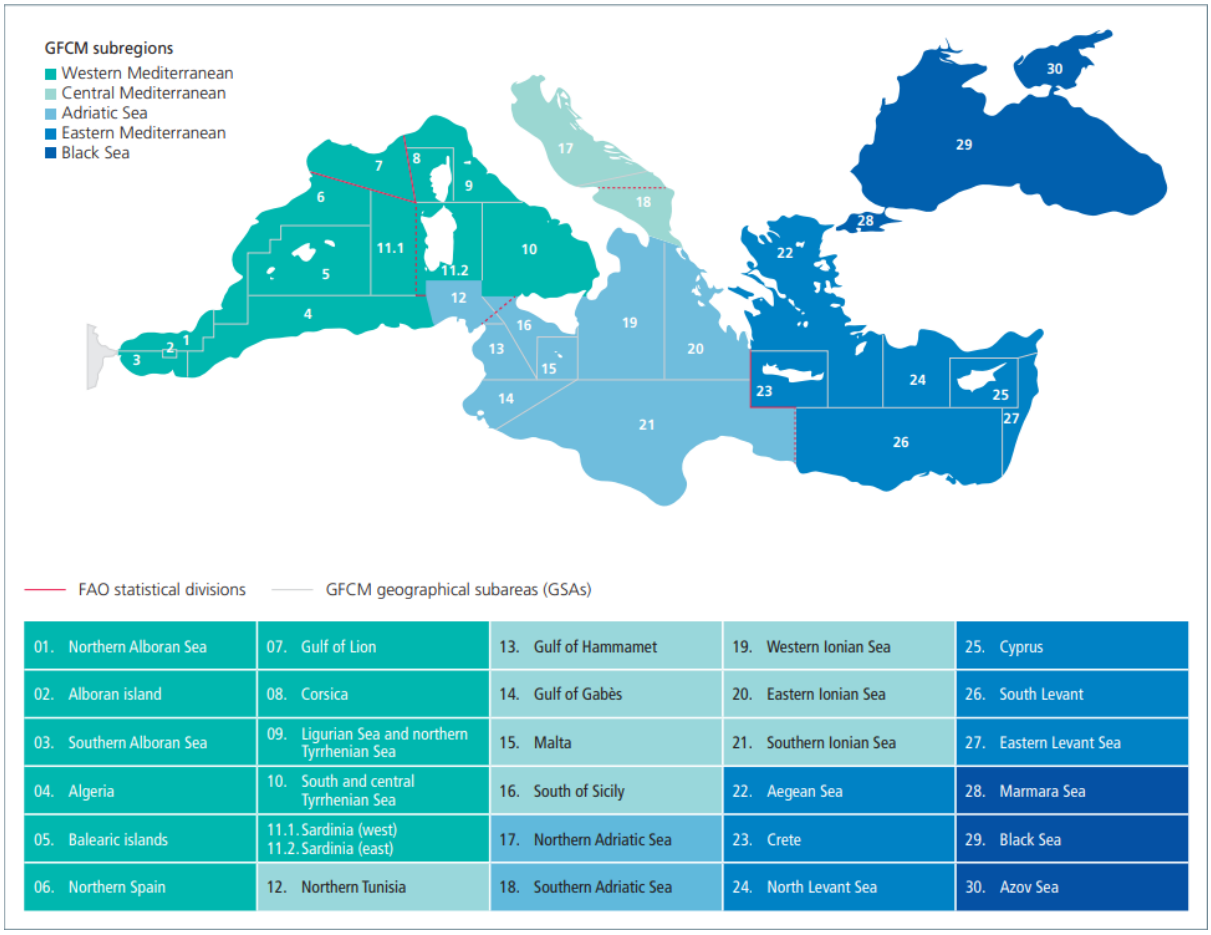


Figure 1: Map of the GFCM area of application
(Subregions and Geographical Subareas)

On basis of the new GFCM Agreement[10] that refers to the "subregional approach to fisheries management and aquaculture development in order to better address the specificities of the Mediterranean and the Black Sea", the concept of subregions has been introduced during the revision process of the fishery data collection framework of GFCM and then reflected into the DCRF manual. As agreed at several GFCM technical meetings held during the intersessional period 2013-2015, the subregional approach answers specific needs in managing the Mediterranean and Black Sea by considering the specificity of each identified area, including its fisheries. The identified five subregions (Western Mediterranean Sea, Central Mediterranean Sea, Adriatic Sea, Eastern Mediterranean Sea and Black Sea) aim at facilitating the integration between data collection and subregional multiannual management plans.

[10] www.fao.org/gfcm/background/legal-framework

The need to establish functional data collection systems in the GFCM area of application has always been a key issue for internal discussion. Many efforts have been made to develop useful tools for the creation of GFCM information systems, associated databases and protocols for data transmission. However, notwithstanding the steps taken since 2010 to encourage and support CPCs to transmit data, the level of compliance still needs to be enhanced. Many datasets have been received in an incomplete state, thus hindering the capacity of the GFCM to use these data to fulfil its mandate.

The rationale behind the design of this framework is to reduce data requirements and encompass them into a single, simple and easy-to-understand manual, providing CPCs with the necessary indications for the collection and transmission of data related to fisheries to the GFCM Secretariat. Moreover, the information gathered should be sufficient and reliable enough to review the status of the different resources, to assess the economic and social dimensions of the fleets and to provide scientific advice on the status of the resources, as well as to allow CPCs to prepare recommendations to manage those resources.

In order to fulfil the GFCM objectives, the data collected within the DCRF encompass area-based information on national fleets and their activities, catch and effort and biological information on main species, including discards and incidental catch of vulnerable species. Socio-economic data is also required in order to assess the economic situation of fishing enterprises and employment trends. Within the DCRF, CPCs should guarantee the quality and completeness of the data at the requested aggregation level and, according to an agreed format, transmit them in a timely manner to the GFCM Secretariat.

The DCRF is based on seven different tasks:

- T1 - Global figures of national fisheries
- T2 - Catch (landing data, catch data per species)
- T3 - Incidental catch of vulnerable species
- T4 - Fishing fleet
- T5 - Fishing effort
- T6 - Socio-economics
- T7 - Biological information (stock assessment input data, length data, other biological data, dolphin fish, red coral, European eel, ecosystem indicators)

Chapter 2 - Components of the DCRF

"It is essential to know exactly what is currently being fished from the wild population, as this affects the stock's ability to survive and, more importantly to reproduce" (FAO, 2002).

This chapter describes basic fisheries data needed for an effective conservation and management of marine living resources in the Mediterranean and Black Sea area, subdivided according to the seven main data components, namely "tasks" identified within the DCRF. Each task, and related subtask (if any), is briefly introduced with a short description. Information is given on the countries concerned, the type of obligation (mandatory and/or optional data) and the requested variables, as well as the frequency of data transmission and the deadline for transmission. For data transmission purposes, information is also provided on the composition of the primary key[11] for each data table.

Structure of each DCRF-Task

- Description
- Countries involved
- Data (mandatory, optional)
- Data confidentiality
- Frequency and deadline of transmission

To gather all the necessary data and information, the GFCM Secretariat has established a deadline reminder through which concerned CPCs are informed by email, on a regular basis, about the upcoming obligations for the transmission of data to GFCM. Full details on parameters, aggregation levels and transmission instructions for each DCRF task together with the reference to the related GFCM recommendation are indicated in the reminder. CPCs should proceed to the timely transmission of their data through the DCRF online platform (Chapter 10 - Data transmission). The datasets gathered by the GFCM Secretariat will then be checked for compliance and quality before their final upload in the GFCM information systems. Data will be made available to experts participating in the GFCM scientific subsidiary bodies (e.g. working groups, subregional committees, SAC and WGBS), according to GFCM data confidentiality policies and procedures. A report on the status of transmitted data (Chapter 8 - Data quality) will be put at the disposal of CPCs in a specific section of the DCRF online platform and the GFCM Secretariat will liaise with CPCs in the event that corrections are needed.

Thereafter, the information will be put at disposal of the relevant GFCM subsidiary bodies for the provision of scientific advice. Also, the GFCM Secretariat will provide, through a biennial report (The State of Mediterranean and Black Sea Fisheries - SoMFi), a regular overview on the status of national/regional fisheries based on the information received through the DCRF online platform.

In developing information systems to collect, validate, analyse and disseminate data and information, the GFCM Secretariat pays particular attention to international codifications and standards (e.g. fishing gear, species, fishing areas), also in line with the work carried out by the Coordinating Working Party on Fishery Statistics (CWP), as well as to all aspects related to data security and confidentiality (Resolution GFCM/35/2011/2).

The DCRF manual assists countries to collect the minimum sets of information required to assess the status of their fisheries and the status of the main stocks, to manage their own resources and to comply with the GFCM requirements. In this regard, classifications of priority species have been made by taking into account different criteria, such as abundance, economic value and conservation status (Appendix A). The list of priority species (Groups 1, 2 and 3) is subject to regular update upon decisions taken by relevant GFCM subsidiary bodies and final approval by the Commission at its annual session.

[11] A primary key is a data field or combination of data fields with values that uniquely identify each data row in a table (DCRF task or subtask). Such combinations of data fields can occur only once in each table and cannot contain null values.

The fisheries data requirements which are reported in the DCRF manual, together with their main purposes and their relation to existing GFCM decisions are detailed in Table 1.

Data can be transmitted separately for each DCRF task, according to the data transmission calendar (Appendix O).

Table 1 - GFCM-DCRF tasks: data and purposes

DCRF TASKS AND SUBTASKS			DATA	PURPOSES	RELATED RECOMMENDATIONS
TASK		SUBTASK			
I	**GLOBAL FIGURES OF NATIONAL FISHERIES**	**-**	Annual data on total landing, number of active fishing vessels, total capacity and total engine power by country	General overview of the fishery in each country with indication of capacity and total landings	Rec. GFCM/41/2017/6
II	**CATCH**	**II.1 / Landing data**	Annual data on total national captures (i.e. landing) by country, GSA and fleet segment	Monitoring the total annual biomass landed by fleet segment, country and area	Rec. GFCM/41/2017/6
		II.2 / Catch data per species	Annual data on total catch (i.e. landing and discards) for the main commercial species reported by country, GSA and fleet segment	Monitoring the trend of total catches (landing and discards) of the main commercial species	Rec. GFCM/41/2017/6
		II.3.1 / Fishing activities - Alboran Sea (blackspot seabream)	Annual data related to fishing activities (i.e. number of exploitation days, exploitation area and catches) by country, GSA, fishing gear and fleet segment	Monitoring the annual catch of blackspot seabream in the context of multiannual management plan for the sustainable exploitation of the species in the Alboran Sea (GSAs 1 to 3)	Rec. GFCM/43/2019/2
		II3.2 / Fishing activities - Black Sea (turbot)	Annual data on fishing activities (i.e. operating days, operating area and total catch) reported by country, GSA, fishing gear and fleet segment	Monitoring the exploitation of turbot in the context of multiannual management plan for turbot fisheries in the Black Sea (GSA 29)	Rec. GFCM/41/2017/4
		II.3.3 / Fishing activities - Ionian Sea (trawl fisheries)	Annual data related to fishing activities (i.e. operating days, operating area and total catch) reported by country and vessel	Monitoring the annual exploitation of Giant red shrimp and Blue and red shrimp in the context of multiannual management plan for sustainable trawling fishing activities in the Ionian Sea (GSAs 19 to 21)	Rec. GFCM/42/2018/4
		II.3.4 / Fishing activities - Levant Sea (trawl fisheries)	Annual data on fishing activities (i.e. exploitation days and area, catches) for Giant red shrimp and Blue and red shrimp in the Levant Sea reported by country and vessel	Monitoring the annual exploitation of Giant red shrimp and Blue and red shrimp in the context of multiannual management plan for sustainable trawling fishing activities in the Levant Sea (GSAs 19 to 21)	Rec. GFCM/42/2018/3
		II.3.5 / Fishing activities - Strait of Sicily (demersal)	Annual data on fishing activities (i.e. exploitation days and area, catches and discards) for European hake and deep-water rose shrimp in the Strait of Sicily reported by country, GSA, and fleet segment	Monitoring the annual exploitation of European hake and of deep-water rose shrimp in the context of multiannual management plan for bottom trawl fisheries exploiting demersal stocks in the Strait of Sicily (GSAs 12 to 16)	Rec. GFCM/42/2018/5

DCRF TASKS AND SUBTASKS			DATA	PURPOSES	RELATED RECOMMENDATIONS
TASK		SUBTASK			
II	CATCH	**II.4.1 / Landing points - Adriatic Sea (demersal)**	Information related to the landing points of demersal stocks reported by country and GSA	Monitoring the landing points for European hake, Norway lobster, Common sole, Deep-water rose shrimp and Red mullet in the context of a multiannual management plan for sustainable demersal fisheries in the Adriatic Sea (GSAs 17 and 18)	Rec. GFCM/43/2019/5
		II.4.2 / Landing points - Black Sea (turbot)	Information related to the landing points of Turbot reported by country and GSA	Monitoring the landing points for Turbot in the context of a multiannual management plan for turbot fisheries in the Black Sea (GSA 29)	Rec. GFCM/41/2017/4
		II.4.3 / Landing points - Ionian Sea (trawl fisheries)	Information related to the landing points of key species reported by country and GSA	Monitoring the landing points for Giant red shrimp and Blue and red shrimp in the context of a multiannual management plan for sustainable trawl fisheries in the Ionian Sea (GSAs 19 to 21)	Rec. GFCM/42/2018/4
		II.4.4 / Landing points - Jabuka Pomo Pit	Information related to the landing points of demersal reported by country	Monitoring the landing points for demersal stocks in the context of the establishment of a fisheries restricted area in the Jabuka/Pomo Pit in the Adriatic Sea	REC. GFCM/41/2017/3
		II.4.5 / Landing points - Levant Sea (trawl fisheries)	Information related to the landing points of key species reported by country and GSA	Monitoring the landing points for Giant red shrimp and Blue and red shrimp in the context of multiannual management plan for sustainable trawl fisheries in the Levant Sea (GSAs 24 to 27)	Rec. GFCM/42/2018/3
		II.4.6 / Designated ports - Red coral	Information related to the ports of Red coral reported by country and GSA	Monitoring the authorized ports for red coral in the context of a management plan for the sustainable exploitation of this species in the Mediterranean Sea	Rec. GFCM/ 43/2019/4
		II.4.7 / Landing points - Strait of Sicily (demersal)	Information related to the landing points of demersal species reported by country and GSA	Monitoring the landings points for European hake and/or deep-water rose shrimp in the context of a multiannual management plan for bottom trawl fisheries exploiting demersal stocks in the Strait of Sicily (GSAs 12 to 16).	Rec. GFCM/42/2018/5

DCRF TASKS AND SUBTASKS			DATA	PURPOSES	RELATED RECOMMENDATIONS
TASK		**SUBTASK**			
II	**CATCH**	**II.4.8 / Designated ports - Alboran Sea (blackspot seabream)**	Information related to the ports of Blackspot seabream reported by country and GSA	Monitoring the ports for Blackspot seabream in the context of a management plan for the sustainable exploitation of this species seabream in the Alboran Sea (GSAs 1 to 3)	Rec. GFCM/43/2019/2
III	**INCIDENTAL CATCH OF VULNERABLE SPECIES**	**-**	Annual data (i.e. number of individuals) on incidental catch of vulnerable species (i.e. seabirds, sea turtles, marine mammals and shark species) by area, country and fishing gear	Quantification of incidental catches of vulnerable species by fleet segment and assessment of the impact of fisheries on species of conservation concern	Rec. GFCM/41/2017/6
IV	**FISHING FLEET**	**IV.1 / Fishing vessels - LOA≤15 m**	Annual data on register of fishing vessels with identification features (i.e. vessel name, registration number, port, fishing gear, geographical subarea, etc.) and information on technical features (i.e. gross tonnage, kilowatt, overall length etc.) of fleets operating in the GFCM area of application	Monitoring of fishing capacity in the GFCM area of application	Rec. GFCM/33/2009/5
		IV.2 / Fishing vessels - LOA>15 m			Rec. GFCM/33/2009/6
		IV.3 / Fishery Restricted Areas (FRA)			Rec. GFCM/33/2009/5
		IV.4.1 / Authorized vessels - Adriatic Sea (Demersal)	Annual data on vessels actively fishing for demersal species in the Adriatic Sea with identification features (i.e. vessel name, registration number, port, fishing gear, etc.) and information on technical features (i.e. gross tonnage, kilowatt, overall length etc.) reported by country	Monitoring the fleet capacity for European hake, Norway lobster, Common sole, Deep-water rose shrimp and Red mullet in the context of a multiannual management plan for sustainable demersal fisheries in the Adriatic Sea (GSAs 17 and 18)	Rec. GFCM/43/2019/5
		IV.4.2 / Authorized vessels - Adriatic Sea (small pelagics)	Annual data on fishing vessels authorized to fish for small pelagic stocks in the Adriatic Sea with identification features (i.e. vessel name, registration number, port, fishing gear, etc.) and information on technical features (i.e. gross tonnage, kilowatt, overall length etc.) reported by country	Monitoring the fleet capacity for small pelagics in the context of a multiannual management plan for fisheries exploiting small pelagic stocks in the northern Adriatic Sea (GSA 17) and on transitional conservation measures for fisheries exploiting small pelagic in the southern Adriatic Sea (GSA 18)	Rec. GFCM/37/2013/1

DCRF TASKS AND SUBTASKS			DATA	PURPOSES	RELATED RECOMMENDATIONS
TASK		SUBTASK			
IV	FISHING FLEET	**IV.4.3 / Authorized vessels - Alboran Sea (blackspot seabream)**	Annual data on authorized and operating fishing vessels to catch blackspot seabream with longlines and handlines, with identification features (i.e. vessel name, registration number, port, fishing gear, etc.) and information on technical features (i.e. gross tonnage, kilowatt, overall length etc.) reported by country	Monitoring the fleet capacity for blackspot seabream in the context of a management plan for the sustainable exploitation of this species in the Alboran Sea (GSA 1 to 3)	Rec. GFCM/43/2019/2
		IV.4.4 / Fishing vessels - Black Sea (turbot)	Annual data on authorized and operating fishing vessels for turbot in the Black Sea with identification features (i.e. vessel name, registration number, port, fishing gear, etc.) and information on technical features (i.e. gross tonnage, kilowatt, overall length etc.) reported by country	Monitoring the fleet capacity for turbot in the context of a multiannual management plan for turbot fisheries in the Black Sea (GSA 29)	Rec. GFCM/41/2017/4
		IV.4.5 / Authorized vessels - Common dolphinfish fisheries	Annual data on fishing vessels authorized to use fish aggregating devices (FADs) for the exploitation of common dolphinfish with identification features (i.e. vessel name, registration number, port, fishing gear, etc.) and information on technical features (i.e. gross tonnage, kilowatt, overall length etc.) reported by country	Monitoring the fleet capacity for common dolphinfish in the context of the establishment of a closed season for common dolphinfish fisheries using FADs	Rec. GFCM/43/2019/1
		IV.4.6 / Fishing vessels - Ionian Sea (trawl fisheries)	Annual data on vessels actively fishing for Giant red shrimp and Blue and red shrimp in the Ionian Sea with identification features (i.e. vessel name, registration number, port, fishing gear, etc.) and information on technical features (i.e. gross tonnage, kilowatt, overall length etc.) reported by country	Monitoring the fleet capacity for Giant red shrimp and Blue and red shrimp in the context of a multiannual management plan for sustainable trawl fisheries the Ionian Sea (GSAs 19 to 20)	Rec. GFCM/42/2018/4
		IV.4.7 / Fishing vessels - Levant Sea (trawl fisheries)	Annual data on vessels actively fishing for Giant red shrimp and Blue and red shrimp in the Levant Sea with identification features (i.e. vessel name, registration number, port, fishing gear, etc.) and information on technical features (i.e. gross tonnage, kilowatt, overall length etc.) reported by country	Monitoring the fleet capacity for Giant red shrimp and Blue and red shrimp in the context of a multiannual management plan for sustainable trawl fisheries in the Levant Sea (GSAs 24 to 27)	Rec. GFCM/42/2018/3

DCRF TASKS AND SUBTASKS			DATA	PURPOSES	RELATED RECOMMENDATIONS
TASK		**SUBTASK**			
IV	**FISHING FLEET**	**IV.4.8 / Authorized vessels and fishers - Red coral**	Annual data on fishers and fishing vessels authorized to harvest red coral with identification features (i.e. vessel name, registration number, port, fishing gear, etc.) and information on technical features (i.e. gross tonnage, kilowatt, overall length etc.) reported by country	Monitoring the harvesting of red coral in the context of a management plan for the sustainable exploitation of red coral in the Mediterranean Sea	Rec. GFCM/ 43/2019/4
		IV.4.9 / Fishing vessels - Strait of Sicily (demersal)	Annual data on authorized and operating fishing vessels (bottom trawlers) exploiting demersal stocks in the Strait of Sicily with identification features (i.e. vessel name, registration number, port, fishing gear, etc.) and information on technical features (i.e. gross tonnage, kilowatt, overall length etc.) reported by country	Monitoring the fleet capacity for demersal stocks, including European hake and of deep-water rose shrimp, in the context of multiannual management plan for bottom trawl fisheries exploiting demersal stocks in the Strait of Sicily (GSAs 12 to 16)	Rec. GFCM/42/2018/5
		IV.4.10 / Fishing vessels - Strait of Sicily (shrimps)	Annual data on vessels actively fishing for Giant red shrimp and Blue and red shrimp in the Strait of Sicily with identification features (i.e. vessel name, registration number, port, fishing gear, geographical subarea, etc.) and information on technical features (i.e. gross tonnage, kilowatt, overall length etc.) reported by country	Monitoring the fleet capacity for Giant red shrimp and Blue and red shrimp in the context of a multiannual management plan for sustainable trawl fisheries the Ionian Sea (GSAs 19 to 20)	Rec. GFCM/43/2019/6
		IV.4.11 / Authorized vessels - European eel	Annual data on authorized fishing vessels to fish for European eel with identification features (i.e. vessel name, registration number, port, fishing gear, geographical subarea, etc.) and information on technical features (i.e. gross tonnage, kilowatt, overall length etc.) reported by country	Monitoring the fleet capacity for European eel in the context of a multiannual management plan for European eel in the Mediterranean Sea	Rec. GFCM/42/2018/1
V	**FISHING EFFORT**	**V.1 / Fishing effort - Fleet segment**	Fishing effort data calculated as a combination of capacity and activity by country, GSA, fleet segment and fishing gear. Information on catch per unit effort (CPUE) for the main commercial species	Accounting for the amount of effort deployed and evaluating fishing pressure and trends in CPUE	Rec. GFCM/41/2017/6
		V.2 / Fishing effort - Fishing gear			
		V.3 / Fishing effort - CPUE			

DCRF TASKS AND SUBTASKS			DATA	PURPOSES	RELATED RECOMMENDATIONS
TASK		SUBTASK			
VI	**SOCIO-ECONOMICS**	**VI.1 / Economic and social data**	Data related to economic and social variables of fishery by country, GSA and fleet segment	Assessing the economic value and social implications of fisheries	Rec. GFCM/41/2017/6
		VI.2 / Operating costs			
		VI.3 / Species value			
		VI.4 / Other economic aspects			
VII	**BIOLOGICAL INFORMATION**	**VII.1 / Stock assessment input data**	Annual data on stock identification and stock biological information on priority species: growth parameters, length/weight relationships, recruitment, biomass. Information on environmental factors that may affect population dynamics	Assessing the status of stocks and provision of scientific advice	Rec. GFCM/41/2017/6
		VII.2 / Length data	Data related to the observed size distribution, in the landing, of identified priority species per GSA	Monitoring the structure of exploited populations	Rec. GFCM/41/2017/6
		VII.3.1 / Size at first maturity	Information on some biological variables (i.e. sex and L50) of identified priority species per GSA	Monitoring the biological rates and dynamics of the exploited species	Rec. GFCM/41/2017/6
		VII.3.2 / Maturity data	Information on some biological variables (i.e. length, sex and maturity) of identified priority species per GSA.	Monitoring the biological rates and dynamics of the exploited species	Rec. GFCM/41/2017/6
		VII.4.1 / Dolphin fish (general information)	Annual data on dolphinfish (i.e. landings and vessels) reported by country, fishing period and GSA	Monitoring the population status of dolphin fish and assessing the effect of seasonal closure on the fishery	Rec. GFCM/30/2006/2
		VII.4.2 / Dolphin fish (statistics)	Annual data on dolphinfish (i.e. GT of vessels, number of FADs, fishing trips, average size of fish caught, transhipments) reported by country and GSA	Monitoring the population status of dolphin fish and assessing the effect of seasonal closure on the fishery	Rec. GFCM/30/2006/2
		VII.5 / Red coral	Information on red coral harvesting, weight, effort, average diameter and depth by country, GSA, statistical grid, landing port and fishing ground	Assessing the status and regulating the exploitation of red coral	Rec. GFCM/ 43/2019/4
		VII.6 / European eel	Annual data on Silver eel, Yellow eel, Silver and yellow eel, and Glass eel (i.e. total catch, fishing days, fishermen) by country, habitats, site, gear type and for the different life stages	Monitoring the status and assessing the level of escapement of European eel	Rec. GFCM/41/2017/6

For the purpose of this framework, the following definitions have been used:

VESSEL GROUP:	Fishing vessels, regardless their size, using the same gear for more than 50 percent of the time at sea during a year.
FLEET SEGMENT:	The combination of a group of fishing vessels of the same size and using the same gear for more than 50 percent of the time at sea during a year[12].
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.
POLYVALENT VESSELS:	All fishing vessels using more than one gear with a combination of passive and active gear, none of which exceeding more than 50 percent of the time at sea during the reference year.
FISHING GEAR:	Equipment used for fishing (e.g. bottom otter trawls, gillnets, harpoons, longlines, midwater pair trawls, pots, purse seines and traps), according to the international standard classification (FAO, 1980) (Appendix D of this manual).
FISHING TRIP:	In the most simple 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 OPERATION:	Any single "action" carried out during a fishing trip whether or not a catch was made. This includes, among others, towing one trawl net, setting a line and hauling pots and traps.
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.
LANDING:	The part of the catch that is retained on board and brought ashore.[13]
BYCATCH:	The part of the catch that is unintentionally captured during a fishing operation in addition to target species. It may refer to the catch of other commercial species that are landed, commercial species that cannot be landed (e.g. undersized,

[12] In order to define the fleet segments, the GFCM classification currently in force has been slightly modified to accommodate the most recent developments (Appendix B).

[13] In accordance with the landing obligation (as reported in the EU Regulation No 1380/2013), total catch of Mediterranean species which are subject to catch limit and minimum sizes must be landed even if they are not to be commercialized.

damage individuals), non-commercial species, as well as to incidental catch of endangered, vulnerable or rare species (e.g. sea turtles, sharks and marine mammals).

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.

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 manual (Appendix E), 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 Barcelona Convention (Convention for the Protection of the Marine Environment and the Coastal Region of the Mediterranean) have been used.

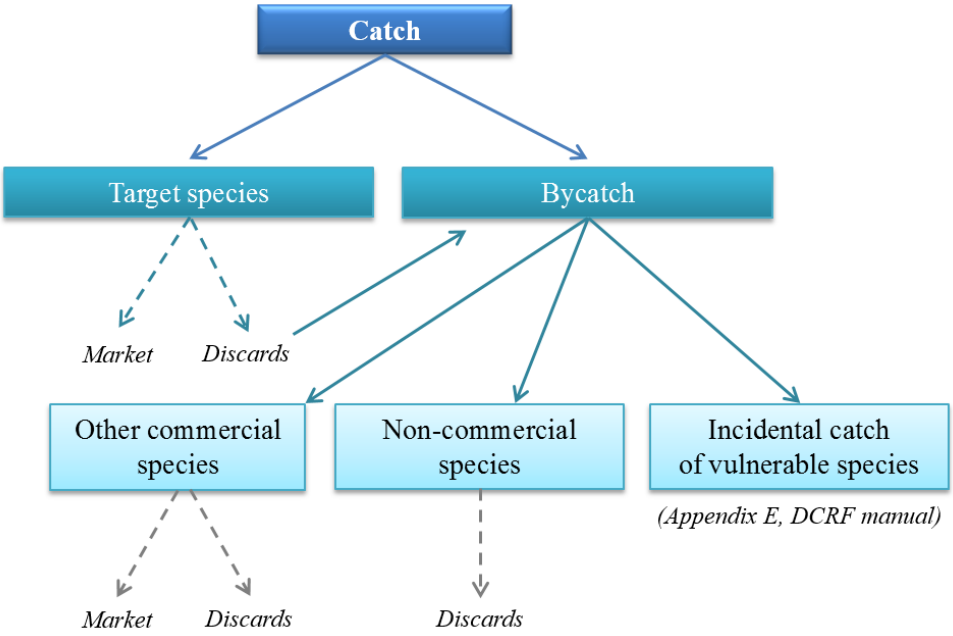


Figure 2: Scheme representing the different components of the catch

The same species can move from one category (i.e. market or discards) to another, depending on size, market demand, season or other criteria. Similarly, other species may be undesirable, or of limited value, in one subregion, but appreciated in others (Figure 2).

2. Task I: Global figures of national fisheries

Description - The objective of this task is to provide a general overview of the fishery in each country, with an indication of total capacity and total landing. Data reported here are totals of some important

variables, and must therefore be in line with the data/information provided through the other tasks and subtasks of the present manual.

Countries involved - This task is addressed to all countries operating in the GFCM area of application.

Data (Mandatory) - Countries should transmit information about total amount of landing, in weight, together with the total number of active fishing vessels, the corresponding total capacity (GT) and engine power (kW).

Table I.1 *Global figures of national fisheries*: General overview
Mandatory data

FIELDS	DEFINITION OF VARIABLES	PK*
Country	*The ISO 3-alpha code of the country under which the vessel is operating (refer to the FAO country codes list)*	X
Reference year	*The year to which the collected data refer*	X
Number of vessels	*The corresponding number of all active fishing vessels operating in the country during the reference year*	
Total landing	*The whole part of the catch that is landed (in tonnes) by all active fishing vessels during the reference year*	
Total capacity (GT)	*The total capacity (sum), in gross tonnage (GT), of all active fishing vessels operating in the country*	
Total engine power (kW)	*The total engine power (sum), in kilowatt (kW), of all active fishing vessels operating in the country*	

** data fields composing the primary key (PK) of the table*

Frequency and deadline of transmission - Countries should transmit the data pertaining to year n-1 by the 31st May of each calendar year (n). Data requested (Table I.1) are mandatory (Appendix O).

Data confidentiality - Data transmitted by countries will be treated in accordance with all necessary measures to comply with the GFCM security and confidentiality provisions, and with the specific provisions of related recommendations (see Table 1). Once transmitted to the GFCM, all the information in Table I.1 may be publicly available, in conformity with the criteria of data access policy approved by the Commission (Chapter 9).

2.1 Task II: Catch

Knowledge of the biomass removed from the ecosystem by fishing operations is fundamental so as to monitor the status of stocks, as well as the impact of fishing on fish populations.

Subtask II.1 - Landing data

Description -This subtask refers to the total amount of landing. The total amount of all landed species, in weight (tonnes) by fleet segment, together with the total number of active fishing vessels, should be reported by country and area (GSA). Total landing figures can be obtained from different sources (e.g. logbooks, sales notes, sampling and interviews).

In order to optimise the sampling, and according to the inputs received by the Subcommittee on Stock Assessment and the Subcommittee on Economic and Social Sciences (GFCM, 2015a, 2015b) fleet segments could be merged (i.e. aggregating length classes) if they:

- have similar exploitation patterns (targeting the same species);
- exploit the same portion of the population (i.e. juveniles or adults).

When a country proposes to aggregate fleet segments, the rationale and corresponding references (e.g. existing scientific studies) should be brought to the attention of the relevant subsidiary bodies, which in turn should confirm the similarity/homogeneity of the combined cells[14]. In the case of merged segments, the code to identify the newly defined fleet segment will be provided by the GFCM Secretariat (section 6.2 Chapter 6).

Countries involved - This task is addressed to all countries operating in the GFCM area of application.

Data (Mandatory) - Landing data (in tonnes) and number of active fishing vessels (Table II.1), are requested by fishing area (GSA) and for all fleet segments, as identified in Appendix B.

Table II.1 *Catch*: Total landing data
Mandatory data

FIELDS	DEFINITION OF VARIABLES	PK*
Country	*The ISO 3-alpha code of the country under which the vessel is operating (refer to the FAO country codes list)*	X
Reference year	*The year to which the collected data refer*	X
GSA	*The geographical subarea code as reported in Appendix L of this manual (Res. GFCM/33/2009/2)*	X
Fleet segment	*The fleet segment code (Appendix B of this manual) or the code corresponding to the merged fleet segments (see section 6.2)*	X
Number of vessels	*The corresponding number of all active fishing vessels (by GSA) operating in the identified fleet segment, during the reference year*	
Total landing	*The whole part of the catch (in tonnes) that is landed by the operating fleet segment in the GSA*	

** data fields composing the primary key (PK) of the table*

Frequency and deadline of transmission - Countries should transmit the data pertaining to year n-1 by 30th June of each calendar year (n). Landing data (Table II.1) are mandatory (Appendix O).

Data confidentiality - Data transmitted by countries will be treated in accordance with all necessary measures to comply with the GFCM security and confidentiality provisions, and with the specific provisions of related recommendations (see Table 1). Once transmitted to the GFCM, all the information in Table II.1 may be made publicly available, in conformity with the criteria of data access policy approved by the Commission (Chapter 9).

[14] Further information could be found in paragraph 6.2.1 Merging procedures of this manual

Subtask II.2 - Catch data per species

Description - For the main commercial species[15], identified at national level, countries should transmit information on total catch by area (GSA) and fleet segment. Total catch should be considered as the weight of the total yearly catches, including retained catch (landings) and the discarded fraction (discards).

Discards data, if available, should be collected and reported in the corresponding table according to identified fleet segments and commercial species. The collection of discards information (i.e. weight in tonnes for the main commercial species) is only compulsory for fleet segments (e.g. trawlers 12-24 m) for which the discard rate is assessed as significant. The discard rate can be considered as being significant when it exceeds 10 percent of the total volume of catch for a given fleet segment in a given GSA. Should the discard level be assessed as insignificant (<10%), there is no need to collect information on discards for the pertaining segment.

Countries involved - This task is addressed to all countries operating in the GFCM area of application.

Data (Mandatory) - Countries should transmit the total catch data (weight), including landing and discards (if present and recorded), by main commercial species, fleet segment (Appendix B) and area (GSA) (Table II.2).

Table II.2 *Catch*: Catch data per species
Mandatory

FIELDS	DEFINITION OF VARIABLES	PK*
Country	*The ISO 3-alpha code of the country under which the vessel is operating (refer to the FAO country codes list)*	X
Reference year	*The year to which the collected data refer*	X
GSA	*The geographical subarea code as reported in Appendix L of this manual (Res. GFCM/33/2009/2)*	X
Fleet segment	*The fleet segment code (Appendix B of this manual) or the code corresponding to the merged fleet segments (see section 6.2)*	X
Species	*The 3-alpha code identifying the main commercial species[16].*	X
Total landing per species	*The total landing (in tonnes) of the mentioned commercial species for the identified fleet segment in the GSA*	
Total discards per species**	*For the mentioned commercial species, the total volume (in tonnes) of discard by the identified fleet segment in the GSA*	
Total catch per species	*The total catch, landing+discard (in tonnes) of the mentioned species for the operating fleet segment in the GSA. If there is no discard, this field should match that of total landing*	

** if any

** data fields composing the primary key (PK) of the table*

[15] "main commercial species" are currently those which summed up together, represent 90% in weight of total landing in the country.
[16] www.fao.org/fishery/collection/asfis

Frequency and deadline of transmission - Countries should transmit the data pertaining to year n-1 by the 30th June of each calendar year (n) (Appendix O). Countries are encouraged to respect this deadline and provide all requested data. Catch data per species (Table II.2) are mandatory.

Data confidentiality - Data transmitted by countries will be treated in accordance with all necessary measures to comply with the GFCM security and confidentiality provisions, and with the specific provisions of related recommendations (see Table 1). Once transmitted to the GFCM, all the information in Table II.2 may be publicly available, in conformity with the criteria of data access policy approved by the Commission (Chapter 9).

2.2 Task III: Incidental catch of vulnerable species

Description - This section refers to the specific reporting of incidental catch of seabirds, sea turtles, seals, cetaceans, sharks and rays species (Appendix E.1) as identified in a number of GFCM recommendations (GFCM/35/2011/3, GFCM/35/2011/4, GFCM/35/2011/5, GFCM/36/2012/2 and GFCM/36/2012/3) and included in Annex II (*List of Endangered or Threatened Species*) and Annex III (*List of species whose exploitation is regulated*) of the *Protocol concerning Specially Protected Areas and Biological Diversity SPA/BD in the Mediterranean of the Convention for the Protection of the Marine Environment and the Coastal Region of the Mediterranean* (Barcelona Convention). Moreover, any incidental taking of rare sharks and rays (Appendix E.2), even if not mentioned in the Barcelona Convention, should also be reported.

Available information on incidental catches of vulnerable species by fishing gear or fleet segment is still limited. It is therefore important to collect existing data and identify additional/alternative sources of information to guide any possible revision of monitoring schemes. Data regarding the number of individuals taken as well as fleet segments and gear types (if available) should be reported. Suitable methods for recording incidental catch include for example on-board observers and/or self-sampling (Chapter 6).

Countries involved - This task is addressed to all countries operating in the GFCM area of application.

Data (Mandatory) - A minimum set of parameters, such as the number of individuals caught per fleet segment (Appendix B) and/or per fishing gear (Appendix D), should be reported. Countries should transmit this information only in the event of incidental catch of vulnerable and rare species (i.e. seabirds, sea turtles, cetaceans, monk seal and sharks), as specified in Table III.1 (Appendix E).
Data should be aggregated by area (GSA) and by species group and/or family, if the detailed information by species is not available (e.g. when individual could not be identified at species or genus level, as in the case of recording seabirds, which include a large number of possible species). It is also important to report the total number of individuals caught, whether they have been released alive, dead or in unknown status.

Table III.1 Incidental catch of vulnerable species
Mandatory data for species listed in Appendix E

FIELDS	DEFINITION OF VARIABLES	PK*
Country	*The ISO 3-alpha code of the country under which the vessel is operating (refer to the FAO country codes list)*	X
Reference year	*The year to which the collected data refer*	X
Date	*The date (dd/mm/yyyy) when the vulnerable species have been recorded*	X
GSA	*The geographical subarea code as reported in Appendix L of this manual (Res. GFCM/33/2009/2)*	X
Source of data	*Source of data:* ***BS*** *(biological sampling on board, at landing place, at market, self-sampling, others)* ***SU*** *(scientific survey) or* ***OT*** *(other)*	X
Fleet segment	*The fleet segment code (Appendix B of this manual) or the code corresponding to the merged fleet segments (see section 6.2)*	X
Fishing gear**	*The code of the fishing gear, as reported in Appendix D of this manual (e.g. GNS)*	X
Group of vulnerable species	*The name of the group of vulnerable species, as reported in Appendix E of this manual (e.g. Cetaceans)*	X
Family**	*The name of the Family, as reported in Appendix E of this manual (e.g. Delphinidae)*	X
Species**	*The scientific name of the species, as reported in Appendix E of this manual (e.g. Orcinus orca)*	X
Total number of individuals caught	*The total number (sum) of individuals caught (regardless of their release) with that particular gear (or at level of fleet segment if information on the gear is not available) in the GSA*	
Total weight of individuals caught**	*The total weight (tonnes) of individuals caught (regardless of their release) with that particular gear (or at level of fleet segment if information on the gear is not available) in the GSA*	
Number of individuals released alive**	*The number (sum) of individuals caught that have been released alive; (if none enter 0)*	
Number of dead individuals**	*The number (sum) of dead individuals; (if none enter 0)*	
Number of individuals released in unknown status**	*The number (sum) of individuals caught, for which there is no information about status during release (e.g. partially damaged); (if none enter 0)*	

** if available

** data fields composing the primary key (PK) of the table*

Frequency and deadline of transmission - Countries should transmit the data pertaining to year n-1 by the 31st July of each calendar year (n) (Appendix O).

Data confidentiality - Data transmitted by countries will be treated in accordance with all necessary measures to comply with the GFCM security and confidentiality provisions, and with the specific provisions of related recommendations (see Table 1). Once transmitted to the GFCM, all the information in Table III.1 may be publicly available, in conformity with the criteria of data access policy approved by the Commission (Chapter 9).

2.3 Task IV: Fishing fleet

Description - The overall objective of this task is to provide information on the fleet operating in the GFCM area of application, in order to compile reliable statistics on fishing capacity for management purposes at regional and subregional level.

Countries should transmit information about all national vessels, boats, ships or other craft that are equipped and used for commercial fishing purposes in the GFCM area of application. Particular attention should be paid to small-scale vessels.

Data collected under this task will make it possible to obtain:

- an accurate source of statistics for the Mediterranean and Black Sea fishing fleet;
- a complete picture of the regional, subregional, and national fishing capacity;
- a better knowledge at regional/subregional level of the age of fleets (safety indicator);
- a picture of historical events: entry into and exit from the fleet, modifications and characteristics.

Countries involved - This task is addressed to all countries operating in the GFCM area of application.

Data (Mandatory) - Data within this task can be grouped into the following categories:

- Administrative (name, port, registration number, etc.)
- Technical (length, tonnage, power, fishing gear etc.)
- Personnel (operator, crew etc.)

The list of mandatory fields is summarized in Table IV.1. Additional information should only be reported for vessels over 15 metres (Table IV.2).

Table IV.1 *Fishing fleet*: Description of vessels
Mandatory data

FIELDS	DEFINITION OF VARIABLES	PK*
Country	*The ISO 3-alpha code of the country under which the vessel is operating (refer to the FAO country codes list)*	X
Reference year	*The year to which the collected data refer*	X
Registration authority	*Name of the authority that issued the vessel registration*	
Vessel name**	*Name of vessel (in Latin characters)*	
National registration number	*The code representing the official vessel identifier as reported in the national fleet register (alphanumeric string)*	X
Vessel registration number	*The code representing the national registration number of the vessel (ISO 3-alpha code of the country plus 9 digits)*	X
International radio call sign (IRCS)	*If applicable, the international radio call (IRCS) sign of the vessel. This information is compulsory in those cases where the vessel is eligible for obtaining the IRCS due to the presence of on-board radiocommunication devices.*	
Maritime Mobile Service Identity (MMSI)	*If applicable, the Maritime Mobile Service Identity (MMSI) of the vessel. Series of nine digits commonly associated to on-board radio equipment. This information is compulsory in*	

FIELDS	DEFINITION OF VARIABLES	PK*
	those cases where vessel is eligible for obtaining the MMSI due to the presence of on-board radiocommunication devices.	
Operational status (active indicator)	*Active/inactive. Permanent status until receives allowance to return to activity (indicator Y/N)*	
Port of registration	*Full name of the port where the vessel is registered.*	
GSA (main geographical fishing area)	*The GSA where the vessel is authorized to fish and operates the majority of the year (see geographical subarea code as reported in Appendix L of this manual - Res. GFCM/33/2009/2)*	
Secondary fishing statistical area (GSA)**	*The GSA where the vessel is authorized to fish and operates occasionally (Appendix L of this manual)*	
Tertiary fishing statistical area (GSA)**	*The GSA where the vessel is authorized to fish and operates occasionally (Appendix L of this manual)*	
Year of entry into fishing activity**	*The year in which the vessel commenced its fishing activity*	
Authorization to fish (licence indicator)	*Any authorization to fish, e.g. licence, permit or any other official denomination; indicator Y/N*	
Main fishing gear used	*The main gear, according to the fishing licence of the vessel or the owner/operator, using the International Standard Statistical Classification of Fishing Gear (ISSCFG), which was adopted during the 10th Session of the Coordinating Working Party on Fishery Statistics (CWP - Madrid, 22-29 July 1980 - FAO, 1980) (Appendix D of this manual).*	
Secondary fishing gear**	*The secondary gear, according to the fishing licence of the vessel or the owner/operator, using the same International Standard Statistical Classification of Fishing Gear as in "main fishing gear used" (Appendix D of this manual).*	
Third fishing gear**	*The tertiary gear, according to the fishing licence of the vessel or the owner/operator, using the same International Standard Statistical Classification of Fishing Gear as in "main fishing gear used" (Appendix D of this manual).*	
Length Overall (LOA)	*The vessel's Length Overall, in metres, which represents the main longitudinal dimension of the hull of the vessel. This value should be provided with an accuracy of 2 digits*	
Gross tonnage (GT)	*The Gross Tonnage, according to the International Convention on Tonnage Measurement of Ships, London, 1969 (in use since 1996)*	

FIELDS	DEFINITION OF VARIABLES	PK*
Power of the main engine (kW)	*The total maximum continuous rated output power, in kW, of all the vessel's main propulsion machinery, which appears on the vessel's certificate or registry or other official manual, according to the International Convention on Standards of Training, Certification and Watch keeping for Fishing Vessel Personnel (STCW-F)*	
Construction year of vessel	*The year in which the vessel was constructed*	
VMS indicator (presence/absence)	*Indicating whether the vessel is equipped with a VMS device. Enter Yes (Y) or No (N)*	

** if any

** data fields composing the primary key (PK) of the table*

Table IV.2 *Fishing fleet*: Additional information for vessels over 15 metres
Mandatory data

FIELDS	DEFINITION OF VARIABLES	PK*
Country	*The ISO 3-alpha code of the country under which the vessel is operating (refer to the FAO country codes list)*	X
Reference year	*The year to which the collected data refer*	X
Registration authority	*Name of the authority that issued registration of the vessel*	
Vessel name**	*Name of vessel (in Latin characters)*	
National registration number	*The code representing the official vessel identifier as reported in the national fleet register (alphanumeric string)*	X
Vessel registration number	*The code representing the national registration number of the vessel (ISO 3-alpha code of the country plus 9 digits)*	X
IMO number	*If applicable, the International Maritime Organization (IMO) number as assigned to the vessel by IHS Maritime & Trade. This information is compulsory in those cases where the fishing vessel is eligible under the IMO Ship Identification Number Scheme (Res. GFCM/41/2017/6).*	
Owner (details)	*Details of the owner(s): name and address*	
Operator (if different from owner)**	*Details of the operators(s): name and address*	
Min. number of crew	*The minimum number of crew required to conduct fishing operations during the reference year*	
Max. number of crew	*The number of crew required to conduct a specific fishing operation, if superior to the value of "Min. number of crew"*	

** if any

**data fields composing the primary key (PK) of the table*

In addition, countries whose vessels conduct fishing activities close to Fisheries Restricted Areas (FRAs - Appendix C) should adequately report *ad hoc* information (Table IV.3). Vessels operating in a fishery for which a management plan exist (e.g. as in Recommendation GFCM/36/2013/1) should also comply with the information required in the management plan.

Table IV.3 *Fishing fleet*: Vessels operating in Fisheries Restricted Areas (FRA)
Mandatory data

FIELDS	DEFINITION OF VARIABLES	PK*
Country	*The ISO 3-alpha code of the country under which the vessel is operating (refer to the FAO country codes list)*	X
Reference year	*The year to which the collected data refer*	X
Registration authority	*Name of the authority that issued registration of the vessel*	
Vessel name**	*Name of vessel (in Latin characters)*	
National registration number	*The code representing the official vessel identifier as reported in the national fleet register (alphanumeric string)*	X
Vessel registration number	*The code representing the national registration number of the vessel (ISO 3-alpha code of the country plus 9 digits)*	X
Fisheries Restricted Area	*Name of the Fisheries Restricted Area as reported in Appendix C of this manual*	
Number of fishing days	*The number of fishing days operated by the vessel in the Fisheries Restricted Area during the year*	
Fishing gear used in the Fisheries Restricted Area	*The fishing gear used to fish in the Fisheries Restricted Area, according to the International Standard Statistical Classification of Fishing Gear (ISSCFG)*	
Period authorized (if applicable) for fishing in the Fisheries Restricted Area**	*Period authorized for fishing in the Fisheries Restricted Area (FRA): from DD/MM/YYYY to DD/MM/YYYY*	

** if any

** data fields composing the primary key (PK) of the table*

Data (Optional) - Countries are also encouraged to provide additional information regarding the equipment of the vessel (refrigeration, navigation, communication, fish processing etc.), even if only one or few optional data fields are available, and to communicate information on its earlier history, if available (previous vessel name and flag state etc.). The full list of optional data fields is included in Table IV.4.

Table IV.4 *Fishing fleet*: Additional vessel equipment information
Optional data

FIELDS	DEFINITION OF VARIABLES	PK*
Country	*The ISO 3-alpha code of the country under which the vessel is operating (refer to the FAO country codes list)*	X
Reference year	*The year to which the collected data refer*	X
Registration authority	*Name of the authority that issued registration of the vessel*	
Vessel name**	*Name of vessel (in Latin characters)*	
National registration number	*The code representing the official vessel identifier as reported in the national fleet register (alphanumeric string)*	X
Vessel registration number	*The code representing the national registration number of the vessel (ISO 3-alpha code of the country plus 9 digits)*	X
Previous vessel name	*The previous name of the vessel, if applicable*	
Previous flag State	*The previous flag of the vessel, if applicable (refer to the code list at www.fao.org/countryprofiles/iso3list.asp.)*	
Previous details of deletion from other registries	*If applicable, the reason why the vessel was deleted from other registries and moved to the current register*	
Period authorized for fishing and/or trans-shipping	*The time period authorized for fishing and/or trans-shipping*	
Power of auxiliary engine(s) kW	*The total installed engine power not included in the value of "power of the main engine"*	
Hull material	*Enter the hull material of the vessel*	
Powered/motorized	*The value indicating whether the power of the vessel's main engine > 0; indicator Y/N*	
Fish hold capacity (m^3)	*The capacity, in m^3, of the vessel's fish hold*	
Lights for fishing	*The number of lights on the fishing vessel, in the case of fishing operations requiring light*	
Navigation equipment	*Textual description of the type of navigation equipment being reported*	
Communication equipment	*Textual description of the type of communication equipment being reported*	
Fish finder	*Textual description of the type of fish finder equipment being regularly used*	
Deck machinery	*Textual description of the deck machinery used to operate fishing gear, listed according to the vessel on which each item is present and the event being reported*	
Refrigeration equipment	*Textual description of refrigeration equipment being reported*	
Fish processing equipment	*Textual description of fish processing equipment being reported*	
Safety equipment	*Textual description of the main item of safety equipment being reported*	
Period authorized for fishing with demersal trawl gear	*The period authorized for fishing with demersal trawl gear (if applicable): from DD/MM/YYYY to DD/MM/YYYY*	

** if any

** data fields composing the primary key (PK) of the table*

Frequency and deadline of transmission - Countries should transmit the data pertaining to year n-1by the 31st May of each calendar year (n) (Appendix O). Data of vessels over 15 metres in overall length should be transmitted as any changes occur, with particular attention to the authorized fishing period,

for which information should be kept updated[17]. Countries are encouraged to respect the deadline and to provide all requested data. Tables IV.1, IV.2 and IV.3 are mandatory. Countries are also invited to provide data as reported in Table IV.4.

Data confidentiality - Data transmitted by countries will be treated in accordance with all necessary measures to comply with the GFCM security and confidentiality provisions, and with the specific provisions of related recommendations (see Table 1). Once transmitted to the GFCM, all the information in Tables IV.1, IV.2, IV.3 and IV.4 may be publicly available, in conformity with the criteria of data access policy approved by the Commission (Chapter 9).

Exception is made for information related to the owner, operator and crew in Table IV.2, which shall be made available to a restricted audience only, and in accordance with agreed security provisions.

2.4 Task V: Fishing effort

Description - Fishing effort is a measure of the amount of fishing activity deployed. It can be calculated through a combination of inputs related to capacity, gear and time. Effort information is needed to analyse changes in the amount of catch and it is crucial for developing multiannual management plans. Usually, fishing effort is calculated by multiplying the fishing capacity deployed (i.e. total GT or power, number of hooks in longlines) by the period of time (number of hours or days spent fishing) and can be obtained through various sources (logbooks, sampling, census, port surveys, etc.).

Also, effort is combined with catch to estimate the rate of catch per unit effort. The catch per unit of fishing effort (CPUE) is a relative measure of fish stock abundance and can be used to estimate absolute abundance; it could be an indicator of fishing efficiency, both in terms of abundance and economic value. In its basic form, the CPUE could be expressed as the captured biomass for each unit of effort applied to species/stock (e.g. total catch of a species divided by the total fishing: kg/number of fish per longline hook days). Declining trends of this estimator could indicate overexploitation, while unchanging value could indicate sustainable fishing.

For the purpose of this framework, the CPUE should be reported only for the priority species belonging to Group 1 and Group 2 (Appendixes A.1 and A.2 - Priority species). CPUE should be calculated as the ratio between total catch (by gear and species) and the nominal effort (by gear as reported in Appendix F.2): CPUE = total catch/nominal effort.

Countries involved - This task is addressed to all countries operating in the GFCM area of application.

Data (Mandatory) - In order to compare and harmonize data at the regional and subregional level, standard effort information is requested both for fishing capacity (e.g. GT, number of hooks) and activity (e.g. fishing days). Effort data (Table V.1) should be reported by GSA and for all fleet segments operating in the country (Appendix B). Countries are also requested to provide estimates of fishing days by fishing gear (Table V.2).

CPUE data (Table V.3) should be reported, by fishing gear and by established nominal effort, for the identified species belonging to Group 1 and Group 2 (Appendixes A.1 and A.2 - Priority species). Mandatory fishing effort measurements are described in Appendix F.

[17] For the purpose of Recommendation GFCM/33/2009/6, vessels larger than 15 metres in overall length not entered into the GFCM Authorized Vessel list are deemed not to be authorized to fish for, retain on board, trans-ship or land species covered by the Commission.

Table V.1 Fishing *effort*: Effort data per fleet segment
Mandatory data

FIELDS		DEFINITION OF VARIABLES	PK*
Country		*The ISO 3-alpha code of the country under which the vessel is operating (refer to the FAO country codes list)*	X
Reference year		*The year to which the collected data refer*	X
GSA		*The geographical subarea code as reported in Appendix L of this manual (Res. GFCM/33/2009/2)*	X
Fleet segment		*The fleet segment code (Appendix B of this manual) or the code corresponding to the merged fleet segments (see section 6.2)*	X
Capacity (by fleet segment)	**Unit**	*The unit of capacity (Appendix F.1 of this manual)*	
	Value	*The total (sum) capacity value per fleet segment in the corresponding GSA*	
Activity (by fleet segment)	**Unit**	*The unit of activity (Appendix F.1 of this manual)*	
	Value	*The total (sum) activity value per fleet segment in the corresponding GSA*	
Nominal effort (by fleet segment)		*The value of the nominal effort per fleet segment, and by GSA, as requested in Appendix F.1 of this manual*	
Number of vessels (by fleet segment)		*The corresponding number of all active fishing vessels (by GSA) operating in the identified fleet segment, during the reference year*	

** data fields composing the primary key (PK) of the table*

Table V.2 Fishing *effort*: Effort data per fishing gear
Mandatory data

FIELDS	DEFINITION OF VARIABLES	PK*
Country	*The ISO 3-alpha code of the country under which the vessel is operating (refer to the FAO country codes list)*	X
Reference year	*The year to which the collected data refer*	X
GSA	*The geographical subarea code as reported in Appendix L of this manual (Res. GFCM/33/2009/2)*	X
Fishing gear	*The fishing gear code (Appendix D of this manual)*	X
Fishing days (by fishing gear)	*Total number of fishing days (sum) per fishing gear in the corresponding GSA*	

** data fields composing the primary key (PK) of the table*

Table V.3 Fishing *effort*: CPUE
Mandatory data for species Group 1 and Group 2

FIELDS		DEFINITION OF VARIABLES	PK*
Country		*The ISO 3-alpha code of the country under which the vessel is operating (refer to the FAO country codes list)*	X
Reference year		*The year to which the collected data refer*	X
GSA		*The geographical subarea code as reported in Appendix L of this manual (Res. GFCM/33/2009/2)*	X
Fishing gear		*The code of the fishing gear (Appendix D of this manual)*	X
Species		*The 3-alpha code identifying the species (Appendix A of this manual)*	X
Capacity (by fishing gear)	Unit	*The unit of capacity (Appendix F.2 of this manual)*	
	Value	*The total (sum) capacity value per fishing gear in the corresponding GSA*	
Activity (by fishing gear)	Unit	*The unit of activity (Appendix F.2 of this manual)*	
	Value	*The total (sum) activity value per fishing gear in the corresponding GSA*	
Nominal effort (by fishing gear)		*The value of the nominal effort per fishing gear, and by GSA, as requested in Appendix F.2 of this manual*	
CPUE		*The CPUE value per species and per fishing gear in the reference year. CPUE should be calculated as the ratio between total catch and nominal effort by gear (as defined in Appendix F.2 of this manual)*	

** data fields composing the primary key (PK) of the table*

Frequency and deadline of transmission - Countries should transmit the data pertaining to year n-1 by the 30th June of each calendar year (n) (Appendix O). Countries are encouraged to comply with this deadline and to provide all requested data.

Data confidentiality - Data transmitted by countries will be treated in accordance with all necessary measures to comply with the GFCM security and confidentiality provisions, and with the specific provisions of related recommendations (see Table 1). Once transmitted to the GFCM, all the information in Tables V.1, V.2 and V.3 may be publicly available, in conformity with the criteria of data access policy approved by the Commission (Chapter 9).

2.5 Task VI: Socio-economics

Description - The objective of this task is to collect information in order to monitor the economic status of the fishing sector. Data collected under this task is needed to develop appropriate policies and strategies, especially in relation to promoting the long-term sustainability of resources and fleets.
Economic data can help to explain fisher behaviour and the overexploitation of fisheries resources. The species that fishers target, the level of exploitation, and the gear that they use are all influenced by the benefits they receive (i.e. the revenue) and the costs they incur.

The systematic collection of socio-economic data is necessary so as to assess the economic consequences of different management options on the varying groups, based on the incentives that these create. Economics provide a framework for the optimal allocation of marine resources for the benefit of society. It provides an approach to valuing the different activities, allowing trade-offs between activities to be assessed and impacts to be measured in a consistent manner.

Economic and social information should be collected by area (GSA) and by fleet segment. Countries collecting these data on a yearly basis are requested to transmit them annually (reference year - 2). Biennial transmission is requested for those countries that do not have annual economic surveys in place.

Economic and social data are generally collected through sampling surveys using questionnaires, but for some fleet segments and some variables, other data sources could be used (e.g. administrative records, auction sales, and census).
Data collected under this task will help to obtain:

- trends in economic performance and social indicators;
- time series analysis of average annual prices for commercial species;
- analysis of the profitability of fleets (income, gross value added, operating cash flow);
- an accurate source of statistical data for landing values and prices;
- a better knowledge of fleet costs and their breakdown in different categories;
- a complete picture of regional, subregional and national employment in the fishery sector.

Exhaustive definitions of concepts related to capital value and costs as well as methodologies for calculating these variables have been detailed in various reports (Franquesa *et al.*, 2001; IREPA, 2006) and workshops (WS on calculating capital value using PIM - Perpetual Inventory Method - and definition of EU-DCF variables. Anonymous, 2011 - see section 5.2 Chapter 5).

Countries involved - This task is addressed to all countries operating in the GFCM area of application.

Data (Mandatory) - The list of data fields and related definitions is reported in Table VI.1, Table VI.2 and Table VI.3. All types of information should refer to one single year of activity. Data are requested by fishing area (GSA) and fleet segment (Appendix B).

Table VI.1 includes data related to capacity, number of active fishing vessels, total landing values and total days at sea. Information on personnel costs, fuel consumption and price, and other operating costs should be reported in Table VI.2.

Table VI.3 requires reporting information on volume and value of landing by commercial species. Data on prices, income and costs should be reported in national currency.

Table VI.1 data are mandatory and based on annual transmission. Tables VI.2 and VI.3 data are mandatory and should be transmitted on a biennial basis. Biennial transmission should only take place for those countries that do not have annual economic surveys in place. Countries collecting these data on a yearly basis are requested to transmit them annually (keeping reference year - 2).

Table VI.1 Socio-economics: *Economic and social data*
Mandatory data (on annual basis)

FIELDS		DEFINITION OF VARIABLES	PK*
Country		*The ISO 3-alpha code of the country under which the vessel is operating (refer to the FAO country codes list)*	X
Reference year		*The year to which the collected data refer*	X
GSA		*The geographical subarea code as reported in Appendix L of this manual (Res. GFCM/33/2009/2)*	X
Fleet segment		*The fleet segment code (Appendix B of this manual) or the code corresponding to the merged fleet segments (see section 6.2)*	X
Capacity (gross tonnage)		*The total capacity, expressed as gross tonnage (GT), of all active fishing vessels[18] belonging to that fleet segment*	
Capacity (engine power)		*The total capacity, expressed as engine power (kW), of all active fishing vessels[14] belonging to that fleet segment*	
Number of vessels		*The corresponding number of all active fishing vessels (by GSA) operating in the identified fleet segment, during the reference year*	
Total landing	**Currency**	*The currency (Euro or US dollar) in which the total value of landing is reported*	
	Value	*The total value of landing of all active fishing vessels belonging to that fleet segment*	
Total days at sea		*The total number of fishing days carried out by all active fishing vessels classified in that fleet segment*	

** data fields composing the primary key (PK) of the table*

Table VI.2 Socio-economics: *Operating costs*
Mandatory data (on biennial basis)
Biennial transmission should only take place for those countries that do not have annual economic surveys in place. Countries collecting these data on a yearly basis are requested to transmit them annually (reference year - 2)

FIELDS	DEFINITION OF VARIABLES	PK*
Country	*The ISO 3-alpha code of the country under which the vessel is operating (refer to the FAO country codes list)*	X
Reference year	*The year to which the collected data refer*	X
GSA	*The geographical subarea code as reported in Appendix L of this manual (Res. GFCM/33/2009/2)*	X
Fleet segment	*The fleet segment code (Appendix B of this manual) or the code corresponding to the merged fleet segments (see section 6.2)*	X
Number of vessels	*The corresponding number of all active fishing vessels (by GSA) operating in the identified fleet segment, during the reference year*	
Personnel costs	*Crew wages, including social security costs and imputed value of unpaid labour (for example, the vessel owner's own labour)*	
Fuel consumption**	*Consumption in litres of fuel (regardless of fuel type)*	

[18] A fishing vessel is considered active according to the criteria defined in Appendix B (first footnote).

FIELDS	DEFINITION OF VARIABLES	PK*
Fuel price**	*Average price of fuel over the reference year (regardless of fuel type) in local currency per litre*	
Total fuel cost**	*Total amount paid for fuel in local currency. These data should be transmitted if no data for "Fuel consumption" or "Fuel price" are available*	
Repair and maintenance costs	*Costs for maintenance and repairs of fishing equipment, gear and vessel parts*	
Commercial costs	*Costs related to sales of vessel output. This includes fish market or wholesaler's fees, transportation of production, purchasing of ice, boxes and packaging*	
Other variable costs	*All purchased inputs (good and services) related directly or indirectly to fishing effort (for example, bait, food consumed during the fishing operation) plus the purchase of components of assets (gear or vessel), but only if these do not improve the lifetime of the asset itself (consumed within the given year)*	
Capital costs	*Depreciation costs plus Opportunity costs.* • *Depreciation costs: consumption of fixed capital; this represents the reduction in value of the fixed assets used in production during the accounting period resulting from physical deterioration, normal obsolescence or normal accidental damage.* • *Opportunity costs: the capital value is related to the opportunity cost of capital, or the required rate of return that is the rate of return that a company would otherwise be able to earn at the same risk level as the investment that has been selected. The opportunity cost of production is the value of the firm's best alternative use of its resources.*	
Value of physical capital	*Value of the vessel, i.e., the hull, engine, all on board equipment and gear. The capital stock must be valued at the prices of the current year and should be depreciated*	
Fixed costs	*The costs not directly connected with the operational activities (i.e. effort and catch/landing), which could include bookkeeping, vessel insurance, legal and/or bank expenses, annual quota for fishers' associations, dock expenses, renewal of fishing licences, etc.*	
Employment	*The number of persons working on the active fishing vessels, both on a part-time and full-time basis*	
Currency	*The currency (Euro or US dollar) in which the operating costs are reported*	

** if available

** data fields composing the primary key (PK) of the table*

Table VI.3 Socio-economics: *Species value*

Mandatory data for species Group 1 and Group 2 (on biennial basis)

Biennial transmission should only take place for those countries that do not have annual economic surveys in place. Countries collecting these data on a yearly basis are requested to transmit them annually (reference year n-2)

FIELDS	DEFINITION OF VARIABLES	PK*
Country	*The ISO 3-alpha code of the country under which the vessel is operating (refer to the FAO country codes list)*	X
Reference year	*The year to which the collected data refer*	X
GSA	*The geographical subarea code as reported in Appendix L of this manual (Res. GFCM/33/2009/2)*	X
Fleet segment	*The fleet segment code (Appendix B of this manual) or the code corresponding to the merged fleet segments (see section 6.2)*	X
Number of vessels	*The corresponding number of all active fishing vessels (by GSA) operating in the identified fleet segment, during the reference year*	
Species	*The 3-alpha code identifying the species (Appendix A of this manual)*	X
Total landing volume	*The total landing (tonnes) of the species mentioned for that fleet segment*	
Total landing value	*The total value of the landing (currency unit, for example, euro), for the species mentioned, of all active fishing vessels belonging to that fleet segment*	
Prices by commercial species	*The average value of species' prices during the reference year*	
Currency	*The currency (Euro or US dollar) in which the species value is reported*	

** data fields composing the primary key (PK) of the table*

Data (Optional) - Countries are encouraged to provide additional information regarding socioeconomic aspects, such as operating subsidies, number of people involved in the crew and divided by age, investments in physical capital, even if only one or few optional data fields are available. The full list of optional data fields is summarized in Table VI.4. Data requested in Table VI.4 are optional and may be transmitted on a biennial basis.

Table VI.4 Socio-economics: *Other economic aspects*

Optional data (on biennial basis)

Biennial transmission should only take place for those countries that do not have annual economic surveys in place. Countries collecting these data on a yearly basis are requested to transmit them annually (reference year n-2)

FIELDS	DEFINITION OF VARIABLES	PK*
Country	*The ISO 3-alpha code of the country under which the vessel is operating (refer to the FAO country codes list)*	X
Reference year	*The year to which the collected data refer*	X
GSA	*The geographical subarea code as reported in Appendix L of this manual (Res. GFCM/33/2009/2)*	X
Fleet segment	*The fleet segment code (Appendix B of this manual) or the code corresponding to the merged fleet segments (see section 6.2)*	X
Operating subsidies	*Includes direct payments, e.g. compensation for halting fishing, refunds of fuel duty or similar lump sum compensation payments.* *Excludes social benefit payments, indirect subsidies, e.g. reduced duty on inputs such as fuel, investment subsidies*	
Investments in physical capital	*Improvements to existing vessel/gear during the given year. These investments aim to improve the lifetime of the assets and are not consumed within the given year*	
Other income	*Includes other income from use of the vessel, e.g. recreational fishing, tourism, oil rig duty, etc. Also, insurance payments for damage/loss of gear/vessel*	
Full-time equivalent (FTE)	*Full-time equivalent employment, which equals the number of full-time equivalent jobs, is defined as total hours worked divided by the average annual number of hours worked in full-time jobs*	
Number of persons in the crew < 25 years-old	*For that fleet segment, the total number of persons in the crew who are younger than 25*	
Number of persons in the crew 25-40 years-old	*For that fleet segment, the total number of persons in the crew who are between 25 and 40 years-old*	
Number of persons in the crew > 40 years-old	*For that fleet segment, the total number of persons in the crew who are older than 40*	
Currency	*The currency (Euro or US dollar) in which these economic aspects are reported*	

** data fields composing the primary key (PK) of the table*

Frequency and deadline of transmission - Countries should transmit the data pertaining to year n-1, as requested in Table VI.1, by the 30th November of each calendar year (n) (Appendix O). Information in Tables VI.2, VI.3 and VI.4, pertaining to year n-2, should be transmitted on a biennial basis by the 31st May of each calendar year (n).

Biennial transmission is foreseen for countries that do not have annual economic surveys in place. Countries that collect such information on a yearly basis are requested to transmit these data (Tables VI.2, VI.3 and VI.4) annually, always considering year n-2. The following table summarizes the two possible transmission scenarios, annual and biennial, together with the data reference year(s):

YEAR OF TRANSMISSION	DATA REFERENCE YEAR(S) FOR TABLES VI.2, VI.3 AND VI.4	
	ANNUAL TRANSMISSION	BIENNIAL TRANSMISSION
2018	2016	2016
2019	2017	-
2020	2018	2017 and 2018
2021	2019	-
2022	2020	2019 and 2020
2023	2021	-
2024	2022	2021 and 2022
[…]	[…]	[…]

Data confidentiality - Data transmitted by countries will be treated in accordance with all necessary measures to comply with the GFCM security and confidentiality provisions, and with the specific provisions of related recommendations (see Table 1). Once transmitted to the GFCM, all the information in Tables VI.1, VI.2, VI.3 and VI.4 may be publicly available, in conformity with the criteria of data access policy approved by the Commission (Chapter 9).

2.6 Task VII: Biological information

Subtask VII.1 - Stock assessment input data

Description - Stock assessments are based on models of population dynamics requiring three primary categories of information: catch, abundance and biology (e.g. growth, size at first maturity and size at recruitment). All data needed to run these models and to analyse their results must be transmitted using the stock assessment forms.

Regular fish stock assessments provide fisheries managers with reliable figures for sound decision-making regarding stock management. Conservation and management measures should be based on the best scientific advice produced by the relevant subsidiary bodies. The main task of SAC and the WGBS is assessing the status of (major) stocks exploited in the GFCM area of application. It is therefore fundamental to have timely provision by countries of relevant and accurate data concerning inputs (fleets, efforts) and outputs (catches, including discards). For this purpose, SAC, taking into account the comments from the WGBS, has developed standard forms Stock Assessment Form (SAF) and procedures to present data and results on stock assessment in the Mediterranean and Black Sea.

On a yearly basis, SAC and the WGBS will identify those species/stocks that should be assessed and for which stock assessment form should be provided.

Relevant GFCM subsidiary bodies have identified a series of criteria for the selection of the stocks for which assessments should be carried out on a yearly basis (GFCM, 2015a). Some of these criteria are of a scientific nature while others are of economic or social importance. The list of criteria is reported below:

- Commercial importance.
- Shared stocks.
- Data availability.
- Social significance (sector of the fleet and or the workforce involved).
- Problematic assessment in previous years with indications of possible solutions by the WGs.
- Ecological aspects (e.g. most discarded species, species belonging to a relevant trophic level, unbalanced population, competing species, low fecundity species that are most vulnerable such as sharks and rays).

- Stability *vs*. fluctuating trends in the time series. Those stocks presenting quite stable dynamics can be assessed every two or three years, while most fluctuating ones (short lived species) should be assessed annually.
- Frequency of assessments. Priority should be given to stocks never or poorly assessed before.
- Stocks that are subject to a management plan that is existing or in the process of being developed.
- Species that can be representative of the exploitation pattern for the whole fishery.

Countries whose fisheries are based on the same stock (i.e. shared stocks) are encouraged to transmit a single stock assessment form. According to the SAC glossary, shared stocks[19] are the "stocks fished by two or more countries". The list of identified shared stocks is reported in Appendix I (GFCM, 2006).

Countries involved - This task is addressed to all countries operating in the GFCM area of application.

Data (Mandatory) - All information required to perform stock assessment should be transmitted by countries through the SAF[20]. It includes catches, fishing gear, a short description of the fleet, historical trends and biological parameters of growth and maturity, as well as a series of reference points (i.e. F, SSB etc.).

Frequency and deadline of transmission - Countries should transmit the stock assessment form, pertaining to year n-1, by the 30th September of each calendar year (n) (Appendix O). The date of data transmission will be linked to the scheduling of the GFCM stock assessment working groups and therefore may differ from year to year.

Data confidentiality - Data transmitted by countries will be treated in accordance with all necessary measures to comply with the GFCM security and confidentiality provisions, and with the specific provisions of related recommendations (see Table 1). Once transmitted to the GFCM, all the information under Subtask VII.1 may be publicly available, in conformity with the criteria of data access policy approved by the Commission (Chapter 9).

Subtask VII.2 - Length data

Description - Length data refer to the observed size frequency of fish, measured according to a given biological sampling plan. The scope of this subtask is to investigate the length distribution of the main commercial species (Appendix A - Groups 1, 2 and 3) by area and fleet segment. Samples might derive (i.e. source of data) from fishery-dependent data (observers on board, observers at landing place, at market or from any other fishery sampling programme) and/or fishery-independent data sources (experimental scientific surveys). When samples come from fishery-dependent data, only the commercial fraction should be reported. Measurements (see section 6.3.1) should be reported within size class intervals of one centimetre or half centimetre for fish (including elasmobranchs) and cephalopods. Size classes of one millimetre should be used for crustaceans. A different level of size aggregation could be requested by relevant subsidiary bodies through the stock assessment forms. For sampling purposes, the three groups of priority species (Appendix A) should be considered. Countries are requested to collect length data for all the species identified in all GFCM subregions where their fisheries take place. Exceptions can be applied according to the criteria reported in section 6.3.

Countries involved - This task is addressed to all countries operating in the GFCM area of application.

Data (Mandatory) - For all the species selected in Group 1, Group 2 and Group 3 (Appendix A), a minimum set of parameters, including the sampled number of individuals per different length class by

[19] In the Mediterranean, although the importance of shared fishery resources is widely recognized, the list of priority shared fishery stocks would require a more in-depth analysis, both in terms of consistency and homogeneity, as discussed during the 31st session of the GFCM (GFCM, 2007).
[20] www.fao.org/gfcm/data/reporting/stockassessment

fleet segment (Appendix B), should be reported (Table VII.2). The mean individual weight by length class should be also reported. The computation of the total weight of the individuals in the sample, per fleet segment and length class, can require an estimate through appropriate length-weight regression equation.

Table VII.2 *Biological information*: Length data
Mandatory data for species Group 1, Group 2 and Group 3

FIELDS	DEFINITION OF VARIABLES	PK*
Country	*The ISO 3-alpha code of the country under which the vessel is operating (refer to the FAO country codes list)*	X
Reference year	*The year to which the collected data refer*	X
GSA	*The geographical subarea code as reported in Appendix L of this manual (Res. GFCM/33/2009/2)*	X
Source of data	*Source of data: **BS** (biological sampling on board, at landing place, at market, self-sampling, others) or **SU** (scientific survey)*	X
Name of the scientific survey* **	*Full name of the scientific survey. If more than one survey is in place, this line should be repeated*	X
Fleet segment **	*The fleet segment code (Appendix B of this manual) or the code corresponding to the merged fleet segments (see section 6.2)*	X
Species	*The 3-alpha code identifying the species (Appendix A of this manual)*	X
Length	*The value of the length class of the measured individuals. Length classes should be reported in centimetres (cm), as a whole number, or in half centimetres (e.g. 0.5, 1.0, 1.5 cm, etc.) for fish (including elasmobranchs) and cephalopods. For crustaceans, length classes should be reported in millimetres (e.g. 1, 2, 3, 4 mm, etc.) (see section 6.3.1)*	X
Number of individuals sampled (per length classes)	*The total number (n) of individuals measured for that fleet segment and length class for the reference year*	
Weight of individuals sampled (per length classes)	*Mean individual weight (kg) by length class for that fleet segment and for the reference year*	
Number of individuals expanded (per length classes)	*The total number of individuals, for a given length class, expanded to the total production (e.g. landing) of each fleet segment.* *In case of an experimental survey, it should be expanded to the total catch of that survey*	

** only if from fishery-dependent data
*** if any

**data fields composing the primary key (PK) of the table*

Frequency and deadline of transmission - Countries should transmit the data pertaining to year n-1 by the 31st July of each calendar year (n) (Appendix O). Length data (Table VII.2) are mandatory for all the species identified in the priority list of species (Appendix A). Exceptions can be applied according to the criteria reported in section 6.3. Countries are encouraged to comply with this deadline and provide all requested data.

Data confidentiality - Data transmitted by countries will be treated in accordance with all necessary measures to comply with the GFCM security and confidentiality provisions, and with the specific

provisions of related recommendations (see Table 1). Once transmitted to the GFCM, all the information in Table VII.2 may be publicly available, in conformity with the criteria of data access policy approved by the Commission (Chapter 9).

Subtask VII.3 - Other biological data

Description - The objective of this subtask is to monitor and investigate the population dynamics of the most important species in the different subregions. The following variables, for at least the Group 1 species identified and listed in Appendix A, should be reported:

- length at first maturity at species level;
- individual information on maturity state;
- individual information on sex.

Samples may be collected during fishery independent surveys (if more than one survey is in place, countries should provide both data) and/or obtained from observers on board and/or at landing place, or in any other fishery sampling programme. Age data are not explicitly requested in this subtask, but should be transmitted through stock assessment forms as appropriate.

Countries involved - This task is addressed to all countries operating in the GFCM area of application.

Data (Mandatory) - The length at first maturity (L_{50}) is conventionally the size at which 50 percent of the population attains an advanced stage of gonad development. The mentioned parameter is a species-specific value that could be influenced by environmental factors (i.e. temperature, food availability) and by population (i.e. density) factors. The data needed to estimate the size at first maturity can be obtained by calculating the percentage of mature individuals per size-class (number of mature individuals/total number per size-class). The number of individuals in each size-class must be sufficient (at least a minimum of 20 per size-class) and the individuals must be collected in the period just before, or very close to, the spawning peak of the species.

Countries should provide the GFCM Secretariat with the values (Table VII.3.1) of the size at first maturity (L_{50}), for the species belonging to Group 1 (Appendix A.1). If the size at first maturity is not estimated through sampling but taken from literature, countries should provide all references. If available (optional), countries are encouraged to provide these data also for species belonging to Groups 2 and 3.

Only for the priority species identified in Group 1, countries should provide the GFCM Secretariat also with the number of fish individuals measured by sex and maturity (Table VII.3.2) and per the identified fleet segment (Appendix B). Exceptions can be applied according to the criteria reported in section 6.3.

Table VII.3.1 *Biological information*: Size at first maturity
Mandatory data for species Group 1

FIELDS	DEFINITION OF VARIABLES	PK*
Country	*The ISO 3-alpha code of the country under which the vessel is operating (refer to the FAO country codes list)*	X
Reference year	*The year to which the collected data refer*	X
GSA	*The geographical subarea code as reported in Appendix L of this manual (Res. GFCM/33/2009/2)*	X
Species	*The 3-alpha code identifying the species (Appendix A of this manual)*	X
Sex	*The code for the sex:* ***M*** *(Male),* ***F*** *(Female)* ***F+M*** *(sex combined)*	X
L_{50}	*The size at first maturity (L_{50} - length at which 50% of the fish are mature), for that species*	
Reference**	*If the size at first maturity is not estimated through sampling but taken from literature, enter the complete bibliographic reference. If available, please enter reference data also for Group 2 and Group 3 species.*	

** if any

** data fields composing the primary key (PK) of the table*

Table VII.3.2 *Biological information*: Maturity data
Mandatory data for species Group 1

FIELDS	DEFINITION OF VARIABLES	PK*
Country	*The ISO 3-alpha code of the country under which the vessel is operating (refer to the FAO country codes list)*	X
Reference year	*The year to which the collected data refer*	X
GSA	*The geographical subarea code as reported in Appendix L of this manual (Res. GFCM/33/2009/2)*	X
Source of data	*Source of data:* ***BS*** *(biological sampling on board, at landing place, at market, self-sampling, others) or* ***SU*** *(scientific survey)*	X
Name of the scientific survey* **	*Full name of the scientific survey. If more than one survey is in place, this line should be repeated*	X
Fleet segment **	*The fleet segment code (Appendix B of this manual) or the code corresponding to the merged fleet segments (see section 6.2)*	X
Species	*The 3-alpha code identifying the species (Appendix A of this manual)*	X
Length	*Value of the length class of the measured individuals. Length classes should be reported in centimetres (cm), as a whole number, or in half centimetres (e.g. 0.5, 1.0, 1.5 cm etc.) for fish (including elasmobranchs) and cephalopods. For crustaceans, length classes should be reported in millimetres (e.g. 1, 2, 3, 4 mm, etc.). (see section 6.3.1)*	X
Sex	*The code for the sex of sampled individuals:* ***M*** *(Male),* ***F*** *(Female)* ***U*** *(Undetermined),* ***ND*** *(Not Determined)*	X
Maturity	*The corresponding maturity stage, as reported in Appendix G of this manual*	X
Number of individuals sampled (per length class, sex and maturity stage)	*The total number (n) of individuals measured per fleet segment, length class, sex and maturity stages for the reference year*	
Weight of individuals sampled (per length class, sex and maturity stage)	*Mean individual weight (kg) by length class for that fleet segment and for the reference year*	
Number of individuals expanded (per length class, sex and maturity stage)	*The total number of individuals per length class, sex and maturity, expanded to the total production (e.g. landing) of each fleet segment. In case of an experimental survey, it should be expanded to the total catch of that survey*	

** only if from fishery-dependent data
*** if any

**data fields composing the primary key (PK) of the table*

Frequency and deadline of transmission - Countries should transmit the data pertaining to year n-1 by the 31st July of each calendar year (n) (Appendix O). Data requested in Tables VII.3.1 and VII.3.2 are mandatory only for species identified in the Group 1 list (Appendix A.1). If available, countries are encouraged to also transmit data for all other species identified in the priority list of Group 2 and Group 3 species (Appendixes A.2 and A.3). Countries are encouraged to comply with this deadline and provide all requested data.

Data confidentiality - Data transmitted by countries will be treated in accordance with all necessary measures to comply with the GFCM security and confidentiality provisions, and with the specific provisions of related recommendations (see Table 1). Once transmitted to the GFCM, all the information in Tables VII.3.1 and VII.3.2 may be publicly available, in conformity with the criteria of data access policy approved by the Commission (Chapter 9).

Subtask VII.4 - Dolphin fish

Description - The objective of this task is to collect information on fishing activities related to dolphin fish (*Coryphaena hyppurus)*. Dolphin fish is an epipelagic species living in open waters, but which also approaches the coast, following ships and gathering in small groups below floating objects. Commonly, fishing Aggregation Devices (FADs) are used to concentrate dolphin fish before the nets are set. This is a traditional fishery, particularly for the western-central Mediterranean.

Countries involved - This task is addressed to Italy, Libya, Malta, Spain and Tunisia.

Data (Mandatory) - Countries should communicate to the GFCM Secretariat data on the year, fishing period, GSAs of fishing operation, total landing and number of active fishing vessels involved (Table VII.4.1).

Table VII.4.1 *Dolphin fish*: General information
Mandatory data

FIELDS	DEFINITION OF VARIABLES	PK*
Country	*The ISO 3-alpha code of the country under which the vessel is operating (refer to the FAO country codes list)*	X
Reference year	*The year to which the collected data refer*	X
Fishing period	*The starting (1-12) and the ending month (1-12) of the fishing period*	X
GSA	*The geographical subarea code, of the fishing operation, as reported in Appendix L of this manual (Res. GFCM/33/2009/2)*	X
Total landing	*The total landing (sum in tonnes) of the dolphin fish in the GSA.*	
Number of vessels	*The corresponding number of all active fishing vessels (by GSA) involved in the fishery of dolphin fish during the reference year*	

**data fields composing the primary key (PK) of the table*

Data (Optional) - Countries are encouraged to provide additional information by GSA, even if only one or few optional data fields are available on aspects related to the dolphin fish fishery. In order to better monitor the total effort, countries should possibly communicate the FADs that were visited and where no fish was found as well as the FADs that were visited and where net was deployed. The full list of optional data fields is included in Table VII.4.2.

Table VII.4.2 *Dolphin fish*: Dolphin fish statistics
Optional data

FIELDS	DEFINITION OF VARIABLES	PK*
Country	*The ISO 3-alpha code of the country under which the vessel is operating (refer to the FAO country codes list)*	X
Reference year	*The year to which the collected data refer*	X
GSA	*The geographical subarea code, of the fishing operation, as reported in Appendix L of this manual (Res. GFCM/33/2009/2)*	X
Total GT of vessels	*Total (sum) gross tonnage (GT), of the active fishing vessels involved in the fishery of dolphin fish*	
Length range of vessels (m)	*The minimum length (in meter) and the maximum length (in meter) of the active fishing vessels involved in the fishery of dolphin fish*	
Average length of vessels (m)	*Value of the mean length (m) for the active fishing vessels involved in the fishery of dolphin fish*	
Total number of FADs	*Total number (sum) of FADs employed during the reference year*	
Total number of fishing trips	*Total number (sum) of trips carried out during the reference year*	
Number of FADs targeted per fishing trip	*Average value of FADs fished per fishing trip where a net was deployed to catch aggregated fish*	
Number of FADs visited per fishing trip	*Average value of FADs visited per fishing trip, including both FADs which were visited but where no dolphin fish were found and FADs where a net was deployed to catch aggregated fish*	
Average size of fish caught during the fishing season	*Average size (in cm) of dolphin fish caught during the reference period*	
Total transhipments	*If present, the weight (tonnes) value of total trans-shipment occurred during the reference year*	
System of collection and treatment of catch and effort data	*"Yes" or "No" if in the country exists any system of collection and treatment of catch and effort data*	

**data fields composing the primary key (PK) of the table*

Frequency and deadline of transmission - Countries should transmit the data pertaining to year n-1 by the 31st July of each calendar year (n) (Appendix O). Collection for data present in Table VII.4.1 is mandatory. However, if additional data are collected, countries are invited to provide these in Table VII.4.2.

Data confidentiality - Data transmitted by countries will be treated in accordance with all necessary measures to comply with the GFCM security and confidentiality provisions, and with the specific provisions of related recommendations (see Table 1). Once transmitted to the GFCM, all the information in Tables VII.4.1 and VII.4.2 may be publicly available, in conformity with the criteria of data access policy approved by the Commission (Chapter 9).

Subtask VII.5 - Red coral

Description - The GFCM has engaged in several initiatives to improve knowledge on red coral (*Corallium rubrum*) with the aim of developing a regional management plan. As a result, the Recommendation GFCM/43/2019/4 involving data transmission by countries harvesting red coral was issued.

Catch and effort data, by fishing ground, statistical grid[21] (Appendix M) and depth are presented together with their definitions in Table VII.5. Other information on red coral (e.g. biological data) from research projects should be requested through a stock assessment form when an assessment is being performed.

For the purpose of this framework, and for red coral only, the following definitions apply:

- *Fishing ground* - The name of the "area" to be provided in the harvest table. This refers to a distinct identifier, such as a national code or name designated by local authorities, or to a practical common sense designation to describe a distinct area where harvest takes place.
- *Population* - This refers to a set of patches that are not isolated from each other (i.e. larvae can be carried by the currents from one patch to another in a few days). For practical purposes, this can also be identified as a "bank". A fishing ground, in the sense defined above, can be constituted by more than one population.
- *Colony* - A coral colony refers to what we see as one coral. This is one whole "tree". It is actually a colony of many small white polyps. Polyps are individuals because they can be removed and grow a new colony through asexual reproduction (i.e. coral "tree"). Each coral starts as one larva that metamorphoses into a first polyp and then multiplies, building the whole colony. There are male and female polyps/colonies which reproduce sexually to create new larvae that settle and create a new coral.

Countries involved - This task is addressed to Algeria, Croatia, France, Greece, Italy, Morocco, Spain and Tunisia.

Data (Mandatory*)* - Total weight (kg), effort (days at sea), average diameter (mm) of the colonies (branch diameter measured at 1 cm above the base) as well as the percentage of the total weight which corresponds to colonies smaller than 7 mm in diameter recorded in the fishing ground are mandatory (Table VII.5). Data should be reported by GSA, statistical grid (Appendix M) and fishing ground.

[21] www.fao.org/gfcm/data/maps/grid

Table VII.5 Red coral: *Harvest*
Mandatory data

FIELDS	DEFINITION OF VARIABLES	PK*
Country	*The ISO 3-alpha code of the country under which the vessel is operating (refer to the FAO country codes list)*	X
Reference year	*The year to which the collected data refer*	X
GSA	*The geographical subarea code as reported in Appendix L of thiss manual (Res. GFCM/33/2009/2)*	X
Statistical grid	*The statistical grid code[22] as per Appendix M of this manual (Rec. GFCM/35/2011/1)*	X
Fishing ground (name)	*The name of the "fishing ground" as an alphanumeric string. This can be a name or a national code that identifies the specific area where the catches occur. This name should be assigned by the country.*	X
Name of landing port	*The name of the authorized port where red coral catches from the reported fishing ground are landed*	X
Effort (number of days)	*Number of days at sea (with or without harvesting)*	
Depth (exact or range in m)	*The exact depth (meter) of the dive at which the harvest took place, if available. If unavailable, a range (minimum and maximum depths) for the several dives of the season in the reported fishing ground.*	
Total weight	*The total number of kg (sum) harvested in the reported fishing ground*	
Percentage (%) in weight of undersize colonies	*Percentage of the total weight of undersize colonies recorded in the fishing ground that correspond to colonies with less than 7 mm diameter (measured at 1 cm of the base)*	
Average diameter (mm)	*Average diameter of the colonies referred to the weight recorded for the reported fishing ground*	

**data fields composing the primary key (PK) of the table*

Frequency and deadline of transmission - Countries should transmit the data (Table VII.5) pertaining to year n-1 by the 30th June of each calendar year (n) (Appendix O). Countries are also invited to provide data relating to the biology of red coral (through a specific stock assessment form), if an assessment is being performed.

Data confidentiality - Data transmitted by countries will be treated in accordance with all necessary measures to comply with the GFCM security and confidentiality provisions, and with the specific provisions of related recommendations (see Table 1). Once received by the GFCM Secretariat, all information contained in Table VII.5 may be made available to an external audience following the specific criteria approved by the Commission (Chapter 9).

Subtask VII.6 - European eel

Description - The objective of this task is to collect information on fishing activities related to European eel (*Anguilla Anguilla*). The European eel is distributed across the majority of coastal countries in Europe and North Africa, with its southern limit in Mauritania (30°N) and its northern limit situated in the Barents Sea (72°N), and spanning all of the Mediterranean basin. The newly hatched *leptocephalus* larvae drift with the ocean currents to the continental shelf of Europe and North Africa where they metamorphose into glass eels and enter continental waters. The growth stage, known as "yellow eel",

[22] www.fao.org/gfcm/data/maps/grid

may take place in marine, brackish (transitional), or fresh waters. Once the maturing stage of "silver eel" is reached, the individuals then migrate to the Sargasso Sea where they spawn and die after spawning, an act not yet witnessed in the wild (ICES, 2014). Fisheries (e.g. fixed traps, fixed and mobile net gear, and rod and line - Appendix H.2) exploit the phase recruiting to continental waters (glass eel), the immature growth phase (yellow eel) and the maturing phase (silver eel). The exploited life stage and the gear types employed vary between local habitat, river, country and international regions (Appendix H.1). Eel's data should be reported at country level.

Detailed information on eel (i.e. biological data, growth parameters) should be reported through a stock assessment form when an assessment is being performed.

Countries involved - This task is addressed to Albania, Algeria, Croatia, France, Egypt, Greece, Israel, Italy, Libya, Montenegro, Morocco, Spain, Syria, Tunisia, and Turkey.

Data (Mandatory) - Countries should transmit to the GFCM Secretariat, for each site and gear type, their data on the reference year, habitat (Appendix H.1), gear types (Appendix H.2), total catch per life stages, fishing days carried out by each gear as well as a the estimated effort (Table VII.6).

Table VII.6 *Eel*: General information
Mandatory data

FIELDS	DEFINITION OF VARIABLES	PK*
Country	*The ISO 3-alpha code of the country under which the vessel is operating (refer to the FAO country codes list)*	X
Reference year	*The year to which the collected data refer.*	X
Habitat	*The code of the habitat where at a given life stage (i.e. yellow, glass, silver) eels are fished (Appendix H.1 of this manual).*	X
Site	*The name of the "site". This can be a name or a national code that identifies the specific area where the catches occur. This name should be assigned by the country.*	X
Gear types	*The code of the gear (Appendix H.2 of this manual) used to fish eel.*	X
Mesh size	*The smaller mesh size of the gear used (only in the case of nets)*	
Number of fishermen	*Number of fishermen using the reported gear type targeting only eel in the reported site.*	
Fishing days	*The total annual number (sum) of fishing days by gear type.*	
Average number of "gear units" per day per fisherman	*The daily average of gear units by fisherman. Gear units depend on the gear types (Appendix H.2 of this manual). It could refers to the number of fyke nets, number of hooks, length of nets, etc.*	
Total catch of silver eel	*The total catch (kg) of eels at the silver life-stage for the reported gear type*	
Total catch of yellow eel	*The total catch (kg) of eels at the yellow life-stage for the reported gear type.*	
Total catch of silver and yellow eel	*The total catch (kg) of eels at the silver and yellow life-stage for the reported gear type.*	
Total catch of glass eel	*The total catch (kg) of eels at the glass eel life stage for the reported gear type.*	
Stocking lifestage	*The code of the life-stage (Appendix H.3 of this manual) of the released stock.*	
Stocking (kg/year)	*The total biomass (Kg/year) of the released stock.*	

**data fields composing the primary key (PK) of the table*

Frequency and deadline of transmission - Countries should transmit the data pertaining to year n-1 by the 30st September of each calendar year (n) (Appendix O). Data requested in Table VII.6 are mandatory.

Data confidentiality - Data transmitted by countries will be treated in accordance with all necessary measures to comply with the GFCM security and confidentiality provisions, and with the specific provisions of related recommendations (see Table 1). Once transmitted to the GFCM, all the information in Table VII.6 may be publicly available, in conformity with the criteria of data access policy approved by the Commission (Chapter 9).

Subtask VII.7 - Ecosystem indicators

Description - Indicators on the effects of fishing on marine communities are essential to support an ecosystem approach to fisheries management and to monitor the impact of fishing activities on the environment as well as the status of exploited fish stocks.

Taking into account the proposal made by the SAC at its sixteenth session (GFCM, 2014d), the following set of common indicators to monitor fisheries resources in the Mediterranean areas was selected:

1) Spawning stock biomass
2) Total landings
3) Fishing mortality
4) Fishing effort[23]
5) CPUE (or LPUE as a *proxy*)
6) Incidental catch of vulnerable and non-target species

Those indicators were proposed bearing in mind the feasibility of collecting associated data, including from fishery-dependent or fishery-independent sources. In general, these could be considered as common indicators throughout the GFCM area of application. Technical work will investigate the methodology to estimate the various indicators proposed, assess their performance as well as their aggregation at the regional and subregional level. It is expected that once the SAC have a clear description of each indicator, they will be incorporated in the DCRF manual.

[23] Those indicators have been agreed upon during the GFCM Scientific Advisory Committee on Fisheries (SAC) at its seventeenth session (GFCM, 2015c).

PART 2

COMMON PRACTICES IN DATA COLLECTION

Introduction

The DCRF is the framework of the GFCM subsidiary bodies for the collection and transmission of the fisheries-related data, as per existing GFCM Recommendations. These data are necessary for the provision of advice in support of decision making. Data collection is crucial to achieve appropriate fisheries management in the GFCM area of application. Countries should therefore provide their best available information in terms of quality and comprehensiveness. The DCRF aims to provide countries with all useful indications for the collection of fisheries data in a standardized way.

The fisheries data collection (FAO, 1999; Sparre, 2000) can be defined as the record of measures of one or more variables from members of a population (e.g. recording the number of trips from a population of fishing vessels).

Regarding sources, the methods for collecting useful information to assess the status of the resources can be derived from the following categories:

fishery-dependent data
: are data obtained from commercial fisheries. There are a variety of approaches for obtaining fishery-dependent data. These consist, for example, of sampling catches and effort at landing sites. Related socio-economic information (i.e. fuel, general costs of fishing trips) and biological information (i.e. species, length) can also be obtained through the use of on board observers, self-reporting, logbooks, sale notes, telephone surveys and/or other sources.

fishery-independent data
: are data obtained from scientific surveys. Surveys are designed to develop unbiased estimate (e.g. indices of abundance) which are independent from commercial fisheries. Since data from surveys are not influenced by specific management measures (e.g. mesh size, limits on number of hooks, seasonal closures), or socio-economic factors, they provided an unbiased image of the fishery.

The collection and accurate interpretation of both fisheries-dependent and independent data are of fundamental importance to understanding the status of exploited resources. Both types of methods should be combined, in order to gain a more accurate picture of the status of resources.

Chapter 3 - Sampling overview

Ideally, in any data collection, all members of a population should be measured. This is hardly feasible, and generally, there is a need to do some kind of sampling. Depending on the different size of the population to be measured, there are two basic data collection methods:

- by *census* (where all members of the whole population are measured);
- by *sampling* (where only a portion of members of the whole population is measured).

Fishery *census* is normally conducted by making a complete record of data from all individuals in the target population. The key advantage of a census is that the estimates are known with certainty. The main disadvantage is the considerable cost involved in collection (e.g. the cost of collecting/interviewing every fisher to obtain data would be prohibitive) and the subsequent compilation of all the data collected. This is generally beyond the budget of most fisheries research centres. For example, the use of a logbook to record fisheries data could be considered as a census, since it (theoretically) requires all vessels that meet certain characteristics to provide the required data. A successful logbook scheme should provide information on quantities of fish retained for landing (per species), fishing effort, landing per unit effort, fishing strategies and details of fishing vessels. The success of a logbook scheme as a census approach will partly depend on the attitudes of those compiling it and on the quality of the data that it may contain.

In a *sampling* procedure, the sample must be representative of the target population as a whole. The key advantage of the sample survey is that the amount of data to be collected and analysed is smaller than in the case of a census. Disadvantages of this system are that samples may not be fully representative, as well as problems of accuracy.

The most common groups of sampling procedures are random sampling and stratified sampling:

- *Random sampling* - this type of sampling involves a selection process in which each member of the population has an equal and independent chance of being selected. In random sampling, there is effectively no control over the sampling probabilities.

- *Stratified sampling* - in this type of sampling, not every member of a population has an equal chance (greater than zero) of being included in the sample. This type of sampling is less likely to produce representative samples than random sampling. In stratified sampling schemes, individuals can be selected on an opportunistic, or on an *ad hoc* basis.

When individuals are selected randomly within strata that have been previously defined, the procedure is called *stratified random sampling*. This system is commonly applied to fisheries.

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. The target population, the observable subset (sample) and the assumed link between them should be clearly identified. 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 the vessels in the fleet, but the observable population might only consist of those vessels which, 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. For biological studies, the population of interest could be all fish in the stock. But the observable population might be restricted to the accessible part of total landings from that stock.

There is no single prescription for the optimum design of a data collection scheme. Generally, it is not feasible to design a perfect sampling strategy for all fisheries, because the underlying conditions may vary from place to place and between 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. Taking all these considerations into account, the data collection strategy might, over time, move from a census to a sampling approach (or *vice versa*), as knowledge develops and requirements or resources change.

Steps in data collection

1) *Define the variables of interest to be collected (e.g. landing, effort, catch, biological and/or economic data etc.).*
2) *Define the population.*
3) *Evaluate existing data sources in relation to the programme objectives.*
4) *Evaluate accessibility of the data.*
5) *Evaluate cost-effectiveness and operational considerations (institutional, financial and human resources).*
6) *Collecting data:*
    - *a) by census;*
    - *b) by sampling;*
        - *b.1) stratified sampling;*
            - *define the sample strata (e.g. fleet segment);*
            - *define the sample unit (e.g. vessel, fishing trip);*
            - *define the stratification criteria and scale (e.g. temporal, geographical);*
            - *define the optimum sample size in each stratum (e.g. how many sample units must be collected in each stratum?).*
        - *b.2) random sampling (random selection of a number of elements from the population as whole, or from each stratum in the stratified random procedure).*
7) *Provide an indicator of quality as estimated from the information collected.*

Another challenge is that the information provided is widely acknowledged as scientifically valid. Particular attention should be placed on acquiring the most reliable information in order to avoid a perception that collected data are of poor quality, and, by extension, that scientific and management advice based on such data is weak too. Appropriate statistical procedures must be applied to estimate the allowable margin of error. In the GFCM context, countries are responsible of data quality and should ensure the accuracy, minimum bias and completeness of the data transmitted.

Countries are expected to:

- develop statistically robust sampling design methods, with the minimum degree of associated error;
- identify strata that are representative of the population and capable of providing sufficient data for the required population;
- take into account temporal (e.g. monthly/quarterly) and spatial (e.g. GSA) segregation.

Chapter 4 - Acquisition of landing and effort data

Landing is usually considered as the amount (weight) of the catch harvested from the sea and brought ashore. Fishing effort is the amount of time and fishing capacity (e.g. GT) used to harvest fish. Effort measurements therefore allow an estimation of the pressure placed by fishing activities on fish stocks.

Landing and effort data may come from different sources and are usually derived from a combination of catch reports, logbooks, observers, market and/or landing survey or landing statistics from port authorities. They can be measured and classified by species, area, fishing gear used, and other factors, and can be collected during the same sampling process, or independently from each other.

Monitoring, both landing and effort, is fundamental to evaluate the performance of a fishery. This information, which could be also coupled with information on fish prices (Chapter 5), will make possible to keep track of the growth of a fishing fleet, evaluating changes in the status of the resources and performing basic analysis of the economic performance of fishing vessels.

Wherever possible, landing and effort data should be collected in an exhaustive way. A census approach would be ideal. However, in many cases, due to budget and human constraints, and due to the fact that in the region there are a very large number of fishing vessels landing their catches in a large number of small landing places, an appropriate sampling system is required (Sparre, 2000; Stamatopoulos, 2002; ICES, 2008).

For the collection of the requested data, the target population should comprise all the vessels, which in most countries could be derived from the fleet register on a yearly basis. Once the population is identified, it can be split and aggregated into homogeneous sampling strata (e.g. fleet segments), on the basis of fishing activity (e.g. trawlers, polyvalent), and of other similar physical characteristics (e.g. total length), as well as of geographical location (i.e. GSA). Within a country or subregion for example, the combination of industrial (i.e. trawlers) and artisanal fisheries plays an important role in sampling design, each having its own characteristics, its own relative importance and its own potential for the supply of data. A trawler may land once every two/three days, while a purse seiner with a small net may land every day, with a combination of species/individuals that is greater than that of a small vessel operating with artisanal gear (i.e. gillnet, trammel net) in the coastal zone. The sample units (i.e. vessels) are then selected randomly (or under some statistical criteria) within each of the stratum identified.

Furthermore, collecting and reporting fisheries statistics (i.e. landing and effort) from different countries and institutions generate a great variety of formats and contents of reported data (e.g. different units of measurement, the definition of statistical areas, the degree of coverage of the data collection system and other important measures). For example, the effort is routinely measured in units of time and/or amount of gear used, but alternative definitions exist, depending on the nature of the fishing unit (e.g. fishing vessel, gear) and the amount of resources expended by that unit. For this reason information should be collected in the most harmonized way. That is one of the purposes of this manual, which recommends that effort data be reported according to the variables and aggregation levels as reported in Appendix F (by fleet segment - Appendix F.1, and by gear - Appendix F.2).

A major shortcoming in using landing data is also the species misidentification. Accurate species identification is one of the most important and difficult aspects of fishery-dependent sampling and is crucial to good fishery management. For many fisheries, however, estimating species-specific landings and the associated uncertainty can be difficult, especially in the case of complex multispecies fisheries: many groups of species (e.g. cephalopods and sharks, but also fish species) are difficult to identify and there are many species still awaiting formal scientific description. In some countries/areas, these difficulties in species identification have led to aggregated data simply being recorded as “sharks” or “Mullidae” or “Cephalopods”. Every effort should be made to ensure that the total landing of the commercial species is correctly identified and reported at species level. Moreover, it is important to use the FAO three-alpha code and, where requested, the Latin binomial (i.e. scientific name), genus and species, in order to avoid any confusion between local names.

Chapter 5 - Acquisition of socio-economic data

The aim of a systematic collection of socio-economic data is to calculate appropriate fisheries indicators, so as to assess the economic and social aspects of fisheries and to evaluate the effects of management measures. The list of socio-economic variables (Task VI) considered in this manual allows the calculation of the most often used and efficient indicators. In general terms, socio-economic data can be collected through a census or a sample survey (Chapter 3). When considering the methodologies used in the collection and compilation of economic data, it is essential to bear in mind the wide variation in the structure of the fishing "industries" in the region. In particular, in the Mediterranean and Black Sea, there are a large number of fishing vessels operating as individual small enterprises, or small fishery enterprises managed at family level, while the fleets organized as large or medium enterprises represent a smaller share in terms of the number of units. In these cases, collection of accurate socio-economic data can be difficult, because access to primary data is fragmented and not structured in well-organized accounting systems. The typology of fishing enterprises also affects data collection methodologies, because in most cases the primary source of information is represented by *ad hoc* questionnaires and not by official balance sheets.

5.1 Data on revenues, expenditures, employment, prices by species and investments

Due to the structure of the Mediterranean and Black Sea fisheries, an appropriate sampling system has to be preferred to a census approach. The sampling survey (e.g. through questionnaires) may provide representative data that can be extended to the population as a whole.

A range of sampling methods could be employed to improve the likelihood that the sample is representative, although a risk always remains that the sample estimates are biased (e.g. the sample could be different in some way to the target population as a whole). However, as the standard error decreases with sample size, statistical techniques can assist in determining the optimal sampling sizes for a desired level of precision and confidence (Sabatella & Franquesa, 2004).

The use of a stratified random sample approach reduces the potential for sample bias, but requires additional information on the target population prior to sample selection. Where the complete sample for particular fleet segments cannot be achieved due to non-response, bias can be reduced by assigning weights to the individual sample responses, so as to rebalance the data. The potential bias arising directly from non-response can be reduced through the replacement of the non-responding boats by boats with similar characteristics, on the assumption that the similar boat is as representative as the boat that failed to respond (Sabatella & Franquesa, 2004).

Data on expenditures include crew wages (e.g. social security costs), energy costs (e.g. total energy costs of the vessel, obtained by multiplying the average annual costs of fuel per litre by the total amount of litres used), and other variable costs (e.g. production shipping, purchase of ice, purchase of boxes etc.).

Employment data refer to full-time equivalent (FTE - see section 5.3) and total employment (i.e. number of jobs on board, equal to the average number of persons working for and paid by the vessel).

Price by species can be considered as the value of landed products calculated on the basis of the ex-vessel (first sale) price of the products by target species. Investments relate to any improvement made to existing vessel/gear during the reference year.

5.2 Capital value and capital costs

Capital value is the sum of all assets (or liabilities) presented on the annual balance sheet. The capital value of the fishing firms considered for the scope of the DCRF comprises the following components:

- Fixed tangible assets - sea-based = vessel, engine, electronics, other equipment on board.
- Fixed tangible assets - shore based = buildings, cars and other facilities on shore.

The value of intangible assets (licences, quota, permits, etc.) plays an important role in operational decisions of fishing companies. However, this value is often difficult to estimate and it has therefore been excluded from this manual.

The estimation of capital value and capital costs should preferably follow the Perpetual Inventory Method (PIM), which is the most important international standard for valuation of tangible capital goods. This method has been exhaustively described by the OECD and is used by national statistical offices and the Farm Accounting Data Network in agriculture (Anonymous, 2011).

PIM proposes to determine the aggregated value of the tangible capital goods used in the current year by aggregating the value of all vintages (year classes). Such aggregation can be based either on historical, current or constant prices. Once the value of the capital goods in a given benchmark year has been determined, the capital value of each subsequent year is calculated by adding investments of that year (gross capital formation), revaluing the existing stock and subtracting the value of capital goods taken out of operation. The capital costs (depreciation and interest) are then calculated using an agreed depreciation schedule and interest rate.

Detailed descriptions of the methodologies to calculate the perpetual inventory method (PIM) are reported in *The Workshop on Calculating Capital Value Using PIM and Definition of DCF variables* (Anonymous, 2011).

The price per capacity unit is the main item for the entire valuation of Gross Capital Stock in fisheries. Its determination requires careful interpretation of the information collected on values of vessels and, if necessary, its adaptation. First, it is important to determine which value indicators can be reliably observed and collected. In principle, three or four types of observable value indicators exist:

- Historic prices, i.e. prices currently paid for newly constructed vessels.
- Second hand prices, i.e. prices currently paid for used vessels.
- Insurance premiums, which are based on insurance values, so insurance values can be derived from them.
- Insurance values, collected, for example, from company administrations or insurance companies.
- Book value as presented on the balance sheets (IREPA, 2006).

5.3 Full-time equivalent

Full-time equivalent (FTE) or “Full-time equivalent employment”, which equals the number of full-time equivalent jobs, is defined as total hours worked divided by the average annual number of hours worked in full-time jobs.

Assuming a full-time fishing year of 2000 hours (as in agriculture), labour input below this level should be considered as part-time. However, standard working time may vary by country and by economic activity or even by region. This means that different standard working times (thresholds) could be applied to different fisheries (country and fleet segments) in order to calculate FTE.

Chapter 6 - Acquisition of biological data

In order to obtain a complete overview of the fishery it is also necessary to monitor some biological variables of living resources (e.g. length distribution, age, weight, sex and maturity). Biological features of the individuals provide demographic information that is crucial for the assessment of stocks, which form the cornerstones of fishery management. For example, information on maturity affords an important understanding of biology and reproduction for initial management purposes and enables the separation of estimates of abundance into values representing the immature and mature populations; age provides a basis for estimating growth and mortality year-class strength variation. Therefore, it is crucial that this information is collected in a standardized and homogenous way.

Since sampling all fleet segments and all commercially important species could be difficult, biological data should only be reported for the major fleet segments and for the major group of species identified at the subregional level (Appendix A and section 6.3). The most important fleet segments can be identified and defined according to the procedure described in section 6.2.2.

6.1 Sampling from different data sources

As mentioned previously, the methods for collecting useful information on biological variables could be subdivided into fishery-dependent and fishery-independent data sources. Fishery-independent data collection from scientific surveys is not always possible: in some countries for example, due to their high costs, annual surveys are not carried out on a regular basis. On the other hand, fishery-dependent sources are more common. Each of these options has positive and negative aspects and the decision on whether to use any of these usually depends on different factors - such as the number of vessels in the fishery, the length of fishing trips, the type of required data and funding available to support data collection. A combination of two or more methods (e.g. sampling on board + at landing) is usually required for an adequate data collection.

In the case of biological variables, sampling strata are still represented by fleet segments, but the sampling unit is the fishing trip, which in the Mediterranean and the Black Sea, is equivalent in most cases to a fishing day (one fishing trip = one fishing day). The fishing trip duration is the time elapsed from the moment when the vessel leaves the port until the moment when it returns to the port. The basic assumption is that when a fishing trip includes more than one fishing day, it should be broken down into fishing days (see also scheme below). This assumption is necessary in order to harmonize data and results between fleet segments, countries and years.

Example of conversion of fishing trips into fishing days for a given vessel. The last row reports the total number of fishing days.

	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 the year	120	125	150

Ideally, the number of fishing trips to be sampled defined in proportion to the fishing effort (e.g. number of days at sea for each fleet segment) of the previous year(s). The minimum number of fishing days to be sampled should be at least one fishing day per month during the fishing season.

Biological data sources

(a) Sampling at landing/market places (fishery-dependent data)

(b) Sampling on commercial vessel (fishery-dependent data)

(c) Self-sampling (fishery-dependent data)

(d) Sampling on research vessel for experimental or/and scientific survey (fishery-independent data)

(a) Sampling at landing/market places

The collection of information through fisheries observer programmes at market/landing places is one of the most common methods used worldwide to collect biological data, species composition, etc. This is the preferred means of gaining accurate and in-depth data, although in most cases this may be restricted by a requirement to purchase fish. During sampling, it may be possible to collect a variety of information, including fishing location and depth, type and amount of gear used, species identification and biological samples (i.e. length and weight). As reported in section 6.1, for the collection of biological data, the sampling unit is often linked to a fishing day/trip.

At the landing place, fish may be found in several different ways, as a bulk of mixed species, or separated by species (in boxes), or even by size categories. In all cases, when the total landing of a given species, or a fraction of a given species (e.g. juveniles or small size fish), is too abundant, it seems reasonable to make a sufficiently representative subsample. Statistical techniques, beyond the scope of this manual, must be applied to obtain the optimum sample size (Gulland, 1966; Cochran, 1977; Baird, 1983; Pauly, 1983; Galluci *et al.*, 1996).

For instance, to get data on the length composition of individuals in the landing, a subsample (e.g. a box) should be selected randomly from each fishing day per target species, also recording the total weight of the catch of that particular species. All the size categories of a given species should be represented in the sample (note: it is important not to collect biological parameters for only small or large individuals). These measurements can either be taken directly at the landing place (when feasible), or the sample can be purchased in order to collect additional biological parameters, such as age, individual weight, sex and maturity stages, and assess them later in the laboratory.

- Sampling mixed species - When faced with a mix of species for sampling, the first basic task is to estimate the proportions of each one in the bulk load. In this case, it will probably be necessary to take larger subsamples of fish from each location in the bulk. Each subsample should be of approximately similar size. There is no guarantee that a large load of fish will be homogeneously mixed. Ideally, sampling would give each fish in the load an equal chance of inclusion in the sample, but this is seldom achievable in practice, given restricted physical access, time and other difficulties. Therefore, to maximize the accuracy of the mean of the sample, the sample should be made up of subsamples of the species taken, for example, from several boxes. If this is impractical, collection of data should try to devise other practical ways to minimize the influence over the choice of individual species, so that all possible classes are present in the sample in roughly the same proportions as they are in the bulk. To improve accuracy further, the number of species collected in a sample should be large, but only if the species are selected independently.

- Sampling single species - For species divided into size categories, following market demand, a sample should be collected from each size category. To maximize accuracy in this case, the sample should be a composite from subsamples of individuals taken from several size

categories. It is essential to record the total weight of landing for that species and, if present, for each size category.

(b) Sampling on board commercial vessel

At sea, ideally fishery observations should make a more precise record of the weight and/or number of individuals by species and per fishing hauls. Sampling on a boat poses many difficulties, apart from those associated with working on an unstable platform. On board commercial vessels, the data collectors must work in a way that will cause the least possible interference with the normal work of the crew and often, they will have a very limited time in which to obtain their samples. If it is not feasible to sample the entire fishing trip, some hauls should be taken randomly. There is no predefined list of hauls upon which one can base a random sample. The idea could be to make a kind of systematic sampling, spreading the samples equally during fishing day(s). On board, catches are often split into categories and subcategories depending on commercial values. For each main commercial species, the total weight should be collected.

(c) Self-sampling

Self-sampling occurs when fishers themselves collect, and sometimes process, biological samples and report on these. It is a tool that has been developed recently to obtain data in an affordable manner, often producing a higher rate of coverage (in time and space). At-sea sampling of commercial fishery catches by observers could result in a relatively expensive exercise, in terms of cost and human resources. From this perspective, sampling by fishers (self-sampling) may offer an alternative, since a larger number of trips can be sampled at a lower cost. However, a major problem with the self-sampling approach is that some scientists and/or managers consider that the data provided by fishers may not have been collected in a sufficiently rigorous manner, and they may be biased as a result (Hoare *et al*., 2011). To avoid these problems, regular and accountable training sessions for fishers can be conducted to guarantee the accuracy and reliability of data collection. Communication, feedback, incentives and shared motivation are essential for good cooperation.

In the event of self-sampling activities, countries should ensure that:

- fishers are trained;
- protocols are well developed;
- results are scrutinized for flaws, and controlled for bias.

(d) Sampling on research vessel for experimental or/and scientific survey

Besides commercial fisheries' statistics, another source of information for biological data is fishery-independent data collected by scientific experimental survey at sea, carried out on commercial or scientific vessels. Surveys provide accurate indices of species/stock abundance and distribution, though the major problem is cost. Surveys require fishing with a standard vessel using standard fishing gear at predetermined fishing stations, selected according to a fixed-grid, fixed-site or stratified random sampling design. Such surveys provide an estimate of average fish density (e.g. per area swept by a trawl net; as fish encounters with longlines or gillnets; number of nautical miles for acoustic survey etc.) over the entire spatial range where the species might be found. It also provides mapping of the spatial distribution of density over the entire range.

In the Mediterranean and Black Sea, a number of countries already undertake regular fishery-independent surveys. Survey data for most species are regularly analysed. Hence, opportunities already exist for some countries to provide biological information for a number of species by analysing available data from these existing surveys. Scientific survey methods and procedures carried out in the Mediterranean and Black Sea are developed and available in different manuals (e.g. MedSudMed, 2006; SoleMon, 2011; Medias Handbook, 2012; Medits Handbook, 2013, 2016).

Information to be collected during each sampling day
at landing/market places or on board commercial vessels

- *fleet segment sampled;*
- *area (GSA) and time period;*
- *gear used;*
- *name of selected target species (Appendix A);*
- *length of all individuals contained in at least one sample (e.g. a single box) of the total commercial landing of that species;*
- *sample weight;*
- *total landed quantity (by weight) of the species selected for sampling;*
- *discarded fraction of the target species;*
- *total weight of all landed species.*
- *Incidental catch of vulnerable species*

6.2 Merging and selection of fleet segments

6.2.1 Merging procedures

In order to optimise the sampling, and according to the inputs received by the Subcommittee on Stock Assessment and the Subcommittee on Economic and Social Sciences (GFCM, 2015a, 2015b), fleet segments could be merged (i.e. aggregating length classes) if they:

- have similar exploitation patterns (targeting the same species);
- exploit the same portion of the population (i.e. juveniles or adults).

When a country proposes to aggregate fleet segments, the rationale and corresponding references (e.g. existing scientific studies) should be brought to the attention of the relevant subsidiary bodies, which in turn should confirm the similarity/homogeneity of the combined cells. In the case of merged segments, the code to identify the newly defined fleet segment will be provided by the GFCM Secretariat.

At the beginning of each sampling year, each country should transmit a list of all fleet segments (based on Appendix B and/or fleet segments resulting from merging process, if any) operating in each GSA (see as an example template 1 below), using a standard template (Appendix N).

Template 1) Fleet segments operating in the GSA

GFCM subregion	*XX*
GSA	*XX*
Country	*XX*
Reference year	*XX*
1) List of all fleet segments operating in the GSA	**Notes**
Small-scale vessels with engine using passive gear < 6 m	
Small-scale vessels with engine using passive gear 6-12 m	
Beam trawlers 6-24 m	length classes have been merged because the exploitation pattern is the same
Pelagic trawlers 12-24 m	
Trawlers 6-24 m	vessels, independently from the length classes, exploit the same portion of the population
Longliners < 6 m	
Longliners 6-24 m	length classes have been merged because the exploitation pattern is the same
Polyvalent vessels 6-12 m	
Polyvalent vessels 12-24 m	
…….	…….

6.2.2 Selection procedures

The collection of biological parameters for all fleet segments, identified by the country in each GSA (template 1), may be difficult to achieve for obvious and practical reasons (i.e. technical cost, human resources), and a selection of fleet segments to be sampled can help. Due to the fact that the main aim of a sampling plan is to estimate parameters that are representative of the population of interest, it is important to find the best compromise between quality and cost.

Following this rationale, only for biological data, a weighting procedure based on landing (tonnes), effort (fishing days) and economic values (total landing value) can be applied to identify the fleet segment to be sampled. To carry out this exercise, the mean values for the two years preceding the reference year (i.e. the year to which the collected data refer) should be used (e.g. for reference year 2013 this means values of 2011 and 2012 - Table 3).

The weighting procedure implies these three steps:

1) **Step one**
   Distribute yearly data on landings (tonnes), effort (fishing days) and value (economic value in national currency) as shown in Tables 3a, 3b and 3c in the examples below. These data, by year, should cover all country fleet segments operating in each GSA. It is important that *all* fleet segments, for which fishing activity has been recorded during the two years preceding the reference year are included in the initial weighting exercise.

Table 3a - Effort values (in fishing days) reported for each cell of the identified fleet segments (based on Appendix B and/or on fleet segments resulting from a merging process, if any). Data should be reported by GSA and by year (for each of the two years preceding the reference year).

		Fleet segments				
		Vessel groups	*Length classes (LOA)*			
			< 6 m	6 - 12 m	12-24 m	> 24 m
Polyvalent	P	Small-scale vessels without engine using passive geas	0	0	115	2
		Small-scale vessels with engine using passive gear	0	30	160	0
		Polyvalent vessels	1	4	20	2
Seiners	S	Purse seiners	0	3	0	0
		Tuna seiners	0	1	3	0
……..		……..	…..	…..	…..	…..

In each cell the total *number of fishing days* by fleet segment and per GSA is reported

Table 3b - Landing values (in tonnes) reported for each cell of the identified fleet segments (based on Appendix B and/or fleet segments resulting from a merging process, if any). Data should be reported by GSA and by year (for each of the two years preceding the reference year).

		Fleet segments				
		Vessel groups	*Length classes (LOA)*			
			< 6 m	6 - 12 m	12-24 m	> 24 m
Polyvalent	P	Small-scale vessels without engine using passive gear	0	0	250	12
		Small-scale vessels with engine using passive gear	0	65	325	09
		Polyvalent vessels	6	24	185	0
Seiners	S	Purse seiners	0	80	0	0
		Tuna seiners	0	150	2800	0
……..		……..	…..	…..	…..	…..

In each cell the total *landing* by fleet segment and per GSA is reported

Table 3c - Economic values of landing (in local currency), reported for each cell of the identified fleet segments (based on Appendix B and/or fleet segments resulting from a merging process, if any). Data should be reported by GSA and by year (for each of the two years preceding the reference year).

		Fleet segments				
		Vessel groups	*Length classes (LOA)*			
			< 6 m	6 - 12 m	12-24 m	> 24 m
Polyvalent	P	Small-scale vessels without engine using passive gear	0	0	27500	2300
		Small-scale vessels with engine using passive gear	0	3330	45000	0
		Polyvalent vessels	650	4400	9600	2850
Seiners	S	Purse seiners	0	5000	0	0
		Tuna seiners	0	1250	2300	0
……..		……..	…..	…..	…..	…..

In each cell the *total value of the landing* (in local currency) by fleet segment and per GSA is reported

2) Step two

Once all the cells of the fleet segments potentially active in each GSA have been filled in, the following steps should be taken:

- List all identified fleet segments (by GSA) following the procedure reported in Table 4.
- Calculate the *mean values* of the selected variable (e.g. effort) based on the two years preceding the reference year.
- Rank the fleet segment cells according to their share of the total effort, in different columns. The shares *(percentage contribution*) should then be added up starting with the largest figure. All fleet segments belonging to the top 90 percent share (*cumulative %*) will be selected for sampling.
- Repeat the same cumulative process for the other two variables (landings and economic value). The fleet segments in the top 90 percent, whether or not they coincide with the previous top 90 percent (e.g. by effort), will be added to the selection.

Table 4 - Example of a weighting exercise for the selection of fleet segments according to the number of fishing days (i.e. effort values):

- in the first column all the fleet segments identified in each GSA are reported;
- in the second column the total number of fishing days carried out in 2011 are reported;
- in the third column the total number of fishing days carried out in 2012 are reported;
- in the fourth column the mean value of fishing days for each fleet segment is reported for the two years preceding the reference year;
- the last two columns report the percentage (%) contribution of each fleet segment and the cumulative values (%) reached. Highlighted in grey are the fleet segments that have been selected, representing 90 percent in terms of fishing effort. These segments represent the basis for the collection of biological data.
- The same exercise should be repeated for each GSA and for landings and economic values contributions.

Fleet segments (GSA)	***total n fishing days 2011***	***total n fishing days 2012***	***Mean values***	***Percentage contribution %***	***Cumulative %***
Small-scale vessels with engine using passive gear 6-12	76 281.29	57 675.66	66 978.48	37.96	37.96
Longliners 12 - 24 m	37 215.3	49 594.56	43 404.93	24.60	62.56
Trawlers 12 - 24 m	38 726.13	31 651.7	35 188.92	19.94	82.50
Trawlers > 24 m	6 558.75	10 080.54	8 319.645	4.71	87.21
Pelagic trawlers 6 - 12 m	7 991.17	2 471.04	5 231.105	2.96	90.17
Trawlers 6 - 12 m	6 014.55	3 754.39	4 884.47	2.77	92.94
Small-scale vessels with engine using passive gear 12 - 24 m	4 689.74	3 310.71	4 000.225	2.27	95.21
Purse seiners 12 - 24 m	4 463.06	1 794.07	3 128.565	1.77	96.98
Longliners 6 - 12 m	2 693.12	1 795.27	2 244.195	1.27	98.25
Beam trawlers 6-12 m	1 518	1 403	1 460.5	0.83	99.08
Tuna seiners > 24 m	1 510.8	272.47	891.635	0.51	99.59
Small-scale vessels with engine using passive gear < 6 m	101.34	1 024.3	562.82	0.32	99.92
Beam trawlers < 6 m	336	0	168	0.10	100.00
Purse seiners 6 - 12 m	0	0	0	0.00	100.00
Beam trawlers > 24 m	0	0	0	0.00	100.00
(report all other fleet segments)	0	0	0	0.00	100.00
			176 463.5	100%	100%

3) Step three

In each GSA the sampling strata, for the estimation of the biological parameters (e.g. length, sex and maturity), will be constituted by all fleet segments above the 90 percent mark, even if they have been identified according to one of the cited criteria only (landings, values and effort).

In addition, a country may also add to the selection any fleet segment not picked up by the exercise but that may be of special importance for any other criteria (i.e.: conservation, ecological or social relevance).

At the beginning of each sampling year, and based on the results of the weighting procedure, each country should transmit a list of those fleet segments operating in each GSA that have been identified for the collection of biological variables, as well as those for which discard information will be collected[24]. To provide these lists by GSA, countries should use a standard template (Appendix N - see example provided in template 2 below).

Template 2) Fleet segments selected for the collection of biological variables

GFCM subregion	*XX*	
GSA	*XX*	
Country	*XX*	
Reference year	*XX*	
2) List of fleet segments selected, through the weighting procedure, for the collection of biological variables	**Discards (Y/N)**	**Notes**
Trawlers 6-24 m	Yes	
Small-scale vessels with engine using passive gear 6-12 m	No	discard represent less than 10% of total catch
Polyvalent vessels 12-24 m	No	no discard
Longliners 6-24 m	No	discard represent less than 10% of total catch
……..	….	……

Once the fleet segments (strata) have been identified through the procedure described above, a certain number of fishing trips to be sampled (e.g. on board, at market, at landing place etc.) should be assigned to the selection. The number of fishing trips to be sampled should ensure good coverage for each of the fleet segments selected. Due to variations in the consistency and composition of fishery fleets, as well as in the corresponding extension and availability of fishing grounds, not only in the region, but also between subregions and countries, trips should be assigned within a country and in each GSA taking into account parameters such as gear, fishing ground and temporal stratification (e.g. month, season).

For the design of a proper stratified sampling exercise, the numbers of trips assigned to each fleet segment must be proportional to the effort and adjusted to the variability in the catches of that fleet segment. Statistical methods must be applied to calculate the right number of samples that takes into account this variability.

Where trips occur across two or more GSAs, sharing the same resources, the landing, effort and value data should be distributed proportionally among the different GSAs. When planning a sampling programme, the number of trips to sample per fleet segment becomes an expectation based on the fishing activities of the previous years, not a target, and may vary if the fleet's activities change over time.

[24] Discards information should be collected only when the discard rate exceeds 10 percent of the total volume of catches for a given fleet segment in a given GSA.

6.3 Selection of species

Usually, due to restricted funds and personnel, it is not possible to collect data (e.g. biological data, effort data etc.) from all species of commercial interest. A limited number of species (namely priority species) should be selected as representative of the entire living resources. The concept of priority species represents a key factor for the management of fisheries resources (Barone *et al*., 2006; AdriaMed, 2007; Ungaro *et al*., 2008). In the context of data collection, priority species are those for which the most complete set of data are required. Their identification has to be based on criteria relevant to the objectives of the GFCM: development, conservation and management. In this regard, not only abundance, but also price and/or market demand and ecological importance should be taken into account as selection criteria. The use of different parameters to identify the priority species is helpful in assigning the correct importance to some species, which may not be very abundant, but which, for example, fetch a high market price.

According to these criteria, three different groups have been established, whereby species are listed at subregional level (GFCM subregions - Appendix L): the first group concerns the **frequency of assessments** (i.e. species that are regularly assessed); the second one concerns the **fishery's importance** (i.e. landing, catch and/or economic value); the third group is based on **conservation criteria** (i.e. endangered species) or impact of their presence on the ecosystem (i.e. non-indigenous species).

Criteria used to identify the main groups of species

Group 1: *Species for which assessment is regularly carried out.*

Group 2: *Species that are important in terms of landing and/or economic values at regional and subregional level, and for which assessment is not regularly carried out.*

Group 3: *Species within international/ national management plans and recovery and/or conservation action plans as well as non-indigenous species with the greatest potential impact.*

The lists of species identified for each group and GFCM subregion are presented in Appendix A. These lists should be considered as a dynamic tool; any change (i.e. deletion or insertion of species) should be brought to the attention of the relevant subsidiary bodies for approval. Future changes could therefore occur on the basis of the information gathered.

Countries are requested to collect biological information for all the species identified in all GFCM subregions (Appendix L) where their fisheries take place. For all the selected species in Group 1, Group 2 and Group 3, length data per fleet segment should be collected (Subtask VII.2 Length data - Chapter 2). Individual information on sex and length at maturity is mandatory for species belonging to G1 (Appendix A.1). Countries are also kindly invited to provide this information for species belonging to G2 and G3, if available (Appendixes A.2 and A.3).

Exceptions can be applied for the collection of biological data related to certain species, according to the following criteria:

1st the species is/are not present in the country;
2nd the species is present in the country, but its weight accounts for less than 2% of total landings of the country.

Both exemption rules are applicable to all countries within each group of identified species. However, the transmission of length data (Table VII.2 - Chapter 2) is strongly encouraged, at least for elasmobranches species (G3), even if the volume of catches does not reach the 2% of the total national

landing. This aims to improve knowledge, especially for some rare elasmobranches species that have a sporadic and unconfirmed presence in the Mediterranean.

At the beginning of each sampling year, each country should transmit a list of the species (Appendix N), based on the identified regional species groups (Appendix A), for which data collection (i.e. length, sex and maturity) will be carried out.

This exercise, at country level, should be repeated for all of the three groups of species. Moreover if a species, which is not present in one of the three groups of species, is important at the national level for any reason, it can be added in the country's sampling scheme, specifying the reason. To provide this list, countries should use a standard template (Appendix N - see example provided in template 3 below).

Template 3) Species for which data collection will be carried out

GFCM subregion	*XX*	
GSA	*XX*	
Country	*XX*	
Reference year	*XX*	
Group 1 species	**Data to be collected (Y/N)**	**Notes**
Merluccius merluccius	Yes	
Mullus barbatus	Yes	
Mullus surmuletus	Yes	
Parapenaeus longirostris	No	Species accounts for 1.2% of total national landings (below the 2% threshold)
Sardina pilchardus	No	Species is not present in the country
Nephrops norvegicus	Yes	
……	…..	
Group 2 species	**Data to be collected (Y/N)**	**Notes**
Eledone cirrhosa	Yes	
Diplodus annularis	No	Species accounts for 1.2% of total national landings (below the 2% threshold)
……	…..	

6.3.1 Length

Length frequency distribution provides information on the demographic structure of the sampled population. Length measures are easy to make, but require many observations in a well-defined and standardized way, in order to allow for comparison of results. The length measurements to be taken depend on the group of species under study. The length of fish and cephalopods is generally measured with graduated fish measuring instruments, called "ichthyometers", while calipers are used for crustaceans.

Bony fish and *Elasmobranchs* - For bony fish, sharks, skates and rays, the length should be considered as the total length (TL). The fish is measured to the lower half centimetre, from the tip of the snout to the end of the caudal fin (Figures 3a and 3b). In elasmobranchs, fork length (FL) could be recorded when the caudal fin is damaged and the total length cannot be taken. Country could also report length

data using the standard length (SL). SL is defined as the measurement taken from the tip of the lower jaw to the posterior end of the hypural bone.

The length classes should be reported in centimetres (as a whole number, or half cm, e.g. 0.5, 1.0, 1.5 etc.).

a)

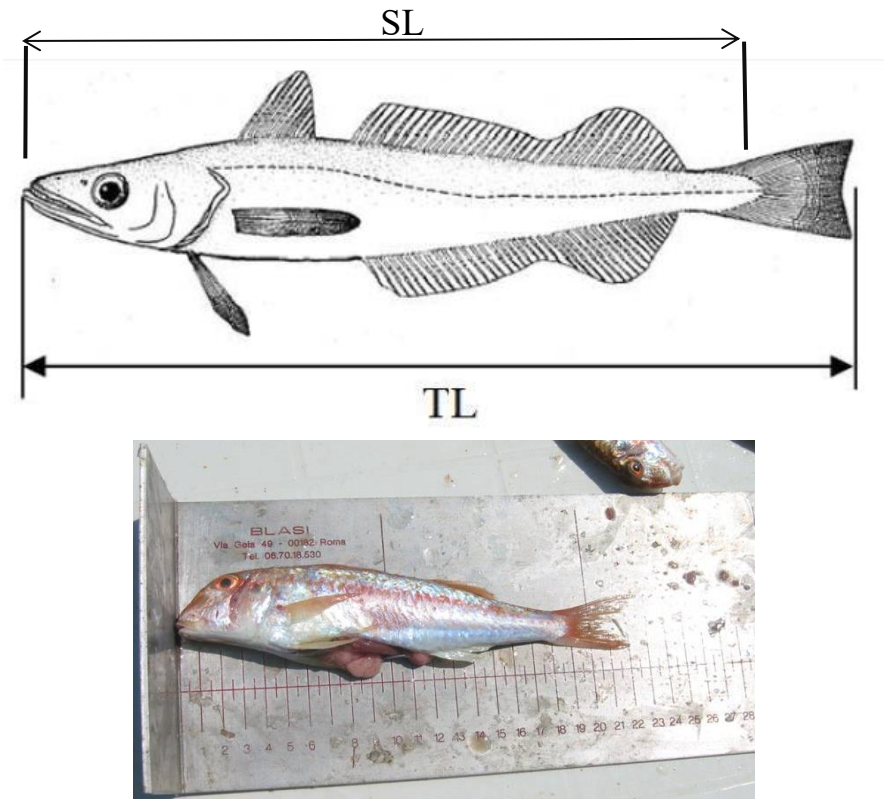


Figure 3a. Illustration showing the measurement of total length (TL) and standard length (SL) in bony fish. TL = Total Length (photo by Carpentieri P.).

b)

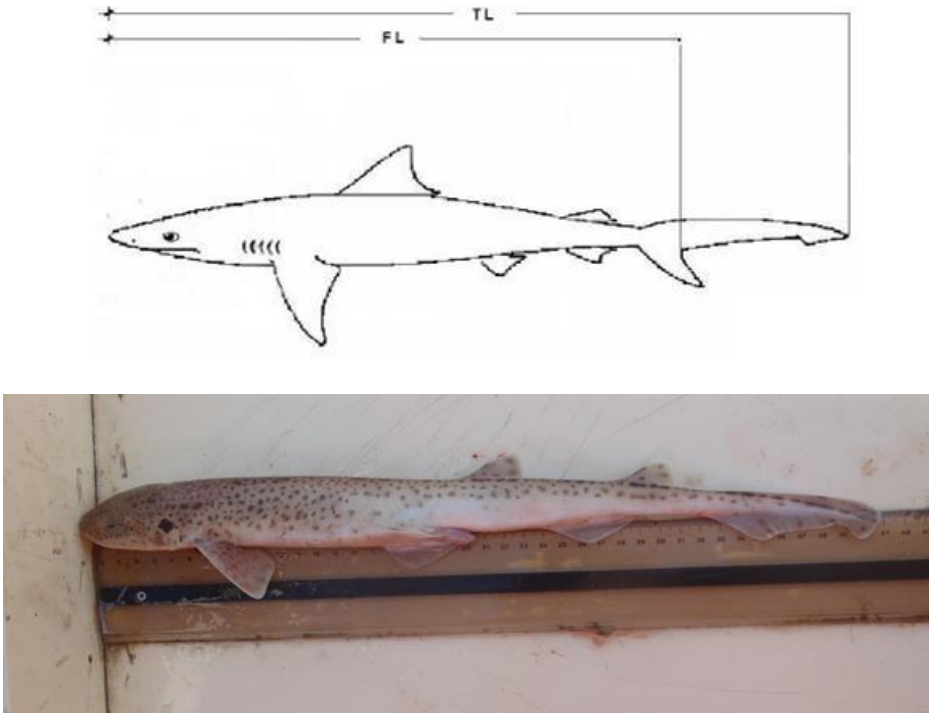


Figure 3b. Illustration showing the measurement of total length in elasmobranchs. TL = Total Length; FL = Fork Length (photo by Carpentieri P.).

Crustaceans - For crustaceans (lobsters, crawfish, shrimps, prawns, stomatopods), the standard measurement is the minimum length of the carapace length (CL). The length classes should be reported in millimetres (as a whole number, e.g. 1, 2, 3, 4 etc.). The crustacean is measured, to the lower millimetre (mm), from the back border of the eye orbit (inside of the eye socket) to the posterior margin of the carapace (Figure 4). All measurements are taken with calipers.

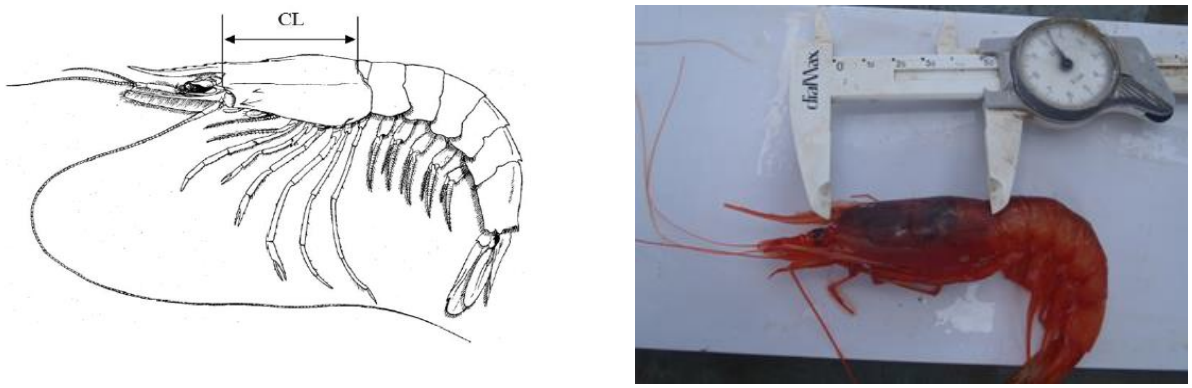


Figure 4. Illustrations showing the measurement of carapace length (CL) for crustacean's decapoda (photo by Carpentieri P.).

Cephalopods - For cephalopods, the length is the dorsal mantle length (ML). The length classes should be reported in centimetres (cm). The cephalopod is measured to the nearest lower half centimetre. The size should be reported in centimetres (as a whole number, or half cm, e.g. 0.5, 1.0, 1.5 etc.). For the Octopoda, measurement is taken along the median line, passing through the eyes, to the apex of the mantle, as shown in Figure 5a. For Decapoda, measurement is made along the dorsal midline from the mantle margin to the posterior tip of the body, excluding long tails (Figure 5b).

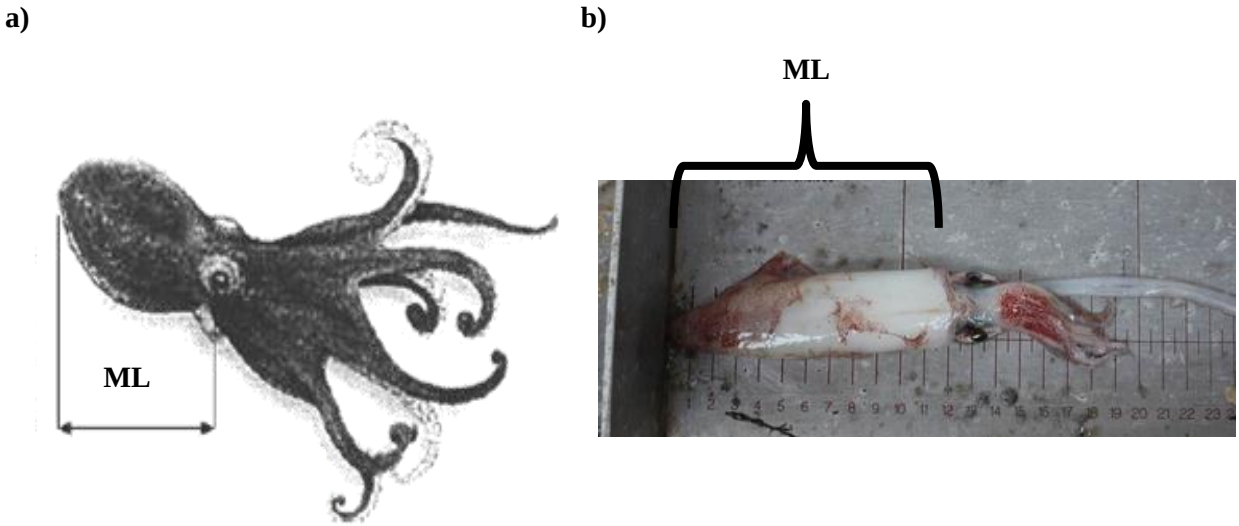


Figure 5. Illustrations showing the measurement of dorsal mantle length (ML) on cephalopods a) Octopoda and b) Decapoda (source: Dimech *et al.*, 2012; MEDITS Handbook, 2013, 2016; photo by Carpentieri P.).

6.3.2 Weight

Individual weight is important biological information, although the weighing of individuals may prove to be more complex depending on prevailing conditions in the workplace. It is essential to establish length-weight relationships for all target species, because at some stage in stock assessments, lengths of fish have to be converted to weights of fish.

The choice of weighing device (e.g. hanging balance, electronic balance) depends on the size of the sampling and working conditions. For fish, elasmobranch and cephalopod species, the total weight of each individual could be reported to the nearest 1 g, using an electronic balance. In the case of crustaceans, the weight should be recorded to the nearest 0.1 g.

The length-weight relationship for single species requires a large set of data in order to obtain good representation of the entire "size ranges" of a species: from the smaller individuals to the larger ones. This will help to increase the accuracy of estimates. It is also important to stress that the length-weight relationship may vary seasonally, and between each sex.

6.3.3 Sex and maturity

Knowledge of the length of the species at maturity and of the spawning periods could improve best practices in the sustainable management of fisheries, particularly with respect to regulations on gear selectivity and fishing seasons.

Macroscopic observations can distinguish sex categories: Male (M), Female (F), Undetermined (U - when, after dissection, it was not possible to determine the species' sex with the naked eye) and Not Determined (ND - individual that has not been examined). It is also important to be aware that some

species are hermaphrodites. This means that fish can change sex during their lifespan, either from male to female (protandrous), or from female to male (protogynous). The change may occur more than once in a lifetime. Some hermaphrodite species have both sexes at the same time. In this latter case, the sex is determined on the basis of the most developed gonad and should be reported accordingly. Those definitions could be applied to all groups of fish, crustaceans, elasmobranchs and cephalopods.

Concerning maturity, the macroscopic determination of the maturation stage of a marine organism is a powerful tool for routinely monitoring "maturation schedules", whatever the scale chosen. It is important to remember that the maturation stage assigned to a given individual is relative to its adulthood condition. An "adult" fish caught and analysed macroscopically in a period that is different from its reproductive season can, in fact, have a resting (or spent) gonad that is similar in appearance to that of a juvenile fish. Ovary and testes change their aspect and their relative weight during maturation, according to the species' physiology, growth and/or external factors (environment and season).

A large number of macroscopic maturation scales is available in literature, varying from over-simplified scales comprising three to four stages, to highly specific and relatively complicated scales (up to nine stages). The need to adopt a common acceptable maturity scale, as well as to establish objective criteria for the definition of each maturity stage, is considered a crucial issue in order to give a common tool for exchanging data and scientific information. The macroscopic maturity stages presented in this manual (Appendix G) are mostly based on the general aspect, shape, dimension, position and colour of the gonads. These scales derive from knowledge and experience gained during different surveys and ongoing working groups, carried out in the Mediterranean and Black Sea area (Ungaro, 2008; ICES, 2010a, 2010b; SoleMon, 2011; Dimech *et al.*, 2012; Medias Handbook, 2012; Medits Handbook, 2013, 2016; Follesa *et al.*, 2015).

It is important that, whatever the maturity scales used by each country in their sampling process, the information gathered (Subtask VII.3 Other biological data - Chapter 2) should be transmitted with reference to the maturity scales herein proposed (Appendix G).

Bony fish - The determination of sex for fish is only possible by dissecting individuals. Very few species have clear external sexual dimorphism, and it is therefore necessary to dissect the fish, since the internal body cavity must be exposed, and the shape and appearance of the gonads examined. In adult females, the eggs are readily seen in the ovaries; in adult males, the testes are typically smooth, whitish and non-granular (Figures 6 and 7).

For fish, a 4 stage scale (Appendix G.1) could be used to report the maturity stage (Medits Handbook, 2013, 2016). The stages (from 0 to 4) are based mainly on the relative volume, the consistency and the colour of the gonads, the presence of sperm in males and the presence and the degree of hydration of the eggs in females.

Figure 6. Sexual macroscopic determination of male (left) and female (right) of *Merluccius merluccius* (photos by Carpentieri P.)

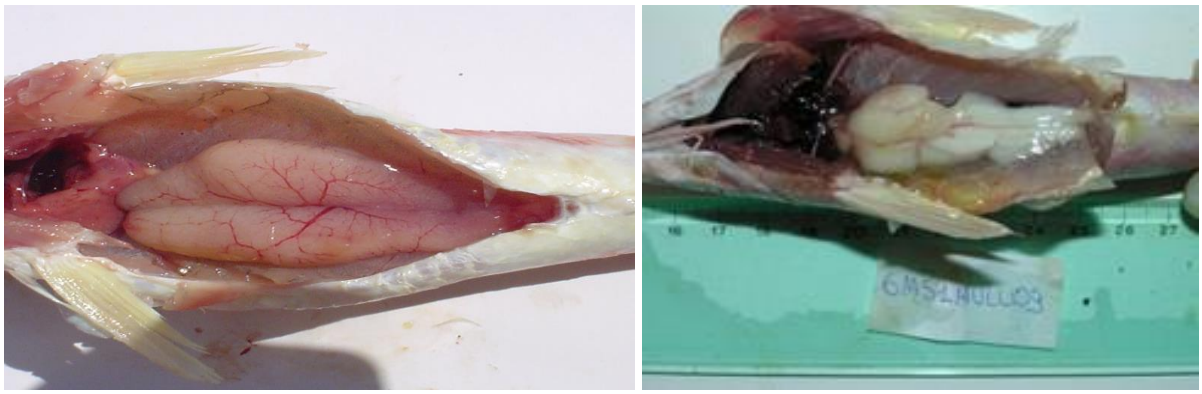


Figure 7. Sexual macroscopic determination of female (left) and male (right) of *Mullus surmuletus* (photos by University of Cagliari/Follesa C.).

Crustaceans - Sex for crustacean's decapods can be determined by the naked eye: the petasma (visible on the 2nd pleopods) and thelycum (present on 4th sternite) will indicate males and females, respectively (Figures 8a and 8b).

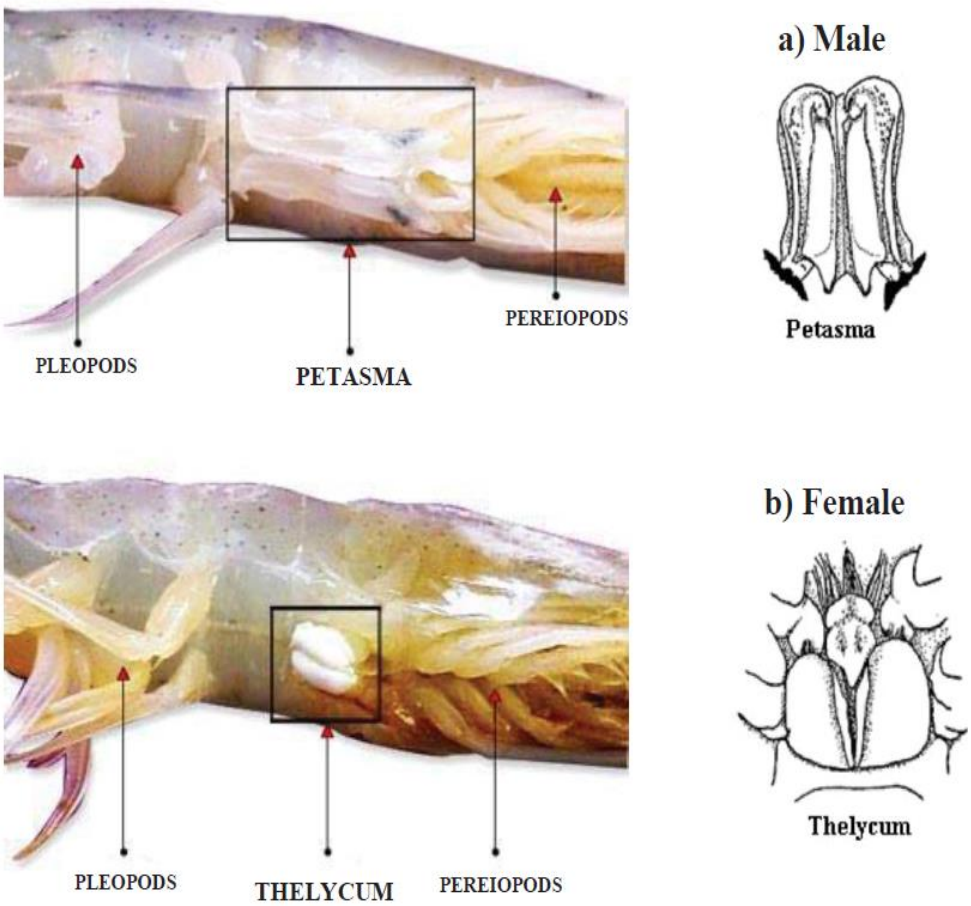


Figure 8. Illustrations showing the sexual macroscopic determination of sex in crustacean's decapods (source: Dimech *et al*., 2012).

For decapods, a five-stage scale (ICES, 2010a) has been chosen to report the maturity stage of the most common species (Appendix G.3). The maturity stage can be determined by examining the colouring and appearance of ovary lobes (females) and the fusion degree of the petasma, presence/absence of the spermatic masses on seminal ampullae and the dimension of the rostrum (males). However, in most cases, it is extremely difficult to determine the maturity stage of crustaceans macroscopically, and considerable experience is required.

The maturity scale proposed by Froglia (1996) was chosen to report maturity stages for stomatopods (i.e. *Squilla mantis*, Appendix G.5 and Figure 9).

Taking into account the difficulties in detailing the maturity condition of gonads in males at macroscopic level, no maturity scales for males were presented in this manual.

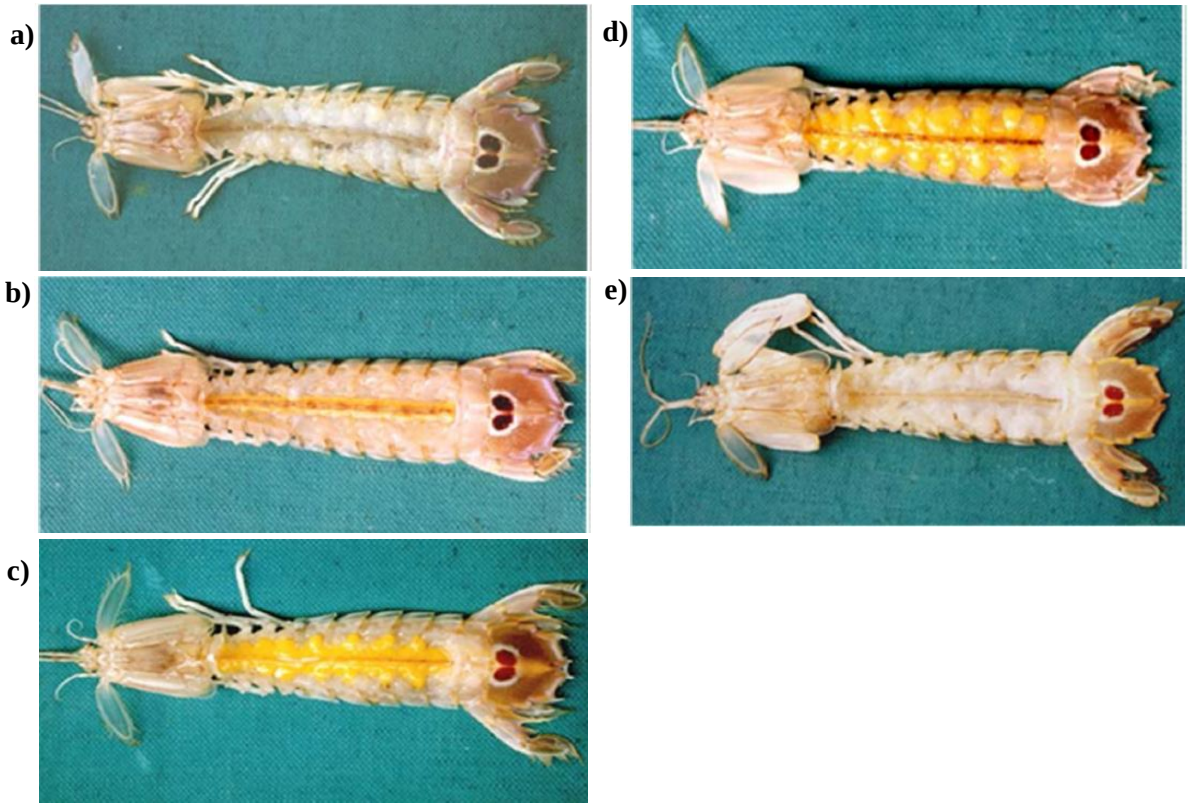
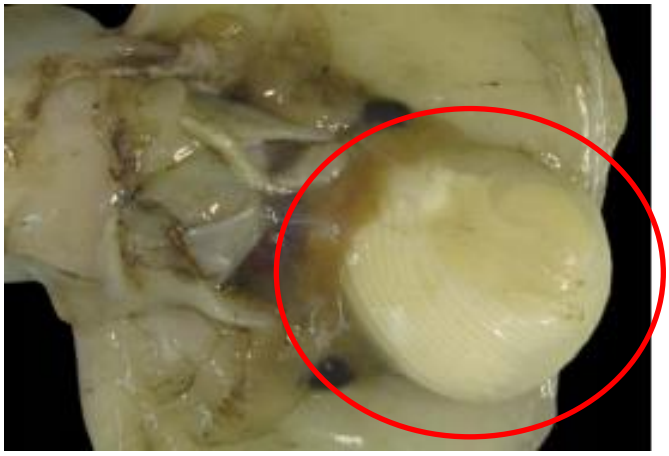


Figure 9. Illustrations showing the sexual macroscopic determination of sex in *Squilla mantis* females, ovaries (dorsal cuticle removed): a) immature b) early maturation c) advanced maturation d) ripe e) spent (source: SoleMon, 2011).

Cephalopods - In the case of cephalopods, sex can be determined by dissecting individuals and checking the presence of a) male and b) female gonads in the mantle cavity (Figures 10a and 10b).

a)



b)

Figure 10. Illustrations showing the sexual macroscopic determination of sex in cephalopods a) *Eledone cirrhosa* spawning male b) *Illex coindetti* spawning female (photos by University of Cagliari/Cuccu D.).

A three-stage scale of maturity (Medits Handbook, 2013, 2016) could be used to report the maturity in cephalopods (Appendix G.2). This scale is based on the development (or size, colouring and appearance) of ovary and nidamental glands in females and the development of testis and spermatophoric complex, including the Needham's sac in males.

Elasmobranchs - For sharks, rays and skates, sex can be determined by the naked eye: pterygopods are organs found on male elasmobranchs (Figure 11). Each male has two pterygopods (or claspers), located along the inner side of the shark or ray's pelvic fin and are used in reproduction. All elasmobranchs have internal fertilization.

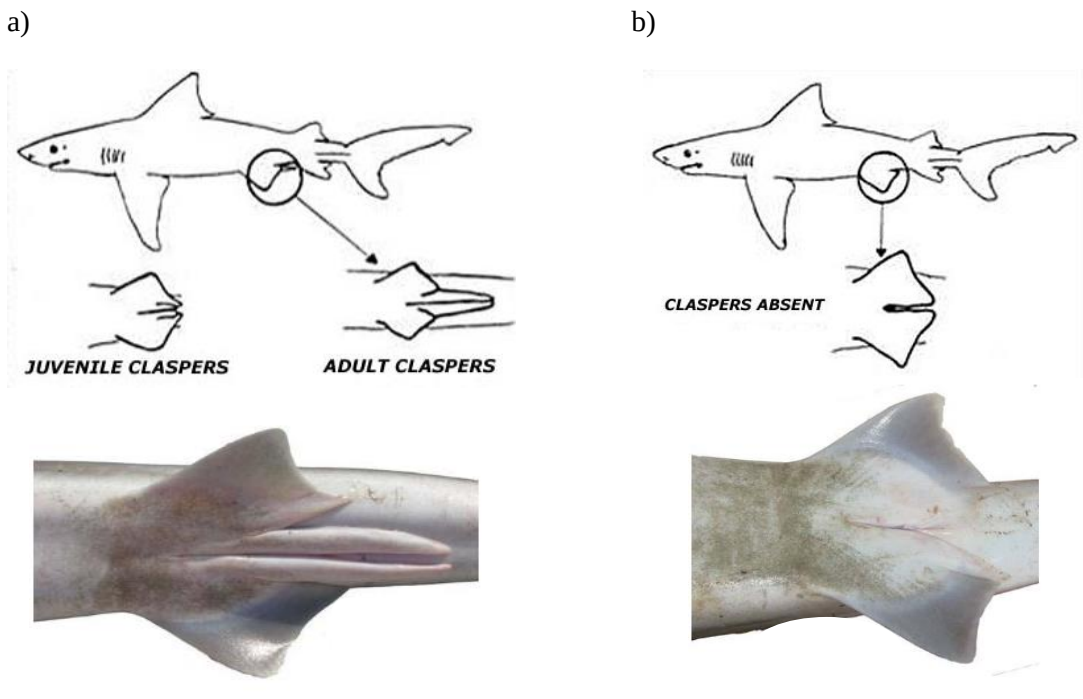


Figure 11. Illustrations showing the sexual macroscopic determination of sex in elasmobranchs a) Male b) Female (source: NOAA - Northeast Fisheries Science Centre).

Based on the degree of development of the pterygopods, it is possible to determine the maturity stages of males. Maturity of females must be determined by internal examination, identifying the development of gonads, ducts and shell glands and/or the presence of embryos and the egg dimensions. Generally, the reproductive system of females consists of ovaries (usually two, but in some species only one is present), shell glands and oviducts. In immature fish, the ovary is barely discernible and contains no eggs, whereas in maturing fish, white eggs are visible in the ovary. In mature fish, the ovaries contain yellow eggs, except immediately after ovulation, in viviparous species, and at the end of the spawning season in oviparous species. In viviparous species, maturity is also associated with changes in the size of the cloaca.

Until 2012, there was no international agreement on the maturity scales to be applied to elasmobranchs. In December 2012, a Workshop on Sexual Maturity Staging of Elasmobranchs - WKMSEL (ICES, 2013) was held, with the main objective of reaching agreement on a common maturity scale for elasmobranchs (sharks, skates and rays), oviparous and viviparous species, across laboratories and countries. The WKMSEL reviewed the maturity scales (Stehmann, 2002; Ungaro, 2008) in use, including in the Mediterranean areas, and proposed two new maturity scales, one for oviparous and other for viviparous species. These scales, based on the development (or size, colouring and appearance) of ovary and nidamental glands in females, and the development of testis and spermatophoric complex, including the Needham's sac in males, could be used to report maturity in elasmobranchs (Appendix G.4).

6.3.4 Age

Having comprehensive and accurate growth information is a key factor in the successful management of fishery resources: knowledge of the age of fish greatly improves population analyses of temporal variation in structure and abundance.

The aged sample also shows the age classes that the population is composed of, or, if the sample is from a particular fishery, the group of age classes exploited by that fishery. Fisheries exert strong selection for certain sizes and therefore ages: most fishing gear are designed to be size/age selective. Fisheries affect population mean size through size selective mortality. For this reason, in addition to the total increase in mortality rate caused by fishing, it is imperative to determine how increased mortality is distributed between age groups in the population.

The strength of each year class is used to forecast stock sizes in the future and show how successful spawning was in each year. The more estimates that can be obtained for the strength of a particular year class (e.g. from consistent sampling in consecutive years), the greater the confidence in the estimate for that year class. These estimates of year class strength can explain variations in total stock abundance and be used to predict future recruitment to the fishery. Moreover, differences in growth rates or population age structures between areas could indicate that multiple stocks occur.

Bony fish - There are several parts of a fish body that can be used for ageing. Currently, the preferred method of ageing fish is examination of otoliths, found within the fish's inner ear. Each year, calcium is deposited in these bony structures in a systematic manner, allowing for the counting of annuli. Scales, vertebrae and various bones can also be used, but otoliths are widely accepted as the best structure for many marine species.

Otoliths, commonly known as "earbones", are paired small and hard structures, located in the semi-circular canals directly behind the brain of bony fish. They are formed by the daily accretion of a layer of calcium carbonate structures, bound within a protein matrix (Figure 12). As the fish grows, a series of concentric opaque and hyaline (translucent) zones are formed. Since the opaque zones are formed in summer and the hyaline zones in winter, the age of the fish may be determined by counting the number of zones. Different species have otoliths of different shapes and sizes. Cartilaginous fish, such as sharks, skates, and rays, have none.

There are various techniques for the removal of otoliths from fish, the choice of which depends on the plane of the cranium section. For teleost, the most commonly used method is from the ventral side, behind the head after removal of the gills.

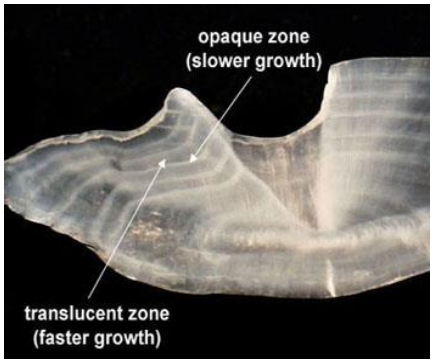


Figure 12. On the left, dissection of fish and extraction of the otolith (photo by Carpentieri P.). On the right, shape of otolith with the alternance of opaque and translucent zones.

The increased standardization in otolith readings between laboratories allows common guidelines, provided by *ad hoc* working groups or experts, to be followed (GFCM, 1982; Campana & Jones, 1992; MedSudMed, 2005; ICES, 2010c, 2010d; Campana, 2014; Carbonara *et al.*, 2015). At the same time, it is important to use different methods, such as the analysis of length frequency distributions, the temporal evolution of the annulus formation on the otolith margin and counts of daily rings, to validate the growth pattern derived from reading (macrostructure interpretation) of hard structures, such as otoliths.

Elasmobranchs - Elasmobranchs have cartilaginous skeletons and therefore lack bony structures with systematic calcium depositing; otoliths are absent and scales do not form discernible growth bands. Some elasmobranch species have hard spines that contain rings suitable for ageing. Most species of elasmobranchs, however, do not have spines, so vertebrae have been used as the ageing structure. Therefore, it is usually the vertebrae (or the fin spine, when present) that should be prepared for age determination. Vertebrae contain concentric pairs of opaque and translucent bands. Several methods have been developed to enhance the concentric pairs of opaque and translucent vertebral bands. Band pairs are counted like rings on a tree, before an age is assigned to the fish based on the count.

Vertebrae (Figure 13) for age determination are usually removed from the cervical or thoracic regions, although the optimal location depends on the species.

a) b)

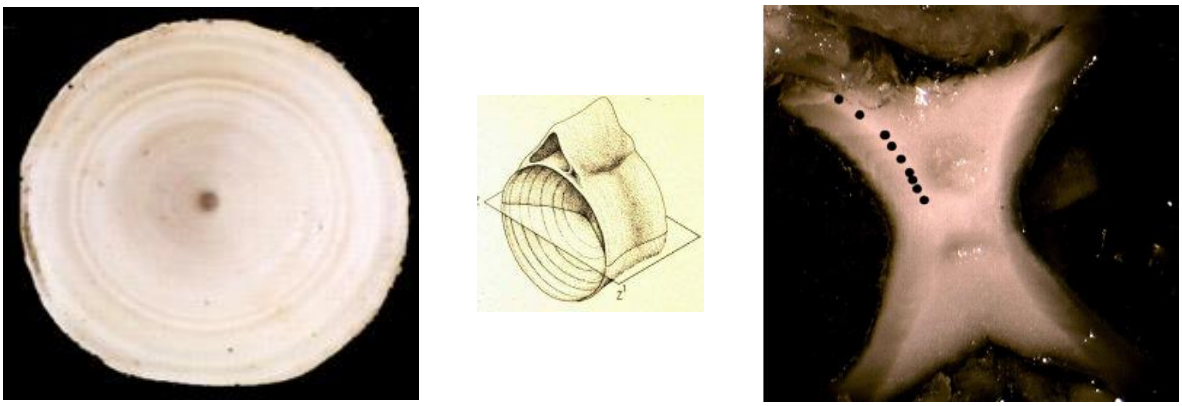


Figure 13. a) Individual vertebrae of an elasmobranch and example of a sagittal cut b) Enhanced vertebral images of *Raja asterias*, annotated to show annual growth bands (source: Campana, 2014).

For many species, the area over the posterior gill slit is often best. A comprehensive summary of more modern ageing methods for elasmobranchs is reported in an *ad hoc* manual (Campana, 2014).
In general, for many species - both elasmobranchs and bony fish - controversies over ageing methodology arise and may last for many years. This is often because several techniques have been used for the same species, and none has been validated to everyone's satisfaction. Indeed, for many species, no reliable or accepted ageing technique has been developed. The aim of age determination studies is to increase precision and accuracy: accuracy refers to the closeness of an age estimate to the true age, whereas precision is a measure of variability between individual readings, either within or between readers. Accuracy can only be assessed through validation experiments, either direct or indirect, while precision can be assessed through intercalibration exercises at different levels (i.e. precision among different readers and/or countries). Indices of precision, among different readers/institutes/countries, may also be a useful tool for conducting comparisons between readers and between methodologies (e.g. otoliths and vertebrae). They can also indicate samples that are "difficult", and that could produce unreliable estimates of age. In order to standardize age reading for target species in the region, the outputs of international workshops on otolith reading should be used as guidelines for interpretation.

Methods for age reading preparation, conservation, validation and programmes are beyond the scope of this manual. However, some general principles of best practice on sample design for catch-at-age are summarized below:

- the number of otoliths/scales/vertebrae should be directly related to the number of age classes in the catch/population;
- age distribution in each reference collection should include all the fish length groups in the catch/landing, and should also ensure that older fish are adequately represented (i.e. from juveniles to very large individuals);
- reference collections should take into account any additional strata, such as sex or spatial units where necessary;
- quantifying precision and bias are important components of ageing studies. Regarding this issue, growth derived from otolith reading needs to be validated using different approaches (e.g. LFDs, seasonal pattern in annual formation, back-calculation, daily rings) before being adopted for any purposes (e.g. stock assessment);
- follow common guidelines, provided by *ad hoc* working groups.

Chapter 7 - Shared stocks

In the Mediterranean, the importance of shared fishery resources is widely recognized, and a list of shared stocks has already been proposed by SAC (GFCM, 2006) (Appendix I).

The term "shared fish stocks" is understood by FAO-GFCM as *"a group of exploitable organisms, distributed over, or migrating across, the maritime boundary between two or more national jurisdictions, or the maritime boundary of a national jurisdiction and the adjacent high seas, whose exploitation is carried out by more than one country and which can only be managed effectively through cooperation between all concerned States."*

In different Mediterranean and Black Sea GSAs, fleets of different countries exploit the same stocks/species, which are either pelagic (e.g. anchovy, sardine) or demersal (e.g. hake, red shrimps *Aristeus antennatus* and *Aristaeomorpha foliacea*), and which could be frequently found in international waters (i.e. outside the 6 or 12 nautical mile border, delimiting national waters). Since the activity of one fleet has a direct effect on the fishing opportunities of others exploiting the same fish stocks, and on the associated ecosystems, management measures applied only by a part of the operating fleets would have a very limited effect on these stocks.

To address this issue, it will be important that all the available information, for the most important commercial stocks in the different areas, be used in the best way possible to gather evidence on the occurrence of shared stocks. This information should be related to:

- fishery activities (catches, target species, landing sites and distribution of fleets and effort);
- existence of physical barriers to the species' lifecycle (e.g. continental shelf interrupted by deep waters);
- differences in biological parameters (e.g. growth, maturity, etc.);
- population genetic, morphological differences (e.g. otolith, meristics, etc.);
- larval dispersal, water circulation and distribution of nurseries and spawning grounds (e.g. fishery independent data source).

The term "shared stocks" can include the following definitions:

(a) Trans-boundary stocks - fish resources crossing the Exclusive Economic Zone (EEZ) boundary or national waters of one coastal State into the EEZ(s), or national waters, of one or more other coastal States.

(b) Highly migratory fish stocks - stocks that can be found both within the coastal State's EEZ/national waters and the adjacent high seas.

(c) Straddling stocks - fish stocks (with the exception of anadromous/catadromous stocks) that are found both within the coastal State's EEZ/national waters and the adjacent high seas.

(d) High seas fish stocks - stocks that can be found exclusively in the high seas.

On the basis of the above criteria, and of the outputs of the work carried out by the FAO regional projects (AdriaMed, 2007) and by GFCM SAC (GFCM, 2008), the list of shared stocks (Appendix I) can be regularly updated and thereafter brought to the attention of the relevant subsidiary bodies for approval.

Chapter 8 - Data quality

The quality of fisheries data is related to the precision and accuracy of measurements made on fisheries variables. It is subject to many factors, including data type, nature of fisheries and economic, social or ecological values of fisheries (Cochran 1977; FAO, 1999; Kolding & Ubal Giordano, 2002; Pennington *et al*., 2002; Vigneau & Mahevas, 2004; ICES, 2008, 2010e). All collected data contain some level of bias and random variation. Improvements needed in precision and accuracy often require greater relative expenditures on sampling and analysis.

Data quality must be ensured in all data collection phases: survey design, field and laboratory methods, data processing and transmission.

Errors deriving from different sources have different statistical characteristics: errors linked to direct measurement of fishery variables (e.g. length, weight), or to well-designed sampling programmes, are likely to be random and small. In some cases, errors associated with fisheries data can be non-random and biased, a characteristic of low-quality data.

Quality indicators such as statistical dispersion parameters are needed to perform quality controls. In the region, the definition of such indicators is in progress and needs to be agreed upon by all CPCs in order to establish control routines.

Generally, a routine quality validation/control should be performed at both internal (e.g. country) and external level (e.g. GFCM Secretariat) to quantify the accuracy and precision level and, if problems are identified, they must be solved before datasets are assembled.

Internal validation

The design and implementation of statistical sampling schemes is placed under the responsibility of the each country.

In order to meet fisheries data requirements in existing GFCM decisions, it may be necessary to improve, standardize and possibly modify current national data collection systems. A more efficient use of sampling resources may require the definition of best practices for sampling design and data analysis, with the aim to obtain accurate variable estimates with minimum bias and uncertainty levels.

It is fundamental that field collection, laboratory techniques and data processing be applied consistently and correctly. The integrity of the data should be also maintained and documented, from sample collection to entry in the data record.

Countries are expected to keep, at the national level, standard data quality documentation as follows:

- *A standard operating procedure* which should include:
  - the quantitative goals of the monitoring programme;
  - the methodological details of all steps performed (e.g. fields and laboratory aspects);
  - details of the procedure related to the analysis and archiving of data.

- *A quality manual* which should describe:
  - the quality assurance system in place;
  - the frequency at which different aspects of quality assurance should be reviewed;
  - the standards that should be met;
  - the actions needed if the standards are not met.

Precision, accuracy, representativeness, completeness, and comparability are all components of the quality that should be taken into account.

Precision	Measure of the proportion of agreement among replicate measurements.
Accuracy	The degree to which a recorded measurement varies from a true or expected value.
Representativeness	The extent to which measurements represents the true value in the population.
Completeness	The proportion of valid data collected with regards the total expected.
Comparability	The extent to which data from different sources can be comparable.

External validation

This validation is performed by the GFCM Secretariat to assess the quality of data transmitted by countries. The Secretariat will:

- check the completeness of data collected;
- identify deficiencies in the data transmissions;
- check differences between countries;
- check problems connected with the quality of existing data, their completeness and the level of comparability;
- check comparability with other sources of information/reference;
- identify significant discontinuities in time of collected data;
- identify significant outcomes.

In particular the external validation aims at taking into consideration a set of indicators. This validation is carried out under the guidance of relevant GFCM subsidiary bodies and in accordance with the decisions taken by the GFCM:

INDICATORS	DEFINITION	CHECKS
TIMELINESS	Data transmission by CPCs meets the deadlines set under relevant recommendations.	• Number of days between the transmission of each data table and the deadline set by relevant recommendations
COMPLETENESS	All data transmitted by CPCs contain all mandatory information as required under relevant recommendations	• Percentage of missing values (mandatory fields) for each data table
CONFORMITY	The data transmitted by CPCs adhere to GFCM standards (codification and format).	• Percentage of data rows with anomalous values for each data table

INDICATORS	DEFINITION	CHECKS
STABILITY	The data transmitted by CPCs vary within acceptable limits compared with the values of the same variables in the recent past.	• Percentage of data rows with values outside the expected range in each data table over time
CONSISTENCY	The data transmitted by CPCs are coherent with the values of similar variables reported in different data tables for the same reference year. The data analysis includes checks with similar variables from other official data sources.	• Number of data rows with incoherent values (data fields) in relevant data tables
ACCURACY	The data transmitted by CPCs are close to a realistic or expected value (sampling coverage, precision and bias checks). The data analysis includes the identification of possible outliers, i.e. values that are outside predefined bounds of statistical control, as well as of any variation in the time series that could imply changes in the methodology or errors in data transmission.	• Number of strata with low sampling effort • Number of strata with high dispersion indices • Number of outliers
ADEQUACY	The data transmitted by CPCs allow relevant GFCM subsidiary bodies to provide scientific advice upon request of the Commission. The adequacy of data should be regularly evaluated both at the national and regional levels. Relevant GFCM subsidiary bodies should make proposals to improve the adequacy standards for the data that are needed for the purpose of scientific advice formulation.	

The results of the external evaluation will be transmitted to the countries, so as to obtain their feedback and overcome any problems identified.

Chapter 9 - Data confidentiality and access policy

One of the key issues considered within the GFCM-DCRF is data confidentiality. In the context of regional data collection, there is a need for a series of common principles for data sharing and dissemination, to ensure confidentiality protection. These principles recall the concept of privacy viewed as a basic human right by the United Nations:[25]

Article 12 of the Universal Declaration of Human Rights
(General Assembly of the United Nations, 1948)
"No one shall be subjected to arbitrary interference with his privacy, family, home or correspondence, nor to attacks upon his honor and reputation. Everyone has the right to the protection of the law against such interference or attacks."

In this sense, the GFCM will, through its Secretariat, define and maintain high levels of protection for the data transmitted by CPCs complying with the GFCM data transmission requirements, as endorsed by the Commission. To this extent, the Secretariat established dedicated online platforms, in line with recent trends at UN-level in terms of secure, flexible and cost-effective IT solutions supporting online cooperative activities and information management.

CPCs will be responsible for the quality and completeness of the data sent to the GFCM. Data and information transmitted by CPCs will be treated by the GFCM Secretariat in accordance with all necessary measures to comply with GFCM security and confidentiality provisions. Once collected and validated by the GFCM Secretariat, data shall be made publicly available to selected audience, in accordance with the following criteria:

Data confidentiality status (DCS)

		P	S	R
		Public	**Semi-private**	**Private**
Online authentication	Audience	Not sensitive information	Partially sensitive information	Sensitive information
No	General public	Yes	No	No
Yes	GFCM meetings attendees	Yes	Yes	No
	SAC, WGBS and GFCM bureau, GFCM Secretariat, users of the DCRF online platform designated by national authorities of CPCs	Yes	Yes	Yes

These criteria may be applied to both raw and aggregated data as defined in the related GFCM decisions and according to the security provision defined by the Commission. Particular attention will be given to crucial requirements such as the flexibility to address emerging needs in data transmission, cost-efficiency, service levels, data security, and privacy provisions in compliance with relevant standards.

[25] Matthews, G. J. & Harel, O. Data confidentiality: A review of methods for statistical disclosure limitation and methods for assessing privacy. Statistics Surveys 5 (2011), 1--29. doi:10.1214/11-SS074. http://projecteuclid.org/euclid.ssu/1296828958

Chapter 10 - Data transmission

The data transmission to the GFCM Secretariat is meant to be performed by CPCs through the dedicated DCRF online platform, available within the GFCM extranet. This online system will allow CPCs to manage the data transmission procedures, in accordance with most of the fisheries data requirements defined in several GFCM Recommendations, and facilitate the communication with the GFCM Secretariat.

The overall online system will be equipped with an automated reminder to better assist CPCs in complying with GFCM data transmission requirements, within deadlines endorsed at Commission level. Moreover, data validation mechanisms will be progressively put in place to ensure compliance with GFCM codifications, standards and data transmission requirements (such as compulsory fields). The aim is to provide CPCs with a familiar and secure environment where the following services are delivered to national eligible users, for the sake of data transmission, through a single access credential system:

- Secure data transmission tools leveraging a flexible and cost-effective infrastructure;
- Online guide in English and French with an introduction for each data table and relevant descriptions for the data fields to compile and the codification standards to comply with;
- At-a-glance compliance reporting system, providing countries with an immediate and exhaustive report of their overall compliance level;
- Historical records of data transmission by countries;
- Notification e-mail system (upon data transmission an automatic message is sent to relevant audience of each PCC as well as to the GFCM Secretariat);
- Dynamic dashboards, including charts and interactive tables (to be progressively put at disposal to the users for data consultation purposes, upon validation and import of the transmitted information in the GFCM Secretariat databases).

The design of the DCRF online platform considers different potential scenarios of data transmission workflows at the national level. If several persons are in charge of various data topics on the basis of roles assigned to them by the national authorities of CPCs, respective access policies could be adjusted in order to deliver relevant features only.

Through the DCRF online platform, several data transmission procedures will be made available in accordance to business needs and validation mechanisms entailed (online forms, upload of predefined Excel/Word templates).

A P P E N D I C E S

Appendix A - Priority species (2021)

A.1 - Group 1 species. Species that drive the fishery and for which assessment is regularly carried out.

		GFCM subregions ►	**Western Mediterranean Sea**	**Central Mediterranean Sea**	**Adriatic Sea**	**Eastern Mediterranean Sea**	**Black Sea**
		GSAs ►	*1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11*	*12, 13, 14, 15, 16, 19, 20, 21*	*17, 18*	*22, 23, 24, 25, 26, 27*	*28, 29, 30*
		Countries ►	*Algeria, France, Italy, Monaco, Morocco, Spain*	*Italy, Greece, Libya, Malta, Tunisia*	*Albania, Bosnia and Herzegovina, Croatia, Italy, Montenegro, Slovenia*	*Cyprus, Egypt, Greece, Israel, Lebanon, Syrian Arab Republic, Turkey*	*Bulgaria, Georgia, Romania, Turkey, Ukraine (Russian Federation)**
Species	**Scientific name**	**FAO 3-alpha code**					
Pelagics	*Engraulis encrasicolus*	ANE	X	X	X	X	X
	Sardina pilchardus	PIL	X	X	X	X	
	Sardinella aurita	SAA	X	X		X	
	Sprattus sprattus	SPR					X
	Trachurus mediterraneus	HMM					X
Demersal	*Aristeus antennatus*	ARA		X		X	
	Aristaeomorpha foliacea	ARS		X		X	
	Lagocephalus sceleratus	LFZ	X	X	X	X	
	Merlangius merlangus	WHG					X
	Merluccius merluccius	HKE	X	X	X	X	
	Mullus barbatus	MUT		X	X	X	X
	Nephrops norvegicus	NEP			X		
	Pagellus bogaraveo	SBR	X				
	Parapenaeus longirostris	DPS	X	X	X		
	Pterois miles	UHQ	X	X	X	X	
	Rapana venosa	RPW					X
	Scophthalmus maximus	TUR					X
	Sepia officinalis	CTC			X		

		GFCM subregions ►	Western Mediterranean Sea	Central Mediterranean Sea	Adriatic Sea	Eastern Mediterranean Sea	Black Sea
		GSAs ►	*1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11*	*12, 13, 14, 15, 16, 19, 20, 21*	*17, 18*	*22, 23, 24, 25, 26, 27*	*28, 29, 30*
		Countries ►	*Algeria, France, Italy, Monaco, Morocco, Spain*	*Italy, Greece, Libya, Malta, Tunisia*	*Albania, Bosnia and Herzegovina, Croatia, Italy, Montenegro, Slovenia*	*Cyprus, Egypt, Greece, Israel, Lebanon, Syrian Arab Republic, Turkey*	*Bulgaria, Georgia, Romania, Turkey, Ukraine (Russian Federation)**
Species	**Scientific name**	**FAO 3-alpha code**					
Demersal	*Solea solea*	SOL			X		
	Squalus acanthias[26]	DGS					X
	Squilla mantis	MTS			X		
Additional species**	*Anguilla anguilla*	ELE	X	X	X	X	
	Corallium rubrum	COL	X	X	X	X	
	Coryphaena hippurus	DOL	X	X	X	X	
	Saurida lessepsianus[27]	SZX				X	

** All States, including those that are not-CPCs and which are known to fish in the GFCM area of application, are encouraged to cooperate in joint actions undertaken in accordance with applicable international obligations (i.e. Article 63 UNCLOS).*
*** as identified by the Mid-term strategy (2017-2020) towards the sustainability of Mediterranean and Black Sea fisheries.*

[26] Species included in Appendix III (species whose exploitation is regulated) of the Barcelona Convention (protocol concerning Specially Protected Areas and Biological Diversity in the Mediterranean).
[27] The species is not currently present in the ASFIS list and therefore the 3-alpha code of its genus (Saurida spp) has been used.

A.2 - Group 2 species. Species which are important in terms of landing and/or economic values at regional and subregional level, and for which assessment is not regularly carried out.

		Western Mediterranean Sea	**Central Mediterranean Sea**	**Adriatic Sea**	**Eastern Mediterranean Sea**	**Black Sea**
	GFCM subregions ►					
	GSAs ►	*1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11*	*12, 13, 14, 15, 16, 19, 20, 21*	*17, 18*	*22, 23, 24, 25, 26, 27*	*28, 29, 30*
	Countries ►	*Algeria, France, Italy, Monaco, Morocco, Spain*	*Italy, Greece, Libya, Malta, Tunisia*	*Albania, Bosnia and Herzegovina, Croatia, Italy, Montenegro, Slovenia*	*Cyprus, Egypt, Greece, Israel, Lebanon, Syrian Arab Republic, Turkey*	*Bulgaria, Georgia, Romania, Turkey, Ukraine (Russian Federation)**
Scientific name	**FAO 3-alpha code**					
Alosa immaculata	SHC					X
Aristeus antennatus	ARA		X		X	
Boops boops	BOG	X	X	X	X	
Chamelea gallina	SVE			X		
Diplodus annularis	ANN		X			
Eledone cirrhosa	EOI	X		X		
Eledone moschata	EDT			X		
Galeus melastomus	SHO	X				
Lophius budegassa	ANK	X	X			
Micromesistius poutassou	WHB	X				
Mullus surmuletus	MUR	X	X		X	
Octopus vulgaris	OCC	X	X	X	X	
Pagellus erythrinus	PAC	X	X	X	X	
Raja asterias	JRS	X				
Raja clavata	RJC	X	X			
Sarda sarda	BON					X
Saurida undosquamis	LIB				X	
Scomber japonicus	MAS	X			X	
Scomber scombrus	MAC	X	X			
Sepia officinalis	CTC			X		

		Western Mediterranean Sea	**Central Mediterranean Sea**	**Adriatic Sea**	**Eastern Mediterranean Sea**	**Black Sea**
	GFCM subregions ►					
	GSAs ►	*1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11*	*12, 13, 14, 15, 16, 19, 20, 21*	*17, 18*	*22, 23, 24, 25, 26, 27*	*28, 29, 30*
	Countries ►	*Algeria, France, Italy, Monaco, Morocco, Spain*	*Italy, Greece, Libya, Malta, Tunisia*	*Albania, Bosnia and Herzegovina, Croatia, Italy, Montenegro, Slovenia*	*Cyprus, Egypt, Greece, Israel, Lebanon, Syrian Arab Republic, Turkey*	*Bulgaria, Georgia, Romania, Turkey, Ukraine (Russian Federation)**
Scientific name	**FAO 3-alpha code**					
Siganus luridus	IGU				X	
Siganus rivulatus	SRI				X	
Solea solea	SOL			X		
Sphyraena sphyraena	YRS		X			
Spicara smaris	SPC			X	X	
Trachurus mediterraneus	HMM					X
Trachurus picturatus	JAA	X				
Trachurus trachurus	HOM	X	X		X	

** All States, including non- CPCs of the GFCM which are known to fish in its competence area, are encouraged to cooperate in joint actions undertaken in accordance with applicable international obligations (i.e. Article 63 UNCLOS).*

A.3 - Group 3 species. Species within international/ national management plans and recovery and/or conservation action plans; non-indigenous species with the greatest potential impact.

		Western Mediterranean Sea	**Central Mediterranean Sea**	**Adriatic Sea**	**Eastern Mediterranean Sea**	**Black Sea**
	GFCM subregions ►					
	GSAs ►	*1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11*	*12, 13, 14, 15, 16, 19, 20, 21*	*17, 18*	*22, 23, 24, 25, 26, 27*	*28, 29, 30*
	Countries ►	*Algeria, France, Italy, Monaco, Morocco, Spain*	*Italy, Greece, Libya, Malta, Tunisia*	*Albania, Bosnia and Herzegovina, Croatia, Italy, Montenegro, Slovenia*	*Cyprus, Egypt, Greece, Israel, Lebanon, Syrian Arab Republic, Turkey*	*Bulgaria, Georgia, Romania, Turkey, Ukraine (Russian Federation)***
Scientific name	**FAO 3-alpha code**					
Callinectes sapidus	CRB	X	X	X	X	
Dalatias licha	SCK	X	X	X	X	
Dipturus oxyrinchus	RJO	X	X	X	X	
Etmopterus spinax	ETX	X	X	X	X	
Galeus melastomus	SHO		X	X	X	
Hexanchus griseus	SBL	X	X	X	X	
*Mustelus asterias**	SDS	X	X	X	X	
*Mustelus mustelus**	SMD	X	X	X	X	
*Mustelus punctulatus**	MPT	X	X	X	X	
Myliobatis aquila	MYL	X	X	X	X	
Portunus segnis	QSO	X	X	X	X	
*Prionace glauca**	BSH	X	X	X	X	
Pteroplatytrygon violacea	PLS	X	X	X	X	
Raja asterias	JRS		X	X	X	
Raja clavata	RJC			X	X	X
Raja miraletus	JAI	X	X	X	X	
Scyliorhinus canicula	SYC	X	X	X	X	X
Scyliorhinus stellaris	SYT	X	X	X	X	
*Squalus acanthias**	DGS	X	X	X	X	

	GFCM subregions ►	**Western Mediterranean Sea**	**Central Mediterranean Sea**	**Adriatic Sea**	**Eastern Mediterranean Sea**	**Black Sea**
	GSAs ►	*1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11*	*12, 13, 14, 15, 16, 19, 20, 21*	*17, 18*	*22, 23, 24, 25, 26, 27*	*28, 29, 30*
	Countries ►	*Algeria, France, Italy, Monaco, Morocco, Spain*	*Italy, Greece, Libya, Malta, Tunisia*	*Albania, Bosnia and Herzegovina, Croatia, Italy, Montenegro, Slovenia*	*Cyprus, Egypt, Greece, Israel, Lebanon, Syrian Arab Republic, Turkey*	*Bulgaria, Georgia, Romania, Turkey, Ukraine (Russian Federation)***
Scientific name	**FAO 3-alpha code**					
Squalus blainville	QUB	X	X	X	X	
Torpedo marmorata	TTR	X	X	X	X	
Torpedo torpedo	TTV	X	X	X	X	
Fistularia commersonii	FIO				X	
Marsupenaeus japonicus	KUP				X	
Metapenaeus stebbingi	MNG				X	
Scomberomorus commerson	COM				X	

** Species included in Appendix III (species whose exploitation is regulated) of the Barcelona Convention (protocol concerning Specially Protected Areas and Biological Diversity in the Mediterranean).*

***All States, including non-CPCs of the GFCM which are known to fish in its competence area, are encouraged to cooperate in joint actions undertaken in accordance with applicable international obligations (i.e. Article 63 UNCLOS).*

Appendix B - Fleet segments
(Combination of vessel groups and length classes)

<table>
<tr><th colspan="3" rowspan="2">Vessel groups</th><th colspan="4">Length classes (LOA)</th></tr>
<tr><th>< 6 m</th><th>6 - 12 m</th><th>12-24 m</th><th>> 24 m</th></tr>
<tr><td rowspan="3">Polyvalent</td><td rowspan="3">P</td><td>Small-scale vessels without engine using passive gear</td><td>P-01</td><td>P-02</td><td rowspan="2">P-03</td><td rowspan="2">P-04</td></tr>
<tr><td colspan="2">P-13</td></tr>
<tr><td>Small-scale vessels with engine using passive gear</td><td>P-05</td><td>P-06</td><td>P-07</td><td>P-08</td></tr>
<tr><td></td><td></td><td>Polyvalent vessels</td><td>P-09</td><td>P-10</td><td>P-11</td><td>P-12</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td colspan="2">P-14</td></tr>
<tr><td rowspan="2">Seiners</td><td rowspan="2">S</td><td>Purse seiners</td><td>S-01</td><td>S-02</td><td>S-03</td><td>S-04</td></tr>
<tr><td></td><td></td><td></td><td colspan="2">S-09</td></tr>
<tr><td></td><td></td><td>Tuna seiners</td><td>S-05</td><td>S-06</td><td>S-07</td><td>S-08</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td colspan="2">S-10</td></tr>
<tr><td rowspan="2">Dredgers</td><td rowspan="2">D</td><td rowspan="2">Dredgers</td><td rowspan="2">D-01</td><td>D-02</td><td>D-03</td><td rowspan="2">D-04</td></tr>
<tr><td colspan="2">D-05</td></tr>
<tr><td rowspan="3">Trawlers</td><td rowspan="3">T</td><td>Beam trawlers</td><td>T-01</td><td>T-02</td><td>T-03</td><td>T-04</td></tr>
<tr><td rowspan="2">Pelagic trawlers</td><td rowspan="2">T-05</td><td>T-06</td><td>T-07</td><td>T-08</td></tr>
<tr><td colspan="3">T-13</td></tr>
<tr><td></td><td></td><td>Trawlers</td><td>T-09</td><td>T-10</td><td>T-11</td><td>T-12</td></tr>
<tr><td rowspan="2">Longliners</td><td rowspan="2">L</td><td rowspan="2">Longliners</td><td rowspan="2">L-01</td><td>L-02</td><td>L-03</td><td>L-04</td></tr>
<tr><td colspan="3">L-05</td></tr>
</table>

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 the vessels using more than one gear, with a combination of passive and active gear, none of which exceeding 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.*
- *The yellow cells contain the codes of reported fleet segments which should be included in the GFCM data transmission. If necessary, fleet segments as identified in the orange cells can be used: P-13 (P-01 + P-02), P-14 (P-11 + P-12), S-09 (S-03 + S-04), S-10 (S-07 + S-08), D-05 (D-02 + D-03), T-13 (T-06 + T-07 + T-08) and L-05 (L-02 + L-03 + L-04). Any proposal for a different aggregation of fleet segments should be brought to the attention of the relevant GFCM subsidiary bodies, mentioning the rationale and corresponding references (e.g. existing scientific studies), which in turn should confirm the similarity/homogeneity of the combined cells.*

Appendix C - Fisheries Restricted Areas (FRAs)

A Fisheries Restricted Area (FRA) is ***a geographically-defined area in which all or certain fishing activities are temporarily or permanently banned or restricted in order to improve the exploitation and conservation of harvested living aquatic resources or the protection of marine ecosystems.***

In the recent years, the GFCM has established FRAs with different types and levels of restriction (i.e. fishing effort limit; time limit; buffer areas, etc.). In the following FRAs, fishing activity is allowed with different types of restrictions and temporal limitations.

Name of FRA	Code	Country	GSA	km^2
Gulf of Lion	**LI**	France, Spain	07	3,741.6
Jabuka/Pomo Pit	**JP**	Italy, Croatia	17	3,143

Gulf of Lion*

For demersal stocks, fishing effort of vessels using towed nets, bottom and midwater longlines and/or bottom-set nets shall not exceed the level of the fishing effort applied in 2008 in the FRA of the eastern Gulf of Lion, as bounded by lines joining the following geographic coordinates (Recommendation GFCM/33/2009/1):

Coordinates
42°40'N, 4°20' E;
42°40'N, 5°00' E;
43°00'N, 4°20' E;
43°00'N, 5°00' E;

Jabuka/Pomo Pit

As per Recommendation GFCM/41/2017/3, in the FRA of Jabuka/Pomo Pit fishing activities are permanently prohibited in Zone A (any professional fishing activity with bottom-set nets, bottom trawls, set longlines and traps is prohibited), whilst in Zone B and C some activities are temporarily prohibited as follows:

- **Zone B** Fishing activities with bottom-set nets, bottom trawls, set longlines and traps shall be prohibited in zone B, from 1 September to 31 October each year and
- **Zone C** Fishing activities with bottom-set nets, bottom trawls, set longlines and traps and recreational fisheries shall be prohibited from 1 September to 31 October each year

ZONE B		ZONE C	
43°03,477' N	14°54,982' E	43°17,436' N	15°29,496' E
42°49,811' N	14°29,550' E	43°24,758' N	15°33,215' E
42°35,205' N	14°59,611' E	43°20,345' N	15°47,012' E
42°49,668' N	15°05,802' E	43°18,150' N	15°51,362' E
42°50,450' N	15°07,431' E	43°13,984' N	15°55,232' E
		43°12,873' N	15°52,761' E
		43°13,494' N	15°40,040' E

** DCRF table IV.3 applies to the Gulf of Lion only since data requirements for Jabuka/Pomo Pit are currently subject to the ongoing DCRF harmonization process*

Appendix D - Fishing gear[28]

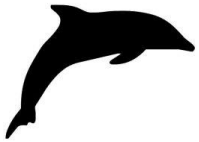
Fishing gear		Code
Surrounding nets	Purse seines	**PS**
	Surrounding nets (nei)	**SUX**
	Surrounding nets without purse lines	**LA**
Seine nets	Beach seines	**SB**
	Boat seines	**SV**
	Seine nets (nei)	**SX**
Trawls	Beam trawls	**TBB**
	Bottom pair trawls	**PTB**
	Bottom trawls (nei)	**TB**
	Midwater pair trawls	**PTM**
	Midwater trawls (nei)	**TM**
	Multiple bottom otter trawls	**OTP**
	Single boat bottom otter trawls	**OTB**
	Single boat midwater otter trawls	**OTM**
	Trawls (nei)	**TX**
	Twin bottom otter trawls	**OTT**
Dredges	Hand dredges	**DRH**
	Mechanised dredges	**DRM**
	Towed dredges	**DRB**
Gillnets and entangling nets	Combined gillnets-trammel nets	**GTN**
	Drift gillnets	**GND**
	Encircling gillnets	**GNC**
	Fixed gillnets (on stakes)	**GNF**
	Gillnets and entantling nets (nei)	**GEN**
	Set gillnets (anchored)	**GNS**
	Trammel nets	**GTR**
Traps	Aerial traps	**FAR**
	Barrier, fences, weirs, etc	**FWR**
	Fyke nets	**FYK**
	Pots	**FPO**
	Stationary uncovered pound nets	**FPN**
	Stow nets	**FSN**
	Traps (nei)	**FIX**
Hooks and lines	Drifting longlines	**LLD**
	Handlines and hand-operated pole-and-lines	**LHP**
	Hooks and lines (nei)	**LX**
	Longlines (nei)	**LL**
	Mechanized lines and pole-and-lines	**LHM**
	Set longlines	**LLS**
	Trolling lines	**LTL**
	Vertical lines	**LVT**

[28] International Standard Statistical Classification of Fishing Gear (ISSCFG, 2016)

Fishing gear		Gear code
Miscellaneous gear	Diving	**MDV**
	Drive-in nets	**MDR**
	Electric fishing	**MEL**
	Gear nei	**MIS**
	Hand implements (Wrenching gear, Clamps, Tongs, Rakes, Spears)	**MHI**
	Harpoons	**HAR**
	Pumps	**MPM**
	Pushnets	**MPN**
	Scoopnets	**MSP**

Appendix E - Vulnerable species

E.1 - Vulnerable species. List of vulnerable species included in Appendix II (endangered or threatened species) and Appendix III (species whose exploitation is regulated) of the Barcelona Convention (*Convention for the Protection of the Marine Environment and the Coastal Region of the Mediterranean*). The list also contains the Amendments of Annexes II and III of the Protocol concerning Specially Protected Areas and Biological Diversity 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 Protocol concerning Specially Protected Areas and Biological Diversity SPA/BD in the Mediterranean of the Convention for the Protection of the Marine Environment and the Coastal Region of the Mediterranean, 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
	Balenidae	*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	*Odontaspis ferox*	Small-tooth sand tiger shark
		Carcharias taurus	Sand tiger
	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**	European storm-petrel (Mediterranena)
		*Hydrobates pelagicus melitensis**	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 (Mediterranenan)
		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

E.2 - Rare elasmobranchs species. This list reports elasmobranchs species that are included in the IUCN Red List of Threatened species (www.iucnredlist.org) or that are considered rare in the Mediterranean and the Black Sea (Bradai *et al.*, 2012).

Group of rare species	Family	Species	Common name
Sharks, Rays, Chimaeras	Alopiidae	*Alopias superciliosus*	Bigeye thresher
	Hexanchidae	*Hexanchus nakamurai*	Bigeye 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
		Taeniura grabata	Round stingray
	Myliobatidae	*Aetomylaeus bovinus*	Bullray
	Rhinopteridae	*Rhinoptera marginata*	Lusitanian cownose ray
	Sphyrnidae	*Sphyrna tudes*	Smalleye hammerhead

Appendix F - Fishing effort measurement

Mandatory

F.1 - Effort measurement by fleet segment

Fleet segments			Effort measurements		
Vessel groups		**Length classes (LOA)**	**Unit of capacity**	**Unit of activity**	**Nominal effort**
P	Small-scale vessels without engine using passive gear Small-scale vessels with engine using passive gear Polyvalent vessels	All	Net length [29] [30]	Fishing days	Net length x Fishing days
			Number of traps/pots [30]	Fishing days	Number of traps/pots x Fishing days
			Number of lines [30]	Fishing days	Number of lines x Fishing days
S	Purse seiners Tuna seiners	All	GT	Number of fishing sets [31] [32]	GT x Number of fishing sets
D	Dredgers	All	GT	Fishing days	GT x Fishing days
T	Beam trawlers Pelagic trawlers Trawlers	All	GT	Fishing days	GT x Fishing days
L	Long liners	All	Number of hooks [30]	Fishing days	Number of hooks x Fishing days

[29] Length of net expressed in 100-metre units (FAO)
[30] Should this information not be available, "GT" may be used as capacity unit upon approval by relevant GFCM subsidiary bodies on a case-by-case basis.
[31] Number of times the gear has been set or shot, whether or not a catch was made (FAO)
[32] Should this information not be available, "fishing days" may be used as activity unit upon approval by relevant GFCM subsidiary bodies on a case-by-case basis.

F.2 - Effort measurement by fishing gear

Fishing gear		Gear code	Unit of capacity	Unit of activity	Nominal effort
Surrounding nets	Purse seines	PS	GT	Number of fishing sets [33] [34]	GT x Number of fishing sets
	Surrounding nets without purse lines	LA			
	Surrounding nets (nei)	SUX			
Seine nets	Beach seines	SB	Net length [35] [36]	Fishing days	Net length x Fishing days
	Boat seines	SV			
	Seine nets (nei)	SX			
Trawls	Beam trawls	TBB	GT	Fishing days	GT x Fishing days
	Bottom pair trawls	PTB			
	Bottom trawls (nei)	TB			
	Midwater pair trawls	PTM			
	Midwater trawls (nei)	TM			
	Multiple bottom otter trawls	OTP			
	Single boat bottom otter trawls	OTB			
	Single boat midwater otter trawls	OTM			
	Trawls (nei)	TX			
	Twin bottom otter trawls	OTT			
Dredges	Hand dredges	DRH	GT	Fishing days	GT x Fishing days
	Mechanised dredges	DRM			
	Towed dredges	DRB			
Gillnets and Entangling Nets	Combined gillnets-trammel nets	GTN	Net length [35] [36]	Fishing days	Net length x Fishing days
	Drift gillnets	GND			
	Encircling gillnets	GNC			
	Fixed gillnets (on stakes)	GNF			
	Gillnets and entantling nets (nei)	GEN			
	Set gillnets (anchored)	GNS			
	Trammel nets	GTR			

[33] Number of times the gear has been set or shot, whether or not a catch was made (FAO)
[34] Should this information not be available, "fishing days" may be used as activity capacity upon approval by relevant GFCM subsidiary bodies on a case-by-case basis.
[35] Length of net expressed in 100-metre units (FAO)
[36] Should this information not be available, "GT" may be used as capacity unit upon approval by relevant GFCM subsidiary bodies on a case-by-case basis

Fishing gear		Gear code	Unit of capacity	Unit of activity	Nominal effort
Traps	Aerial traps	FAR	Number of traps/pots [36]	Fishing days	Number of traps/pots x Fishing days
	Barrier, fences, weirs, etc	FWR			
	Fyke nets	FYK			
	Pots	FPO			
	Stationary uncovered pound nets	FPN			
	Stow nets	FSN			
	Traps (nei)	FIX			
Hooks and Lines	Handlines and hand-operated pole-and-lines	LHP	Number of lines [36]	Fishing days	Number of lines x Fishing days
	Mechanized lines and pole-and-lines	LHM			
	Trolling lines	LTL			
	Vertical lines	LVT			
	Drifting longlines	LLD	Number of hooks [36]	Fishing days	Number of hooks x Fishing days
	Hooks and lines (nei)	LX			
	Longlines (nei)	LL			
	Set longlines	LLS			
Miscellaneous gear	Diving	MDV	Number / Length / GT	Fishing days	Number / Length / GT x Fishing days
	Drive-in nets	MDR			
	Electric fishing	MEL			
	Gear nei	MIS			
	Hand implements (Wrenching gear, Clamps, Tongs, Rakes, Spears)	MHI			
	Harpoons	HAR			
	Pumps	MPM			
	Pushnets	MPN			
	Scoopnets	MSP			

Appendix G - Scales of maturity stages

G.1 - *Bony fish*

Stages	Maturation state	Reproductive apparatus aspect	
0	UNDETERMINED	Sex not distinguished by naked eye. Gonads very small and translucent, almost transparent. Sex undetermined.	
		Females	*Males*
1	IMMATURE-VIRGIN	Small pinkish and translucent ovary shorter than 1/3 of body cavity. Eggs not visible to naked eye.	Thin and whitish testis shorter than 1/3 of body cavity.
2a	VIRGIN-DEVELOPING	Small pinkish/reddish ovary shorter than 1/2 of body cavity. Eggs not visible to naked eye.	Thin whitish testis shorter than 1/2 of body cavity.
2b	RECOVERING	Pinkish-reddish/reddish-orange and translucent ovary; length about 1/2 of body cavity. Blood vessels visible. Eggs not visible to naked eye.	Whitish/pinkish testis, more or less symmetrical; length about 1/2 of body cavity.
2c	MATURING	Ovary pinkish-yellow in colour with granular appearance; length about 2/3 of body cavity. Eggs are visible to naked eye through the *ovaric tunica*, which is not yet translucent. Under light pressure, eggs are not expelled.	Whitish to creamy testis; length about 2/3 of body cavity. Under light pressure, sperm is not expelled.
3	MATURE/SPAWNER	Ovary orange-pink in colour, with conspicuous superficial blood vessels; length from 2/3 to full length of body cavity. Large transparent, ripe eggs are clearly visible and could be expelled under light pressure. In more advanced conditions, eggs escape freely.	Whitish-creamy soft testis; length from 2/3 to full length of body cavity. Under light pressure, sperm could be expelled. In more advanced conditions, sperm escapes freely.
4a	SPENT	Reddish ovary shrunk to about 1/2 length of body cavity. Flaccid ovaric walls; ovary may contain remnants of disintegrating opaque and/or translucent eggs.	Bloodshot and flabby testis shrunk to about 1/2 length of body cavity.
4b	RESTING	Pinkish and translucent ovary; length about 1/3 of body cavity. Eggs not visible to naked eye.	Whitish/pinkish testis, more or less symmetrical; length about 1/3 of body cavity.

G.2 - *Cephalopods*

Stages	Maturation state	Reproductive apparatus aspect	Sex
0	Undetermined	Sex not distinguished by naked eye. Sex undetermined.	U
1	Immature-Virgin	Small and translucent Nidamental glands (NG)/Oviducal glands (OG). Ovary is semi-transparent, stringy and lacking granular structure. Small semi-transparent NG/OG. Oviduct meander not visible. Total absence of spermatophores.	F
		Testis small. Spermatophoric complex (SC) semi-transparent; Vas deferens not visible. Penis appears as a small prominence of SC.	M
2a	Developing	NG/OVG enlarged. NG covering some internal organs. Whitish ovary with granular structure clearly visible, not reaching the posterior half of the mantle cavity. Oviduct meander clearly visible. Eggs very small. Absence of spermatophores.	F
		Enlarged testis with structure not clearly visible. Vas deferens is whitish or white and the spermatophoric organ has white streak.	M
2b	Maturing	Large NG covering the viscera below. Ovary occupies the whole posterior half of mantle cavity, containing reticulated oocytes of all sizes tightly packed and probably a few ripe ova at its proximal part. Oviducts fully developed but empty. Maturing eggs visible to naked eye. Few spermatophores.	F
		Vas deferens is white, meandering, enlarged. Needham's sac (SS) with structure less whitish particles inside. Normally the Needham's sac is without functional spermatophores, but sometimes some immature/abortive ones could occur. Testis tight, crispy, with visible structure.	M
3a	Mature	Large NG as previously. Ovary containing higher percentage of large reticulated eggs and some large ripe ova with smooth surface. In Teuthoidea ripe ova in oviducts. Eggs medium and big, and visible both in oviducts and in the ovary. Well-developed spermatophores.	F
		Testis as before. Spermatophores packed in the Needham's sac.	M
3b	Spent	NG/OG large but soft and running. Ovary shrunk and flaccid, with only immature oocytes attached to the central tissue and a few loose large ova in the coelom. In Teuthoidea, oviduct may contain some mature ova but are no longer packed.	F
		Disintegrating spermatophores in the Needham's sac and the penis.	M

G.3 - *Crustaceans*

Stages	Maturation state	Reproductive apparatus aspect				
		Colouring of fresh ovary	*Parapenaeus longirostris*	*Aristaeomorpha foliacea*	*Aristeus antennatus*	*Nephrops norvegicus*
1	Immature	whitish or translucid	Ovaries not visible without dissection. The ovaries are thin and translucent with a tubular appearance adherent to the dorsal portion of the stomach, not extending to the abdomen.	Ovaries not visible without dissection. The ovaries are thin and translucent with a tubular appearance adherent to the laterals of the stomach, not extending to the abdomen.	Ovaries not visible without dissection. The ovaries are thin and translucent with a tubular appearance adherent to the laterals of the stomach, not extending to the abdomen.	Ovaries not visible without dissection. The ovaries are translucent, thin and threadlike.
2	Developing	*A. foliacea*: flesh coloured; *A. antennatus:* ivory coloured with orange pink-violet dotting; *N. norvegicus*: cream; *P. longirostris*: cream orange;	Ovaries are barely visible without dissection. The cephalic lobes start to cover the sides while the abdominal extensions occupy all somites.	Ovaries barely visible without dissection. Cephalic lobes small but distinguishable. The gonad generally extends up to 3rd abdominal somite.	Ovaries barely visible without dissection. Cephalic lobes small but distinguishable. The gonad extends to the full length of the abdomen.	Ovaries barely visible without dissection. The gonads extends up to the 1st somite of the abdomen and have a granular appearance.
3	Maturing	*A. foliacea*: light and dark grey; *A. antennatus:* lilla; *N. norvegicus*: light green; *P. longirostris*: light green or grey green;	Ovaries are clearly visible through integument. Ovaries developed and turgid, with cephalic lobes and abdominal extensions occupying the entirely the dorsal portion. The gonads appear granular.	Ovaries are clearly visible through integument. Ovaries developed and turgid, with evident cephalic lobes. The gonad generally extends to the 4th abdominal somite	Ovaries are clearly visible through integument. Cephalic and abdominal extensions are well developed and turgid.	Ovaries are clearly visible through integument. The gonad occupies one third of the cephalotoracic space. The gonads extend up to the 1st somite of the abdomen.
4	Mature	*A. foliacea*: black; *A. antennatus:* violet; *N. norvegicus*: dark grey; *P. longirostris*: brightgreen or olive green;	Turgid ovaries extending to the whole dorsal area. Lobes and extensions well developed. Eggs well visible.	Turgid ovaries extending to the whole dorsal area. Lobes well developed and abdominal extensions may reach the 5th somite. Eggs well visible.	Turgid ovaries occupying the whole dorsal area. Lobes and abdominal extensions well developed. Eggs well visible.	Turgid ovaries occupying the whole dorsal cephalotoracic space and extending up to the 2nd somite. Eggs visible.
5	Spent/Resting /Recovering	uncoloured	Ovaries after spawning are fully extended but loose turgidity becoming flaccid.	Ovaries large but flaccid with blackish spots.	Ovaries large but flaccid with purple spots.	Ovaries flaccid with green spots. Re-absorption of ovarian material. Most likely with green eggs on pleopods.

G.4 - *Elasmobranchs oviparous*

Oviparous elasmobranchs		Females		Males	
MATURATION STATE	STAGES	MATURATION STATE	REPRODUCTIVE APPARATUS ASPECT	MATURATION STATE	REPRODUCTIVE APPARATUS ASPECT
IMMATURE	**1**	IMMATURE	Ovaries: small and whitish. Undistinguishable ovarian follicles. Oviducal gland often not visible. In some species a thickening of the uteri where the gland will develop may be visible. Uteri: thread-like and narrow.	IMMATURE	Claspers: flexible, non-calcified and shorter than pelvic fins. Testes: small and undeveloped (in skates, sometimes with visible lobules). Ducts: straight and thread-like.
	2	DEVELOPING	Ovaries: follicles of different stages of development. Some small and medium-sized yolked follicles may be present. Oviducal gland: distinguishable and developing. Uteri: enlarging.	DEVELOPING	Claspers: flexible, partially calcified and usually as long as or longer than pelvic fins. Testes: developing (in skates, lobules clearly visible but not fully developed). Ducts: developing and beginning to coil.
MATURE	**3a**	CAPABLE OF REPRODUCTION	Ovaries: presence of large yolked follicles ready to be ovulated. Oviducal glands: fully developed. Uteri: fully developed.	CAPABLE OF REPRODUCTION	Claspers: rigid, fully calcified, and longer than pelvic fins (in some sharks they may only be as long as the pelvic fins). Testes: fully developed (in skates, with fully formed lobules). Ducts: tightly coiled and filled with sperm.
	3b	EGG LAYING	Uteri: presence of egg capsules.	ACTIVE	Claspers: similar to stage 3a, however with clasper glands dilated, sometimes swollen and reddish. Sperm may be present in clasper groove or glands. Testes: similar to stage 3a. Ducts: sperm observed inside (after a cut) or flowing out of the cloaca on pressure.
	4a	POST-LAYING	Ovaries: flaccid with few follicles of different sizes. Few large vitellogenic follicles entering atresia. POFs and atretic follicles may be visible. Oviducal glands: fully developed but may be reduced in size. Uteri: enlarged and flaccid.	REGRESSING	Claspers: fully formed, similar to stage 3. Testes shrunken and flaccid, (in skates, with few visible lobules). On pressure sperm does not flow. Sperm ducts: empty and flaccid.
	4b	REGENERATING	Ovaries: large with small and medium-sized yolked follicles. Pre-ovulatory follicles absent. Oviducal glands: fully developed but may be reduced in size. Uteri: enlarged.	-	-

G.4 - *Elasmobranchs viviparous*

Viviparous elasmobranchs		**Females**			**Males**	
MATURATION STATE	STAGES	MATURATION STATE	REPRODUCTIVE APPARATUS ASPECT	STAGES	MATURATION STATE	REPRODUCTIVE APPARATUS ASPECT
IMMATURE	**1**	IMMATURE	Ovaries: small and whitish; undistinguishable ovarian follicles. Oviducal gland: often not visible. In some species a thickening of the uteri where the gland will develop may be visible. Uteri: thread-like and narrow.	**1**	IMMATURE	Claspers: flexible, non-calcified and usually shorter than pelvic fins. Testes: small and undeveloped. Ducts: straight and thread-like.
	2	DEVELOPING	Ovaries: follicles of different stages of development. Some small and medium-sized yolked follicles may be present. Oviducal gland: distinguishable and developing. Uteri: enlarging.	**2**	DEVELOPING	Claspers: flexible, partially calcified and as long as or longer than pelvic fins. Testes: developing and may start to segment in sharks; in rays lobules clearly visible but do not occupy the whole surface. Ducts: developing and beginning to coil.
MATURE	**3**	CAPABLE OF REPRODUCTION	Ovaries: presence of large yolked follicles ready to be ovulated. Oviducal glands: fully developed Uteri: fully developed.	**3a**	CAPABLE OF REPRODUCTION	Claspers: rigid, fully calcified, and longer than pelvic fins. Testes: fully developed; for some shark species testes are fully segmented. Ducts: tightly coiled and filled with sperm.
				3b	ACTIVE	Claspers: similar to stage 3a, however with clasper glands dilated, sometimes swollen. Sperm may be present in clasper groove or glands. Testes: similar to stage 3a. Ducts: sperm observed inside after a cut or flowing out of the cloaca on pressure.
				4	REGRESSING	Claspers: fully formed, similar to stage 3. Testes shrunken and flaccid, (in skates, with few visible lobules). On pressure, sperm does not flow. Sperm ducts: empty and flaccid. Seminal vesicle developed but empty.

G.4 - *Elasmobranchs viviparous*

Viviparous elasmobranchs		**Females**			**Males**	
MATURATION STATE	STAGES	MATURATION STATE	REPRODUCTIVE APPARATUS ASPECT	STAGES	MATURATION STATE	REPRODUCTIVE APPARATUS ASPECT
MATERNAL	**4a**	EARLY PREGNANCY	Uteri: well filled and rounded with yolk content (usually candle shaped). Embryos cannot be observed.	-	-	-
	4b	MID PREGNANCY	Uteri: well filled and rounded. Embryos are always visible, small and with a relatively large yolk sac.	-	-	-
	4c	LATE PREGNANCY	Uteri: embryos fully formed, yolk sacs reduced or absent.	-	-	-
	5	POST-PARTUM	Ovaries: shrunken without follicle development and with atretic (degenerating) follicles. Uteri: enlarged and flaccid.	-	-	-
MATURE	**6**	REGENERATING	Ovaries: large with small and medium-sized yolked follicles. Pre-ovulatory follicles absent. Atretic follicles may be present. Oviducal glands: fully developed but may be reduced in size. Uteri: enlarged.	-	-	-

G.5 - *Stomatopods*

Maturation state	Stages	Reproductive apparatus aspect
IMMATURE	**0**	ovaries filamentous and hyaline; 6th-8th sternites hyaline
QUIESCENT	**1**	filamentous ovaries with evident brown dots (chromatophores), 6th-8th sternites hyaline
EARLY MATURATION	**2**	narrow yellow ovaries, 6th-8th sternites whitish
MATURATION	**3**	yellow ovaries extending up to half of abdomen width, not visible through cutile on the ventral side of telson, 6th-8th sternites white.
RIPE	**4**	yellow ovaries extending over half abdominal width, visible through cutile on the ventral side of telson, 6th-8th sternites milky white.
SPENT	**5**	similar to quiescent ovaries, sometime with fewyellow dots, but 6th-8th sternites still white.

Appendix H - European eel fishery

H.1 - European eel habitats

Habitat	Code
Lagoon	**LGN**
Lake	**LAK**
Managed lagoon*	**MLG**
River	**RIV**

* Coastal lagoons which displays also fixed barriers at the sea channel

H.2 - Gear types for the European eel fishery

Gear types	Code	Gear units
Barrier	**BAR**	Meters*
Eel longlines	**ELL**	Number of hooks
Fishing rod	**FRD**	Number of rods
Glass eel net	**GEN**	Number of nets
Gillnets	**GLN**	Meters
Shore lift net	**SLN**	Number*
Spear fishing	**SPF**	Number*
Traps fyke nets	**FYK**	Number of fyke nets
Umbrella	**UMB**	Number of umbrellas

*if other units are used please indicate

H.3 - Stocking eel life stages

Life stage code	Name	Definition
G	Glass eel	Young, unpigmented eel, recruiting from the sea into continental waters. WGEEL considers that the term “glass eel” includes all recruits of the 0+ cohort age. In some cases, however, it also includes the early pigmented stages.
GY	Glass eel + yellow eel	A combination of glass and yellow eel. For some traps, glass eel and yellow eel were not separated in historical data sets, although glass eel was dominant.
Y	Yellow eel	Life stage resident in continental waters, often defined as a sedentary phase, although migration within and between rivers as well as to and from coastal waters occurs and concerns young pigmented eels (small eels sometimes called “elvers” or “bootlace eels”). In particular, some recruit series far up in the river (e.g. Meuse) or in the Baltic Sea consist of multiple age classes of young yellow eel, typically from 1 to 10+ years of age; they are referred to as “yellow eel recruits”.
QG	Quarantined glass eel	Eel that has been held in water tanks for some days or months between first capture and then release into a natural water basin, and that has been fed and grown during that time.
OG	Ongrown glass eel	Ongrown eel (see above) that has been held in isolation between capture and restocking.

Appendix I - Shared stocks

English common name	Scientific name	Area	Countries*
Dolphin fish	*Coryphaena hippurus*	Western Mediterranean	Italy, Malta, Spain and Tunisia
Horned octopus	*Eledone cirrhosa*	Adriatic Sea	Albania, Croatia, Italy and Serbia-Montenegro
Musky octopus	*Eledone moschata*	Adriatic Sea	Albania, Croatia, Italy, Slovenia and Serbia-Montenegro
Anchovy	*Engraulis encrasicolus*	Adriatic Sea	Albania, Croatia, Italy, Slovenia and Serbia-Montenegro
Anchovy	*Engraulis encrasicolus*	Aegean Sea	Greece and Turkey
Anchovy	*Engraulis encrasicolus*	Gulf of Lion	France and Spain
Shortfin mako	*Isurus oxyrhinchus*	All Mediterranean	All countries
Porbeagle	*Lamna nassus*	All Mediterranean	All countries
European squid	*Loligo vulgaris*	Adriatic Sea	Albania, Croatia, Italy, Slovenia and Serbia-Montenegro
Blackbellied angler	*Lophius budegassa*	Adriatic Sea	Albania, Croatia, Italy, Slovenia and Serbia-Montenegro
Monkfish or angler	*Lophius piscatorius*	Adriatic Sea	Albania, Croatia, Italy, Slovenia and Serbia-Montenegro
Hake	*Merluccius merluccius*	Adriatic Sea	Albania, Croatia, Italy, Slovenia and Serbia-Montenegro
Hake	*Merluccius merluccius*	Gulf of Lion	France and Spain
Hake	*Merluccius merluccius*	North Tyrrhenian and Corsica	France and Italy
Hake	*Merluccius merluccius*	Sicily Channel	Italy, Libya, Malta and Tunisia
Blue whiting	*Micromesistius poutassou*	Adriatic Sea	Albania, Croatia, Italy and Serbia-Montenegro
Blue whiting	*Micromesistius poutassou*	North Tyrrhenian and Corsica	France and Italy
Red mullet	*Mullus barbatus*	Western Mediterranean	Corsica and Sardinia
Red mullet	*Mullus barbatus*	Adriatic Sea	Albania, Croatia, Italy, Slovenia and Serbia-Montenegro
Striped red mullet	*Mullus surmuletus*	Western Mediterranean	Corsica and Sardinia
Norway lobster	*Nephrops norvegicus*	Adriatic Sea	Albania, Croatia, Italy, Slovenia and Serbia-Montenegro
Norway lobster	*Nephrops norvegicus*	North Tyrrhenian and Corsica	France and Italy

English common name	Scientific name	Area	Countries*
Black spot seabream	*Pagellus bogaraveo*	Alboran Sea and the Straits of Gibraltar	Morocco and Spain
Common pandora	*Pagellus erythrinus*	Adriatic Sea	Albania, Croatia, Italy, Slovenia and Serbia-Montenegro
Common spiny lobster	*Palinurus elephas*	Western Mediterranean	Corsica and Sardinia
Common spiny lobster	*Palinurus elephas*	Sicily channel	Italy and Tunisia
Pink spiny lobster	*Palinurus mauritanicus*	Sicily channel	Italy and Tunisia
Deepwater rose shrimp	*Parapenaeus longirostris*	Adriatic Sea	Albania, Croatia, Italy and Serbia-Montenegro
Blue shark	*Prionace glauca*	All Mediterranean	All countries
Sardine	*Sardina pilchardus*	Adriatic Sea	Albania, Croatia, Italy, Slovenia and Serbia-Montenegro
Sardine	*Sardina pilchardus*	Aegean Sea	Greece and Turkey
Atlantic mackerel	*Scomber scomber*	Adriatic Sea	Albania, Croatia, Italy, Slovenia and Serbia-Montenegro
Common cuttlefish	*Sepia officinalis*	Adriatic Sea	Albania, Croatia, Italy, Slovenia and Serbia-Montenegro
Common sole	*Solea vulgaris*	Adriatic Sea	Albania, Croatia, Italy, Slovenia and Serbia-Montenegro
Sprat	*Sprattus sprattus*	Adriatic Sea	Croatia, Italy, Slovenia
Albacore	*Thunnus alalunga*	All Mediterranean	All countries
Bluefin tuna	*Thunnus thynnus*	All Mediterranean	All countries
Swordfish	*Xiphias gladius*	All Mediterranean	All countries

SAC provisional shared stocks list/Liste provisoire des stocks partagés du CSC (GFCM, 2006) (Annex H - Report of the ninth session of the Scientific Advisory Committee on Fisheries, Rome, Italy, 24-27 October 2006).

*Contracting parties in 2006

Appendix L - Geographical subareas (GSA) and GFCM subregions

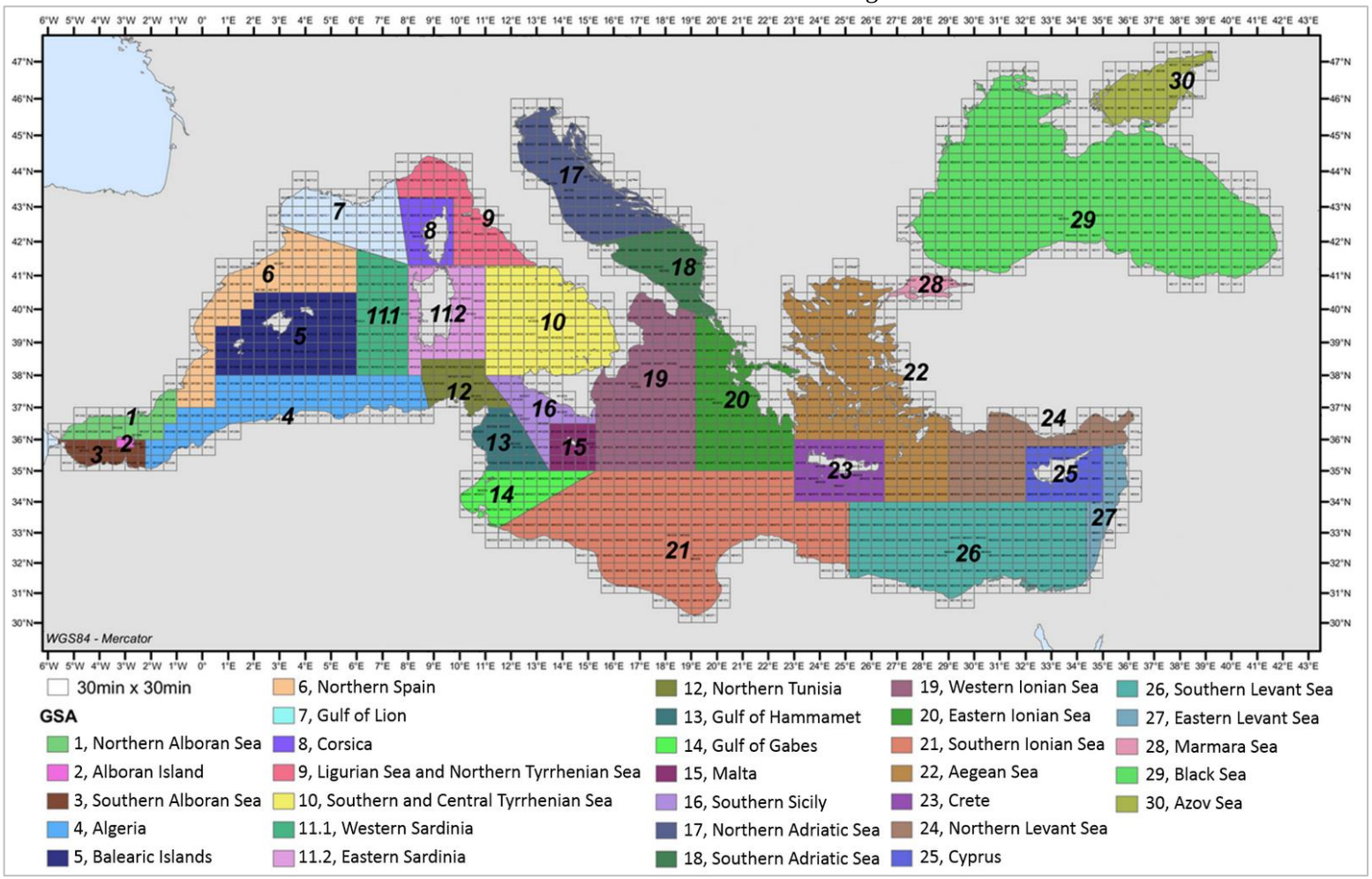
GSA	Name
1	Northern Alboran Sea
2	Alboran Island
3	Southern Alboran Sea
4	Algeria
5	Balearic Islands
6	Northern Spain
7	Gulf of Lion
8	Corsica
9	Ligurian Sea and Northern Tyrrhenian Sea
10	Southern and Central Tyrrhenian Sea
11.1	Western Sardinia
11.2	Eastern Sardinia
12	Northern Tunisia
13	Gulf of Hammamet
14	Gulf of Gabès
15	Malta
16	Southern Sicily
17	Northern Adriatic Sea
18	Southern Adriatic Sea
19	Western Ionian Sea
20	Eastern Ionian Sea
21	Southern Ionian Sea
22	Aegean Sea
23	Crete
24	Northern Levant Sea
25	Cyprus
26	Southern Levant Sea
27	Eastern Levant Sea
28	Marmara Sea
29	Black Sea
30	Azov Sea

GFCM subregions	GSAs	Countries
Western Mediterranean Sea	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11	Algeria, France, Italy, Morocco, Spain
Central Mediterranean Sea	12, 13, 14, 15, 16, 19, 20, 21	Greece, Italy, Libya, Malta, Tunisia
Adriatic Sea	17, 18	Albania, Bosnia and Herzegovina, Croatia, Italy, Montenegro, Slovenia
Eastern Mediterranean Sea	22, 23, 24, 25, 26, 27	Cyprus, Egypt, Greece, Israel, Lebanon, Syrian Arabic Republic, Turkey
Black Sea	28, 29, 30	Bulgaria, Georgia, Romania, Turkey, Ukraine (Russian Federation)*

**All States, including non-CPCs of the GFCM which are known to fish in its competence area, are encouraged to cooperate in joint actions undertaken in accordance with applicable international obligations (i.e. Article 63 UNCLOS).*

Appendix M - Geographic statistical grid for red coral

Mediterranean and Black Sea statistical grid[37]



[37] www.fao.org/gfcm/data/maps/grid

Appendix N - Templates for the selection of fleet segments and species (by GSA)

Template 1) Fleet segments operating in the GSA

GFCM subregion	
GSA	
Country	
Reference year	
1) List of all fleet segments operating in the GSA	**Notes**

Template 2) Fleet segments selected for the collection of biological variables

GFCM subregion		
GSA		
Country		
Reference year		
2) List of fleet segments selected, through the weighting procedure, for the collection of biological variables	**Discards* (Y/N)**	**Notes**

** discards information should be collected only when the discard rate exceeds 10 percent of the total volume of catches for a given fleet segment in a given GSA.*

Template 3) Species for which data collection will be carried out

GFCM subregion		
GSA		
Country		
Reference year		
Group 1 species**	**Data to be collected (Y/N)**	**Notes**
Group 2 species**	**Data to be collected (Y/N)**	**Notes**
Group 3 species**	**Data to be collected (Y/N)**	**Notes**

***exemption rules are applicable if the weight of the species accounts for less than 2% of total landings of the country (regardless of the GSAs)*

Appendix O - Data transmission calendar

DCRF Tasks and Subtasks			Reference year	Frequency (Annual or Biennial)	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
I	***Global figures of national fisheries***		n-1	A					X							
II	***Catch***	II.1 / Landing data	n-1	A						X						
		II.2 / Catch data per species	n-1	A						X						
		II.3.1 / Fishing activities - Alboran Sea (blackspot seabream)	n-1	A											X	
		II.3.2 / Fishing activities - Black Sea (turbot)	n-1	A	X											
		II.3.3 / Fishing activities - Ionian Sea (shrimps)	n-1	A	X											
		II.3.4 / Fishing activities - Levant Sea (shrimps)	n-1	A	X											
		II.3.5 / Fishing activities - Strait of Sicily (demersal)	n-1	A								X				
		II.4.1 / Landing points - Adriatic Sea (demersal stocks)	n	A											X	
		II.4.2 / Landing points - Black Sea (turbot)	n	A											X	
		II.4.3 / Landing points - Ionian Sea (shrimps)	n	A											X	
		II.4.4 / Landing points - Jabuka Pomo Pit	n	A				X								
		II.4.5 / Landing points - Levant Sea (shrimps)	n	A											X	
		II.4.6 / Designated ports (Red coral)	n	A						X						
		II.4.7 / Landing points - Strait of Sicily (demersal stocks)	n	A											X	
		II.4.8 / Designated ports - Alboran Sea (blackspot seabream)	n	A		X										
III	***Incidental catch of vulnerable species***		n-1	A							X					
IV	***Fishing fleet***	IV.1 / Fishing vessels - LOA≤15 m	n-1, n	A					X							
		IV.2 / Fishing vessels - LOA>15 m	n-1, n	A					X							
		IV.3 / Fishing vessels - Fishery Restricted Areas (FRA)	n-1, n	A					X							
		IV.4.1 / Authorized vessels - Adriatic Sea (demersal)	n	A	X											
		IV.4.2 / Authorized vessels - Adriatic Sea (small pelagics)	n	A											X	
		IV.4.3 / Authorized vessels - Alboran Sea (blackspot seabream)	n	A		X										
		IV.4.4 / Fishing vessels - Black Sea (turbot)	n	A	X											
		IV.4.5 / Authorized vessels - Common dolphin fish fisheries	n	A							X					
		IV.4.6 / Fishing vessels - Ionian Sea (shrimps)	n	A	X											

DCRF Tasks and Subtasks			Reference year	Frequency (Annual or Biennial)	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
IV	***Fishing fleet***	IV.4.7 / Fishing vessels - Levant Sea (shrimps)	n	A	X											
		IV.4.8 / Authorized vessels and fishers - Red coral	n	A						X						
		IV.4.9 / Fishing vessels - Strait of Sicily (demersal stocks)	n	A											X	
		IV.4.10 / Fishing vessels - Strait of Sicily (shrimps)	n	A						X						
		IV.4.11 - Authorized vessels - European eel	n	A						X						
V	***Fishing effort***	V.1 / Fishing effort - Fleet segment	n-1	A						X						
		V.2 / Fishing effort - Fishing gear	n-1	A						X						
		V.3 / Fishing effort - CPUE	n-1	A						X						
VI	***Socio-economics***	VI.1 / Economic and social data	n-1	A											X	
		VI.2 / Operating costs	n-2*	A / B*					X*							
		VI.3 / Species value	n-2*	A / B*					X*							
		VI.4 / Other economic aspects	n-2*	A / B*					X*							
VII	***Biological information***	VII.1 / Stock Assessment input data**	n-1	A											X	
		VII.2 / Length data	n-1	A							X					
		VII.3.1 / Size at first maturity	n-1	A							X					
		VII.3.2 / Maturity data	n-1	A							X					
		VII.4.1 / Dolphin fish (general information)	n-1	A							X					
		VII.4.2 / Dolphin fish (statistics)	n-1	A							X					
		VII.5 / Red coral	n-1	A						X						
		VII.6 / European eel	n-1	A									X			

*Data reference year is "n-2", on an annual or biennial basis.
Biennial transmission should only take place for those countries that do not have annual economic surveys in place. Countries collecting these data on a yearly basis are requested to transmit them annually (keeping reference year - 2).
**The date of data transmission will be linked to the scheduling of the GFCM stock assessment working groups and therefore may differ from year to year.

Notes - *At the beginning of each sampling year, each country should transmit three templates containing: all the fleet segments (based on Appendix B and/or the fleet segments resulting from merging process, if any) operating in each GSA with indication of those fleet segments that, based on the weighting procedure, have been identified for the collection of biological variables, as well as all the species (G1, G2 and G3) for which the biological data collection will be carried out (sections 6.2 and 6.3 - Appendix N).*

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Handbook for data collection on recreational fisheries in the Mediterranean and the Black Sea

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TECHNICAL
PAPER

669

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Preparation of this document

This handbook has been prepared by the General Fisheries Commission for the Mediterranean (GFCM) of the Food and Agriculture Organization of the United Nations (FAO) to address the priorities identified by Mediterranean and Black Sea countries in the context of existing international commitments and regional strategies. The impetus for the handbook development originated with the GFCM's mid-term strategy (2017–2020) towards the sustainability of Mediterranean and Black Sea fisheries (mid-term strategy), namely its Target 2 which aims at supporting livelihoods for coastal communities through sustainable small-scale fisheries. In particular, one output of this target was the collection of robust and timely information on the impacts of small-scale fisheries and recreational fisheries on marine living resources and on their interactions with other human activities in coastal communities. This document addresses this output by providing a clear methodological framework to allow Mediterranean and Black Sea countries to implement suitably harmonized sampling and survey monitoring schemes for recreational fisheries and is foreseen to support continued improvement in recreational fisheries data collection, as foreseen in the GFCM 2030 Strategy for sustainable fisheries and aquaculture in the Mediterranean and the Black Sea.

The collection of recreational fisheries data is limited in many countries and the lack of reliable estimates of catch, effort and socio-economic data has led to the exclusion of recreational fisheries data from stock assessments, with implications for fisheries management. The GFCM Scientific Advisory Committee on Fisheries (SAC) has highlighted the potential issues posed by this lack of data, particularly for stocks which are overexploited by commercial fisheries and for which recreational fisheries might be an additional component of fishing mortality. At the same time, it has been observed that the data-poor nature of recreational fisheries also undermines the sustainable development of this sector, in light of its potential for positive socio-economic contributions to coastal communities. In light of this, this handbook provides information on the basic set of information necessary for monitoring recreational fisheries and presents a framework for the implementation of harmonized regional data collection, based on a standard methodology, in order to facilitate the comparison of results in the Mediterranean and Black Sea region.

The handbook was elaborated under the expert guidance and overall coordination of Fabio Grati (GFCM Recreational Fisheries Specialist), who prepared the first draft, ensuring consistency with GFCM priorities and existing methodologies in place, as well as applicability across the region. Anna Carlson (GFCM Fishery Officer for Socio-Economic Issues), Paolo Carpentieri (GFCM Fishery Resources Monitoring Specialist) and Jacopo Cerri (Consultant) also provided expert inputs to the handbook's preparation and revision.

At the suggestion of the twentieth session of the SAC (FAO, 2018a), the experience from select pilot studies in the Mediterranean and the Black Sea was incorporated into the handbook. The handbook also benefitted from extensive revisions from the experts of the GFCM Working Group on Recreational fisheries (WGRF) in 2020. These consultations contributed to fine-tune the methodology and adapt the handbook to the different characteristics and recreational fisheries scenarios found in the Mediterranean and the Black Sea, so that it could be useful and replicable in different countries and areas. The handbook was endorsed on the occasion of the first meeting of the WGRF (GFCM, 2021).

The publication of this work was coordinated by Dominique Bourdenet (GFCM Scientific Editor) who ensured editing, layout and publishing, with the assistance of Ysé Bendjeddou (GFCM Publication and Documentation Specialist) and Matthew Kleiner (GFCM Editing and Communications Intern). The overall graphic design and layout of the publication was managed by Chorouk Benkabbour.

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Contents

Preparation of this document iii
Abstract viii
Acknowledgements ix
Abbreviations and acronyms x
Definitions xi
Background xiii

1. Introduction 1
1.1 Objectives of the handbook 1
1.2 Definition of recreational fisheries 1
1.3 Status quo 2

2. Data collection 5
2.1 Defining the target population 7
2.1.1 National license system 8
2.1.2 General population screening survey 9
2.1.3 Mandatory fee-free online registration 11
2.2 Sampling strategy 11
2.2.1 Non-probability sampling 12
2.2.2 Probability sampling 12
2.3 Stratifying the population 14
2.4 Estimating the sample size 15
2.5 Selecting the sample 16
2.6 Additional considerations 17

3. Methodology 19
3.1 Off-site surveys 19
3.1.1 Logbook surveys 19
3.1.2 Recall surveys 25
3.2 On-site surveys 26
3.2.1 Other on-site methods 28
3.3 Type of information to be collected 30
3.3.1 Fishing effort 30
3.3.2 Catch data 30
3.3.3 Economic data 33

4. Data analysis 35
4.1 Data quality check 35
4.2 Response and completion rates 36
4.3 Measuring central tendency and data dispersion within a sample 38
4.4 Estimators: estimating population mean, totals and variance 39
4.4.1 Simple estimations 40
4.4.2 In-depth estimations 40

5. Stakeholder engagement 45

References 47

Annexes 53

Annex 1. GFCM area of application, subregions and geographical subareas 53

Annex 2. Codes for recreational fishing techniques 54

Annex 3. Template for screening survey and enrollment of fishers in data collection panel 55

Annex 4. Templates for mandatory fee-free online registration of marine recreational fishers 56

Annex 5. Template for logbook and/or recall survey 59

5.a. General information for logbook and/or recall survey 59

5.b. Catch information for logbook and/or recall survey 60

5.c. Released species information for logbook and/or recall survey 61

5.d. Expenditure information per fishing trip for logbook survey 62

5.e. Expenditure information per month for recall survey 63

Annex 6. Template for on-site surveys 64

6.a. General information for on-site survey 64

6.b. Catch information for on-site survey 65

6.c. Released species information for on-site survey 66

Annex 7. Fishing effort measurement 67

Tables

Table 1. Example of sample sizes needed by population size and level of sampling error 15

Figures

Figure 1. Distribution of the main taxa targeted by recreational fisheries across the GFCM subregions 3

Figure 2. Total survey error components linked to the steps in the measurement and representational inference process 5

Figure 3. Process for the identification of a sample of recreational fishers to participate in data collection 7

Figure 4. Extraction of a sample from the target population 7

Figure 5. Process for the identification of recreational fishers from a general population screening 10

Figure 6. Process for the identification of recreational fishers from a general population screening 12

Figure 7. Stratification of the target population 14

Figure 8. Example of computerized routine to select random samples 17

Figure 9a. Example of how to compile a logbook (general information) 22

Figure 9b. Example of how to compile a logbook (retained species information) 23

Figure 9c. Example of how to compile a logbook (released species information) 24

Plates

Plate 1. Measurement of total length in bony fish 32

Plate 2. Measurement of total length and carapace length in crustacean's decapoda 32

Plate 3. Measurement of dorsal mantle length in cephalopods 33

Abstract

Marine recreational fisheries are an integral part of Mediterranean and Black Sea coastal life and are commonly practiced throughout the region. However, despite their ubiquity and potential socio-economic contribution, recreational fisheries are a data-poor sector. Data collection programmes to monitor their impact are limited and can vary widely from one country to another, thus impairing proper consideration of the recreational fisheries sector in policy-making and undermining efforts towards sustainable fisheries management at the regional level.

The main goal of this handbook is therefore to provide a clear methodological framework to allow Mediterranean and Black Sea countries to implement suitably harmonized sampling and survey monitoring schemes for recreational fisheries. The handbook consists of five parts. A first section provides an introduction to the recreational fisheries sector in the Mediterranean and Black Sea region, including the rationale for improving data collection. The second section provides guidance on how to set up a data collection programme, including how to define the target population – particularly in the absence of an up-to-date census or complete licensing system – as well as how to select a sample for data collection. Next, in section three, the handbook provides a comprehensive explanation of the harmonized regional methodology for carrying out data collection, including through a combination of on-site and off-site techniques. This section also presents a minimum set of necessary information allowing for monitoring recreational fisheries (namely, fishing effort data, catch data and economic data), while, at the same time, allowing for flexibility to accommodate national specificities and data collection needs. Section four then provides a short primer to guide readers through the data analysis process. A final section highlights the importance of engaging stakeholders in the data collection process and provides advice on how to do so.

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Abbreviations and acronyms

ABS	address-based sampling
CPCs	contracting parties and cooperating non-contracting parties (GFCM)
CPUE	catch per unit effort
FAO	Food and Agriculture Organization of the United Nations
GFCM	General Fisheries Commission for the Mediterranean
GSA	geographical subarea (GFCM)
ICES	International Council for the Exploration of the Sea
MEDAC	Mediterranean Advisory Council
Mid-term stategy	mid-term strategy (2017–2020) towards the sustainability of Mediterranean and Black Sea fisheries (GFCM)
RDD	random digit dialing
RPAS	remotely piloted aircraft systems
SAC	Scientific Advisory Committee on Fisheries (GFCM)
SCESS	Sub-Committee on Economic and Social Sciences (GFCM)
WGRF	Working Group on Recreational fisheries (GFCM)

Definitions

Angling	Fishing with handlines, fishing rods and/or poles using natural and/or artificial baits.
Avidity	The frequency of fishing trips undertaken over a commonly defined period.
Catch	The total number or weight of individuals caught during fishing operations, including fish that were caught and released.
Catch-and-release	The process of capturing a fish, usually by angling, and releasing it alive. Catch-and-release procedures range from legally required to mandatory release of protected sizes and species to voluntary catch-and-release of fish that could have been retained.
Fishing effort	The amount of fishing gear of a specific type used on the fishing grounds over a given unit of time (e.g. total number of fishing days by fleet segment).
Geographical subareas (GSAs)	Geographical subareas were established by the GFCM within its area of application (Mediterranean and Black Sea) in order to compile data, monitor fisheries and assess fisheries resources in a georeferenced manner (see Annex 1).
Harvest	The part of the catch that is kept, not released.
Jurisdiction	A province or territory with recreational fisheries management responsibility.
Logbook survey	A survey of recruited fishers who are asked to record their effort and/or catch in supplied logbooks.
Mail survey	Data collected through questionnaires sent to recipients by post asking for information about previous fishing activity, catch or expenses.
Non-resident	Someone that fishes in a particular area, but is excluded from the resident sampling frame for surveys in that area.
Off-site sampling	Selecting respondents outside of areas where fishing activity takes place or can be observed, e.g. household and/or over the phone.
Online survey	Questionnaire that can be completed over the internet. Online surveys are usually created as web forms with a database to store the answers and a statistical software to provide analytics.
On-site sampling	Selecting respondents at principal areas of activity, e.g. fishing sites.

Panel survey	An ongoing survey of a group of fishers who have been enrolled in a panel for a fixed period.
Random digit dialing (RDD)	A method of selecting people for telephone statistical surveys by generating telephone numbers at random.
Recreational fisheries	A non-commercial fishing activity exploiting marine living resources for recreation, tourism or sport.
Screening survey	A survey to identify the target population of recreational fishers and their fishing characteristics.
Sport fishing	An organized activity involving free competition between fishers to catch the largest fish of certain species, the largest number of specimens or the largest total weight, depending on the rules of each particular competition.
Survey	A method of gathering information from a number of individuals, known as a sample, in order to learn something about the larger population from which the sample is drawn.

Background

Marine recreational fisheries, including sport fishing, is an integral part of Mediterranean and Black Sea coastal life and communities. It has high cultural importance in the region and represents an important economic component of coastal tourism, which constitutes one of the region's main maritime sectors in terms of gross value added and employment. Nevertheless, despite the perceived socio-economic benefits, the lack of reliable catch estimates has resulted in recreational fisheries being excluded from stock assessments. This can be challenging for assessing stocks that are already overexploited by commercial fisheries and for which recreational fisheries might present an additional component of fishing mortality. Such a shortage of catch data, coupled with the limited availability of data on the socio-economic impact of recreational fisheries, impairs proper consideration of this sector in policy-making and undermines efforts toward the sustainable management of fish stocks (Hyder *et al.*, 2014). The data-poor nature of the recreational fisheries sector also compromises the potential of its development for positive socio-economic contributions to coastal communities (Arlinghaus *et al.*, 2019).

Considering that the main objective of the General Fisheries Commission for the Mediterranean (GFCM) of the Food and Agriculture Organization of the United Nations (FAO) is to ensure the conservation and the sustainable use, at the biological, social, economic and environmental levels, of marine living resources, as well as the sustainable development of aquaculture in the Mediterranean and in the Black Sea, recreational fisheries activity needs to be duly considered. Catch mortality should include all reported or estimated commercial fishing landings, plus landings from recreational fisheries and subsistence fisheries and, ideally, estimates of post-release mortality too. Such data boasts a wide range of existing or potential end users, including national governments, the scientific community, as well as the GFCM.

Improved information on this sector will help to design effective and enforceable control measures and to support the development of long-term regional management plans and marine spatial planning. These are crucial issues that should be urgently addressed in order to foster better management of marine living resources in the Mediterranean and the Black Sea.

1. Introduction

1.1 OBJECTIVES OF THE HANDBOOK

Mediterranean and Black Sea fisheries face serious challenges, with approximately 75 percent of the scientifically assessed stocks considered to be fished outside of safe biological limits (FAO, 2020). To take concerted action towards improving this situation, the General Fisheries Commission for the Mediterranean (GFCM) of the Food and Agriculture Organization of the United Nations (FAO) developed a programmatic multiannual mid-term strategy (2017–2020) towards the sustainability of Mediterranean and Black Sea fisheries (mid-term strategy) (GFCM, 2017a).

The implementation of the mid-term strategy sought to reverse the trend in the status of commercially exploited stocks by means of a series of targets, outputs and activities. In this context, Output 2.1 of Target 2, "Robust and timely information on the impacts of small-scale fisheries and recreational fisheries on living marine resources and on their interactions with other human activities in coastal communities," foresaw the establishment of a permanent working group on recreational fisheries and the assessment of the impacts of recreational fisheries, providing the impetus for preparing this handbook. The collection of recreational fisheries data is still a recent development in many countries and there exists no clear framework for the integration of these data in stock assessments or fishery management.

The main goal of this handbook is therefore to provide a clear methodological framework to allow Mediterranean and Black Sea countries to implement suitably harmonized sampling and survey monitoring schemes for recreational fisheries. The information that this handbook suggests collecting is considered as the basic set necessary for monitoring recreational fisheries. At the same time, it is important to take into account national specificities and data collection needs when implementing a recreational fisheries monitoring programme, including whether the collection of additional information, such as social data or data on interactions with vulnerable species, would be necessary.

1.2 DEFINITION OF RECREATIONAL FISHERIES

In order to understand each other and communicate using a common language, recreational fishers, managers, politicians and scientists need a proper definition of recreational fisheries for research, management and legal purposes. Past discussions on recreational fisheries within the context of GFCM statutory and technical meetings have primarily focused on the identification of a harmonized definition for recreational fisheries. Deliberations from the Transversal Workshop on the Monitoring of Recreational Fisheries in the GFCM Area (GFCM, 2010a) and the eleventh session of the former Sub-Committee on Economic and Social Sciences (SCESS) (GFCM, 2010b) agreed on the following definition for recreational fishing: "Fishing activities exploiting marine living aquatic resources for leisure or sport purposes, from which it is prohibited to sell or trade the catches obtained". It was further specified that "leisure purposes" refers to "fishing practiced for pleasure", whereas "sport purposes" refers to "fishing contests practiced within an established institutional framework which sets rules, collects data on catches and informs on the outcomes of the event" (GFCM, 2010a). Building on these discussions, the following

definition has been adopted within two GFCM recommendations (Recommendation GFCM/43/2019/2 on a management plan for the sustainable exploitation of blackspot seabream in the Alboran Sea (geographical subareas 1 to 3) and Recommendation GFCM/42/2018/1 on a multiannual management plan for European eel in the Mediterranean Sea) (GFCM, 2019):

> *"Recreational fishing means a non-commercial fishing activity exploiting marine living resources for recreation, tourism or sport"*

This definition is considered to be the working definition of the GFCM, barring further decision-making by the GFCM.

It must be noted, however, that there exists an array of definitions in the literature and within national legislations pertaining to recreational fisheries and its constituent parts and related sectors (Pawson, Glenn and Padda, 2008), with subsequent implications for the regulation of these sectors at the national level. For example, in general, there are some discrepancies between national legislations over the term "sport fishing". In some countries, "recreational" and "sport" fishing have different meanings, while in others, they are used interchangeably (EAA, 2004). However, as in the GFCM definition, some definitions interpret "sport fishing" as a type of recreational fishery that is more sportive, competition-oriented and technically complex than general recreational or leisure fishing (Pawson, Glenn and Padda, 2008).

Furthermore, national definitions differ over the role of subsistence fishing within recreational fisheries. In reality, not all non-commercial fishing can be described as purely recreational. In the Mediterranean and Black Sea region, it is common for fishing activity to meet both recreational and personal consumption needs, with the catch directly consumed by the fisher and/or his/her family. The FAO Technical Guidelines for Responsible Fisheries touch on this issue by defining recreational fishing as "fishing of aquatic animals (mainly fish) that do not constitute the individual's primary resource to meet basic nutritional needs and are not generally sold or otherwise traded on export, domestic or black markets" (FAO, 2012).

Nevertheless, there is overwhelming consensus among various definitions at the regional level that recreational fisheries have a non-commercial, non-profit purpose and expressly exclude the sale of the catch (Hyder *et al.*, 2017a).

1.3 STATUS QUO

In the Mediterranean and the Black Sea, some countries already collect specific types of data, including estimates of recreational catch and release of bluefin tuna (*Thunnus thynnus*), European eel (*Anguilla anguilla*) and elasmobranchs (European Commission, 2016). However, standard and harmonized monitoring programmes for recreational fisheries, with statistically robust sampling designs, are not yet regularly implemented in most countries. Therefore, with a view to moving towards an assessment of recreational fisheries in the GFCM area of application, the GFCM proposed a roadmap to pilot recreational fisheries assessments towards the development of a harmonized regional methodology (GFCM, 2017b).

As a first step, in 2017, the GFCM circulated a questionnaire on national marine recreational fisheries among its contracting parties and cooperating non-contracting parties (CPCs). Preliminary information collected within the context of this questionnaire shows that marine recreational fisheries in the Mediterranean and the Black Sea involve many different techniques such as rod and line, speargun, traps, longlines and hand-gathering (see Annex 2) that can be employed from different locations (i.e. shore, boat, underwater) and target a broad range of taxa (e.g. finfish, shellfish, crustaceans, etc.).

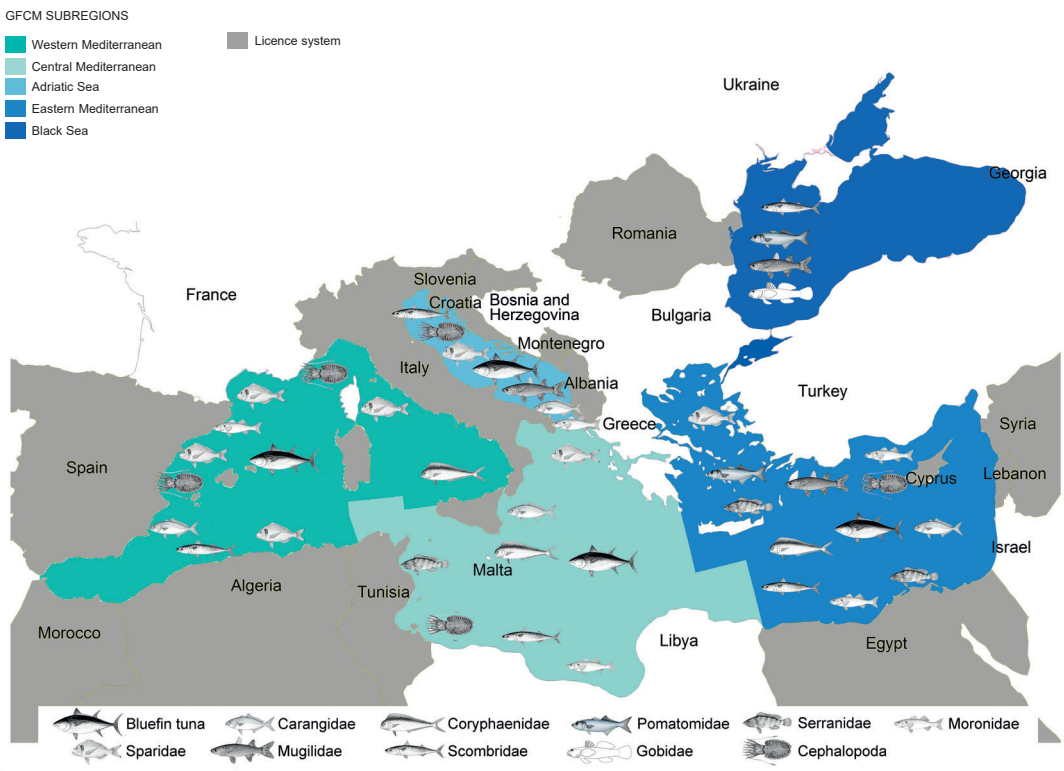
In the Black Sea, recreational fishers primarily target four taxa: Scombridae, Gobidae, Mugilidae and Pomatomidae (primarily bluefish (*Pomatomus saltatrix*)).

In the Mediterranean, however, the catch composition includes a higher number of taxa, and slight variations in the target species are observed among the four GFCM Mediterranean subregions (Annex 1). The following are targeted in all Mediterranean subregions: bluefin tuna; small pelagics, particularly Scombridae such as Atlantic mackerel (*Scomber scombrus*) and Atlantic bonito (*Sarda sarda*); large pelagics, particularly Carangidae such as greater amberjack (*Seriola dumerili*) and leerfish (*Lichia amia*); Coryphaenidae, particularly dolphinfish (*Coryphaena hippurus*); Sparidae, particularly gilthead seabream (*Sparus aurata*) and common dentex (*Dentex dentex*); and Cephalopoda, particularly European squid (*Loligo vulgaris*), common cuttlefish (*Sepia officinalis*) and common octopus (*Octopus vulgaris*).

As noted above, subregional variations do occur, for example: Serranidae are mostly represented by different species of grouper, which are targeted along the western coast of the Adriatic Sea and on the rocky bottoms of the western, central and eastern Mediterranean; Mugilidae and bluefish are mainly exploited in the eastern Mediterranean and the Adriatic Sea; and Moronidae, which are represented exclusively by the European seabass *(Dicentrarchus labrax)*, are targeted in all countries bordering the Adriatic, as well as in Egypt, Libya, Spain and Turkey. A summary of the main nekton taxa targeted by recreational fisheries in the GFCM area of application is provided in Figure 1. Contracting parties and cooperating non-contracting parties for which national licensing systems for marine recreational fisheries are in place are highlighted in dark gray.

FIGURE 1

Distribution of the main taxa targeted by recreational fisheries across the GFCM subregions



Note: based on responses to the GFCM questionnaire on national marine recreational fisheries (2017).
Source: FAO, 2018b.

2. Data collection

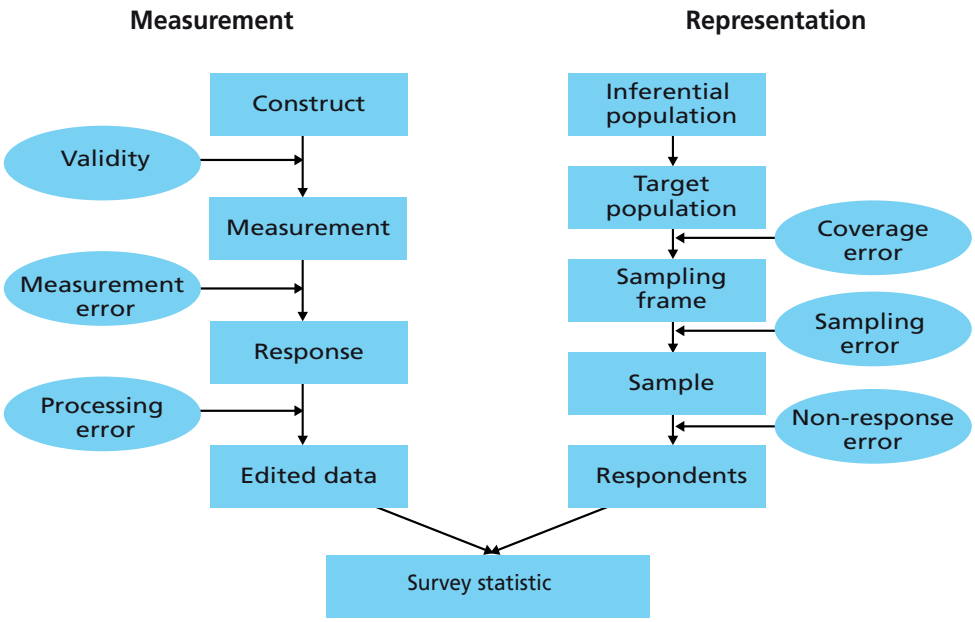
Decisions on how to monitor recreational fisheries depend on various factors, including the goals of the survey, its geographical scale, available sampling frames, the spatial distribution of fishing effort and the types of fishing methods used (Hartill *et al.*, 2012). Multiple methods exist to perform this task, each one with its advantages and limitations, and various designs are available to obtain representative estimates. As measuring the entire study area is impossible, survey sampling, in its various forms (e.g. catch analysis, questionnaires) is usually the favoured approach; by collecting a sample of observations, researchers try to obtain a comprehensive representation of the phenomenon of interest.

A good conceptual framework for understanding how to design a survey, and where eventual problems can arise, is the total survey error framework (Groves and Lyberg, 2010) (Figure 2). This framework can be divided in two components: representation and measurement.

Representation refers to the study's potential for generalization: how well do the interviewed fishers represent the whole fishing community in the study area? This question presents two different approaches:

- **Census surveys** collect information from all the statistical units in the target population (e.g. from all the recreational fishers that exist, at a certain time, in the Mediterranean and the Black sea).
- **Sample surveys** collect information from a small group of statistical units in the target population (e.g. only from some of the recreational fishers that exist in the Mediterranean and the Black sea). When certain conditions characterize data collection, findings from sample surveys can be generalized to the whole population of statistical units.

FIGURE 2
Total survey error components linked to the steps in the measurement and representational inference process



Source: Groves and Lyberg, 2010.

While census surveys paint an exhaustive and representative picture of a certain phenomenon, sample surveys are far more common, for many different reasons:

- selecting a sample is less time-consuming than selecting every item in the population;
- selecting a sample is less expensive than performing a census;
- census surveys are often unfeasible in practice and sometimes they are unethical; and
- sample surveys can be easily repeated over time to track changes in the phenomena they investigate, while censuses cannot be easily repeated.

On the other hand, the measurement component of the total survey error framework (Figure 2) refers to the ability to adequately measure the relevant phenomenon, in this case recreational fishing effort, catch and economic data. Various methods are available to perform this task, ranging from in-depth qualitative interviews to simple questionnaires (Vaske, 2008). These methods will be described in further detail in Section 3.

In recreational fisheries, effort, catch and economic data are frequently collected by means of sample surveys all around the world (Sparrevohn and Storr-Paulsen, 2012; Bellanger and Levrel, 2017). This handbook will guide readers through the implementation of such a survey, as it is considered the most relevant approach for harmonized data collection by all countries in the Mediterranean and the Black Sea region. It is important to note that in the implementation of a sample survey, errors may be introduced at different stages. As such, it is useful to consider the total survey error framework (Figure 2) when conceptualizing the survey design in order to minimize error to the greatest possible extent. A combination of multiple data collection methodologies and different sampling approaches can help minimize the total survey error, while providing researchers with considerable flexibility in monitoring recreational fisheries. To this end, it may be useful to consider complementing a traditional sample survey with on-site data collection and/or any number of new monitoring technologies being used for recreational fisheries, such as mobile applications for data collection (Venturelli, Hyder and Skov, 2017) and social media data mining (Sbragaglia *et al.*, 2019).

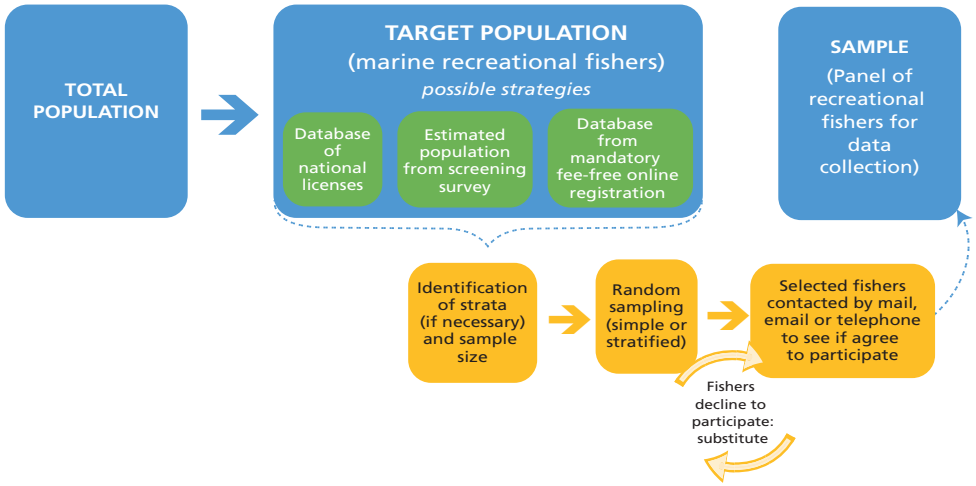
In the Mediterranean and the Black Sea, this methodological flexibility is important in order to adapt to the different characteristics and recreational fisheries scenarios found.

This handbook presents a harmonized framework for data collection in the Mediterranean and the Black Sea, while facilitating the necessary flexibility to adapt to the different specificities of the region. The subsequent sections of this handbook will guide readers through the process of defining a sample of recreational fishers to participate in data collection, as outlined in Figure 3, as well as provide guidance on the data to be collected and analysed.

Adaptability and flexibility

During the early years of data collection, it is best to focus on developing a complete understanding of the methodology and being flexible enough to make customizations as required. Setting up a simple but effective method will allow a country to move to more advanced survey techniques in due course.

FIGURE 3
Process for the identification of a sample of recreational fishers to participate in data collection

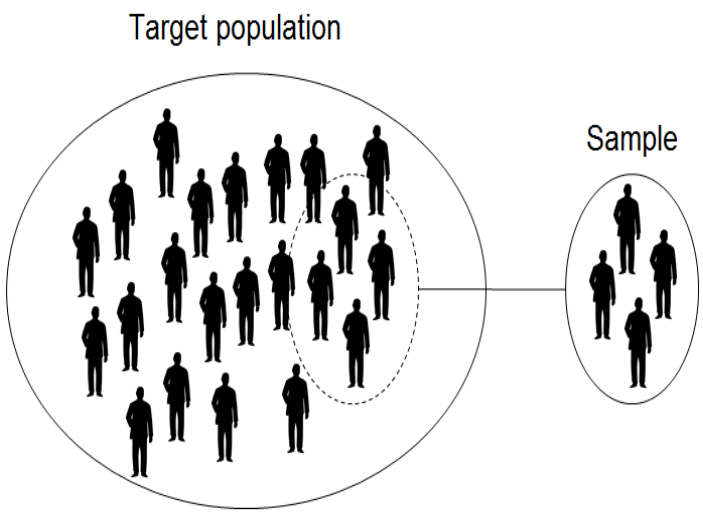


2.1 DEFINING THE TARGET POPULATION

In order to set up a sample survey, a sample should be selected by isolating some statistical units from the target population, also known as the statistical universe (Figure 4). The ultimate goal of sampling is to obtain an overview of a certain target population from a subset of units.

The first step of any sampling strategy is therefore defining the target population to which the results of the survey will be generalized. The population is the full list of units for which the survey will be conducted and about which conclusions will be drawn, in this case, the full population of marine recreational fishers. Sometimes, a complete list of all the units comprising the population is available, though this is not always the case: sampling methods therefore differ between populations with and without lists.

FIGURE 4
Extraction of a sample from the target population



Data sources for target populations may vary across Mediterranean and Black Sea countries, and some methods for identifying the target population that may be practical for some countries may not be feasible or cost-effective for others. Many countries do not have licensing programmes and databases that can provide a complete list of all recreational fishers. In fact, most of the compulsory recreational fisheries license systems in force either grant registration exceptions for some participants or do not ensure that all participants actually register or renew their licenses when they expire. Similarly, while some countries boast active recreational fisheries federations or associations which include a high number of fishers, the membership of these organizations should only be considered as completely representing the target population when membership is obligatory for all recreational fishers. With that said, recreational fisheries federations and associations can serve as valuable partners in engaging stakeholders in data collection (see Section 5).

Where recreational fisheries license programmes do exist, are obligatory and cover all types of recreational fisheries, it is still worthwhile to consider the level of compliance with the relevant license regulations. If non-compliance is high and fishing without a permit is common, then alternative data sources for the target population may need to be found to account for this higher overall number of fishers. In general, it is important that data collection accounts for the peculiarities of each country's sector, while at the same time ensuring that national datasets are organized in a way so as to eventually allow for their combination at the desired level in a statistically valid way.

On the other hand, sampling from populations without a list is more complex and less straightforward, as it requires careful designs to estimate inclusion probabilities through time-consuming methods of field sampling, such as aerial surveys, point-counts or capture-recapture models (Zischke and Griffiths, 2014). It is therefore suggested that, where complete national licensing systems or similar registries do not exist, a simple sampling frame should be adopted, such as the general population or all national households, for which lists are typically readily available. This approach is considered more effective and more easily tailored to the specificities of the Mediterranean and the Black Sea region than approaches based on sampling without a list. In this light, the following sections outline three possible strategies that have been identified as appropriate for defining the target population of recreational fishers in Mediterranean and Black Sea countries, each one with its advantages and limitations.

2.1.1 National license system

The identification of recreational fisher populations is much easier and cost-effective when information can be obtained from national marine recreational fisheries license systems and registration databases. Direct list frames of fishers, or fishing vessel operators, can be constructed from fishing license programmes, fishing permit programmes or fishing club memberships (when registration with these programmes/clubs is obligatory). Some fishers may participate in more than one list frame by being, for example, both a license holder and a fishing club member. It may also be the case that a list frame includes fishers who have not fished during the survey reference period; this issue can, however, be accounted for at later stages in the study. A list frame of fishers should identify license holders, when appropriate, by postal mailing address, e-mail address, telephone number, mobile telephone number and, possibly, a national identity (ID) or social security number. Ideally, fishing licenses should cover all possible recreational fisheries categories and should identify the fishing category (or categories) practiced by each license holder, namely fishing from the coast, a boat and/or underwater fishing.

As of 2017, based on the data collected through the GFCM questionnaire on national marine recreational fisheries, most license systems in force in the Mediterranean and the Black Sea were dedicated to boat fishing, while coastal and underwater fishing,

in many cases, did not require a license. Such data sources face potential limitations, however, in the form of national confidentiality protection requirements, which might impede the use of contact lists for survey purposes. Researchers should make all attempts to avoid potential pitfalls related to these limitations, including through familiarization with existing legal frameworks for data collection. For countries that do not have a complete license system in place, alternative options are described below. Suggested options include performing a screening survey or a mandatory fee-free online registration. A screening survey could also be valid for those countries without a complete license system in place (e.g. licenses are mandatory only for boat fishing) to cover the missing portion of the recreational fisher population (e.g. shore and underwater fishing).

2.1.2 General population screening survey

When a list of recreational fishers from a license system is not available or is incomplete, it is possible to conduct a screening survey, sampling from a broad coverage system, such as a complete frame of resident households. It may not be necessary to conduct a screening survey every year; every two to three years would be sufficient. It is preferable to use a screening survey only as a means to identify recreational fishers for a more detailed follow-up survey. A flow chart outlining this process is provided below (Figure 5). Therefore, the first correspondence could be limited to determining if any household residents participate in recreational fisheries, collecting their contact information and recruiting them for participation in a more detailed follow-up survey. The survey should collect the minimal data needed to define and profile the fishing population.

A template for the enrollment of fishers for data collection from a screening survey is shown in Annex 3. First of all, there is a need to collect information on the gender and age of all members of the household. The second question concerns who went fishing at sea during the last year and how many times they went per fishing mode (a rough estimate is sufficient). The last question is perhaps the most important and concerns the respondent's availability to enroll in a panel that will be contacted by phone (mobile phone number would be ideal) every month for data collection. Respondents agreeing to participate in this panel would then be provided with a logbook (Annex 5) in order to keep records of requested information (as described in Section 3.1.1).

When requesting this information, privacy concerns must be considered and so it is recommended to consult national privacy laws prior to initiating this work. Common principles for data sharing and dissemination should always be respected when carrying out data collection, in line with the concept of privacy constituting a basic human right as recognized by the United Nations.[1]

At the global level, both address-based sampling (ABS), i.e. complete lists of residential mailing addresses for mail or face-to-face surveys of recreational fisheries, and random-digit-dialing (RDD), i.e. directory-based telephone surveys that provide access to a majority of a resident fishing population, have been widely used. For over 30 years, RDD telephone surveys have served as the mainstay of the survey research industry (Link *et al.*, 2008). Over the past decade, however, participation in most RDD telephone surveys has declined due, most likely, to factors such as the growth of call-screening technologies, heightened privacy concerns in the face of frequent telemarketing calls and the proliferation of non-household telephone numbers, which are typically non-voice and unassigned numbers (Link *et al.*, 2008).

[1] Article 12 of the Universal Declaration of Human Rights (General Assembly of the United Nations, 1948) states "No one shall be subjected to arbitrary interference with his privacy, family, home or correspondence, nor to attacks upon his honour and reputation. Everyone has the right to the protection of the law against such interference or attacks."

Additionally, RDD frames may exclude households without a landline telephone (e.g. due to increased use of cellular telephones). Increasingly, though, these RDD surveys are conducted using computer-assisted telephone interviewing technology or, where georeferenced mobile phone information is available, computer-assisted mobile interviewing, which help circumvent the problems associated with fewer and fewer people having landline telephones. However, probability sample design alternatives to RDD that are comparable in speed, efficiency and cost are scarce. Address-based sampling is one such alternative that may provide survey research with a cost-effective alternative to RDD, as the growth of database technology has allowed for the development and maintenance of large, computerized dwelling address databases. In New Zealand, an advanced face-to-face survey from a dwelling list is already performed, although this may not offer an optimal solution for all Mediterranean and Black Sea countries due to the high budgetary requirements for its implementation.

In the event that both approaches are possible, ABS and RDD directory frames should be compared and evaluated to determine which provides the most complete coverage for an effective screening of resident recreational fishers in each country. Ideally, in order to reduce biases that may result from the undercoverage of any one list frame, it would be best to use a dual frame approach. In this way, it is possible to assess the coverage of the list frame by comparing recreational fishers occurring in both frames to those appearing only in one. Furthermore, one could consider stratifying coastal and non-coastal municipalities and applying design weights (e.g. 70 percent coastal, 30 percent non-coastal) in order to oversample coastal municipalities, where a higher number of marine recreational fishers are expected to be found.

The screening approach described in this section would therefore provide access to the resident population, excluding non-resident (i.e. tourist) marine fishers. In countries where tourists represent an important component of recreational fisheries, it is necessary to implement a supplementary survey frame dedicated to non-residents. A possible solution for creating a list of non-resident marine recreational fishers could be to enforce a mandatory fee-free online registration as described in the following section.

FIGURE 5
Process for the identification of recreational fishers from a general population screening

2.1.3 Mandatory fee-free online registration

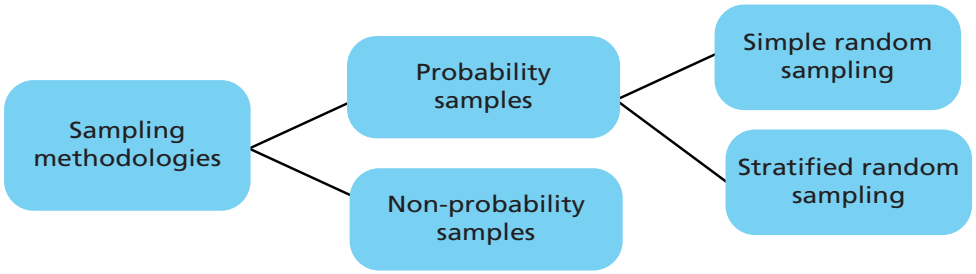
When a complete list of recreational fishers is not available, a list of non-resident fishers does not exist, and a screening survey is not feasible, then the third solution would be to enforce the registration of participants through the implementation of an online fee-free registration programme, which collects a valid name, address, e-mail address and telephone number for each participant. This approach has been recently endorsed by the Mediterranean Advisory Council (MEDAC) as a valid method for the assessment of recreational fisheries in the Mediterranean (MEDAC, 2016). Such registration should be mandatory for both residents and tourists, regardless of age and of whether recreational fishing takes place from the shore, from a boat or underwater. The word "license" should not be used in this case in order to avoid conflict and refusal from the part of the population (ICES, 2010); the word "census" could be suggested instead. The use of an online registration offers many advantages, including ease of access, time saving and efficient data management. However, a possible source of bias could arise from the internet not being user-friendly for certain groups of recreational fishers, such as the elderly – although this was not found to be the case in a study in Spain by Gordoa, Dedeu and Boada (2019). To avoid such bias, it is recommended that fishing shops assist fishers in online registration and print a copy of the document for the fishers, certifying their registration.

The first step in implementing such an approach would be to create a dedicated online platform, which should be endorsed by the national administration in charge of managing fishing activity, such as a ministry for example. This step entails minor costs, as internet domains are relatively low-cost. Recreational fishers planning to pursue their fishing activities in marine national waters should register online by completing a number of mandatory fields with some general details (name, e-mail, place and date of birth, nationality, etc.). Once the general profile has been filled in, an ID number, valid for a lifetime, should be assigned to each fisher. Afterwards, fishers should be required to complete a second form requesting a list of compulsory supplementary data: type and avidity for every type of recreational fishing practiced and name of an eventual affiliation to a marine recreational fisheries association. In some cases, such as the Balearic Islands registration system, users are also required to specify the main areas in which they fish. Once the fishers have completed the compulsory data entry, a certificate should be delivered, either directly through the registration website or sent via e-mail. This certificate should be fee-free but mandatory, in order to perform any kind of marine fishing in national waters. Fishers should be requested to print this certificate and keep it with them whenever carrying out marine recreational fishing activities. A template for a mandatory fee-free online registration is shown in Annex 4. It is desirable that the online registration be linked to a national database, where all information collected is organized and stored.

2.2 SAMPLING STRATEGY

Once the target population has been defined, observations (i.e. recreational fishers) can be sampled according to two criteria: probability and non-probability sampling (Figure 6).

FIGURE 6
Process for the identification of recreational fishers from a general population screening



2.2.1 Non-probability sampling

Non-probability sampling, also known as purposive sampling, describes a family of sampling techniques (e.g. convenience sampling, haphazard sampling, purposive sampling, expert sampling, diversity sampling, modal instance sampling, quota sampling, etc.) where the odds of any member being selected for a sample cannot be calculated and sampling relies on the subjective judgement of the researcher (Sabatella and Franquesa, 2003). These methods present some advantages, such as convenience, speed and low cost. However, with these surveys, it is impossible to know how well the population is represented, as the results cannot be generalized. A further bias comes from the fact that confidence intervals and margins of error cannot be calculated, rendering the results meaningless (Cochran, 1977; Lohr, 1999; Levine *et al.*, 2008). This is the main reason why non-probability sampling should not be considered in the quantification of recreational fisheries in the Mediterranean and the Black Sea. Non-probability sampling should be considered only when some particular conditions apply. For example, the use of online registration constitutes a form of non-probability sampling, which does not allow for any formal inference. However, on some occasions where the sampling frame is unavailable, it may be the only feasible approach.

2.2.2 Probability sampling

Within probability sampling, sample unit selection is based on known probabilities calculated from demographic data collected during the initial screening survey and from data provided by the most recent national census. This approach allows the researcher to make unbiased and mathematically sound inferences about the population of interest (Levine *et al.*, 2008). In sampling designs for populations with a list, the two most common forms of probability sampling are simple random sampling and stratified random sampling. These sampling methods have two features in common: i) every element of the population has a known non-zero probability of being sampled; and ii) random selection of the sample is applied (Pinello, Gee and Dimech, 2017).

Simple random sampling

In simple random sampling, all the units from the target population have the same probability of being chosen. For example, if there is a list of all the recreational anglers who fish in a certain coastal area and the annual number of gilthead seabream caught by an angler within a fishing season must be determined, the procedure is as follows: extract a random sample of anglers, ask them the number of gilthead seabreams they landed over the course of the fishing season, calculate an estimator (Hankin, Mohr and Newman, 2019) expressing the total or the average number of gilthead seabreams that were landed and then calculate the associated variance of the estimate. Provided the sample is large enough, it can be reasonably claimed that simple random sampling

offers an adequate picture of the recreational gilthead seabream fishery in the coastal area being investigated.

Stratified random sampling

Stratified random sampling, on the other hand, represents a suitable choice when the target measurements vary between the units being sampled. Using the example of a situation where a list of recreational fishers exists at the national level and the goal is to estimate how many people are exclusive sea fishers (i.e. they do not fish in freshwater), if simple random sampling is adopted, the sample of fishers might contain respondents from only inland areas. This sample is therefore likely to be biased, as it would underestimate the total number of sea fishers, as sea fishing is almost certainly more common in coastal areas. Instead, respondents could be divided on the basis of their geographical provenance, for example by creating two subgroups of respondents, one from inland and one from coastal areas. Then fishers can be randomly sampled from each one of these two groups: the estimates will be correct, as the observations are correctly weighted. The two groups of respondents, from inland and from coastal areas, are called strata and they have to be mutually exclusive: a fisher cannot be a resident, at the same time, of a coastal area and an inland area.

Both simple random sampling and stratified random sampling are correct, meaning that, if sampling is well designed, they provide researchers and managers with unbiased estimates of the phenomenon of interest, and that the standard error of the estimates can be calculated correctly (Hankin, Mohr and Newman, 2019). If the variable of interest – say the probability of being an exclusive sea fisher – is strongly associated to the strata, then stratified random sampling can provide researchers with more accurate estimates. On the other hand, if there is no strong variation between strata, simple random sampling is preferred, as inference from stratified random sampling might be inaccurate. Choosing each one of these approaches should be carefully predicated on the basis of evidence at hand.

Statistical weighting of survey data

A final approach is called weighting. Weighting offers a way to account for unbalanced sampling, once data has been collected. This procedure is particularly useful when simple random sampling is adopted but can also be applied to stratified random sampling schemes. Weights are calculated for target populations catalogued in lists; they cannot be calculated for populations without a list. As an example, imagine a random sample of recreational boats, from which the total seasonal catch of common cuttlefish is to be estimated. Random sampling is carried out, collecting a sample of 410 boats. It is realized, however, that the sample is unbalanced in terms of fishing activity: while 40 percent of fishing boats in the whole study area use specialized gear to catch common cuttlefish, only 10 percent of boats in the sample use specialized gear to target common cuttlefish. Recreational boats targeting common cuttlefish are therefore under-represented within the sample, while boats targeting other species are over-represented, with consequent errors (i.e. a deflated value) in estimated harvests of cuttlefish.

Weights could be estimated as (Vaske, 2008):

$$Weight = \frac{Population\ percentage}{Sample\ percentage}$$

Therefore, weights for boats that target common cuttlefish correspond to: 40/10 = 4, while weights for boats that are targeting other species are equal to 60/90 = 0.66. By multiplying each boat's reported catch by its corresponding weight, the estimates are adjusted.

Weighting is a powerful tool to correct estimates but requires accurate knowledge of the target population and is not always feasible. Multiple approaches are available,

including the use of multiple variables, or the use of weighting to correct non-response bias. Relevant references, including survey method texts, can provide further details (Vaske, 2008; Groves *et al.*, 2009; Dillman, Smyth and Christian, 2014).

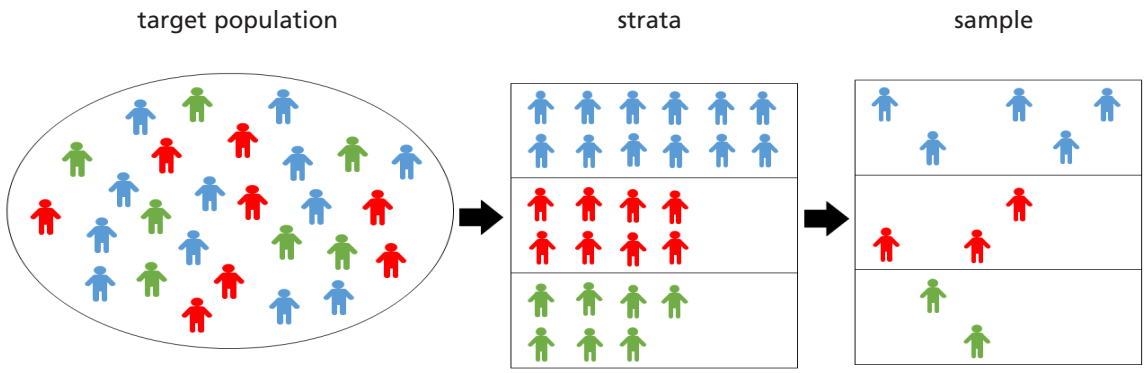
2.3 STRATIFYING THE POPULATION

Once the target population has been defined, either through a national license system, a screening survey or a mandatory fee-free online registration, the sample size can be estimated (i.e. number of observations) and the sample of recreational fishers can be selected. However, in the case of a stratified random sampling, one further step is required: there is a need to identify the strata. As previously mentioned, an important principle is that strata should be mutually exclusive, as simply illustrated in Figure 7.

For example, if the respondents were divided equally between residents of coastal and inland areas and a sample of 640 units was needed, 320 respondents (50 percent) would therefore have to be sampled at random from the inland stratum and 320 respondents (50 percent) from the coastal stratum.

Therefore, stratification could be based on residents' spatial provenance, grouping by criteria such as area of residence or specific jurisdiction (e.g. GFCM geographical subarea (GSA) – see Annex 1, subnational, region, port, etc.) rather than on fishing habits (e.g. boat fishing, shore fishing or underwater fishing), as the same recreational fisher may engage in various different types of fishing activities. Fishing habits could be taken into account to weight observations, but it is recommended to make sure that this choice is motivated by: i) a good rationale for why recreationists with different fishing habits might differ; and ii) evidence on the soundness of existing data on recreational fisheries. Any bias in estimated proportions of recreationists will further affect estimates made through weighting.

FIGURE 7
Stratification of the target population



2.4 ESTIMATING THE SAMPLE SIZE

The biggest advantage of probabilistic survey sampling lies in its capacity to provide accurate representations of large populations from surveys of small groups of units; a minimum number of units, however, is required to make inferences about the target populations. The minimum number of observations necessary is usually defined on the basis of the desired sampling error, the size of the target population and the variability of the trait of interest: a higher number of units is needed to make inference about a large and heterogeneous population than for a tiny and homogeneous one. Similarly, to obtain highly accurate estimates, a greater number of units is needed than for coarser estimates. Table 1 provides an example from Salant and Dillman (1994).

TABLE 1
Example of sample sizes needed by population size and level of sampling error

Population size	± 3% Sampling error		± 5% Sampling error		± 10% Sampling error	
	50/50 split	*80/20 split*	*50/50 split*	*80/20 split*	*50/50 split*	*80/20 split*
100	92	87	80	71	49	38
250	203	183	152	124	70	49
500	341	289	217	165	81	55
750	441	358	254	185	85	57
1 000	516	406	278	198	88	58
2 500	748	537	333	224	93	60
5 000	880	601	357	234	94	61
10 000	964	639	370	240	95	61
25 000	1 023	665	378	234	96	61
50 000	1 045	674	381	245	96	61
100 000	1 056	678	383	245	96	61
1 000 000	1 066	682	384	246	96	61
100 000 000	1 067	683	384	246	96	61

Source: Salant and Dillman, 1994.

Sample size for random sampling may be easily estimated in cases of populations with lists of units. Here follows an example of the formula provided by Vaske (2008):

$$Ns = \frac{(Np)\times(p)\times(1-p)}{\left[(Np-1)\times(B/C)^2\right]+\left[(p)\times(1-p)\right]}$$

where:

Ns = the sample size

Np = the size of the target population (e.g. the number of recreational fishers reported on a list)

p = the prevalence of the target variable (e.g. the number of recreational fishers who are exclusive sea fishers, who do not fish in freshwater)

B = the desired level of sampling error which can be accepted (e.g. 5 percent = 0.05)

C = the Z-statistic associated with the confidence interval (e.g. for a 95 percent confidence interval, Z = 1.96)

For stratified random sampling, the number of observations within each stratum can be obtained through proportionate stratification. The procedure requires the following steps:

1. Compute the desired sample size (see formula above).
2. Calculate the proportion of each stratum in the target population.
3. Assign the number of observational units proportionally to each stratum.

This procedure is called proportionate stratification and takes the following formula:

$$n_h = \left(\frac{N_h}{N}\right) \cdot n$$

where:

n_h = the number of observations in each stratum of the sample
N_h = the number of observations in each stratum of the population
N = the total number of observations in the population
n = the total number of observations collected with sampling

2.5 SELECTING THE SAMPLE

Once the target population has been defined (see Section 2.1) and stratified (see Section 2.3) and the sample size determined (see Section 2.4), the sample of recreational fishers to be enrolled in subsequent data collection can be selected. In order to initiate this process, each fisher must possess a unique ID, identifying him or her from all other fishers. In the case of a licensing system, this unique ID could be the license number, whereas in the case of screening surveys or mandatory fee-free online registration, each member of the target population should be assigned a unique ID. Following the methodology of random sampling, the basic condition required for the selection of the sample is randomness. To avoid human error, this process should be carried out by a computerized routine, ensuring that all members of the population share an equal chance of appearing in the sample, thereby guaranteeing randomness. This computerized routine can be performed simply in Microsoft Excel, following these steps (Figure 8):

1. Enter the complete target population list frame in the Excel file, ensuring that each fisher is identified by a unique ID.
2. Assign a random number to each ID by means of the RAND function in Microsoft Excel by typing =RAND() and hitting enter. A randomly generated number will appear in the cell.
3. To ensure the RAND function does not continue to change the value of the randomly generated numbers, copy and paste all random numbers generated using "paste special – value" to insert the value only in the column with the random number.
4. Sort the list of IDs by their random number, from smallest to largest.
5. According to the chosen sample size (*n*), select the first *n* rows of the list: they constitute the randomly selected sample units.

This simple and straightforward procedure guarantees the perfect randomness of the sample (Pinello, Gee and Dimech, 2017).

Once the sample population has been selected, the fishers should be contacted (by e-mail or telephone) in order to determine whether or not they are willing to participate in the data collection. If they agree to participate in the data collection, then they should be enrolled in the panel survey; fishers who decline to participate shall be substituted by other fishers randomly selected from the database. All attempts should be made to encourage participation and to avoid replacement whenever possible, as replacement can result in a less representative sample. When feasible, it is useful to collect demographic and fishing avidity data from those who refuse to participate, as this information can facilitate adjusting statistical weights to account for non-response error.

FIGURE 8
Example of computerized routine to select random samples

STEP 1

	A	B	C	D
1	ID			
2	1			
3	2			
4	3			
5	4			
6	5			
7	6			
8	7			
9	8			
10	9			
11	10			
12	11			
13	12			
14	13			
15	14			
16	15			
17	16			
18	17			
19	18			

STEP 2

	A	B	C	D
1	ID	Random numbers		
2	1	0.40795484121		
3	2	0.12845466897		
4	3	0.65770634522		
5	4	0.07759856331		
6	5	0.46540075623		
7	6	0.87541332138		
8	7	0.97566432311		
9	8	0.73242430743		
10	9	0.54786965421		
11	10	0.56359821065		
12	11	0.37664809832		
13	12	0.89467563297		
14	13	0.48675094327		
15	14	0.98006574344		
16	15	0.04567895		
17	16	0.18657965643		
18	17	0.3678954321		
19	18 = Rand ()			

STEP 3

	A	B	C	D
1	ID	Random numbers		
2	1	0.4079548421		
3	2	0.5409865742		
4	3	0.02439870		
5	4	0.396948965		
6	5	0.659354280		
7	6	0.196493582		
8	7	0.6573209382		
9	8	0.7692759202		
10	9	0.874027539		
11	10	0.657098365		
12	11	0.39672892		
13	12	0.496492174		
14	13	0.002975662		
15	14	0.856743020		
16	15	0.376950281		
17	16	0.948677433		
18	17	0.759207512		
19	18	0.645839734		

STEP 4

	A	B	C	D
1	ID	Random numbers		
2	1	0.3849454491		
3	2	0.756328737		
4	3	0.09634201		
5	4	0.483920188		
6	5	0.295824718		
7	6	0.981839539		
8	7	0.739291029		
9	8	0.392093754		
10	9	0.285386549		
11	10	0.387652915		
12	11	0.498286423		
13	12	0.73954201		
14	13	0.297163209		
15	14	0.875927542		
16	15	0.2954310865		
17	16	0.021783974		
18	17	0.297493214		
19	18	0.536839202		

STEP 1: the total population includes 18 recreational fishers (each assigned an ID number and entered into the Excel file) and the objective is to randomly select 50 percent of them (nine fishers). STEP 2: with the RAND function, create 18 random numbers. STEP 3: copy and paste as values these numbers. STEP 4: sort the fisher ID by the random numbers from smallest to largest and select the first nine fisher IDs (i.e. 8, 2, 12, 7, 1, 6, 16, 18 and 11). These nine fisher IDs constitute the sample.

2.6 ADDITIONAL CONSIDERATIONS

Selecting a sample goes beyond sampling design and the random extraction of statistical units. In practice, many other decisions are involved in the process, governing coverage error, sampling error and non-response error (see Figure 2). Notably:

- The sampling frame might not fully overlap with the range of statistical units in the population. Some units, given certain sampling mechanisms, may not be covered by the survey, thereby biasing the estimates. A famous case involves the use of online surveys: not every person has access to the internet, meaning not every person can be recruited in an online survey and, therefore, online surveys are often biased compared to other survey administration modes (Vaske, 2011). Considering that internet usage may be limited in rural areas and developing countries and among the elderly, estimates from online surveys risk strong biases for recreational fisheries surveys in the Mediterranean and the Black Sea where these three groups make up a significant portion of the target population.
- Sampling error: as discussed in Section 2.2, sampling might be biased. For example, simple random sampling may fail to be balanced in terms of relevant groups of units (strata), biasing subsequent inferences.
- Non-response error: certain mechanisms adopted for unit selection might produce problems due to people not responding to the survey; self-administered surveys, if overly time-consuming and cognitively demanding, may be rejected by less motivated respondents, or by respondents with a lower level of literacy. In turn, non-respondents might differ from respondents in relation to the target variable that researchers aim to estimate, thereby biasing final estimates. A simplified example is a self-administered mail survey, delivered to a random sample of fishers, which asks them many different questions about seasonal catch. The questionnaire is well-designed and protects privacy, but it is too long and difficult to understand. Therefore, those fishers with low literacy

levels (and – for the sake of this simplified example – correspondingly lower income levels) do not respond. As a result, responses come from those fishers with higher literacy rates (and correspondingly higher income levels). Owing to this latter group's higher income, they likely use more expensive and more efficient fishing gear, resulting in an overestimation of the average seasonal catch.

Defining a sample frame and an administration mode are two practical aspects of survey implementation that affect the estimation of recreational fishers in the Mediterranean and the Black Sea.

3. Methodology

Once the sampling frame of recreational fishers has been identified – regardless of the data source (i.e. license system, screening survey or mandatory fee-free online registration) – there are a number of different methods for contacting recreationists and collecting effort, catch and economic data.

Each method comes with its advantages and disadvantages in terms of species and geographical coverage, measurement accuracy and scalability of results (Wynne-Jones *et al.*, 2014). Ideally, data collection procedures should minimize coverage, sampling, and non-response bias. Moreover, data collection should refrain from asking sensitive questions and should avoid making respondents feel uncomfortable about their answers (Krumpal, 2013). If these two conditions are met, data collection can provide catch statistics that are unbiased and sufficiently precise for use in stock assessments and for informing fisheries management.

There are two broad types of approaches to data collection:

- off-site surveys; and
- on-site surveys.

Off-site surveys are characterized by researchers drawing observational units without going into the field. This context implies that they are inevitably conducted for target populations whose lists are known and available and that they collect mostly self-reported measurements.

On-site surveys, on the other hand, involve sampling fishers by going into the field and approaching and interviewing them.

As a general recommendation, both off-site and on-site surveys should aim to ask as few questions as possible in order to minimize the cognitive burden for respondents. Furthermore, sensitive questions should be avoided and all efforts should be made to build a trust-based relationship with respondents, particularly in the case of economic data collection (see Section 3.3.4). Available evidence indicates that sharing detailed information about the scope of the questionnaire and providing feedback on the scientific findings to the respondents is useful in promoting trust (Vaske, 2008).

3.1 OFF-SITE SURVEYS

Off-site surveys offer a means of measuring all forms of fishing activity across large spatial areas to produce total harvest estimates. There are certain potential advantages to such methods, particularly in terms of geographical coverage and their ability to reach all the various types of recreational fishers, even those who are the hardest to recruit in on-site surveys. Respondents can be asked about fishing over defined periods (e.g. day by day or over an extended period), especially when enrolled in a panel-type survey (Wynne-Jones *et al.*, 2014). However, it is important to note that off-site surveys always rely on self-reported information. Off-site surveys can take two forms:

- logbook surveys; and
- recall surveys.

3.1.1 Logbook surveys

Logbooks provide a very cost-effective means of collecting both fishing effort, catch and economic data. A template of a logbook is included in Annex 5. The logbook could be delivered to selected recreational fishers as a paper book/diary at the beginning of the survey period. Alternatively, online logbooks or a dedicated application for mobile phones could be developed. As a first step, delivering paper logbooks is suggested as

they ensure maximum coverage. Each page of the logbook should correspond to one fishing trip. Should a fisher engage in multiple fishing modes (e.g. from a boat, from the shore or underwater) within the same day, each fishing mode should be considered a separate fishing trip and a separate logbook should be completed. Fishers should be asked to complete the logbook with:

- general information (Annex 5.a), including:
  - name and surname of the panel participant;
  - whether the logbook information is reported for a single fisher (the panel participant) or multiple fishers (in the case that the panel participant pools his/her catch with other fishers during the fishing trip and it is not possible to determine the panel participant's individual catch). In the case of multiple fishers, the number of fishers (gender disaggregated) and their ages should be reported;
  - location of the fishing ground, such as the GFCM GSA, the city or distance from the coast: this can be reported through geographical coordinates (if available through GPS or mobile phone data) and/or by describing the location (e.g. by reporting the basin and distance from the nearest harbor);
  - total fishing time: the date and time of the fishing trip's start and the date and time of the fishing trip's end;
  - fishing mode: whether fishing took place from a boat, from the shore or underwater;
  - information about the fishing effort: fishing gear used, time spent fishing per gear (fishing time), number of units used for each fishing gear (e.g. number of rods, hooks, etc.). In case "multiple fishers" was selected at the top of the logbook, then the cumulative fishing effort for all fishers should be reported;
  - catch by gear code: in case "multiple fishers" was selected at the top of the logbook, then the cumulative catch for all fishers should be reported;
- retained species information (Annex 5.b), including:
  - biological data of the retained catch, including length, weight and sex (if known);
- released species information (Annex 5.c), including:
  - information on the released catch, including the length and post-release status; and
- expenditures (Annex 5.d), including:
  - the value of all expenditures made in relation to the fishing trip, including any expenditures incurred prior to the fishing trip (e.g. the purchase of new equipment) since the last logbook was completed.

Fishing effort will be estimated taking into account the total fishing time of the trip (ending time minus starting time, including travel to/from the port in the case of boat fishing). In the example shown in Figure 9.a, the total fishing time is eight hours. Data on fishing effort must be reported for each gear/technique used during the trip. The effective fishing (soak) time per gear should be differentiated from total fishing time since the catch should be standardized using effective fishing time. In this example, five hours were dedicated to fishing with hooks (three hooks in total), and three hours for traps (two traps in total). With regard to hook fishing, it is important to know how many hooks were used; if, for example, a total of three rods/handlines were used and each rod/handline had a tackle with three hooks, then the total number of hooks will be nine.

When more than one person participates in the fishing trip and the individual effort and/or catch of each person cannot be determined (e.g. when several people are fishing on the same boat, collectively using the same gear and the catch is pooled together), then fishing effort should reflect the cumulative effort of all participants and the total

cumulative catch should be reported. During the data analysis phase, the catch and effort of the logbook owner can be estimated as the mean of the effort and the mean of the catch of all fishers participating in the fishing trip. For this reason, the number of fishers is requested.

The catch must be recorded by gear typology. A list of gear codes is recorded in Annex 2 as well as in Annex 5.a and Annex 6.a. The gear code is needed to ensure that the respondent is referring to the correct gear and to facilitate the work of the researcher in identifying the gear without errors. In the first column, the gear code must be reported (see Annexes 5.a, 5.b and 5.c), while in the column titled "Species," a valid name of the species should be written. The scientific name would be the ideal way to report a catch, but recreational fishers do not usually know the scientific name of each species. Therefore, it would be better to ask for the common name and, in case such a name is ambiguous, then it would be advised to contact the fisher and ask for an explanation. Following the example in Figure 9.b, the first species recorded is the common pandora (*Pagellus erythrinus*), one specimen has been kept (total length = 25 cm, corresponding to a weight of 0.3 kg) and one specimen has been released. In the template for released catch (see Annex 5.c) it would be important to report whether the released fish was alive, almost dead, dead or not known, when released back into the sea. For example, in Figure 9.c, in the case of the Mediterranean horse mackerel (*Trachurus mediterraneus*) under the "catch information" logbook template (see Annex 5.b), it is noted that three specimens were caught, with total lengths indicated for each one, followed by their three respective weights. In the case of the abundant catch of black gobies (*Gobius niger*) reported in Figure 9.a, it is sufficient to write the total number of fish (40) and the total weight (1.2 kg) in the "general information" logbook template (see Annex 5.a). For cephalopods, the mantle length in cm must be recorded in the "catch information" logbook template (see Annex 5.b), as in the case of the common cuttlefish recorded in Figure 9. Crustaceans must be measured for carapace length in mm. For other taxa (i.e. echinoderms), it would be sufficient to report number and total weight in the "general information" logbook template (see Annex 5.a). For further details on measuring catch, see Section "3.3.2 Catch".

Some fishers might not update their logbooks on a regular basis, which could ultimately bias the study. In this case, follow-up by the researcher would be necessary to determine why the relevant fishers did not fill out their logbook every month. Regular communication and follow-up with panel participants could help increase the proportion of completed logbooks. Another source of bias is the so-called "prestige bias", which involves fishers exaggerating catch size or numbers and providing deliberately false information to make a better impression on others. On the other hand, certain political or cultural contexts may lead fishers to understate their catch to avoid management repercussions or due to superstitions believing in bad luck derived from sharing information about the size of the catch. Both forms of bias might be reduced by emphasizing that data will be reported anonymously, that it will be combined with other means of data collection (e.g. on-site surveys), that honesty is important for the ethics of fishing and that exaggerating data might have negative consequences for the management of fish stocks (Ayal *et al.*, 2015).

It would be useful to train recreational fishers in filling out the logbooks by means of training courses (e.g. online tutorials, seminars, etc.). Within such training courses, it is important to emphasize that logbooks should be completed on a regular basis, rather than just before they are to be collected by researchers, as the latter routine might introduce recall bias and present negative consequences for fisheries management. Logbooks should be collected regularly, for instance every month, and data should be entered into a database for subsequent analysis.

FIGURE 9.a
Example of how to compile a logbook (general information)

Logbook and recall template – general information

Logbook [x] Recall [ ] Reference month and year _____

Name and surname of panel participant *Mario Rossi*

Information reported for:

Only the panel participant [ ]

Multiple fishers (in case the panel participant's catch is pooled with other fishers on the same trip) [x]

If multiple fishers:

No. Fishers: ♂ *2* age *45* *51* ; ♀ *1* age *35*

Fishing location	
Geographical subarea (GSA)	*17*
City	*Venice*
Distance from the coast (in nm)	*3*

Total fishing time

	Start	End
Date	*13 May 19*	*13 May 19*
Hour	*06:00*	*14:00*

Fishing mode* Boat [x] Shore [ ] Underwater [ ]

Gear	Gear code	Fishing time per gear (in hours)	Number of units used per gear
Hand implements	MHI		
Harpoons	HAR		
Diving	MDV		
Diving (speargun)	MDS		
Diving (hand)	MDH		
Cast nets	FCN		
Boat seines	SV		
Beach seines	SB		
Hooks and lines (not specified)	LX	*5*	*9*
Handlines and hand-operated pole and lines	LHP	*5*	*3*
Traps (not specified)	FIX	*3*	*2*
Pots	FPO		
Gillnets and entangling nets (nei)	GEN		
Gillnets	GNS		
Trammel nets	GTR		
Longlines (not specified)	LL		
Lift nets (not specified)	LN		
Scoop nets	MSP		
Gear not known	NK		
Gear not specified	MIS		

Catches

No.	Gear code	Species	No. Retained	Weight (kg) Retained	No. Released
1	*LX LHP*	*common pandora*	*1*	*0.3*	*1*
2	*LX LHP*	*horse mackerel*	*3*	*1.1*	
3	*LX LHP*	*gilthead seabream*	*1*	*1*	*1*
4	*LX LHP*	*black goby*	*40*	*1.2*	
5	*FIX*	*cuttlefish*	*2*	*1.2*	
6					
7					
8					
9					
10					

Comments:

** Complete one logbook/recall template per fishing mode*
*** Provide a description of the fishing gear in the comments section*

FIGURE 9.b

Example of how to compile a logbook (retained species information)

Logbook and recall template – retained species information

Logbook [x] **Date** *13 May 19* | **Recall** [ ] **Reference month and year** _____

No.	Gear code	Species (retained)	Length*	Weight (kg)	Sex**	Fishing mode***		
						Boat	Shore	Under water
1	*LX LHP*	*common pandora*	*25*	*0.3*	*nd*	*x*		
2	*LX LHP*	*horse mackerel*	*25*	*0.3*	*nd*	*x*		
3	*LX LHP*	*horse mackerel*	*30*	*0.4*	*nd*	*x*		
4	*LX LHP*	*horse mackerel*	*30*	*0.4*	*nd*	*x*		
5	*LX LHP*	*gilthead seabream*	*40*	*1*	*nd*	*x*		
6	*FIX*	*cuttlefish*	*14*	*0.5*	*male*	*x*		
7	*FIX*	*cuttlefish*	*16*	*0.7*	*female*	*x*		
8								
9								
10								
11								
12								
13								
14								
15								
16								
17								
18								
19								
20								
21								
22								
23								
24								
25								

** Total length for fish (cm), mantle length for cephalopods (cm), carapace length for crustaceans (mm)*
*** If known (M: male; F: female; ND: not determined)*
**** Select only one fishing mode (boat, shore, underwater) per row*

FIGURE 9.c

Example of how to compile a logbook (released species information)

Logbook and recall template – released species information

Logbook [x] **Date** *13 May 19* | **Recall** [ ] **Reference month and year** _____

No.	Gear code	Species (released)	Length*	Post-released status**				Fishing mode***		
				Alive	Almost dead	Dead	Not known	Boat	Shore	Under water
1	*LX LHP*	*common pandora*	*12*	*x*				*x*		
2	*LX LHP*	*gilthead seabream*	*15*		*x*			*x*		
3										
4										
5										
6										
7										
8										
9										
10										
11										
12										
13										
14										
15										
16										
17										
18										
19										
20										
21										
22										
23										
24										
25										

** Total length for fish (cm), mantle length for cephalopods (cm), carapace length for crustaceans (mm)*
*** Mark the corresponding cell*
**** Select only one fishing mode (boat, shore, underwater) per row*

Logbook surveys are also an effective way to measure economic expenditures. Once reliable economic baseline data have been established, less frequent economic data collection could be foreseen (e.g. every two to five years, rather than annually), in order to simplify data collection and to avoid overburdening respondents. Selected recreational fishers should be asked to register the money they spent to carry out their fishing activity during each fishing trip, including for fishing equipment (e.g. rods, reels, hooks, lines, swivels, spearguns, underwater accessories, traps, etc.), bait (e.g. natural or artificial bait), travel and accommodation (e.g. train, plane, car, hotels, etc.), boat expenses (e.g. charter, rental, boat ownership expenses such as fuel costs, mooring fees and taxes, boat maintenance, etc.), electronics (GPS, echo sounder, radar, etc.), license fees and other costs. In the case of underwater fishing, boat expenditures should also be included if the fishing is performed using a boat. A more detailed description of the information to be collected is recorded in Section 3.3.3, and a template for collecting this information through the logbook can be found in Annex 5.d. The monetary value to be inserted in each cell should be indicated in the local currency. To facilitate regional comparison, the survey coordinator should convert those values into a common currency, such as EUR or USD, by applying current conversion rates.

3.1.2 Recall surveys

An alternative to logbook surveys is the recall survey, which relies on contacting, via e-mail and/or telephone, selected recreational fishers and asking them to recall information about their catch, effort and expenditures over a specific timeframe. Extended timeframes (e.g. one-time surveys with a six- or 12-month recall period) can significantly overestimate total recreational fishing effort. Typically, an average catch per trip is recalled and then multiplied by the assumed number of trips. This can potentially lead to a severe overestimation of the catch, as there is a general tendency to exaggerate participation rates in recreational events (Tarrant and Manfredo, 1993; Connelly and Brown, 1995; Vaske, Huan and Beaman, 2003). This is not always the case, however, as noted in Connelly and Brown (2011); therefore, anglers and recreational fishers should, in general, be treated as a heterogeneous group (Arlinghaus, Bork and Fladung, 2008; Johnston, Arlinghaus and Dieckmann, 2010). Respondents generally prefer to recall the catch in numbers, in which case converting those numbers into weight can present issues. A specific problem with recall surveys is that the longer the timeframe over which respondents are supposed to recall, the more the results tend to be biased (Tarrant and Manfredo, 1993), so a short recall period would be preferred to minimize possible recall errors. A one- to two- month recall period is suggested as it is feasible yet not too long. At a more advanced stage in implementing recreational fisheries monitoring programmes, it could be worthwhile to contact more avid fishers more often during the peak season, although that may not be necessary in the early stages of trialing these methods in a country.

The same information is required for the recall survey and for the logbook, meaning that interviewers can use the same template as the logbook survey for catch and effort data (see Annexes 5.a, 5.b, 5.c), filling in one template per fishing trip. As is the case with the logbook, when a fisher engages in more than one fishing mode (e.g. fishing by boat, shore or underwater) in the same day, each fishing mode should be considered a separate fishing trip and therefore a separate logbook should be completed. For economic expenditures, the information to be collected is identical between the logbook and the recall survey, however, the reference period differs. The logbook (see Annex 5.d) should include all expenditures made in relation to the specific fishing trip, including any expenditures since the last fishing trip. On the other hand, the recall survey (see Annex 5.e) should collect information in relation to all expenditures made during the recall survey's reference period (e.g. the previous one to two months). In all

cases, it is helpful to supply the fisher with a copy of the logbook template in advance, so that he or she may keep notes and to facilitate jogging his or her memory at the time of the recall survey interview.

Recall surveys can also be used as a complement to logbook surveys. Selected fishers who are involved in the logbook programme should be contacted on a monthly basis by telephone in order to verify the information reported in the logbook over the previous month. Logbook information requiring verification could include the fishing areas (e.g. wrong or questionable geographical coordinates, doubtful locations, etc.); the number of gear used (e.g. verifying that the number of hooks is reported rather than the number of rods, etc.); the common name of the target species (e.g. matching the correct scientific names to the species); eventual peculiar numbers or weights of catch (e.g. very high number of fishes, wrong correlation between length and weight, etc.); and other eventual anomalies observed in the logbook.

3.2 ON-SITE SURVEYS

On-site surveys entail sampling fishers by going directly into the field and interviewing them. On-site methods potentially represent a more accurate and direct approach as fishery-independent staff members follow randomized probabilistic designs to collect the data, usually soon after any fishing effort has taken place. Detection of, and correction for, any bias are also potentially more feasible given the direct and verifiable nature of the data collected. Unfortunately, on-site methods tend to be comparatively expensive and logistically onerous, thus limiting the scale at which they can be applied (Hartill, Watson and Bian, 2011). This type of survey could therefore be useful as a means of validating and integrating the data acquired through off-site surveys (e.g. logbook, recall), providing additional data on catch size and species composition. In this way, an off-site logbook or recall-based survey method could function as the primary means of estimating mean catch rates and effort, with on-site sampling conducted by trained interviewers only used to validate the self-reported off-site data. On-site surveys can therefore contribute to the detection of discrepancies between self-reported data and data measured in the field.

In some countries, such as those with limited coastlines or a limited number of access sites, it may be possible to conduct on-site surveys as the primary means of collecting fishing effort and length data directly from fishers, in view of estimating catch per unit of effort (CPUE) (see Section 3.3.1). In other countries this may not be a feasible or cost-effective option.

Whether using an on-site survey as the primary means of data collection or simply to validate off-site surveys, the main purpose of an on-site survey is to collect data on as much recreational catch as possible, for as many species as possible. Engaging recreational fisheries stakeholders through federations and associations is one way to reach a high number of fishers (see Section 5). Interviews can be carried out at harbors, beaches, ramp sites, slip ways, etc. The locations can vary, so it is important to include all specific locations with fishing participants in the sample frame. The catch data to be collected should include the species of fish, the number of fish caught of that species, the number of fish kept and the number of fish released. In addition, interviewers should attempt to obtain length and weight measurements from a random sample of the kept fish that the angler is willing to make available.

Biases may arise within the on-site survey when fishers are selected for sampling based on accessibility or convenience (e.g. by sampling only vessels that arrive in port within certain hours). This selection would not constitute a random sample of the population because the probability of selection would be unknown, thereby invalidating the interpretation of the data (Grafton *et al.*, 2006). The probabilities associated with sampling at different times of day should be controlled consulting expert knowledge of fishing patterns in different areas and seasons. See Section 3.2.1 for information on other on-site data collection methods, beyond this traditional approach.

How the interviewer introduces himself or herself to the fisher is one of the most important considerations and can frequently determine the success of the interview. It is important to establish a relationship of trust with the interviewee in order to promote honest responses. It is therefore recommended to use the following approach when introducing oneself to a potential interviewee on-site:

> *"Hello, my name is ____ and I am doing a recreational fisheries scientific research survey for _____ (institution) on behalf of _____ (e.g. Ministry of Fisheries). Can I ask you a few questions about your fishing today?"*

If the fishers wish to know the objective of the study, it should be clearly explained that the main aim of the survey is to collect information on local recreational fisheries in order to foster their sustainable management and that the anonymity of the participant is ensured.

The information listed below should be annotated during in the interview.

General information (Annex 6.a)

- Date of interview
- Whether information is being reported for a single fisher or for a group of fishers (in the case that gear/catch are pooled and it is not possible to determine one fisher's individual catch). In this latter case, the number of fishers (gender disaggregated) and their age should be reported.
- Fishing location: the location of the fishing ground should be requested. Questions can be formulated in the following manner: "Roughly, where did you fish today? Could you please estimate the distance from the coast?" It can indeed be useful to bring a map and ask fishers to indicate directly on the map where the fishing ground is located. In the event that fishers are particularly collaborative, they could be asked to provide the exact fishing location by geographic coordinates (latitude and longitude).
- Total fishing time: the time spent during the whole fishing session should be recorded. For example, in the case of a boat trip, this also includes the navigation time. The time should be clearly written in order to understand whether it refers to before (a.m.) or after (p.m.) noon. The date should be reported for both starting time and ending time of the boat trip to avoid errors for fishing sessions taking place over multiple calendar days.
- Fishing time and number of gear: for each gear used, it is necessary to ask the fishing time (how long the gear was in the water) and the number of gear (e.g. number of rods and total number of hooks).
- Number and weight of retained species, as well as the number of released species, by gear. Each species must be recorded using the local name or the scientific name (if possible). In case there are doubts about the correct identification, it is advisable to take a picture, using the timestamp on the photo to associate the pictures with the interviews. For each species, register the number of specimens and their total weight, as well as the number of released individuals.
- Fishing trips performed during the previous year – in order to roughly estimate the avidity of the fisher, the fisher should be asked to guess how many fishing trips they performed over the previous year. This can sometimes be a difficult question for a fisher to answer and it may be necessary to prompt the fisher with potential responses (e.g. "was it five, 20 or 50 times?"). This question should be asked to all fishers of the party and should refer to the fishing mode (boat, shore or underwater fishing).

- Willingness to participate in a panel survey: as it is important to collect contacts for subsequent diary/logbook or recall surveys, interviewed fishers should be asked whether they are willing to be contacted in the future. If their answer is in the affirmative, then contact information, including name and mobile phone number (preferable to a landline phone number), should be collected. This information should be requested at the end of the interview, once fish have been measured and a rapport established with the fisher.
- Comments: any comments the interviewer may have regarding the interview should be noted here. These annotations can help to understand eventual oddities that may emerge during the survey and could include, for example, the bait used or whether each fisher is listed in the national list of household telephone numbers.

Retained species information (Annex 6.b)

- Total length, weight (and sex if possible) of retained species by gear: to facilitate completing this task, it is useful to ask: "Can I please measure your fish?" If the fisher agrees, then every retained species must be measured, rounding down to the closest half cm for total length. Although useful, weight and sex are not mandatory, as weight can be estimated subsequently by means of the length/weight relationship, and it is usually required to open the belly of the fish in order to determine the sex.

Released species information (Annex 6.c)

- The length of each released specimen should be requested, as well as information on the post-release status (e.g. alive, almost dead, dead, unknown).

3.2.1 Other on-site methods

In countries where more extensive on-site data collection is considered feasible (e.g. in countries with limited coastlines), two alternative survey methods, in addition to the traditional on-site data collection approach described above, could be considered to estimate catch and effort: the bus route method and aerial-access surveys.

Bus route method

Robson and Jones (1989) developed a procedure for collecting recreational fisheries catch and effort, which is analogous to a "bus route" and allows for a limited number of interviewers to sample a high number of access sites. Instead of visiting just one or two access sites a day (the traditional approach), each interviewer makes a complete circuit of all access sites over the course of each sampling day (Jones *et al.*, 1990). The agents have a precise schedule to follow each day and they arrive and depart from each site on a predetermined timetable. Because the starting point along the circuit is chosen randomly each day, each site is visited randomly throughout the day over the survey period. This method is particularly appropriate when there are many access sites to be sampled. For example, if the study area consists of 12 access sites, it would be unreasonable to spend a full day at only one of so many access sites as each site would then be sampled infrequently over the whole survey period. With the bus route method, one interviewer (or one crew of interviewers) covers all 12 sites within a single day. Following a traditional approach, the same number of interviewers would visit only one to two sites per day.

Aerial-access surveys

The use of observers in aircraft flying at low altitudes (150 to 300 m, depending on the minimum-permissible altitude under civil aviation regulations) offers an additional means of counting recreational fisheries vessels or fishers from the shore. There are two

forms of aerial-access design: the random-count design (described by Pollock, Jones and Brown, 1994 and used by English, Shardlow and Webb, 1986; English, Searing and Nagtegaal, 2002; Coutin, Conron and MacDonald, 1995; and Soupir *et al.*, 2006) and the less commonly reported maximum-count design (Parker, 1956; Dauk, 2000; Dauk and Schwarz, 2001; Lockwood, Peck and Oelfke, 2001).

The random-count design divides the day into two or more time bins, and flights are scheduled to take place at a random time within one or more diurnal strata on each survey day. The estimated number of hours fished in a given time bin is defined as the product of the number of hours occurring within that time bin and the aerial count. This estimate is then multiplied by a catch rate estimate for the same period to provide a catch estimate for this time interval (Hartill, Watson and Bian, 2011). Flights can be scheduled to take place during all time bins within a day, and the estimates of catch and effort obtained for each time bin can then be summed to provide total estimates for that day. Estimates from a random subsample of available days can then be averaged and generalized to provide catch end effort estimates for a larger temporal stratum, such as an entire summer season. Alternatively, time bins can be randomly sampled at a lower intensity across all survey days over a larger temporal stratum. Care must be taken, however, to ensure that at least one time bin is selected from each survey day and that sufficient replicates are sampled for each time bin across all surveyed days. Regardless of which random-count design is used, the high number of flights required to adequately estimate the total level of effort occurring on a sample day and across all sample days is potentially prohibitive, yet unavoidable, as these flights offer the sole means of estimating levels of effort when this design is used (Hartill, Watson and Bian, 2011).

Maximum-count aerial-access designs, such as that described in Hartill, Watson and Bian (2011), represent a more cost-effective option as only a single flight is required per survey day. A count of fishing vessels made during this flight is used in conjunction with creel survey data to describe the distribution of effort throughout the day. The substantial reduction in flight costs is offset to some extent by the need to station creel survey clerks at selected access points throughout the day. Nevertheless, results from this study (Hartill, Watson and Bian, 2011) suggest that catch rates vary throughout the day, and the best means of correctly accounting for these changes is to interview fishers throughout the day. The same study showed that it would be preferable to combine aerial count and fisher interview data together at the level of the primary sampling unit, i.e. the day. Estimates of total effort and catch were calculated for each randomly selected survey day and then averaged over their respective temporal strata. Hartill, Watson and Bian (2011) observed that the advantages of linking data from the aerial survey and fisher interviews on each survey day to estimate levels of effort are twofold: i) fewer flights are required to assess levels of effort, which can significantly reduce aircraft operating costs; and ii) a defined relationship between these two data sources can be used to estimate levels of effort on those days when flights are cancelled, which is a common problem with aerial-access surveys.

Both the above-mentioned forms of aerial-access surveys are rather high-cost data collection methods. With rapid advances and decreasing prices, however, in the field of remotely piloted aircraft systems (RPAS) – colloquially known as drones – researchers have access to a potentially innovative and cost-effective tool for implementing this kind of survey. In addition to improved cost-efficiency over existing techniques and the potential for highly replicable flight routes and for accessing remote or inaccessible locations, RPAS also boast the added advantage of being able to produce high-resolution mapping and capture footage beyond the visible spectrum, as well as providing non-invasive survey techniques for marine fauna. However, this technology is hindered by several important limitations,

including range, logistical considerations when operating over water, regulatory requirements and battery life (Desfosses *et al.*, 2019). Furthermore, it must be noted that only limited studies have evaluated the suitability of RPAS as a recreational fisheries data collection tool to date (Desfosses *et al.*, 2019). While these tools offer a number of potential benefits, it is important that they be adequately evaluated in order to provide researchers with a more complete understanding of the potential biases they may introduce (Beckmann *et al.*, 2019) and their eventual suitability for the sustainable management of marine living resources (Desfosses *et al.*, 2019).

3.3 TYPE OF INFORMATION TO BE COLLECTED

Independent of the chosen survey method (logbook, recall or on-site), in order to define the relationship between the sample and the statistical universe, it is necessary to collect basic personal data, such as gender, age and residence. Place of residence is required to spatially allocate the fisher within the sampled population. For off-site surveys (logbook and recall) it is also recommended to collect names and the mobile phone numbers. Other personal information is not relevant for the specific aims of this study (e.g. profession, education), unless the study has specific socio-economic objectives.

3.3.1 Fishing effort

Fishing effort is a measure of the fishing activity deployed by a certain fishing segment and can be useful to calculate CPUE, which is needed to analyse changes in catch quantities. This information is crucial for developing multiannual management plans.

Fishing effort can be calculated through a combination of inputs related to capacity, gear and time.

In particular, it is useful to collect the following data:

- Number of fishing trips: the number of fishing trips conducted during the interview period. A fishing trip is defined as a single fishing session, either performed from the shore, from a boat or underwater (i.e. starting from the shore or from a boat).
- Total fishing time (hours): the total duration (in hours) of a fishing trip (including navigation in the case of boat fishing).
- Fishing time (hours): the number of hours using a specific gear (e.g. for set nets, longlines and traps, the time from setting to pulling in; for hooks and spearguns, the fishing time, etc.).
- Number of gear used: the number of nets (e.g. scoop net, cast net, beach seine, etc.). This also refers to the number of panels for gillnets (or length of total set nets used), the number of hooks used with rods or handlines and the number of traps.

Guidance on how to measure fishing effort by fishing gear is provided in Annex 7.

3.3.2 Catch data

The objective of collecting catch data is to monitor and investigate the population dynamics of the most important species in the area of study. Knowledge of the biomass (by species) removed from the ecosystem by fishing operations is fundamental to monitoring the status of stocks, as well as the impact of fishing on fish populations, gear selectivity and catch at age.

In particular, it is useful to collect the following data:

- Species caught: identify the valid common name in order to define the scientific name of each species caught.
- Number of specimens kept: the number of specimens caught and retained by species (including all taxa, such as molluscs, crustaceans, echinoderms, etc.).

- Number of specimens released and their post-release status: the number of specimens caught and released by species (including all taxa, such as molluscs, crustaceans, echinoderms, etc.).
- Status of specimens after release: i) "alive" – strong body movements and none or only minor injuries; ii) "almost dead" – weak body movements and major injuries; iii) "dead"; and iv) "not known" – when the status was not observed.
- Length (cm): length measurements are easy to make but require a well-defined and standardized notation to allow for comparison of results. The length measurements to be made depend on the group of species under study. The lengths of fish and cephalopods should be generally measured, whenever possible, with graduated fish measuring instruments, called ichthyometers, while calipers are used for crustaceans (see below).
- Weight (kg): the weight of each single individual. If it is not possible to collect this information, it is possible to convert length into weight by consulting the length-weight relationship.
- Sex: determining the sex of caught individuals ranges from easy to extremely difficult. For most fish, it would be necessary to open its belly and check the gonads, and this operation should be authorized by the recreational fisher. Macroscopic observations can distinguish four sex categories: male (M); female (F); undetermined (U) – when, after dissection, it was not possible to determine the species' sex with the naked eye; and not determined (ND) – for individuals that have not been examined. For some fish taxa (e.g. some gobies, elasmobranchs, etc.), it is possible to determine the sex by observing some external morphological features (e.g. fins, claspers, etc.).

Data on catch can be combined with effort data to estimate the CPUE, which is a relative measure of fish stock abundance. Catch per unit effort can be used to estimate absolute abundance and could be an indicator of fishing efficiency (GFCM, 2018). In its basic form, the CPUE could be expressed as the captured biomass per each unit of effort applied to a species/stock (e.g. total catch of a species divided by the total fishing: kg/number of fish per longline hook days, or numbers retained or caught per trip). Declining trends of this estimator could indicate overexploitation, while steady values could indicate sustainable fishing.

Further consideration must also be made for the role of catch-and-release – when fish are unhooked or set free from a trap or net and returned to the water alive – as a considerable portion of fish caught by recreational fisheries can be released (Ferter *et al.*, 2013). The rates of released specimens, including species- and fishery-specific catch-and-release mortality rates, are unknown for most recreational hook fisheries, and therefore there is a need to estimate these mortality rates for use in stock assessments. A mixture of desk-based study and experimental work is required to compile data on the mortality of hook-and-line-caught fish and to bolster the evidence base in order to account for survival. Such studies should consist of reviewing existing literature, assessing the potential for extrapolation between species and fisheries, setting up generic mortality profiles, and conducting species-specific mortality studies to fill existing data gaps (ICES, 2014). This information is lacking for most target species in the Mediterranean and the Black Sea and, until such information becomes available, a precautionary approach could be adopted, assuming a survival rate of zero for those released species with no survival estimate.

How to measure fish, crustaceans and cephalopods

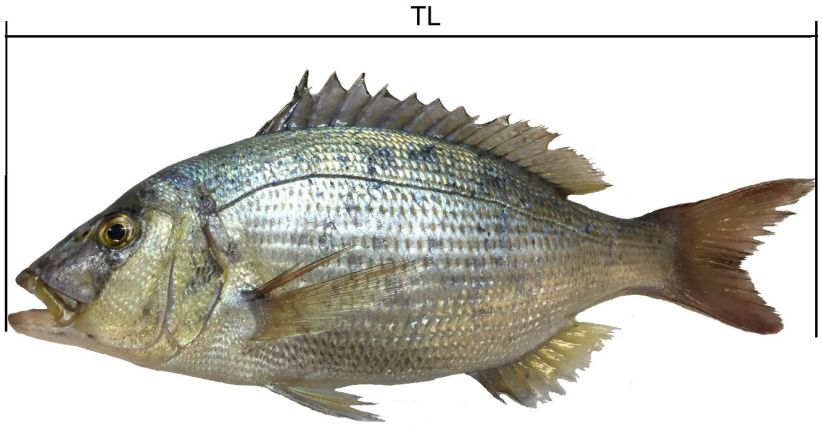
Bony fish and elasmobranchs: for bony fish, sharks, skates and rays, the length should be considered as the total length. The fish is measured, rounding down to the closest half cm, from the tip of the snout to the end of the caudal fin (Plate 1).

The length classes should be reported in cm (as a whole number, or half cm, e.g. 0.5, 1.0, 1.5 etc.).

Crustaceans: for crustaceans (lobsters, crawfish, shrimps, prawns, stomatopods), the standard measurement is the minimum carapace length. The length classes should be reported in mm (as a whole number, e.g. 1, 2, 3, 4 etc.). The crustacean is measured, rounding down to the nearest mm, from the back border of the eye orbit (inside of the eye socket) to the posterior margin of the carapace (Plate 2). All measurements are taken with calipers.

PLATE 1

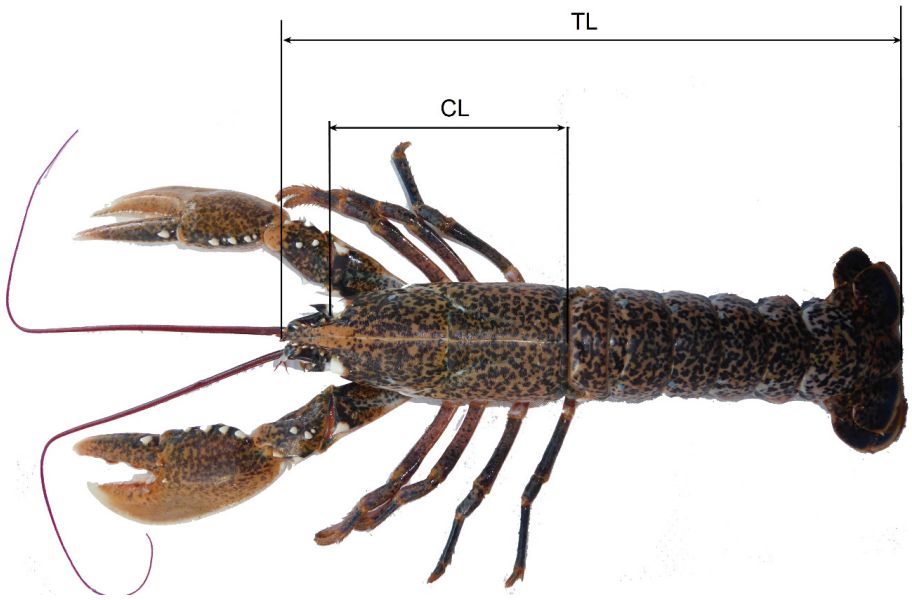
Measurement of total length in bony fish



Common dentex (*Dentex dentex*) © A. Lucchetti

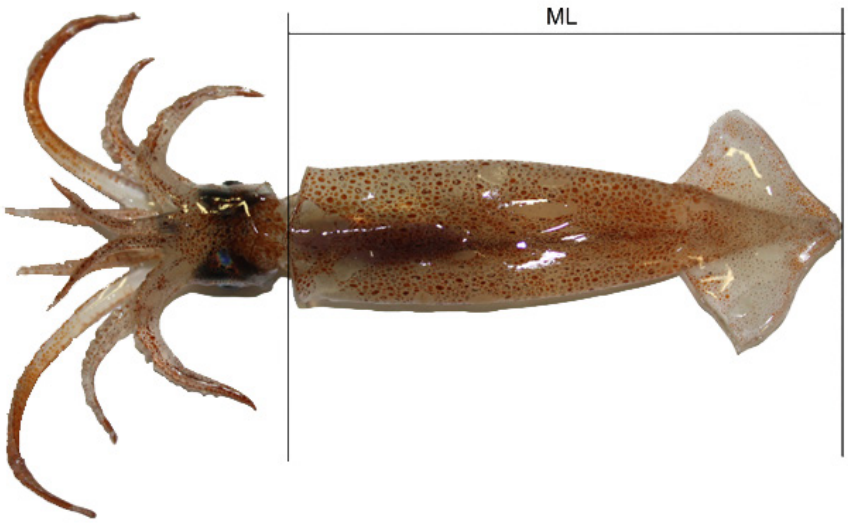
PLATE 2

Measurement of total length and carapace length in crustacean's decapoda



European lobster (*Homarus gammarus*) © A. Lucchetti

PLATE 3
Measurement of dorsal mantle length in cephalopods



Broadtail shortfin squid (*Illex coindetii*) © A. Lucchetti

Cephalopods: for cephalopods, the length is defined as the dorsal mantle length. The length classes should be reported in cm. The cephalopod is measured rounding down to the nearest half cm. The size should be reported in cm (as a whole number, or half cm, e.g. 0.5, 1.0, 1.5 etc.). For decapoda, measurement is made along the dorsal midline from the mantle margin to the posterior tip of the body, excluding long tails (Plate 3).

3.3.3 Economic data

Although recreational fisheries do not generate a direct commercial output, it has been shown that these fisheries generate significant economic value, through, for example, their contribution to the tourism sector (Gaudin and De Young, 2007). For this reason, the assessment of the economic impact of this sector is essential and economic data are an important component of any recreational fisheries data collection programme. Considering that recreational fisheries are, by definition, non-commercial, meaning that it is prohibited to sell or trade the catch obtained, non-market valuation techniques must therefore be applied. While both revealed and stated preference methods can be used to assess the value of recreational fisheries, revealed preference methods, such as the travel cost method and the hedonic pricing method, are most commonly used. These methods assess expenditures made as a proxy for economic value. Data on the costs recreational fishers incur help to explain their behavior and are useful in understanding the wider economic impact of this fishing activity. A simple method for calculating recreational fisheries expenditures is through a logbook or recall survey, by asking recreational fishers to report or recall the expenses incurred to carry out their leisure activity over the reference period. In the case of a logbook, fishers should include all expenditures in relation to the current fishing trip, as well as any expenditures made since their last fishing trip (e.g. purchase of a new rod, etc.). In the case of a recall survey, all expenditures within the recall period should be reported. Templates are provided in Annex 5.d, for logbooks, and Annex 5.e, for recall surveys. A description of the variables to be collected for which expenditures should be calculated is listed below:

- Equipment: the costs incurred for the purchase of equipment. For shore fishing and boat fishing, these may include the purchase of rods, hooks, reels, cast nets, etc., whereas for underwater fishing, these may include the purchase of a speargun, fins, mask, wetsuit, etc.
- Bait: the expenditures for both artificial baits (jigs, lures, spinner baits, etc.) and natural baits (worms, sardines, anchovies, shrimps, etc.).
- Travel and accommodation: the travel costs to/from the fishing site. These may include the costs of staying in a hotel (for the days spent fishing), roundtrip expenses to/from the fishing site, such as train or airplane tickets or expenses for travel by car (fuel costs, highway and parking fees, rental car expenses, etc.).
- Fishing license fees: it should be indicated whether the license is an annual, semi-annual, quarterly, monthly, weekly or daily license.
- Boat expenses: these may include, the purchase of a boat, boat rental or charter fishing fees, fuel costs (including two strokes lubrication oil), boat taxes (mooring, ramp, etc.), boat maintenance costs (engine maintenance, antifouling, etc.), as well as electronics (echo sounder, GPS, radar, etc.).

4. Data analysis

4.1 DATA QUALITY CHECK

Once data have been collected, they should be analysed and generalized to describe the total population. Before these actions can be completed, however, a critical step is to carry out a data quality check and the necessary data treatments. The accuracy of a survey estimate refers to the proximity of the estimate to the true population value and the difference between the two is referred to as the error of the survey estimate. This latter value is a fundamental component in the following steps for making estimates. Unfortunately, in practice, a true measure of sampling error can never be obtained, only an estimate (Pinello, Gee and Dimech, 2017).

Sampling errors refer to those errors encountered in the estimate of a particular parameter of the universe resulting from the fact that not all of the population, but only a subset (the sample), is the object of observation.

Non-sampling errors can be defined simply as all other errors in the estimate arising during the course of any survey activities other than sampling (e.g. the way you run the survey). Unlike sampling errors, they can be present in both sample surveys and censuses and are extremely difficult, if not impossible, to measure mathematically. With this in mind, both survey designers and data quality evaluators must ensure that non-sampling error is avoided to as great an extent as possible, or at least either randomly distributed in order to eliminate its effect on the calculation of population estimates or brought under statistical control.

The most common non-sampling errors result from poor coverage and selection bias, low response rates, non-responses, interviewer errors and data entry errors. Non-sampling errors are systematic errors, which tend to accumulate over the course of the entire survey and these types of errors often lead to a bias in final results. While sampling errors decline with an increase in sample size (disappearing completely for censuses), the same is generally not true for non-sampling errors.

It is worth noting that, even for well-designed and well-implemented surveys, non-response represents a serious threat to the validity of estimates. It is fundamental to ensure that non-respondents do not belong to a specific segment of the target population, thereby limiting the validity of the inferences. This point is of utmost importance and non-responses must be investigated to ensure that they have the same characteristics as respondents. The likely reason for each non-response should be recorded for each non-respondent, so that appropriate weighting and calibration methods are applied to correct for non-response.

Prior to producing estimates for end-users, a certain amount of data checking and monitoring must be performed to confirm the completeness and quality of primary data (FAO, 2002). Such control functions involve:

- Monitoring: providing summary lists and reports offering quick indications as to the availability of samples on boat activities and catch in each estimation context.
- Data range check: providing lists that record “extreme” values (the range of values) for catch, sample effort and prices. Values that appear too high or too low should be verified.
- Sample size check: providing lists showing expected sample size and accuracy level for boat activities and landings.

To guarantee quality assurance of recreational catch estimates from national surveys and to document bias in data collection, the Working Group on Recreational Fisheries Surveys of the International Council for the Exploration of the Sea (ICES) has developed a quality assurance toolkit for evaluation (ICES, 2013). The aim of this evaluation is to provide statements of quality of recreational data for end-users, including stock assessment scientists, and to identify potential improvements to survey design. The quality assurance toolkit consists of three modules – sampling designs, implementation and data analysis – with the objective of minimizing bias and supporting an accurate estimate of precision, in order to make the most efficient use of sampling resources.

4.2 RESPONSE AND COMPLETION RATES

Among the most important rates is the so-called "response rate". When data are collected through a nationwide screening survey, the first step of data analysis is to identify the fraction of recreational fishers out of the total population who responded to the survey. The percentage of this active fraction is defined as the response rate (Arlinghaus, Tillner and Bork, 2014; Hyder *et al.*, 2017b). For self-administered surveys, like mail surveys, a response rate can be calculated by dividing the number of fishers who took part in the survey by the total number of fishers contacted. The rate can then be converted to a percentage, by multiplying it by 100. For example, when 200 persons answer a telephone survey out of a sample of 1 000 individuals, the response rate is 0.2 (i.e. 20 percent). The response rate can likely be increased by sending out multiple reminders, especially if units are surveyed through self-administered questionnaires. In this case, it is important to record the rates for each wave of reminders, to obtain a more nuanced overview of the survey effectiveness. For example, a survey could have a 0.8 response rate in the first wave, a 0.6 rate in the second wave (following the first reminder), a 0.3 rate in the third wave (following the second reminder), and so on. Response rates generally decrease over time, wave after wave, and reminders might draw on a considerable proportion of the budget. It is highly recommended to account for reminders when planning the financial resources for a survey.

When the response rate is below one, a certain amount of non-response has occurred. Non-response can be easily imagined, in self-administered questionnaires, as fishers who received a questionnaire and never sent it back. Non-response can represent a severe bias affecting estimates. Accounting for non-response is complex and can be achieved through one of four available approaches (Fox, Negrete-Yankelevich and Sosa, eds., 2015):

- Resampling: it addresses non-response by replacing non-respondents with a corresponding number of randomly re-sampled units. In stratified random sampling, replacements are taken from the same strata as the missing observations.
- Data imputation: it is based on model fitting and "fills" missing observations with predicted data from a model, but only when observations are missing completely at random, which is rarely the case in practice.
- Calibration: it incorporates information from auxiliary variables associated with non-response into estimators.
- Weighting: it assigns varying importance to collected observations on the basis of the proportion of non-respondents in the sample. Weighting is particularly common in survey studies (Vaske, 2008) and merits a short explanation. For example, a self-administered mail survey of 1 000 households, asking about the presence of recreational fishers in the household and collecting data about seasonal catch, could have a response rate of only 30 percent and find that 80 percent of households contain at least one recreational fisher. In this

case, a non-response check should be carried out by knocking at the door of 90 percent of non-respondents: in this non-response check, only 40 percent of households host recreationists. This finding suggests that the likelihood of answering the questionnaire was linked to the presence of recreational fishers in the household, as they were interested in the survey and motivated to respond. For example, a previous census revealed that only 50 percent of households contain recreational fishers. So, the sample probably includes too many households containing recreationists. Observations might therefore be weighted on the basis of pre-existing information on the statistical population. Weights can be expressed as:

weight = population percentage / sample percentage

In this case, the catch from households containing fishers would be weighted by a factor of 0.63 (0.5 / 0.8 = 0.63), while the catch from households which do not contain fishers would be weighted by a factor of 2.5 (0.5 / 0.2 = 2.5). The potential of weighting the data to adjust for non-response makes clear the importance of non-response checks, to appreciate differences between respondents and non-respondents. It is important that strata that are represented and under-represented are identified carefully, just as when weighting observations: weighting for strata that are not relevant will further bias findings. Moreover, researchers are encouraged to pay attention to the quality and the sample size of non-response checks.

Another fundamental rate is the completion rate. In most quantitative surveys, respondents answer structured questionnaires, each containing a fixed number of questions. The completion rate represents the proportion of respondents who answered each question and can also be calculated as a geometric mean for all the questions in the survey. Low completion rates usually indicate that a questionnaire is too cognitively demanding for respondents, that perceived privacy protection is low or that the reporting burden is too high on the fishers. Piloting might provide researchers with valuable insights, which can contribute to increasing completion rates. The completion rate should be calculated for each question as the fraction of the total number of questionnaires administered in which the question was answered. In addition, multiple completion rates can be averaged by calculating their geometric mean, which summarizes the overall extent to which questionnaires were completed.

For example, a questionnaire could be designed to measure three common forms of non-compliance affecting recreational fisheries, each of a different sensitivity level and with different potential sanctions: throwing away leftover fishing lines into the sea (low sanctions), catching undersized fish (medium sanctions) and fishing within a commercial harbour, which is often forbidden for safety reasons but is also quite common (high sanctions). In the case of this example, from over 1 000 questionnaires collected, not surprisingly, it is discovered that 896 respondents answered the first question, 451 answered the second question and only 86 respondents answered the third question. Completion rates for the three questions are, respectively, 0.89, 0.45 and 0.09.

$$Geometric\ mean = \sqrt[n]{X_1 * X_2 * \ldots * X_n}$$

In this case, the average completion rate is 0.32. Of course, completion rates are usually equal to 1.0 when surveys do not include self-reported information but instead simply measure certain traits of the observational units. In a field survey where technicians count fishing boats, there is no such thing as a response rate. Response rate is a common issue in self-administered surveys, like mail, online or telephone surveys.

4.3 MEASURING CENTRAL TENDENCY AND DATA DISPERSION WITHIN A SAMPLE

Once data have been collected, it is fundamental to characterize the sample in terms of its centrality measures and in terms of its variability.

Centrality measures provide values around which observations are organized. The most well-known measure is the arithmetic mean, defined as the sum of all measurements divided by the number of observations in the data set:

$$\overline{x_a} = \frac{1}{n} \cdot \sum_{i=1}^{n} x_i$$

The arithmetic mean can also be calculated for a quantitative character x, divided into K classes, as:

$$\bar{x_a} = \frac{1}{n} \cdot \sum_{j=1}^{K} c_j \cdot n_j$$

where K is the number of classes in the frequency distribution, c_j is the central value of each class and n is the absolute frequency of the character in the class. This procedure correctly estimates the mean if each class's central value corresponds to the mean of that class's values. This situation occurs when the character is equally distributed among classes.

In case it is desirable to assign different weights to the various observations, it is possible to compute the weighted arithmetic mean:

In this case, x_i represents values of the character within each class and p_i the weights to be assigned to each class. For example, three groups of fishers that might buy fishing licenses to go fishing around a protected area are surveyed: exclusive recreational shore anglers (n = 1 200), exclusive recreational spearfishers (n = 500) and exclusive boat anglers (n = 100). Each of these three groups pays a different fee for a seasonal fishing license: EUR 20, EUR 50 and EUR 100 respectively. If the goal is to estimate average expenditures, the different sizes of the various classes must be taken into account: (EUR 20 × 1 200 + EUR 50 × 500 + EUR 100 × 100) / (1 200 + 500 + 100) = EUR 32.7.

Two alternative measures of central tendency are:

- the mode, the value of the distribution which appears with the highest frequency; and
- the median, the middle value that splits the distribution of the measurements into two equal halves.

It is worth noticing that the median and the mode are the only measures of central tendency that can be used for ordered variables, where values are ranked relative to each other but not measured absolutely.

For a series of quantitative measures, with an uneven number of elements, the median can be calculated as (n + 1) / 2, where n is the number of observations. On the other hand, the median for a series with an even number of elements can be calculated as the semi-sum of the two central units, n/2 and (n + 1) / 2. The median is far more robust than the arithmetic mean against extreme values. If the sample of recreational fishers is highly heterogeneous, with few respondents boasting extremely high/low catch, using the median will provide a more accurate measure of the data centrality, compared to the arithmetic mean.

$$\bar{x_a} = \frac{\sum_{i=1}^{n} x_i \cdot p_i}{\sum_{i=1}^{n} p_i}$$

Variability indexes, on the other hand, represent the tendency of observational units to take different values of the same measure. Typically, variability indexes have two characteristics:

- their minimum value occurs when all observations have the same value of a certain measure; and
- they increase with higher diversity of observations in the sample.

The most common indexes are based on differences between values for observational units and their respective arithmetic means. The variance, for example, can be expressed as the average squared difference between units and the mean:

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

The variance is always positive, and it can be converted to the original scale, by a square root. This procedure generates another measure of variability: the standard deviation. As it is obtained through a square root, the standard deviation can be both positive and negative: if a sample of seasonal fish catch has a standard deviation of 40 kg, this means that measured fish catch are distributed within 40 kg above or below the arithmetic mean. Sharing the same measurement scale as the mean, standard deviation is usually preferred to the variance. It is possible to measure the variability of observations in terms of percentage, through the coefficient of variation (CV):

$$CV = \frac{Standard\ deviation}{Arithmetic\ mean} \cdot 100$$

The coefficient of variation represents the ratio of the standard deviation to the mean, and it is useful for comparing the degree of variation between two or more distributions, even if their means are drastically different from one another. For example, if a distribution has a coefficient of variation of 37.3 and another distribution has a coefficient of 61.3, the second distribution is more heterogeneous than the first one.

It is a common feature of recreational catch that a select few people catch most of the fish while others catch no fish at all, and consequently catch distributions are generally skewed highly positive. The sampling distribution of mean catch rate estimated from such a distribution becomes more normal with increasing sample size, and when the sample size is large enough, the standard error can be used to define the confidence interval around the estimated parameter. However, in many surveys, sample sizes are too small for normality to be assumed. In these situations, the bootstrapping technique provides an appropriate alternative to parametric methods (Efron and Tibshirani, 1993). The basic idea of bootstrapping is that inferences about a population from sample data can be modelled by resampling the sample data and performing inferences about a sample from resampled data. As the population is unknown, the true error in a sample statistic against its population value is unknown. In bootstrap-resamples, the population is in fact the sample, and this is known; hence the quality of inference of the "true" sample from resampled data is measurable. A comparison of bootstrapping methods for calculating confidence intervals on catch estimates from recreational fisheries surveys is explained in further detail in Hoyle and Cameron (2003).

4.4 ESTIMATORS: ESTIMATING POPULATION MEAN, TOTALS AND VARIANCE

For most applications, researchers and practitioners need to make minimal adjustments to proceed with the information obtained from their samples. Two routine operations that are performed in every form of survey research are the estimation of participation rates, which should always be reported, and the use of raising factors in order to shift from sample totals to population totals. Calculating these two

forms of information is straightforward and does not pose any particular problem to practitioners and researchers.

4.4.1 Simple estimations

Participation rate

In case the data source comes from a nationwide screening survey, the first step of data analysis is to identify the fraction of recreational fishers from the total population. The percentage of the active fraction is called participation rate (Arlinghaus, Tillner and Bork, 2014; Hyder *et al.*, 2017b). The participation rate is calculated by dividing the number of active recreational fishers by the total number of people constituting the population, then multiplying the resulting quotient by 100 to get the percentage.

Example: if by means of a telephone survey, 1 000 people are randomly contacted and it is obtained that 200 of them perform marine recreational fishing, then the participation rate is 20 percent.

Raising factor

The raising factor is the factor by which the numbers in the sample have to be multiplied to give the total numbers in the population sampled (FAO, 1966). This is a vital step in combining and analysing sample data.

Example: assume that n catch units (or fishing effort) are sampled randomly from N made by a segment/stratum (e.g. boat fishing) during a quarter of a year, and total numbers of fish (or fishing days) is denoted by y. The mean number (or mean weight) per trip is:

$$\bar{y} = \frac{\sum y}{n}$$

and the estimated total caught number (or weight) Y for the segment/stratum is:

$$Y = \bar{y}N$$

The raising factor is thus:

$$\frac{N}{n}$$

This approach could be used also for raising length frequency distribution of catches (ICCAT, 2016).

4.4.2 In-depth estimations

For most types of data collection procedures, such as non-probabilistic sampling, working with sample statistics is enough: they are easy to calculate and highly informative about the data at hand. However, for making rigorous inference from probabilistic sampling, considering information in the sample is not enough, for two reasons.

First, a practitioner or researcher needs to understand if, and how, collected information must be treated, accounting for those units that were not observed. While sample means may coincide with population means in simple random sampling, this does not hold for other forms of sampling designs.

Moreover, measuring the uncertainty associated with a certain estimate presents another daunting task: this calculation differs among different sampling designs.

A complete overview of statistical estimators is needed to address these two issues. The following section is more technically demanding than the previous one and briefly introduces how statistical estimators can be constructed. This text refers to a design-based paradigm, which is covered in detail in Hankin, Mohr and Newman (2019). Complete understanding of this paradigm is not necessary if using non-probabilistic sampling or if simply aiming to measure means and totals in simple random sampling.

This short section introduces statistical estimation of population parameters, following design-based inference. It serves three purposes: first, it shows how it

is possible to move from sample statistics to population-level estimates; second, it explains the properties characterizing good estimation; and finally, it explains why estimates always come with uncertainty. Until now, it has always been explained how to calculate population measures, such as the mean, without focusing on their accuracy. Well-designed random sampling, such as simple random sampling, enables one to do this: the mean of the sample corresponds to the population mean. However, this approach ignores the fact that when moving from samples to populations, estimates are also characterized by uncertainty. Ignoring uncertainty is dangerous and it is encouraged to better understand estimators, to better interpret information at hand.

An estimator is a statistic used to estimate a population parameter and incorporated in a formula that can be applied to sample data to generate a numerical estimate of a chosen population parameter. For example, estimating the average seasonal catch of a certain fish species by recreational fishers in a certain area is based on the arithmetic mean, which is then calculated over the sample:

$$\hat{Mean} = \sum_{i \in S} y_i / n$$

However, it is important to note that population mean is an estimated value. It is different from sample mean, which comes with no uncertainty, because its calculation is exclusively based on observed data only. Estimated population mean is uncertain, because its value depends on S, which is the overall sample space containing all the samples that can be extracted. Given a realized sample selection $S = s$, the population mean will be calculated as:

$$\hat{Mean} = \sum_{i \in s} y_i / n$$

Therefore, it will be calculated using the sample s and y values of its units. While y values are fixed, the population mean is a random variable, because several different samples could be extracted from the target population. If different recreational fishers are sampled and their average catches are calculated, these will differ slightly: estimators account for this variability. The probability distribution of the estimator, as a random variable, is the distribution generated by all the possible samples that could be extracted, the sampling distribution. The sampling distribution of the population parameter is essential to assessing the performance of a certain estimator in estimating a population parameter.

The sampling distribution of an estimator depends on, at least, three elements: the distribution of the population variable, the sampling design and the estimator itself. Just as the location and spread of the distribution of the observed values can be characterized, they can also be characterized for a sampling distribution, in terms of expectation and sampling variance. Expectation is a measure of the average value of the

$$Bias = Expected\ value\ of\ the\ estimator - Real\ value\ of\ the\ population\ parameter$$

estimator, and variance is inversely related to its precision: the higher the variance, the lower the precision of the estimate. A good estimator has a low, or nonexistent, bias:

Bias is the difference between the expected value of the estimator and the real value of the population parameter: if bias is zero, the estimator is unbiased, and its expected value is centered on the real value of the population parameter. This does not mean that the estimation will be precise, but rather that its distribution will always be sampled on the real value which it is attempting to estimate. For example, in a simple random sampling survey estimating average seasonal catch from recreational fishers, the estimator is unbiased if its distribution has an expected value centered on the real average catch of fish that all the recreational fishers in the study area attain. This may seem like an obvious concept, but it is not: only few statistical designs guarantee

unbiased estimates and an analytical, not approximated, estimation of the variance.

$$MSE = Variance + (Bias)^2$$

Another important metric is the mean squared error (MSE), which corresponds to:

The mean squared error is a sum of the variance and the squared value of the bias and it provides an overall measure of estimator precision. It is possible to calculate the standard error (SE) and the coefficient of variation (CV) of the estimator:

$$SE = \sqrt{Variance\ of\ the\ estimator}$$

$$CV = Standard\ error / Expected\ value$$

Finally, because of the central limit theorem, which states that the distribution of a sample mean converges to a Gaussian distribution when $n \to \infty$, regardless of the shape of the sampled distribution, it is possible to compute confidence intervals for the estimator. It is important to note that it is not always possible to obtain an exact expression of the variance of an estimator; in many situations, variance can only be approximated with the Delta method, based on Taylor series.

For simple random sampling without replacement, where n observations are extracted from a population of N units, estimating sample mean (μ, e.g. the average seasonal catch of a certain species among anglers), proportion (π, e.g. the proportion of recreational fishers among the inhabitants in a certain area, for y_i which is 1 or 0) and total (τ, e.g. the total number of recreationists which fish in a certain area) is straightforward through the use of mean per unit estimators (*mpu*):

From population mean $\mu = \frac{\sum_{i=1}^{N} y_i}{N}$ sample mean is estimated as: $\hat{\mu} = \frac{\sum_{i=1}^{N} y_i}{N}$

From population proportion $\pi = \frac{\sum_{i=1}^{N} y_i}{N}$ sample proportion is estimated as:

$$\hat{\pi}_{mpu} = \frac{\sum_{i \in S} y_i}{n}$$

From population total $\tau = \sum_{i=1}^{N} y_i = N\mu$ sample total is estimated as:

$$\hat{\tau}_{mpu} = N \cdot \sum_{i \in S} y_i / n = N\hat{\mu}_{mpu}$$

Similarly, it is possible to estimate the sampling variance for the averages (μ), proportions (π) and totals (τ). In this case, the parameter of interest will be denoted as θ:

$$V_{\hat{\mu}_{mpu}} = V_{\hat{\pi}_{mpu}} = \frac{(1-f) \cdot \hat{\sigma}^2_{mpu}}{n}$$

or

$$V_{\hat{\tau}_{mpu}} = N^2 \cdot \hat{V} \cdot (\mu_{mpu})$$

where f is the sampling fraction, the fraction of the N units that appear in the sample of size n.

$$\hat{\sigma}^2_{mpu} = \frac{\sum_{i \in S} \left(y_i - \hat{\mu}_{mpu}\right)^2}{n-1}$$

When using stratified random sampling, the situation is slightly more complex. Units are divided into L strata of size N_h, $h=1, 2, \ldots, L$, such that the sum of their observations equals N, the size of the population. Samples are selected independently from each of the L strata, usually through simple random sampling. With any particular stratum, it is possible to obtain unbiased estimates of means, proportions and totals. Moreover, by using properly weighted stratified estimators it is also possible to

obtain unbiased estimates of the overall parameters, across strata. The main advantage of stratified random sampling lies in its capacity to significantly reduce the variance of estimated parameters, compared to simple random sampling. However, if strata are not correctly identified, estimation will be biased. In the next few lines there will be references to stratified estimators of a population parameter, denoted by the lowercase "*st*" (e.g. μ_{st}) and combining information from multiple strata, and to stratum-specific estimators, denoted by the lowercase "*h*" (e.g. μ_h).

The overall population mean (μ) can be expressed as:

$$\mu = \sum_{h=1}^{L} W_h \cdot \mu_h$$

It corresponds to the weighted average of the stratum means, weighted on the basis of the stratum weights, the fraction of the total number of units which are contained in a certain stratum ($W_h = N_h/N$). Then the stratified estimator of the population mean is:

$$\hat{\mu}_{st} = \sum_{h=1}^{L} W_h \cdot \hat{\mu}_h$$

Individual stratum means are estimated using the mean-per-unit estimator, obtained from *Sh* which is a random set of sample units selected from stratum *h*.

$$\hat{\mu}_{st} = \sum_{j \in Sh} y_{hj}/n_h$$

For simple random sampling within strata, the expected value of the mean for each stratum (μ_h) corresponds to the mean of sampled variables in the stratum (μ):

$$E(\hat{\mu}_h) = \mu_h$$

Therefore, the expected value of the overall mean (μ_{st}) is also unbiased:

$$\hat{\mu}_{st} = \sum_{j \in Sh} y_{hj}/n_h$$

The stratified estimator of the variance of the mean is:

$$V(\hat{\mu}_{st}) = \sum_{h=1}^{L} W_h^2 \, V(\hat{\mu}_h)$$

And considering that the stratum-specific estimator of the variance of the mean is:

$$V(\hat{\mu}_h) = \left(\frac{N_h - n_h}{N_h}\right)\left(\frac{\sigma^2{}_h}{n_h}\right)$$

Then the stratified estimator of the variance of the mean is:

$$V(\hat{\mu}_{st}) = \sum_{h=1}^{L} W_h^2 \left(\frac{N_h - n_h}{N_h}\right)\left(\frac{\sigma^2{}_h}{n_h}\right) \text{ where } \hat{\sigma}^2{}_h = \sum_{j=1}^{N_h} \frac{(y_{hj} - \mu_h)^2}{N_h - 1}$$

For estimating population proportions (π), the same procedure is applied, assuming that y_j is always 1 or 0:

$$\hat{\pi}_{st} = \sum_{h=1}^{L} W_h \cdot \hat{\pi}_h$$

$$V(\hat{\pi}_{st}) = \sum_{h=1}^{L} W_h^2 \left(\frac{N_h - n_h}{N_h}\right)\left(\frac{\sigma^2{}_h}{n_h}\right) \text{ where } \hat{\sigma}^2{}_h = \left(\frac{N_h}{N_h - 1}\right)\pi_h(1 - \pi_h)$$

Finally, for totals (τ), the procedures are almost identical:

$$\hat{\tau}_{st} = N\hat{\mu}_{st} = \sum_{h=1}^{L} \hat{\tau}_h \text{ and also } E(\hat{\tau}_{st}) = E(N\hat{\mu}_{st}) = NE(\hat{\mu}_{st}) = N\mu = \tau$$

And the variance is:

$$V(\hat{\tau}_{st}) = \sum_{h=1}^{L} V(\hat{\tau}_h) \text{ then } V(\hat{\tau}_{st}) = \sum_{h=1}^{L} N_h^2 \left(\frac{N_h - n_h}{N_h}\right)\left(\frac{\sigma^2{}_h}{n_h}\right)$$

5. Stakeholder engagement

Recreational fisheries stakeholders include all parties with an interest in the development of sustainable recreational fisheries. The term "stakeholder" is most often employed to refer to the recreational fishers themselves, including the federations and associations of recreational fishers and charters (e.g. Federazione Italiana Pesca Sportiva e Attività Subacquee in Italy, Federación Española de Pesca y Casting in Spain, etc.). However, the term "stakeholder" can also include the public authorities at both the local and national levels (e.g. port authorities and ministries in charge of fisheries management, respectively), environmental associations, non-governmental organizations and research institutes. This list is by no means exhaustive and other organisms/stakeholders, such as other users of the aquatic resources and representatives from secondary industries (e.g. the gear and tourism industries) could be included (Gaudin and De Young, 2007). In this context, the relevant advisory councils in European Union countries (European Commission, 2013) that also work on recreational fishery issues (e.g. MEDAC for the Mediterranean) play an important role, since their opinion includes mediation efforts with recreational fishers and other fisheries sectors sharing and exploiting the same fishing resources.

Engaging stakeholders is vital for delivering a successful survey and, ultimately, for the sustainable management of recreational fisheries. When properly achieved, stakeholder engagement can help develop credibility and trust between researchers, decision-makers and fishers. This trust is essential to ensuring robust participation in studies, facilitating accurate data reporting, building a healthy platform for decision-making discussions and securing buy-in for eventual management measures. The overall objective of stakeholder engagement should be to close the gap between decision-making and practice.

Stakeholders can be engaged at all stages of the survey process. During the planning and development of the survey, the views of the recreational fishing community should be considered, as they know far more about recreational fisheries than most scientists, while scientists know much more about scientific methods than the recreational fishing community. By involving stakeholders in the planning of surveys, clear communication can be established regarding survey objectives and how surveys are designed to produce reliable results, helping to develop credibility and trust. During the data collection phase of the survey, stakeholder engagement is even more crucial. Stakeholder engagement could be promoted by means of panels for data collection, reference groups and committees, distribution of leaflets (via mail, websites or meetings), websites, journals/newspapers and other media (ICES, 2011). It is important to engage stakeholders as early as possible in data collection and monitoring initiatives in order to build trust through open discussions and transparent processes.

Working together leads to all parties' experiences and knowledge being incorporated in the design and implementation of recreational fisheries surveys. This involvement enhances the quality of the data collected, leading to greater utility for scientists and the recreational fishing community alike (ICES, 2012). Finally, efforts should be made to ensure survey results are reported back to stakeholders at the end of the survey. Communicating results empowers stakeholders to actively participate in management and decision-making processes. Recreational fisheries clubs, federations and associations can be particularly useful partners in this regard. In this way, the data collected is useful not only for public authorities, but also for angling organizations that may wish to develop their own policies and regulations (ICES, 2012).

There are many successful examples of such stakeholder engagement in the context of recreational fisheries. These include the Marine Recreational Information Program of the United States, which applied new communication methods in order to re-establish trust in their recreational fishery estimates. The programme achieved this success by providing fact sheets, videos and background information on a website (NOAA, 2021). In this case, a communications team was established to provide expert advice in order to effectively communicate with stakeholders. To improve messaging, videos were chosen as a new communication method. Similarly, the experience from co-management committees (e.g. the case of the Roses Bay in Spain's Catalonia region) has showed that when recreational fishers were included in fisheries co-management committees, providing them with a forum to share their perspectives and engage in decision-making, fishers were surprisingly willing to self-regulate.

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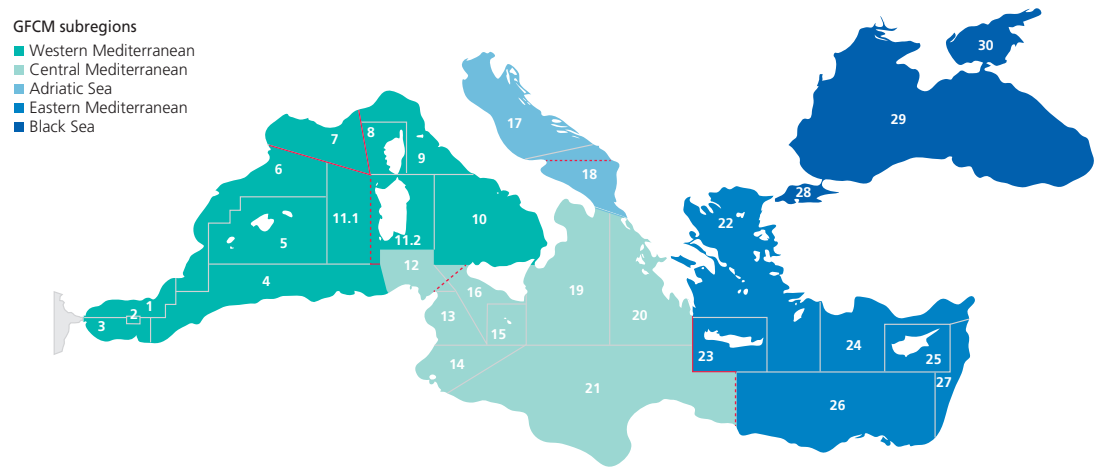
Annexes

ANNEX 1. GFCM AREA OF APPLICATION, SUBREGIONS AND GEOGRAPHICAL SUBAREAS



FAO statistical divisions — GFCM geographical subareas (GSAs)

Source: FAO, 2020.

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

ANNEX 2. CODES FOR RECREATIONAL FISHING TECHNIQUES

Gear name	Main recreational fishing gear and codes	
	Code	*Notes*
Hand implements	MHI	Wrenching gear, clamps, tongs, rakes, spears
Harpoons	HAR	Knife, harpoon
Diving	MDV	
Diving (speargun)	MDS*	
Diving (hand)	MDH*	
Cast nets	FCN	
Boat seines	SV	
Beach seines	SB	
Hooks and lines (not specified)	LX	
Handlines and hand-operated pole and lines	LHP	Rod, handline
Traps (not specified)	FIX	
Pots	FPO	
Gillnets and entangling nets (nei)	GEN	
Gillnets	GNS	
Trammel nets	GTR	
Longlines (not specified)	LL	
Lift nets (not specified)	LN	
Scoop nets	MSP	
Gear not known	NK	
Gear not specified	MIS	

Adapted from FAO, 2016.

ANNEX 3. TEMPLATE FOR SCREENING SURVEY AND ENROLLMENT OF FISHERS IN DATA COLLECTION PANEL

Template for screening survey and enrollment of fishers in data collection panel

Phone number _____ **City** _____

Number of members of the household _____

Age	Gender		Marine recreational fisher?		Number of fishing trips in the previous year			Panel		
					Boat	Shore	Underwater	Willingness to participate?		If YES. Contact info (phone/email)
	♂	♀	Yes	No				Yes	No	
	♂	♀	Yes	No				Yes	No	
	♂	♀	Yes	No				Yes	No	
	♂	♀	Yes	No				Yes	No	
	♂	♀	Yes	No				Yes	No	
	♂	♀	Yes	No				Yes	No	
	♂	♀	Yes	No				Yes	No	
	♂	♀	Yes	No				Yes	No	
	♂	♀	Yes	No				Yes	No	
	♂	♀	Yes	No				Yes	No	
	♂	♀	Yes	No				Yes	No	

ANNEX 4. TEMPLATES FOR MANDATORY FEE-FREE ONLINE REGISTRATION OF MARINE RECREATIONAL FISHERS

Template for online registration

STEP 1 – general information

Name _____

Surname _____

Date of birth _____

Place of birth _____

Nationality _____

Address _____

E-mail _____

Telephone No. _____

Gender ☐ ♂ ☐ ♀

Template for online registration

STEP 2 – avidity

ID No. _____

Fishing mode	Gear	How many fishing trips did you perform last year?				
Boat	Hand implements	1-5	6-10	11-25	26-50	>50
	Harpoons	1-5	6-10	11-25	26-50	>50
	Diving	1-5	6-10	11-25	26-50	>50
	Diving (speargun)	1-5	6-10	11-25	26-50	>50
	Diving (hand)	1-5	6-10	11-25	26-50	>50
	Cast nets	1-5	6-10	11-25	26-50	>50
	Boat seines	1-5	6-10	11-25	26-50	>50
	Hooks and lines (not specified)	1-5	6-10	11-25	26-50	>50
	Handlines and hand-operated pole and lines	1-5	6-10	11-25	26-50	>50
	Traps (not specified)	1-5	6-10	11-25	26-50	>50
	Pots	1-5	6-10	11-25	26-50	>50
	Gillnets and entangling nets (nei)	1-5	6-10	11-25	26-50	>50
	Gillnets	1-5	6-10	11-25	26-50	>50
	Trammel nets	1-5	6-10	11-25	26-50	>50
	Longlines (not specified)	1-5	6-10	11-25	26-50	>50
	Lift nets (not specified)	1-5	6-10	11-25	26-50	>50
	Scoop nets	1-5	6-10	11-25	26-50	>50
	Gear not known	1-5	6-10	11-25	26-50	>50
	Gear not specified	1-5	6-10	11-25	26-50	>50
Shore	Hand implements	1-5	6-10	11-25	26-50	>50
	Harpoons	1-5	6-10	11-25	26-50	>50
	Diving	1-5	6-10	11-25	26-50	>50
	Diving (speargun)	1-5	6-10	11-25	26-50	>50
	Diving (hand)	1-5	6-10	11-25	26-50	>50
	Cast nets	1-5	6-10	11-25	26-50	>50
	Beach seines	1-5	6-10	11-25	26-50	>50
	Hooks and lines (not specified)	1-5	6-10	11-25	26-50	>50
	Handlines and hand-operated pole and lines	1-5	6-10	11-25	26-50	>50
	Traps (not specified)	1-5	6-10	11-25	26-50	>50
	Pots	1-5	6-10	11-25	26-50	>50
	Gillnets and entangling nets (nei)	1-5	6-10	11-25	26-50	>50
	Gillnets	1-5	6-10	11-25	26-50	>50
	Trammel nets	1-5	6-10	11-25	26-50	>50
	Longlines (not specified)	1-5	6-10	11-25	26-50	>50
	Lift nets (not specified)	1-5	6-10	11-25	26-50	>50
	Scoop nets	1-5	6-10	11-25	26-50	>50
	Gear not known	1-5	6-10	11-25	26-50	>50
	Gear not specified	1-5	6-10	11-25	26-50	>50
Underwater	Hand implements	1-5	6-10	11-25	26-50	>50
	Harpoons	1-5	6-10	11-25	26-50	>50
	Diving	1-5	6-10	11-25	26-50	>50
	Diving (speargun)	1-5	6-10	11-25	26-50	>50
	Diving (hand)	1-5	6-10	11-25	26-50	>50
	Gear not known	1-5	6-10	11-25	26-50	>50
	Gear not specified	1-5	6-10	11-25	26-50	>50

Template for online registration

STEP 3 – certificate

Name _____

Surname _____

Nationality _____

Address _____

ID No. _____

Issuing date _____

Expiration date _____

ANNEX 5. TEMPLATE FOR LOGBOOK AND/OR RECALL SURVEY

5.a. General information for logbook and/or recall survey

Logbook and recall template – general information

Logbook ☐ Recall ☐ Reference month and year _____

Name and surname of panel participant _____

Information reported for:
Only the panel participant ☐

Multiple fishers (in case the panel participant's catch is pooled with other fishers on the same trip) ☐

If multiple fishers:

No. Fishers: ♂ ____ age ____
♀ ____ age ____

Fishing location		**Total fishing time**		
Geographical subarea (GSA)	_____		Start	End
City	_____	Date		
Distance from the coast (in nm)	_____	Hour		

Fishing mode* Boat ☐ Shore ☐ Underwater ☐

Gear	Gear code	Fishing time per gear (in hours)	Number of units used per gear
Hand implements	MHI		
Harpoons	HAR		
Diving	MDV		
Diving (speargun)	MDS		
Diving (hand)	MDH		
Cast nets	FCN		
Boat seines	SV		
Beach seines	SB		
Hooks and lines (not specified)	LX		
Handlines and hand-operated pole and lines	LHP		
Traps (not specified)	FIX		
Pots	FPO		
Gillnets and entangling nets (nei)	GEN		
Gillnets	GNS		
Trammel nets	GTR		
Longlines (not specified)	LL		
Lift nets (not specified)	LN		
Scoop nets	MSP		
Gear not known	NK		
Gear not specified	MIS		

Catches					
No.	Gear code	Species	No. Retained	Weight (kg) retained	No. released
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					

Comments:

** Complete one logbook/recall template per fishing mode*
*** Provide a description of the fishing gear in the comments section*

5.b. Catch information for logbook and/or recall survey

Logbook and recall template – retained species information

Logbook ☐ **Date** _____	**Recall** ☐ **Reference month and year** _____

No.	Gear code	Species (retained)	Length*	Weight (kg)	Sex**	Fishing mode***		
						Boat	Shore	Under water
1								
2								
3								
4								
5								
6								
7								
8								
9								
10								
11								
12								
13								
14								
15								
16								
17								
18								
19								
20								
21								
22								
23								
24								
25								

** Total length for fish (cm), mantle length for cephalopods (cm), carapace length for crustaceans (mm)*
*** If known (M: male; F: female; ND: not determined)*
**** Select only one fishing mode (boat, shore, underwater) per row*

5.c. Released species information for logbook and/or recall survey

Logbook and recall template – released species information

Logbook ☐ **Date** _____	**Recall** ☐ **Reference month and year** _____

No.	Gear code	Species (released)	Length*	Post-released status**				Fishing mode***		
				Alive	Almost dead	Dead	Not known	Boat	Shore	Under water
1										
2										
3										
4										
5										
6										
7										
8										
9										
10										
11										
12										
13										
14										
15										
16										
17										
18										
19										
20										
21										
22										
23										
24										
25										

** Total length for fish (cm), mantle length for cephalopods (cm), carapace length for crustaceans (mm)*
*** Mark the corresponding cell*
**** Select only one fishing mode (boat, shore, underwater) per row*

5.d. Expenditure information per fishing trip for logbook survey

Logbook template - expenditures

Expenditures per fishing trip

(Any expenditures since the last logbook date, such as purchases of new equipment, should be reported)

Start date of fishing trip: _____

Type of expenditure	Value	Currency
Rods and reels		
Nets (set nets, lift, scoop, etc.)		
Accessories (hooks, lines, etc.)		
Speargun		
Underwater accessories (fins, mask, etc.)		
Traps		
Artificial baits (jigs, lures, etc.)		
Natural baits (worms, sardines, etc.)		
Travel and accommodation		
License fee		
Boat rental		
Charter		
Fuel		
Taxes		
Electronics (GPS, radar, etc.)		
Boat maintenance		
Others _____		
Others _____		
Others _____		
Others _____		

Comments:

5.e. Expenditure information per month for recall survey

Recall template - expenditures

Expenditures per month

Reference month and year: _____

Type of expenditure	Value	Currency
Rods and reels		
Nets (set nets, lift, scoop, etc.)		
Accessories (hooks, lines, etc.)		
Speargun		
Underwater accessories (fins, mask, etc.)		
Traps		
Artificial baits (jigs, lures, etc.)		
Natural baits (worms, sardines, etc.)		
Travel and accommodation		
License fee		
Boat rental		
Charter		
Fuel		
Taxes		
Electronics (GPS, radar, etc.)		
Boat maintenance		
Others _____		
Others _____		
Others _____		
Others _____		

Comments:

ANNEX 6. TEMPLATE FOR ON-SITE SURVEYS

6.a. General information for on-site survey

On-site survey template – general information

Date of interview _____

Information by:
Single fisher ☐ Multiple fishers (in the case that catches are pooled) ☐

No. Fishers: ♂ ____ age ☐☐☐☐☐☐☐
♀ ____ age ☐☐☐☐☐☐☐

Fishing location

Geographical subarea (GSA) _____
City _____
Distance from the coast (in nm) _____
Latitude _____
Longitude _____

Total fishing time

	Start	End
Date		
Hour		

Gear	Gear code	Fishing mode*			Fishing time per gear (in hours)	Number of units used per gear
		Boat	Shore	Under-water		
Hand implements	MHI					
Harpoons	HAR					
Diving	MDV					
Diving (speargun)	MDS					
Diving (hand)	MDH					
Cast nets	FCN					
Boat seines	SV					
Beach seines	SB					
Hooks and lines (not specified)	LX					
Handlines and hand-operated pole and lines	LHP					
Traps (not specified)	FIX					
Pots	FPO					
Gillnets and entangling nets (nei)	GEN					
Gillnets	GNS					
Trammel nets	GTR					
Longlines (not specified)	LL					
Lift nets (not specified)	LN					
Scoop nets	MSP					
Gear not known	NK					
Gear not specified	MIS					

Catches

No.	Gear code	Species	No. retain	Weight (kg) retain	No. release
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					

Number of fishing trips performed by the interviewee during the previous year:

Boat	
Shore	
Underwater	

Willingness of interviewee to participate in a follow-up panel? If yes, name and (mobile) telephone number:

Comments:

** Complete one logbook/recall template per fishing mode*
*** Provide a description of the fishing gear in the comments section*

6.b. Catch information for on-site survey

On-site survey template – retained species information

Date _____

No.	Gear code	Species (retained)	Length*	Weight (kg)	Sex**	Fishing mode***		
						Boat	Shore	Under water
1								
2								
3								
4								
5								
6								
7								
8								
9								
10								
11								
12								
13								
14								
15								
16								
17								
18								
19								
20								
21								
22								
23								
24								
25								

** Total length for fish (cm), mantle length for cephalopods (cm), carapace length for crustaceans (mm)*
*** If known (M: male; F: female; ND: not determined)*
**** Select only one fishing mode (boat, shore, underwater) per row*

6.c. Released species information for on-site survey

On-site survey template – released species information

Date _____

No.	Gear code	Species (released)	Length*	Post-released status**				Fishing mode***		
				Alive	Almost dead	Dead	Not known	Boat	Shore	Under water
1										
2										
3										
4										
5										
6										
7										
8										
9										
10										
11										
12										
13										
14										
15										
16										
17										
18										
19										
20										
21										
22										
23										
24										
25										

** Total length for fish (cm), mantle length for cephalopods (cm), carapace length for crustaceans (mm)*
*** Mark the corresponding cell*
**** Select only one fishing mode (boat, shore, underwater) per row*

ANNEX 7. FISHING EFFORT MEASUREMENT

Gear name	Effort measurement by fishing gear			
	Code	*Unit of capacity*	*Unit of activity*	*Nominal effort*
Hand implements	MHI	Number	Fishing days	Number x fishing days
Harpoons	HAR	Number	Fishing days	Number x fishing days
Diving	MDV	Number	Fishing days	Number x fishing days
Diving (speargun)	MDS**	Number	Fishing days	Number x fishing days
Diving (hand)	MDH**	Number	Fishing days	Number x fishing days
Cast nets	FCN	Number	Fishing days	Number x fishing days
Beach seines	SB	Net length*	Fishing days	Net length x fishing days
Hooks and lines (not specified)	LX	Number of hooks	Fishing days	Number of hooks x fishing days
Handlines and hand-operated pole and lines	LHP	Number	Fishing days	Number x fishing days
Traps (not specified)	FIX	Number of traps	Fishing days	Number of traps x fishing days
Pots	FPO	Number of pots	Fishing days	Number of pots x fishing days
Gillnets and entangling nets (nei)	GEN	Net length*	Fishing days	Net length x fishing days
Gillnets	GNS	Net length*	Fishing days	Net length x fishing days
Trammel nets	GTR	Net length*	Fishing days	Net length x fishing days
Longlines (not specified)	LL	Number of hooks	Fishing days	Number of hooks x fishing days
Lift nets (not specified)	LN	Number	Fishing days	Number x fishing days
Scoop nets	MSP	Number	Fishing days	Number x fishing days

** Length of net expressed in 100-m units*
*** Adapted from FAO, 2016.*

Office of Communications – November 2020

Handbook for data collection on recreational fisheries in the Mediterranean and the Black Sea

Corrigendum

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Page	Location	Text in printed PDF	Text in corrected PDF
Cover page	Logos	The GFCM logo was added.	
Title page	Authors	Authors'affiliations were added.	
60	Annex 5.b	The table was updated.	
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Marine recreational fisheries are an integral part of Mediterranean and Black Sea coastal life and are commonly practiced throughout the region. Recreational fisheries also represent an important driver of coastal tourism, which constitutes one of the region's most important maritime sectors in terms of gross value added and employment. However, despite their ubiquity and potential socio-economic contribution, recreational fisheries are a data-poor sector and can vary widely from one country to another, thus impairing proper consideration of the recreational fisheries sector in policy-making and undermining efforts towards sustainable fisheries management at the regional level. The main goal of this handbook is therefore to provide a clear methodological framework to allow Mediterranean and Black Sea countries to implement suitably harmonized sampling and survey monitoring schemes for recreational fisheries. This handbook establishes a minimum set of necessary information for monitoring recreational fisheries, while, at the same time, allowing for flexibility to accommodate national specificities and data collection needs. It also provides guidance on the data analysis process as well as advice to successfully engage stakeholders in the data collection process.

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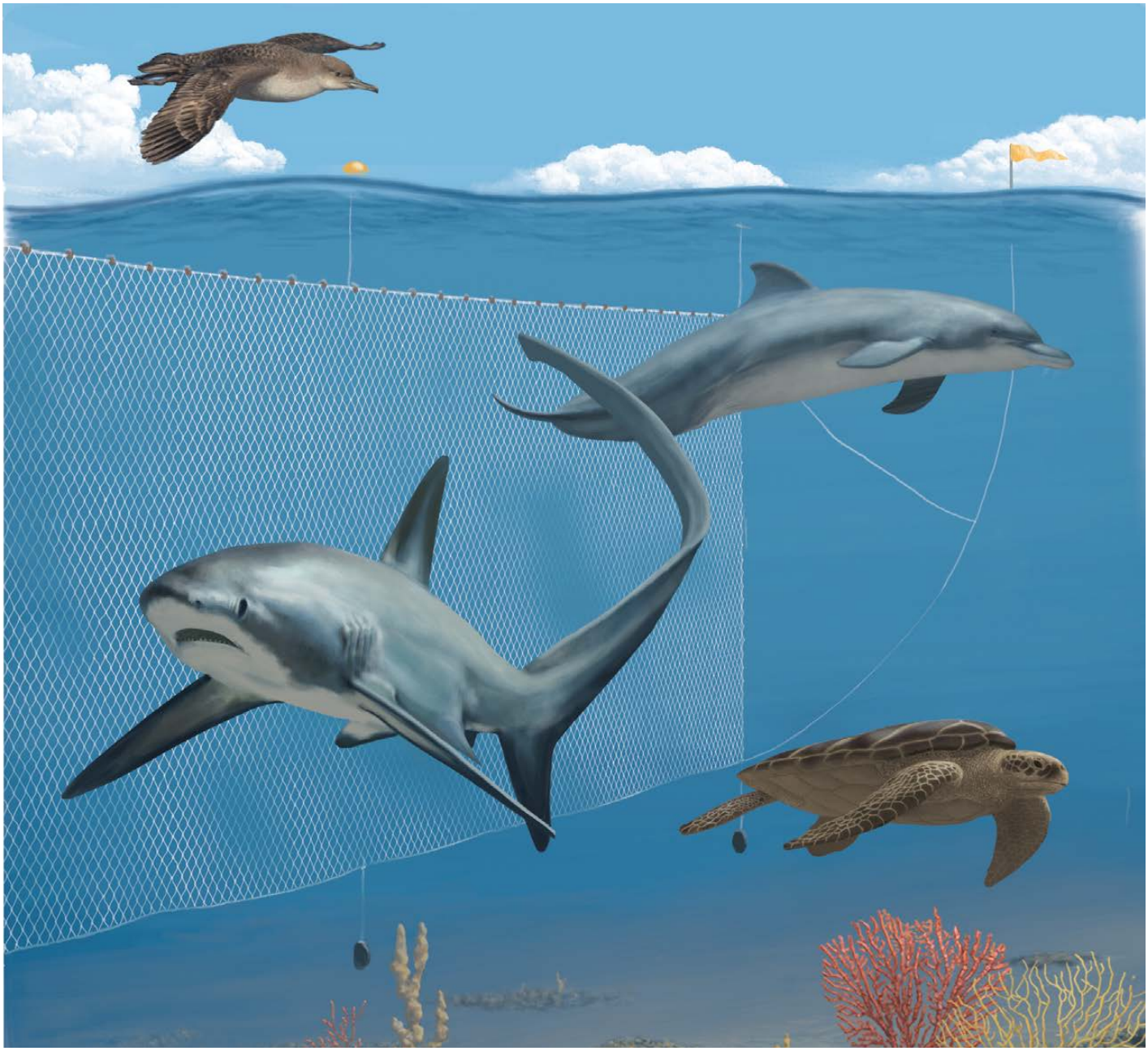

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GENERAL FISHERIES COMMISSION FOR THE MEDITERRANEAN

STUDIES AND REVIEWS 101

INCIDENTAL CATCH OF VULNERABLE SPECIES IN MEDITERRANEAN AND BLACK SEA FISHERIES
A REVIEW

edited by

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FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS
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Preparation of this document

This publication was prepared in the context of the joint project "Understanding Mediterranean multi-taxa bycatch of vulnerable species and testing mitigation – a collaborative approach" (the MedBycatch project), funded by the MAVA Foundation.

The different chapters were commissioned to international experts – namely Wolf Isbert, Verónica Cortés, Jacob González-Solís (Seabirds), Alessandro Lucchetti (Sea turtles), Fabrizio Serena (Elasmobranchs), Fulvio Garibaldi (Marine mammals), Giovanni Chimienti, Gianfranco D'Onghia and Francesco Mastrototaro (Macrobenthic invertebrates) – who compiled baseline information and performed the analyses, highlighting interactions with fishing activities and vulnerable species, major bias and knowledge gaps, and proposing approaches to address challenges in data collection.

The project partners – namely the General Fisheries Commission for the Mediterranean (GFCM), the Agreement on the Conservation of Cetaceans of the Black Sea, Mediterranean Sea and Contiguous Atlantic Area (ACCOBAMS), the Specially Protected Areas Regional Activity Centre (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) – arranged the peer-review process through their own pools of taxon-specific experts, alongside the members of the Scientific Committee of the MedBycatch project.

Abstract

This publication offers an overview of historical and current trends in the bycatch of five important groups of vulnerable species in the Mediterranean and the Black Sea: seabirds, sea turtles, elasmobranchs, marine mammals and macrobenthic invertebrates. Interactions between these groups and fisheries are known to occur in the context of nearly all commonly used types of fishing gear and can result in injury or death to the animals. Each chapter in this review focuses on one of the five groups of vulnerable species, describing and presenting data from surveys and studies conducted over recent decades. The chapters are further subdivided according to fishing gear and GFCM subregion (western, central and eastern Mediterranean, the Adriatic Sea and the Black Sea).

The incidental catch records included in this review are derived from a variety of approaches. Surveys completed by onboard observers, while demanding more time and resources, represent the most comprehensive and accurate of these methods. Less reliable data come from non-systematic, opportunistic data collection, such as questionnaire surveys answered by fishers. Though many geographic areas and vessel groups remain underrepresented in the available data, coverage has generally increased in recent years and insight continues to emerge on the key dynamics governing the bycatch of vulnerable species in the Mediterranean and Black Sea.

Seabird bycatch has mainly been recorded from the western Mediterranean and in longline fisheries. Bottom trawlers, on the other hand, have the greatest impact on sea turtles, especially in the northern Adriatic Sea, Tunisia, Egypt and Turkey. The vessel groups most implicated in elasmobranch bycatch vary by subregion, with longliners accounting for nearly 80 percent of incidental captures in the central Mediterranean, for example, while pelagic trawlers are responsible for an even greater majority of incidental captures in the neighbouring Adriatic Sea. Historically, marine mammals were often caught in large-mesh driftnets, but the incidental capture of these species has declined since bans on driftnets were put in place in the late 1990s. Unsurprisingly, macrobenthic invertebrates, including soft and hard corals, sponges, echinoderms and molluscs, are most affected by bottom trawls, as they are dragged across the seafloor these species inhabit.

Vulnerable species are not the only ones to come out the worse for wear from their interactions with fishing activities. Fishers also risk economic losses resulting from damage done to their nets by entrapped individuals or from the depredatory behaviour of species that feed on bait meant to lure target species. Raising awareness amongst fishers and relevant stakeholders of the threats currently facing vulnerable populations across the Mediterranean and the Black Sea, as well as their importance to local ecosystems, will help to improve relations between fisheries and these species and to ease transitions toward safer practices. New technologies that can mitigate the bycatch of vulnerable species must continue to be tested and implemented in fisheries and standardized procedures for data collection should be established to better understand the many factors influencing bycatch in the region.

Contents

Preparation of this document iii
Abstract iv
Contents v
Tables, figures and plates viii
Preface xiv
Acknowledgements xv
Abbreviations and acronyms

INTRODUCTION 1

METHODOLOGY 3

1. SEABIRDS 7
Executive summary 7
1.1 Description of the group 8
1.1.1 Seabirds and fisheries 8
1.1.2 Mediterranean and Black Sea seabird species 11
1.2 Historical records of interactions with fisheries 14
1.3 Analysis of recent data from literature (2008–2018) 15
1.3.1 Bottom trawlers 15
1.3.2 Small-scale fisheries 17
1.3.3 Purse seiners 20
1.3.4 Longliners 21
1.3.5 Pelagic trawlers 24
1.3.6 Tuna seiners 27
1.3.7 Dredgers 27
1.4 Outlook 27
1.4.1 Records on the distribution of seabird bycatch 27
1.4.2 Data collection: progress and challenges 33
1.5 Acknowledgements 36
1.6 Bibliography 36

2. SEA TURTLES 49
Executive summary 49
2.1 Description of the group 50
2.1.1 Loggerhead sea turtle 51
2.1.2 Green sea turtle 54
2.1.3 Leatherback sea turtle 55
2.2 Historical records of interactions with fisheries 56
2.3 Analysis of recent data from literature (2008–2019) 59
2.3.1 Bottom trawlers 60
2.3.2 Pelagic trawlers 67
2.3.3 Small-scale fisheries 69
2.3.4 Longliners 76
2.3.5 Purse seiners 86
2.3.6 Tuna seiners 88
2.3.7 Dredges 88
2.4 Outlook 89
2.5 Acknowledgements 93
2.6 Bibliography 94

3. ELASMOBRANCHS **113**
Executive summary **113**
3.1 Description of the group **114**
3.2 Historical records of interactions with fisheries **122**
3.2.1 Bottom trawlers 124
3.2.2 Small-scale fisheries 129
3.2.3 Purse seiners 131
3.2.4 Longliners 132
3.2.5 Pelagic trawlers 134
3.2.6 Tuna traps 135
3.2.7 Pelagic driftnets 136
3.3 Analysis of recent data from literature (2008–2019) **136**
3.3.1 Bottom trawlers 137
3.3.2 Small-scale fisheries 149
3.3.3 Purse seiners 158
3.3.4 Longliners 161
3.3.5 Pelagic trawlers 169
3.3.6 Tuna seiners 171
3.3.7 Dredgers 172
3.4 Outlook **173**
3.4.1 Results 173
3.4.2 Future scenarios 177
3.5 Acknowledgements **179**
3.6 Bibliography **179**

4. MARINE MAMMALS **201**
Executive summary **201**
4.1 Description of the group **202**
4.1.1 Pinnipeds 203
4.1.2 Cetaceans 204
4.2 Historical records of interactions with fisheries **207**
4.2.1 Pinnipeds 207
4.2.2 Cetaceans 210
4.3 Analysis of recent data from literature (2008–2019) **221**
4.3.1 Pinnipeds 221
4.3.2 Cetaceans 223
4.4 Depredation **236**
4.5 Outlook **238**
4.6 Acknowledgements **242**
4.7 Bibliography **242**

5. MACROBENTHIC INVERTEBRATES **261**
Executive summary **261**
5.1 Vulnerable marine ecosystems **262**
5.1.1 Cold-water coral reefs 273
5.1.2 Mesophotic stony coral communities 274
5.1.3 Coral gardens 274
5.1.4 Sea pen fields 277
5.1.5 Deep-sea sponge aggregations 277
5.1.6 Tube-dwelling anemone patches 279
5.1.7 Crinoid fields 279
5.1.8 Oyster reefs and other giant bivalves 279
5.1.9 Seep and vent communities 280
5.1.10 Other dense emergent fauna 280

5.2 Incidental catch of vulnerable marine ecosystem indicator taxa **282**
5.2.1 Bottom trawlers 282
5.2.2 Set longliners 287
5.2.3 Small-scale fisheries 289
5.3 Outlook **290**
5.3.1 Interactions between fisheries and VMEs 290
5.3.2 Future scenarios 293
5.4 Acknowledgements **294**
5.5 Bibliography **294**

GLOSSARY **316**

Tables, figures and plates

Tables

Chapter 1

Table 1. Incidental catch of seabirds in bottom trawlers (data from literature 2008–2019) 16

Table 2. Incidental catch of seabirds in small-scale fisheries (data from literature 2008–2019) 18

Table 3. Incidental catch of seabirds in purse seiners (data from literature 2008–2019) 21

Table 4. Incidental catch of seabirds in longlines (data from literature 2008–2019) 25

Chapter 2

Table 1. Incidental catch of loggerhead sea turtles (capture events per year) and mean mortality estimates for the most important types of fishing gear in the Mediterranean Sea, by GFCM subregion 61

Table 2. Incidental catch of sea turtles in bottom trawlers (data from literature 2008–2019) 64

Table 3. Incidental catch of sea turtles in pelagic trawlers (data from literature 2008–2019) 68

Table 4. Incidental catch of sea turtles in small-scale fisheries (data from literature 2008–2019) 73

Table 5. Incidental catch of sea turtles in drifting longlines (data from literature 2008–2019) 80

Table 6. Incidental catch of sea turtles in set longlines (data from literature 2008–2019) 84

Table 7. Incidental catch of sea turtles in purse seiners (data from literature 2008–2019) 87

Chapter 3

Table 1A. Species in Annex II of the SPA/BD Protocol covered by Recommendations GFCM/36/2012/3 and GFCM/42/2018/2 117

Table 1B. Species in Annex III of the SPA/BD Protocol covered by Recommendations GFCM/36/2012/3 and GFCM/42/2018/2 120

Table 2. Minimum landing size for piked dogfish (*Squalus acanthias*) in Black Sea countries 122

Table 3. Incidental catch of conservation-priority elasmobranch species in bottom trawlers (data from literature 2008–2019) 146

Table 4. Incidental catch of conservation-priority elasmobranch species in small-scale fisheries (data from literature 2008–2019) 154

Table 5. Incidental catch of conservation-priority elasmobranch species in purse seiners (data from literature 2008–2019) 160

Table 6. Incidental catch of conservation-priority elasmobranch species in longlines (data from literature 2008–2019) 166

Table 7. Incidental catch of conservation-priority elasmobranch species in pelagic trawlers (data from literature 2008–2019) 171

Table 8. Incidental catch of conservation-priority elasmobranch species in tuna seiners (data from literature 2008–2019) 172

Chapter 4

Table 1. Cetacean species in the Mediterranean and the Black Sea 206

Table 2. Incidental catch of cetaceans in pelagic driftnets 211

Table 3. Incidental catch of cetaceans in purse seiners 219

Table 4. Incidental catch of cetaceans in various types of fishing gear 220

Table 5. Incidental catch of Mediterranean monk seal in various types of fishing gear 221

Table 6. Incidental catch of cetaceans in bottom trawlers and midwater pair trawlers 224

Table 7. Incidental catch of cetaceans in small-scale fisheries 230

Table 8. Incidental catch and estimated mortality rates of cetaceans in drifting longlines 235

Table 9. Estimated number of vessels, fishing effort, stated catch rate and potential total incidental catch of cetaceans from the fishers' survey for the turbot gillnet fishery 240

Table 10. Indicative incidental catch of vulnerable species in other types of fishing gear in the Black Sea 240

Chapter 5 Table 1. Vulnerable marine ecosystem indicator features, habitats and taxa present in the Mediterranean Sea 266

Table 2. Examples of families, genera and species included in vulnerable marine ecosystem indicator taxa, and main references 267

Figures

Methodology Figure 1. GFCM area of application, subregions and geographical subareas 3

Chapter 1 Figure 1. Number of recorded events of seabird incidental catch by GFCM subregion 28

Figure 2. Number of recorded events of seabird incidental catch by country 28

Figure 3. Number of recorded events of seabird incidental catch by fishing gear 28

Chapter 3 Figure 1. Historical trends in chondrichthyan landings in the Mediterranean and the Black Sea (1970–2018) 123

Figure 2. Piked dogfish (*Squalus acanthias*) landings by Black Sea bottom trawlers (1967–2017) 145

Figure 3. Reported incidental catch of elasmobranchs by fishing vessel group in the Mediterranean and the Black Sea (data from literature 2008–2019) 173

Figure 4. Reported incidental catch of elasmobranchs by fishing vessel group by Mediterranean subregion (data from literature 2008–2019) 174

Figure 5. Reported elasmobranch conservation-priority species by Mediterranean subregion (data from literature 2008–2019) 175

Chapter 5 Figure 1. GFCM Fisheries restricted areas for the conservation of fishery resources and marine habitats 272

Plates

Chapter 1 Plate 1. Seabirds following a trawler 16

Plate 2. Specimens of Mediterranean shearwater caught by longlines 24

Chapter 2 Plate 1. Sea turtle incidentally caught by a bottom trawler 64

Plate 2. Sea turtle incidentally caught by a set net 73

Chapter 3 Plate 1. Mediterranean elasmobranch species listed in Annex II of the SPA/BD Protocol 118

Plate 2. Mediterranean elasmobranch species listed in Annex III of the SPA/BD Protocol 121

Plate 3. A great white shark with a longline hook in its mouth 162

Chapter 4 Plate 1. Mediterranean monk seal (*Monachus monachus*) 204

Plate 2. Black Sea dolphins
Black Sea common dolphin (*Delphinus delphis ponticus*), Black Sea bottlenose dolphin (*Tursiops truncatus ponticus*) and Black Sea harbour porpoise (*Phocoena phocoena relicta*) 205

Plate 3. Common dolphin (*Delphinus delphis*) 239

Plate 4. Black Sea bottlenose dolphin (*Tursiops truncatus ponticus*) 240

Chapter 5 Plate 1. Examples of corals representing vulnerable marine ecosystem indicator taxa 276

Plate 2. Examples of vulnerable marine ecosystem habitats 281

Preface

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 an important threat to the profitability and sustainability of fisheries, as well as to the conservation of the marine environment and its ecosystems. Understanding bycatch and adopting effective measures to reduce it are essential steps towards minimizing the incidental catch of vulnerable species and, more generally, conserving the marine ecosystems, as well as ensuring a sustainable fishery sector.

For the Mediterranean and the Black Sea, two semi-enclosed seas highly susceptible to human-induced stressors, the absolute numbers of the incidental catch of vulnerable species (seabirds, sea turtles, elasmobranchs, marine mammals and macrobenthic invertebrates) are not (yet) available to fishery managers. Without adequate monitoring and reliable information on incidental catch rates, the actual level and type of interactions between fishing activities and these vulnerable groups are difficult to estimate. However, in general, quantifying incidental catch rates is particularly complicated given that these captures are not systematically logged or reported, and observer programmes do not cover the entirety of a fleet, being often patchy in location and time. The result is that little is known of the scope of the problem, despite its importance.

This review aims to develop a baseline and reference for the incidental catch of vulnerable species in Mediterranean and Black Sea fisheries, with a view to supporting the identification of priorities in terms of bycatch management and environment conservation. It compiles, into one single document, the available data, including historical records on the incidental catch of vulnerable species, taken from existing literature, databases and other grey literature sources and collated in a standardized way, subdivided into GFCM vessel groups and subregions (namely, western, central and eastern Mediterranean, Adriatic Sea and Black Sea).

This work highlights that major knowledge gaps exist in most of the GFCM subregions and that available data are often flawed due to the fact that, until recently, no standardized protocol for data collection existed, thus affecting data reliability and preventing quantitative comparisons among studies, areas and temporal scales. Indeed, to date, data on the incidental catch of vulnerable species have been collected in an opportunistic way, gathered from studies covering only a small portion of the total fishing activity, resulting in important knowledge gaps for many types of fishing gear, countries and/or subregions. This analysis also brings to light the general difficulties in obtaining solid estimates on the incidental catch of vulnerable species, since the available information is subject to a number of shortcomings (lack of onboard observer programmes, problems with species identification, inadequate spatial and temporal coverage, etc.), which increase uncertainty.

In general, the incidental catch is not equal for seabirds, sea turtles, elasmobranchs, marine mammals and macrobenthic invertebrates, depending on the type of gear and area, among other factors. Seabirds are mainly bycaught in the western Mediterranean, mostly by small-scale longlines (both demersal and pelagic), in coastal zones close to important breeding sites, such as the Balearic Islands, considered a hotspot for breeding sites. For sea turtles, incidental catch estimates and associated mortality rates show great variability, not only between subregions and fishing gear, but also within the same area from one year to the next – mainly due to a lack of standardization in the frequency, temporal scale and type of data collected. As for elasmobranchs,

their life cycle, associated with their low resilience to fishing pressure, are among the main reasons for the concerning observed decline of elasmobranch populations in most of the world's seas, including the Mediterranean and the Black Sea. In the region, fishing activities only sporadically target elasmobranchs, and the majority of the available data point to individuals caught as bycatch by several types of gear, sometimes in greater numbers/biomass than the target species. Sharks and rays are then subsequently either discarded at sea or retained and landed to be sold, including, regrettably, protected species. As a result of bycatch, many Mediterranean shark and ray species are locally disappearing from areas in which their presence has been historically commonly recorded. Marine mammals are incidentally caught mainly by the pelagic driftnets targeting large pelagic commercial species, such as tunas, though the related ban in the early 2000s has had positive and tangible effects, considerably reducing the incidental catch of both dolphins and whales. However, in the Black Sea, set nets deployed to catch turbot, incidentally catch the three Black Sea endemic cetacean subspecies, including the harbour porpoise (the only harbour species present in the GFCM area of application). Over the last ten years, most likely linked to the observed decline in the incidental catch of cetaceans, the number of related studies has considerably reduced, offset by research on depredation issues, which aims to quantify the importance of this other type of interaction between marine mammals and fisheries by assessing the extent of damage often caused to fishers and the related socio-economic impacts. Regarding macrobenthic invertebrates (which may form vulnerable marine ecosystems), bottom trawls represent the fishing practice with the highest impact although little is known about the bycatch of these species by set longlines and small-scale fisheries. This review confirms that, despite the scattered data available, the scale and dimension of the incidental catch of vulnerable species in the Mediterranean and the Black Sea is not negligible, especially for given species across some specific areas.

Monitoring incidental catch in fisheries as regularly as possible, through both direct observations and indirect methodologies, in line with standard protocols such as those developed by the GFCM, is essential in order to fuel management decisions and to possibly incorporate protection and/or mitigation measures in management plans and other binding instruments. Indeed, efficient monitoring and reporting of incidental catches at the regional level contributes to identifying sensitive areas, fishing gear, and seasons, as well as earmarking the level of vulnerability of the species against these factors, thus better enabling relevant stakeholders to take targeted action towards ensuring the sustainability of Mediterranean and Black Sea fisheries and preserving vulnerable populations, endemic species, as well as the ecosystems in which they live. In addition, the identification and testing of different types of mitigation measures, adapted according to the species, areas or gear (and, for the specific case of cetaceans, type of depredation), are key towards reducing interactions. Their suitability and effectiveness should be evaluated against baseline information and over time, and replicated as appropriate.

Available data can already be taken into account for conservation purposes, and the preliminary insights on the level of bycatch for some vulnerable species call for the application of precautionary approach principles. For example, the case of elasmobranchs requires specific attention, considering the current indications of the state of many shark and ray species (i.e. endangered or critically endangered), calling for an improvement and/or extension of existing management and conservation approaches (such as fishing bans in mating areas and the systematic release of live specimens), as well as the potential protection of additional species. In parallel, the launch of awareness campaigns among the fishing community should be envisaged in addition to the enforcement of monitoring, control and surveillance measures including against illegal fishing.

It is hoped that this baseline work can serve as further incentive to take bold action to reduce the incidental catch of vulnerable species and thus ensure more sustainable fisheries and healthier seas. A number of efforts are already being deployed to specifically address the issue of incidental catch –through ad hoc projects supporting data collection and bycatch mitigation and the adoption of decisions, based on existing evidence and/or the precautionary approach – but more needs to be done, in terms of data availability and reliability, to facilitate the implementation of conservation measures at the local, national, subregional and regional level.

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Abbreviations and acronyms

ACCOBAMS	Agreement on the Conservation of Cetaceans in the Black Sea, Mediterranean Sea and contiguous Atlantic area
AIS	automatic information system
BPUE	bycatch per unit effort
BRDs	bycatch reduction devices
CBD	Convention on Biological Diversity
CCL	curved carapace length
CPUE	catch per unit effort
CITES	Convention on International Trade in Endangered Species of Fauna and Flora
DCRF	Data Collection Reference Framework (GFCM)
DNA	deoxyribonucleic acid
FAD	fish aggregating device
FAO	Food and Agriculture Organization of the United Nations
GEN	gillnets and entangling nets, not specified
GFCM	General Fisheries Commission for the Mediterranean
GND	driftnet
GNS	set gillnet
GPS	global positioning system
GSA	geographical subarea (GFCM)
GTR	trammel net
IBAs	important bird areas
ICCAT	International Commission for the Conservation of Atlantic Tunas
ICES	International Council for the Exploration of the Sea
IEO	Spanish Institute of Oceanography
IUCN	International Union for Conservation of Nature
IUCN-MED	IUCN Centre for Mediterranean Cooperation
LL	longline
LLD	drifting longline
LLS	set longline
MAP	Mediterranean Action Plan
MEDASSET	Mediterranean Association to Save the Sea Turtles
MEDLEM	Mediterranean Large Elasmobranchs Monitoring
MEDITS	international bottom trawl survey in the Mediterranean
MCS	monitoring, control and surveillance
OTB	bottom otter trawl
PS	purse seine
PTM	midwater pair trawl
REM	remote electronic monitoring
ROV	remotely operated vehicle
SPA/BD Protocol	Barcelona Convention Protocol concerning Specially Protected Areas and Biological Diversity in the Mediterranean
SPA/RAC	Specially Protected Areas Regional Activity Centre
SSF	small-scale fisheries
TL	total length
TM	midwater trawl
UN Environment	United Nations Environment Programme
UNEP-MAP	UN Environment/Mediterranean Action Plan
VME	vulnerable marine ecosystem
VMS	vessel monitoring system

Introduction

Data collection on the incidental catch of vulnerable species (elasmobranchs, sea turtles, marine mammals, seabirds and macrobenthic invertebrates) in the Mediterranean and the Black Sea has traditionally been carried out using varying protocols at different geographic scales. The absence of a systematic reporting of the incidental catch of vulnerable species has always made data comparison at a regional level difficult, despite national and international obligations in this regard. In fact, observations and reports tend to lack standardization and continuity and important knowledge gaps exist. Furthermore, efficient mitigation techniques for the multi-taxa bycatch of vulnerable species, as well for different fishing operations and types of gear, are yet to be developed in the region.

The joint project, "Understanding Mediterranean multi-taxa bycatch of vulnerable species and testing mitigation: a collaborative approach" (the MedBycatch project) was established with the aim to support Mediterranean countries in developing a common standardized data collection methodology and in testing appropriate mitigation solutions to be potentially replicated at the regional level, with a view to providing elements for the formulation of national/regional strategies towards the reduction of the incidental catch of vulnerable species and the sustainability of fisheries.

Among the expected outputs of the project was the creation of a knowledge base and the production of baseline information on vulnerable marine species affected by fishing activities. This regional review, reporting all published information on the incidental catch of vulnerable species in the Mediterranean and the Black Sea, represents one of the outputs of the project.

The MedBycatch project is the fruit of 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 Centre (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, it capitalizes on the complementarities among the partners' fields of work and mandates with a view to promoting synergies as well as sharing resources and expertise.

The implementation of the MedBycatch project involves field observation programmes (on board, at landing sites), interviews and self-sampling operations, across different types of fishing gear (i.e. bottom trawls, gillnets and demersal longlines), as well as training, awareness raising, identification and testing of mitigation techniques. Although originally implemented in three Mediterranean countries (Morocco, Tunisia and Turkey), the project develops tools and builds knowledge applicable to the entire Mediterranean and Black Sea area.

The main project outputs include:
- standardized regional protocols for multi-taxa data collection, inclusive of methodological annexes for observations on board and at landing sites, as well as self-sampling and questionnaires;
- capacity-building and training activities, including for teams of national onboard observers and for fishers on self-sampling methodologies;

- data analysis on the impacts of various fleet segments on the incidental catch of vulnerable species and on the spatial and temporal distribution of incidental catch per select fleet segments;
- identification and quantitative assessment of fishing practices and fisheries leading to incidental catch (e.g. fishing areas, seasonality, vessel carrying capacity, market, etc.);
- awareness-raising initiatives on the impacts of the incidental catch of vulnerable species; and
- testing of mitigation measures, including the implementation and monitoring of possible methods and tools in select fisheries and countries.

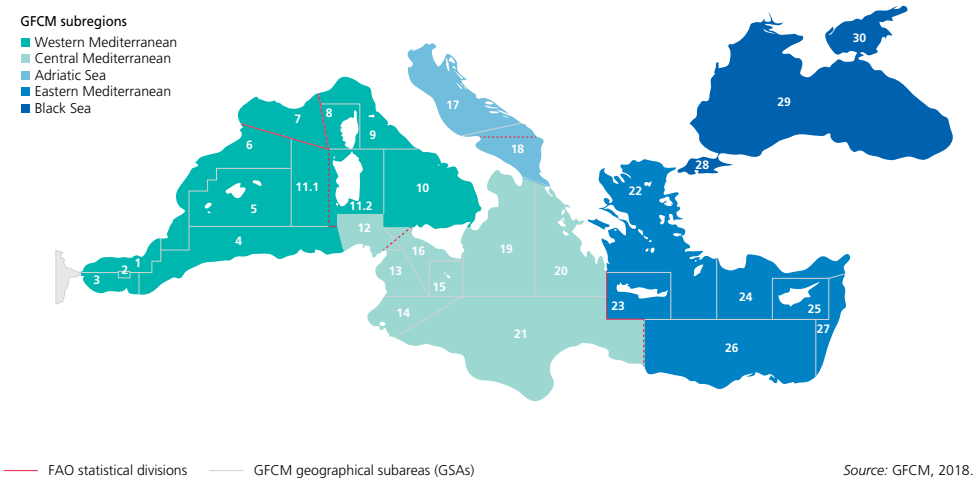
A steering committee oversees the proper and effective coordination and implementation of the project and a scientific committee provides technical feedback and advice. The scientific committee is composed of project partners, national focal points, as well as international taxon-specific experts and one fishery expert.

Methodology

This publication compiles recent data (from 2008) on the incidental catch of vulnerable species – seabirds, sea turtles, elasmobranchs, marine mammals and macrobenthic invertebrates – in the Mediterranean and the Black Sea (FAO major fishing area 37 and GFCM area of application) available in literature and scientific works, national and regional statistics, databases and other relevant sources (including grey literature and technical reports, master theses and personal communications), as well as data derived from opportunistic and irregular surveys (such as non-systematic observations on board and partly interview-based studies and self-reporting questionnaires). In each chapter, the information is grouped by GFCM subregion (Figure 1) and by vessel group (i.e. bottom trawlers, pelagic trawlers, small-scale vessels, purse seiners, tuna seiners, dredgers and longliners) as defined by the GFCM Data Collection Reference Framework. This approach enabled a comparative analysis of the different vessel groups across the western, central and eastern Mediterranean, the Adriatic Sea and the Black Sea.

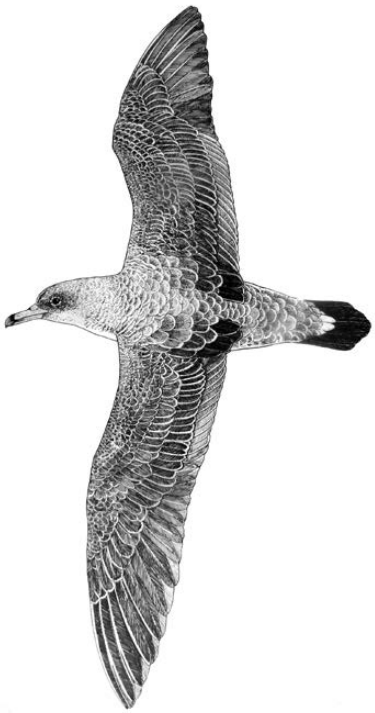
Within the chapters, as appropriate and relevant, the information is presented at the scale of smaller aggregation levels, i.e. by geographical subareas, commonly used by the GFCM as the minimal management unit. Each chapter provides a general description of the relevant group of vulnerable species, with a focus on the species inhabiting the Mediterranean and the Black Sea, followed by an overview of historical records (data published before 2008) of interactions of vulnerable species with fisheries, with tables summarizing, by vessel group, all the results from the literature cited. The chapter sections cover all vessel groups and subregions, even when no information is available (in which case "data not available" is indicated) so as to clearly show knowledge gaps. Finally, an outlook provides take-home messages and conclusions, highlighting the most impactful fishing gear for each group of vulnerable species, as well as the main challenges for a systematic collection of reliable data and future scenarios.

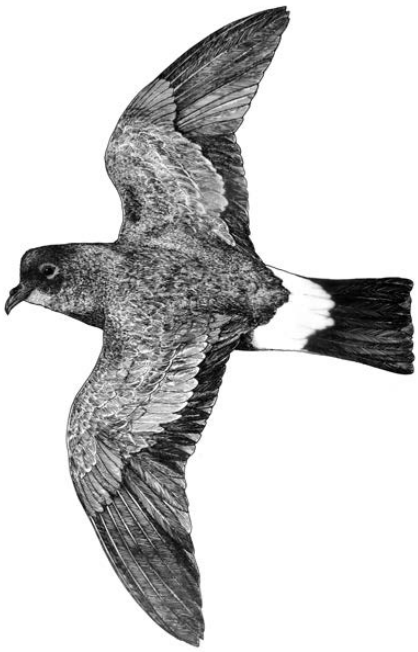
FIGURE 1
GFCM area of application, subregions and geographical subareas



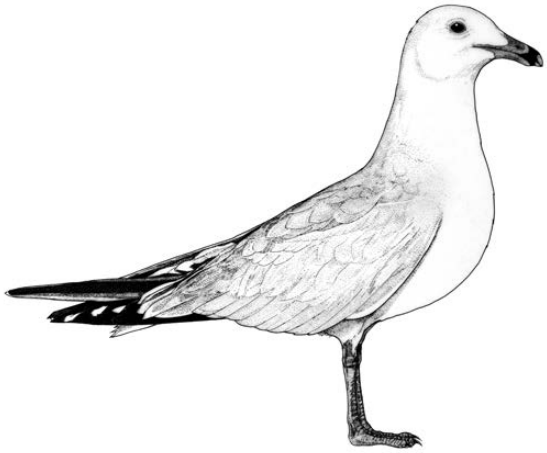
Source: GFCM, 2018.

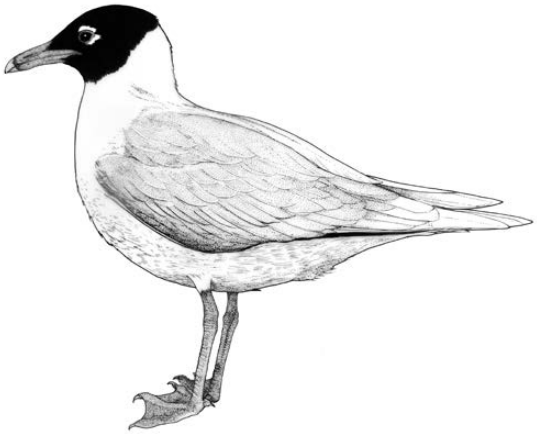
01. Northern Alboran Sea	07. Gulf of Lion	13. Gulf of Hammamet	19. Western Ionian Sea	25. Cyprus
02. Alboran island	08. Corsica	14. Gulf of Gabès	20. Eastern Ionian Sea	26. South Levant
03. Southern Alboran Sea	09. Ligurian Sea and northern Tyrrhenian Sea	15. Malta	21. Southern Ionian Sea	27. Eastern 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





SEABIRDS





Scopoli's shearwaters (*Calonectris diomedea*) flying close to the sea surface

1. Seabirds

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Executive summary

The effects of fisheries on seabirds can be manifold: (1) overexploitation by fisheries can decrease the availability of some prey for seabirds; (2) abundant fishery discards provide a very predictable food resource for scavenging seabirds that would otherwise be unattainable; and (3) seabirds can get caught in some types of fishing gear and possibly drown while trying to snatch at bait on longlines or they can collide with warp cables during shooting and hauling (trawls) or become entangled in floating or set nets. This review focuses on the latter aspect. The incidental catch records of seabirds presented here are derived from a variety of different approaches, including monitoring programmes with onboard observers, non-systematic, opportunistic data collection, such as questionnaire surveys answered by fishers, tagging/ringing recovery programmes, personal comments from scientists, self-reporting by fishers, beach surveys or recoveries from rescue

centres. Overall, the data available on seabird bycatch in Mediterranean and Black Sea fisheries are scarce and unequally distributed, with data mainly gathered in the western Mediterranean. No records could be found for the Black Sea or from North African Mediterranean countries. About 68 percent of records originated from the western Mediterranean Sea, with only limited data available from the other GFCM subregions: eastern Mediterranean (16.7 percent), central Mediterranean (9.7 percent) and Adriatic Sea (6.5 percent). Moreover, the records from the western Mediterranean came mainly from two countries: Italy (6.9 percent), and especially Spain (63.3 percent), where the only known study involving regular data collection of seabird bycatch over a long time period (2000–to date) is conducted. Considering the overall impact of different vessel groups/fishing gear, no records of seabird bycatch were found for pelagic trawls (midwater pair trawls), tuna seiners or dredgers. In contrast, about 50 percent of the available literature and records in the Mediterranean on seabird bycatch refer to longline fisheries, followed by set nets (16.7 percent) and bottom trawls (14 percent). This dynamic is consistent with data available from other regions of the world, indicating that research effort is focused primarily on the impact of longlines and set nets. No direct link could be found between the overall fishing capacity of single countries or of GFCM subregions and their seabird bycatch. Small-scale fisheries are active close to the coasts, where breeding sites and rafting areas of several seabird species are located. Small-scale fisheries use relatively small boats, from 6 to 15 metres, so many of them measure below the length at which positioning systems are mandatory. Urgency should therefore be given to improving the methods for recording fishing effort and incidental catch, particularly in small-scale fisheries, and to understanding more precisely the factors that influence interactions between seabirds and fisheries. New technologies for tracking seabirds (global positioning system (GPS), radar detectors, portable cameras) and fishing vessels (vessel monitoring system (VMS) and automatic identification system (AIS), onboard cameras) can also provide crucial data in this regard. This knowledge is critical for developing and implementing appropriate incidental catch mitigation measures. For a seabird bycatch mitigation strategy to be effective in the long term, it should be, among other factors, practical, easy to implement and manage, safe, and cost-effective for the fishers, while also being in their interest to pursue. In particular, these considerations apply to small-scale fisheries, where proper mitigation measures can not only reduce seabird bycatch, but also help to avoid bait loss and interruptions of settings when seabirds are released, and can therefore have potential economic benefits. Finally, the achievement of these objectives can only be guaranteed through the assistance of fishers, scientists, conservationists and policy makers.

1.1 Description of the group

1.1.1 Seabirds and fisheries

Seabirds are long-lived species with late maturity and low fecundity, and therefore any impact on their adult survival rates could have severe negative consequences for the viability of their populations (Brothers, Cooper and Løkkeborg, 1999; Furness, 2003; FAO, 2016; BirdLife International, 2017a). As described above, the effects of fisheries on seabirds can be manifold:

- overexploitation by fisheries can decrease the availability of some prey for seabirds, which can result in lower survival and reproductive success in some seabird species (Crawford, 2004; Cury *et al.*, 2011; Grémillet *et al.*, 2018; Guillemette *et al.*, 2018);
- abundant fishery discards provide a very predictable food resource, in space and time, for scavenging seabirds, which would otherwise be unattainable (Furness, 2003; Arcos, Louzao and Oro, 2008), potentially creating a dependency in the birds; and

– seabirds can get caught in some types of fishing gear and possibly drown while trying to snatch at bait on longlines, or collide with warp cables during shooting and hauling (trawls), or become entangled in floating or set nets (gillnets and entangling nets; FAO, 2018a), from now on referred to as "set nets" (Anderson *et al.*, 2011; Bicknell *et al.*, 2013; Žydelis, Small and French, 2013).

Although these effects from fisheries have uneven impacts on seabirds, they are interrelated and interact in complex and unexpected ways, potentially jeopardizing seabird populations, especially at a local scale.

Several studies carried out in the northwestern Mediterranean have shown that fisheries discards, such as those from demersal trawlers and purse-seiners, can create a strong dependency in some seabird species (Oro and Ruiz, 1997; Arcos, Oro and Sol, 2001; Arcos and Oro, 2002a, 2002b). Discards have changed the diet, distribution and foraging behaviour (Oro *et al.*, 1997; Arcos, Oro and Sol, 2001; Navarro *et al.*, 2009; Cama *et al.*, 2013; Bécares *et al.*, 2015), as well as the demographic parameters, of some Mediterranean seabirds (Louzao *et al.*, 2006; Genovart *et al.*, 2016), particularly large gulls and shearwaters. For instance, it is estimated that the availability of discards influences the breeding performance of the Balearic shearwater (*Puffinus mauretanicus*) and that discards can represent up to 40 percent of its diet during the breeding season (Arcos and Oro, 2002a; Louzao *et al.*, 2006). The predictability and abundance of trawling discards are the main factors in the population increase in yellow-legged gulls (*Larus michahellis*) in the western Mediterranean; a strong population increase of a generalist species, such as the yellow-legged gull can have associated negative effects on other smaller seabird species in the same area (i.e. predate on them or their eggs and chicks) and can alter local ecosystem structure and functioning (Louzao *et al.*, 2006; Real *et al.*, 2017).

Seabirds' potential dependency on discards may also have negative long-term effects as the induced changes in the foraging strategies of several species may increase the risk of incidental catch in fishing gear (Furness, 2003; Anderson *et al.*, 2011; Bicknell *et al.*, 2013), greater intake of pollutants (Arcos *et al.*, 2002) and low-quality food (Grémillet *et al.*, 2008). For instance, in the western Mediterranean, Scopoli's shearwaters (*Calonectris diomedea*) were observed to adapt to the fishing schedules of different fleets and to their relative abundance (Bartumeus *et al.*, 2010). On days without trawling discards, birds seek alternative resources and show stronger presence around longliners, increasing their risk of bycatch on hooks (Laneri *et al.*, 2010; Báez *et al.*, 2014; Soriano-Redondo *et al.*, 2016). In the long term, the elimination of the discard practice could reduce the presence of seabirds around fishing vessels, which may also reduce the risk of fishery-induced mortality (Bicknell *et al.*, 2013). Direct interactions between seabirds and fishing gear can result in incidental lethal captures, while the fate of seabirds released alive is often unknown (Pott and Wiedenfeld, 2017). However, landing fish discards may cause seabirds to seek food elsewhere and therefore considerably increase the bycatch of seabirds in bait fisheries, such as longliners, or increase predation rates on other seabirds (Votier *et al.*, 2004). These potential knock-on effects highlight the need to urgently implement mitigation measures and monitor seabird communities, especially in European countries where the European Union landing obligation[1] (discard ban) is applied (Soriano-Redondo *et al.*, 2016).

1. Regulation (EU) No 1380/2013 of the European Parliament and of the Council of 11 December 2013 on the Common Fisheries Policy, amending Council Regulations (EC) No 1954/2003 and (EC) No 1224/2009 and repealing Council Regulations (EC) No 2371/2002 and (EC) No 639/2004 and Council Decision 2004/585/EC. Official Journal of the European 2013, L354, 22–61.

Presently, most of the information available on seabird bycatch is derived from geographical areas with highly industrialized fishery activities, such as longline fleets in the Southern Hemisphere and the North Pacific (Anderson *et al.*, 2011; Pott and Wiedenfeld, 2017), although a growing number of studies are emerging from the North Atlantic and the Baltic Sea. Seabird interactions with fishing gear have been recorded in longlines (for example, Gales, Brothers and Reid, 1998; Weimerskirch, Capdeville and Duhamel, 2000; Fangel *et al.*, 2015; Oliveira *et al.*, 2015), trawlers (for example, Sullivan, Reid and Bugoni, 2006; Croxall, 2008; Watkins, Petersen and Ryan, 2008), set nets (for example, Žydelis *et al.,* 2009; Oliveira *et al.*, 2015; Hanamseth *et al.*, 2018), purse seines (for example, Schlatter *et al.*, 2009; Suazo *et al.*, 2014; Oliveira *et al.*, 2015) and traps (Shester and Micheli, 2011; Oliveira *et al.*, 2015).

Global estimates of annual seabird mortality have been calculated for specific vessel groups, types of fishing gear and geographical areas. For instance, Anderson *et al.* (2011) estimated that bycatch mortality from longliners ranged from 160 000 to 320 000 seabirds per year. BirdLife International (2017a) judged that trawl and longline fisheries together could be responsible for the incidental catch of about 300 000 seabirds annually at a global level. Additionally, Žydelis, Small and French (2013) estimated that set nets may catch about 400 000 seabirds per year. Unfortunately, no global seabird bycatch estimates exist for other types of fishing gear. Indeed, the quantification and extent of seabird bycatch are difficult to determine, in part due to substantial spatial and temporal variations of these stochastic events, as well as the diversity of fishing strategies and gear types around the world.

In comparison to other geographical areas of the Northern Hemisphere, the Mediterranean and the Black Sea are characterized by a dearth of information on seabird bycatch (Cooper *et al.*, 2003; Anderson *et al.*, 2011; Žydelis, Small and French, 2013). This shortcoming is mainly due to the fishing fleet composition of the Mediterranean and the Black Sea, which is dominated by small-scale fisheries (about 80 percent of total fishing vessels) and to the lack of systematic onboard observer programmes on most of the fleets (Anderson *et al.*, 2011; Fric *et al.*, 2012; Tarzia *et al.*, 2017b; FAO, 2018b; Genovart *et al.*, 2018).

Although the number of studies and reports has increased slightly over the last decade, information is lacking for several types of fishing gear and their potential impacts within several GFCM subregions and geographical subareas. The main reason behind this knowledge gap is the under-reporting of small-scale fisheries, which are often difficult to monitor (BirdLife International, 2009; Anderson *et al.*, 2011; Pott and Wiedenfeld, 2017). For the Mediterranean and the Black Sea, risk assessments by the Working Group on Bycatch of Protected Species of the International Council for the Exploration of the Sea (ICES, 2013b) for set nets and longlines (both demersal and pelagic) suggested high (longlines) to very high (nets) risks for diving seabirds (i.e. foraging and pursuing prey underwater for extended periods down to depths of 20 m), and medium (nets) to very high (longlines) risks for surface seabirds (i.e. foraging mainly at the surface within the first metre of the water column (Butler, 2000). Risks for seabirds posed by pelagic and bottom trawlers were considered low to medium, especially for surface seabirds. Purse seines, dredgers and traps were judged to present a low risk of bycatch for all seabird taxa.

The 2016 report on *The State of Mediterranean and Black Sea Fisheries* (FAO, 2016) estimated an annual incidental catch rate of at least 5 100 seabirds for the Mediterranean and the Black Sea, mainly composed of shearwaters and gulls (Belda and Sánchez, 2001; Cooper *et al.*, 2003; Valeiras and Camiñas, 2003). This number likely underestimates the true value due to the aforementioned lack of onboard observer programmes for most fisheries/gear types and fisheries probably pose an

even higher risk to Mediterranean seabird populations, given their comparatively low abundance in this basin.

Several authors have highlighted the need to fill knowledge gaps concerning the impact of fisheries in the Mediterranean and the Black Sea, where negative interactions with fishing activities are considered to be one of the reasons behind the decline of some seabird populations (Cooper *et al.*, 2003; Laneri *et al.*, 2010; Genovart *et al.*, 2016). Indeed, the published literature highlights that bycatch rates in some Mediterranean areas could have important consequences on seabird populations (Anderson *et al.*, 2011; Cortés and González-Solís, 2018).

A number of bycatch-susceptible seabird species in the Mediterranean are included in the "Threatened" categories of the International Union for Conservation of Nature (IUCN) Red List of Threatened Species and the Annex II of the Barcelona Convention Protocol concerning Specially Protected Areas and Biological Diversity in the Mediterranean (SPA/BD Protocol) (BirdLife International, 2009; Cortés, Arcos and González-Solís, 2017; UNEP-MAP RAC/SPA, 2018). For instance, Žydelis, Small and French (2013) indicated the high susceptibility of the Balearic (*Puffinus mauretanicus*) and the Yelkouan shearwater (*Puffinus yelkouan*) to set nets, while others highlighted the consistent incidental catch of both species, as well as Scopoli's shearwater (*Calonectris diomedea*), in pelagic and demersal longline fisheries of the western Mediterranean (García–Barcelona *et al.*, 2010; FAO, 2016; BirdLife International, 2017b; Cortés, Arcos and González-Solís, 2017). These species have relatively small populations (BirdLife International, 2009; UNEP-MAP RAC/SPA, 2013), and while bycatch is partly considered as the main driver of decline, as in the example of the Balearic shearwater (Genovart *et al.*, 2016), populations are negatively affected by other factors as well, including the decrease and degradation of available coastal habitat, introduced predators and various types of pollution.

1.1.2 Mediterranean and Black Sea seabird species

Seabird diversity and population size in the Mediterranean Sea are considered low in comparison to more eutrophic oceanic or upwelling regions (BirdLife International, 2009; Coll *et al.*, 2010; UNEP-MAP RAC/SPA, 2013). As such, Coll *et al.* (2010) listed fifteen Mediterranean species of breeding seabirds, ten of which belong to the gulls and terns (Charadriiformes), four to the shearwaters and storm petrels (Procellariiformes) and one shag species (Pelecaniformes). Three of these fifteen species are endemic: the Balearic and Yelkouan shearwaters and Audouin's gull (*Larus audouinii*), as well as two endemic subspecies, the European storm petrel (*Hydrobates pelagicus melitensis*) and the Mediterranean shag (*Phalacrocorax aristotelis desmarestii*). In addition to these, resident species of the Mediterranean seabird community are the yellow-legged gull (*Larus michahellis*), Mediterranean gull (*Larus melanocephalus*) and slender-billed gull (*Larus genei*). The terns are represented by the lesser-crested tern (*Thalassens bengalensis* (*emigrata*)), gull-billed tern (*Gelonchelidon nilotica*), sandwich tern (*Thalassens sandvicensis*), Caspian tern (*Hydroprogne caspia*), common tern (*Sterna hirundo*) and little tern (*Sternula albifrons*) (Coll *et al.*, 2010; UNEP-MAP RAC/SPA, 2013).

The Black Sea is of high importance for several seabird species, including the Mediterranean gull (*Larus melanocephalus*), 90 percent of whose world population is found in this area, the pygmy cormorant (*Microcarbo pygmaeus*) (75 percent of the world population), and the slender-billed gull (*Larus genei*) (65 percent of the world population) (Nankinov, 1996). Additionally, the Black Sea is also considered as an important congregation and foraging area for the Yelkouan shearwater outside the breeding season (Pérez-Ortega and Isfendiyaroglu, 2017).

All the above-mentioned species have been observed to interact with fishing gear, while the main breeding sites and distribution of the majority of these species are found within the Mediterranean and the Black Sea. However, available information on terns indicates that these birds are less susceptible to incidental catch events in fisheries compared to shearwaters, gulls and shags. Therefore, the focus of the following section is on shearwaters, gulls and shags.

Shearwaters and storm petrels (Procellariiformes)

Scopoli's shearwater (*Calonectris diomedea*) is classified as "Least Concern" on the IUCN Red List, but its population is considered to be decreasing (BirdLife International, 2018d), with an estimated global population ranging from 140 000 to 223 000 pairs. The species' main breeding colonies are concentrated in the western and central Mediterranean (the world's largest colony is the island of Zembra, Tunisia, followed by the island of Linosa, Italy), while the largest known colony in the eastern Mediterranean is in the Strofades archipelago (Ionian Sea, Greece) (FAO, 2016; BirdLife International, 2018d; A. Vulcano, personal communication, 2019).

The Balearic shearwater (*Puffinus mauretanicus*) breeds exclusively in the Balearic Islands (western Mediterranean, Spain) and is classified as "Critically Endangered" on the IUCN Red List due to rapid population declines (BirdLife International, 2018a). Owing to the alarming situation of this species, its Species Action Plan was updated to cover its complete distribution range in order to halt the negative population trend (Arcos, 2011). However, while in previous years, estimates of the Balearic shearwater ranged from 3 000 to 4 500 pairs (Arcos *et al.*, 2012), a more recent estimate based on counts at sea indicated an overall population of 25 000 birds (i.e around 5 000 breeding pairs) (Genovart *et al.*, 2016; Arcos *et al.*, 2017). Thus, the estimate of the breeding population size ranges between 3 000–7 000 pairs, though, in general, such an optimistic estimate should be considered with caution (BirdLife International, 2018a).

The Yelkouan shearwater (*Puffinus yelkouan*) is regarded as "Vulnerable" on the IUCN Red List, as it shows a decreasing population trend (BirdLife International, 2018b). Due to the alarming situation of the Yelkouan shearwater, an International Single Species Action Plan for the Conservation of the Yelkouan shearwater was adopted in May 2018, which covers the complete distribution range of *P. yelkouan*, in order to halt the negative population trend (Gaudard, 2018). Although Oppel *et al.* (2011) indicated that the magnitude and potential causes for the decline of the Yelkouan shearwater are unknown, a number of studies have demonstrated the susceptibility of shearwater species to incidental catch in fisheries (for example, Besson, 1973; Cortés, Arcos and González-Solís, 2017; Tarzia *et al.*, 2017b; Cortés, García-Barcelona and González-Solís, 2018). The species distribution covers the Mediterranean Basin and the Black Sea, with the main breeding colonies found in the western, central and eastern Mediterranean Sea, while small colonies are also found in the Black Sea. The latter area is additionally considered as an important congregation area during the non-breeding season (Oppel *et al.*, 2011; FAO, 2016; BirdLife International, 2018b; Pérez-Ortega and İsfendiyaroğlu, 2017). Bourgeois and Vidal (2008) estimate that the total population ranges between 11 400 and 54 500 breeding pairs, while Garcia Robles, Deceuinck and Micol (2016) place it at around 21 500 to 32 800 pairs. The difference between these values indicates that a strong degree of uncertainty exists; these censuses probably overestimate the actual population, which could consist of only a few thousand breeding pairs.

As the smallest seabird breeding in the region, the Mediterranean storm petrel (*Hydrobates pelagicus melitensis*) is included in Annex II of the SPA/BD protocol (UNEP-MAP RAC/SPA, 2018). In contrast to the European storm petrel (*H. pelagicus*), this endemic subspecies is still not assessed

by the IUCN Red List (BirdLife International, 2018), while it is estimated that the number of breeding pairs accounts for less than a tenth of the estimated total population, with 10 000 to 16 000 breeding pairs (Lago, Austad and Metzger, 2019). The authors indicated that this subspecies is restricted to a few rat-free islands in the Mediterranean and that half of all nesting pairs are concentrated in the central Mediterranean on the Maltese islet of Filfla (5 000–8 000 pairs) (Lago, Austad and Metzger, 2019).

Gulls (Charadriiformes)

Audouin's gull (*Larus audouinii*) is listed as "Least Concern" on the IUCN Red List with a stable population trend (BirdLife International, 2020). The population of *L. audouinii* mainly breeds in the western Mediterranean (90 percent), with the Ebro Delta acting as the core breeding area over the last two decades and hosting over 67 percent of the global population (Mañosa, Oro and Ruiz, 2004; BirdLife International, 2020), though in recent years large numbers of birds have moved to breed in adjacent areas. After being considered a highly threatened species in the 1970s, the high levels of protection afforded to Audouin´s gull at its breeding sites have resulted in a significant increase in the population (Mañosa, Oro and Ruiz, 2004; BirdLife International, 2020). Currently, the global population is estimated at 60 000 to 66 000 individuals (BirdLife International, 2020). Nevertheless, although in some areas of the western Mediterranean Sea, the population has recovered from low population levels, in the eastern part of the Mediterranean, populations seem to be declining. For example, data from Cyprus indicate a decline of over 70 percent in ten years with a current population there of less than 30 breeding pairs (R. Snape, personal communication, 2019).

The yellow-legged gull (*Larus michahellis*) is listed as "Least Concern" on the IUCN Red List, with an increasing population trend (BirdLife International, 2019b). The yellow-legged gull exhibits a broad distribution pattern, resident in all of southern Europe (which includes the Mediterranean), the Black and the Caspian Sea. The European population size is estimated at 409 000 to 534 000 pairs, and currently the yellow-legged gull is not included in Annex II of the SPA/BD protocol (BirdLife International, 2019b; UNEP-MAP RAC/SPA, 2018).

Shags (Pelecaniformes)

The European shag (*Phalacrocorax aristotelis*[2]) is assessed as "Least Concern" on the IUCN Red List, though it shows a decreasing population trend (BirdLife International, 2018c). Its distribution ranges from northern Europe to northern Africa along the Atlantic coast, and it is also present across the entire Mediterranean and Black Sea area, with nesting sites in Turkey and Italy. The current global population size of the European shag is assessed to lie between 230 000 and 240 000 individuals (BirdLife International, 2018c).

The Mediterranean Sea endemic subspecies, *Phalacrocorax aristotelis desmarestii* (syn. *Gulosus aristotelis desmarestii*), is not separately assessed on the IUCN Red List, and it is listed only on the National Red List of France and Spain as "Vulnerable" and included in Annex I of the Birds Directive (Madroño, González and Atienza, 2004; National Red List, 2008; European Commission, 2016b, 2016c). It is estimated that the population size of Mediterranean shag ranges between 2 700 and 10 000 breeding pairs across the whole Mediterranean Sea, with an unknown population trend over the long term (European Commission, 2016c; European Environment Agency, 2019).

2. Also known as *Gulosus aristotelis*.

The pygmy cormorant (*Microcarbo pygmaeus*) is assessed as "Least Concern" on the IUCN Red List with an increasing population trend (BirdLife International, 2019a). Its breeding grounds range from southeastern Europe to western Central Asia, on the coasts of the Black, Caspian and Aral seas, and it winters primarily in the coastal countries of the eastern Mediterranean and the Black Sea (Barati, Javan and Sehhatisabet, 2008; BirdLife International, 2019a). The population of the pygmy cormorant is estimated at between 45 000 and 180 000 individuals and is separated into two populations, one breeding in eastern Europe and Turkey (centred on the Black Sea), the other in western Asia (centred on the Caspian Sea) (Barati, Javan and Sehhatisabet, 2008; BirdLife International, 2019a).

1.2 Historical records of interactions with fisheries

Seabirds have long been interacting with fisheries as they use, and compete for, the same productive fishing areas and resources. The expansion and growth of fishing activities over the last century has led to stronger and more complex interactions (Tudela, 2004; Arcos, Louzao and Oro, 2008). However, the issue of seabird bycatch in the Mediterranean and the Black Sea passed unrecognized for decades. The first evidence of the phenomenon was collected in the French Mediterranean in the early 1970s, when an annual mortality of Balearic/Yelkouan shearwaters was estimated at several hundred caught in set nets, shortly after the introduction of nylon materials for this type of fishing gear (Besson, 1973).

It was not until the early 2000s that the seabird bycatch issue became more apparent in the region, particularly in relation to longline fisheries (Belda and Sánchez, 2001; Sánchez and Belda, 2003; Valeiras and Camiñas, 2003; Louzao and Oro, 2004). However, there remained either information gaps from a number of countries or errors in the systematic collection of the available data, which were therefore insufficient to assess the impacts on seabird populations (Cooper *et al.*, 2003; ICES, 2008). Seabird bycatch was reported in at least six countries (France, Greece, Italy, Malta, Spain and Tunisia), but the most extensive information came from the western Mediterranean. Indeed, Spain was the only country that provided quantitative information on the mortality rates in longline fisheries (Belda and Sánchez, 2001; Cooper *et al.*, 2003). As a result, Belda and Sánchez (2001) estimated that between 650 and 2 800 birds were caught annually by drifting and set longliners operating around the Columbretes Islands (northwestern Mediterranean), where an important breeding colony of Scopoli's shearwater is found, with a higher mortality rate reported by set longlines. This estimate took into account the mortality of seven different seabird species, although Scopoli's shearwater was the most susceptible to incidental catch (66 percent of the seabird bycatch). For this species, the incidental catch observed mainly consisted of adult breeders, therefore potentially impacting 4–6 percent of the breeding population in the area (Belda and Sánchez, 2001). Moreover, it was demonstrated that seabird bycatch could also have negative effects on fishers due to bait loss and reduced catch (Sánchez and Belda, 2003). These findings highlighted that incidental catch was affecting not only the viability of Scopoli's shearwaters in the region, but also the fishing efficiency of longline fishers. At that time, night setting was proposed as the best measure to prevent seabird incidental capture and minimize economic loss for fishers (Belda and Sánchez, 2001; Sánchez and Belda, 2003).

Evidence collected from longline fisheries across the Mediterranean region showed that shearwater species were the most impacted seabirds, with Scopoli's shearwaters caught in the greatest numbers by far (Cooper *et al.*, 2003; Louzao and Oro, 2004; García-Barcelona *et al.*, 2010) and with all three shearwater species (Scopoli's, Balearic and Yelkouan) specifically affected, mainly

by small-scale set longliners (Cortés, Arcos and González-Solís, 2017). In addition to Scopoli's shearwaters, France, Greece, Italy, Malta, Spain and Tunisia reported incidental catch of Balearic and Yelkouan shearwaters. For these latter two species, no accurate data on mortality rates in longlines existed, since most information available came from intermittently reported events. However, it was suspected that in the Spanish Mediterranean, species such as shearwaters were being caught on occasion in large numbers by set longlines, resulting in mass mortality events (Arcos, Louzao and Oro, 2008; Louzao *et al.*, 2011).

In general, set longlines seemed to cause the most substantial seabird bycatch, since studies carried out on drifting longliners operating in the western Mediterranean found relatively lower mortality levels (Valeiras and Camiñas, 2003; García-Barcelona *et al.*, 2010), potentially due to the larger baits and hooks used by drifting longlines. García-Barcelona *et al.* (2010) estimated an average total bycatch by drifting longliners of around 500 seabirds per year, 40 percent of which were Scopoli's shearwaters. However, the incidental catch rates by longlines varied between, for example, target species, vessels, fishing grounds and seasons.

In the case of set net fisheries, the information available is very scarce. Louzao and Oro (2004) have provided evidence of incidental catch in set nets from the Balearic Islands (Spain) particularly impacting the Mediterranean shag. Similarly, another record from the same area (the island of Cabrera, Balearic Islands) indicated an incidental catch of 28 Mediterranean shags in set nets in 1992 (Moreno Pérez, personal communication, 2019). Regarding the other fisheries of the Mediterranean and the Black Sea, no incidental catch has been documented by trawlers, purse-seiners and traps since the early 2000s. Indeed, in the case of trawlers, several studies carried out in the western Mediterranean did not find any seabird mortality in a large number of operations monitored between 1994 and 2003 (Arcos and Oro, 2002a; Abelló, Arcos and Gil de Sola, 2003; Abelló and Esteban, 2012).

1.3 Analysis of recent data from literature (2008–2018)

Overall, the data available on the bycatch of seabirds in the Mediterranean and the Black Sea are scarce, and often data are unavailable for some GFCM subregions, countries or vessel groups. No information on seabird bycatch could be found from North Africa and from many eastern Mediterranean countries. All records of incidental seabird catch in fisheries found in the literature are summarized in Tables 1 through 4, presented by fishing fleet and by GFCM subregion.

1.3.1 Bottom trawlers

Western Mediterranean

The available information shows a low probability of seabird bycatch in bottom trawlers. Questionnaires completed by Spanish fishers (450 surveys, including fishers from the Atlantic) indicated a low to very low risk of seabird bycatch in trawl fisheries from the western Mediterranean (Cama and Arcos, 2013). This risk assessment integrates the estimation of one annual event of seabird bycatch in this area with a very low number of seabird individuals affected. Genovart *et al.* (2016) recorded three incidental catch events by bottom trawlers, in which 20 Balearic shearwaters were caught during ten commercial and scientific fishing hauls (Table 1). In contrast, information from scientific hauls (120 bottom trawl hauls) (Abelló and Esteban, 2012) and observer data from 150 field trips (J.M. Arcos, personal communication, in Cama and Arcos, 2013) conducted in the western Mediterranen revealed very low (two Balearic shearwaters) or no bycatch, respectively (Table 1).

PLATE 1
Seabirds following a trawler

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TABLE 1 – Incidental catch of seabirds in bottom trawlers (data from literature 2008–2019)

Bibliographic reference	Reference years	Gear	GFCM subregion	Country	Species	Reported individuals in bycatch events	Estimated bycatch (percent or individuals/ year)	Source of data	Fishing effort
Abelló and Esteban, 2012	2011	OTB	Western Mediterranean	Spain	*Puffinus mauretanicus*	2	-	onboard observation	~120 scientific hauls
Cama and Arcos, 2013	unspecified	OTB	Western Mediterranean	Spain	-	0	-	onboard observation	150 fishing surveys
Genovart, Oro and Tavecchia 2017	2014	OTB	Western Mediterranean	Spain	*Puffinus mauretanicus*	14	-	onboard observation	5 scientific hauls
Genovart, Oro and Tavecchia 2017	2014	OTB	Western Mediterranean	Spain	*Puffinus mauretanicus*	~6	-	self-reporting fishers	-
SEO/BirdLife, 2019	2018	OTB	Western Mediterranean	Spain	*Larus michahellis*	1	-	self-reporting fishers	521 fishing trips
ICES, 2018	2016	OTB	Adriatic Sea	-	*Phalacrocorax aristotelis desmarestii*	1	-	-	25 fishing days

Note: OTB = bottom otter trawl.

Central Mediterranean

No records of seabird bycatch could be found in the existing literature.

Adriatic Sea

One European shag caught by a bottom trawl was reported for the Adriatic Sea (ICES, 2018; Table 1). This record is based on 25 days of observation on bottom trawlers in this area (ICES, 2018). No further records were found for bottom trawls in this area.

Eastern Mediterranean
No records of seabird bycatch could be found in the existing literature.

Black Sea
No records of seabird bycatch could be found in the existing literature.

1.3.2 Small-scale fisheries

The search for records within this vessel group focused on set nets, traps and small-scale longliners (passive fishing gear). The data available for small-scale fisheries reveal that some of these types of fishing gear can have a very high impact at a local scale on certain seabird taxa. While small-scale longlines mainly affect shearwaters (see below), set net fisheries may have impacts on birds with intense diving behaviour, such as cormorants.

Western Mediterranean
Set nets
Data collected through questionnaires provided to fishers (450 surveys from the Atlantic and Mediterranean, Spain) showed that incidental catch in set nets is relatively infrequent and does not affect a large number of seabirds in the western Mediterranean (Cama and Arcos, 2013). The authors estimated that around five incidental catch events could occur annually in these fisheries in each of the Spanish locations considered (Catalonia, Valencian Community and the Balearic Islands) with one to many (>10) seabird individuals/set caught in each incident (Cama and Arcos, 2013). The overall risk for seabirds, which takes into account the number of incidents and the number of seabirds per capture, varies regionally from very low to very high (with high variation locally in Catalonia and the Valencian Community) (Cama and Arcos, 2013). For the western Mediterranean, these authors suggested that this fishing gear affects mostly shearwaters and gulls, and, to a lesser extent, cormorants/shags, alcids (puffins, guillemots, razorbills, auks, etc.) and gannets. Nevertheless, data obtained from beach surveys carried out over four months of two consecutive years along the coast of Mar Menor (Murcia, southeastern Spain), a coastal salty lagoon in the western Mediterranean, have demonstrated a high mortality rate of cormorants and grebes from set nets (Zamora Urán, 2014, 2015) (Table 2). These studies showed that high numbers of great cormorants (*Phalacrocorax carbo*) (333–439 individuals) and black-necked grebes (*Podiceps nigricollis*) (48–60 individuals) were found dead each year. This mortality was mainly associated with the presence of an average of 32 to 80 set nets per month in this area, and since both species are divers that hunt their prey underwater, they are therefore highly susceptible to being caught by this kind of fishing gear (Žydelis, Small and French, 2013). Zamora Urán (2014, 2015) also estimated that these mortality events could affect up to 30–40 percent and 4.6–5.7 percent of the local winter populations of great cormorant and of the black-necked grebe, respectively.

Small-scale longlines
Higher incidental catch rates were observed in small-scale set longliners from the Iberian Peninsula and Balearic Islands, in comparison to medium-scale longliners (Cortés, Arcos and González-Solís, 2017) (Table 2). In this study, the estimate of annual seabird bycatch from small-scale fisheries was almost twice (675 individuals/year) that of the medium-scale fleet (357 individuals/year), with an overall mortality of 81 percent. The species most affected by this fishery were shearwaters (*Puffinus* spp.) (47 individuals not distinguished); over 90 percent of the *Puffinus* spp. individuals were caught in a single setting. Another study from the Catalonian coast (northeastern Spain) analysed records from self-reporting surveys of fishers, which covered over 400 fishing trips,

TABLE 2 – Incidental catch of seabirds in small-scale fisheries (data from literature 2008–2019)

Bibliographic reference	Reference years	Gear	GFCM subregion	Country	Species	Reported individuals in bycatch events	Estimated mortality due to bycatch (percent or individuals/ year)	Source of data	Fishing effort
Zamora Urán, 2014	Nov 2012–Feb 2013	set nets	Western Mediterranean	Spain	*Phalacrocorax carbo* *Podiceps nigricollis* *Larus michahellis*	333 48 1	– – –	stranding data	–
Zamora Urán, 2015	Nov 2013–Feb 2014	set nets	Western Mediterranean	Spain	*Phalacrocorax carbo* *Podiceps nigricollis* *Larus michahellis*	439 60 13	– – –	stranding data	–
BirdLife International, 2017b	April–June 2017	LLS, occasionally traps or set nets	Western Mediterranean	Spain	*Puffinus mauretanicus; Puffinus yelkouan; Calonectris diomedea; Larus* spp.*; Morus bassanus; Phalacrocorax* spp.	685 (405)	–	self-reporting fishers	403 fishing days
Cortés *et al.*, 2017; Cortés, pers. comm., 2019	2011–2015	LLS	Western Mediterranean	Spain	*Larus michahellis* *Puffinus mauretanicus* *Puffiunus yelkouan* *Puffinus spp.* *Calonectris diomedea* *Larus audouinii*	4(1) 8(8) 1(1) 47(5) 27(5)	675 (148–1 556)	onboard observer	117 fishing days; 113 219 hooks
Cortés *et al.*, 2017; Cortés, pers. comm., 2019	2011–2015	LLS	Western Mediterranean	Spain	*Calonectris diomedea; Puffinus mauretanicus; Puffinus yelkouan; Puffinus spp.; Larus audouinii; Morus bassanus; Larus melanocephalus; Thalassens sandvicensis*	252	–	self-reporting fishers	–
Genovart *et al.*, 2017	1992–2012	sport trolling	Western Mediterranean	Spain	*Larus audouinii*	40	0.02% (juvenile), 0.1% (adult)	opportunistic information	–
Cortés and González-Solís, unpubl. data	2013– 2015	fish traps	Western Mediterranean	Spain	*Phalacrocorax aristotelis desmarestii* *Phalacrocorax carbo*	4 1	– –	opportunistic information	–
González-Solís, unpubl. data	2018	fish traps	Western Mediterranean	Spain	*Phalacrocorax aristotelis desmarestii*	3	–	opportunistic information	–
SEO/BirdLife, 2019	2018	LLS	Western Mediterranean	Spain	*Calonectris diomedea; Phalacrocorax aristotelis; Larus michahellis; Puffinus mauretanicus; Puffinus yelkouan; Puffinus spp.; Phalacrocorax carbo; Larus melanocephalus*	36	–	self-reporting fishers	1 375 fishing trips
		set nets fishing traps	Western Mediterranean	Spain	*Phalacrocorax aristotelis* *Phalacrocorax aristotelis*	4 2	– –		
Genovart *et al.*, 2017	2005– 2013	GNS	Adriatic Sea	Croatia	*Phalacrocorax aristotelis desmarestii*	9	3.5% (juvenile)	opportunistic information	-
Karris *et al.*, 2013; G. Karris, pers. comm., 2019	2010	set nets	Eastern Mediterranean	Greece	*Phalacrocorax aristotelis desmarestii*	1	-	questionnaire to fishers (n=139)	-

Note: GNS = set gillnet; LLS = set longline. The numbers in brakets correspond to the number of individuals recovered alive in the study.

mostly conducted by small-scale longliners, carried out between April and June 2017 (BirdLife International, 2017b) (Table 2). Overall, 685 individuals caught were reported, mainly Balearic (51.8 percent), Yelkouan (43.9 percent) and Scopoli's (4 percent) shearwaters, as well as a number of gulls (16 individuals; *Larus* spp.), one shag and a gannet (*Morus bassanus*). Fortunately, almost 60 percent of the birds were released alive. These reports revealed that the highest catches occurred in unweighted gear of the small-scale longlines (5.86 seabirds/1 000 hooks) compared to weighted gear (2.99 seabirds/1 000 hooks) and medium-scale longliners (0.49 seabirds/1 000 hooks) using the *piedra-bola* system (i.e. a line with hooks hanging off it at regular intervals, which hangs near the bottom with alternating weights and buoys, as used by set longliners) (BirdLife International, 2017b; Cortés, Arcos and González-Solís, 2017).

Traps

Based on opportunistic information collection, a few incidental catch records for this subregion exist: three individuals of cormorants/shags were caught by traps in Catalonia (Spain) (Cortés and González-Solís, unpublished data) (Table 2); five individuals (four Mediterranean shags, one great cormorant) were recorded in fish traps between 2013–2015; and a further three immature specimens of the Mediterranean shag were found in traps in 2018 (González-Solís, unpublished data). In a questionnaire given to fishers, Cama and Arcos (2013) noted that traps were less frequently used in Spanish Mediterranean waters than in the Atlantic, and that the incidental catch of shags, shearwaters and gannets was highly irregular and comprised low numbers of individuals.

Central Mediterranean

Set nets

No records of seabird bycatch could be found in the existing literature.

Small-scale longlines

No records of seabird bycatch could be found in the existing literature.

Traps

No records of seabird bycatch could be found in the existing literature.

Adriatic Sea

Set nets

Only one reference could be found concerning a small-scale fishery operating in Croatia: 29 Mediterranean shags were recorded dead over eight years of sampling (nine died due to incidental catch in set nets, while 20 died due to unknown causes) (Genovart *et al.*, 2017) (Table 2). The authors inferred that set nets in Croatia were responsible for 9 percent of juvenile shag mortality and the annual probability for juveniles dying in fishing gear was estimated at 3.5 percent (Genovart *et al.*, 2017).

Small-scale longlines

No records of seabird bycatch could be found in the existing literature.

Traps

No records of seabird bycatch could be found in the existing literature.

Eastern Mediterranean

Set nets

Information available for this GFCM subregion is sourced from Greece, with no data available from other countries. Based on data from questionnaires of coastal fisheries in the Aegean and Ionian Sea, Fric *et al.* (2012) noted that Mediterranean shag (*Phalacrocorax aristotelis desmarestii*) were mainly caught by set nets, which also affected the Yelkouan shearwater (*Puffinus yelkouan*), occasionally catching high numbers of individuals. Karris *et al.* (2013) (Table 2) used questionnaires for fishers to assess and quantify the potential impact of set nets on Scopoli's (*Calonectris diomedea*) and Yelkouan shearwaters, Mediterranean shags, and Audouin's gulls (*Larus audouinii*) in the Ionian Sea (150 fishers). Based on these data, the authors estimated an incidental mortality of 1.3 Mediterranean shag individual caught by the whole fleet in this area annually. No other seabird species were observed to be caught by this fleet (Karris *et al.*, 2013). Further data from the Ionian and the Aegean Sea, obtained by questionnaires and onboard observers, suggested that an estimated 2.7–3.3 percent of the local population of the Mediterranean shag may contribute to the annual incidental catch in set nets and longline fleets from these areas (Karris, Portolou and Fric, 2015). Additionally, the authors inferred that set nets do not affect Scopoli's and Yelkouan shearwaters, or Audouin's gull, as no catch was recorded.

Small-scale longlines

Examining small-scale longliners in the Aegean and Ionian Sea revealed that this method of fishing can have impacts on seabird populations, at least at the local scale (Karris, Portolou and Fric, 2015). Based on questionnaires and onboard observations (2009–2012) in the southern Ionian Sea, the percentage share of local/regional breeding populations that may be affected annually, especially by small-scale set longliners, was estimated: Scopoli's shearwater (1.8–2.1 percent), Mediterranean shag (2.7–3.3 percent) and Audouin's gull (0.9–1.9 percent). It was also highlighted that, at the local scale, small-scale longlines can also impact Yelkouan shearwaters, though estimates are not available (Karris, Portolou and Fric, 2015; G. Karris, personal communication, 2018) (Table 2).

Black Sea

No records of seabird bycatch could be found in the existing literature.

1.3.3 Purse seiners

Western Mediterranean

Very few data are available for this fishery in the western Mediterranean. Based on questionnaires given to Spanish fishers by Cama and Arcos (2013), it was estimated that up to five events, each involving just a few seabirds (<10), can occur in purse seine fisheries annually, with variations at the local scale: an overall low to medium seabird bycatch risk was observed in purse seiner activities, with the Strait of Gibraltar exhibiting the highest risk of incidental catch. This study confirmed that incidental catch in purse seines mostly concerns shearwater species (*Puffinus* spp.) It should be also reported that around 25 dead Balearic shearwaters were found washed ashore on a beach in the western Mediterranean (Valencian Community) (Genovart, Oro and Tavecchia, 2017) (Table 3); this finding could not be clearly associated with a specific fishing gear, but the presence of dislocated wings on several of the seabirds indicates impacts from trawlers or purse seiners. Nevertheless, no incidental bycatch was recorded by fishers during an additional study conducted in Spanish Mediterranean waters (SEO/BirdLife, 2019) (Table 3).

TABLE 3 – Incidental catch of seabirds in purse seiners (data from literature 2008–2019)

Bibliographic reference	Reference years	Gear	GFCM subregion	Country	Species	Reported individuals in bycatch events	Estimated bycatch (percent or individuals/ year)	Source of data	Fishing effort
Genovart, Oro and Tavecchia, 2017	2013	PS/OTB	Western Mediterranean	Spain	*Puffinus mauretanicus*	~ 25	-	stranding data	-
SEO/BirdLife (2019)	2018	PS	Western Mediterranean	Spain	no bycatch observed	0	-	self-reporting fishers	223 fishing trips

Note: PS = purse seine; OTB = bottom otter trawl.

Central Mediterranean

No records of seabird bycatch could be found in the existing literature.

Adriatic Sea

No records of seabird bycatch could be found in the existing literature.

Eastern Mediterranean

No records of seabird bycatch could be found in the existing literature.

Black Sea

No records of seabird bycatch could be found in the existing literature.

1.3.4 Longliners

High mortality of seabirds, particularly shearwater species, has been found to occur in some Mediterranean longline fisheries. Other seabirds, such as gulls, cormorants, skuas and terns, also contribute to this kind of bycatch. Generally, two types of longlines are used in the Mediterranean and the Black Sea: set longlines (sometimes also called bottom or demersal longlines) deployed on the sea bottom, and drifting longlines (sometimes also called surface or pelagic longlines) used in the water column at variable depths. Therefore, these two types of vessel groups are presented separately in the considerations of some GFCM subregions (i.e. in the western Mediterranean).

Western Mediterranean

Drifting longliners

The results of questionnaires compiled from Spanish fishers indicated that seabird bycatch events in the drifting longline fisheries of the western Mediterranean may occur more than five times a year, each involving a few (<10) to many (>10) individuals caught and varying locally and/or regionally (Cama and Arcos, 2013). The risk of incidental catch in drifting longlines is high to very high for the northeastern Spanish coast (Catalonia, Valencian Community) and Balearic archipelago and low in the Alborán Sea. Cama and Arcos (2013) highlighted that specifically in the Balearic Sea, 80 percent of drifting longline fishers catch seabirds incidentally more than five times a year. The species most affected by this gear is the Scopoli's shearwater (*Calonectris diomedea*), due to the large hooks used, which prevent the capture of smaller shearwater species (Cama and Arcos, 2013). However, a single event of 145 Balearic (*Puffinus mauretanicus*) and Yelkouan (*Puffinus yelkouan*) shearwater specimens (137 of which were found dead) from the Ebro Delta (northwestern Mediterranean) demonstrates the potentially high impact of set longliners (García-Barcelona *et al.*, 2016) (Table 4). Additionally, onboard observers from 2013 recorded 40 individuals of the northern gannet (*Morus bassanus*) caught during a single fishing trip by a drifting longliner

(González-Solís *et al.*, 2014). A questionnaire given during the same study (involving six fishers on drifting longliners) confirmed frequent bycatch, mainly of gannets, shearwaters and gull species; this dynamic is also partly supported by independently observed interactions of the yellow-legged gull (*Larus michahellis*), Scopoli's shearwater and *Puffinus* spp. with this kind of fishery (González-Solís *et al.*, 2014). In contrast, no seabirds were caught during onboard observations made aboard Ligurian semi-pelagic swordfish longliners, which involved 48 fishing trips between 2010 and 2013 (Garibaldi, 2015) (Table 4). In general, the present review highlights the need to obtain an overall estimate of the potential effects of drifting longlines on seabirds in Mediterranean waters.

Set longliners

The estimates of the aforementioned questionnaires revealed that seabird bycatch in set longliners in Spanish waters may occur more than five times a year, with each event involving one to many (>10) individuals caught, while varying locally and/or regionally (Cama and Arcos, 2013). The incidental catch risk for seabirds was highest locally in Catalonia and especially in the Balearic archipelago: 50 percent of set longline fishers in the Balearic Sea reported incidental catch of seabirds (mostly shearwaters and gulls) more than five times a year (Cama and Arcos, 2013). Conversely, onboard observer data from thirty fishing trips conducted in 2013 did not report any bycatch from set longliners, although frequent interactions between this fishery and several seabird species (Audouin's and yellow-legged gulls, Scopoli's shearwater) were recorded (González-Solís *et al.*, 2014). In the same study, a questionnaire (answered by 24 fishers on set longliners, including some small-scale vessels) revealed that 29 percent of fishers recorded seabird bycatch at least once annually, with reported incidents of species such as gannets, shearwaters, gulls and cormorants. Nevertheless, seabird bycatch was considered as rare or even exceptional (González-Solís *et al.*, 2014).

Observations onboard set longliners (medium-scale) off the Iberian Peninsula, carried out over a four-year study period (2011–2015), resulted in an estimated annual mortality of around 360 seabirds for the Catalonian fleet (Cortés, Arcos and González-Solís, 2017) (Table 4). Additionally, on fishing days without onboard observers during the four-year study period, fishers continued to report seabird bycatch and recorded 487 individuals: this highlights the hidden mortality when considering onboard observation only (Table 4). Nevertheless, the number and the composition of the species caught was similar to the onboard observations made in the same study, comprising the three shearwater species (Balearic, Yelkouan and Scopoli's), gulls (yellow-legged, Audouin's and black-legged kittiwake (*Rissa tridactyla*)) and the northern gannet. Further, more recent onboard observations carried out on set longliners in 2015 and 2016 in Catalonian waters recorded six seabirds (three Scopoli's shearwaters and three yellow-legged gulls) caught during 232 fishing sets with an average of 0.031 bird/1 000 hooks (BirdLife International, 2017b) (Table 4). However, the authors also indicated that, over the same period, an additional 40 individuals were caught by neighbouring vessels or on the same vessels during trips without observers.

Specific effects of drifting and set longliners on shearwater populations

Among the potential impacts of longliners on seabird population sizes, other studies analysed the effects of this fishing gear on different seabird age classes. Based on data from ringed individuals of Audouin's gull from Catalonia (data collection carried out over 20 years) and Scopoli's shearwater from the Balearic archipelago (28 years), Genovart *et al.* (2017; Table 4) estimated that 23 percent and 28 percent of total adult mortality, respectively, were caused by longline incidental catch in these areas. The authors further estimated that 3.4–6.0 percent of Scopoli's shearwater adults die in longlines in the western Mediterranean. However, the data collected cannot precisely attribute

these deaths to the fishing gear type, though it is assumed that these individuals were mainly caught by small-scale demersal longliners, which are abundant in the area (Genovart *et al.*, 2017). Furthermore, dead individuals (639) of the three shearwater species (Scopoli's, Balearic and Yelkouan) caught by set and drifting longliners were recorded over 12 years by observers or fishers in the northwestern Mediterranean Sea (Cortés, García-Barcelona and González-Solís, 2018) (Table 4). The analysed data revealed a higher mortality of adults in all three species compared to subadults and immatures. In addition, the authors observed differences in the incidental catch composition (age and sex of individuals) according to the breeding period: for instance, Scopoli's shearwater males exhibited an overall higher mortality than females; when analysing the breeding periods separately, this male bias was significantly higher only during the pre-laying period; in both *Puffinus* shearwaters (i.e. Balearic and Yelkouan), male-biased mortality was observed during the pre-laying period, while mortality in females was higher in the chick-rearing period (Cortés, García-Barcelona and González-Solís, 2018). The mortality differences between the sexes were explained by different foraging behaviours during the breeding periods, which resulted in differential interactions with longliners.

Central Mediterranean

Two studies from this region applying different approaches indicated rather low seabird incidental catch in longline fisheries. While no seabirds were caught during the observations made onboard Maltese tuna longliners, covering 85 fishing days in 2008 (Burgess *et al.*, 2010) (Table 4), a second self-reporting study exhibited low incidental catch of seabirds. This latter study was carried out from May 2008 through the end of April 2010, with most trips (221) occurring between May and August, by seven Maltese fishers, covering 443 fishing trips in total (163 drifting and 280 set longlines). During this period, one Scopoli's shearwater was caught by drifting longlines, while one Scopoli's shearwater and one black-legged kittiwake were caught by set longliners. The estimated annual total seabird bycatch for both methods in this area was 52 and 94 individuals, respectively (Darmanin, Caruana and Dimech, 2010).

Adriatic Sea

No records of seabird bycatch could be found in the existing literature.

Eastern Mediterranean

Set longlines have impacts on certain seabird species in the southern Ionian Sea. Studies based on questionnaires given to fishers (150 surveys) carried out between 2009 and 2011 indicated that set longlines caught up to 351 Scopoli's shearwaters and four Mediterranean shags annually (Karris *et al.*, 2013) (Table 4). In the case of drifting longlines, annual mortality was estimated at 42 Scopoli's shearwaters and one Mediterranean shag, respectively. Additionally, these questionnaires revealed that the Yelkouan shearwater and Audouin's gull were not impacted by these types of gear. Based on data from questionnaires of longliners and other coastal fisheries in the Aegean and Ionian Sea, Fric *et al.* (2012) noted that Scopoli's and Yelkouan shearwaters and Audouin's gulls can be affected by this fishery, at least occasionally. Preliminary data from a questionnaire and from an onboard observer programme (Table 4) conducted in 2015 and 2016 in the Aegean Sea demonstrated again that longliners can have relevant impacts, especially on shearwaters and gulls (D. Sahin, unpublished data): a questionnaire given to 57 fishers revealed a high frequency of bycatch of Yelkouan and Scopoli's shearwaters (43.8 and 7 percent, respectively) and the yellow-legged gull (40.3 percent). The results also showed quite a high overall frequency for shags and cormorants combined (31.6 percent). Sahin (personal communication, 2019) assumed that the relatively high *Phalacrocorax* spp. bycatch could be associated with the type of drifting longlines used by fishers

in some locations. Instead of fishing offshore, drifting longlines can be set very close to the shore, thereby increasing the risk of cormorant and shag bycatch (D. Sahin, unpublished data). The preliminary data from an onboard observer programme (mainly set longliners) carried out on 17 fishing trips indicate higher bycatch of Yelkouan shearwaters (estimate of 680 individuals/year) and lower bycatch of yellow-legged gulls (170 individuals/year) and Mediterranean shags (85 individuals/year), which partly confirmed the results obtained by the questionnaires (D. Sahin, unpublished data). In contrast, another study in the Aegean Sea on drifting longliners (onboard observers surveying 50 operations) could not detect any seabird bycatch between 2008 and 2013 (Ceyhan and Akyol, 2014; Table 4).

Black Sea
No records of seabird bycatch could be found in the existing literature.

PLATE 2
Specimens of Mediterranean shearwater caught by longlines

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1.3.5 Pelagic trawlers

Western Mediterranean
No records of seabird bycatch could be found in the existing literature.

Central Mediterranean
No records of seabird bycatch could be found in the existing literature.

Adriatic Sea
No records of seabird bycatch could be found in the existing literature.

Eastern Mediterranean
No records of seabird bycatch could be found in the existing literature.

TABLE 4 – Incidental catch of seabird in longlines (data from literature 2008–2019)

Bibliographic reference	Reference years	Gear	GFCM subregion	Country	Species	Reported individuals in bycatch events	Estimated mortality due to bycatch (percent or individuals/ year)	Source of data	Fishing effort	Notes
C. Carboneras, pers. comm., 2008 in García-Barcelona *et al.*, 2010	May 2008	LL	Western Mediterranean	Spain	*Puffinus yelkouan*	60	-	opportunistic information	one fishing set or day (not specified)	-
González-Solís *et al.*, 2014	2013	LLD	Western Mediterranean	Spain	*Morus bassanus*	40	-	onboard observer	one fishing trip	-
González-Solís *et al.*, 2014	2013	LLS	Western Mediterranean	Spain	no bycatch observed	0	-	onboard observer	30 fishing trips	-
Garibaldi, 2015	2010–2013	LLD	Western Mediterranean	Italy	no bycatch observed	0	-	onboard observer	48 fishing trips, 32 000 hooks	-
García-Barcelona *et al.*, 2016	2015	LLD	Western Mediterranean	Spain	*Puffinus yelkouan; Puffinus mauretanicus*	145 (8 released alive); 64.6%; 35.4%	-	onboard observer	one fishing set	-
Genovart *et al.*, 2016	1985–2004 2010–2014	LL	Western Mediterranean	Spain	*Puffinus yelkouan*	16	-	opportunistic information	–	Literature, wildlife recovery centres
		LL	Western Mediterranean	Spain		5	-	opportunistic information	–	ringing of 1 344 individuals
BirdLife International, 2017b	2015–2016	LLS	Western Mediterranean	Spain	*Calonectris diomedea; Larus michahellis*	6		onboard observer	81 fishing trips, 232 settings, 195 000 hooks	–
					Calonectris diomedea; Larus michahellis	~40		seft reporting fishers		–
Cortés *et al.*, 2017; V. Cortés, pers. comm	2011–2015	LLS	Western Mediterranean	Spain	*Morus bassanus*	1		self-reporting fishers	–	reported by fishers over 4 years of the study period
					Puffinus mauretanicus	5				
					Puffinus yelkouan	2				
					Puffinus spp.	3				
					Calonectris diomedea	2				
					Larus audouinii					
					Larus michahellis					
					Rissa tridactyla					
					Calonectris diomedea; Puffinus mauretanicus; Puffinus yelkouan; Puffinus spp.*; Larus audouinii; Morus bassanus; Larus melanocephalus; Thalassens sandvicensis*	487				

TABLE 4 (Continued)

Bibliographic reference	Reference years	Gear	GFCM subregion	Country	Species	Reported individuals in bycatch events	Estimated mortality due to bycatch (percent or individuals/ year)	Source of data	Fishing effort	Notes
Genovart, Oro and Tavecchia, 2017	2008		Western Mediterranean	Spain	*Puffinus mauretanicus*	12	-	opportunistic information	-	Offshore, boat transect 4 miles, birds with hooks
	2009–2015	LLS	Western Mediterranean	Spain	*Puffinus mauretanicus; Puffinus yelkouan*	>100	-	onboard observer	one fishing set	massive catch in one set during 2009–2015
	2015	LLS	Western Mediterranean	Spain	*Puffinus mauretanicus; Puffinus yelkouan*	20–30	-	opportunistic information	-	mortality reported by fishers
	2015	LL	Western Mediterranean	Spain	*Puffinus mauretanicus;*	5	-	stranding data	-	signs of neck injuries (hooks?)
	2015	LL	Western Mediterranean	Spain	*Puffinus yelkouan*	2	-	stranding data	-	signs of neck injuries (hooks?)
Genovart *et al.*, 2017	1985–2013	LL	Western Mediterranean	Spain	*Calonectris diomedea*	14	1.2% (immature), 3.4% (adult)	opportunistic information	-	3 071 individuals captured and banded
	1992–2012	LL	Western Mediterranean	Spain	*Larus audouinii*	15	34% (juvenile), 16% (immature), 2.5% (adult)	opportunistic information	-	21 679 individuals captured and banded
SEO/BirdLife, 2019	2018	LLS	Western Mediterranean	Spain	Calonectris diomedea	1	-	self-reporting fishers	833 fishing trips	-
Burgess *et al.*, 2010	April–June 2008	LLD	Central Mediterranean	Malta	no bycatch observed	0	-	onboard observer	85 fishing days, 109 155 hooks	-
Darmanin *et al.*, 2010	May 2008–April 2010	LLD	Central Mediterranean	Malta	*Calonectris diomedea*	1	52*	self-reporting fishers	163 fishing trips	-
		LLS	Central Mediterranean	Malta	*Calonectris diomedea; Rissa tridactyla*	2	94*	self-reporting fishers	280 fishing trips	-
Fric, 2013	2009–2012	LLD	Eastern Mediterranean	Greece	no bycatch observed	0	-	onboard observer	30 trips, 142 fishing days	-
Karris *et al.*, 2013; G. Karris, pers. comm.					*Calonectris diomedea;*	351	-	questionnaire to fishers (n=150)	–	bycatch rate 0.0626 birds/1 000 hooks
	2010	LLS	Eastern Mediterranean	Greece	*Phalacrocorax aristotelis desmarestii*	4	-			bycatch rate 0.00071 birds/1 000 hooks
		LLD	Eastern Mediterranean	Greece	*Calonectris diomedea*	42	-	questionnaires to fishers (n=150)	–	bycatch rate 0.06976 birds/1 000 hooks
Ceyhan and Akyol, 2014	2008–2013	LLD	Eastern Mediterranean	Turkey	no bycatch observed	0	-	onboard observer	50 fishing days	-
C. Sahin, unpublished data	2015–2016	LLS	Eastern Mediterranean	Turkey	*Puffinus yelkouan*	680	–	onboard observer	17 fishing trips	–
					Larus michahellis	170	–			
					Phalacrocorax aristotelis desmarestii	85	–			

Note: LL= Longline; LLS = set longline; LLD = drifting longline.
*estimated number of seabirds caught annually (mortality rate not specified).

1.3.6 Tuna seiners

Western Mediterranean
No records of seabird bycatch could be found in the existing literature.

Central Mediterranean
No records of seabird bycatch could be found in the existing literature.

Adriatic Sea
No records of seabird bycatch could be found in the existing literature.

Eastern Mediterranean
No records of seabird bycatch could be found in the existing literature.

1.3.7 Dredgers

Western Mediterranean
No records of seabird bycatch could be found in the existing literature.

Central Mediterranean
No records of seabird bycatch could be found in the existing literature.

Adriatic Sea
No records of seabird bycatch could be found in the existing literature.

Eastern Mediterranean
No records of seabird bycatch could be found in the existing literature.

1.4 Outlook

1.4.1 Records on the distribution of seabird bycatch

The records presented in this report are sourced from a variety of approaches, including regular monitoring programmes with onboard observers as well as non-systematic, opportunistic data collection such as questionnaire surveys with fishers, tagging/ringing-recovery programmes of seabirds, personal comments from scientists, self-reporting by fishers, beach surveys or recoveries from wildlife centres. Figures 1–3 present tallies of events involving seabirds caught accidentally by fisheries (2008–2018) grouped by GFCM subregion, country and vessel group. Each event represents the incidental catch of seabirds (from 1 to 200) during one fishing operation (Cortés, García-Barcelona and González-Solís, 2017). Studies, personal comments and reports of single events were counted equally within the same record, with the awareness that this puts a strong study bias on rare events, lending them the same weight as studies reporting regular bycatch occurrence. When a study addressed several vessel groups/gear types, it was counted for each relevant group or gear type (Figure 3).

Seabird bycatch by GFCM subregion
Overall, the data available on seabird bycatch in fisheries of the Mediterranean and the Black Sea are scarce and unequally distributed, with data mainly gathered in the western Mediterranean

(Figure 1). No records could be found for the Black Sea or from African Mediterranean countries. About 68 percent of the records found originated from the western Mediterranean Sea, with only some data available from the other GFCM Mediterranean subregions: eastern (16.7 percent), central (9.7 percent) and the Adriatic Sea (6.5 percent). More specifically, the records from the western Mediterranean Sea were sourced from Italy (6.9 percent), and especially from Spain (63.3 percent), where the only study with regular data collection of seabird bycatch over a long time period (2000–to date) could be found; this observer programme on longliners targeting large pelagic fish species is conducted by David Macías López and Salvador García-Barcelona (Spanish Institute of Oceanography (IEO), Málaga, Spain). Additionally, for this subregion, a number of other records were gathered through opportunistic data collection (for example, see Zamora Urán, 2014, 2015; Garibaldi, 2015; Genovart *et al.*, 2016, 2017), while some data were also obtained from personal onboard observations over longer timeframes during ship cruises (J.M. Arcos, personal communication, in Cama and Arcos, 2013; F. Garibaldi, personal communication, 2018; Cortés, Arcos and González-Solís, 2017) and from the recovery of banded birds (Genovart *et al.*, 2016, 2017). No published data of this kind could be found for any of the other Mediterranean subregions or for the Black Sea. For the central Mediterranean, records came from Malta only, while for the eastern subregion, information was obtained from Greece and Turkey (Figure 2). One record for the Adriatic Sea refers to Croatia, while the other could not be assigned to any country.

FIGURE 1
Number of recorded events of seabird incidental catch by GFCM subregion

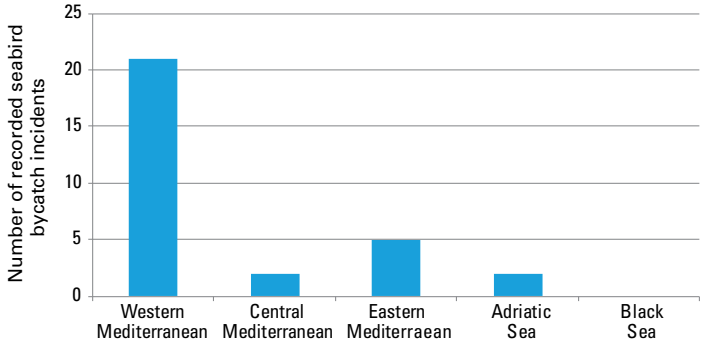


FIGURE 2
Number of recorded events of seabird incidental catch by country

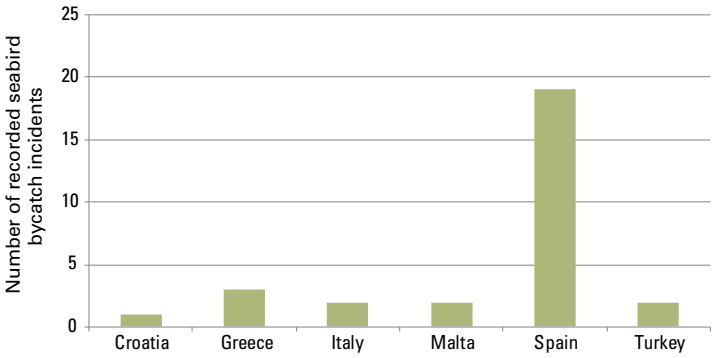
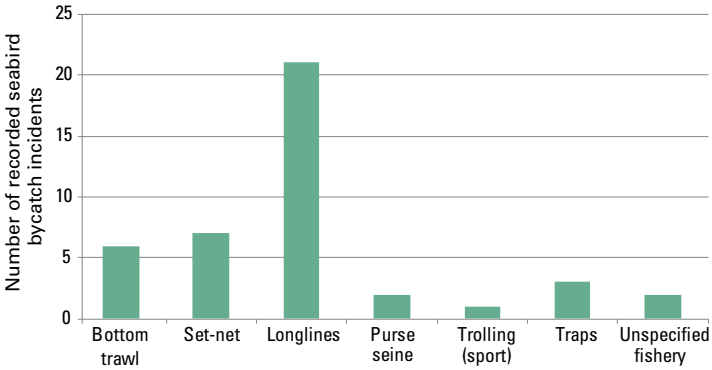


FIGURE 3
Number of recorded events of seabird incidental catch by fishing gear



This general tendency is partly in line with a data assessment performed by the United Nations Environment Programme (UNEP) on the Mediterranean quality status (UNEP-MAP, 2017). This report highlights that data for seabird distribution and abundance in the Mediterranean showed an increasing seabird diversity gradient from southeast to northwest. With the acknowledgement that some seabird species may be rare or absent in the eastern Mediterranean, this gradient was also associated with varying degrees of monitoring effort, since for many countries in the southern and eastern part of the Mediterranean, information is patchy or completely lacking; this applies to some countries of the Adriatic Sea as well (UNEP-MAP, 2017). Similarly, other authors from the eastern Mediterranean have already recognized the current dearth of information and requested more basic data on seabird population assessments and distribution patterns (for example, Zakkak, Panagiotopoulou and Halley, 2013; Turan *et al.*, 2016). The information on the distribution, feeding sites, demographic parameters and size of certain seabird populations is essential for the identification of important bird areas (IBAs), as well as for assessing the effects of fisheries on seabird populations (UNEP-MAP, 2017).

The reasons behind the observed unequal data distribution across the Mediterranean are unclear. One possible explanation could involve the relation between incidental catch numbers and fishing capacity across the GFCM area of application. According to the 2018 report on *The State of Mediterranean and Black Sea Fisheries* (FAO, 2018b), over 86 500 fishing vessels (as of 2017) are registered in the Mediterranean and the Black Sea. Even though this should be considered as an underestimate of the real fleet size, as it lacks information specifically on small-scale fleets (FAO, 2018b), it provides data on the distribution of vessels across the Mediterranean subregions and the Black Sea. According to this report, most vessels are registered in the eastern (30.6 percent) and central (26.4 percent) Mediterranean, while the vessel number is lower in the western Mediterranean (17.3 percent), the Adriatic Sea (12.3 percent) and the Black Sea (13.4 percent). Polyvalent vessels (defined as vessels using more than one gear type, either passive and/or active) represent the main share of all vessel groups over all GFCM subregions (Mediterranean Sea mean: 77.8 percent; Black Sea mean: 91.3 percent) (FAO, 2018b). Higher percentages were found for specific vessel groups in certain subregions, such as in the Adriatic Sea, where trawlers represent 15 percent of vessels, the western Mediterranean, where trawlers account for 13 percent and purse seiners/pelagic trawlers account for 11.6 percent), and the eastern Mediterranean, where "other vessel groups," including all longliners, comprise 17.7 percent of vessels) (FAO, 2018b).

Further complicating the picture, a comparison of the fishing capacities and shares of fishing vessels (percentage share of total in the Mediterranean and the Black Sea) of single countries from which records were obtained shows that Spain, with by far the most available records, exhibited a distinctly lower value than Italy, Croatia and Greece, and a slightly lower value compared to all North African Mediterranean countries (FAO, 2018b). Consequently, no direct link could be found between the overall fishing capacity of single countries or GFCM subregions and the currently available information on seabird bycatch. It is assumed that many additional aspects contribute to the observed unequal data distribution. On the one hand, financial resources of European countries may be greater compared to those of developing countries, but this difference cannot be the only reason, as a lack of data from more prosperous regions has already been indicated by several authors (for example, Anderson *et al.*, 2011; Žydelis, Small and French, 2013; Lewison *et al.*, 2014; Fangel *et al.*, 2015). Therefore, among the many aspects hampering the collection of this kind of information (for example, Fangel *et al.*, 2015), a scientific emphasis on certain regions or countries may explain some trends observed in the present data distribution.

Additionally, a current general unawareness of this problem is reflected by the very few records available indicating zero seabird bycatch (Burgess *et al.*, 2010; J.M. Arcos, personal communication, 2019 in Cama and Arcos, 2013; Fric *et al.*, 2013, Ceyhan and Akyol, 2014; Garibaldi, 2015). Considering the present shortage of seabird bycatch information, especially with regard to certain areas of the Mediterranean and the Black Sea, these kinds of "negative records" may be highly useful for obtaining greater insight into efforts taken toward tackling this issue in different areas and vessel groups. In several studies on the incidental catch of vulnerable species (marine mammals, sea turtles and elasmobranchs) in different vessel groups of the Mediterranean and the Black Sea (for example, Ceylan, Şahin and Kalayci, 2013; Tsagarakis, Palialexis and Vassilopoulou, 2014; Fortuna *et al.*, 2010; Bonanomi *et al.*, 2018), sometimes it is not clearly stated whether seabirds were even considered. Therefore, it would be highly advantageous if studies publishing data and information on incidental catch indicated whether or not seabirds were observed in bycatch.

Seabird bycatch in relation to vessel group/fishing gear

In terms of the overall impacts of vessel group/fishing gear, no records of seabird bycatch were found for pelagic trawls (midwater pair trawls), tuna seiners or dredgers. In contrast, most records referred to the longline fishery (see Figure 3). This dynamic may be due in part to the recommendation from ICES to give priority to monitoring of, and data collection from, set longline fisheries in the European Union's Mediterranean countries (ICES, 2013a). Additionally, it may also reflect the higher susceptibility of seabirds to being caught in longlines and the concern shared by scientists regarding this impact. Moreover, the longline fishery is of high importance in the Mediterranean Sea, specifically in the western part, with Spain boasting the largest longline fleet, consisting of 389 vessels (FAO, 2016) and characterized by a great diversity of longline gear and configurations for targeting different commercial fish species in coastal and offshore areas (Valeiras and Camiñas, 2003; Macías López *et al.*, 2012). Lastly, the Mediterranean is inhabited by some endemic and threatened (according to the IUCN Red List) shearwater species, for whom the western part represents an important area for breeding colonies, as well as a major feeding ground, for other seabirds as well (Cortés, Arcos and González-Solís, 2017). For instance, it hosts the entire global population of the critically endangered Balearic shearwater (*Puffinus mauretanicus*) and an important portion of the Audouin's gull (*Larus audouinii*) population. Thus, the higher fishing activity and the increased susceptibility of these seabirds to different kinds of fishing gear (for example, Cortés, Arcos and González-Solís, 2017) may have contributed to increased efforts and number of studies performed in that area.

About 50 percent of the available literature and records in the Mediterranean on seabird bycatch refer to longline fisheries, followed by set nets (16.7 percent) and bottom trawls (14.3 percent) (see Figure 3 for absolute values). This sequence is in line with data available from other regions of the world, which indicate that research effort is focused on the impacts of longlines and set nets (Žydelis *et al.*, 2009; Pott and Wiedenfeld, 2017). However, some authors have stressed that seabird bycatch represents a "multi-gear problem," with high bycatch rates recorded in trawl fisheries from the Southern Hemisphere (see Moore and Žydelis, 2008, and references therein). In contrast, the very few data available for the Mediterranean and the Black Sea, sourced from only European countries, indicate instead a low to medium risk of seabird bycatch in trawl fisheries (midwater and bottom) (ICES, 2013b). This risk estimate is based on expert opinions considering the likelihood of bycatch of certain taxa by each vessel group/fishing gear and integrates the abundance data for these taxa and the fishing effort of all gear types from countries where this information is available, i.e. mostly the Mediterranean and Black Sea countries that are part of the European Union

(ICES, 2013b). Furthermore, the available literature indicates rather low mortality of seabird populations from trawl fisheries in the Mediterranean and the Black Sea (Tudela, 2004; Ancha, 2008; Abelló and Esteban, 2012), though current information on this potential impact is scarce and more research is needed to conduct a proper assessment (Abelló and Esteban, 2012). Other types of fishing gear, such as purse seines and traps, were considered to be of rather low risk for seabirds. Nevertheless, the scarce available data presented in this review highlight again the need for more information and systematic data collection, as in other geographical areas, some severe impacts on seabirds were recorded by purse seiners and also trawlers (for example, González-Zevallos, Yorio and Caille, 2007; Waugh, MacKenzie and Fletcher, 2008; Shester and Micheli, 2011; Maree *et al.*, 2014; Suazo *et al.*, 2014; Oliveira *et al.*, 2015; Baker and Hamilton, 2016).

Longliners

Available data confirm that longliners can have a higher impact on seabirds in some coastal areas of the Mediterranean Sea. In almost all cases, when seabird bycatch was recorded, shearwater species were represented in the bycatch (see Table 4). Generally, however, the extent of seabird bycatch may differ between drifting and set longliners (for example, García-Barcelona *et al.*, 2010; Báez *et al.*, 2014). Indeed, in studies that considered both set and drifting longliners, estimates of annual seabird bycatch were always lower in the drifting than in the set longlines (Dimech *et al.*, 2009; Cama and Arcos, 2013; Karris *et al.*, 2013), which is in line with the available data at the global scale (Anderson *et al.*, 2011). In particular, seabird bycatch in small-scale set longlines is more common and results in a higher mortality rate, specifically for the three endemic shearwater species (Dimech *et al.*, 2009; Darmanin, Caruana and Dimech, 2010; FAO, 2016; Cortés, Arcos and González-Solís, 2017; Cortés and González-Solís, 2018; SEO/BirdLife, 2019). However, incidental catch events in drifting longlines usually affect high numbers of caught seabirds (>100) (Garcí-Barcelona *et al.*, 2016; Genovart, Oro and Tavecchia, 2017).

The higher seabird bycatch in small-scale set longlines compared to drifting longlines is explained by the smaller hook and bait size used, which increase the likelihood of their being swallowed by various seabird species (Cortés and González-Solís, 2018). Furthermore, studies from the western Mediterranean Sea showed that small-scale longliners exhibit higher seabird bycatch in comparison to those of the industrial fleet (BirdLife International, 2017b; Cortés, Arcos and González-Solís, 2017). Similarly, in the eastern Mediterranean, higher seabird bycatch in longline and set net fisheries was also observed on vessels fishing closer to the coast (Karris *et al.*, 2015). It has been suggested that small-scale fisheries may cause high seabird bycatch because they fish in proximity to the coast, often close to breeding colonies or rafting areas and in shallow waters (Karris *et al.*, 2015; BirdLife International, 2017b; Cortés, Arcos and González-Solís, 2017; Sánchez-Román *et al.*, 2019). However, in comparison to larger fisheries, mortality rates can generally be lower, owing to the lower setting speed of small-scale vessels, as fishers are able to stop and release hooked birds alive. Additionally, these vessels fish in shallower waters and may use longlines equipped with lighter weights and longer branch lines, which can allow birds to reach the surface and breathe, thus increasing their chances of survival (for example, BirdLife International, 2017b; Cortés, Arcos and González-Solís, 2017).

The greater research effort made on seabird bycatch due to longline fisheries (especially in the western Mediterranean) has resulted in more information being available concerning the factors and parameters influencing these incidents than for other types of fishing gear. Several studies and experiments have addressed the impacts of a number of factors on seabird bycatch, such as weather conditions, distance from the coast, gear configuration, bait type, time of day of

setting, target species of the fishery, breeding or non-breeding periods (BirdLife International, 2017b; Cortés, Arcos and González-Solís, 2017; Gladics *et al.*, 2017; Cortés and González-Solís, 2018; Cortés, García-Barcelona and González-Solís, 2018), and even the presence or absence of other fisheries in the area (Laneri *et al.*, 2010; Soriano-Redondo *et al.*, 2016). These studies provide a comprehensive basis for the development of proper mitigation measures, still lacking for other types of fishing gear. Nevertheless, as already mentioned, most of the studies reported above were undertaken in the northwestern Mediterranean and coverage should be extended to other regions of the Mediterranean and the Black Sea. Clearly, further work must be carried out on gear configurations and operational practices in order to avoid seabird bycatch without compromising the ability to catch targeted fish. Additionally, more information on the survival rates of released birds is highly necessary to obtain a complete assessment of fishery-induced mortality, as well as to develop rescue protocols to maximize survival likelihood (BirdLife International, 2017b).

Small-scale fisheries

Gillnets and set nets (anchored or floating in the water column) can create a risk of entanglement when seabirds are diving for benthic prey and fish (Žydelis, Small and French, 2013). Some of the specific traits of set nets used in the Mediterranean and the Black Sea vary, mainly depending on the species targeted (pelagic or demersal), which in turn influence the season, as well as the fishing location (spatial and temporal target species availability) (Maynou, Recasens and Lombarte, 2011). Therefore, set nets are used at different distances from the coast (close to the shore or offshore), at varying depth ranges (in deeper or shallower waters), and in a variety of fishing areas (potentially overlapping with important seabird foraging or breeding areas), thereby potentially exposing seabirds to incidental catch, depending on the traits of each species (for example, foraging distances, hunting behaviour under water, diving depth) (Oppel *et al.*, 2018). Although fewer data are available for gillnets and entangling nets than for longlines, records indicate occasional impacts of these gear types on local populations of seabirds, especially on cormorants/shags and grebes, but also on shearwaters (see Table 2), notably small shearwater species (SEO/BirdLife, 2019). For diving seabirds (for example, cormorants, shags, grebes and small shearwater species), the risk of getting caught in fixed demersal set nets is higher than for surface seabirds, who exhibit a higher risk of capture in pelagic nets or longlines (for example, gulls, terns and large shearwaters). The bycatch of diving seabirds is explained by their intense diving behaviour, as well as by the strongly coastal behaviour of some species, such as cormorants and shags (Grémillet and Wilson, 1999; Bildsøe, Jensen and Vestergaard, 2008), which increases the likelihood of entanglement in coastal set nets. Regarding shearwaters, small shearwater species such as *Puffinus* spp. (notably the Balearic and Yelkouan shearwaters) may forage closer to the coast than larger species, resulting in a higher susceptibility to capture by set nets for those smaller species. Moreover, small shearwater species exhibit stronger diving behaviour than large shearwaters, such as *Calonectris* spp. (including Scopoli's shearwater), thus further increasing their risk of incidental catch. While the overall impact of set nets is assumed to be lower in the Mediterranean in comparison to other geographical areas (Žydelis, Small and French, 2013), this cannot be confirmed as data are still scarce or lacking from several subareas of the Mediterranean and the Black Sea (see Žydelis *et al.*, 2009; Žydelis, Small and French, 2013).

Regarding mitigation measures, very little and only rather general information exists for set nets, in comparison to longlines. Usually, the species and number of individuals caught by gillnets and entangling nets depend on several factors, such as location, weather conditions, water transparency, time of day, setting depth, soak time, mesh size and seabird abundance (Žydelis, Small and French,

2013). In 2016, the European Union adopted new fisheries management measures for its countries, including in the Mediterranean and the Black Sea. Although these included technical measures for static nets (such as twine thickness and mesh size) and temporal and spatial closures in certain areas, no precise mitigation measures were adopted to address seabird bycatch. Given the relatively short foraging distances from the coast of the seabirds most affected by set nets (Oppel *et al.*, 2018), some authors advised that new measures should establish a minimum distance from seabird breeding areas for the setting of static nets (Tarzia *et al.*, 2017a). Mitigation measures studied in other geographical areas, such as acoustic or visual alerts, could potentially decrease seabird bycatch under specific conditions (Bull, 2007; Mangel *et al.*, 2014; Martin and Crawford, 2015; Hanamseth *et al.*, 2018). While further studies concerning the efficacy of different mitigation measures are still necessary, it has been suggested that a combination of measures might be more effective than one single solution (Bull, 2007). Additionally, another approach likely to decrease seabird bycatch rates could be in the adjustment of setting time (for example, at dawn or dusk, or in the daytime), though this requires a comprehensive knowledge of the temporal movement and behavioural activity of seabirds (Bull, 2007), which is often lacking in the Mediterranean and the Black Sea.

1.4.2 Data collection: progress and challenges

Overall, most seabird bycatch records refer to longlines and set nets, which are often used in small-scale fisheries. However, in many geographical areas, small-scale fisheries are currently not monitored properly with regard to impacts on non-target species (Hanamseth *et al.*, 2018). Although less studied than industrial fisheries, small-scale fisheries may have negative effects on seabirds (Žydelis *et al.*, 2009; Laneri *et al.*, 2010). Furthermore, considering the scale and frequency of seabird bycatch in some areas of the Mediterranean, it is highly recommended to begin studying and understanding the nature and extent of interactions between seabirds and fisheries throughout the entire basin in a systematic way.

In fact, most of the available data on seabird bycatch are derived from opportunistic and irregular surveys, such as beach surveys, ringing-recovery programmes and non-systematic onboard observations. A relevant part of the data also comes from interview-based studies and self-reporting questionnaires, but the lack of a standardized protocol before recently (FAO, 2019) has impeded the assessment of data reliability and comparisons between studies (Moore *et al.*, 2010). Nevertheless, interviews with fishers can provide important qualitative information, especially for data-poor areas, and provide indications on the basic dynamics of seabird bycatch, such as the extent of its occurrence, the species involved and the most critical periods (Moore *et al.*, 2010; Cortés, Arcos and González-Solís, 2017). In general, alternative, and more robust, carefully designed monitoring methods (for example, standardized onboard observations and questionnaires, including for small-scale fisheries) are required to correctly estimate seabird bycatch (Žydelis *et al.*, 2009; Fangel *et al.*, 2015), despite the challenges involved with pursuing such objectives: effective onboard observer programmes are expensive, for example, and data collection is a time-demanding task, involving multiple shiptime operations over many trips (Moore and Žydelis, 2008; Žydelis *et al.*, 2009; Fangel *et al.*, 2015). Nevertheless, this approach currently seems to offer the most reliable way forward in understanding the impacts of fisheries on seabirds, as well as on other vulnerable species. The use of remote electronic monitoring by cameras – already used in some parts of the world to monitor bycatch – can be especially relevant for studies concerning small-scale fisheries, where systematic onboard observations are often not feasible (Moore *et al.*, 2010; Bartholomew *et al.*, 2018).

The current dearth of data is also due to the fact that the activities of all fishing vessels cannot be controlled systematically. Some Mediterranean fishing vessels are equipped with the satellite-based VMS, which provides data on location, course and vessel speed to fisheries authorities at regular intervals (GFCM, 2009, 2014; Burgos, Gil and Del Olmo, 2013). However, this monitoring system is only compulsory for European Union vessels above 12 m length overall and for non-European Union vessels above 15 m length overall, while smaller fishing vessels are not obliged to use this system. Similarly, these criteria also apply to the AIS, which helps to identify and monitor fishing vessels continuously (Kroodsma *et al.*, 2018).

The data presented in this review indicate that most seabird bycatch data come from small-scale fisheries (particularly longliners and set nets), which are active close to the coasts where the breeding or rafting sites of several seabird species are located. Unfortunately, small-scale fisheries use relatively small boats, from 6 to 15 m long (BirdLife International, 2017b; Cortés, Arcos and González-Solís, 2017; GFCM, 2018), many of which measure below the length requiring positioning systems. Therefore, to understand the potential impact of small-scale fisheries on seabirds, it is essential to obtain reliable information on the fishing effort of this vessel group, which entails knowing when, where and what gear they use year-round (Burgos, Gil and Del Olmo, 2013; GFCM, 2018).

In terms of regional instruments, the GFCM issued a recommendation for the development of mechanisms to record potential seabird bycatch incidences in Mediterranean fisheries and to keep them to the "lowest levels possible," specifically with regard to those species listed in the Barcelona Convention, and produced good practice guides for the handling of seabirds caught incidentally in Mediterranean drifting longline fisheries (GFCM, 2011; Tarzia *et al.*, 2017a; FAO and ACCOBAMS, 2018; FAO 2019). In addition, European Union countries can apply measures through the process detailed under Article 11 of the Common Fisheries Policy – specifically for measures related to marine protected areas (MPAs). However, no European Union country has yet proposed joint measures to tackle seabird bycatch in their MPAs through this process. The European Commission further proposed that the European Union adopt a regulation to conserve the marine environment through technical measures in 2016 (European Commission, 2016a), with the intention of applying baseline mitigation measures to all European Union longline vessels in the Mediterranean.

The above-mentioned developments reflect an increasing awareness of the issue of seabird bycatch in the Mediterranean Sea. This change also comes out of work carried out by many scientists (universities, research institutes, non-governmental organizations) in different countries (for example, Greece, Italy, Malta, Spain and Turkey) within the framework of research projects and programmes, such as the LIFE programme of the European Union (Hellenic Ornithological Society, 2012; Fundación Biodiversidad, 2014; BirdLife Malta, 2016, 2019; European Commission, 2021).

Overall, developments and technical advances in recent decades have allowed for new approaches in studying seabird–fishery interactions and identifying high-risk areas of incidental catch. The advances made in communication markets and in the miniaturization of electronics (sensors, batteries, improved memory storage) have increased exponentially the possibilities to study the biology and ecology of seabirds and other megafauna, including their physiology and behaviour, by means of satellite tracking, geolocation, GPS, accelerometers, ship radar detectors and other loggers (López-López, 2016; Hays *et al.*, 2016; Weimerskirch *et al.*, 2018). Furthermore, current

technical advances allow fishery data (such as VMS and AIS) gathered on a large spatial and temporal scale to be collected and made accessible, helping to identify areas with high fishing activity and relate these dynamics to seabird movement and behaviour (for example, Sugishita, Torres and Seddon, 2015; Soriano-Redondo *et al.*, 2016; Le Bot, Grémillet and Lescroël, 2018). Similar to seabird tracking data (for example, BirdLife International, 2021), the world wide web provides data from global ship tracking (VMS/AIS) on online platforms (for example Global Fishing Watch, 2017), enabling the assessment of potential overlaps between fishing effort and the distribution of marine megafauna, even in areas where surveillance is challenging owing to logistical issues. However, despite calls for the urgent implementation of these types of monitoring systems across the entire fishing fleet, including small-scale vessels, many fishing vessels are not yet obliged to carry monitoring systems (see above), undermining the potential of these approaches. A novel approach could be the use of cameras onboard fishing vessels to record the incidental catch of vulnerable species (for example, Bartholomew *et al.*, 2018).

Research projects over the last decade (2009–2019) have led to an increasing number of studies dealing with seabird bycatch in the Mediterranean Sea (for example, Darmanin, Caruana and Dimech, 2010; Laneri *et al.*, 2010; Karris *et al.*, 2013; Báez *et al.*, 2014; Ceyhan and Akyol, 2014; Garibaldi, 2015; Genovart, Oro and Tavecchia, 2017; Cortés, García-Barcelona and González-Solís, 2018). These investigations refer not only to scientific peer-reviewed publications, but also to reports from NGOs, such as BirdLife International and their national partners (for example, BirdLife International, 2009, 2017a; SEO/BirdLife, 2014). Besides the publication of valuable scientific papers and reports related to this topic, scientists and partners within research projects/programmes have also conducted awareness campaigns with dissemination activities and materials aimed at fishers (such as cards and posters to help identify seabird species). Furthermore, they inform authorities and provide recommendations to decision makers, as well as enable concerned citizens to understand and become aware of the issue of seabird bycatch. These activities include, for instance, the recruitment and training of volunteers, the distribution of questionnaires for the general public, meetings with institutions and national authorities, and events such as exhibitions and public lectures (for example, Fric, 2013).

In particular, seabird bycatch mitigation requires increasing commitment from national authorities to take responsibility for tackling the issue, with greater awareness and involvement from the fishing community (Cortés and González-Solís, 2018). For instance, under the framework of BirdLife International, together with their national partners, experts and scientists, a European Task Force has been established in order to enhance collaboration with fishers toward improving knowledge of seabird bycatch and developing technical solutions (Tarzia *et al.*, 2017a; BirdLife International, 2017b).

The data presented in this review are often sourced from questionnaire surveys of fishers. These interviews not only provided valuable information on seabird incidental catch, but they also raised the awareness of this issue among the fishing community. Some authors have already highlighted that the systematic collection of data depends greatly on the collaboration and willingness of fishers, which is often a limiting factor (Žydelis *et al.*, 2009; Fangel *et al.*, 2015; Oliveira *et al.*, 2015). This complication is understandable considering that logbook entries and questionnaires add extra work to the fishers' schedules and are related to an issue of a "somewhat discomforting character" for them, if they are asked to report detailed information on incidental catch (Fangel *et al.*, 2015).

This dilemma has been acknowledged by most scientists who collaborate with fishers; some scientists further highlighted that an intended "seabird bycatch mitigation strategy" should be targeted among other objectives, offering practical, easy to implement and manage, safe, and cost-effective alternatives for the fishers (Maree *et al.*, 2014; Cortés and González-Solís, 2018). A practical mitigation strategy would also be in the fisher's' best interests, at least for small-scale fisheries, where proper mitigation measures can not only reduce seabird bycatch, but also prevent bait loss and interruptions in settings when birds are released (BirdLife International, 2017b; Cortés, Arcos and González-Solís, 2017). In conclusion, there is currently an urgent need to improve the methods for recording fishing effort and incidental catch, particularly in small-scale fisheries, and to understand more precisely the factors influencing interactions between seabirds and fisheries in order to develop and implement appropriate mitigation measures. Finally, the achievement of these objectives can only be guaranteed through the assistance and collaboration of fishers, scientists, conservationists and policy makers (Oliveira *et al.*, 2015).

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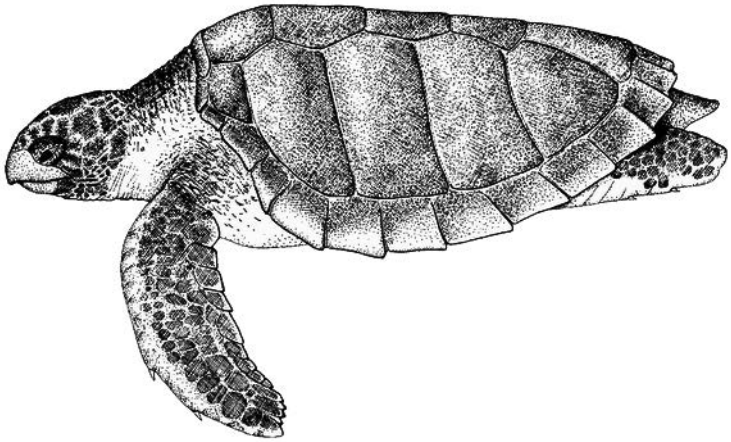
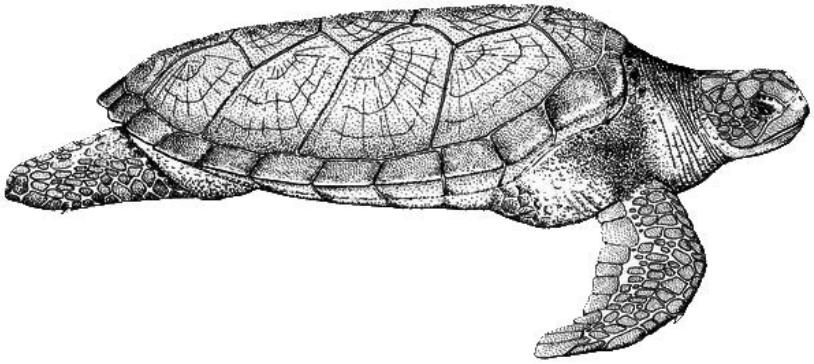
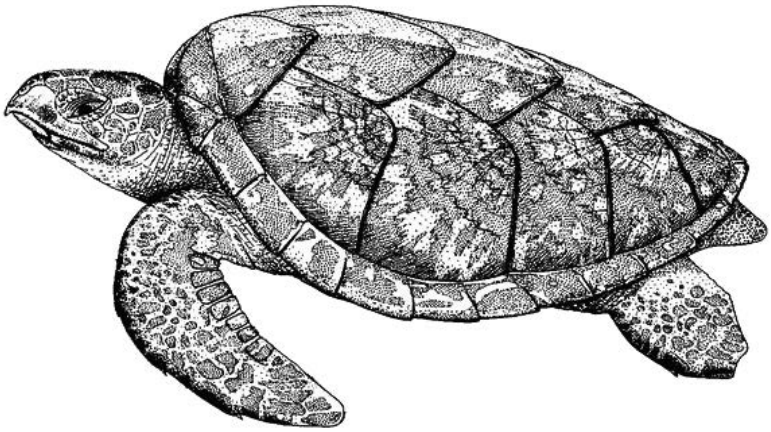


SEA TURTLES





Green sea turtles (*Chelonia mydas*)

2. Sea turtles

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Executive summary

In the Mediterranean and the Black Sea, scientific efforts over the last ten years have focused on the study of sea turtle biology, ecology and the protection of nesting sites. As a result, fairly complete information is available on sea turtles' major migratory routes, prey preferences, neritic foraging habitats, growth rates, genetic structure, and the areas hosting their main nesting sites, among other important traits and behaviours. However, some knowledge gaps still remain on key aspects of biology and ecology, particularly on interactions with sea turtles in areas of fishing activity. These gaps mainly persist because structured and standardized surveys for the observation of sea turtle bycatch have not yet been developed. The bycatch estimates presented in this review are mostly based on documents and data obtained by onboard observers and from interviews with fishers. These estimates are often biased, however, by a lack of reliable information representing the entire fleet and fishing effort, resulting in high variability between geographical areas, years and fishing gear. However, the information gathered up to now allows an outline to be drawn of the impacts of different types of fishing gear on sea turtles and of the most impacted areas. In the last ten years, bottom trawling has become the fishery with the greatest impact on sea turtles, registering around 51 000 capture events and an estimate of around 9 000 dead, largely concentrated on the continental shelves of the northern Adriatic Sea, Tunisia, Egypt and Turkey. Drifting longliners and set net fisheries are responsible for the bycatch of about 27 000 and 31 000 sea turtles, respectively, with about 5 300 and 16 000 dead, especially in the western and central Mediterranean. Set longlines catch around 12 000 sea turtles each year, causing the death of around 2 600, with the eastern and the southcentral Mediterranean the areas of main concern. The presence of sea

turtles in the Black Sea is so rare that it is not feasible to assess the impact of fishing activities, even if some specimens are occasionally found in set nets. Direct mortality rates show great variability between different types of fishing gear, but also within the same gear based on several factors: gear-related features (including mesh opening size and net slackness in passive nets, hook size and shape, branch line length in the longline, etc.); operational factors (e.g. soaking time in set nets, depth setting in the longlines, towing time in bottom trawls, etc.); environmental factors (such as sea water temperature); and ecological factors (e.g. sea turtle–fishery interactions occurring wherever fishing activities overlap with sea turtle habitats). Set nets, and especially trammel nets, appear to be responsible for the highest direct mortality rate (51 percent on average). Compared to the oldest estimates, the current figures seem to lend increased importance to bottom trawls, which could be considered the most impactful of fishing activities, while sea turtle bycatch in drifting longlines appears to be far less dramatic than depicted in the past. This shift is due to recent advanced data analysis, which considers the diversity of catch rates associated with longlines used in different areas and targeting different commercial species (such as swordfish, albacore and bluefin tuna). Moreover, the introduction of the mesopelagic longline, in early 2010, seems to have strongly reduced sea turtle bycatch in Spanish and Italian waters. In this regard, the implementation of technical solutions for reducing sea turtle bycatch in the Mediterranean is either low or non-existent. Thus, bycatch reduction devices (BRDs) should be tested more and adapted according to fishing gear, country and fishery. Apart from the negative impacts on sea turtle populations, the incidental catch of sea turtles can also cause losses in earnings through damage done to nets. Therefore, as many projects have demonstrated, collaboration with fishers is key to decrease incidental catch and reduce delayed mortality. Involving fishers and establishing permanent cooperation with them are fundamental for increasing the chances of sea turtle post-capture survival. Awareness campaigns on handling sea turtles should be further encouraged for fishers, personnel operating in the rescue centres, those involved in the protection of nesting sites and for local people who live in these coastal areas. However, this type of campaign needs to be complemented and reinforced by a binding cooperation between the fishing industry, management bodies and research institutions, whose collaboration is paramount for the protection of sea turtles.

2.1 Description of the group

The Mediterranean Sea hosts populations of three sea turtle species: the loggerhead sea turtle (*Caretta caretta*), the green sea turtle (*Chelonia mydas*) and the leatherback sea turtle (*Dermochelys coriacea*). While the loggerhead sea turtle is quite common everywhere in the Mediterranean, with important nesting sites in Greece, Libya, Turkey and Cyprus, the green sea turtle is less common and mainly inhabits the easternmost part of the Mediterranean (Turkey, Syria, Cyprus, Lebanon, Israel, Egypt, Greece and Libya), with nesting sites in Turkey, Cyprus and Syria. Some individuals of green sea turtle can be found rarely in the Adriatic Sea, in Tunisia, in Malta and in the western part of the basin. The leatherback sea turtle is rare, and although it is almost certain that the species does not nest in this basin, it is occasionally observed throughout the Mediterranean (Camiñas, 1998; Bradai and El Abed, 1998; Bradai *et al.*, 2004). The olive ridley turtle (*Lepidochelys olivacea*) is also found in the Mediterranean on rare occasions, having been reported in Spain (Revuelta *et al.*, 2015), as well as the Kemp's ridley (*L. kempii*) turtle, observed in Spain, France, Malta and Italy (Oliver and Pigno, 2005; Tomás and Raga, 2008; Insacco and Spadola, 2010; Sénégas, Sacchi and Lescure, 2016; Carreras *et al.*, 2014) and the hawksbill turtle (*Eretmochelys imbricate*), which has been reported in France, Albania, Malta, Tunisia and Spain (Mourgue, 1909; Frommhold, 1959; Groombridge, 1989; Brongersma and Carr, 1983; Mateo and Pleguezuelos, 2001; Gasc *et al.*, 2004; Bellido *et al.*, 2006;).

In the Black Sea, the loggerhead sea turtle (*Caretta caretta*) is found mostly in the western part of the basin (Nankinov, 1999), though there are no nesting beaches and observations are quite unusual (Márquez and Bauchot, 1987). Even rarer is the presence of the green sea turtle, with some sightings from the western side of the basin (Nankinov, 1999; Öztürk *et al.*, 2011), and one confirmed record from the eastern side in 2016, which was incidentally caught by a gillnet targeting Atlantic bonito (Orhan *et al.*, 2016). Accordingly, sea turtle bycatch seems not to be a conservation issue in the Black Sea.

Since the early 1980s, loggerhead, green and leatherback turtles have been included, among other sea turtle species, in the lists of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) and on the Red List of the International Union for Conservation of Nature (IUCN), although the conservation activities of several non-governmental organizations began even earlier, in the late 1970s (Casale *et al.*, 2018).

Human-induced, on-land threats to sea turtle populations are mainly associated with modifications made to the beaches hosting nesting sites. The construction of new buildings, coastal erosion and sediment changes (due, for example, to breakwater barriers, beach nourishment and beach cleaning) reduce the habitat available for nesting, thus preventing females from accessing suitable nesting sites. Furthermore, artificial lights from land can scare away females approaching the beaches and disorient hatchlings. Similarly, tourist activities can discourage females from coming ashore, with particular concern around motorboat strikes in busy waters frequented by sea turtles. In addition, the presence of other animals (such as dogs, foxes, birds and crabs) can present an issue for the survival of clutches and hatchlings. Indeed, it has been estimated that predation levels at unprotected nests can range from 38 to 80 percent of the individuals (Demetropoulos and Hadjichristophorou, 2010; Fuller *et al.*, 2010). Climate change can also have negative effects on sea turtle nesting areas, causing increased storm frequency and sea level rise, heightening the risk of nest inundation (especially of those not monitored) (Varela *et al.*, 2019), and can lead to a "coastal squeeze," i.e. reducing the number of beaches and amount of space available to the turtles (Casale *et al.*, 2018). Moreover, rising ambient temperatures, which affect incubation temperatures, can increase female sex bias or compromise the success of nests.

So far in the Mediterranean, stranded individuals represent the best available source of information on the relative importance of different threats. The indication is that interactions with fisheries constitutes one of the main causes of sea turtle mortality in the Mediterranean Sea (Camiñas, 2004; Bjerregaard Walsh, 2018; Casale *et al.*, 2018). Conversely, scientific studies on sea turtles in the Mediterranean, which began in association with conservation projects, have mainly focused on the monitoring and protection of nesting sites.

2.1.1 Loggerhead sea turtle

On a global scale, the IUCN Red List of Threatened species has listed the loggerhead sea turtle (*Caretta caretta*) as "Vulnerable," with a decreasing population trend observed (Casale and Tucker, 2017). However, according to the current IUCN Red List criteria, the status of the loggerhead sea turtle in the Mediterranean Sea has recently changed from "Endangered" to "Least Concern" (Casale, 2015). This revision is mainly due to the observation, in recent years, of a positive trend in the total number of nesting sites (used as an index of population abundance). However, using nesting females as a proxy for overall population dynamics comes with its own disadvantages and risks, as they represent only a small proportion of a sea turtle population. Moreover, the effort and

methodologies in the monitoring of nests can vary within and across study sites. Thus, the "Least Concern" status should be taken with caution and considered as entirely conservation-dependent, as the current population numbers are the result of decades' worth of intense conservation efforts, especially at nesting sites (Casale and Margaritoulis, eds., 2010), and the cessation of these programmes would likely be followed by a population decrease. Due to the long sexual maturation time of these animals and the available indexes of abundance (for example, nest counts), the Mediterranean subpopulation would probably not qualify for a threatened category within five years of the cessation of conservation programmes, as prescribed for triggering the "Near Threatened" category (IUCN Standards and Petitions Committee, 2014).

The loggerhead turtle is a highly migratory species inhabiting a wide range of habitats (<200 m depth) over the course of its lifetime. After hatching, young sea turtles begin an oceanic phase in major current systems, which are important for pelagic development. Heppell *et al.* (2003) report that sea turtle populations mainly consist of juveniles of small size that never come ashore. Juvenile loggerhead sea turtles usually float on the surface, are positively buoyant and prey upon epipelagic animals. After spending 4 to 19 years in pelagic environments, loggerhead sea turtles – once they have reached around 25 cm in curved carapace length (CCL) – gather together in neritic feeding areas rich in benthic prey and grow until they reach sexual maturity at 21 to 34 years (Avens and Snover, 2013 report 10 to 39 years; UNEP/MAP SPA/RAC, 2017). When foraging on the seabed, larger juveniles and adult loggerhead sea turtles feed upon benthic animals, like crustaceans (e.g. *Liocarcinus vernalis*) and molluscs, such as bivalves (e.g. *Mytilus galloprovincialis*), gastropods (e.g. *Bolinus brandaris*) and cephalopods. In some areas, they also feed on fish discarded by fishing vessels (Tomás, Aznar and Raga, 2001). In contrast, in oceanic habitats, loggerhead sea turtles are diurnal predators, spending most of their time close to the surface. Their diet is mainly composed of gelatinous plankton, such as jellyfish and tunicates, though it is also supplemented by fish and squid.

Adults migrate to breed between foraging grounds and nesting areas. During non-breeding periods, adults reside in coastal foraging habitats, sometimes with developing juveniles. Migration for breeding occurs every 2.5 to 3 years for females, while males have shorter migration intervals.

According to Wallace *et al.* (2010), the Mediterranean Sea is frequented by loggerhead sea turtles belonging to three independent regional management units: the Mediterranean, the northwest Atlantic and the northeast Atlantic; it seems that only individuals from the Mediterranean regional management unit reproduce in the region. The loggerhead sea turtle is common throughout the Mediterranean region, with high densities recorded in the westernmost part of the Mediterranean Sea (from the Alboran Sea to the Balearic Islands), the Strait of Sicily, Ionian Sea, Gulf of Gabès in Tunisia, Adriatic Sea, and off the southeastern coast of Turkey. Juveniles from rookeries originating in the Atlantic mostly remain within the westernmost part of the Mediterranean. The average size of nesting females has been used to estimate the age at sexual maturity of loggerhead sea turtles through growth models applied to size at maturity. The mean size of males and females nesting in the Mediterranean is 80 cm (Casale *et al.*, 2005a, 2014), with an average age at sexual maturity of 25 years (Casale and Heppell, 2016). Piovano *et al.* (2011) found that loggerhead sea turtles of Mediterranean origin grew faster than their conspecifics with Atlantic origins by exploiting the richer feeding grounds in the Mediterranean Sea. In agreement with Casale and Heppell (2016), they also discovered that the age of sexual maturity for loggerhead sea turtles of Mediterranean origin is 24 years; therefore, loggerhead sea turtles nesting in the Mediterranean are smaller and younger than those nesting in the western North Atlantic. Hochscheid, Kaska

and Panagopoulou (eds., 2018) reported that 8 653 to 11 638 loggerhead sea turtle clutches are documented annually at 25 major (>20 nests and >10 nests/km/yr) and 72 minor (<20 nests or <10 nests/km/yr) nesting sites. Based on an estimated clutch frequency of two nests per female annually, these figures correspond to approximately 1 822 nesting females per year. Casale *et al.* (2018) reported that most of the annual nesting sites for loggerhead sea turtles (around 96 percent of the total) are located along the coasts of Greece (more than 3 300), Turkey (around 2 800), Cyprus (around 1 360) and Libya (around 600, even if knowledge gaps exist for this country). Loggerhead sea turtle (*Caretta caretta*) nesting sites also occur in much smaller numbers annually in Lebanon (around 55) and Tunisia (around 22). In recent years, loggerhead sea turtles have been consistently exhibiting low levels of nesting activity at locations in the western (Spain, Italy, France and Malta) and eastern Mediterranean (Israel, Egypt and Syria). On average, each clutch comprises about 110 eggs and the mean hatching success ranges between 56 and 86 percent.

The duration of incubation is negatively correlated with nest temperature and varies between Mediterranean beaches, ranging from 36 (Mingozzi *et al.*, 2007) to 89 days (Margaritoulis, 2005; Margaritoulis, Rees and Riggall, 2011).

Within the Mediterranean, the distribution of the loggerhead sea turtle is driven by the basin's main circulation system, as studies based on genetics, tagging and incidental catch have demonstrated – see Casale *et al.* (2018) and references therein. Recent satellite tracking studies and data from incidental catches of loggerhead sea turtle have revealed the southern Tyrrhenian Sea to be an important area for juveniles and adults foraging on pelagic prey (Blasi and Mattei, 2017; Luschi *et al.*, 2018). Other pelagic areas observed, probably used as foraging sites, are off Algeria, in the Strait of Sicily, and in the western and central Ionian Sea. Unfortunately, similar satellite tracking data are not available for all areas, particularly for the Levantine Basin.

Neritic foraging grounds are more frequented by larger individuals. The Levantine Basin seems to provide a nursery area for loggerhead sea turtles originating from eastern rookeries, whereas sea turtles hatching in Greece and the central Mediterranean nesting areas disperse mainly througout the Ionian Sea, southcentral Mediterranean and Adriatic Sea (Casale and Mariani, 2014). These dispersal patterns are supported by high incidences of small sea turtle (<30 cm) strandings along the Ionian and Adriatic coasts of Italy and the southern coasts of Turkey. Based on simulations, dispersal into the western basin is unlikely to occur during the first six months of life. The western basin of the Mediterranean is considered less suitable, as post-hatchlings would not survive the cold-water winter temperatures. However, recent observations of sporadic nesting sites on Spanish, French, and Tuscan (North Tyrrhenian Sea) coasts suggest increasing dispersal capabilities of the loggerhead sea turtle and the colonization of new suitable habitats, indicating an adaptability to changing environments (Sénégas *et al.*, 2009; Carreras *et al.*, 2018).

A rough indication of the abundance of individuals can be provided by specimens collected as incidental catch, particularly by bottom trawlers. The highest catch rates of loggerhead sea turtles in the Mediterranean have been observed over the continental shelves off Tunisia, in the Adriatic Sea and in the easternmost part of the Levantine Basin, off Turkey, Syria and Egypt (Casale, 2011). These results are also supported by flipper tagging, stranding reports and satellite tracking (Luschi and Casale, 2014). Loggerhead sea turtles are furthermore known to frequent some neritic areas in the western Mediterranean, including Spanish waters, the Balearic Islands and, to a lesser extent, the southwestern coast of Italy. Usually loggerhead sea turtles tend to spend the winter within or near their foraging areas.

In an attempt to provide a rough calculation of the loggerhead sea turtle population living in the Mediterranean, starting from nest counts and using other available data, Casale and Heppell (2016) estimated that the loggerhead turtle population (with several assumptions) lay between 1 200 000 and 2 360 000 individuals. Importantly, the population trend, based on a temporal comparison of nesting sites, seems to be positive.

2.1.2 Green sea turtle

The green sea turtle (*Chelonia mydas*) is listed as "Endangered" in the IUCN Red List and a decreasing population trend is observed (Seminoff, 2004). Young green sea turtles leave their nesting beaches just after hatching and begin an oceanic phase, floating passively in major current systems serving as pelagic habitats for development. After a number of years in these pelagic environments, the young turtles gather in neritic areas, rich in seagrass and/or marine algae, where they forage and grow until maturity. Once they reach sexual maturity (27–50 years), they begin to make breeding migrations between foraging grounds and nesting areas. During non-breeding periods, adults inhabit coastal neritic feeding grounds that sometimes coincide with juvenile developmental habitats.

The green sea turtle is mainly concentrated in the eastern basin, particularly in the Levantine Basin, where post-hatchling green sea turtles are well distributed (Turkey, Syria, Cyprus, Lebanon, Israel and Egypt). The presence of juveniles in Greece and the central and southern Adriatic Sea, suggests that green sea turtles might be using oceanic habitats when migrating from natal sites to the Adriatic Sea. Indeed, monitoring studies show that nesting activity is increasing, reflecting an upward trend in adult female individuals.

Recent studies suggest that the Levantine Basin provides the main nursery area for green sea turtles. Turkey, Cyprus and Syria host the main nesting sites of green sea turtle, with about 1 450, 620 and 140 nests per year, respectively (Casale and Heppell, 2016; Casale *et al.*, 2018). Meanwhile, Hochscheid, Kaska and Panagopoulou (eds., 2018) reported that between 1 164 and 2 674 green sea turtle clutches are laid annually in 12 major (>20 nests and >10 nests/km) and 53 minor (<20 nests or <10 nests/km) nesting sites in Turkey, Cyprus and Israel. No updated data have come from Lebanon and Egypt, where green sea turtle nesting also occurs. An estimated clutch frequency of three nests per female per season leads to an approximate calculation of 784 nesting females per year. On average, each clutch produces 114 eggs and hatching success ranges between 70 and 77 percent, while the mean incubation duration ranges from 49 to 60 days. Females are known to revisit their natal beaches at two- to four-year intervals to lay their eggs.

Information on the neritic foraging sites of green sea turtles is scarce, but stranding reports and incidental catch data have revealed that their feeding grounds are mainly distributed along the coasts of Turkey, Cyprus, Syria, Egypt, Libya, Greece and in the southern Adriatic Sea, and that the green sea turtle begins to frequent neritic waters at smaller sizes than the loggerhead sea turtle. Stokes *et al.* (2015) found furthermore that the coastlines of Egypt and Libya host high densities of migrating green sea turtles following the nesting season, particularly in July–September, and likely also during the pre-nesting period (April–June). Therefore, Libya and Egypt can be considered as important foraging grounds for this species. Indeed, recent satellite and stable isotope analyses have similarly suggested that Egypt is a major contributor to nesting aggregations in Cyprus (Bradshaw *et al.*, 2017).

The diet of green sea turtle juveniles is similar to that of loggerhead sea turtles, while adults larger than 60 cm are primarily herbivores, feeding mainly on the seagrass *Cymodocea nodosa*, which grows in shallow and sheltered bays (Casale *et al.*, 2018). In Cyprus, green sea turtle juveniles larger than 30 cm also feed on seagrass (Cardona *et al.*, 2010).

Using similar methods for calculating loggerhead sea turtle numbers, Casale and Heppell (2016) have estimated that the green sea turtle population in the Mediterranean Sea ranges from 261 000 to 1 252 000 individuals, and importantly that the population trend overall is positive.

2.1.3 Leatherback sea turtle

The leatherback is an oceanic, deep-diving sea turtle inhabiting tropical, subtropical and subpolar seas and listed as "Vulnerable" in the IUCN Red List of Threatened Species (Wallace, Tiwari and Girondot, 2013). So far, only one comprehensive review of the available data for the leatherback sea turtle (*Dermochelys coriacea*) in the Mediterranean has been published (Casale *et al.*, 2003), while several scientific papers report the presence of this species at the local level (for example, Taškavak and Farkas, 2013; Karaa *et al.*, 2013; Bearzi *et al.*, 2015). This species is the largest sea turtle and is able to carry out extensive migrations between different feeding areas during different seasons, to and from nesting areas. Indeed, the Mediterranean pelagic feeding grounds of leatherback sea turtles are frequented by individuals from Atlantic populations. Both adults and large juveniles (>145 cm) seem to frequent the Mediterranean (Casale *et al.*, 2003), while small juveniles are limited to tropical waters and do not enter. It is worth noting that small juveniles have never been reported, suggesting that neither the Mediterranean nor the Northeast Atlantic are areas in which the Atlantic populations of this species spend time as small juveniles (Casale *et al.*, 2003). As further evidence, a distribution analysis by Eckert (2002), based on 98 small individuals (<145 cm) around the world, suggested that leatherback sea turtles do not leave tropical waters before reaching a size of about 100 cm, probably due to thermal constraints.

Reproduction in Mediterranean waters is considered absent or exceptional (Lescure, Delaugerre and Laurent, 1989). The main nesting areas of this species are concentrated in the tropical waters of Central and South America (Camiñas, 1998). Females produce multiple, i.e. between three and ten clutches of 60 to 90 eggs during the nesting season, with a migration interval of multiple years (2+) between subsequent reproductive seasons. The leatherback sea turtle seems to feed mainly on jellyfish, salps, siphonophores, and other pelagic invertebrates (Bjorndal, 1997).

Casale *et al.* (2003) collected a total of 411 individual records for the whole Mediterranean. Most of the specimens were found stranded and had probably been caught by small-scale nets, longlines or trawls. Meanwhile, Karaa *et al.* (2013) noted a total of 51 records of leatherback sea turtles in Tunisian waters (based on scientific and grey literature, including technical and scientific congress reports, as well as on unpublished/personal observations), mainly during the warm period of the year, possibly as a result of the abundance of jellyfish during that season. On the other hand, the data available may reflect the consequences of intensified human activities during the warm period of the year rather than the actual temporal distribution of the species. Similarly, Camiñas *et al.* (2018) reported that from 1999 to 2016, ten leatherback sea turtles were found in the incidental catch of the Spanish surface longline fleet in the western Mediterranean Sea. In this area, the observed incidental capture of leatherback sea turtles corresponded to 0.001 catches/1 000 hooks. Likewise, during a similar period, 32 stranded leatherback sea turtles were documented in the Alboran Sea from 1997 to 2015 (Bellido Lopez *et al.*, 2018). In

contrast, only a few specimens were recorded in the eastern basin, including from Greece, Syria, Israel, Cyprus, Turkey and Egypt (Casale *et al.*, 2003). It is possible that the distance from the Atlantic is only one of the factors determining the distribution of this highly vagile species in the Mediterranean (Casale *et al.*, 2003).

2.2 Historical records of interactions with fisheries

In the Mediterranean Sea, sea turtles have been historically exploited by fisheries for food and trade since the late nineteenth century through the mid-1960s (Margaritoulis *et al.*, 2003), especially in the Levantine Basin (Hornell, 1935; Sella, 1982). Sea turtles were fished mainly at sea, though the available information reports that sea turtles were also collected from their nesting beaches. While green sea turtles were primarily targeted, the loggerhead turtle population was impacted as well. At the beginning of the last century, the loggerhead sea turtle was considered the most abundant species (Gruvel, 1931), and Flower (1933) highlighted the importance of the loggerhead sea turtle in the so-called turtle soup. According to Sella (1982), it is estimated that from the end of the First World War to the mid-1930s, at least 30 000 sea turtles, both green and loggerhead, were caught in the eastern Levant Sea. However, it is difficult to assess the impact of sea turtle fisheries, as stated by Sella (1982) and Mendelssohn (1983), as intensive fishing was carried out not only for local consumption but also for export, mainly to the United Kingdom of Great Britain and Northern Ireland, resulting in a high exploitation of the *Chelonia* population in the eastern Mediterranean, across Cyprus, Lebanon, Egypt and Turkey (see Gruvel, 1931; Nada, 2005; Venizelos and Nada, 2000; Boura, Abdullah and Nada, 2015).

As far as other Mediterranean areas, the first records in Italy are from Faber (1883) and Stossich (1880), who reported that *Chelonia caretta* (an earlier scientific name of the loggerhead sea turtle) was quite common and even caught in the Trieste harbour, while a few specimens of green sea turtle (*Chelonia mydas*) were caught in the Adriatic Sea. The Clodia database (Università degli Studi di Padova, 2020) of the Chioggia fish market (Italy, northern Adriatic Sea) reports sea turtle landings from the Second World War through 1988, when an annual average of 0.13 tonnes of sea turtle (likely loggerheads) were sold at the market, with peaks in 1968 (0.8 tonnes) and 1972 (0.9 tonnes). Similarly, sea turtles were included on a price list of an unpublished statistical report conducted between 1895 and 1987 in Croatia (Lazar, 2010). Mingaud (1894) reported the first capture of loggerhead sea turtles in France, and Laurent *et al.* (1997) stated that some specimens observed at the Station biologique de Tamaris (Provence, France) were captured between 1920 and 1927. More recently, Di Palma (1978) documented a specialized fishery operating in the Aeolian Islands, north of Sicily (Italy) before 1980, catching about 500 to 600 sea turtles per year. Although fishing for sea turtles has been banned in Italy since 1980, the exploitation of incidentally caught sea turtles allows for the continuation of some local traditions involving the illegal sale of sea turtle shells (Argano *et al.*, 1990). Additional studies revealed that green sea turtle meat was historically sold also in Malta (Gramentz, 1989), Spain (Mayol and Castello Mas, 1983), Algeria and Morocco (Laurent, 1990). Furthermore, Benhardouze *et al.* (2004) and Benhardouze *et al.* (2009) investigated the use of loggerhead turtles in northern Morocco and did not observe meat being sold in stores or markets, though some loggerhead carapaces were still sold as late as 2003 in craft shops or displayed as decoration on restaurant walls.

In Tunisia, Laurent and Lescure (1994) reported that loggerhead turtles caught by the Tunisian fishing fleet in 1990 were being sold on the market. The Port Services Agency declared that 883 sea turtles were landed in 1986, 2 122 in 1987 and 2 913 in 1988 (Laurent and Lescure, 1994;

Laurent *et al.*, 1990). Although the sale of sea turtles in Tunisian fish markets was prohibited in 1990, there has persisted a black market for local consumption (Laurent *et al.*, 1996) or for carapaces as ornaments (Bradai, 1993). Laurent *et al.* (1996) similarly reported that in Egypt, both loggerhead and green sea turtles were sold at fish markets, despite legislation prohibiting this practice. In addition, a study based on interviews with fishers in Syria in 2004 revealed the existence of a sea turtle market (Jony and Rees, 2009).

In general, direct harvesting of sea turtles for commercial purposes declined after the 1970s due to the introduction of protective legislation and trade restrictions in all Mediterranean countries. However, sea turtle incidental catch concerns began growing from 1960 to 1970, in response to the increasing industrialization of fishing practices and fishing effort.

Subsequently, at the end of the 1980s through the beginning of the 1990s, studies on sea turtle bycatch started to produce reliable data (e.g. Camiñas, 1988; Laurent, 1990; Bradai, 1992; De Metrio and Megalofonou, 1988). Indeed, incidental catch estimates reported up to the beginning of 2000 made it possible to identify the most problematic areas, though the reported data should be considered with caution, due to a lack of information from several Mediterranean subregions and of procedures for data standardization. Lewison, Freeman and Crowder (2004) have suggested that the Mediterranean is a global hotspot for interactions between longlines and loggerhead sea turtles and estimated that between 60 000 and 80 000 loggerhead sea turtles were captured by drifting longliners in 2000 alone. However, their analysis was based on the assumption of homogeneous incidental catch rates covering the entire region, which may actually differ from reality (Báez, Real and Camiñas, 2007; Camiñas *et al.*, 2006a, 2006b; Báez *et al.*, 2007).

A detailed review of data from sea turtle–fishery interactions before 2000 was carried out by Gerosa and Casale (1999), who showed that drifting longlines had the highest interaction rates with sea turtles, followed by bottom trawls and set nets. Drifting longlines targeting swordfish (*Xiphias gladius*) and albacore (*Thunnus alalunga*) appeared to be the fishing method incidentally catching the most loggerhead sea turtles – almost entirely in the western and central parts of the basin (Demetropoulos and Hadjichristophorou, 1995). In the Mediterranean Sea, only one of the three species present, the loggerhead sea turtle, was regularly noted among the incidental catch of this fishing method. Panou *et al.* (1992) reported around 35 000 loggerhead sea turtles caught annually as bycatch in the western and central Mediterranean, of which 15 000 to 20 000 specimens or more were caught each year by the Spanish fishing fleet off the Balearic Islands (Camiñas, 1988; Aguilar, Más and Pastor, 1995). Furthermore, Aguilar, Más and Pastor (1995) showed that the highest catch rate (9.8 sea turtles per boat daily) was observed in the southwestern Mediterranean in 1990. In contrast, the catch rate strongly decreased (0.16 sea turtles per boat daily), according to Panou *et al.* (1992, 1999), in the Greek waters of the Ionian Sea.

Nevertheless, in terms of mortality, non-homogeneous results have been obtained by various authors, with mortality rates ranging from 0 percent (Ogren, 1994) to 29.5 percent (Balazs and Pooley, eds., 1994). The available data indicate that 15.6 percent of captured specimens show the hook inserted in the mouth (Aguilar *et al.*, 1995); this type of hooking usually allows the the animal to survive. In general, direct mortality induced by longlines appeared to be low; this conclusion was supported by the fact that hooked loggerhead sea turtles are able to maintain enough power to raise themselves with the lines to the surface and breathe. The greatest number of sea turtles caught with drifting longlines was reported between June and August and mainly consisted of juveniles and subadults, ranging from 27 to 50 cm CCL. The catch rate with set

longlines was unknown at that time, and the mortality rate was clearly related to the depth setting (one main line at a depth greater than 200 m) (Bolten, Bjorndal and Martins, 1994). Indeed, set longlines were considered responsible for a potential mortality (delayed) of about 40 percent, as hooked juveniles could not reach the surface to breathe (Casale, 2008; Casale, Freggi and Rocco, 2008; Jribi *et al.*, 2008).

Bottom trawls were considered the second most impactful of fishing gear types for sea turtle populations, in terms of number of catches per year. Loggerhead sea turtles are probably incidentally caught in bottom trawls during towing operations occurring while sea turtles forage along the bottom. Records available before 2000 showed a significant incidental catch rate in Tunisia (2 000–5 000 sea turtles caught per year; Bradai, 1992; Laurent *et al.*, 1996) and in the Adriatic Sea (2 500 sea turtles caught per year; Lazar and Tvrtkovic, 1995). Sea turtle bycatch was reported also in Egypt (Laurent *et al.*, 1996), Turkey (Laurent *et al.*, 1996) and Greece (Margaritoulis *et al.*, 1992), especially on shallower sea bottoms (Oruç, 2001; Oruç, Demirayak and Sat, 1996), although estimates were not available at that time. More recently, Casale, Laurent and De Metrio (2004) reported more than 4 200 loggerhead sea turtles caught annually in the northwestern Adriatic; Margaritoulis *et al.* (2003) recorded around 300–400 loggerhead and 200 green sea turtles captured each year in Greece; Casale *et al.* (2007) reported around 4 000 loggerhead sea turtle catches per year by Italian trawlers in the central Mediterranean; and Jribi, Bradai and Bouain (2004, 2007) recorded more than 5 000 loggerhead sea turtles caught annually in Tunisia: individuals between 50 and 70 cm CCL represented the majority of the impacted population. Fortuitously, the direct mortality rate was judged not to be very high, ranging from 0 to 10 percent (Tunisia) of capture events (Jribi, Bradai and Bouain, 2004, 2007).

Gillnets are a traditional type of fishing gear used widely across the Mediterranean and present in all coastal zones. Although poor historical data are available for this type of fishing, a high mortality rate (around 74 percent) is reported from different Mediterranean countries (for example, Argano *et al.*, 1992). Concerning trammel nets, the mortality rate records available in the literature are: 94.4 percent for the loggerhead sea turtle in Corsica, with trammel nets placed at depths of >60 m (Delaugerre, 1987), 53.7 percent in France (Laurent, 1991) and 83 percent in Croatia (Lazar, Ziza and Tvrtkovic, 2006). In contrast, lower mortality rates were found in Tunisia, at 5.2 percent (Bradai, 1993).

Beginning in the late 1970s and early 1980s, attention was focused on driftnets (local names include *spadara* and *thonaille*) targeting large pelagic fish species, due to their impacts on marine mammals, pelagic sharks and sea turtles. Indeed, by the end of the 1980s, intensive use of large driftnets in the Mediterranean had led to a marked decline in large pelagic vertebrates (i.e. sharks, cetaceans and sea turtles), as well as overexploitation of target species, for example, swordfish (Tudela, 2004). Since a very similar scenario had been described in several countries around the world, the use of driftnets raised conservation concerns on a global scale. This fishing method spread quickly in the 1980s, spurred by a desire for higher catch efficiency, which encouraged fishers, for example, to use the swordfish driftnet instead of the traditional longline technique, as it was considered more selective and less harmful for the environment. The unrestrained use and lengthening of nets (up to 60 km) began to worry various governments because of the excessive pressure put on the stocks of target species and the number of marine mammals incidentally captured (Northridge, 1991). As a result, driftnets longer than 2.5 km have been banned in European Union waters since 1992, except in some specific areas (Council of the European Union, 1992).

From 1998, all driftnets, irrespective of size, have been prohibited in European Union countries when intended for capturing highly migratory species, such as bluefin tuna, tuna-like species, swordfish, and large and medium-sized pelagic species in general (Council of the European Union, 1997; 1998; 2007), thus shifting the burden of incidental catch issues from the northern part of the Mediterranean basin to the southern part. Nonetheless, illegal drift netting by European fishing vessels continues to be reported, prompting criticism of European Union compliance with international obligations (Oceana, 2009). In 2003, the use of these nets was therefore also banned by the International Commission for the Conservation of Atlantic Tunas (ICCAT) through Recommendation [03–04] relating to Mediterranean swordfish, which was adopted in 2005 by the General Fisheries Commission for the Mediterranean (GFCM) through its Recommendation GFCM/29/2005/3 concerning selected ICCAT recommendations. Although this gear has been in use for over fifteen years, the catch data available and experts' opinions remain controversial; while it is certain that considerable incidental capture of marine mammals has occurred, the number of sea turtles caught is still little known. Data from research carried out in the Tyrrhenian Sea and the Ligurian Sea between 1990 and 1991 by Di Natale (1995) show an average bycatch per unit effort (BPUE) of 0.005 loggerheads/km of net for about 100 fishing vessels. Bănaru *et al.* (2010) reported similar values for French driftnets (0.002 loggerheads/km of net) operating illegally up to 2007–2009. Furthermore, Aguilar, Más and Pastor (1995), and Silvani, Gazo and Aguilar (1999) reported catches of a few hundred loggerhead sea turtles per year in Spain. Other data presented a much more worrying situation: De Metrio and Megalofonou (1988) estimated 16 000 loggerhead sea turtle captures seasonally by a small group of 29 vessels operating near the Ionian coast of Calabria with nets up to 12 km long, and a 20–30 percent mortality rate. In general, it is reasonable to assume that driftnets have been very dangerous when placed along the migratory routes of sea turtles moving from feeding zones to nesting areas and vice versa.

2.3 Analysis of recent data from literature (2008–2019)

Available data on sea turtle bycatch in the Mediterranean Sea have increased over time and become more reliable as monitoring programmes have expanded, along with data standardization. However, the information remains biased since it is not distributed equally over the Mediterranean and Black Sea. Moreover, the data obtained for most areas and types of fishing gear used do not come from specific monitoring surveys, adding uncertainty to the viable quantification of captures and mortality. Often, data could only be gathered opportunistically, therefore representing single incidences of sea turtle bycatch. Furthermore, Mediterranean and Black Sea fisheries are essentially multi-species- and multi-gear-oriented, while fishing fleets mostly consist of small artisanal vessels, i.e. vessels of the small-scale fisheries (SSF) sector, dispersed in small ports or along the coast. Therefore, the collection of data on incidental catch is difficult, and extrapolating the data from the few surveys conducted often comes with biases, due to the lack of reliable information representative of the entire fleet. Similarly, information from large-scale vessels in some areas can be biased due to a lack of knowledge (for example, of vessel numbers and catch composition) and the relative importance of the different vessel groups

In the last ten years, information on sea turtle bycatch collected by onboard observers has been collated with information derived from interviews with fishers and logbooks. Sea turtle incidental catch data collected by direct interviews have the potential to help develop effective conservation measures, even if their results might underestimate the true figures of sea turtle bycatch (FAO, 2019; Carruthers and Neis, 2011; Lucchetti, Vasapollo and Virgili, 2017b; Casale *et al.*, 2020).

The information gathered up until now, especially over the last ten years, does allow for an outline to be drawn of the impacts caused by the various types of fishing gear and of the most impacted areas, i.e. different types of fishing gear may induce different capture and mortality rates and affect different ecological phases of sea turtles in different areas. Sea turtle–fishery interactions occur wherever fishing activities overlap with sea turtle habitats (Lucchetti, Punzo and Virgili, 2016; Lucchetti, Vasapollo and Virgili, 2017a, 2017b). For example, the capture of loggerhead sea turtles depends on various parameters, with the most important factor being fishing effort: number of vessels, engine power, i.e. kilowatts, horsepower and gross tonnage, time at sea (e.g. hours per day, days per year), number of hooks on longlines, and so on. All these parameters are essential, though mortality rates vary and largely depend on gear type, onboard practices and the sea turtles' ability to survive forced apnoea due to the long soaking time of nets (i.e. turtles can be forcibly submerged for lengths of time greater than their average dive times, which may result in the turtles becoming comatose and eventually drowning) (Lutcavage and Lutz, 1997). Therefore, to properly understand sea turtle bycatch rates and impacts, it is necessary to determine the types of fishing gear used, the fishing effort and areas exploited, as well as the sea turtle habitats and their movement patterns.

The current review should be considered as an updated estimate of sea turtle bycatch rates in Mediterranean and Black Sea fisheries; when no recent information was available, historical data (prior to 2008) were used. However, in general, outliers (data that differ significantly from other collected observations) have not been used for the purposes of this review. In cases where multiple estimates were available for the same area and fishing gear from different bibliographic sources, the most recent fishery data were considered. For each type of fishing gear, mean mortality rates obtained for the entire Mediterranean were examined, even though this is not the best way to make estimates at the basin level, as the mortality rate depends on many factors. However, for some areas no data were available, leaving mean rates as the only way to make estimates.

Overall, it was possible to estimate sea turtle bycatch and the mortality induced by different types of fishing gear as summarized in Table 1. Nevertheless, it should be noted that data for some countries and types of fishing gear were missing, so the estimate could be biased.

As highlighted in Table 1, the differences between the data produced by Casale (2011) and the data collected up to 2018 are mainly due to Casale's inclusion of incidental catch estimates for drifting longlines. The most recent review of Mediterranean incidental catch (Casale *et al.*, 2018), estimated that over 132 000 sea turtles were caught annually, of which 44 000 might be dead.

It is useful to underline that the estimates made in previous reviews by Casale (2008; 2011), which represent an important portion of the available data, were obtained for certain areas, by expanding the same sea turtle bycatch data, i.e. BPUE, published by other authors to the fishing effort in those areas.

For the types of fishing gear described, the FAO code provided in the International Standard Statistical Classification of Fishing Gear (ISSCFG) (FAO, 2016); Nédélec and Prado, 1980) is also reported.

2.3.1 Bottom trawlers

Based on estimates made after 2008, Mediterranean bottom trawlers are considered to catch a total of around 50 000 sea turtles per year (Table 1), with a corresponding mortality rate of

TABLE 1 – Incidental catch of loggerhead sea turtles (capture events per year) and mean mortality estimates for the most important types of fishing gear in the Mediterranean Sea, by GFCM subregion

	Bottom trawl (mean mortality 18%)		Drifting longline (mean mortality 20%)		Small-scale (mean mortality 51%)		Set longline (mean mortality 23.9%)		Total	
	Bycatch	Dead	Bycatch	Dead	Bycatch	Dead	Bycatch	Dead	Bycatch	Dead
Adriatic Sea	18 204	3 277	1 251	250	8 908	4 543	0	0	28 363	8 070
Central Mediterranean	19 732	3 552	14 472	2 894	6 157	3 140	5 270	1 260	4 5631	10 846
Eastern Mediterranean[1]	10 430	1 877	2 210	442	13 826	7 051	6 843	1 635	33 309	11 006
Western Mediterranean	2 300	414	8 786	2 410	2 058	1 050	258	62	13 402	3 382
Western Mediterranean[2]			37 828	7 566					42 444	9 091
Total	**50 666**	**9 120**	**26 719**	**5 344**	**30 949**	**15 784**	**12 371**	**2 957**	**120 705**	**33 204**
Total[2]			**55 761**	**11 152**					**149 747**	**39 013**

Notes:

1. Loggerhead and green sea turtle data are reported together because separate information on the two species is not always available.
2. Bycatch and direct mortality estimates in grey calculated by Casale (2011) for drifting longline bycatch in Spain and Morocco.

around 18 percent. Although catch rates are high, mortality rates are regarded as being relatively low. Therefore, other fishing vessels, such as those using set nets, while they may exhibit lower catch numbers, can have an effect comparable to that of bottom trawlers in terms of the resulting mortality.

The bottom trawl has historically been recognised as the second most impactful fishing gear on sea turtle populations in terms of the number of catches per year. However, recent estimates (Lucchetti, Vasapollo and Virgili, 2017a, 2017b) obtained from Italian waters alone have suggested that the impacts of this gear are comparable or even greater than those of drifting longlines.

Bottom trawlers mainly affect sea turtles in their demersal phase, as they prefer coastal shallow waters for feeding when they are juveniles and subadults. The data available after 2008 confirm that the Gulf of Gabès, the northern and central Adriatic Sea, southern Turkey, and, to a lesser extent, Egypt and southern Sicily represent hotspots for sea turtle–bottom trawler interactions, due to the shallow waters (<100 m deep) and rich benthic communities that make these areas the most important neritic feeding habitats in the whole Mediterranean (see Table 2).

Western Mediterranean

This area of the Mediterranean generally shows a low annual level of sea turtle bycatch due to trawlers: Spain (around 200–400 individuals), France (around 25–100), Morocco (around 200), Italy (around 300) and Algeria (around 650) (Casale 2008, 2011; Alvarez de Quevedo *et al.*, 2010). An exception comes from the neritic habitat near the Valencian Community (eastern Spain; around 200–300 sea turtles; Domènech *et al.*, 2015), as this area mainly hosts oceanic foraging habitats for sea turtles. Therefore, in the western Mediterranean, drifting longlines, rather than bottom trawls, are the major concern.

Central Mediterranean

The wide central Mediterranean area is known to host oceanic and neritic habitats for loggerhead sea turtles. Around 4 000 sea turtles per year are estimated to be caught in the Strait of Sicily,

mainly around the island of Lampedusa, due to the high fishing pressure from bottom trawlers in this area (Lucchetti, Vasapollo and Virgili, 2017a, 2017b; Casale *et al.*, 2007).

Jribi, Bradai and Bouain (2004, 2007) have also estimated that the annual incidental catch in bottom trawls in the Gulf of Gabès area (Tunisia) alone is around 5 500 sea turtles. Furthermore, in other Tunisian fishing grounds, about 10 000 sea turtles overall are estimated to be caught annually. Casale *et al.* (2007) have likewise confirmed the importance of this area for both juveniles and adults of loggerhead sea turtle (*Caretta caretta*). Elsewhere, more than 4 000 sea turtles per year appear to be caught in Libya (Casale, 2011), while a few catches are reported from Greece, mainly during the winter (Margaritoulis and Teneketzis, 2003).

Adriatic Sea

The northern Adriatic, with its shallow waters, flat seabed and rich benthic communities, is a major feeding habitat for sea turtles nesting in Greece, Turkey, Cyprus and Libya (Bertuccio *et al.*, 2019), as well as an important fishing ground for bottom-towed fishing gear (Lucchetti and Sala, 2012). Indeed, geographical subarea 17 (i.e. the central-northern Adriatic) is frequented by over 1 000 bottom trawlers, mainly from Italy and Croatia, and to a lesser extent from Slovenia, Montenegro and Albania, while aerial surveys have made it possible to estimate the sea turtle population in the Adriatic Sea at over 70 000 turtles (Fortuna *et al.*, 2011). Therefore, loggerhead sea turtle-trawler interactions are quite common. This area, due to its geomorphological characteristics, could represent a natural cul-de-sac for sea turtles, especially for those wintering in this basin, so that multiple incidental catch events (up to eight sea turtles caught hourly during towing; A. Lucchetti, personal observation, 2018) are not uncommon. Therefore, the Adriatic Sea represents a key area for the management and conservation of this species, and especially for the population nesting in Greece.

Lucchetti, Vasapollo and Virgili (2017a, 2017b) recently reported that more than 14 000 capture events may occur annually in the Adriatic Sea, involving only the Italian fishing fleet. Furthermore, Lucchetti *et al.* (2018) clearly showed that the Rapido trawl (a type of beam trawl rigged with 5–7 cm long teeth) is also heavily responsible for sea turtle bycatch and sea turtle injuries following impacts with its rigid frame and teeth. Casale, Laurent and De Metrio (2004) reported around 4 300 capture events annually in the northwestern Adriatic alone, but they also observed that incidental catch rates in the eastern part of the Adriatic Sea were 15 times higher than in the western part. Elsewhere, although incidental catch estimates available for Croatia are quite old and based on the work of Lazar and Tvrtkovic (1995), these authors estimated around 2 500 catches annually, of which around 500 came from the centre and 2 000 from the northern coastal areas of Croatia. However, this figure was obtained through interviews and therefore may be an underestimate. Around 560 sea turtles were also estimated to be caught annually by Albanian fishers, according to Casale (2011).

Eastern Mediterranean

Turkey, Greece and Egypt are considered the countries whose fisheries have the greatest impacts on sea turtles (both loggerhead and green sea turtles) in the eastern basin (Table 2), with estimates of around 3 500, 2 900 and 2 000 sea turtles caught per year, respectively. The eastern Mediterranean coast of Turkey represents an important area for sea turtle nesting and feeding (Baran and Kasparek, 1989). Oruç (2001) observed in this area that the bycatch of green sea turtles was greater than that of loggerhead sea turtles, with mostly juveniles caught (81 percent).

In Israel, Casale (2011) reported an annual incidental catch estimate of six sea turtles (calculated by applying a conservative catch rate, equal to the minimum recorded in the Mediterranean), while more recently, Levy *et al.* (2015) noted in contrast an estimate of around 1 300 sea turtles caught per year. Casale (2011) also estimated a bycatch of 107 sea turtles per year in Cyprus and of around 200 in Syria. Elsewhere, in Lebanon, bottom trawling is forbidden. In light of the available data, it is estimated that over 10 000 sea turtles per year are caught by bottom trawlers in the eastern basin.

Black Sea

Very little information is available from the Black Sea and it is not possible to make estimates. Due to the limited presence of sea turtles in Black Sea waters, incidental catch in this area is not considered a conservation problem for sea turtle populations.

Bottom trawlers overview

In general, the direct mortality induced by bottom trawls is low and sea turtles are usually released alive. Indeed, underwater videos recorded that sea turtles are still able to swim in the net after capture (TartaLife, 2013). Various studies (Table 2) report different mortality rates, and it is assumed that a reliable mortality rate of sea turtles incidentally caught in bottom trawls ranges between 10 and 20 percent.

In bottom trawls, the incidental catch of loggerhead sea turtles probably occurs during towing operations when sea turtles are foraging on the bottom. For this reason, the incidental catch, and sometimes the mortality rate, mainly depend on three operative parameters: the duration of the trawl (greater mortality when towing time is higher than one hour) (Henwood and Stunz, 1987), the intensity of the fishing effort in a certain zone (high number of vessels in a restricted area might lead to multiple catches) (Epperly, Braun and Veishlow, 1995), and water temperature (maximum time before apnoea decreases as water temperature rises, due to increasing oxygen consumption) (Lutz, Bergey and Bergey, 1989). While mortality caused by trawlers may be due partly to the physical stress exerted on the animal caught inside the net, it is mainly due to forced apnoea (Hare, 1991). Delayed mortality due to decompression sickness is a matter of further concern (García-Parraga *et al.*, 2014). Thus, longer or faster-moving tows, which depend on several parameters (including the nature of the fishing area and target species), are likely responsible for higher mortality rates. In fact, the mortality rate for a towing time less than one hour may be negligible (Henwood and Stuntz, 1987; Laurent and Lescure, 1994; Lucchetti, Vasapollo and Virgili, 2017a, 2017b). Therefore, towing time could be one of the main factors affecting mortality rates, though additional factors such as seasonal differences may increase the impact, especially of bottom trawls, with mortality higher in the winter than in summer due to the cold (Gerosa and Casale, 1999; Gilman, Bianchi and Attwood, 2009; Maxwell *et al.*, 2018). On the other hand, higher water temperatures associated with increased metabolic rates can dramatically reduce sea turtles' ability to survive apnoea, for example, in warm Tunisian waters (National Research Council, 1990).

Based on recent incidental catch estimates obtained by different authors (Table 2), and taking into account that the estimates may sometimes refer to partially overlapping areas, it is assumed that around 50 000 sea turtles are caught annually by Mediterranean bottom trawlers, with likely 9 000 dead:

- In the western Mediterranean, around 2 300 capture events may occur annually, with around 400 dead;

- In the central Mediterranean, about 20 000 sea turtles may be caught annually, mainly by Tunisian and Italian trawlers, with possibly 3 500 dead;
- In the Adriatic Sea, around 18 000 capture events may occur annually, with more than 3 000 dead;
- In the eastern Mediterranean, around 10 000 sea turtles may be caught annually, with about 2 000 dead.

PLATE 1
Sea turtle incidentally caught by a bottom trawler

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TABLE 2 – Incidental catch of sea turtles in bottom trawlers (data from literature 2008–2019)

Bibliographic reference	Reference years	Gear	GFCM subregion	Country	Species	Reported or estimated individuals in bycatch events[1]	Estimated mortality rate due to bycatch
Lazar and Tvrtkovic, 1995; Lazar *et al.*, 2003	1995	OTB	Adriatic Sea	Croatia (north)	*Caretta caretta*	1 950	12.5%
Lazar and Tvrtkovic 1995; Lazar *et al.*, 2003	1995	OTB	Adriatic Sea	Croatia (centre)	*Caretta caretta*	459	12.5%
Lazar *et al.*, 2004	1990–2002	OTB	Adriatic Sea	Slovenia–Croatia	*Caretta caretta*	-	0–10%
Casale *et al.*, 2004	2004	OTB	Adriatic Sea	Italy (northwestern Adriatic)	*Caretta caretta*	4 273	9.4% (43.8% potential)
Casale, 2008	2005	OTB	Adriatic Sea	Albania	*Caretta caretta*	444	-
Lazar, 2010	-	OTB	Adriatic Sea	Croatia	*Caretta caretta*	2 500	12.5%
Casale, 2008	2008	OTB	Adriatic Sea	Italy (northwestern Adriatic)	*Caretta caretta*	5 833–49 547[2]	-
Casale, 2008	2008	OTB	Adriatic Sea	Italy (southern Adriatic–Ionian)	*Caretta caretta*	849	-
Casale, 2008	2008	OTB	Adriatic Sea	Slovenia	*Caretta caretta*	57	-
Casale, 2011	2011	OTB	Adriatic Sea	Albania	*Caretta caretta*	564	-
Casale, 2011	2011	OTB	Adriatic Sea	Italy (northwestern Adriatic)	*Caretta caretta*	5 878–49 508[2]	-
Casale, 2011	2011	OTB	Adriatic Sea	Slovenia	*Caretta caretta*	210	-
Casale, 2011	2011	OTB	Adriatic Sea	Italy (southern Adriatic–Ionian Sea)	*Caretta caretta*	316	-
Lucchetti *et al.*, 2017a	2017	OTB	Adriatic Sea	Italy (central–northwestern Adriatic)	*Caretta caretta*	14 705	15%
Laurent *et al.*, 1990	1988	OTB	Central Mediterranean	Tunisia	*Caretta caretta*	2 800–4 400	-

TABLE 2 (continued)

Bibliographic reference	Reference years	Gear	GFCM subregion	Country	Species	Reported or estimated individuals in bycatch events[1]	Estimated mortality rate due to bycatch
Bradai, 1992	1992	OTB	Central Mediterranean	Tunisia (Gulf of Gabès)	*Caretta caretta*	2 000–2 500	-
Laurent and Lescure, 1994	1994	OTB	Central Mediterranean	Tunisia	*Caretta caretta*	3 500–4 000	-
Laurent *et al.*, 2001	1999–2000	OTB	Central Mediterranean	Greece (Ionian Sea)	*Caretta caretta*	0–211(±415)	0%
Margaritoulis, Politou and Laurent, 2003	2001	OTB	Central Mediterranean	Greece (Ionian Sea)	*Caretta caretta*	0–448	0%
Margaritoulis *et al.*, 2003	2000	OTB	Central Mediterranean	Greece (Ionian Sea)	*Caretta caretta*	211	-
Casale *et al.*, 2007	2003–2005	OTB	Central Mediterranean	Italy (Central Mediterranean)	*Caretta caretta*	4 056	-
Jribi and Bradai, 2008	2008	OTB	Central Mediterranean	Tunisia (whole continental shelf)	*Caretta caretta*	14 000	-
Casale, 2008	2008	OTB	Central Mediterranean	Tunisia (other than Gulf of Gabès)	*Caretta caretta*	5 458	-
Casale, 2008	2008	OTB	Central Mediterranean	Greece (Ionian Sea)	*Caretta caretta*	119	-
Casale, 2008	2008	OTB	Central Mediterranean	Tunisia (Gulf of Gabès)	*Caretta caretta*	5 457	-
Casale, 2008	2008	OTB	Central Mediterranean	Egypt	*Caretta caretta*	1 978	-
Casale, 2008	2008	OTB	Central Mediterranean	Libya	*Caretta caretta*	2 479	-
Casale, 2008	2008	OTB	Central Mediterranean	Italy	*Caretta caretta*	1 016–12 880[2]	-
Casale, 2008	2008	OTB	Central Mediterranean	Malta	*Caretta caretta*	8	-
Casale, 2011	2011	OTB	Central Mediterranean	Greece (Ionian Sea)	*Caretta caretta*	8	-
Casale, 2011	2011	OTB	Central Mediterranean	Libya	*Caretta caretta*	4 726	-
Casale, 2011	2011	OTB	Central Mediterranean	Italy (Lampedusa Island)	*Caretta caretta*	1 014	-
Casale, 2011	2011	OTB	Central Mediterranean	Italy (other than Lampedusa)	*Caretta caretta*	3 040–12 880[2]	-
Casale, 2011	2011	OTB	Central Mediterranean	Malta	*Caretta caretta*	4	-
Casale, 2011	2011	OTB	Central Mediterranean	Tunisia	*Caretta caretta*	10 940	-
Lucchetti *et al.*, 2017a	2017	OTB	Central Mediterranean	Italy (south Sicily-Ionian Sea)	*Caretta caretta*	3 620	15%
Jribi *et al.*, 2004, 2007	1992–2004	OTB	Central Mediterranean	Tunisia (Gulf of Gabès)	*Caretta caretta*	5 458	3.3%
Margaritoulis *et al.*, 1992	1989–1990	OTB	Eastern Mediterranean	Greece (Lakonikos Bay)	*Caretta caretta*	38	2.6%
Margaritoulis *et al.*, 1992	1989–1990	OTB	Eastern Mediterranean	Greece (Lakonikos Bay)	*Chelonia mydas*	6	-
Margaritoulis, Politou and Laurent, 2003	2001	OTB	Eastern Mediterranean	Greece (Thracian Sea)	*Caretta caretta*	0–418	0%
Laurent *et al.*, 2001	1999–2000	OTB	Eastern Mediterranean	Greece (Thracian Sea)	*Caretta caretta*	133–410	0%
Margaritoulis *et al.*, 2003	1999	OTB	Eastern Mediterranean	Greece (Thracian Sea)	*Caretta caretta*	410	-

TABLE 2 (continued)

Bibliographic reference	Reference years	Gear	GFCM subregion	Country	Species	Reported or estimated individuals in bycatch events[1]	Estimated mortality rate due to bycatch
Margaritoulis *et al.*, 2003	2000	OTB	Eastern Mediterranean	Greece (Thracian Sea)	*Caretta caretta*	298	-
Oruç, 2001; Oruç *et al.*, 1996	1996–1997/2001	OTB	Eastern Mediterranean	Turkey	*Caretta caretta*	43	0.3–5%
					Chelonia mydas	3	
Nada and Casale, 2008; Laurent *et al.*, 1996	1996–2008	OTB	Eastern Mediterranean	Egypt	*Caretta caretta*	1 916 (1 114–2 228)	1–10%
Casale, 2008	2008	OTB	Eastern Mediterranean	Greece (Thracian Sea)	*Caretta caretta*	2 296	-
Casale, 2008	2008	OTB	Eastern Mediterranean	Cyprus	*Caretta caretta*	150	-
Casale, 2008	2008	OTB	Eastern Mediterranean	Turkey (Aegean Sea)	*Caretta caretta*	1 143	-
Casale, 2008	2008	OTB	Eastern Mediterranean	Turkey (Levant Sea)	*Caretta caretta*	2 380	-
Nada and Casale, 2011	2007	OTB	Eastern Mediterranean	Egypt	*Caretta caretta*–*Chelonia mydas*	1 916 (1 114–2 228)	-
Casale, 2011	2011	OTB	Eastern Mediterranean	Cyprus	*Caretta caretta*	107	-
Casale, 2011	2011	OTB	Eastern Mediterranean	Israel	*Caretta caretta*	6	-
Casale, 2011	2011	OTB	Eastern Mediterranean	Syria	*Caretta caretta*	205	-
Casale, 2011	2011	OTB	Eastern Mediterranean	Turkey (Aegean Sea)	*Caretta caretta*	1 144	-
Casale, 2011	2011	OTB	Eastern Mediterranean	Turkey (Levant Sea)	*Caretta caretta*	2 321	-
Casale, 2011	2011	OTB	Eastern Mediterranean	Greece (Thracian Sea)	*Caretta caretta*	2 878	-
Levy *et al.*, 2015	2012	OTB	Eastern Mediterranean	Israel	*Caretta caretta*–*Chelonia mydas*	1 124–1 506	47.1%
Laurent, 1991; Delaugerre, 1987	1987–1991	OTB	Western Mediterranean	France	*Caretta caretta*	51	3.3–3.7%
Claro *et al.*, 2010	1991-2010	OTB	Western Mediterranean	France	*Caretta caretta*	38	<10%
Laurent, 1990	1990	OTB	Western Mediterranean	Algeria	*Caretta caretta*	284	0-10%
Carreras *et al.*, 2004	2001	OTB	Western Mediterranean	Spain (Balearic Islands)	*Caretta caretta*	13	50%
Alvarez de Quevedo *et al.*, 2006	2004–2006	OTB	Western Mediterranean	Spain	*Caretta caretta*	265	-
Alvarez de Quevedo *et al.*, 2010	2003–2004	OTB	Western Mediterranean	Spain (northeastern)	*Caretta caretta*	249 (83–515)	15.7%
Casale, 2008	2008	OTB	Western Mediterranean	Spain (north)	*Caretta caretta*	270	-
Casale, 2008	2008	OTB	Western Mediterranean	Spain (Balearic Islands)	*Caretta caretta*	13	-
Casale, 2008	2008	OTB	Western Mediterranean	Spain (south)	*Caretta caretta*	177	-
Casale, 2008	2008	OTB	Western Mediterranean	France (mainland)	*Caretta caretta*	92	-
Casale, 2008	2008	OTB	Western Mediterranean	France (Corsica)	*Caretta caretta*	27	-
Casale, 2008	2008	OTB	Western Mediterranean	Algeria	*Caretta caretta*	284	-
Casale, 2008	2008	OTB	Western Mediterranean	Italy (Tyrrhenian Sea)	*Caretta caretta*	822	-

TABLE 2 (continued)

Bibliographic reference	Reference years	Gear	GFCM subregion	Country	Species	Reported or estimated individuals in bycatch events[1]	Estimated mortality rate due to bycatch
Casale, 2011	2011	OTB	Western Mediterranean	France	*Caretta caretta*	25	-
Casale, 2011	2011	OTB	Western Mediterranean	Algeria	*Caretta caretta*	667	-
Casale, 2011	2011	OTB	Western Mediterranean	Morocco	*Caretta caretta*	199	-
Casale, 2011	2011	OTB	Western Mediterranean	Italy (Tyrrhenian Sea–Sardinia)	*Caretta caretta*	306	-
Lucchetti *et al.*, 2017a	2017	OTB	Western Mediterranean	Italy (Tyrrhenian Sea–Sardinia)	*Caretta caretta*	1 769	15%
Casale, 2011	2011	OTB	Western Mediterranean	Spain (north)	*Caretta caretta*	265	-
Casale, 2011	2011	OTB	Western Mediterranean	Spain (Balearic Islands)	*Caretta caretta*	13	-
Casale, 2011	2011	OTB	Western Mediterranean	Spain (south)	*Caretta caretta*	99	-
Domènech *et al.*, 2015	2010	OTB	Western Mediterranean	Spain	*Caretta caretta*	500	-
Domènech *et al.*, 2015	2010	OTB	Western Mediterranean	Spain (Valencia region)	*Caretta caretta*	173–304	16%
Casale, 2008	2008	OTB	Entire Mediterranean Sea	-	*Caretta caretta*	>35 000	20%
Casale, 2011	2011	OTB	Entire Mediterranean Sea	-	*Caretta caretta*	39 276	20%
Casale *et al.*, 2004; Casale, 2008; Laurent *et al.*, 1996; Lazar and Tvrtkovic, 1995; Oruç, 2001	-	OTB	Entire Mediterranean	-	*Caretta caretta*	30 000	5% (20–25% potential)
Argano, 1979	-	OTB	-	Italy	*Caretta caretta*	1 000–1 500	-
Casale *et al.* 2004, 2007; De Metrio and Casale, 2001	*	OTB	-	Italy	*Caretta caretta*	8 500	14% (57% potential)

Notes: OTB = bottom otter trawl.

In grey data collected before 2008.

1. The data reported here are derived either from direct observations or from yearly estimates. Please refer to the original paper for the methodology used to obtain the value(s).
2. Data estimated and considered as outliers.

2.3.2 Pelagic trawlers

In pelagic or midwater pair trawls, the net is rigged to operate in mid-water to capture small pelagic species, such as anchovy (*Engraulis encrasicolus*) and sardine (*Sardina pilchardus*), and, to a lesser extent, other pelagic fish, including horse mackerel (*Trachurus* spp.) and mackerel (*Scomber* spp.). During the daytime, small pelagic species form large schools close to the sea bottom; therefore, this type of gear is used during the day with the groundrope towed close to the bottom. Under these circumstances, sea turtles are likely to be incidentally caught when feeding on the bottom, as already observed for bottom trawls. Most midwater trawlers operate in pairs, with the trawl net being towed by two boats working together. Single net pelagic trawls saw use almost exclusively

in France, but they have not been employed since 2007, due to the difficult economic situation (a shortage of resources and a rise in fuel prices) in the Gulf of Lion sardine fishery (Monaco and Prouzet, eds., 2014).

Western Mediterranean

No data available from the pelagic trawlers operating in this subregion (i.e. France).

Central Mediterranean

No data available for pelagic trawlers operating in this subregion.

Adriatic Sea

In the Adriatic Sea, between 150 and 2 000 sea turtles are estimated to be incidentally caught annually (around 800 sea turtles per year on average) (Table 3), with especially high numbers near the Po river mouth (geographical subarea 17, i.e. central-northern Adriatic), an area with a high

TABLE 3 – Incidental catch of sea turtles in pelagic trawlers (data from literature 2008–2019)

Bibliographic reference	Reference years	Gear	GFCM subregion	Country	Species	Reported or estimated individuals in bycatch events[1]	Estimated mortality rate due to bycatch
Casale *et al.*, 2004 Laurent *et al.*, 2001	1999–2000	PTM	Adriatic Sea	Italy (northwest)	*Caretta caretta*	124–161	7.7% (+31% comatose)
Fortuna *et al.*, 2008	2006-2008	PTM	Adriatic Sea	Italy (central-northwest)	*Caretta caretta*	1 550	-
Casale, 2008	2008	PTM	Adriatic Sea	Italy (northwest)	*Caretta caretta*	161	-
Sala *et al.*, 2017	2007	PTM	Adriatic Sea	Italy (central-northwest)	*Caretta caretta*	1 939	6%
Sala *et al.*, 2017	2008	PTM	Adriatic Sea	Italy (central-northwest)	*Caretta caretta*	474	9%
Sala *et al.*, 2017	2009	PTM	Adriatic Sea	Italy (central-northwest)	*Caretta caretta*	1 276	5%
Sala *et al.*, 2017	2010	PTM	Adriatic Sea	Italy (central-northwest)	*Caretta caretta*	595	7%
Sala *et al.*, 2017	2011	PTM	Adriatic Sea	Italy (central-northwest)	*Caretta caretta*	395	6%
Sala *et al.*, 2017	2012	PTM	Adriatic Sea	Italy (central-northwest)	*Caretta caretta*	671	3%
Sala *et al.*, 2017	2013	PTM	Adriatic Sea	Italy (central-northwest)	*Caretta caretta*	1 414	20%
Sala *et al.*, 2017	2014	PTM	Adriatic Sea	Italy (central-northwest)	*Caretta caretta*	1 274	-
Sala *et al.*, 2017	2015	PTM	Adriatic Sea	Italy (central-northwest)	*Caretta caretta*	343	9%
Sala *et al.*, 2017	2016	PTM	Adriatic Sea	Italy (central-northwest)	*Caretta caretta*	132	-
Oruç, 2001	1996–1997	TM	Eastern Mediterranean	Turkey (southeast)	*Caretta caretta* *Chelonia mydas* *Trionyx triunguis*	71 249 389	0.3–5%

Notes:

PTM = midwater pair trawl.

TM = midwater trawl.

In grey data collected before 2008.

1. The data reported here are derived either from direct observations or from yearly estimates. Please refer to the original paper for the methodology used to obtain the value(s).

density of sea turtles feeding on abundant prey along the sea bottom. The great variability of sea turtle bycatch observed over the years is mainly due to changes in fishing effort, as vessels easily switch from pelagic to bottom trawls from one year to another.

Eastern Mediterranean

In southeastern Turkey, Oruç (2001) found that the impact of pelagic trawlers (86 percent of the incidental catch observed) was higher than that of bottom trawlers, with the greatest affect on green sea turtles (around 77 percent of the marine turtles caught). In addition, in the area between Mersin and Iskenderun, the euryhaline Nile soft-shelled turtle (*Trionyx triunguis*), which lives in freshwater and brackish habitats, can be found in the bycatch of pelagic trawlers (Oruç, 2001).

Black Sea

No pelagic trawlers operate in this subregion.

Pelagic trawlers overview

The mortality reported for this fishery is usually low (8 percent, on average) and most of the sea turtles caught are alive and healthy and usually released back into the sea immediately after capture. In the Adriatic Sea, this fishery may be responsible for around 70 events in which individuals were found dead each year. In Turkey, pelagic trawlers cause incidental catch of both sea and freshwater turtles, though with a low direct mortality rate (0–5 percent).

2.3.3 Small-scale fisheries

Most SSF in the Mediterranean use gillnets and/or trammel nets, generally called set nets. Set nets represent a problem for sea turtles mainly in coastal areas, where these types of nets are used (Lazar, Margaritoulis and Tvrtkovic, 1998, 2004; Argano *et al.* 1992). Set nets, being positioned on the sea bottom, can interact with sea turtles in the demersal phase. Therefore, these types of fishing gear have potential impacts on sea turtles if deployed at depths less than 50 m. At the same time, set nets can also be used in waters deeper than 200 m and interact with post-pelagic stage loggerheads. In this case, the likelihood of fatal decompression rises with increasing depth of gear deployment (Fahlman *et al.*, 2017).

Sea turtles can become entangled in nets when trying to feed on previously captured fish or if they do not perceive the presence of the nets at all (Suggett and Houghton, 1998). When caught, they can be forced underwater for an unsustainable period of time (Laurent, 1991; Laurent *et al.*, 1996). Drowning is the main reason behind sea turtle mortality in this fishing gear: the animals, once entangled in the net, cannot reach the surface to breathe. Therefore, the soaking time and bottom depth setting strongly influence the probability of survival: the longer the setting time, the lower the probability of survival; the deeper the net setting (up to 50 m), the lower the probability of reaching the surface to breathe. Environmental parameters may also affect sea turtle mortality: high water temperatures (such as in North African countries), associated with high metabolic rates, can strongly weaken resistance to forced immersion. Moreover, sea turtles rely extensively on visual cues, particularly when foraging (Swimmer *et al.*, 2005), due to their well-developed visual system endowed with a wide spectral range (Mäthger, Litherland and Fritsches, 2007; Southwood *et al.*, 2008). Therefore, water turbidity and the setting of nets at night negatively affect the likelihood of sea turtles seeing them. In addition, various technical parameters of set nets could strongly influence the probability of catching sea turtles; for example, the use of large mesh openings and highly slack netting could increase the risk of turtles' entanglement. Moreover,

with the same mesh openings used, trammel nets are more dangerous than gillnets (Lucchetti, Vasapollo and Virgili, 2017b).

However, quantifying captures in these SSF is difficult to assess due to the high number of small boats widely distributed along Mediterranean coasts using this gear. According to GFCM (FAO, 2018), SSF account for about 80 percent of the Mediterranean fleet, with more than 74 000 vessels. Passive set nets (gillnets, trammel nets, combined nets and small driftnets) are among the principal types of fishing gear used by SSF to target a variety of demersal, benthic and pelagic species (Lucchetti *et al.*, 2015). The technical and operating features of the different types of fishing gear influence the quantities of incidental catch and its composition. However, as the technical properties of fishing gear are not always documented, the incidental catch data in this review have been generically assigned to set nets.

Although information about set net–sea turtle interactions in the Mediterranean is scarce, and spatially and temporally scattered, by merging the incidental catch data obtained from different regions of the Mediterranean (Table 4), an estimate of around 31 000 sea turtles caught annually emerges. These estimates are higher than those obtained by Casale (2008, 2011). Both juvenile and adult life stages of loggerhead turtles are affected, as confirmed by biometric data, indicating that the size of sea turtles caught ranges from 21 to 80 cm carapace length (Lucchetti, Vasapollo and Virgili, 2017b; Casale *et al.*, 2005a, 2005b; Echwikhi *et al.*, 2010a). Larger adult green turtles are also occasionally caught in set nets off Cyprus (Snape *et al.*, 2013).

Western Mediterranean

In the western Mediterranean, sea turtle bycatch in SSF seems to be lower than in the rest of the Mediterranean, with estimates of about 1 000 to 3 000 sea turtles caught per year, mainly off France and the Balearic Islands. Casale (2008, 2011) estimated that around 1 500 to 1 700 sea turtles can be caught in French Mediterranean waters each year. Nevertheless, according to recent observations (after 2008) carried out on gillnets, sampling indicates much lower values – between 300 and 500 sea turtles per year – mainly resulting from a reduction in the number of active netters (Pascual-Fernandez *et al.*, 2015). Most bycatch takes place in the spring or summer and mainly involves juveniles (Oliver, 2008). Carreras, Cardona and Aguilar (2004) estimated that in 2001, around 300 sea turtles were caught in all types of set nets in the Balearic Islands. This low estimate probably follows from the fact that set nets are positioned close to the bottom, and in this area of the Mediterranean basin, sea turtles usually remain near the surface. Moreover, the depth at which these nets are set prevents the depredation activity of sea turtles.

In Morocco, Casale (2008) estimated around 1 700 captures per year, but these estimates were further revised (Casale, 2011) to around 300 sea turtles annually. No data or reliable estimates are available from Algeria or for the entire Tyrrhenian Sea.

Central Mediterranean

Considering the sea bottom characteristics in the central Mediterranean, set nets present a matter of concern for sea turtle bycatch in this basin, especially on the continental shelf of Tunisia, which is considered to be one of the main sea turtle foraging habitats in the Mediterranean. Echwikhi *et al.* (2010b) estimated that around 450 sea turtles may be caught annually in the southern part of the Gulf of Gabès alone. However, these estimates cannot be extrapolated to the entire length of the Tunisian coast, due to the unusual characteristics of this area and its fishery (for example, the types of fishing gear used and the species targeted). Casale (2011), taking into account the

BPUE calculated by Echwikhi *et al.* (2010b) in the southern Gulf of Gabès, has described a worst-case scenario, with more than 4 000 catches per year in Tunisia, and, using a similar approach, 300–350 per year in Libya.

Casale (2011) also reported around 500 captures per year in Italian waters. However, Lucchetti, Vasapollo and Virgili (2017a), based on data collected from interviews with fishers, estimated around 1 500 catches annually in the Ionian Sea and the Strait of Sicily.

In the Gulf of Gabès (Tunisia), one of the Mediterranean areas with the highest sea turtle abundance, Echwikhi *et al.* (2010b) found a mean value of 0.339 sea turtles caught per km of gillnet. Therefore, these data confirm that sea turtle bycatch rates vary greatly according to fishing areas and target species.

Adriatic Sea

In the Adriatic Sea, Italy, Croatia and Slovenia combined can catch 9 000 sea turtles per year in set nets. Lazar, Ziza and Tvrtkovic (2006) estimated an annual bycatch between 650 and 4 000 sea turtles on the eastern side of the Adriatic Sea, with a mean annual catch of around 2.8 sea turtles per vessel. Lucchetti, Vasapollo and Virgili (2017a, 2017b) estimated that the annual incidental catch per vessel in the Adriatic (Italian fleet) ranged from 1.8 (southern Adriatic) to 5.3 (at the Po River Delta), for a total of more than 5 000 sea turtles caught per year. Indeed, Lucchetti, Vasapollo and Virgili (2017b) recently found a distinct bycatch hotspot during the summer period in the central-northern Adriatic. The high abundance of sea turtles in this survey area is probably linked to the nutrient input from the Po River and its effect of increasing phytoplankton concentrations. In the area identified as a hotspot, the bycatch rate in trammel nets and gillnets (0.7 and 0.5 sea turtles per km of net, respectively) was greater than the rates found in other Mediterranean areas. In contrast, in the southern Adriatic Sea, Lucchetti, Vasapollo and Virgili (2017b) estimate that 2 000 sea turtles are caught per year.

Eastern Mediterranean

The eastern basin is a matter of concern, as it is estimated that more than 13 000 sea turtles may potentially be captured on an annual basis in set nets (Table 4), with most catches – more than 4 000 sea turtles per year – occurring along the southern coast of Turkey, another 1 000 to 4 000 per year in Cyprus, around 3 000 in Egypt, and 2 500 in Greece.

Casale (2011), on the other hand, used secondary data to estimate sea turtle bycatch in both set nets and bottom longlines, applying the original data collected by Godley *et al.* (1998) to the 2011 fishing effort statistics. By considering more recent data, the estimate for the entire basin could be as high as 16 000 sea turtles per year. Indeed, juveniles are frequently caught close to nesting areas in Greece, Turkey and Cyprus (Suggett and Houghton, 1998; Godley *et al.*, 1998).

Casale (2011) applied the annual capture rate (per vessel) estimates of Godley *et al.* (1998) in Cyprus to the number of vessels registered at the time of his study and estimated that 3 600 sea turtles were captured in set nets. The mean mortality rate of 60 percent estimated by Casale (2011) was also found by Snape *et al.* (2013) to be of an appropriate order; therefore the number of sea turtle mortalities occurring annually in set nets around Cyprus is likely around 2 150. Trammel nets targeting mainly siganids (rabbitfishes), but also the Mediterranean parrotfish (*Sparisoma cretense*), *Mullus* spp. (particularly the red mullet, *M. barbatus*), *Dentex* spp. (particularly the common dentex, *D. dentex*) and *Pagellus* spp. (particularly the common pandora, *P. erythrinus*),

appear to be responsible for a large proportion of these catches, because they are set close to shore in shallow waters (Snape, 2015; Snape *et al.*, 2013), with especially strong impacts on juvenile green sea turtles. Gillnets targeting bogue (*Boops boops*) and picarels *Spicara* spp. (represented in the Mediterranean by the blotched picarel, *S. maena,* and the picarel, *S. smaris*) also capture loggerhead sea turtles, although these nets are soaked for short periods and therefore result in fewer captures and fewer mortalities (Snape *et al.*, 2013). Recent incidental catch monitoring as part of the MedBycatch project (GFCM, 2021) has found that large mesh (100 mm) set nets targeting the greater amberjack (*Seriola dumerili*), frequently capture loggerhead sea turtles and inflict a high mortality rate. Additionally, some sea turtles caught in deeper waters (for example, up to 70 m) show signs of decompression sickness and die post-capture on the deck or en route to rehabilitation. Moreover, the longer average soaking time of gillnets may lead to a greater risk of decompression sickness (Fahlman *et al.*, 2017).

Black Sea

Little information is available from the Black Sea and it is not possible to make estimates. Due to the limited presence of sea turtles in Black Sea waters, incidental catch in this area is not considered an issue for the conservation of sea turtle populations.

Small-scale fisheries overview

To summarize, sea turtle mortality caused by set nets depends on several factors: gear-related features (including mesh opening size, hanging ratio, net type, vertical netting slackness and twine thickness, among others), operational factors (soaking time, depth setting), environmental factors (such as sea water temperature), as well as the dimensions of the sea turtles, since survival of larger individuals (with high duration of apnoea) is possible if the capture occurs before gear retrieval (Cambiè, 2011). Some studies (Carreras, Cardona and Aguilar, 2004; Lucchetti, Vasapollo and Virgili, 2017b) highlighted that the use of gillnets with large meshes presents a serious threat of entanglement to sea turtles; similarly, trammel nets with large meshes in their external panels cause comparable catch rates. Therefore, large mesh sizes, such as the ones used in Tunisia for demersal fish species (14-16 cm mesh size; Echwikhi *et al.*, 2010b) increase entanglement of sea turtles. Lucchetti, Vasapollo and Virgili (2017b) concluded that fishing gear should be redesigned by encouraging the use of gillnets with small meshes (less than 70 mm mesh opening) to reduce sea turtle entanglements. Moreover, the authors suggested that the use of trammel nets should be reduced, especially during the summer, while alternative and less impactful types of gear (such as fish pots) should be encouraged. In conclusion, technical solutions, including smaller mesh openings, reduced slackness, flotation devices and thin twine, could allow traditional fishing practices to survive while improving the conservation of protected species.

The direct mortality associated with these types of gear seems to be very high in comparison with that of bottom trawls (Table 4). According to the different parameters affecting survival probability (as described above), the mortality rates reported for different areas vary greatly, ranging from heights of 87 percent in Corsica (Delaugerre, 1987) and 69 percent in Sardinia and Tunisia (Cambiè, 2011; Echwikhi *et al.*, 2010b) to the low values registered in Tunisia (5.2 percent) (Bradai, 1993) and Turkey (10 percent) (Godley *et al.*, 1998). In the Adriatic Sea, recent estimates (20–30 percent) (Lucchetti, Vasapollo and Virgili, 2017a, 2017b; Virgili, Vasapollo and Lucchetti, 2018), in agreement with the values obtained in Spain (21.4 percent) (Álvarez De Quevedo, 2010), are quite low in comparison with the mortality rates found in other areas. Combining all the available data (Table 4), the mean mortality rate for the entire Mediterranean Sea is estimated at around 51 percent, taking into account the high diversity of types of fishing gear (i.e. trammel net, gillnets, entangling nets

not specified) and fishing tactics (for example, depth setting and time setting, among others) in each region. By applying a flat rate (51 percent) and the rates found in the different areas, it is estimated that between 13 000 and 17 000 sea turtles die annually due to Mediterranean set nets.

PLATE 2
Sea turtle incidentally caught by a set net

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If a sea turtle survives, there may still be a delayed mortality due to injuries and necrosis after entanglement and/or release. In all studies, the delayed mortality (i.e. after turtles have been released) is unknown, although recently Snoddy and Williard (2010) suggested that, at least in North Carolina (USA), up to 30 percent of turtles that survived gillnet entanglement died after release. Moreover, differences in the habitats of adults and juveniles relative to the different types of fishing gear used might make juveniles more susceptible to gillnet and trammel net entanglement than adults. Tomás, Aznar and Raga (2001) have documented scavenging behaviour in juvenile loggerheads (i.e. foraging for fish that are discarded due to low commercial value or because they measure below the minimum legal size), which might also lead them to depredate from static fishing gear, thereby making them more vulnerable to entanglement than their adult counterparts.

Based on the incidental catch estimates obtained by different authors, and taking account that sometimes the estimates could refer to partially overlapping areas, it is roughly calculated that around 31 000 sea turtles are caught by Mediterranean set net fisheries per year:

- In the western Mediterranean Sea, around 800–2 000 capture events per year may occur, with around 500–1 000 dead;
- In the central Mediterranean, 6 000 sea turtles may be caught annually, mainly by Tunisian and Italian vessels, with possibly 2 400–3 100 dead;
- In the Adriatic Sea, around 9 000 capture events per year may occur annually, with about 3 500–4 500 dead;
- In the eastern Mediterranean, around 14 000 sea turtles per year may be caught, with around 4 800–7 000 dead; the maximum value is from Casale (2011).

TABLE 4 – Incidental catch of sea turtles in small-scale fisheries (data from literature 2008–2019)

Bibliographic reference	Reference years	Gear	GFCM subregion	Country	Species	Reported or estimated individuals in bycatch events[1]	Estimated mortality rate due to bycatch
Lazar and Tvrtković, 2003; Lazar *et al.*, 2003	2000–2002	GEN	Adriatic Sea	Slovenia–Croatia	*Caretta caretta*	-	54.9–65.4%
Lazar *et al.*, 2004	1990–2002	GEN	Adriatic Sea	Slovenia–Croatia	*Caretta caretta*	-	62.5%
Lazar *et al.*, 2006	2006	GEN/GNS	Adriatic Sea	Slovenia–Croatia	*Caretta caretta*	658–4 038	54.9–73%
Lazar *et al.*, 2006	2006	GEN	Adriatic Sea	Slovenia	*Caretta caretta*	270	74.7%
Casale, 2008	2008	GEN	Adriatic Sea	Slovenia	*Caretta caretta*	393	-
Casale, 2011	2011	GEN	Adriatic Sea	Slovenia	*Caretta caretta*	433	-

TABLE 4 (continued)

Bibliographic reference	Reference years	Gear	GFCM subregion	Country	Species	Reported or estimated individuals in bycatch events[1]	Estimated mortality rate due to bycatch
Lucchetti *et al.*, 2017a	2017	GEN	Adriatic Sea	Italy (central-northern)	*Caretta caretta*	5 433	21–24%
Lucchetti *et al.*, 2017b	2017	GEN	Adriatic Sea	Italy (south)	*Caretta caretta*	2 818	-
Virgili *et al.*, 2018	2015–2016	GEN	Adriatic Sea	Italy	*Caretta caretta*	-	30%
White *et al.*, 2008	N/A	Stationary fish trap (*Stavnike*)	Adriatic Sea	Albania (Patoku Lagoon)	*Caretta caretta*	103	-
Laurent *et al.*, 1990	1988	GEN/LL	Central Mediterranean	Tunisia	*Caretta caretta*	800–1 650	-
Bradai, 1993	1993	GEN	Central Mediterranean	Tunisia (Gulf of Gabès)	*Caretta caretta*	920–2 000	5.2%
Casale, 2011	2011	GEN	Central Mediterranean	Tunisia	*Caretta caretta*	2 000	-
Casale, 2008	2008	GEN	Central Mediterranean	Malta	*Caretta caretta*	185	-
Casale, 2008	2008	GEN	Central Mediterranean	Libya	*Caretta caretta*	5 624	-
Casale, 2008	2008	GEN	Central Mediterranean	Tunisia	*Caretta caretta*	4 600	-
Casale, 2011 (based on Echwikhi *et al.*, 2010a, 2010b; Jribi *et al.*, 2010)	2010	GEN	Central Mediterranean	Tunisia	*Caretta caretta*	4 200	69.4%
Casale, 2011	2011	GEN	Central Mediterranean	Libya	*Caretta caretta*	322	-
Casale, 2011	2011	GEN	Central Mediterranean	Malta	*Caretta caretta*	65	-
Lucchetti *et al.*, 2017a	2017	GEN	Central Mediterranean	Italy (Ionian Sea)	*Caretta caretta*	1 095	-
Lucchetti *et al.*, 2017a	2017	GEN	Central Mediterranean	Italy (Strait of Sicily)	*Caretta caretta*	475	-
Echwikhi *et al.*, 2010b; Echwikhi *et al.*, 2011	2007–2008	GEN	Central Mediterranean	Tunisia (southeast region)	*Caretta caretta*	443	69.4%
Godley *et al.*, 1998	1995	GEN/LL	Eastern Mediterranean	Cyprus	*Caretta caretta*	684	10%
Godley *et al.*, 1998	1995	GEN/LL	Eastern Mediterranean	Turkey (southeast)	*Caretta caretta*	1 328	10%
Nada and Casale, 2011	2007	GEN	Eastern Mediterranean	Egypt	*Caretta caretta*–*Chelonia mydas*	1 763–3 526	-
Nada and Casale, 2008; Casale, 2008	2008	GEN	Eastern Mediterranean	Egypt	*Caretta caretta*	754	-
Casale, 2008	2008	GEN	Eastern Mediterranean	Turkey	*Caretta caretta*	5 000	-
Casale, 2008	2008	GEN	Eastern Mediterranean	Cyprus	*Caretta caretta*	3 300	-
Casale, 2008	2008	GEN	Eastern Mediterranean	Egypt	*Caretta caretta*	651	-
Casale, 2011	2011	GEN	Eastern Mediterranean	Greece	*Caretta caretta*	2 533	-
Casale, 2011	2011	GEN	Eastern Mediterranean	Syria	*Caretta caretta*	875	-
Casale, 2011	2011	GEN/LL	Eastern Mediterranean	Cyprus	*Caretta caretta*	3 568	-
Casale, 2011	2011	GEN	Eastern Mediterranean	Egypt	*Caretta caretta*	2 791	-
Casale, 2011	2011	GEN/LL	Eastern Mediterranean	Turkey	*Caretta caretta*	4 728	-

TABLE 4 (continued)

Bibliographic reference	Reference years	Gear	GFCM subregion	Country	Species	Reported or estimated individuals in bycatch events[1]	Estimated mortality rate due to bycatch
Levy *et al.*, 2015	2012	GEN	Eastern Mediterranean	Israel	*Caretta caretta–Chelonia mydas*	1 672	74%
Snape *et al.*, 2013	2009–2011	GEN	Eastern Mediterranean	Cyprus	*Caretta caretta–Chelonia mydas*	800–1 100	60%
Panagopoulou *et al.*, 2017	2013	GEN	Eastern Mediterranean	Greece (Crete)	*Caretta caretta*	120	-
Laurent, 1991	1990	GTR (for lobster)	Western Mediterranean	France	*Caretta caretta*	low	100%
Laurent, 1991	1990	GTR (for sole)	Western Mediterranean Sea	France	*Caretta caretta*	2[2]	53%
Laurent, 1991	1990	GTR (for mixed species)	Western Mediterranean	France	*Caretta caretta*	0.12[2]	28%
Laurent, 1991	1990	GNS	Western Mediterranean	France	*Caretta caretta*	0.8[2]	33%
Claro *et al.*, 2010	1991-2010	GEN	Western Mediterranean	France	*Caretta caretta*	44	>50%
Carreras *et al.*, 2004	2001	GTR (for lobster)	Western Mediterranean	Balearic Islands (Spain)	*Caretta caretta*	196	77.7%
Carreras *et al.*, 2004	2001	GNS (for red mullet)	Western Mediterranean	Balearic Islands (Spain)	*Caretta caretta*	low	50%
Alvarez de Quevedo *et al.*, 2006; Carreras *et al.*, 2004	2004–2006	GEN	Western Mediterranean	Spain	*Caretta caretta*	267	-
Delaugerre, 1987	1987	GEN	Western Mediterranean	Corsica (France)	*Caretta caretta*	low	87.5%
Laurent *et al.*, 1996	1987–1996	GEN	Western Mediterranean	France	*Caretta caretta*	low	28.5%
Laurent *et al.*, 1996	1987–1996	GEN	Western Mediterranean	Corsica (France)	*Caretta caretta*	low	75%
Casale, 2008	2008	GEN	Western Mediterranean	Spain (north)	*Caretta caretta*	65	-
Casale, 2008	2008	GEN	Western Mediterranean	Spain (Balearic Islands)	*Caretta caretta*	6–196	-
Casale, 2008	2008	GEN	Western Mediterranean	France	*Caretta caretta*	1 509	-
Casale, 2008	2008	GEN	Western Mediterranean	Morocco	*Caretta caretta*	1 765	-
Casale, 2011	2011	GEN	Western Mediterranean	France	*Caretta caretta*	1 676	-
Casale, 2011	2011	GEN	Western Mediterranean	Morocco	*Caretta caretta*	282	-
Cambiè, 2011	1992–2001	GEN	Western Mediterranean	Italy (central-west Sardinia)	*Caretta caretta*	92	69%
Lozano *et al.*, 2011	2008–2010	GEN	Western Mediterranean	Spain (Cabo de Gata–Níjar Marine Reserve)	*Caretta caretta*	11	-
Lucchetti *et al.*, 2017a, 2017b	2017	GEN	Western Mediterranean	Italy (Tyrrhenian Sea)	*Caretta caretta*	11 787[3]	-
Lucchetti *et al.*, 2017a, 2017b	2017	GEN	Western Mediterranean	Italy (Sardinia)	*Caretta caretta*	1 365[3]	-
Álvarez de Quevedo *et al.*, 2010	2003–2004	GEN	Western Mediterranean	Spain (northeastern)	*Caretta caretta*	67 (33–101)	21.4%

TABLE 4 (continued)

Bibliographic reference	Reference years	Gear	GFCM subregion	Country	Species	Reported or estimated individuals in bycatch events[1]	Estimated mortality rate due to bycatch
Benhardouze *et al.*, 2012	2003–2007	GND[4]	Western Mediterranean	Morocco (northwestern)	*Caretta caretta*	719	6.3%
Benhardouze *et al.*, 2012	2003–2007	GND[4]	Western Mediterranean	Morocco (northwestern)	*Dermochelys coriacea*	101	-
Argano *et al.*, 1992	1992	GEN	-	Italy	*Caretta caretta*	-	50%
Casale, 2011	2011	GEN	-	Italy	*Caretta caretta*	523	45.5%
Casale, 2008	2008	GEN	-	Italy	*Caretta caretta*	1 338	-
Casale, 2008	2008	GEN	-	Greece	*Caretta caretta*	2 694	-
Casale, 2008	2008	GEN	-	Entire Mediterranean	*Caretta caretta*	30 000	50%-60%
Casale, 2011	2011	GEN	-	Entire Mediterranean	*Caretta caretta*	22 921–31 153	60%

Notes:

GNS = set gillnet; GTR = trammel net; GEN = gillnets and entangling nets not specified; GND = driftnet; LL = longline.
In grey data collected before 2008.

1. The data reported here are derived either from direct observations or from yearly estimates. Please refer to the original paper for the methodology used to obtain the value(s).
2. Bycatch per vessel per year (obtained from interviews with fishers).
3. Data not considered for the calculation of total estimates.
4. The use of driftnets is forbidden since 2005.

2.3.4 Longliners

The main causes of mortality in longlines are injuries due to ingested hooks and branch lines and the subsequent drowning of sea turtles (Work and Balazs, 2002; Casale, 2011).

The features of hooks can be identified by various parameters, including their general shape (J-shaped or circle), dimensions (for example, total length, length diameter, gap between point and shank, shank length, width, throat and barb size), material (steel, inox), point (with barb or without), and shape of the eye (flat or twisted). In the hooking process, the most important parameters are: the overall hook width, which can be correlated with sea turtle mouth dimensions; its gap, which ensures deeper penetration of the point and better holding power over the fish; and its shape, which can influence the hooking position. The hook size and shape (J-shaped or circle) influence the probability that the hook is swallowed and of the sea turtle becoming hooked internally, which increases the chances of delayed mortality after release (Read, 2007).

Nevertheless, in addition to the hook, the branch lines can easily kill sea turtles, especially if, when ingested, they are long enough to affect intestinal peristalsis (Bjorndal, Bolten and Lagueux, 1994; Orós, Calabuig and Deniz, 2004; Di Bello, Valastro and Staffieri, 2006; Casale *et al.*, 2007). In these cases, death typically occurs after many days. Unfortunately, it is common practice for fishers to cut the branch lines from the deck while the captured sea turtle is still in the water (they save time because sea turtles are often very heavy to lift out of the water), thereby releasing most sea turtles caught with branch lines longer than 1 m (Guglielmi, Di Natale and Pelusi, 2000). The branch line can either be ingested or trap fins or other parts; in both cases, the consequences could be dangerous for the sea turtle. Therefore, it appears that hooks can cause death in the short term and branch lines over the long term (Casale *et al.*, 2007).

Moreover, the type of bait and its olfactory attraction strongly influence sea turtle bycatch in drifting longlines, with squid bait being more attractive than mackerel (Piovano *et al.*, 2004, 2005;

Rueda *et al.*, 2006). There is also evidence of released turtles being caught again on other nearby longlines (Tomás *et al.*, 2001).

Generally, two types of longlines are used in the Mediterranean Sea: set longlines (sometimes also called bottom or demersal longlines), which are deployed on the sea bottom, and drifting longlines (sometimes also called surface or pelagic longlines), which are used in the water column at variable depths. Therefore, the two corresponding types of vessel groups are presented separately in the following records.

a) Drifting longliners

Drifting longlines targeting swordfish, albacore and bluefin tuna (*Thunnus thynnus*), deployed over the continental shelf and in offshore waters, are historically considered as the main concern to sea turtles in the Mediterranean Sea, in terms of bycatch per year (Gerosa and Casale, 1999; Margaritoulis *et al.*, 2003; Deflorio *et al.*, 2005). The incidental capture of loggerhead sea turtles in their pelagic phase with longlines mainly occurs from late spring to late autumn (May–September), with most captures recorded over the summer. To summarize, Morocco, southern Spain, the Balearic Islands, the southern Ionian Sea–Strait of Sicily and the northern Ionian Sea–southern Adriatic Sea are the regions with the highest catch per unit effort using drifting longlines (for example, Casale, 2008, 2011; Echwikhi *et al.*, 2010a; Alvarez de Quevedo *et al.*, 2013; Báez *et al.*, 2014).

Western Mediterranean

The western Mediterranean, especially the area around the Balearic Islands, seems to be the most problematic area for high incidental catch rates in drifting longlines, partly due to the high concentration of Mediterranean sea turtles in the western basin, as well as of those entering from the Atlantic Ocean via Gibraltar (Camiñas and de la Serna, 1995; Argano *et al.*, 1992). Results indicate that drifting longlines for swordfish are responsible for greater incidental catch than drifting longlines for bluefin tuna and albacore (Camiñas, Valeiras and de la Serna, 2003; Báez, Real and Camiñas, 2007; Camiñas *et al.*, 2006b, 2016; Báez *et al.*, 2007, 2014b). Spain was considered to be the country with the highest number of sea turtle captures per year, with past estimates ranging from 22 000 to 35 000 sea turtles annually (Table 5). Casale (2011) reported around 35 000 captures per year, with Spain accounting for around 20 000 and Morocco for around 15 000 sea turtles, respectively. In Morocco, Laurent (1990) had previously estimated a much lower rate, at around 3 600 sea turtles per year.

However, in Spain, recent estimates made by Báez *et al.* (2018, 2019) from 2000 to 2016 indicate that the incidental catch rate could be less marked than previously calculated, with around 5 600 (3 000–9 000) sea turtles caught per year. These estimates are even lower than those found by Alvarez de Quevedo, San Félix and Cardona (2013), who reported about 10 000 catches per year. In recent years (2013–2016), bycatch estimates in this area have further decreased to around 2 400 turtles per year (Báez *et al.* (2019). The difference in these estimates could be due to the spatial overlap in fishing grounds and loggerhead distributions, the technical differences in fishery operations and in the configuration of types of fishing gear, as well as the real fishing effort, none of which were considered in the past. Báez *et al.* (2018, 2019) observed a clear decreasing trend that could also be due to the recent gradual introduction of mesopelagic or semipelagic longlines (since 2007 in Spain and since 2010 in Italy) (Camiñas, 2015; Garibaldi, 2015; Báez *et al.* 2019), which replaced, for example, the surface longline gear previously used by the main Italian fishing fleets (i.e. in the Ligurian Sea and Ionian Calabria) (Garibaldi, 2015; Cambié *et al.*, 2013). This

technological innovation is particularly important because of its implications for the bycatch rates of sea turtles. The mesopelagic longline is set in deeper waters (150–200 m), usually for a longer period, and with a lower number of hooks per set, compared to a traditional surface longline. The results show that sea turtle bycatch strongly decreases and around 90 percent of the catch is composed of swordfish. Moreover, Garibaldi (2015) reported that with the mesopelagic longline, sea turtle bycatch is reduced to zero.

Nevertheless, bycatch estimates for longliners can vary highly for the same area. For example, the estimates for Morocco increased from 3 600 sea turtles per year, as estimated by Laurent (1990), to 14 800 sea turtles per year, as calculated by Casale (2011; secondary data based on Benhardouze, 2004).

Elsewhere, 2 500 to 5 000 sea turtle captures per year by longliners have been estimated to occur in the western Italian regions (Tyrrhenian Sea and Sardinia; Casale, 2008, 2011), while Algeria seems to play a smaller role overall, with around 200 to 300 catches per year; Casale (2008) confirms the estimate made by Camiñas (2004). However, estimates for the Tyrrhenian Sea should also be revised in light of the introduction of mesopelagic longlines in this area.

Thus, considering past and recent estimates for longliners, sea turtle bycatch in the western Mediterranean could range between 12 000 and 38 000 captures per year, with the highest estimates coming from Morocco and Spain, generated by Casale (2011).

Central Mediterranean

The central Mediterranean, particularly the Strait of Sicily and the Ionian Sea, connects the eastern and western basins and also borders the Adriatic Sea; therefore, this area is intensely frequented by sea turtles in the oceanic phase migrating between the basins and foraging in the area. The Ionian Sea is also frequented by small sea turtles, which probably hatched in the major nesting sites of Greece. Indeed, sea turtles caught by longlines are reported from areas close to neritic foraging grounds, such as Greece (Kapantagakis, 2001) and Tunisia (Jribi *et al.*, 2008). Moreover, catch rates suggest a high number of captures in the area by the Italian fishing fleet (Casale, Freggi and Rocco, 2007), with other fleets present in the same area, including the Maltese, Greek and Tunisian fleets (Table 5). In Malta, loggerhead sea turtles were also the most abundant non-target bycatch species (Burgess *et al.*, 2010).

More than 14 000 sea turtles can be incidentally caught annually in this area (around 11 000 sea turtles per year if the minimum values are considered), mainly in Italian (up to 6 000 sea turtles per year; Casale, 2011; Lucchetti, Vasapollo and Virgili, 2017a), Tunisian (around 1 000 sea turtles per year; Casale, 2011), Greek (around 3 300 sea turtles per year; Casale, 2011) and Libyan (around 1 410 sea turtles per year; Casale, 2011) waters.

Adriatic Sea

In the Adriatic Sea, only the southern part seems to show notable incidental catch, with around 1 000 sea turtles caught annually Fortuna *et al.*, 2008; Casale, 2011), though, in the last five years, some vessels have begun to catch swordfish, bluefin tuna and albacore in the central Adriatic during summer and autumn, meaning that the number of sea turtles caught may be higher (Lucchetti, Vasapollo and Virgili, 2017a).

Eastern Mediterranean

In the eastern basin, the use of longlines is more limited and around 2 000 sea turtles may be caught annually as bycatch, mainly by Egypt, accounting for 1 300–3 000 sea turtles per year (Casale, 2011; Nada and Casale, 2011).

Black Sea

No data are available for drifting longliners operating in the Black Sea.

Drifting longliners overview

Technical and operational factors affect sea turtle mortality in drifting longliners, including the number of hooks, hook size and shape, the use of a roller, the type of bait and materials, boat length, and the number of fishers onboard. Indeed, Camiñas *et al.* (2006a, 2006b) found that bycatch and direct mortality differed significantly according to the type of boat and gear. Albacore and bluefin tuna drifting longliners generally result in higher direct mortality of the hooked sea turtles than do swordfish longlines. This difference is probably due to the gear structure (mainly the hook size), but it could also be a result of the fishing depth or the distance from the coast (Báez *et al.*, 2007, 2011), or even the higher amount of catch, which causes the fishing gear to sink further, thereby increasing sea turtle mortality by drowning.

According to Table 5, the direct mortality induced by drifting longlines appears to be low when compared with other types of gear. However, great variability has been observed, depending on several parameters (such as area, fishing tactics, target species, depth setting, vessel and gear properties), so that mortality rates should be considered case by case, and not as a flat value. Delayed mortality is a major cause of concern because it is largely unknown and suspected to be high (National Marine Fisheries Service, 2001; Camiñas and Valeiras, 2001; Kapantagakis and Lioudakis, 2006; Lewison, Freeman and Crowder, 2004; Deflorio *et al.*, 2005). Post-release mortality depends strongly on the position of the hooks along the digestive tract, potentially attaching to, for example, the mouth, oesophagus, stomach or intestines (Camiñas and Valeiras, 2001). If the hook is swallowed in the lower oesophagus or in the stomach, the sea turtle has a very low chance of survival. Conversely, sea turtles caught with a hook in the mouth or in the upper oesophagus seem to face less life-threatening odds, though a hook in the mouth could compromise feeding performance, especially if it prevents closure of the mouth (Casale, Freggi and Rocco, 2007; Casale *et al.*, 2007). Aguilar, Más and Pastor (1995) have reported a post-release mortality of 24.4 percent, while Álvarez de Quevedo, San Felix and Cardona (2013) found a post-release mortality ranging from 31 to 38 percent within the 90 days following release.

Bàez *et al.* (2019) recently discovered that loggerhead sea turtle bycatch in the Spanish surface fleets had significantly decreased over the previous eight years as an indirect effect of the introduction of new technology and fishing strategies. Indeed, sea turtle mortality by drifting longlines can be strongly affected by the depth of the main line setting. Juvenile loggerhead sea turtles are capable of diving to depths below 200 m, though they mainly stay in the upper 30 m (Dellinger, 2000; Dellinger and Ferreira, 2005). In general, loggerhead sea turtles spend most of their time at less than 40 m and they do not dive deeper than 100 m (Polovina *et al.*, 2003; Báez *et al.*, 2019). Thus, the primary depths at which interactions with longlines occur are in the upper 20 m of the water column (Dellinger and Ferreira, 2005). In fact, several studies have confirmed the very low direct mortality rate due to shallow-set longline gear activities (Pinedo and Polacheck, 2004; Piovano, Swimmer and Giacoma, 2009; Deflorio *et al.*, 2005; Gilman *et al.*, 2006; Jribi *et al.*, 2008). Recent studies confirm that by modifying only the depth of fishing

(i.e. leaving the longline at a depth inaccessible to sea turtles), the bycatch of loggerhead turtles can be reduced by up to 99.5 percent compared to surface longlines (Garibaldi, 2015; Cambiè *et al.*, 2013; Baèz *et al.*, 2019;). Therefore, shallower longlines result in lower direct mortality, while deeper longlines reduce bycatch rates.

Furthermore, sea turtle mortality seems to be correlated with setting time. For example, Camiñas *et al.* (2006) found that around 93 percent of loggerhead sea turtles were caught on the second half of the longline, i.e. the last part of the gear to be hauled back onboard. Therefore, the longer the set time, the more captured sea turtles may die. Indeed, by merging the data obtained in different areas, the mean mortality rate may be around 20 percent, i.e. ranging from 0 to 40 percent.

Based on the incidental catch estimates obtained by different authors for longlines, and considering that: a) sometimes the estimates could refer to partially overlapping areas; b) the bycatch estimates and mortality rates reported for certain areas show great variability (according to the reference year and type of longline); and c) the direct mortality and the delayed mortality are not always reported or are sometimes not clearly reported, it is calculated that between 27 000 and 56 000 sea turtles – if the estimates made for Morocco by Casale (2011) are taken into account – are caught annually by Mediterranean drifting longlines, with a direct mortality rate of around 20 percent, on average.

- The western Mediterranean is the area that raises the most concern. However, great variability in the estimates, especially regarding the Balearic Islands, prevents a clear picture of the situation from emerging. Older references indicate that around 38 000 sea turtles may be caught each year, with potentially more than 7 000 dead, while more recent estimates report about 9 000 sea turtles (and around 1 800 dead) caught in the western Mediterranean.
- In the central Mediterranean, the estimates are biased as the data from the Aegean Sea could be shared (and overlap) between the eastern and the central Mediterranean (especially for the Greek data). However, it is estimated that around 14 000 sea turtles may be caught annually, with around 2 900 dead.
- In the Adriatic Sea (mainly the southern Adriatic), around 1 200 capture events may occur annually, with around 250 dead. However, with increasing fishing effort in recent years from drifting longlines targeting swordfish, the overall rate could be higher;
- In the eastern Mediterranean, longliners are less important than in other areas, so that sea turtle bycatch is around 2 200 sea turtles annually, with about 400 dead.

TABLE 5 – Incidental catch of sea turtles in drifting longlines (data from literature 2008–2019)

Bibliographic reference	Reference years	Gear	GFCM subregion	Country	Species	Reported or estimated individuals in bycatch events[1]	Estimated mortality rate due to bycatch
Casale, 2011; Fortuna *et al.*, 2008	2009	LLD	Adriatic Sea	Italy	*Caretta caretta*	1 025	-
Lucchetti *et al.*, 2017a	2017	LLD	Adriatic Sea	Italy (central-northern)	*Caretta caretta*	226	14%
Gramentz, 1989	1989	LLD	Central Mediterranean	Malta	*Caretta caretta*	1 000–2 000	-
Panou *et al.*, 1992	1992	LLD	Central Mediterranean	Greece (Cephalonia)	*Caretta caretta*	50	-
Panou *et al.*, 1999	1989–1995	LLD	Central Mediterranean	Greece (Ionian Sea)	*Caretta caretta*	280	-
Freggi and Casale, 2006	2001–2002	LLD	Central Mediterranean	Italy (Lampedusa Island)	*Caretta caretta*	-	33%[2]

TABLE 5 (continued)

Bibliographic reference	Reference years	Gear	GFCM subregion	Country	Species	Reported or estimated individuals in bycatch events[1]	Estimated mortality rate due to bycatch
Kapantagakis, 2001	1999–2000	LLD	Central Mediterranean	Greece (east Ionian-Aegean)	*Caretta caretta*	3 310	-
Kapantagakis, 2001	1999–2000	LLD	Central Mediterranean	Greece (east Ionian-Aegean)	*Dermochelys coriacea*	171	-
Salter, 1995	1990–1991	LLD	Central Mediterranean	Greece	*Caretta caretta*	-	15–50%
STECF, 2005	1999–2005	LLD	Central Mediterranean	Greece (Ionian Sea)	*Caretta caretta*	3 181	-
Kapantagakis and Lioudakis, 2006	1999–2000	LLD	Central Mediterranean	Greece (Aegean and south Ionian Sea)	*Caretta caretta*	1 145–5 474	4.7%
Kapantagakis and Lioudakis, 2006	1999–2000	LLD	Central Mediterranean	Greece (Aegean and south Ionian Sea)	*Dermochelys coriacea*	0–342[3]	4.7%
De Metrio *et al.*, 1983	1983	LLD	Central Mediterranean	Italy (Ionian Sea–Gulf of Taranto)	*Caretta caretta*	250–1 000	-
Deflorio *et al.*, 2005	1999–2000	LLD	Central Mediterranean	Italy (Ionian Sea)	*Caretta caretta*	1 084–4 447	0% (high potential delayed mortality)
Jribi *et al.* 2008; Echwikhi *et al.*, 2006	2004–2005	LLD	Central Mediterranean	Tunisia (southern Gulf of Gabès)	*Caretta caretta*	486	0–9%
Casale *et al.* 2007, Casale, 2008; Casale, Freggi and Rocco, 2007	2007	LLD	Central Mediterranean	Italy (Lampedusa Island)	*Caretta caretta*	2 148	>30% (potential)
Cambiè *et al.*, 2010	2007	LLD	Central Mediterranean	Italy (south Ionian)	*Caretta caretta*	500	-
Casale, 2008	2008	LLD	Central Mediterranean	Tunisia	*Caretta caretta*	1 000	-
Casale, 2008	2008	LLD	Central Mediterranean	Libya	*Caretta caretta*	1 142	-
Casale, 2008	2008	LLD	Central Mediterranean	Malta	*Caretta caretta*	2 965	-
Burgess *et al.*, 2010	2008	LLD	Central Mediterranean	Malta	*Caretta caretta*	320	-
Echwikhi *et al.*, 2010a	2008	LLD	Central Mediterranean	Tunisia (Gulf of Gabès)	*Caretta caretta*	437	12%
Casale, 2011	2011	LLD	Central Mediterranean	Malta	*Caretta caretta*	3 101	-
Casale, 2011	2011	LLD	Central Mediterranean	Libya	*Caretta caretta*	1 410	-
Casale, 2011	2011	LLD	Central Mediterranean	Italy (Ionian Sea)	*Caretta caretta*	3 553	-
Casale, 2011	2011	LLD	Central Mediterranean	Italy (central Mediterranean)	*Caretta caretta*	2 148	-
Casale, 2011	2011	LLD	Central Mediterranean	Tunisia	*Caretta caretta*	972	-
Casale, 2011	2011	LLD	Central Mediterranean	Greece (eastern Ionian-Aegean Sea)	*Caretta caretta*	3 310	-
Lucchetti *et al.*, 2017a	2017	LLD	Central Mediterranean	Italy (Strait of Sicily, around Lampedusa)	*Caretta caretta*	5 679	14%
Nada and Casale, 2011	2007	LLD	Eastern Mediterranean	Egypt	*Caretta caretta*–*Chelonia mydas*	2 081 (1 095–3 285)	>30%
Casale, 2011	2011	LLD	Eastern Mediterranean	Egypt	*Caretta caretta*	1 275	-

TABLE 5 (continued)

Bibliographic reference	Reference years	Gear	GFCM subregion	Country	Species	Reported or estimated individuals in bycatch events[1]	Estimated mortality rate due to bycatch
Argano and Baldari, 1983	1978	LLD	Western Mediterranean	Spain	*Caretta caretta*	650–3 750	-
Mayol *et al.*, 1988	1985	LLD	Western Mediterranean	Spain	*Caretta caretta*	17 712	-
Camiñas, 1986	1985	LLD	Western Mediterranean	Spain	*Caretta caretta*	20 326	-
Camiñas, 1988	1986–1987	LLD	Western Mediterranean	Spain	*Caretta caretta*	16 315–16 697	-
Groombridge, 1989	-	LLD	Western and Central Mediterranean	-	*Caretta caretta*	35 000	-
Màs and Garcia, 1990	1989	LLD	Western Mediterranean	Spain (eastern basin)	*Caretta caretta*	5 935–7 568	-
Laurent, 1990	1988	LLD	Western Mediterranean	Morocco	*Caretta caretta*	3 581	-
Laurent, 1990	1988	LLD	Western Mediterranean	Algeria	*Caretta caretta*	324	-
Camiñas *et al.*, 1992	1989	LLD	Western Mediterranean	Spain	*Caretta caretta*	15 339	-
Màs *et al.*, 1992	1991	LLD	Western Mediterranean	Spain	*Caretta caretta*	22 880	-
Aguilar *et al.*, 1993	1992	LLD	Western Mediterranean	Spain	*Caretta caretta*	4 363–6 620	-
Aguilar *et al.*, 1995	1990	LLD	Western Mediterranean	Spain	*Caretta caretta*	35 637	20–30%
Aguilar *et al.*, 1995	1990–1991	LLD	Western Mediterranean	Spain	*Caretta caretta*	22 225–23 637	20–30%
Camiñas, 1996	1993	LLD	Western Mediterranean	Spain	*Caretta caretta*	1 953	-
Camiñas, 1996	1994	LLD	Western Mediterranean	Spain	*Caretta caretta*	5 364	-
Camiñas, 1996	1995	LLD	Western Mediterranean	Spain	*Caretta caretta*	11 673	-
Aguilar *et al.*, 1995; Camiñas *et al.*, 2001	1988/1995/2001	LLD	Western Mediterranean	Spain (Balearic Islands)	*Caretta caretta*	15 000–18 000	0.4%–7.7% (20–30% potential)
Laurent *et al.*, 2001; Mejuto *et al.*, 2006	-	LLD	Western Mediterranean	Spain	*Caretta caretta*	2 000–20 000	-
Camiñas, 2004	2004	LLD	Western Mediterranean	Algeria	*Caretta caretta*	250	-
Carreras *et al.*, 2004	2001	LLD	Western Mediterranean	Balearic Islands (Spain)	*Caretta caretta*	-	7.7%
Benhardouze, 2004	-	-	Western Mediterranean	Morocco	-	193	-
Benhardouze, 2004	-	-	Western Mediterranean	Morocco (Tangier region)	-	206	-
Camiñas, 2005	1984	LLD	Western Mediterranean	Spain	*Caretta caretta*	17 092	-
Camiñas *et al.*, 2006a, 2006b	1999–2004	LLD	Western Mediterranean	Spain	*Caretta caretta*	-	0.5–4.2%
Casale, 2008, 2011	2008	LLD	Western Mediterranean	Morocco	*Caretta caretta*	14 822	-
Casale, 2008	2008	LLD	Western Mediterranean	Algeria	*Caretta caretta*	294	-
Casale, 2008	2008	LLD	Western Mediterranean	France	*Caretta caretta*	317	-
Casale, 2008	2008	LLD	Western Mediterranean	Spain (north, Catalonia)	*Caretta caretta*	130	-

TABLE 5 (continued)

Bibliographic reference	Reference years	Gear	GFCM subregion	Country	Species	Reported or estimated individuals in bycatch events[1]	Estimated mortality rate due to bycatch
Casale, 2008	2008	LLD	Western Mediterranean	Spain (Balearic Islands)	*Caretta caretta*	102	-
Casale, 2008	2008	LLD	Western Mediterranean	Spain (south)	*Caretta caretta*	19 008	-
Casale, 2008	2008	LLD	Western Mediterranean	Italy (Tyrrhenian Sea)	*Caretta caretta*	5 055	-
Casale, 2008	2008	LLD	Western Mediterranean	Italy (Ionian Sea)	*Caretta caretta*	3 053	-
Álvarez de Quevedo *et al.*, 2010	2003–2004	LLD	Western Mediterranean	Spain (north, Catalonia)	*Caretta caretta*	124 (49–199)	0%
Benhardouze *et al.*, 2012	2003–2007	LLD	Western Mediterranean	Morocco (Tangier region)	*Caretta caretta*	51	-
Álvarez de Quevedo *et al.*, 2013	2007–2008	LLD	Western Mediterranean	Spain	*Caretta caretta*	10 656	32–37%
Báez *et al.*, 2014b	2006–2007	LLD	Western Mediterranean	Spain	*Caretta caretta*	6 060	40%
Báez *et al.*, 2014b	1999–2012	LLD	Western Mediterranean	Spain	*Caretta caretta*	56–597	-
Báez *et al.*, 2014b	2010	LLD	Western Mediterranean	Spain	*Dermochelys coriacea*	3	-
Casale, 2011	2011	LLD	Western Mediterranean	Italy (Tyrrhenian Sea, Sardinia)	*Caretta caretta*	5 572	-
Casale, 2011	2011	LLD	Western Mediterranean	Spain	*Caretta caretta*	20 176	-
Lucchetti *et al.*, 2017a	2017	LLD	Western Mediterranean	Italy (Tyrrhenian Sea, Sardinia)	*Caretta caretta*	2 506	14%
Camiñas *et al.*, 2018	1999–2016	LLD	Western Mediterranean	Spain	*Dermochelys coriacea*	1	-
Báez *et al.*, 2018	2004–2016	LLD	Western Mediterranean	Spain	*Caretta caretta*	5 639 (2 724–9 169)	-
Báez *et al.*, 2019	2000–2016	LLD	Western Mediterranean	Spain	*Caretta caretta*	5 317–5 565	1 861–1 955[4]
Báez *et al.*, 2019	2000–2003	LLD	Western Mediterranean	Spain	*Caretta caretta*	8 800–11 800	-
Báez *et al.*, 2019	2015–2016	LLD	Western Mediterranean	Spain	*Caretta caretta*	2 375	50%–low[5]
Báez *et al.*, 2019	2000–2016	LLD (for swordfish)	Western Mediterranean	Spain	*Caretta caretta*	3 000	-
Báez *et al.*, 2019	2000–2016	LLD (for albacore)	Western Mediterranean	Spain	*Caretta caretta*	833	-
Casale, 2008	2008	LLD	-	Entire Mediterranean	*Caretta caretta*	53 347	40%
Casale, 2011	2011	LLD	-	Entire Mediterranean	*Caretta caretta*	57 371	30%
Lewison *et al.*, 2004; NMFS, 2001	2001–2004	LLD	-	Entire Mediterranean	*Caretta caretta*	60 000–80 000	17–42% (potential)

Notes: LLD = drifting longline.

In grey data collected before 2008.

1. The data reported here are derived either from direct observations or from yearly estimates. Please refer to the original paper for the methodology used to obtain the value(s).
2. This estimate considers only the effect of the hook; considering the effect of the branch line on the mortality is even higher.
3. Only one specimen of leatherback sea turtle (Dermochelys coriacea) caught; the estimate of 342 sea turtles caught is obtained by extrapolating the bycatch to the whole fleet and fishing effort.
4. Estimates in number.
5. 50% for mesopelagic longlines, low mortality for drifting longlines (50–1 000 specimens).

These figures can be worse when considering the delayed mortality (more than 30–40 percent; Casale, Freggi and Rocco, 2007; Álvarez de Quevedo, San Felix and Cardona, 2013).

b) Set longliners

Set longlines are widely used in the Mediterranean, especially in the eastern Mediterranean. Gilthead seabream (*Sparus aurata*), common dentex and pink dentex (*Dentex* spp.), common pandora, seabreams (*Diplodus* spp.), groupers (*Epinephelus* spp.) and European seabass (*Dicentrarchus labrax*) are usually the main target species of set longlines. Taking into account the dimensions of the target species, set longlines usually employ smaller hooks than do drifting longlines. Therefore, their hooks can be swallowed by sea turtles feeding on the bait or on the prey captured by the set longlines. Nevertheless, set longlines, used at depths of 200–700 m, are not usually considered an issue for interactions with sea turtles (Bolten, Bjorndal and Martins, 1994). However, this fishing method is widely used also in shallower waters, where it results in sea turtle captures, mainly of juveniles. The data collected from the scientific literature suggest that set longlines are responsible for around 12 000 captures per year (Table 6).

TABLE 6 – Incidental catch of sea turtles in set longlines (data from literature 2008–2019)

Bibliographic reference	Reference years	Gear	GFCM subregion	Country	Species	Reported or estimated individuals in bycatch events[1]	Estimated mortality rate due to bycatch
Bradai, 1993	1993	LLS	Central Mediterranean	Tunisia (Gulf of Gabès)	*Caretta caretta*	2 000	0.5%
Casale *et al.*, 2007	2007	LLS	Central Mediterranean	Italy (Lampedusa Island)	*Caretta caretta*	257	-
Jribi *et al.*, 2008; Echwikhi *et al.*, 2006	2004–2005	LLS	Central Mediterranean	Tunisia (southern Gulf of Gabès)	*Caretta caretta*	733 (469–1090)	12.5% (33% potential)
Casale, 2008	2008	LLS	Central Mediterranean	Tunisia	*Caretta caretta*	1 000	-
Casale, 2008	2008	LLS	Central Mediterranean	Greece (Aegean Sea)	*Caretta caretta*	98	-
Casale, 2008	2008	LLS	Central Mediterranean	Malta	*Caretta caretta*	286	-
Casale, 2008	2008	LLS	Central Mediterranean	Libya	*Caretta caretta*	13 378[2]	-
Casale, 2011	2011	LLS	Central Mediterranean	Tunisia	*Caretta caretta*	1 466	-
Echwikhi *et al.*, 2012	2007–2008	LLS	Central Mediterranean	Tunisia (southern Gulf of Gabès)	*Caretta caretta*	142	43.8%
Casale, 2011	2011	LLS	Central Mediterranean	Libya	*Caretta caretta*	3 310	-
Casale, 2011	2011	LLS	Central Mediterranean	Malta	*Caretta caretta*	41	-
Nada and Casale, 2008	2008	LLS	Eastern Mediterranean	Egypt	*Caretta caretta*	2 218	>30%
Casale, 2008	2008	LLS	Eastern Mediterranean	Turkey	*Caretta caretta*	5 000	-
Casale, 2008	2008	LLS	Eastern Mediterranean	Greece	*Caretta caretta*	6 064	-
Casale, 2011	2011	LLS	Eastern Mediterranean	Greece	*Caretta caretta*	1 034	-
Casale, 2011	2011	LLS	Eastern Mediterranean	Syria	*Caretta caretta*	275	-

TABLE 6 (continued)

Bibliographic reference	Reference years	Gear	GFCM subregion	Country	Species	Reported or estimated individuals in bycatch events[1]	Estimated mortality rate due to bycatch
Casale, 2011	2011	LLS	Eastern Mediterranean	Egypt	*Caretta caretta*	806	-
Casale, 2011	2011	LLS	Eastern Mediterranean	Turkey	*Caretta caretta*	4 728	-
Levy *et al.*, 2015	2012	LLS	Eastern Mediterranean	Israel	*Caretta caretta*-*Chelonia mydas*	129	10%
Álvarez de Quevedo *et al.*, 2006; Carreras *et al.*, 2004	2004–2006	LLS	Western Mediterranean	Spain	*Caretta caretta*	21	-
Álvarez de Quevedo *et al.*, 2010	2003–2004	LLS	Western Mediterranean	Spain (northeastern)	*Caretta caretta*	11 (1–21)	-
Casale, 2011	2011	LLS	Western Mediterranean	France	*Caretta caretta*	22	-
Casale, 2008	2008	LLS	Western Mediterranean	Spain	*Caretta caretta*	96	-
Casale, 2008	2008	LLS	Western Mediterranean	Morocco	*Caretta caretta*	3 366	-
Casale, 2011	2011	LLS	Western Mediterranean	Morocco	*Caretta caretta*	127	-
Casale, 2008	2008	LLS	Western Mediterranean	Algeria	*Caretta caretta*	88	-
Casale, 2011	2011	LLS	Western Mediterranean	Algeria	*Caretta caretta*	98	-
Kaddouri *et al.*, 2018	2016	LLS	Western Mediterranean	Morocco (northwestern)	*Caretta caretta*	17	-
Benhardouze *et al.*, 2012	2003–2007	LLS	Western Mediterranean	Morocco (Tangier region)	*Caretta caretta*	91	16.6%
Casale, 2011	2011	LLS	-	Italy	*Caretta caretta*	471	-
Casale, 2008	2008	LLS	-	Italy	*Caretta caretta*	2 645	Potential mortality 40%
Casale, 2008	2008	LLS	-	Entire Mediterranean	*Caretta caretta*	12 000–34 000	Potential mortality 40%
Casale, 2011	2011	LLS	-	Entire Mediterranean	*Caretta caretta*	12 656	-

Notes:
LLS = set longline.
In grey data collected before 2008.
1. The data reported here are derived either from direct observations or from yearly estimates. Please refer to the original paper for the methodology used to obtain the values.
2. Estimated on the basis of values from Egypt and Tunisia.

Western Mediterranean

In the western basin, the incidental catch from set longlines seems to be less important than from drifting longlines. For example, Spain, Morocco and Algeria each appear to catch only around 100 sea turtles per year (Table 6).

Central Mediterranean

In the central Mediterranean, the data collected allow for an estimate of over 5 000 capture events per year. Tunisian set longliners, for example, seem to be responsible for around 1 000 catches annually. Indeed, Jribi *et al.* (2008) reported that the total bycatch of set longlines in Tunisian waters is higher than that of drifting longlines, due to greater fishing effort. Meanwhile, around 600 sea turtles annually can be added to this figure from Italy (Lampedusa Island), Algeria and

Malta combined (Table 6). Furthermore, Casale (2011) estimated about 3 310 captures per year from Libya alone.

Eastern Mediterranean

The eastern basin sees intensive fishing effort from set longliners, with incidental catch estimates of about 7 000 sea turtles per year, mainly in Greece (between 1 000 and 6 000), Turkey (around 5 000) and Egypt (between 800 and 2 000). In Greece, the estimates made by Casale in 2008 (6 000 sea turtles per year), based on the fishing effort at that time, have been subsequently revised downward by the same author in 2011 (to around 1 000 sea turtles per year).

Adriatic Sea

No data are available for set longliners operating in the Adriatic Sea.

Black Sea

No data are available for set longliners operating in the Black Sea.

Set longliners overview

The mortality induced by set longlines is difficult to evaluate; direct mortality seems to be low, but the studies conducted at sea turtle rescue centres show a high post-release mortality, over both the short and long term.

The mortality rate appears to be concentrated among young sea turtles, as larger specimens are often able to drag the main line, with its weights, up to the surface to breathe or even break the branch lines. According to Casale (2008), set longlines seem to be responsible for a potential (delayed) mortality of about 40 percent, though data obtained from the review lead to a lower estimate of average mortality rate – around 24 percent.

To summarize, about 12 000 sea turtles may be caught annually in the Mediterranean Sea by set longlines, with about 3 000 dead.

- Around 7 000 sea turtles caught per year (and around 1 400 dead) in the eastern basin;
- Around 5 000 sea turtles caught per year (and 1 000 dead) in the central Mediterranean;
- Around 300 sea turtles caught per year in the western basin.

2.3.5 Purse seiners

Purse seining is an important fishing technique in the Mediterranean, developed around the end of the 1950s and targeting either small fish, such as sardine and anchovy, or bluefin tuna. Information on sea turtle bycatch and mortality in purse seines is scarce, probably since these fisheries do not heavily impact sea turtles (Universitat de Barcelona, 1995). Purse seines are made of a long wall of netting framed by a floatline on top and a leadline at the bottom, which is used to surround a school of fish, both from the sides and from underneath, thereby preventing them from escape by diving downwards. Unfortunately, sea turtles may be captured while the school of fish is encircled. After the setting is completed, the net is closed by hauling in the purse line and the fish can no longer escape. The vessel begins to haul back the net by means of a mechanized power block (if there is one) or by hand, and the catch is slowly herded into the bunt (i.e. the section of the net hung to form a bag or pocket, which is hauled in last). Once most of the purse seine has been retrieved, the fish are grouped within a restricted area along one side of the vessel. Subsequently, the fish are harvested from the purse seine using a large scoop net. Fish caught by

this gear remain alive within the net and are then transferred into large tanks with water and ice. Therefore, caught sea turtles are still alive in the net at the end of the hauling process, and their mortality is negligible (Sacchi, 2008).

Some authors highlighted that traditional fish aggregating devices (FADs) might present a serious threat to sea turtles (Blasi *et al.*, 2016). Fish aggregating devices are permanent, semi-permanent or temporary structures or devices used in some fisheries to concentrate schools of fish, mainly dolphinfish (*Coryphaena hippurus*), and other large pelagic fish species such as the greater amberjack. Purse seines, with and without purse lines, are generally used to catch the fish aggregated below the FAD. Blasi *et al.*, (2016) reported that loggerhead sea turtles show a strong tendency to aggregate near FADs, as these represent foraging hotspots to sea turtles. Fish aggregating devices are potentially dangerous because the turtles can become entangled in their anchoring lines of nylon, which can wrap around the sea turtles' necks, flippers and posterior limbs. Sea turtle–FAD interactions can occur at all life stages, although bycatch seems to be more frequent for smaller turtles (Blasi *et al.*, 2016).

Despite the importance of this fishery for some Mediterranean countries (Morales-Nin *et al.*, 2000; Morales-Nin 2011; Scott and Lopez, 2014; FAO CopeMed II, 2016; Sinopoli *et al.*, 2019), the indirect impacts of FADs on sea turtles have potentially been underestimated up to now and require further study.

Western Mediterranean

A few catches have been registered in the western basin (Carreras, Cardona and Aguilar, 2004), but the reported mortality was negligible (Camiñas, 1997; Sacchi, 2008). Laurent (1990) reported that around 260 sea turtles per year are caught in Algeria by purse seines targeting sardines (Table 7). Laurent (1991) reported that in France, purse seines targeting small and large pelagic species can catch from zero to five turtles per vessel per year and that turtles are always released alive.

TABLE 7 – Incidental catch of sea turtles in purse seiners (data from literature 2008–2019)

Bibliographic reference	Reference years	Gear	GFCM subregion	Country	Species	Reported or estimated individuals in bycatch events[1]	Estimated mortality rate due to bycatch
Nada and Casale, 2011	2007	PS	Eastern Mediterranean	Egypt	*Caretta caretta–Chelonia mydas*	99	-
Levy *et al.*, 2015	2012	PS	Eastern Mediterranean	Israel	*Caretta caretta–Chelonia mydas*	67	0–2%
Nada and Casale, 2008	2008	PS	Eastern Mediterranean	Egypt	*Caretta caretta*	37	-
Laurent, 1990	1989	PS	Western Mediterranean	Algeria	*Caretta caretta*	262	-
Álvarez de Quevedo *et al.*, 2010	2003–2004	PS	Western Mediterranean	Spain (northeastern)	*Caretta caretta*	4 (3–5)	-
Carreras *et al.*, 2004	2001	PS	Western Mediterranean	Spain Balearic Islands	*Caretta caretta*	6	-
Universitat de Barcelona, 1995	1995	PS	Western Mediterranean	Spain	*Caretta caretta*	1.5 per vessel/ year	0%
Kaddouri *et al.*, 2018	2016	PS	Western Mediterranean	Morocco (northwestern)	*Caretta caretta*	21	-

Notes: PS = purse seine.
In grey data collected before 2008.
1. The data reported here are derived either from direct observations or from yearly estimates. Please refer to the original paper for the methodology used to obtain the values.

Central Mediterranean
No data were available for purse seiners operating in the Central Mediterranean.

Eastern Mediterranean
The collected information confirms that purse seine incidental catch could represent an issue in the eastern basin, as the Egyptian and Israeli fishing fleets each catch almost 100 sea turtles annually in purse seiners (Nada and Casale, 2011) (Table 7).

Adriatic Sea
No data were available for purse seiners operating in the Adriatic Sea.

Black Sea
No data were available for purse seiners operating in the Black Sea.

2.3.6 Tuna seiners

Western Mediterranean
No data available.

Central Mediterranean
No data available.

Eastern Mediterranean
No data available.

Adriatic Sea
No data available.

Black Sea
No data available.

2.3.7 Dredges

Western Mediterranean
A few catches (21 sea turtles per year) were reported by Álvarez de Quevedo *et al.* (2010) in whelk dredges operating in the waters off Catalonia (northeastern Spain). Dredges probably interact with sea turtles feeding along the seabed in coastal waters.

Central Mediterranean
No data available.

Eastern Mediterranean
No data available.

Adriatic Sea
No data available.

Black Sea
No data available.

2.4 Outlook

In the Mediterranean Sea, scientific efforts over the last ten years have focused on the study of sea turtle biology and ecology and the protection of their nesting sites. As a result, quite complete information is available on the areas hosting their main nesting sites, their major migratory routes (mainly detected through satellite tracking and tagged sea turtles), prey preferences, neritic foraging habitats, growth rates and genetic structure, among other aspects (see Casale *et al.*, 2018 for a review). However, knowledge gaps still remain, as highlighted in this review, on the incidental capture of sea turtles and their interactions with different types of fishing gear. This lack of information mainly persists because structured and standardized survey methods (e.g. questionnaires, observations onboard, etc.) have not been developed and/or implemented until recently (FAO, 2019). The current shortcomings can be partially justified by the fact that onboard observations are demanding in terms of the time, resources and personnel required. These challenges also explain why, in in the last ten years, surveys based on interviews with fishers are often heavily relied upon to assess incidental catch (for example, Nada and Casale, 2011; Carreras, Cardona and Aguilar, 2004; Lucchetti, Vasapollo and Virgili, 2017a; Domènech *et al.*, 2015; Levy *et al.*, 2015). Indeed, in cases of poor data availability from onboard observations – the best way to achieve the clearest picture of sea turtle bycatch – involving and interviewing fishers and stakeholders may offer an effective alternative data collection method when resources are limited (FAO, 2019). Such a method can provide data on sea turtle bycatch, which is sufficient to arrive at estimates of minimum annual incidental catch, to identify high-risk types of fishing gear/location/season combinations and to prioritize areas for further research and the introduction of management measures.

The sea turtle bycatch estimates obtained by onboard observers and interviews with fishers, while sometimes reporting great variability between geographical areas and fishing gear types, can also show similar diversity within the same area from one year to another, as well as in relation to different aspects of sea turtle life history, such as nesting intervals and migration and feeding patterns, among other factors. This is mainly due to a lack of clear knowledge of the true fishing effort, and thus incidental catch data are usually inaccurately extrapolated to the entire fleet by using a nominal rather than a real fishing effort. Moreover, the characteristics of a fishery, together with different gear properties and fishing tactics (such as fishing depth and setting time) could affect the BPUE.

Presently, few national standardized onboard observer programmes are in place and monitoring often covers only a very limited number of industrial fisheries, while information on many coastal artisanal fisheries is poor. Furthermore, some geographical areas are not yet covered for many reasons (such as for political or economic motives). This situation has led to estimates of sea turtle bycatch in some countries based on BPUE figures from neighbouring countries, which, while certainly not the ideal approach, is often the only possible one. Moreover, it is rarely accurate to extrapolate the estimated data for a type of fishing gear to the whole fleet. Indeed, within the same vessel type (e.g. drifting longliners), the type of gear or fishing strategy used, according to the target species (e.g. bluefin tuna or swordfish), can result in different bycatch rates. The case of the incidental catch (and mortality) estimates obtained for Spanish longliners, following the introduction new technology and fishing strategies in the longline fleets, is emblematic of this issue: before the 2000s, 22 000, or even 35 000, sea turtle captures per year were reported

(e.g. Aguilar, Más and Pastor, 1995); however, recent estimates (Báez *et al.*, 2018, 2019) seem to paint quite a different picture, with around 3 000–9 000 catches annually until 2013, and around 3 000 more recently (2013–2016).

Thus, in order to obtain a reliable estimate of the number of incidental captures in an area, for example, in a geographical subarea, it is essential to identify:

- The real fishing effort (including the number of vessels, number of fishing days, number of hooks/nets per vessel, among many other factors);
- The BPUE for each type of fishing gear used in that area, taking account that the BPUE for the same gear could vary greatly according to gear properties, fishing tactics, target species and environmental conditions.

As mentioned above, due to a lack of standardized protocols to record sea turtle bycatch, the estimates obtained from this review should be considered as an indication of the magnitude of the issue. However, even if gaps and weaknesses do exist in the estimates gathered, it is possible to gain a perspective of the scale of the phenomenon, in relation to the most impactful fishing gear types and the different areas of the Mediterranean. Nevertheless, when data only referred generically to "turtles," it was not possible to discern incidental catch estimates at the species level.

The information collected allowed an estimate to be made of around 121 000 sea turtles potentially caught in the Mediterranean each year, with about 33 000 considered potentially dead. In the last ten years, bottom trawlers seem to represent the fishery with the greatest impact on sea turtles, responsible for around 51 000 catches and 9 000 dead (17.6 percent). Drifting longline and set net fisheries are responsible for about 27 000 and 31 000 capture events, respectively, with about 5 300 (19.6 percent) and 16 000 (51.6 percent) dead. Set longlines catch around 12 000 sea turtles each year, with around 2 600 dead (21.7 percent). Other types of fishing gear seem to have a negligible impact on sea turtles, except for midwater pair trawls in the northern Adriatic Sea and in southern Turkey, two important foraging areas for sea turtles. However, if the estimates made by Casale (2011) for Morocco (14 800 catches per year) and Spain (20 200 catches per year) are instead taken into account (without judging which of these or the previous estimates are the most accurate), the bycatch numbers in the western basin rise markedly, to around 38 000 captures and about 7 600 dead (20 percent) with drifting longlines. These estimates lead to a total bycatch (aggregating all the different types of fishing gear) of 150 000 sea turtles and 39 000 dead (26 percent). Considering the precautionary approach, the first scenario (121 000 capture events and 33 000 dead, i.e. 27.3 percent) seems to be the most reliable. The presence of sea turtles in the Black Sea is so rare that it was not feasible to assess the impact of fishing activities, even though the sea turtles recorded in this area were in fact found in set nets.

Compared to past estimates, the current figures seem to highlight the importance of sea turtle bycatch in bottom trawls, which could be considered the most impactful of types of fishing gear, especially on the continental shelves of the northern Adriatic Sea, Tunisia, Egypt, Turkey and Israel. On the other hand, the estimates made after 2008 suggest that the incidental catch in drifting longlines in the western basin (operated mainly by the Spanish fleet) could be considered less severe than was estimated in the past. What appears like an apparent reduction in sea turtle bycatch could be due to advanced data analysis, which takes into consideration the different catch rates associated with longlines used in different areas and targeting different species (such as swordfish, albacore and bluefin tuna). Moreover, the introduction of the mesopelagic longline seems to have strongly reduced sea turtle bycatch in this area. This effect was also observed

in the Ligurian Sea (Italy) by Garibaldi (2015). An explanation for reduced bycatch could be that loggerhead turtles usually spend most time at less than 20 m and do not dive deeper than 70–100 m (Houghton *et al.*, 2002; Polovina *et al.*, 2003).

An analysis of the various fisheries and their interactions with sea turtles in the Mediterranean show diverse impacts, depending on species, country and gear. Based on the available data, the most important vessel groups interacting with sea turtles in all countries are pelagic and bottom trawlers (with higher interactions recorded in the northern Adriatic, Turkish Mediterranean Sea, and off Tunisia) and drifting longliners (with higher interactions recorded off Spain and Italy). In general, sea turtle bycatch in SSF is a critical issue, though difficult to assess due to the large number of small boats scattered along the Mediterranean coastline and the logistical problems involved with data collection through onboard observations.

The estimates of direct mortality rates show great variability between different fishing gears, but also within the same gear, since gear-related, operational, environmental and ecological factors (such as migratory routes) may all affect sea turtle mortality. Interactions between fishing activities and sea turtles mostly occur when fishing activities overlap with sea turtle habitats and migratory routes. Therefore, bottom trawls and set nets mainly interact with sea turtles in their neritic foraging habitats while sea turtles feed on the bottom. Moreover, in overwintering grounds, sea turtles exhibit intermittent dormancy, resting for longer periods on the seabed, in addition to reduced metabolic rates, which decrease their mobility (Broderick *et al.*, 2007; Hochscheid *et al.*, 2007). As a result, when feeding on the bottom, sea turtles are more vulnerable to any fishing gear operating on the seabed (e.g. bottom trawls). In contrast, drifting longlines mainly interact with sea turtles in the pelagic environment, when they are feeding or migrating between different basins.

The estimates of bycatch-induced mortality depend on the capacities of sea turtles to survive forced apnoea and consequent drowning. Set nets seem to be responsible for the highest mortality rates (51 percent on average), with the highest values recorded for trammel nets set in deep waters (with mortality rates greater than 80 percent). Mortality rates vary according to different types of set nets (gillnets, trammel nets, among others), gear properties (such as mesh size, hanging ratio, vertical netting slackness and netting twine thickness), operational factors (soaking time, depth setting) and environmental factors (such as sea water temperature), as well as the dimensions of sea turtles. Sea turtles may also die if released with pieces of netting tangled around their bodies, as these can be ingested or cause necrosis of the flippers (Margaritoulis, Koutsodendris and Panagopoulou, 2007). Moreover, differences in habitat use by adults and juveniles, in relation to different types of fishing gear, appears to make juveniles more susceptible to gillnet and trammel net entanglement than adults. In fact, Tomás, Aznar and Raga (2001) described juvenile loggerheads as scavengers of discards, noting that this behaviour might lead them to depredate from static fishing gear, thereby making them more vulnerable to entanglement than their adult counterparts. Furthermore, recent studies (TartaLife, 2013) have demonstrated that set nets with larger meshes (more than 70–80 mm mesh openings) are more harmful than nets with smaller meshes. Similarly, trammel nets seem to induce higher mortality rates than gillnets. Bycatch mitigation measures should be one of the priorities for set net fisheries in the eastern Mediterranean Sea (especially trammel nets in shallow waters), as most nesting occurs in this area.

The other gear types, i.e. bottom trawls, drifting and set longlines, showed similar mean direct mortality rates (18, 20 and 21 percent on average, respectively), even if within the same gear type, mortality could vary greatly according to different factors.

Towing time can be considered as the main factor influencing sea turtle mortality in bottom trawls (long towing time results in prolonged apnoea and increases the risk of injuries caused by contact with the net, the bottom or debris, including rocks and timber also caught in the net), even though environmental factors, such as water temperature, can also greatly affect survival. In general, however, direct mortality induced by bottom trawls is low and sea turtles are usually released alive.

In longlines, direct mortality observed at gear retrieval is often low, when compared with other types of fishing gear (such as set nets), but the post-release mortality is suspected to be higher (up to 40 percent; Álvarez de Quevedo, San Félix and Cardona, 2013). Báez *et al.* (2013) found that the type of longline (according to the target species and depth setting) significantly affects the bycatch rate and the size of the turtles caught: drifting longlines targeting albacore and using smaller hooks tend to capture smaller loggerheads but show the highest BPUE; conversely, surface longlines targeting bluefin tuna and traditional surface longlines targeting swordfish, both using larger hooks, tend to select for larger animals. Moreover, surface longlines targeting swordfish have the lowest BPUE. In addition, Báez *et al.* (2007) found that the probability of catching sea turtles decreases with greater distance from the coast and, to a lesser extent, with increasing depth. Thus, sea turtle bycatch in longline fisheries can be substantially reduced by restricting fishing effort within 35 nautical miles of the coast and by setting the main line deeper (i.e. at depths below which sea turtles are abundant; Garibaldi, 2015; Cambiè *et al.*, 2013).

Over the last 20 years, a number of studies have been carried out to find technical solutions to reduce sea turtle bycatch. However, the level of implementation of such measures to reduce bycatch (for example, BRDs) in the Mediterranean is either low or zero. Most of the studies have dealt with drifting longlines and have mainly focused on the effects of hook shape, hook size and type of bait in relation to sea turtle bycatch (MRAG Ltd., Lamans S.A. Management Services and AZTI-Tecnalia, 2008; Piovano, Swimmer and Giacoma, 2009). The studies carried out in the Mediterranean (for example, Piovano *et al.,* 2004, 2005; Rueda *et al.,* 2006) highlighted the positive effects of circle hooks and mackerel bait as a means to reduce sea turtle mortality and bycatch. Unfortunately, only a few studies have been carried out to reduce sea turtle bycatch in bottom trawls and set nets. The results obtained from studies using turtle excluder devices (TEDs) in bottom trawls, mainly carried out in Italy (TartaLife, 2013) and Turkey (Atabey and Taskavak, 2001), are promising and should be replicated in other areas. Similarly, experiments with visual deterrents (ultraviolet light-emitting diodes) mounted on set nets, based on the findings of Wang, Fisler and Swimmer (2010), Wang *et al.* (2013) and Ortiz *et al.* (2016), have shown positive results in Italy (TartaLife, 2013; Virgili *et al.*, 2018) and Turkey (Snape, 2014). Therefore, BRDs should be tested more and adapted according to country, fishery and subregion.

As many projects have demonstrated, such as the Project on mitigating interactions between endangered marine species and fishing activities (2015–2018) carried out by the Agreement on the Conservation of Cetaceans of the Black Sea, Mediterranean Sea and Contiguous Atlantic Area (ACCOBAMS) and the GFCM (ACCOBAMS, 2018), the collaboration of fishers and the establishment of permanent cooperation with them is key for the conservation of sea turtles (Rueda and Sagarminaga, 2008). In this regard, the use of proper gear/devices or the right fishing tactics can decrease incidental catch. Moreover, the first operations carried out onboard by fishers following the capture of a sea turtle are fundamental in reducing delayed mortality. Thus, education/awareness campaigns for fishers and other users on handling sea turtles (for example, Gerosa and Aureggi, 2001; FAO and ACCOBAMS, 2018) should be further encouraged (i.e. including advice on keeping the sea turtles onboard and allowing them to recover before release,

making sure sea turtles are warm during winter and cool during summer, cutting the branch lines as close as possible to sea turtles' mouths, delivering injured sea turtles to rescue centres, and removing hooks from sea turtle mouths when possible, etc.).

In summary, reducing sea turtle bycatch in the Mediterranean could be improved through a multidisciplinary approach that consists of:

- improving data collection regarding sea turtle bycatch and mortality (including post-release mortality) in relation to different gear types, in terms of estimates, areas and periods of interaction;
- identifying and applying suitable changes to fishing gear and practices (while considering the economic and social consequences);
- identifying reliable management policies, such as replacing some types of fishing gear, at least in certain periods, setting up (temporarily) closed areas and seasons, among others;
- awareness campaigns on correct handling procedures for fishers, for personnel operating in the rescue centres, for those involved in the protection of nesting sites and for local people who live in these coastal areas.

Therefore, a binding cooperation between the fishing industry, management bodies and research institutions is of paramount importance for protecting sea turtles.

Improving the data collection of sea turtle bycatch remains urgent. Currently, only a few national programmes for onboard observers are active. Very often, the data available cover a few industrial fisheries, while a general lack of information remains for many coastal fisheries. To remedy this situation, systematic surveys to monitor sea turtle bycatch in different fisheries should be urgently launched, particularly in order to identify the incidental catch rates and mortality rates in each area and by gear type. Effective reporting and monitoring would allow scientists and managers to develop a more complete overview of the situation and to identify priority areas for management actions. Therefore, the use of a standard sampling procedure should be encouraged (FAO, 2019). Detailed data need to be collected on fleet structure, fishing effort, fishing gear and fishing tactics, so that the incidental catch data gathered through onboard surveys can be more accurately extrapolated. Additionally, logbooks and interviews with stakeholders should guarantee a reasonable knowledge base for sea turtle bycatch. This approach can be used as a first assessment of the extent of the problem in areas where information on bycatch is scarce or it can be applied to those fisheries presenting challenges to the use of observers (e.g. small vessels that cannot host an observer onboard). However, to be effective and useful, logbooks and interviews should be conducted and compiled using a standardized system across the different countries. Thus, stakeholder involvement determines the success of these projects, not only in gathering better bycatch data more widely, but in ultimately reducing the mortality rates of incidentally caught sea turtles in the Mediterranean Sea.

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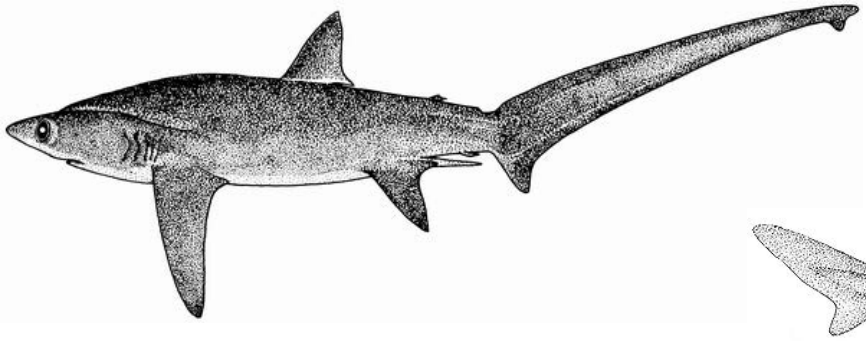

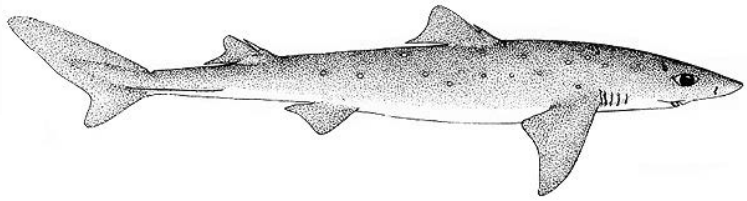

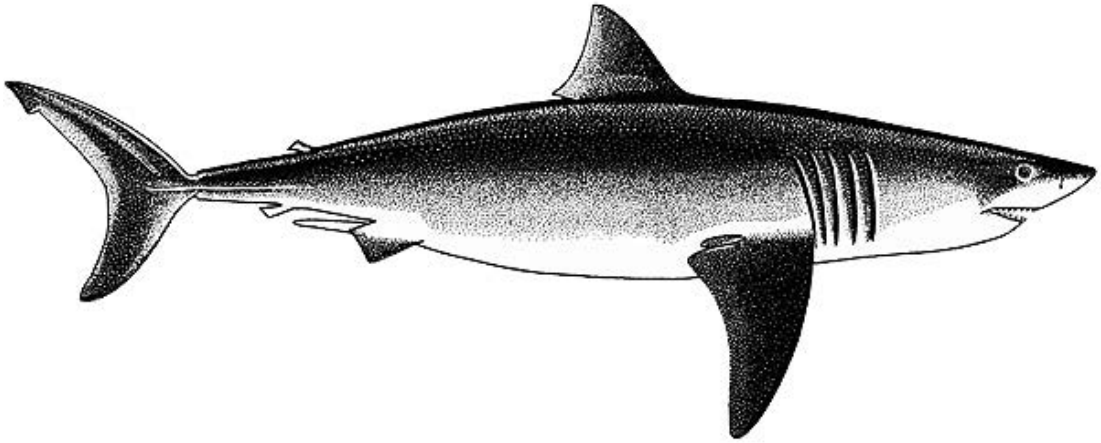

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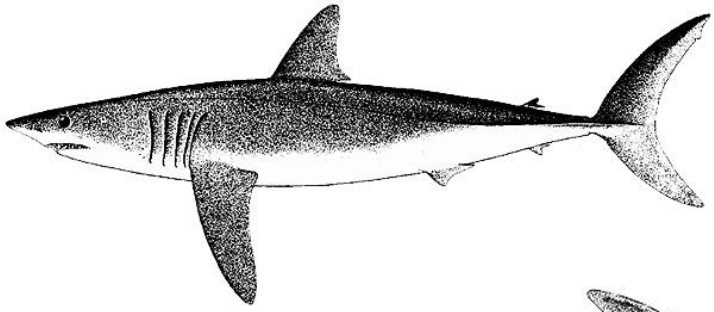

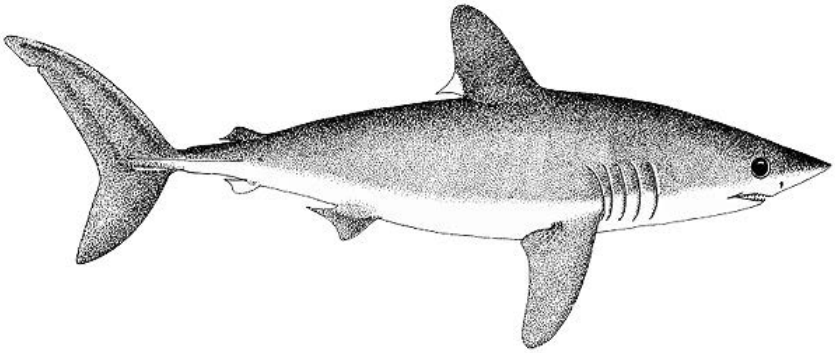

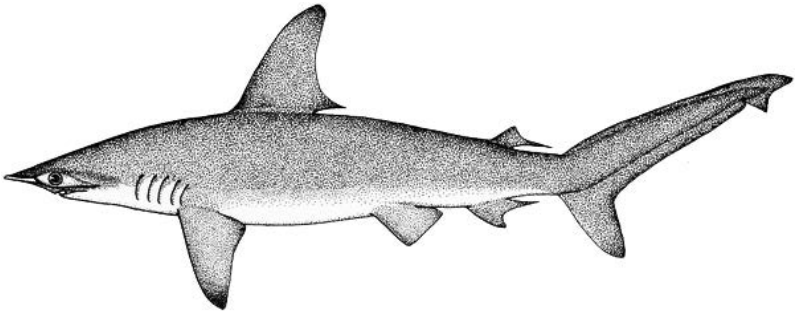

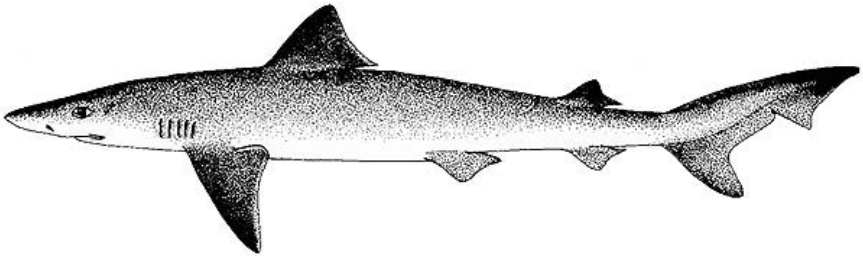

Spintail devil ray (*Mobula mobular*)

3. Elasmobranchs

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Executive summary

Mediterranean and Black Sea ecosystems contribute about seven percent of global chondrichthyan (cartilaginous fishes, including sharks, skates, rays and chimaeras) diversity, with at least 48 species of sharks and 38 species of batoids (rays and skates). As K-strategists (low population growth rates, late sexual maturity and production of relatively few offspring), chondrichthyans have low resilience to anthropogenic pressures, making them particularly vulnerable to human activities. Over a relatively short time, human pressure has caused a worrying decline in chondrichthyan populations worldwide, including in the Mediterranean and the Black Sea. At the Mediterranean level, 24 species of elasmobranchs are considered by regional conventions or regulations to require conservation efforts, such as those described by the Convention for the Protection of the Marine Environment and the Coastal Region of the Mediterranean (Barcelona Convention) and in recommendations of the European Union and the General Fisheries Commission for the Mediterranean (GFCM), among others. Currently, about 28 percent of Mediterranean and Black Sea chondrichthyan species are granted a legal protection framework.

In the Mediterranean Sea, though almost no fishing activity currently targets elasmobranchs and finning is banned by international decisions, elasmobranchs are often still caught as bycatch in many fisheries; depending on the species, individuals are either discarded or landed despite generally low market values. In any case, chondrichthyan incidental catch rates threaten to be

unsustainable for the long-term survival and conservation of some species, particularly for those assessed as "Endangered" or "Critically Endangered" in the International Union for Conservation of Nature (IUCN) Mediterranean Red List of Threatened Species (IUCN, 2021). Similarly, in the Black Sea, the piked dogfish (*Squalus acanthias*°) has been assessed as depleted by the GFCM and a recovery plan should be implemented. In order to better understand the impacts of fisheries on elasmobranchs, it is necessary to carefully monitor all fishing activities to understand the composition of the catch, including discards and species' post-capture survival rates.

Using sources such as scientific papers and reports, as well as unpublished information, it was possible to obtain baseline information regarding interactions between elasmobranchs and fishing activities in the Mediterranean and the Black Sea at the subregional scale, with a focus on the 33 conservation-priority species identified by GFCM recommendations (identified with the symbol "°" in this review). From 2008 to 2019, a total of 25 312 specimens belonging to various conservation-priority species were reported in the relevant literature from the various subregions. According to the sources gathered and analysed in this review, most conservation-priority elasmobranch bycatch comes from longliners (set and drifting together) (55 percent), followed by small-scale fisheries (18 percent), bottom trawlers (13 percent), pelagic trawlers (11 percent), and purse and tuna seiners (almost 3 percent). In particular, 78 percent of the total bycatch events involving elasmobranchs in the central Mediterranean subregion are reported from longline fisheries (set and drifting), whereas in the Adriatic Sea, the large majority of elasmobranch bycatch records are reported from pelagic trawlers (85 percent). Most bycatch records from bottom trawlers come from the eastern Mediterranean (32 percent), while the bycatch of sharks and rays in small-scale fisheries is most frequently reported from the western Mediterranean area (52 percent). Very few records could be found for the Black Sea region, probably due to the small populations of elasmobranch species in this area; however, the *S. acanthias*° is reported as a major bycatch component of Black Sea small-scale fisheries and bottom trawlers. The highest diversity of elasmobranch conservation-priority species is found in the eastern Mediterranean Sea, followed by the central Mediterranean, though the majority of bycatch records available come from the central Mediterranean; almost all records from the Adriatic Sea, meanwhile, concerned only three species.

Standard fishery measures for the recovery of bony fish are seldom effective for elasmobranch species. In fact, the best measures to ensure the conservation of shark populations are those that aim to reduce fishing mortality by avoiding fishing activities in nurseries and reproduction sites, and by releasing individuals that are still alive when caught.

One of the most difficult issues related to assessing elasmobranch bycatch is species identification. Easy tools should be provided to fishers to help them recognize Mediterranean species and distinguish protected species from commercial ones, as well as to record catches. The precautionary approach becomes very important for these species with limited data available to assess their conservation status. For this reason, it is crucial to gather information systematically from all fisheries data collection framework programmes in place and to enforce current management measures. Nevertheless, information campaigns for fishers and stakeholders are required in order to raise awareness of the current legal framework and the ecological roles played by these vulnerable animals in sustaining the health of marine ecosystems.

3.1 Description of the group

The Chondrichthyes (i.e. cartilaginous fishes, including sharks, skates, rays and chimaeras) consist of two subclasses, the Holocephali (chimaeras) and the Neoselachii (sharks and rays). Taxonomic studies considering both morpho-biometric and genetic aspects have led to increasingly improved knowledge of the different species in general. Globally, 599 shark species belong to 37 families; 818 batoid species belong to 26 families; and 57 Holocephali species belong to three families of chimaeras (The ETYFish Project, 2019; Ebert, Fowler and Compagno, 2013; Nelson, Grande and Wilson, 2016; Last *et al.*, eds, 2016; Roskov *et al.*, 2020).

Mediterranean and Black Sea ecosystems contribute about seven percent of this chondrichthyan diversity, with at least 48 species of sharks and 38 species of batoids (rays and skates); of these, only 10 species live in the Black Sea (Bilecenoğlu, Kaya and Cihangir, 2014). Up until recently, the only species of chimaera thought to be present in the Mediterranean was the rabbit fish (*Chimaera monstrosa*). However, in recent years Syrian and Egyptian researchers have found another species of chimaera, the large-eyed rabbit fish (*Hydrolagus mirabilis*), originating from the Atlantic Ocean (Serena, 2005; Hassan, 2013; Farrag, 2016; FAO, 2018a; FAO, 2018b; Serena *et al.*, 2020). Of the 48 Mediterranean shark species, about half have demersal habits, while the remaining half are considered to be free swimming in the water column. In contrast, almost all the batoids are demersal and only two species, the pelagic stingray (*Pteroplatytrygon violacea*) and the spintail devil ray (*Mobula mobular*), have pelagic habits. Some species of rays, as well as certain sharks, such as the bluntnose sixgill shark (*Hexanchus griseus*), are known to make movements by detaching themselves from the seabed relatively effortlessly in order to swim upwards in the water column (Mundy, 2005; Castro, Woodley and Brudek, 1999).

Although the chondrichthyans have maintained the same optimal evolutionary status they achieved relatively quickly more than 400 million years ago, at the global level their populations are currently threatened by two main phenomena: alterations in the marine habitat, coupled with the development of increasingly intensive and technological fisheries, and the quite recent phenomenon of finning (i.e. the act of removing fins and discarding the rest of the shark), which is of great concern for the conservation of shark populations (Ferretti and Myers, 2006; da Silva Rodrigues Filho and Bráullio de Luna Sales, 2017; Hareide *et al.*, 2007; Oliver *et al.*, 2015).

As K-strategists (low population growth rates, late sexual maturity and production of relatively few offsprings), chondrichthyans have low resilience to anthropogenic pressures, making them particularly vulnerable and limiting their recovery capacity from fishing mortality, both direct and indirect (Cavanagh and Gibson, 2007; da Silva Rodrigues Filho and Bráullio de Luna Sales, 2017; Stevens *et al.*, 2000; Ferretti *et al.*, 2010; Oliver *et al.*, 2015; Dulvy *et al.*, 2016). Over a relatively short amount of time, anthropogenic pressure has caused a worrying decline in elasmobranch populations worldwide, including in the Mediterranean basin (Coll, Navarro and Palomera, 2013; Başusta, Başusta and Özgürözbek, 2016; Bargnesi, Lucrezi and Ferretti, 2020; Myers *et al.*, 2007; Ferretti *et al.*, 2008; Heithaus *et al.*, 2008; Camhi *et al.*, 2009; Guisande *et al.*, 2013; Worm *et al.*, 2013; Barausse *et al.*, 2014; Oliver *et al.*, 2015; Dulvy *et al.*, 2014, 2016). Chondrichthyans are, in fact, considered among the most threatened marine animals worldwide; based on the last IUCN Shark Specialist Group's assessment of 1 041 species, at least 24 percent are classified as "Near Threatened" at the global level (Cavanagh and Gibson, 2007; Dulvy *et al.*, 2014, 2016; Nieto *et al.*, 2015). At the Mediterranean level, between 53 and 71 percent of elasmobranch species are at conservation, risk with many showing an elevated and deteriorating regional threat status

(i.e. Mediterranean Sea) compared to their global status (Bargnesi, Lucrezi and Ferretti, 2020; Cashion, Bailly and Pauly, 2019). For example, 9 out of 16 shark species reported in domestic FAO Mediterranean landings are considered more threatened regionally than they are at the global level (Cashion, Bailly and Pauly, 2019).

Unlike other species considered vulnerable (for example, marine mammals and sea turtles) that are generally protected by various international conventions and national regulations, cartilaginous species are not totally protected, even though they often constitute important proportions of bycatch in all fisheries at the global scale. Referring to the Mediterranean and the Black Sea, current instruments in place, such as the Convention for the Protection of the Marine Environment and the Coastal Region of the Mediterranean (Barcelona Convention), Regulation 2019/124 of 30 January 2019 of the Council of the European Union (Council of the European Union, 2019), and Recommendation GFCM/36/2012/3 on fisheries management measures for conservation of sharks and rays in the GFCM area of application, later amended by GFCM/42/2018/2 on fisheries management measures for the conservation of sharks and rays in the GFCM area of application (GFCM, 2021), consider only a few species of elasmobranchs from a conservation point of view. In particular, Recommendation GFCM/36/2012/3 on fisheries management measures for conservation of sharks and rays in the GFCM area of application and Recommendation GFCM/42/2018/2 on fisheries management measures for the conservation of sharks and rays in the GFCM area of application refer to the annexes of the Barcelona Convention Protocol concerning Specially Protected Areas and Biological Diversity in the Mediterranean (SPA/BD Protocol)[1]. They are accomplished by granting full protection to the Mediterranean elasmobranch species included in Annex II of the SPA/BD Protocol (List of endangered or threatened species) and by requesting detailed reports on any catch of species included in Annex III of the SPA/BD Protocol (List of species whose exploitation is regulated). These species are listed in Table 1A and Table 1B (also shown in Plate 1 and Plate 2), together with their assessment in the International Union for Conservation of Nature (IUCN) Mediterranean Red List of Threatened Species (IUCN, 2021). Among all the elasmobranch species cited in this review, conservation-priority species as defined by GFCM Recommendation GFCM/42/2018/2 (Table 1A, Table 1B) are marked with the symbol "°". The GFCM recommendations, *inter alia*, also ban finning practices within the GFCM area of application. However, some countries, in addition to those foreseen by the European Union and GFCM regulations, have adopted stricter specific national legislative measures. For example, Malta also identifies 24 species of elasmobranchs of national interest under strict protection, as well as an additional 14 species subject to specific management measures (Ministry for the Environment, Sustainable Development and Climate Change, 2019). Likewise, Turkey protects the sandbar shark (*Carcharhinus plumbeus*°) (Bilecenoğlu, 2008) and the piked dogfish (*Squalus acanthias*°) in the Black Sea (FAO, 2018c, 2020a; Table 2).

1. The SPA/BD Protocol is main tool in the Mediterranean for implementing the 1992 Convention on Biological Diversity (CBD) as regards the in situ sustainable management of coastal and marine biodiversity.

Table 1A – Species in Annex II of the SPA/BD Protocol covered by Recommendations GFCM/36/2012/3 and GFCM/42/2018/2

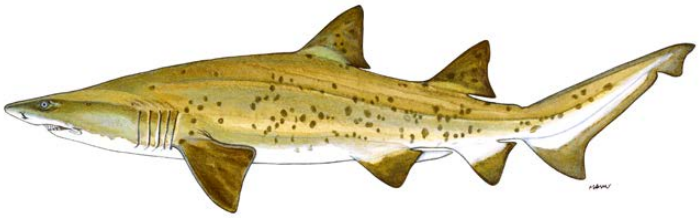
Annex II of the SPA/BD Protocol (List of endangered or threatened species) Fishing is prohibited in the Mediterranean and the Black Sea and the reporting of any incidental catch to the GFCM is mandatory	**IUCN Red List category[1]**	
Carcharias taurus (Rafinesque, 1810)	Critically Endangered	(Walls and Soldo, 2016)
Carcharodon carcharias (Linnaeus, 1758)	Critically Endangered	(Soldo, Bradai and Walls, 2016)
Cetorhinus maximus (Gunnerus, 1765)	Endangered	(Sims *et al.*, 2016a)
Dipturus cf. batis (Linnaeus, 1758)	Critically Endangered	(Dulvy *et al.*, 2016)
Galeorhinus galeus (Linnaeus, 1758)	Vulnerable	(McCully, Dureuil and Farrell, 2016)
Gymnura altavela (Linnaeus, 1758)	Critically Endangered	(Walls *et al.*, 2016)
Isurus oxyrinchus (Rafinesque, 1810)	Critically Endangered	(Walls and Soldo, 2016)
Lamna nasus (Bonnaterre, 1788)	Critically Endangered	(Ellis *et al.*, 2016c)
Leucoraja circularis (Couch, 1838)	Critically Endangered	(McCully *et al.*, 2016)
Leucoraja melitensis (Clark, 1926)	Critically Endangered	(Dulvy and Walls, 2015)
Mobula mobular (Bonnaterre, 1788)	Endangered[3]	(Marshall *et al.*, 2019)
Odontaspis ferox (Risso, 1810)	Critically Endangered	(Pollard *et al.*, 2016)
Oxynotus centrina (Linnaeus, 1758)	Critically Endangered	(Soldo and Guallart, 2016)
Pristis pectinata (Latham, 1794)	Critically Endangered	(Kyne, 2016a)
Pristis pristis (Linnaeus, 1758)	Critically Endangered	(Kyne, 2016b)
Rhinobatos cemiculus[2] (Geoffroy Saint-Hilaire, 1817)	Critically Endangered[3]	(Kyne and Jabado, 2019)
Rhinobatos rhinobatos (Linnaeus, 1758)	Endangered	(Bradai and Soldo, 2016)
Rostroraja alba (Lacépède, 1803)	Endangered	(Ellis, Morey and Walls, 2016)
Sphyrna lewini (Griffith and Smith, 1834)	Critically Endangered[3]	(Rigby *et al.*, 2019a)
Sphyrna mokarran (Rüppell, 1837)	Critically Endangered[3]	(Rigby *et al.*, 2019b)
Sphyrna zygaena (Linnaeus, 1758)	Critically Endangered	(Ferretti *et al.*, 2016a)
Squatina aculeata (Cuvier, 1829)	Critically Endangered	(Soldo and Bariche, 2016b)
Squatina oculata (Bonaparte, 1840)	Critically Endangered	(Ferretti *et al.*, 2016b)
Squatina squatina (Linnaeus, 1758)	Critically Endangered	(Ferretti *et al.*, 2016d)

Notes:

1. IUCN Red List Categories: Not Evaluated (NE), Data Deficient (DD), Least Concern (LC), Near Threatened (NT), Vulnerable (VU), Endangered (EN), Critically Endangered (CR), Extinct in the Wild (EW), Extinct (EX).
2. *Glaucostegus cemiculus* is the new name assigned to the species; however, the name *Rhinobatos cemiculus,* which is the one listed in Annex II of the SPA/BD Protocol, has been used in the main text of this review.
3. Species for which the Mediterranean assessment is still in progress; thus the global assessment has been reported instead.

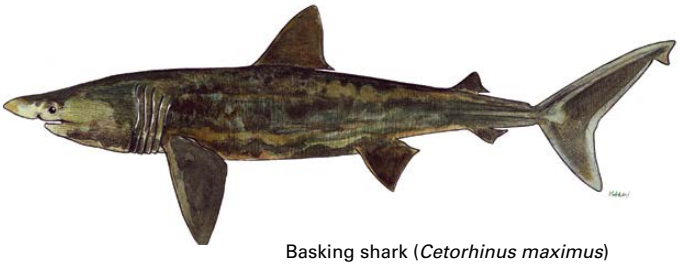
PLATE 1

Mediterranean elasmobranach species listed in annex II of the SPA/BD Protocol

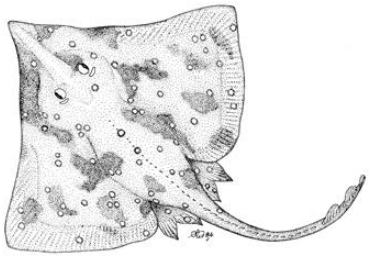


Sand tiger shark (*Carcharias taurus*)

Spiny butterfly ray (*Gymnura altavela*)



Basking shark (*Cetorhinus maximus*)

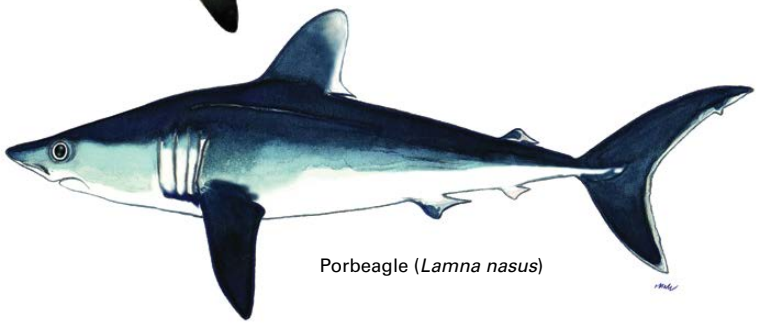


Common skate (*Dipturus cf. batis*)

Tope shark (*Galeorhinus galeus*)

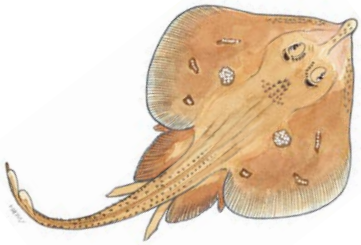
Great white shark (*Carcharodon carcharias*)

Sandy ray (*Leucoraja circularis*)



Porbeagle (*Lamna nasus*)

Shortfin mako shark (*Isurus oxyrhinchus*)



Maltese skate (*Leucoraja melitensis*)

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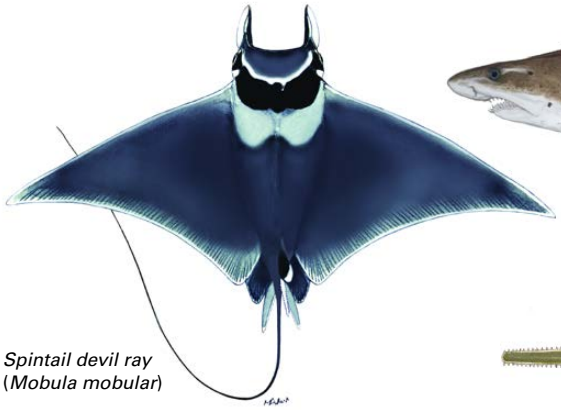
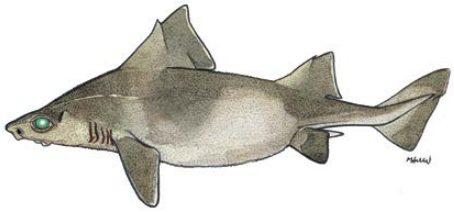
PLATE 1 (Continued)



Spintail devil ray (*Mobula mobular*)

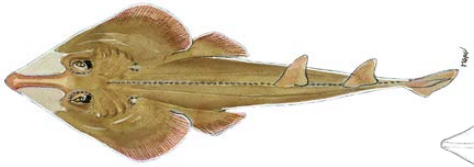
Smalltooth sand tiger (*Odontaspis ferox*)

Smalltooth sawfish (*Pristis pectinata*)

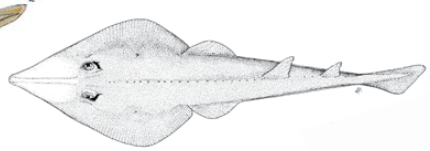


Angular roughshark (*Oxynotus centrina*)

Common sawfish (*Pristis pristis*)

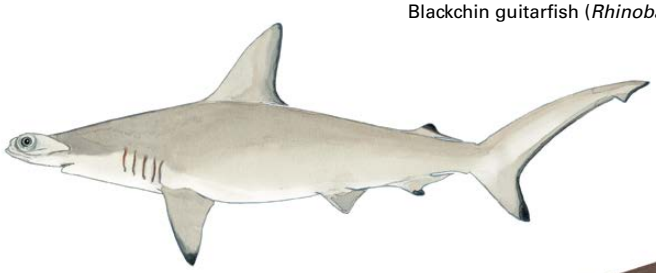


Common guitarfish (*Rhinobatos rhinobatos*)

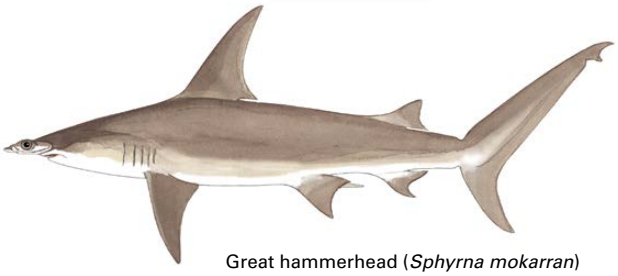


Blackchin guitarfish (*Rhinobatos cemiculus*)

White skate (*Rostroraja alba*)

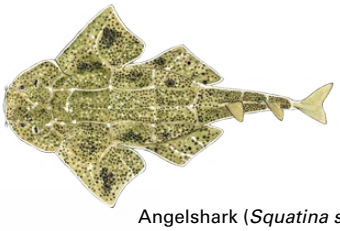


Scalloped hammerhead (*Sphyrna lewini*)

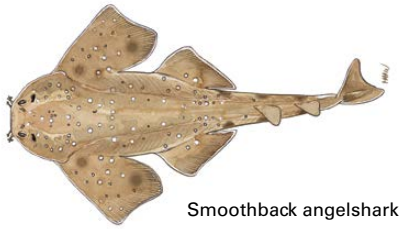


Great hammerhead (*Sphyrna mokarran*)

Smooth hammerhead (*Sphyrna zygaena*)



Angelshark (*Squatina squatina*)



Smoothback angelshark (*Squatina oculata*)

Sawback angelshark (*Squatina aculeata*)

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Table 1B – Species in Annex III of the SPA/BD Protocol covered by Recommendations GFCM/36/2012/3 and GFCM/42/2018/2

Annex III of the SPA/BD Protocol (List of species whose exploitation is regulated) Fishing of these species is allowed in the Mediterranean Sea, but the reporting of any catch to the GFCM is mandatory	**IUCN Red List category[1]**
Alopias vulpinus (Bonnaterre, 1788)	Endangered (Ellis *et al.*, 2016a)
Carcharhinus plumbeus (Nardo, 1827)	Endangered (Ferretti *et al.*, 2016c)
Centrophorus granulosus[2] (Bloch and Schneider, 1801)	Critically Endangered (Guallart *et al.*, 2016)
Heptranchias perlo (Bonnaterre, 1788)	Data Deficient (Soldo and Bariche, 2016a)
Mustelus asterias (Cloquet, 1821)	Vulnerable (Farrell *et al.*, 2016)
Mustelus mustelus (Linnaeus, 1758)	Vulnerable (Farrell and Dulvy, 2016)
Mustelus punctulatus (Risso, 1827)	Vulnerable (Dulvy, Farrell and Buscher, 2016)
Prionace glauca (Linnaeus, 1758)	Critically Endangered (Sims *et al.*, 2016b)
Squalus acanthias (Linnaeus, 1758)	Endangered (Ellis *et al.*, 2016b)

Notes:

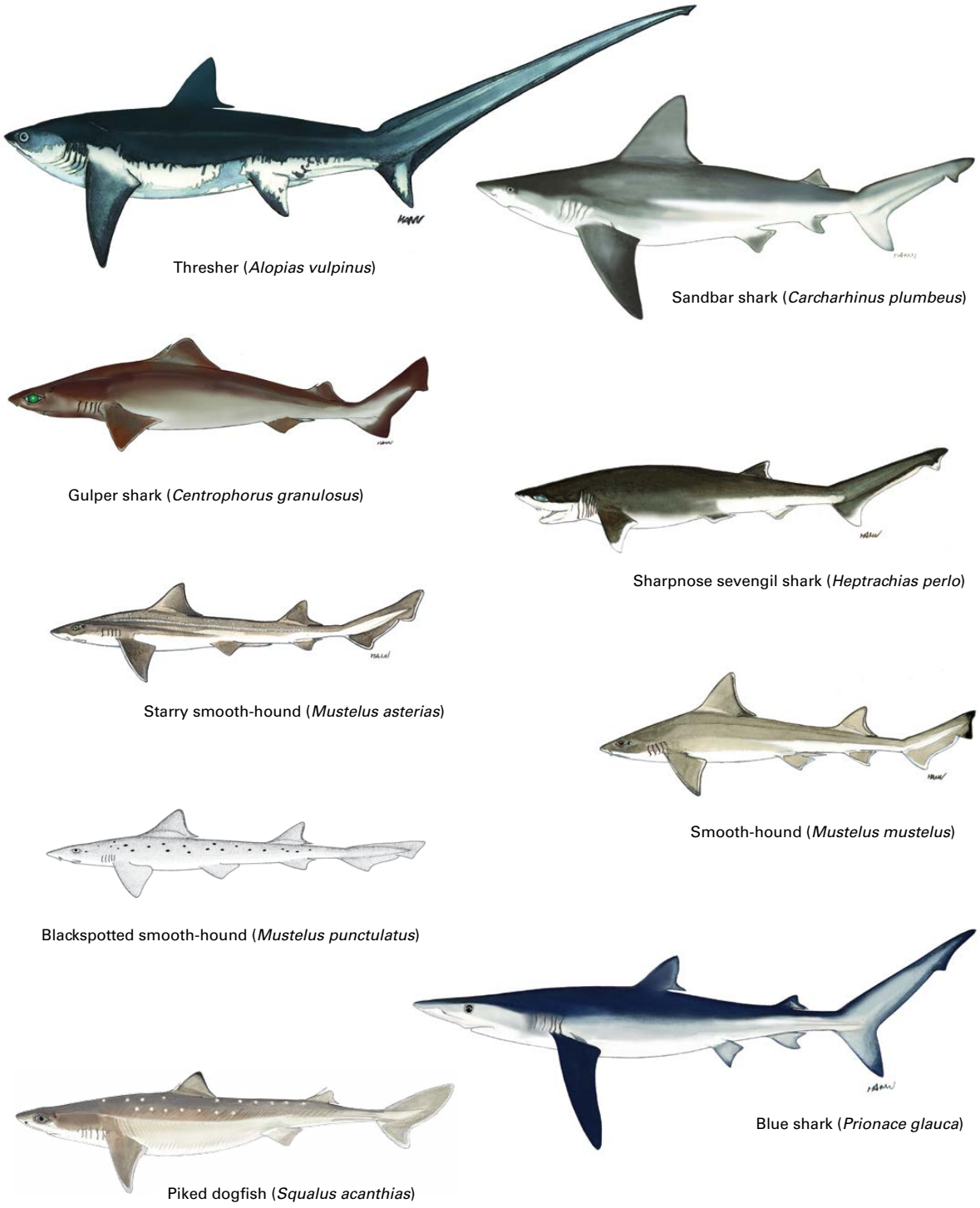
1. IUCN Red List Categories: Not Evaluated (NE), Data Deficient (DD), Least Concern (LC), Near Threatened (NT), Vulnerable (VU), Endangered (EN), Critically Endangered (CR), Extinct in the Wild (EW), Extinct (EX).
2. *Centrophorus* cf. *uyato* is the new name assigned to the species; however, the name *Centrophorus granulosus*, which is the one listed in Annex III of the SPA/BD Protocol, has been used in the main text of this review.

According to GFCM recommendations, about 28 percent of Mediterranean and Black Sea elasmobranch species (i.e. the 24 species of Annex II of the SPA/BD Protocol) are currently granted a legal protection framework. The remaining species, including those listed in Annex III of the SPA/BD Protocol, can be regularly fished and marketed, notwithstanding their current assessment status. For this reason, management problems can arise around the proper identification of protected versus non-protected species, especially for those management and control bodies responsible for deciding administrative sanctions.

In the Mediterranean, almost no fishing activity currently targets elasmobranchs and finning has been banned by international decisions (European Parliament and Council of the European Union, 2013; GFCM, 2014a). Only sporadic fishing activities target elasmobranch species in some areas, such as in the northern Adriatic and in the Strait of Sicily, where vessels using gillnets target smooth-hound sharks (*Mustelus*° spp.) and dogfish sharks (*Squalus* spp.) (Ferretti and Myers, 2006; Bradai, Bradai and Enajjar, 2012). Nevertheless, fishing of protected guitarfishes (*Rhinobatos*° spp.) still occurs in the Gulf of Gabès (Bradai, Bradai and Enajjar, 2018; Bargnesi, Lucrezi and Ferretti, 2020; Bradai *et al.*, 2016; Marino *et al.*, 2017). In general, data on directed shark fisheries are difficult to obtain as these fisheries are often artisanal and operate in countries where regular fishery data reporting comes with greater challenges for a variety of reasons (Ferretti and Myers, 2006; Bradai, Bradai and Enajjar, 2012; Ferretti *et al.*, 2010).

Only 10 cartilaginous species are assumed to be present in the Black Sea (Bilecenoğlu, Kaya and Cihangir, 2014; Serena, 2005; FAO, 2018a, 2018b; McEachran and Capapé, 1984; Fredj and Maurin, 1987; Fischer, Schneider and Bauchot, 1987; Serena, Mancusi and Barone, 2014; Serena *et al.*, 2020), and no regular fishing activities exclusively target elasmobranchs in this area either. Some seasonal fisheries targeting piked dogfish *S. acanthias*°, however, do exist in Bulgaria (GFCM, 2011, 2016b, 2018b). In general, the most commonly caught elasmobranch species in the Black Sea, the piked dogfish (*S. acanthias*°) and the thornback ray (*Raja clavata*), are found in the incidental catch of fisheries (especially those using trawls, set nets and, more rarely, longlines) targeting turbot (*Scophthalmus maximus*), red mullet (*Mullus barbatus*) and European whiting (*Merlangius merlangus*) (Avsar, 2001; GFCM, 2016b; STECF, 2017; Sağlam and Bascinar, 2008;

PLATE 2
Mediterranean elasmobranch species listed in Annex III of the SPA/BD Protocol



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Yıldız and Karakulak, 2017; Bengil and Başusta, 2018; Demirhan, Engin and Can, 2005; Ceylan, Şahin and Kalayci, 2013). Due to high bycatch rates, the *S. acanthias*° Black Sea population has been declared as depleted by the GFCM for a long time, and specific management measures have been adopted since 2015 (see GFCM, 2011, 2014b, 2016a, 2016b, 2017a, 2017b, 2018a, 2018b), though the implementation of a full recovery plan is still advised (GFCM, 2018). The different minimum landing sizes adopted by Black Sea countries for *S. acanthias*° are presented in Table 2.

Table 2 – Minimum landing size for piked dogfish (*Squalus acanthias*) in Black Sea countries

Bulgaria	Georgia	Romania	Russian Federation	Turkey	Ukraine
90 cm	85 cm*	120 cm	85 cm*	No fishing of this species is allowed	85 cm*

Notes:
Total length; *standard length (GFCM, 2017a).

Though chondrichthyans are mostly caught as bycatch in fisheries targeting more valuable resources, available evidence indicates that in the Mediterranean, they are generally declining in abundance, diversity and range, and that they are possibly faring worse than chondrichthyan populations elsewhere in the world (Ferretti and Myers, 2006; Cavanagh and Gibson, 2007; Bargnesi, Lucrezi and Ferretti, 2020; Cashion, Bailly and Pauly, 2019; Walker *et al.*, 2005; Dulvy *et al.*, 2016). A few studies (Cavanagh and Gibson, 2007; Dulvy *et al.*, 2016) have indicated that bycatch in fisheries probably presents the main threat to elasmobranch populations in the Mediterranean Sea, with all species of Mediterranean elasmobranchs potentially affected, while they show different sensitivities to other threats, such as pollution (around 30 percent threatened), habitat loss (around 30 percent), direct fisheries (around 9 percent), among others. The vulnerability of Mediterranean elasmobranch species to fishing gear is high: all species may be caught in trawlers, almost all (94 percent) in various types of nets[2] and two thirds of Mediterranean species (67 percent) by longliners (Cavanagh and Gibson, 2007).

This review attempts to compile the relevant information on interactions between fisheries and elasmobranchs available in scientific publications, reports, databases, news, *inter alia*. Bibliographic items were searched for in electronic archives, papers, and on the internet by means of key words. However, it is important to note that given the heterogeneity of elasmobranchs as a taxonomic group (including protected and unprotected species, demersal and pelagic species, commercial and non-commercial species), relevant information on elasmobranch interactions with fisheries was sometimes buried within studies whose objectives were not bycatch-related; for example, they may have focussed on catch composition of a given fleet, fish weight-length relationships, occurrence of species in a given area, molecular and deoxyribonucleic acid (DNA) analysis, and so on. The historical section of this chapter focuses on data collected up to around 2008, including anecdotal facts from the previous century, for all elasmobranch species. The section on recent data focuses on data collected between 2008 and 2019, with an emphasis on GFCM priority-conservation species as identified by Recommendation GFCM/36/2012/3 (see above); in both sections, the information collected is organized by fishing vessel group and subregion.

3.2 Historical records of interactions with fisheries

Historically, the diversity of chondrichthyans used to be high throughout the Mediterranean (Dulvy *et al.*, 2016). Human impacts (including exploitation, pollution, fisheries and habitat degradation) have caused, however, a significant reduction in species richness throughout the basin, with historic declines in elasmobranch abundance reported (Bradai, Bradai and Enajjar, 2018; Bargnesi, Lucrezi and Ferretti, 2020; Ferretti *et al.*, 2008, 2015; Fortibuoni *et al.*, 2010; Dulvy *et al.*, 2016). At present, a decreasing trend in diversity can be observed across the Mediterranean, from the eastern part to the western part (Ferretti *et al.*, 2008, 2015; Fortibuoni *et al.*, 2010; Serena *et al.*, 2020), though in the past, the presence of elasmobranchs had been considered higher in the

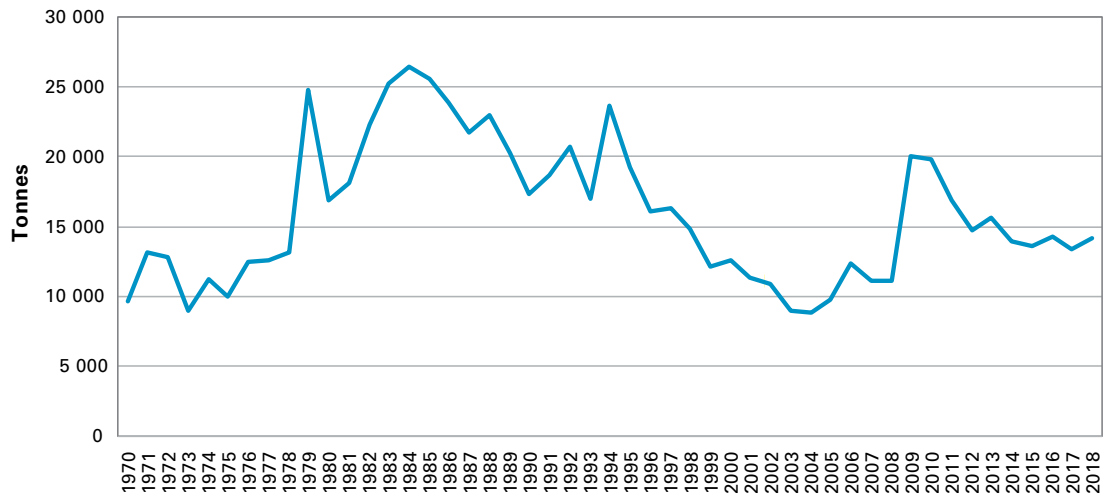
2. These include purse seines, gillnets and driftnets (use banned in 2005).

western than in the eastern Mediterranean, with peak abundances (still true) in the Strait of Sicily and along the coasts of Tunisia and Libya (Bradai, Bradai and Enajjar, 2012; Coll *et al.*, 2010).

As mentioned, in the Mediterranean Sea, elasmobranchs are mostly found in the bycatch of fisheries targeting more valuable fish and crustacean species (Vannuccini, 1999; Ferretti and Myers, 2006; Geraci *et al.*, 2017), though what are regarded as discards in more developed countries may have a certain market value in southern and eastern Mediterranean countries (Ferretti and Myers, 2006). In general, about 46 species of demersal elasmobranchs caught in trawl fisheries are commercially valuable (Ferretti and Myers, 2006).

According to FAO, beginning in the 1950s, landings of sharks and rays gradually increased, peaking in the mid-1980s before declining again by over 50 percent (Dent and Clarke, 2015; Bonanomi *et al.*, 2017). In fact, the analysis of the historical series (the last 46 years) of Mediterranean chondrichthyan landings shows that a significant decline followed the maximum of the mid-1980s, reaching a minimum at the beginning of the 2000s. After another relative maximum at the end of the first decade of the 2000s, a new decline has been observed due to the contributions of newly involved countries, such as Libya (Bradai, Bradai and Enajjar, 2018), to FAO official statistics (Figure 1). Indeed, the overall fishing capacity and effort in the Mediterranean area, before it stabilized around 2010, increased rapidly beginning in the late 1970s (Ferretti and Myers, 2006; Cavanagh and Gibson, 2007; Bell, Watson and Ye, 2017), causing overexploitation of some Mediterranean and Black Sea fish stocks (FAO, 2016, 2018c), with direct and indirect effects on elasmobranch species (Cavanagh and Gibson, 2007; Tsikliras *et al.*, 2015). These impacts included local reductions of coastal elasmobranch diversity by more than 50 percent over 50 years of fishing exploitation and the local disappearance of certain species once considered common (Ferretti and Myers, 2006; Bargnesi, Lucrezi and Ferretti, 2020; Ferretti *et al.*, 2005, 2013; Barausse *et al.*, 2014; Dulvy *et al.*, 2016; Fortibuoni *et al.*, 2016).

FIGURE 1
Historical trends in chondrichthyan landings in the Mediterranean and the Black Sea (1970–2018)



Source: FAO, 2020b.

Indeed, the situation may be even worse, as this figure reports only the official landings that reached the market and does not include all the non-desirable shark catch that was returned to the sea (i.e. discards), making it extremely difficult to quantify the actual magnitude of shark bycatch in the Mediterranean Sea (Vannuccini, 1999; Ferretti and Myers, 2006). Furthermore, data reported from scientific research showed that some of the most frequent species caught as bycatch are not even listed in official statistics. In particular, this has long been the case for the blue shark (*Prionace glauca*°) and other vulnerable species with no commercial value. The most important shark species landed in the Mediterranean, as already reported by FAO (Vannuccini, 1999), have always been *Mustelus*° spp. and the piked dogfish (*Squalus acanthias*°).

3.2.1 Bottom trawlers

Bottom trawlers have always been responsible for catching various demersal shark and ray species, and several studies, mainly focusing on discards and catch composition, have provided information on the elasmobranch species most caught in trawl nets (Bradai, Bradai and Enajjar, 2012). Given that bottom trawlers do not target sharks, the catch rate is expected to be random and non-homogeneous over time for the same gear, country and subregion (Vannuccini, 1999; Serena *et al.*, 2008; Bradai, Bradai and Enajjar, 2012, 2018; Serena *et al.*, 2009; Ramírez-Amaro *et al.*, 2018). The species accounting for the most bycatch in trawls have historically been *Mustelus*° spp. and the common stingray (*Dasyatis pastinaca*) (Vannuccini, 1999), though official statistics often only thoroughly report the former due to their higher commercial value than the latter, which is usually discarded at sea.

In the Alboran Sea, Torres *et al.* (2001) reported that bottom trawlers targeting red shrimp (*Aristeus antennatus*) caught, by biomass, more blackmouth catshark (*Galeus melastomus*) than the target red shrimp species. Twenty-one specimens of spintail devil ray (*Mobula mobular*°) were collected at the Algiers fish market between 1996 and 2001 as bycatch during trawling off the the Algerian coast (Hemida, Mehezem and Capapé, 2002). In the same area, between 1996 and 2002, sharks belonging to the genus *Carcharhinus*, *C. altimus* (41 individuals), *C. brachyurus* (17 individuals), *C. brevipinna* (2 individuals), *C. obscurus* (10 individuals) and *C. plumbeus*° (28 individuals) were caught during trawling and longliner fishing operations as bycatch at depths between 30 and 150 m (Hemida *et al.*, 2002).

In the Balearic Islands, Carbonell *et al.* (2003) analysed the catch composition of bottom trawlers and noted that the small-spotted catshark (*Scyliorhinus canicula*), the blackmouth catshark (*Galeus melastomus*) and the velvet belly (*Etmopterus spinax*), combined, represented 4.9 to 8.2 percent in weight of the total catch. In fact, small-spotted catshark catch reached proportions similar to those of the target species in the coastal fishery (targeting red and striped red mullet) and in the shelf trawl fishery (targeting European hake). In contrast, the bycatch of blackmouth catshark and velvet belly represented a small proportion of the total catch of the slope fishery targeting red shrimp (*Aristeus antennatus*).

The size range of the small-spotted catshark (*Scyliorhinus canicula*) ran between 7 and 53 cm total length (TL). Juveniles and adults were distributed throughout the whole area, although adults appeared to be more abundant in coastal zones. The length distribution of the blackmouth catshark (*Galeus melastomus*) showed a trend of size increasing with depth; the size range was between 9 and 63 cm TL. For both species, individuals smaller than 35 cm TL were usually discarded. Only 25 percent by number and 60 percent by weight of the total small-spotted catshark catch was

landed. For the total blackmouth catshark catch, the corresponding percentages were 10 percent by number and 35 percent by weight.

The elasmobranch communities exploited by the bottom trawl fishery off the Balearic Islands (northwestern Mediterranean) have been analysed in different studies (for example, Massutì and Moranta, 2003; Moranta *et al.*, 2008; Guijarro *et al.*, 2012). From 1965 to 2009, Guijarro *et al.* (2012) identified a total of 25 elasmobranch species in the fishing grounds off the Balearic Islands; the predominant species were *Galeus melastomus, Scyliorhinus canicula* and the thornback ray (*Raja clavata*). Temporal trends and depth correlations between the shelf and the slope for the other elasmobranch species (i.e. *Hexanchus griseus, Centrophorus granulosus°, Dalatias licha, Centroscymnus coelolepis, Mustelus asterias°, M. mustelus°, Scyliorhinus canicula, Dipturus oxyrinchus, Leucoraja circularis°, L. fullonica, L. naevus, Squalus blainville, S. acanthias°, Torpedo marmorata, Raja asterias, R. clavata, R. miraletus, R. brachyura, R. polystigma, R. radula, Bathytoshia lata, D. pastinaca* and *Myliobatis aquila*) were also recorded.

In the Gulf of Lion, long-term changes in the diversity of elasmobranch species responsive to the evolution of the bottom trawl fishery were observed from 1994 to 2009 (Farrugio and Cebrian, 2013). The abundance of some marketable species, including small sharks such as the smooth-hound shark (*Mustelus mustelus°*), the starry smooth-hound (*Mustelus asterias°*), the nursehound (*Scyliorhinus stellaris*) and the longnose spurdog (*Squalus blainville*), had declined over that time period. Only two species of rays, *Raja clavata* and *R. asterias*, the most abundant and frequent in the area, were still being fished during the most recently surveyed years, even as *R. clavata* showed a decrease in its biomass indices, as well as a reduction in its distribution area in the Gulf of Lion. In fact, concerns about the exploitation sustainability of Rajidae populations in the Gulf of Lion were already being voiced by scientists as early as the late 1990s.

Conversely, a strong resilience to population declines of non-commercial species has been confirmed, even in cases where a low level of abundance was initially observed, such as for the three species of electric rays *Torpedo marmorata*, *T. torpedo* and *Tetronarce nobiliana* or the angular rough shark *Oxynotus centrina°*. Similarly, as a result of the impacts on other commercial species, the small-spotted catshark (*Scyliorhinus canicula*), and the blackmouth catshark (*Galeus melastomus*) became the most abundant elasmobranchs on the continental shelf and on the slope, respectively.

Furthermore, off the Languedocian coast (French Mediterranean), Capapé and Reynaud (2011) investigated the maturity and reproductive cycle of the piked dogfish (*Squalus acanthias°*); 209 specimens (110 males and 99 females) were collected from 1997 to 2005 by bottom trawling at depths between 80 and 100 m on sandy-muddy and detrital bottoms.

The occurrence, abundance and size trends of 25 demersal chondrichthyans were recorded (Marongiu *et al.*, 2017) over a period of 22 years (1994–2015) as part of the MEDITS[3] dataset in geographical subarea (GSA) 11 (the sea surrounding the island of Sardinia, Italy). Temporal trends in the abundance indices were found to be stable or increasing in all depth strata (from 10 to 800 m). Almost all elasmobranch species showed stability in size structure analyses, apart from the blonde ray (*Raja brachyura*) and the longnose skate (*Dipturus oxyrinchus*), which showed increasing trends; the chondrichthyan species examined in the study area did not seem to show an alarming conservation status (Marongiu *et al.*, 2017).

3. International bottom trawl survey in the Mediterranean (MEDITS survey programme).

Similarly, a long time series of elasmobranch catch rates off the Tuscan coast of Italy (northwestern Mediterranean) was studied by Ligas *et al.* (2013) in order to estimate variations in population abundance and evaluate the influence of environmental and anthropogenic factors. Trawl survey and landing data showed that elasmobranch fauna had undergone a drastic decline over 50 years and that the subsequent rebound fell far short of a recovery to historical levels; *Galeus melastomus*, *Etmopterus spinax*, *Dipturus oxyrinchus*, *Scyliorhinus canicula* and two skates (*Raja asterias* and *R. clavata*) were the species most commonly occurring, whereas *Squalus acanthias*°, *Mustelus*°spp. and *Squatina squatina*° had not been found in the landings analysed from 1991 to 2009.

Along the eastern coast of Algeria, Hemida and Capapé (2002) reported the capture of a single specimen of the rare bramble shark (*Echinorhinus brucus*) in bottom trawl fishing operations at depths greater than 500 m. Capapé *et al.* (2008) also analysed the biology of the rare deep-sea shark the kitefin shark (*Dalatias licha*) off the southwestern Mediterranean coast by studying individuals caught by bottom trawlers: of the 47 specimens of *D. licha* observed, eight were caught off the northern Tunisian coast between 1970 and 2007 by bottom trawlers fishing at depths between 200 and 600 m on sandy-muddy bottoms, and 39 off the Algerian coast, between 1996 and 2007, also in bottom trawls operating at similar depths and over similar sediments. The results indicated that the kitefin shark probably feeds mainly on fish, occasionally on cephalopods, reproduces in alternate years and that the breeding period occurs over the summer in this region. Furthermore, around the Algerian coasts, the small-spotted catshark (*Scyliorhinus canicula*) is caught mainly by bottom trawlers targeting other demersal fish and crustacean species – axillary seabream (*Pagellus acarne*), red mullet (*Mullus barbatus*), European hake (*Merluccius merluccius*) and deep-water pink shrimp (*Parapenaeus longirostris*). A stock assessment performed over the period 2000–2010 indicated that the small-spotted catshark was being overfished, with 42–51 cm the most exploited length class (GFCM, 2011).

In the Adriatic Sea, Jukic-Peladic *et al.* (2001) analysed the composition of trawl surveys carried out in 1948 and in 1998 to identify temporal changes in the composition of demersal fish resources after 50 years of fishing activity. A decrease in elasmobranch diversity and abundance frequency was the main change observed: life history parameters appeared to be determining factors, since small-sized species such as the small-spotted catshark (*Scyliorhinus canicula*) or the brown ray (*Raja miraletus*) were frequently collected in both surveys, while bigger shark species and most other rays disappeared or rarely turned up during the 1998 survey.

Likewise in the Adriatic Sea, Gračan *et al.* (2013, 2016) provided the first detailed information on the reproductive traits and age and growth estimates of the piked dogfish (*Squalus acanthias*°); they based their findings on 224 specimens (132 females and 92 males) collected onboard commercial bottom trawls between 2005 and 2007. In addition, Ferretti *et al.* (2013), with data obtained from trawl surveys carried out over the period 1950–2010, detected a decreasing trend in the elasmobranch community, including two species that were judged to have locally disappeared in the Adriatic Sea – the blue skate (*Dipturus cf. batis*°) and the Lusitanian cownose ray (*Rhinoptera mariginata*). According to these authors, catch rates had declined by 94 percent since 1950, and 11 species ceased being detected in some specific areas of the Mediterranean, including the white skate (*Rostroraja alba*°) and the rough skate (*Raja radula*).

In other studies, Barausse *et al.* (2014) evaluated, by integrating long-term time series of landings (1945–2012) with extensive surveys of the fish market in Chioggia, Italy, which is home to the major fishing fleet of the northern Adriatic Sea, the status of elasmobranch populations subject to

direct and indirect fishing pressure in the area. The analysis of the data highlighted a dramatic decline in a variety of trawl fisheries (bottom, beam and midwater) of elasmobranch landings, particularly of skates and catsharks (*Scyliorhinus* spp.), whose catch rates were found to be 2.4 and 10.6 percent of their average 1940 levels, respectively. The authors found that the data reflected similarly large reductions in abundance and also confirmed that several species formerly present in the basin were no longer detected, now considered to have locally disappeared, e.g. the skates *Dipturus cf. batis*°, *Rostroraja alba*° and *Raja montagui* (= *R. polystigma*).

In the wide area of the Strait of Sicily, between the southern Italian region and the northern coast of Africa, elasmobranchs have been a common bycatch of bottom trawl fleets since the 1970s. A research project on demersal resources in the Strait of Sicily dating back to 1991 (Vannuccini 1999), revealed that the presence of sharks caught as bycatch was dependent on depth: 95 percent of the incidental elasmobranch catch occurred within the first 200 m, with the most common species, *Dasyatis pastinaca* and *Mustelus mustelus*°, caught between 0 and 100 m; other species (*Etmopterus spinax, Galeus melastomus*, *Scyliorhinus canicula and Scyliorhinus stellaris*) were found at depths between 200 and 700 m.

Bibliographic and scientific bottom trawl survey data gathered off the southern coast of Sicily, from 1994 to 2009 and between depths of 10 and 800 m, were also analysed by Ragonese *et al.* (2013) in order to prepare a checklist of demersal sharks and chimaeras sensitive to exploitation by fisheries. Out of the 27 previously reported demersal shark and chimaera taxa in the Mediterranean, only 20 were sampled during the surveys in the investigated area. Among the species sampled in the surveys, only two ubiquitous (*Squalus blainville* and *Scyliorhinus canicula*) and three deep-water (*Chimaera monstrosa*, *Centrophorus granulosus*° and *Galeus melastomus*) species showed a wide geographical distribution with a consistent abundance. Excluding the rare (such as *Oxynotus centrina*°) or uncommon sharks (e.g. *Squalus acanthias*°), the estimated occurrence frequencies and abundance indices revealed a possible risk of local extinction for the almost exclusively (e.g. angelshark, *Squatina*° spp.), or preferentially (e.g. nursehound, *Scyliorhinus stellaris*), neritic species.

More recently, Geraci *et al.* (2017) provided a similar overview of the demersal (sharks-chimaeras) and bottom-dwelling (batoids) data obtained during the experimental international bottom trawl survey in the Mediterranean (MEDITS) carried out from 1994 to 2013 in the Strait of Sicily (see also the Elasmostat project; Serena, ed., 2014). Overall, 37 species were recorded as captured at least once: 16 demersal species of the shark-chimaera category and 21 batoids. In particular, four shark-chimaera orders (Chimaeriformes, Hexanchiformes, Squaliformes and Carcharhiniformes) and three batoid orders (Myliobatiformes, Rajiformes and Torpediniformes) were found. In the investigated area, the analysis of the density index and the biomass index temporal evolution from 1994 to 2013 showed a slight recovery of sharks-chimaeras and a steady state for batoids.

In Tunisia, a rare and now protected species, the common guitarfish (*Rhinobatos rhinobatos*°) was recorded commonly in the bycatch of commercial bottom trawlers operating along the coast of the Gulf of Gabès between 2001 and 2005 (a total of 498 specimens were identified) (Enajjar, Bradai and Bouain, 2008). In the same area, in order to collect biological data on the longnose skate (*Dipturus oxyrinchus*), monthly sampling was conducted onboard a commercial bottom trawler in December 2006 and January 2007; a total of 561 individuals were collected at depths between 80 and 185 m (Kadri *et al.*, 2014).

On a broader geographical scale, Bertrand *et al.* (2000) carried out a subregional cross-cutting study, covering the European waters of the western and central Mediterranean, the Adriatic Sea and part of the eastern Mediterranean (up to Crete, Greece). From the bottom trawl survey data obtained during spring campaigns conducted between 1994 and 1998, they identified 44 species of chondrichthyans, including 24 skates, 19 demersal sharks and 1 chimaera from 10 to 800 m in depth. Among these 44 species, only 8 species were found to occur across the entire sampled area.

In the north Aegean Sea and the central Aegean plateau (Cyclades plateau), a scientific campaign carried out on trawlers between 1991 and 1996 evaluated the presence and abundance of three elasmobranch species, *S. canicula*, *Raja montagui* (= *R. polystigma*) and the marbled electric ray, *Torpedo marmorata*, which represented 2.2, 0.08 and 0.05 percent, in numbers, of the total catch and 67, 21 and 22 percent of their total occurrence in hauls, respectively (Damalas *et al.*, 2010). In a subsequent ten-year study, carried out in the central Aegean Sea and divided between two sub-periods (1995–2000 and 2003–2006), based on bottom trawl fishery datasets, a total of 30 elasmobranch species were identified, accounting for 14.3 percent of the total catch in terms of weight and 2.2 percent in terms of number. In particular, seven species alone represented almost 95 percent of the total in number (50 057 specimens collected); they consisted of four sharks and three skates: *Scyliorhinus canicula* (52.5 percent), *Galeus melastomus* (10.3 percent), *Squalus blainville* (10.0 percent), *Etmopterus spinax* (9.2 percent), *Raja clavata* (7.6 percent), *Dipturus oxyrinchus* (3.9 percent) and *Raja miraletus* (1.2 percent) (Damalas and Vassilopoulou, 2011).

Still in the Aegean Sea, Maravelias *et al.* (2012) analysed fisheries-independent scientific bottom trawl survey data for two of the most abundant cartilaginous demersal species in the Aegean Sea, the small-spotted catshark (*Scyliorhinus canicula*) and the thornback ray (*Raja clavata*), covering an 11-year sampling period from the mid-1990s through 2008. Over the studied period, these two species represented more than 70 percent (14.4 and 60.3 respectively) of the total abundance of demersal elasmobranchs caught; the findings revealed a declining trend in *R. clavata* and *S. canicula* abundance from the late 1990s until 2004. Filiz and Mater (2002) obtained a further 247 specimens of seven species (three shark species, *Scyliorhinus canicula, Mustelus mustelus*° and *Squalus acanthias*°, and four ray species, *Torpedo marmorata, Raja clavata, Raja miraletus* and *Dasyatis pastinaca*) caught by commercial fishers using bottom trawls in the North Aegean Sea between July 1999 and March 2000. Meanwhile, also in the Aegean Sea, Corsini-Foka (2009) reported the capture of a single specimen of the rare smalltooth sand tiger (*Odontaspis ferox*°) in September 2007 by bottom trawling, 1.5 nautical miles off the southern coast of Rhodes at a depth of 70 m.

Elsewhere, in the Aegean Sea, Filiz and Bilge (2004) analysed the length–weight relationships of 24 fish species caught by commercial bottom trawling in the trawl area of *Sığacık* Bay. The catch included many elasmobranch species, such as *Scyliorhinus canicula* (637 individuals), *Mustelus mustelus*° (35 individuals), *Squalus acanthias*° (32 individuals), *Torpedo marmorata* (37 individuals), *Dipturus oxyrinchus* (8 individuals), *Raja clavata* (37 individuals), *R. miraletus* (13 individuals), *Dasyatis pastinaca* (29 individuals), *Gymnura altavela*° (9 individuals) and *Myliobatis aquila* (14 individuals). In the same area, Yiğin and İşmen (2009), also analysing the length–weight relationships of elasmobranch species caught by bottom trawl fisheries, recorded 936 individuals belonging to nine different species: *Dasyatis centroura* (i.e. *Bathytoshia lata*) (8 individuals), *Gymnura altavela*° (2 individuals), *Leucoraja naevus* (1 individual), *Aetomylaeus bovinus* (1 individual), *Dipturus oxyrinchus* (179 individuals), *Rostroraja alba*° (126 individuals), *Myliobatis aquila* (66 individuals), *Dasyatis pastinaca* (71 individuals) and *Raja radula* (204 individuals).

İşmen *et al.* (2007) analysed the weight–length relationships of 63 fish species sampled by a commercial bottom trawl vessel at depths ranging from 28 to 370 m between February 2005 and April 2006 in Saros Bay, Turkey. Among these were found: *Dasyatis pastinaca* (48 individuals), *Heptranchias perlo*° (14 individuals), *Hexanchus griseus* (5 individuals), *Myliobatis aquila* (14 individuals), *Dipturus oxyrinchus* (118 individuals), *Raja clavata* (112 individuals), *R. miraletus* (30 individuals), *R. radula* (49 individuals), *Rostroraja alba*° (43 individuals), *Galeus melastomus* (93 individuals), *Scyliorhinus canicula* (1501 individuals), *Squalus blainville* (299 individuals), *Torpedo marmorata* (20 individuals) and *Mustelus mustelus*° (26 individuals).

In the Marmara Sea, from 2006 to 2007, Deniz *et al.* (2011) collected specimens of *Squalus acanthias*° (8 individuals), *S. blainville*, (18 individuals), *Mustelus mustelus*° (2 individuals), *Raja oxyrinchus* (2 individuals), *Oxynotus centrina*° (1 individual) and *Dasyatis pastinaca* (12 individuals) caught by bottom trawl and beam trawl vessels operating at depths of 30–100 m. In the same area, a total of 620 piked dogfish (*Squalus acanthias*°; 346 females and 274 males) were collected between February 2005 and September 2007 from commercial bottom trawls in order to estimate age and growth parameters (Yiğin and İşmen, 2016). In the Turkish Mediterranean Sea, Yeldan *et al.* (2013) analysed temporal changes in some Rajiformes species caught by commercial bottom trawlers along the west coast of İskenderun Bay from 2004 to 2011. Six species belonging to six different Rajiformes families were identified over the sampling period, including the common stingray (*Dasyatis pastinaca*), the spiny butterfly ray (*Gymnura altavela*°), the common guitarfish (*Rhinobatos rhinobatos*°), the rough ray (*Raja radula*), the common eagle ray (*Myliobatis aquila*) and the marbled electric ray (*Torpedo marmorata*). The only significant annual changes were found for *R. rhinobatos*°.

Further east, Golani (1986) recorded the first appearance of demersal species of sharks, at depths of 1 330–1 440 m, off the eastern Mediterranean coast of Israel among the bycatch of a commercial bottom trawler. These species included: the little sleeper shark (*Somniosus rostratus*), the gulper shark (*Centrophorus granulosus*°), the kitefin shark (*Dalatias licha*) and the blackmouth catshark (*Galeus melastomus*).

In the Black Sea, the piked dogfish (*Squalus acanthias*°) has always been one of the most heavily caught non-target species in bottom trawls. The end of the 1970s and the 1980s had a crucial impact on the *S. acanthias*°, when fishing activities conducted by Turkey and, to a lesser extent, by the Russian Federation, led to the overexploitation of *S. acanthias*° population. Turkey alone reached a maximum catch of 10 887 tonnes in 1979. The 1990s saw a continued and progressive decline in the catch of *S. acanthias*°, ultimately leading to an all-time low of around 62 tonnes in 2014. Between 1989 and 2000, Turkey's annual landings of *S. acanthias*° ranged between 4 558 and 2 390 tonnes (Shlyakhov and Daskalov, 2008), followed by a sharp decline to below 100 tonnes in 2009. Similarly, data for the Black Sea populations of thornback ray (*Raja clavata*) indicated patterns of overexploitation, with maximum landings of 3 390 tonnes and 3 078 tonnes between 1979 and 1983 (Radu and Nicolaev, 2010).

3.2.2 Small-scale fisheries

Trammel nets and gillnets, as well as longlines, are the types of gear most commonly used in Mediterranean small-scale fisheries. The nets are often used at night and the length of the set nets depends on the size of the fishing boat (Bradai, Saidi and Enajjar, 2012). Occasionally, these have been reported to catch several non-target species of sharks and rays, mostly demersal ones, such

as the small-spotted catshark (*Scyliorhinus canicula*), piked dogfish (*Squalus acanthias*°), nursehound (*Scyliorhinus stellaris*), common eagle ray (*Myliobatis aquila)*, bull ray (*Aetomylaeus bovinus)*, requiem shark (*Carcharhinus* spp.) and stingray (*Dasyatis* spp.), though the pelagic tope shark (*Galeorhinus galeus*°) and the basking shark (*Cetorhinus maximus*°) have also been found (Bradai, Saidi and Enajjar 2012; Costantini *et al*., 2000; Mancusi *et al*., 2005; Morey *et al*., 2006). Concerning pelagic elasmobranch species, Mancusi *et al.* (2005) indicated that throughout the Mediterranean Sea, among the 323 records of basking sharks (*Cetorhinus maximus*°) registered since the mid-nineteenth century, 15 percent came from incidental catch in trammel nets.

In a study conducted in the Balearic Islands by Morey *et al.* (2006), trammel nets caught up to 12 species of elasmobranchs (ten sharks and two rays) representing 10 percent by abundance and 28 percent by biomass of the total catch. The most common species were the common stingray (*Dasyatis pastinaca*), rough ray (*Raja radula*) and marbled electric ray (*Torpedo marmorata*), representing 48 percent, 24 percent and 15 percent of the elasmobranch catch, respectively. The contribution of elasmobranchs to the total biomass of the catch was estimated at 11 to 25 percent, regardless of the season. The most abundant species were *Dasyatis pastinaca*, *Raja* spp., *Scyliorhinus* spp. and *Torpedo* spp. The common eagle ray (*Myliobatis aquila*) was scarce, while the sharks, namely the velvet belly (*Etmopterus spinax*), blackmouth catshark (*Galeus melastomus*) and longnose spurdog (*Squalus blainville*), were mainly encountered during the spring. An unidentified species belonging to the genus *Squatina*° has been observed only on one occasion.

Elsewhere off Corsica, a twelve-year seasonal survey (2001–2012) of the small-scale fishery (gillnets and trammel nets) targeting demersal fish and the common spiny lobster (*Palinurus elephas*) within and near the Scandola marine protected area has provided data on the catch and discards of elasmobranchs in the local artisanal fisheries. While the contribution of elasmobranchs to the total catch was estimated at 11 to 25 percent regardless of the season, their mean contribution to discards was 49 percent, reaching up to 74 percent in summer. The composition of the biomass of the elasmobranchs caught was: *Dasyatis pastinaca* (26 percent), *Raja* spp. (33 percent), *Scyliorhinus* spp. (23 percent), *Torpedo* spp. (6 percent), *Squalus blainvillei* (1 percent) and *Myliobatis aquila* (1 percent), with 10 percent remaining undefined (Le Direach *et al*., 2013).

In the Gulf of Gabès (Tunisia), gillnets targeting demersal fish also caught a conspicuous quantity of blackchin guitarfish (*Rhinobatos cemiculus*°) as bycatch, especially from April to August, with a total of 513 specimens collected from commercial gillnet and trawl catches between 2002 and 2004 (Enajjar, Bradai and Bouain, 2008, 2012). In Libyan waters, Lamboeuf (2000) reported artisanal gillnets targeting sharks, though no quantitative nor qualitative assessments are available. Meanwhile, off the Maghrebine shore (Algerian and Tunisian coasts), Capapé *et al.* (2003), in their review of the historical captures of basking sharks (*Cetorhinus maximus*°), reported the presence of four individuals in the bycatch of Tunisian gillnets, caught in 1981, 1992, 1998 and 1999, respectively, while in Algerian gillnets, three *Cetorhinus maximus*° were caught in 1998.

In the waters off Piran, Slovenia, in the summer of 2000, two juvenile basking sharks (*Cetorhinus maximus*°) were accidentally caught: a juvenile male was entrapped in special nets designed for small sharks (mainly species from the genus *Mustelus*°), while the other was caught (entangled) in a flatfish net (Lipej *et al*., 2000). Likewise, two specimens of *Cetorhinus maximus*° (2.5 m long and 2.6 m long, respectively) were also recorded as bycatch, caught by a gillnet along the coast of Israel in 1965 (Ben-Tuvia, 1971). Although the type of set net was not specified, three individuals of the same species were also caught along the Turkish coast in 1987 (Kabasakal, 2004) and 1995

(Kıdeyş, 1997). More recently, in 2001 and 2006, Kabasakal (2002, 2013) reported the capture of two individuals (6 m long and 3 m long, respectively) in a gillnet and in a stationary net in the northern Levantine basin.

In addition to *Cetorhinus maximus*°, young thresher sharks (*Alopias vulpinus*°) were reported as bycatch in trammel nets in Turkish and Tunisian coastal waters (Kabasakal, 2007; Hattour and Nakamura, 2004). In 2005, the capture of a 3.5 m-long bigeye thresher shark (*Alopias superciliosus*) by a coastal netter operating in Turkish waters was reported by Kabasakal and Karhan (2008). Furthermore, Kabasakal (2007) recorded the incidental capture of 15 individuals of *A. vulpinus*°), in gillnets and trammel nets in Turkish coastal waters over a study period covering ten years (1997 to 2007).

In another investigation, carried out in the Aegean Sea, elasmobranchs (mainly belonging to the Rajidae family) represented about 6 to 10 percent of the total weight of the small-scale catch (Stergiou, Moutopoulos and Erzini, 2002). Still in the Aegean Sea, one specimen of blackchin guitarfish (*Rhinobatos cemiculus*°) was reported in 1995 from the bycatch of set nets operating along the northeastern coast of Rhodes at depths of 40 m, while in 2006, set nets were responsible for the bycatch of two individuals of angular roughshark (*Oxynotus centrina*°) at depths of 40 m (Corsini-Foka, 2009). Elsewhere, in the northern Aegean Sea, Karakulak, Erk and Bilgin (2006) studied the length–weight relationships of 47 coastal fish species from Gökceada Island. Samples were caught at depths between 0 and 30 m by gill and trammel nets between March 2004 and February 2005; the elasmobranch species observed included *Dasyatis pastinaca* (12 individuals), *Raja radula* (25 individuals) and *Torpedo marmorata* (22 individuals).

In the same fishing grounds, Ceyhan, Hepkafadar and Tosunoglu (2010) carried out a total of 22 fishing trials with trammel nets, accompanied by local fishers, from September 2006 to May 2007 and six trials with traditional artisanal longlines in 2007, from July to August in Izmir Bay. Catch rate, catch per unit effort (CPUE), biomass ratios and size selectivity were investigated in order to analyse the smooth-hound shark (*Mustelus mustelus*°) fishery. It was noted that the catch composition and the corresponding proportions of various species were significantly different in longlines (51 individuals) than they were in trammel nets (139 individuals). While the mean CPUE of longlines was 119.2±14.3 kg per 1 000 hooks, these values for 150 mm and 170 mm trammel nets were 5.3±1.2 kg per 1 000 m of net and 12.7±3.9 kg per 1 000 m of net, respectively. During a study conducted off the northeastern Mediterranean coast of Turkey, between April 2004 and December 2005, a total of 115 common guitarfish (*Rhinobatos rhinobatos*°), 66 females and 49 males, were caught by a commercial gillnetter (44 mm mesh size) and by bottom trawlers and in a longline fishery (Başusta *et al.*, 2008).

In the Black Sea, *S. acanthias*° catch has always been reported by the coastal fisheries, including by those using static nets. The landings of *S. acanthias*° by Ukrainian small-scale fisheries from 1997 to 2007 totalled 907 tonnes (with the lowest value, of 20 tonnes, recorded in 1997 and a peak of 172 tonnes in 2003) (GFCM, 2014b).

3.2.3 Purse seiners

Purse seiners usually target large and small pelagic species. They are considered relatively selective in terms of discards/catch rates. Although little information is available in the relevant literature on the bycatch of encircling nets, it is reported that purse seiners, while targeting bluefin

tuna and small pelagic species, have been responsible for the sporadic capture of pelagic sharks, such as of the shortfin mako (*Isurus oxyrinchus*°), basking shark (*Cetorhinus maximus*°) and thresher (*Alopias vulpinus*°), and of stingrays (Notarbartolo and Serena, 1988; Hattour, 2000; Fromentin and Farrugio, 2005; Bradai, Saidi & Enajjar, 2012;). Furthermore, in the central Mediterranean, over 70 percent of great white shark (*Carcharodon carcharias*°) bycatch was reported by purse seiners (Fergusson, 1996; Bradai, Saidi and Enajjar, 2012; Saidi *et al.*, 2005, 2007).

Data collected onboard commercial purse seiners in Greek waters (Aegean and Ionian seas) over 13 seasonal sampling periods from 2003 to 2008 revealed the presence of the common stingray (*Dasyatis pastinaca*) (4 individuals), spotted ray/speckled ray (*Raja montagui/polystigma*) (3+1 individuals), cuckoo ray (*Leucoraja naevus*) (1 individual), small-spotted catshark (*Scyliorhinus canicula*) (1 individual) and electric ray (*Tetronarce nobiliana*) (1 individual) in bycatch (Tsagarakis *et al.*, 2012). In the Levantine basin, according to Abudaya *et al.* (2017), the spintail devil ray (*Mobula mobular*°) has also been the target of an opportunistic purse seine (locally called *shanshula*) fishery since the early 1970s, with fishing occurring from January to April, when the animals enter coastal areas; in 2005 and 2006, 62 and 363 individuals were caught, respectively, while no catch was recorded in 2007 and 2008 (see Table 6). Elsewhere, one specimen of the spiny butterfly ray (*Gymnura altavela*°) was captured in 1999 by a purse seine operating along the northwestern coast of Rhodes (Aegean Sea), at a depth of 60 m (Corsini-Foka, 2009). The same author additionally reported the capture in Dodecanese waters of a single specimen of bull ray (*Aetomylaeus bovinus*) in 2001 and of an electric ray (*Torpedo nobiliana*) in 1998.

In the north Aegean Sea, two juvenile great white sharks *Carcharodon carcharias*° measuring 180 cm and 230 cm TL were reported as bycatch off Thásos and Kavállah, respectively (Fergusson, 1996).

In 2007, the capture of a bigeye thresher shark (*Alopias superciliosus*), measuring 450 cm TL, by a purse seiner operating in Turkish waters was documented by Kabasakal and Karhan (2008). In Turkish coastal waters, Kabasakal (20 7) also reported the incidental capture of two individuals of thresher (*Alopias vulpinus*°), caught in 1996 and 2004, respectively, by purse seiners.

3.2.4 Longliners

Several types of longlines are used in the Mediterranean basin. Depending on the species targeted, either demersal or pelagic, these are also referred to as set (bottom) longlines and drifting (surface) longlines, respectively. Drifting longlines target, according to the hook size and immersion depth, mainly swordfish (*Xiphias gladius*), albacore (*Thunnus alalunga*) and bluefin tuna (*Thunnus thynnus*). These fishing lines have always led to significant bycatch of sharks (Bradai, Saidi and Enajjar, 2012); at least 15 species of sharks (*Prionace glauca*°, *Carcharodon carcharias*°, *Isurus oxyrinchus*°, *Alopias vulpinus*°, *Galeorhinus galeus*°, *Lamna nasus*°, *Alopias superciliosus*, *Sphyrna zygaena*°, *Pteroplatytrygon violacea*, *Mobula mobular*°, *Hexanchus griseus*, *Carcharhinus plumbeus*°, *Squalus blainville*, *Mustelus mustelus*° and *Cetorhinus maximus*°) have been reported as bycatch in drifting longliners (Di Natale, 1998; Vannuccini, 1999; Garibaldi, 2006; Mejuto, Garcia-Cortés and de la Serna, 2002; Bradai, Saidi and Enajjar, 2012; Megalofonou, Dimitris and De Metrio, 2009; Filanti *et al.*, 1986; Megalofonou *et al.*, 2005; Peristeraki *et al.*, 2008). Megalofonou, Dimitris, and De Metrio (2009) reported that a total of 870 blue sharks (*Prionace glauca*°), ranging from 70 to 349 cm TL, were sampled from the swordfish longline fishery in the Mediterranean Sea over the period 1998–2003.

Indeed, studies on drifting longline fisheries targeting swordfish and tuna across the Mediterranean have shown that sharks and rays represent about 6.2 percent by number and 13.5 percent by weight of the total catch: the catch rate was highest in the Alboran Sea (34.3 percent; CPUE of 3.8 individuals per 1 000 hooks) followed by the Adriatic Sea (15.1 percent; CPUE of 1 individual per 1 000 hooks) (Megalofonou *et al.*, 2005). In general, the blue shark (*Prionace glauca*°) was the species most represented in the catch of drifting longliners, accounting for about 71 percent of the total elasmobranch catch, followed by the tope shark (*Galeorhinus galeus*°), at about 13 percent, and the shortfin mako shark (*Isurus oxyrinchus*°), at about 10 percent (Megalofonou, Damalas and Yannopoulos, 2005; Megalofonou, Dimitris and De Metrio, 2009; Megalofonou *et al.*, 2005).

The Alboran Sea represents the area of the western Mediterranean where Spanish fleets targeting swordfish with drifting longlines achieved the highest bycatch rates of pelagic sharks (between 78 percent and 92 percent of the total bycatch in weight). The most heavily caught species were, in order of increasing total weight, *P. glauca*°, *I. oxyrinchus*° and *A. vulpinus*° (UNEP-MAP-RAC/SPA, 2014; Valeiras and de la Serna, 2003; Macías, Gómez-Vivez and de la Serna, 2004; Castro *et al.*, 1999; de la Serna *et al.*, 2002; Megalofonou *et al.*, 2005). Likewise, in the Strait of Gibraltar, Buencuerpo, Rios and Moron (1998), carrying out a study on the composition of the pelagic shark catch in drifting longlines targeting swordfish, reported the presence of *Isurus oxyrinchus*° (3.4 individuals/1 000 hooks), *Prionace glauca*° (19.6 individuals/1 000 hooks), *Alopias vulpinus*° (0.01 individual/1 000 hooks), *Alopias superciliosus* (0.25 individual/1 000 hooks) and *Sphyrna zigaena*° (0.42 individual/1 000 hooks).

Along the coast of Morocco, studies have shown that shark bycatch did not exceed 3 percent of the total weight landed by drifting longliners (Srour and Abid, 2004; Bradai, Saidi and Enajjar, 2012). Regarding pelagic Batoidea, the only species reported as bycatch in drifting longlines was the common pelagic stingray (*Pteroplatytrygon violacea*) (Macías, Gómez-Vivez and de la Serna, 2004; Báez *et al.*, 2009). Over the period 1998–1999, another study examined different swordfish longliners, operating in the waters of southern Spain: sharks represented 13.5 percent of the biomass of the sampled catch, with the main species being blue shark (*P. glauca*°), shortfin mako (*I. oxyrinchus*°), common thresher shark (*Alopias vulpinus*°) and tope shark (*Galeorhinus galeus*°). As a comparison between the different study areas, sharks represented 34.3 percent, 1.7 percent and 1.4 percent of the total biomass caught in the Alboran Sea, Balearic Islands and Catalan Sea, respectively (Megalofonou *et al.*, 2005).

To understand the scale of the impact in the Alboran Sea, Báez *et al.* (2009) analysed variations in swordfish capture and total bycatch under different oceanographic and technical conditions in the artisanal longline fishery operating during the summer period. In 2004, a total of 42 650 hooks were deployed over the course of the observed fishing operations (i.e. approximately 6 percent of the hooks deployed in this area over the period). Nine different species were caught during the observation period: blue shark (*Prionace glauca*°) (60 individuals), bluefin tuna (*Thunnus thynnus*) (1 individual), common dolphinfish (*Coryphaena hippurus*) (31 individuals), common stingray (*Dasyatis pastinaca*) (1 198 individuals), loggerhead sea turtle (*Caretta caretta*) (4 individuals), shortfin mako (*Isurus oxyrinchus*°) (11 individuals), swordfish (*Xiphias glaudius*) (359 individuals), thresher shark (*Alopias vulpinus*°) (3 individuals) and tope shark (*Galeorhinus galeus*°) (1 individual). In line with previous studies, the authors observed that the bycatch (or incidental capture) per unit effort (BPUE) values in the open Mediterranean waters of Andalusia and Murcia were low in comparison to other Mediterranean areas.

In an earlier study carried out in the southern Adriatic Sea, Marano *et al.* (1988) reported that blue shark (*Prionace glauca*) landings accounted for 74.4 percent by weight and 61.2 percent by number of the total bycatch. In comparison, in the Aegean Sea, elasmobranch bycatch in set longlines represented between 6 and 19 percent of the total catch (Stergiou, Moutopoulos and Erzini, 2002).

In general, these records indicate the blue shark (*P. glauca*°) as the most common species found in the bycatch of drifting longliners, followed by the mako (*I. oxyrinchus*°) (Bradai, Saidi and Enajjar, 2012).

Set longliners are usually found to be responsible for bycatch of batoids and demersal shark species (Bradai, Saidi and Enajjar, 2012); in the Aegean Sea, several species of Rajidae (*Raja radula, R. clavata* and *R. miraletus*) accounted for 6 to 19 percent of the total catch. These rates varied according to the hook size (Stergiou, Moutopoulos and Erzini, 2002). A total of 526 longnose spurdog (*Squalus blainville*) specimens were obtained from bottom trawl and set longline catches in the eastern Mediterranean Sea from December 2004 to December 2009 in order to investigate the reproductive biology and the embryonic development of the species. The bottom trawl hauls were carried out at depths between 125 and 475 m in the Aegean Sea, while the longlines were set at depths between 350 and 480 m in the Levantine basin (Kousteni and Megalofonou, 2011).

Along the eastern coast of Rhodes in the Aegean Sea, a set longliner captured an individual of spintail devil ray (*Mobula mobular*°) at a depth of 30 m in 1995 (Corsini-Foka, 2009); in the same area, set longliners caught a specimen of kitefin shark (*Dalatias licha*) at depths of 550–750 m in 2004 and a specimen of common guitarfish (*Rhinobatos rhinobatos*°) in 2008 at a depth of 40 m (Corsini-Foka, 2009). In 2004, the same authors reported the capture of six individuals of longnosed skate (*Dipturus oxyrinchus*) at depths of 300–400 m.

By analysing data from drifting longline fisheries operating in the open waters of the southeastern Mediterranean Sea, Damalas and Megalofonou (2012) have identified a statistically significant decline in species richness, with the probability of shark occurrence reduced to its lowest levels in recent years. Blue shark (*Prionace glauca*°) was the predominant species, accounting for approximately 70 percent of all large sharks encountered. During the periods 1998–2001 and 2003–2005, researchers followed 62 Greek and two Cypriot commercial longliner fishing boats targeting swordfish or tuna and operating from 24 fishing ports. Large sharks were present in 207 out of a total 1 360 fishing sets (exerting an effort of almost a million hooks). In these sets, 249 large shark specimens were observed, belonging to at least ten species and five families: *Prionace glauca*° (170 individuals), *Isurus oxyrinchus*° (25 individuals), *Galeorhinus galeus*° (22 individuals), *Alopias vulpinus*° (13 individuals), *Carcharhinus plumbeus*° (11 individuals), *Alopias superciliosus* (2 individuals), *Carcharodon carcharias*° (1 individual), *Heptranchias perlo*° (1 individual), *Hexanchus nakamurai* (1 individual) and the first recorded sighting of a milk shark, *Rhizoprionodon acutus* (1 individual) in the region.

3.2.5 Pelagic trawlers

Concerning pelagic trawling, Capapé *et al.* (2003), in their review on the historical capture of basking sharks (*Cetorhinus maximus*°) off the Maghrebine shore (Algerian and Tunisian coasts), reported the bycatch of two specimens off Tunisia in 1976 and 1981, and of five specimens off Algeria in 2000 (4 individuals) and in 2002 (1 individual).

In Slovenian waters, Mavrič *et al.* (2004) recorded, for the first time, the presence of the pelagic stingray (*Pteroplatytrygon violacea*): nine individuals were caught by pelagic trawlers targeting anchovies and red bandfish (*Cepola macrophthalma*) between May and September 2004. In the Adriatic Sea, an investigation into cetacean bycatch (Fortuna *et al.*, 2010) analysing data from sixteen independent observers monitoring a total of 3 141 hauls between 2006 and 2008 revealed important elasmobranch bycatch information. The observation coverage ranged between 0.9 and 6.3 percent of the regional fishing effort, and the study reported 15 elasmobranch species from bycatch over the survey period; among these, the following conservation-priority species were found: *Alopias vulpinus*° (13 individuals), *Carcharhinus plumbeus*° (1 individual), *Squalus acanthias*° (374 individuals), *Mustelus asterias*° (15 individuals), *M. mustelus*° (80 individuals), *M. punctulatus*° (18 individuals) and *Prionace glauca*° (1 individual). Other species also included *Scyliorhinus canicula, Aetomylaeus bovinus, Myliobatis aquila, Dasyatis pastinaca, Pteroplatytrygon violacea*, *Raja clavata, R. asterias* and *Torpedo marmorata*. According to the study, all species of shark and skate found in bycatch were marketed, including piked dogfish (*Squalus acanthias*°) and smooth-hounds (*Mustelus*°spp.), while the bull ray (*A. bovinus*), common eagle ray (*M. aquila*), pelagic stingray (*P. violacea*) and common stingray (*D. pastinaca*) were usually discarded at sea. Furthermore, in the Adriatic Sea, Lipej *et al.* (2013) reported the bycatch of 84 pelagic stingrays obtained during 50 sampling cruises carried out in the Gulf of Trieste, Italy and adjacent waters from April 2004 to October 2005. Pelagic trawling was conducted in the shallow coastal areas over muddy and muddy-detritic bottom sediments at depths from 20 to 30 m, with the large majority of specimens caught during the summer period.

From the French Mediterranean coast, Ferretti (2014) reported on the last record of a sawfish *Pristis*° sp. caught in the Mediterranean by fishing activities. It was recorded by a tuna fishing boat operating off Grau-du-Roi (Languedoc-Roussillon, France) in 1959. While there is evidence that sawfishes may occur in the Mediterranean Sea (Ferretti, 2014; Ferretti *et al.*, 2015), the incidental catch from the different vessel groups is currently not documented.

3.2.6 Tuna traps

Regarding tuna traps, a few studies have reported elasmobranch bycatch in this type of disused coastal fishing gear. In particular, as tuna has always provided a primary food source for Mediterranean great white sharks (*Carcharodon carcharias*°) (Barrull and Mate, 2001; Moro *et al.*, 2019), interactions between these large predators and tuna traps, once numerous in the Mediterranean, have been recorded. Likewise, Storai *et al.* (2011) have recorded a long data series of large elasmobranch bycatch in six traditional tuna traps (*tonnare*) off Sardinia (Italy) from 1990 to 2009. Over this period, 15 spintail devil ray (*Mobula mobular*°) and 27 large sharks were caught as bycatch: *M. mobular*° (15 individuals); smooth hammerhead (*Sphyrna zygaena*°) (2 individuals); blue shark (*Prionace glauca*°) (2 individuals); bluntnose sixgill shark (*Hexanchus griseus*) (3 individuals); thresher (*Alopias vulpinus*°) (11 individuals); basking shark (*Cetorhinus maximus*°) (4 individuals); great white shark (*Carcharodon carcharias*°) (2 individuals); shortfin mako (*Isurus oxyrinchus*°) (1 individual); copper shark (*Carcharhinus brachyurus*) (1 individual); and dusky shark (*Carcharhinus obscurus*) (1 individual).

At the Sidi Daoud tuna trap, off northeastern Tunisia, Hattour, Macias and de la Serna (2005) have reported that the great white shark (*C. carcharias*°), the shortfin mako (*I. oxyrinchus*°) and the thresher shark (*Alopias* spp.) accounted for the trap's elasmobranch bycatch, constituting 2.3 percent of the biomass of the total catch. Likewise, along the Libyan coast in June 2002, a great white shark *C. carcharias*° remained trapped for two days in a tuna cage containing 60 tonnes of bluefin tuna

(Galaz and De Maddalena, 2004). Finally, the Mediterranean Large Elasmobranchs Monitoring (MEDLEM) programme (see section 3.3) recorded about 70 incidental catches from 1879 to 2015, with about 68 percent of them that were white sharks (Mancusi *et al.*, 2020). Other cases of sharks trapped in tuna cages in the Mediterranean include an instance of two blue sharks (*P. glauca*°) caught in a cage between Italy and Spain in 2001 and a shortfin mako (*I. oxyrinchus*°) stuck in a cage between the Balearic Islands and Murcia, Spain in 2002 (Galaz and De Maddalena, 2004).

3.2.7 Pelagic driftnets

The bycatch of large elasmobranchs (for example, the blue shark *Prionace glauca*°, great white shark *Carcharodon carcharias*°, common thresher *Alopias vulpinus*°, shortfin mako *Isurus oxyrinchus*° and the basking shark *Cetorhinus maximus*°) has been at historically high levels in various pelagic driftnet fisheries (Vannuccini, 1999; Silvani, Gazo and Aguilar, 1999; Megalofonou, Damalas and Yannopoulos, 2005; Di Natale *et al.*, 1995; Mancusi *et al.*, 2005; Megalofonou *et al.*, 2005; Tudela *et al.*, 2005). The use of this kind of unselective fishing gear has been banned in the Mediterranean Sea, however, since 2005, so its impacts are not treated in detail in this review.

3.3 Analysis of recent data from literature (2008–2019)

In order to adequately assess elasmobranch bycatch in fisheries, it is necessary to carefully monitor all fishing activities, while at the same time examining in detail the existing information available in the scientific literature and from fisheries data. Nonetheless, unlike other vulnerable species (for example, sea turtles), elasmobranchs include numerous and very different species, of which some are protected, others are of commercial value, and yet others are discarded at sea, according to the region and the demand from local markets (see Section 3.1). In addition, sharks and rays are not commonly distinguished at the species level in fisheries, not only in the Mediterranean and Black Sea, but all over the world (Dulvy and Forrest, 2010; Stevens *et al.*, 2000); records usually report (only) the landed species as mixed sharks or *Raja* spp. or sharks nei[4], etc. Therefore, accurate records of elasmobranch bycatch are difficult to obtain from fisheries statistics, as commercial fishing data rarely differentiate between the various elasmobranch species caught. When working from the scientific literature, the task can be equally challenging, as the data on catch and bycatch of elasmobranchs are often pulled together and reported as the biomass percentage of the total catch and/or landings, while the number of specimens caught is frequently unavailable, especially for smaller demersal species. Conversely, when the number of specimens caught is indeed reported, sometimes information on the total catch of the fishing vessel group is not registered.

The following sections include data from scientific literature, reports and databases collected over the period 2008–2018, organized by fishing vessel group and subregion. Tables and graphs only include references from which information regarding the number of caught individuals of priority-conservation elasmobranch species could be extracted according to a specific fishing vessel group. Nevertheless, any interpretation of the results should be taken with caution and in consideration of the limitations listed above. Among these data sources, one important archive is the MEDLEM[5] database (Serena, Mancusi and Barone, 2014; Mancusi *et al.*, 2020), which has

4. "Not elsewhere included".
5. MEDLEM is a network of researchers involving Mediterranean and Black Sea scientists from various research institutes and voluntary associations. All the experts of this network can directly contribute to updating the database with data, including bycatch events and elasmobranch biological information collected in their countries.

been used for obtaining the most recent (2008–2019) bycatch records of elasmobranch species. The figures included in the MEDLEM database represent an underestimate of the real situation, though they still provide useful baseline information on elasmobranch species recorded in the catch of select fishing vessels, sorted by types of gear. When MEDLEM provided data that were also published in scientific literature, only the latter were cited for the purpose of this review in order to avoid duplicates of the same information.

The vessel groups considered in this review correspond to those provided by the GFCM Data Collection Reference Framework (DCRF): bottom trawlers, small-scale fisheries, purse seiners, longliners, pelagic trawlers, tuna seiners and dredgers (GFCM, 2018c). The latter category does not appear in this review, as dredgers do not impact sharks and rays in any GFCM subregion. Meanwhile, the category of tuna seiners also takes into consideration the few tuna traps left in the Mediterranean. Small-scale longliners, which are a major component of artisanal fishing fleets, have been considered as a separate category in the review of small-scale fisheries due to their relative importance.

Data are reported for the five GFCM subregions: western Mediterranean, central Mediterranean, Adriatic Sea, eastern Mediterranean and Black Sea. Among all the species of elasmobranchs cited in this review, conservation-priority species as defined by GFCM Recommendation GFCM/42/2018/2 (Table 1A, Table 1B) are marked with the symbol "°".

3.3.1 Bottom trawlers

Bottom trawling is a common multi-target fishing activity conducted throughout the Mediterranean and Black Sea, providing the highest income among all fishing sub-sectors (Tudela, 2004). Although bottom trawlers represent only about 8 percent of the Mediterranean fleet, they contribute approximately 21 percent of the landed catch, which figure emphasizes their economic importance (Bradai, Saidi and Enajjar, 2018; FAO 2018c). Almost all the shark and ray species in the region can potentially be caught by both pelagic and bottom trawlers (Cavanagh and Gibson, 2007); 62 species have been recorded in trawl catches in Greece, 62 species in Spain and 74 species in Italy (Bradai, Saidi and Enajjar, 2018).

As previously indicated, throughout the Mediterranean and Black Sea, several demersal elasmobranch species are commonly caught in bottom trawl fisheries, including the small-spotted catshark (*Scyliorhinus canicula*), the blackmouth catshark (*Galeus melastomus*), the velvet belly lanternshark (*Etmopterus spinax*), the longnose spurdog (*Squalus blainville*), smooth-hounds (*Mustelus*° spp.), the thornback ray (*Raja clavata*), the speckled ray (*Raja polystigma*), the starry ray (*Raja asterias*), the brown ray (*Raja miraletus*), among others. Pelagic species are also sometimes caught by bottom trawlers. These include the common thresher shark (*Alopias vulpinus*°), blue shark (*Prionace glauca*°), great white shark (*Carcharodon carcharias*°), shortfin mako (*Isurus oxyrinchus*°) and, occasionally, the basking shark (*Cetorhinus maximus*°). Rays, such as the common eagle ray (*Myliobatis aquila*) and the spintail devil ray (*Mobula mobular*°), are also affected (WWF, 2019; Bradai, Saidi and Enajjar, 2012, 2018; Başusta, Başusta and Özgürözbek, 2016). Unfortunately, for this fishing group, the information reported very often concerns a listing of species without an estimate of the bycatch rate by fishing effort and/or absolute numbers of caught individuals.

The data reported officially by countries to the GFCM are presented in Table 3 (FAO, 2018d, 2019).

Table 3 includes information on the incidental catch of conservation-priority sharks and batoid species from sources individually reporting the elasmobranchs caught by bottom trawlers. In this sense, Table 3 provides only an indicative overview, as some of the other studies cited below lack this information.

Western Mediterranean

In the western Mediterranean, most of the chondrichthyans are bottom-dwelling species inhabiting demersal ecosystems on the continental shelf and slope; these characteristics make them especially vulnerable to bottom trawling, which is the most important fishery in the western Mediterranean in terms of both the fishing capacity of the fleet and its catch (Cavanagh and Gibson, 2007). This fishery operates over a wide bathymetric range (50–800 m), exploiting different communities and thus gathering a large number of species in its catch, including bony fishes, decapod crustaceans, cephalopods and other invertebrates, as well as chondrichthyans, which represent an important fraction of bycatch and discards (Moranta *et al.*, 2008; Ramírez-Amaro *et al.*, 2020). A study based on fishery-independent scientific surveys evaluated the population trends of demersal chondrichthyans in the Spanish western Mediterranean and revealed that most of the sharks and batoids (i.e. *Scyliorhinus canicula, Torpedo mamorata, Raja clavata* and *Galeus melastomus*) currently forming these communities, have shown resilience to the impacts of fishing over the last two decades. These results could be explained by the evolution of the trawl fishery (i.e. a reduction of effort and a shift to deeper waters) over the last few years, combined with the greater resilience generally displayed by some species (e.g. *S. canicula*). By contrast, decreasing trends were detected only for the deep-water species *Etmopterus spinax* and *Dipturus oxyrinchus* (Ramírez-Amaro *et al.*, 2020).

In another study, Navarro *et al.* (2014), carrying out an investigation into the diet of the rare kitefin shark (*Dalatias licha*), collected a total of 36 specimens of *D. licha* between 2011 and 2013 (13 in 2011, 18 in 2012 and 5 in 2013); 32 of these were incidentally caught by the bottom trawling fleet operating in the Gulf of Lion and the Catalan Sea at depths between 350 and 550 m and between 400 and 1 200 m, respectively.

In the northwestern Mediterranean, Barría *et al.* (2015) analysed the morphological parameters of threatened chondrichthyans. All chondrichthyan specimens analysed in the study were collected from the Gulf of Lion or the Catalan Sea between September 2011 and June 2013. The samples were obtained from commercial bottom trawling vessels and from two experimental oceanographic surveys (Dos-Mares and Ecotrans projects; Spanish Government) conducted at depths ranging between 40 and 2 200 m. A total of around 811 individuals belonging to 20 species from seven families and six genera were collected. Among the elasmobranchs were found: *Etmopterus spinax* (143 individuals), *Galeus melastomus* (179 individuals), *Scyliorhinus canicula* (171 individuals), *Centrophorus granulosus*° (3 individuals), *Dalatias licha* (37 individuals), *Hexanchus griseus* (6 individuals), *Oxynotus centrina*° (3 individuals), *Dipturus oxyrinchus* (2 individuals), *Leucoraja naevus* (3 individuals), *Raja asterias* (77 individuals), *R. clavata* (8 individuals), *R. montagui* (= *R. polystigma*) (2 individuals), *R. polystigma* (3 individuals), *Centroscymnus coelolepis* (122 individuals), *Somniosus rostratus* (5 individuals), *Squalus acanthias*° (2 individuals), *Torpedo marmorata* (16 individuals), *T. nobiliana* (1 individual) and *T. torpedo* (28 individuals).

Elsewhere, around Ibiza in the Balearic Islands, Guallart, Morey and Bartolì (2019) recorded the presence of an immature female sharpnose sevengill shark (*Heptranchias perlo*°) in the bycatch of a commercial bottom trawler targeting blue and red shrimp (*Aristeus antennatus*). This sighting represented the first substantiated record of the species around the Balearic Islands (GSA 5).

In the MEDLEM database, about 20 percent of the available records of elasmobranch bycatch in bottom trawls are from the western Mediterranean, taking into consideration all species from 2008–2018. In the western Mediterranean, data mainly focus on the bluntnose sixgill shark (*Hexanchus griseus*), which accounts for 39 percent (15 individuals) of the reported bycatch of sharks and rays in bottom trawls; the records of priority-conservation species from the MEDLEM database are presented in Table 3.

Central Mediterranean

In this GFCM subregion, two of the Mediterranean's major trawler fleets (Mazara del Vallo, Italy and Sfax, Tunisia) are present. Meanwhile, the Gulf of Gabès has already been identified as a nursery and sensitive area for several Tunisian elasmobranchs, including *Carcharhinus plumbeus*°, *Mustelus mustelus*°, *Rhinobatos rhinobatos*°, *Glaucostegus cemiculus*° and *Gymnura altavela*° (Bradai, Saidi and Enajjar, 2012, 2018).

In the Gulf of Gabès (Tunisia), Hamdaoui (2009) reported, over a sampling period spanning six months in 2009, 14 species of sharks and 17 species of batoids (rays) caught by bottom trawlers, representing 64.6 percent of all elasmobranch species recorded in the area. The CPUE was estimated at 79.4 kg per trip, 7.6 kg per trawling day and 0.8 kg per haul for all elasmobranchs. As far as the contributions of the different groups, sharks represented 23.7 kg per trip, 2.5 kg per trawling day and 0.27 kg per haul, while the batoids accounted for 55.7 kg per trip, 5 kg per trawling day and 0.54 kg per haul. Fishes, cephalopods and crustaceans represented 74.2 percent, 12.3 percent and 9.4 percent, respectively, of the total landings. In comparison, the overall bycatch of elasmobranchs constituted, on average, 5.4 percent of the total landings (i.e. 1.7 percent sharks and 3.7 percent batoids) and contributed 62 percent to the national production of cartilaginous fish. The CPUE was estimated for some rare species: white skate (*Rostroraja alba*°) (0.1 specimen per landing); spiny butterfly ray (*Gymnura altavela*°) (0.05 specimen per landing); sharpnose sevengill shark (*Heptranchias perlo*°) (0.05 specimen per landing); starry smooth-hound (*Mustelus asterias*°) (0.019 specimen per landing); and great white shark (*Carcharodon carcharias*°) (0.014 specimen per landing). The conservation-priority species caught as bycatch over the sampling period are reported in Table 3.

More recently, in the Gulf of Gabès, Marouani *et al.* (2017) investigated the diet of the shortnose spurdog (*Squalus megalops*) (630 individuals) and longnose spurdog (*S. blainville*) (232 individuals) between January 2007 and May 2009. They were able to collect a large number of monthly samples of these two species from local commercial trawlers operating in the upper 70 m of the water column, thereby highlighting the impacts of these vessels on the species.

Also in the Gulf of Gabès, in the context of an experimental trawl survey carried out during the spring of 2014, 15 elasmobranch species belonging to eight families were incidentally caught, of which the brown ray (*Raja miraletus*), thornback ray (*Raja clavata*), common stingray (*Dasyatis pastinaca*), common smooth-hound (*Mustelus mustelus*°) and shortnose spurdog (*Squalus megalops*) were the most common; in the area, elasmobranch bycatch represented 12.6 percent of the total catch and the CPUE was estimated at 2.96 kg per haul (GFCM, 2014a).

In the same area, El Kamel-Moutalibi *et al.* (2014) reported four specimens of the rare sharpnose sevengill shark (*Heptranchias perlo*°) caught off the northern Tunisian coast between 2007 and 2014: two males (one juvenile and one adult) and two females (one juvenile and one adult). Of these four individuals, only two were certainly bycaught in a bottom trawl. *H. perlo*°, considered to be a rare species and probably threatened, is still present in the area.

In the MEDLEM database, about 8 percent of the available records of elasmobranch bycatch in bottom trawls are from the central Mediterranean, taking into consideration all species caught from 2008 to 2018, and mainly concern the bluntnose sixgill shark (*Hexanchus griseus*) (12 individuals). The records of priority-conservation species are presented in Table 3.

Adriatic Sea

In the Adriatic Sea, although the fishing effort by bottom trawlers has always been high, the bycatch records of large elasmobranch species in the MEDLEM database represent only 3 percent of the data: four individuals of the bluntnose sixgill shark (*Hexanchus griseus*), in addition to one individual of basking shark (*Cetorhinus maximus*°) and two of blue shark (*Prionace glauca*°).

In a recent investigation, Ćetković (2018) described the composition and abundance of shark bycatch in Montenegrin fisheries from fisheries data collected over a three-year survey (2016–2018) and recorded in onboard field observations and at the landing points of four vessel groups: drifting longliners, nets (gillnets and trammel nets) and bottom trawlers. The main goals of the research were to define which species could be found in Montenegrin landings, as well as to make a preliminary assessment of their abundance in the catch of the surveyed gear types. In the surveyed bottom trawls, the shark bycatch included 487 individuals of small-spotted catshark (*Scyliorhinus canicula*), five individuals of smooth-hound (*Mustelus mustelus*°), two individuals of longnose spurdog (*Squalus blainville*), and two individuals of angular roughshark (*Oxynotus centrina*°), all of which were released alive by the fishers.

In 2018, a female great torpedo ray (*Tetronarce nobiliana*) was captured by a commercial bottom trawler off southern Albania at a depth of 550 m. Its total body weight was 5.6 kg, while the specimen's TL and disc width were 70 cm and 50 cm, respectively (Bakiu and Troplini, 2018).

In the Italian Adriatic Sea, Bargione *et al.* (2019) investigated the life history traits, in relation to age structure and reproduction, of the piked dogfish (*Squalus acanthias*°) from mid-February 2012 to mid-July 2013 and in 2016. A total of 326 individuals were caught by bottom trawlers and analysed for the purposes of the study: catches occurred on sandy bottoms ranging from 40 to 90 m deep, at 15–50 nautical miles from the coast. According to the results obtained, the authors concluded that the reduction of *S. acanthias*° bycatch represented an urgent concern and that mitigation measures should be promptly adopted, fishers trained on how to release live sharks, and nursery/mating areas identified and closed during specific times of the year. In addition, awareness campaigns should be launched to reduce shark meat consumption, especially in the Italian Adriatic region.

Eastern Mediterranean

In the eastern Mediterranean, the vessel group using bottom trawls is not as developed as in other areas of the Mediterranean. In recent years, however, bottom trawling has increased, with direct impacts on the fishing of accessory species, such as elasmobranchs. Many studies, especially from Turkish Mediterranean waters, have been published, indicating a high diversity of elasmobranch species in this area of the Mediterranean. As recently pointed out by Kabasakal (2019) in a review of elasmobranch research in Turkish waters, until the last quarter of the twentieth century, most of the knowledge around these species was based on a limited number of anecdotal studies. Since the mid-1990s, however, a remarkable improvement has followed in the number and quality of elasmobranch-specific studies and publications, resulting in a gradual filling of the gaps in scientists' understanding of sharks and rays. Of a total 96 articles on the sharks and rays

inhabiting Turkish waters published between 1968 and 2018 (Kabasakal, Karhan and Sakinan, 2017), only two elasmobranch-specific articles had been published prior to 1990, eight scientific articles were published between 1990 and 2000, and as many as 88 papers dealing with different aspects of sharks and rays have been since. The following section reports only on some of these studies, though the facts are clearly emerging to show that that the eastern Mediterranean should be considered as rich and important as the central Mediterranean Sea in terms of elasmobranch diversity and for conservation priorities.

In Egyptian Mediterranean waters, Moftah *et al.* (2011) classified sharks using morphological and DNA barcoding. Fifty-one shark specimens belonging to six families were collected from the commercial catch received at two major fish markets in Alexandria, namely the Abu Qir Fishing Centre and the Rasel-Tin Fishing Centre (Anfoushi). The fishing boats were operating in Alexandrian waters over the period of sample collection from May to November 2008. The study confirmed the presence of piked dogfish (*Squalus acanthias*°), angular roughshark (*Oxynotus centrina*°), angelshark (*Squatina squatina*°), small-spotted catshark (*Scyliorhinus canicula*), nursehound (*Scyliorhinus stellaris*), smooth-hound (*Mustelus mustelus*°), blackspotted smooth-hound (*Mustelus punctulatus*°) and bignose shark (*Carcharhinus altimus*) (Table 3). Though the study did not specify the relevant fishing vessel groups, the species composition can be linked to bottom trawlers.

In Iskenderun Bay in the northeastern Mediterranean, Yağlıoğlu *et al.* (2015) assessed the elasmobranch bycatch of a bottom trawl fishery by examining the total biomass, species composition, depth distribution, seasonal distribution and abundance of elasmobranchs in 52 commercial bottom trawls carried out between 2009 and 2010. It was estimated that elasmobranchs represented 23 percent (190.1 kg per km^2) of the total fish biomass (840.8 kg per km^2) in Iskenderun Bay; bycatch also included priority-conservation species, though absolute values were not provided. The batoids, *Dasyatis pastinaca*, *Gymnura altavela*°, *Raja clavata* and *Rhinobatos*° spp. (*R. rhinobatos*° and *R. cemiculus*°), occurred frequently and represented between 11.1 and 38.5 percent, respectively, of the total elasmobranch biomass. Other batoid species, *Dipturus oxyrinchus*, *Raja miraletus*, *Torpedo marmorata* and *Torpedo torpedo*, each represented between 0.1 and 2.8 percent of the total elasmobranch biomass. In addition, the shark species, *Mustelus mustelus*°, *Scyliorhinus stellaris*, *Scyliorhinus canicula*, *Galeus melastomus* and *Squatina squatina*°, each accounted for between 0.45 and 1.7 percent of the whole elasmobranch biomass. Single or sporadic captures were also recorded for the following shark and batoid species: the shortfin mako shark (*Isurus oxyrinchus*°), sandbar shark (*Carcharhinus plumbeus*°), bignose shark (*Carcharhinus altimus*), angular roughshark (*Oxynotus centrina*°), rough ray (*Raja radula*), Lusitanian cownose ray (*Rhinoptera marginata*) and the bull ray (*Aetomylaeus bovinus*).

Also in Iskenderun Bay, Yemisken, Dalyan and Eryilmaz (2014) analysed and compared the fish species found in the catch and discards of trawl fisheries during the fishing closure period and the fishing period, with sampling carried out from May 2010 to January 2011 on a commercial trawler. The results showed that chondrichthyan species abundance (number) represented 0.9 percent (465 individuals) of the total discarded catch, with only three species retained as commercial catch: the smooth-hound (*Mustelus mustelus*°) (1 individual); sandbar shark (*Carcharhinus plumbeus*°) (2 individuals); and blackchin guitarfish (*Rhinobatus cemiculus*°) (1 individual). Chondrichthyan species biomass (weight) represented 51 percent of the discarded catch, with the spiny butterfly ray (*Gymnura altavela*°) (203 individuals) and common stingray (*Dasyatis pastinaca*) (125 individuals) the most common species among the chondrichthyans in the study area. The discard rate of

chondrichthyan species was estimated at 12.5 percent in May, 19.1 percent in August, 2.3 percent in October and 5.1 percent in January.

In the same area, in Mersin Bay, Turkey, Ergüden and Bayhan (2015) reported the first instance of an individual of the rare sawback angelshark (*Squatina aculeata*°) caught as incidental catch by bottom trawlers, in 2014. In the same area, a female specimen of the basking shark (*Cetorhinus maximus*°) (TL 245 cm; 75 kg weight) was incidentally caught by a bottom trawler at a depth of about 25 m in March 2014 (Ergüden *et al.*, 2020). Further west, in the Gulf of Antalya (Turkey), Kebapçıoğlu *et al.* (2010) analysed 30 hauls from a bottom trawl survey carried out over the summer of 2009, in order to determine the catch composition, abundance and biomass of the demersal fish stocks. A total of 84 fish species were identified, including nine elasmobranchs. The spiny butterfly ray (*Gymnura altavela*°) and common stingray (*Dasyatis pastinaca*) were among the five species with the highest biomass index values, indicating a high abundance of these species in the area.

Similarly, in the Gulf of Antalya, Özbek, Çardak and Kebapçioğlu (2016) also recorded the abundance and biomass of the spiny butterfly ray (*Gymnura altavela*°) at various depth levels and in different seasons. A total of 116 hauls were carried out between August 2009 and April 2010 at six stations and six depth levels (25, 50, 75, 100, 150 and 200 m) using a commercial bottom trawl. From 40 hauls, 172 individuals of *G. altavela*° were sampled; the frequency of occurrence was 41.7 percent at depths between 25 and 100 m but zero at 150 and 200 m. In another study conducted along the west coast of İskenderun Bay, Yeldan *et al.* (2013) analysed the temporal changes in some Rajiformes[6] species caught by commercial bottom trawlers from 2004 to 2011 (see Section 3.2); the priority-conservation species sampled from 2008 to 2011 are reported in Table 3. In the same area, two individuals of the rare angular roughshark (*Oxynotus centrina*°) were obtained from the discarded catch of commercial trawlers fishing at depths of 120 to 150 m off the Cape of Akinci (Ras al-Khanzir) on 14 May 2014 (Başusta, Turan and Başusta, 2015). According to the authors, the occurrence of a gravid female and an adult male of *O. centrina*° in the northeastern Mediterranean Sea strongly indicates the presence of a nursery and mating area. Furthermore, off Samandag, Iskenderun Bay, Kapiris *et al.* (2014) reported the rare occurrence of a starry smooth-hound (*Mustelus asterias*°), caught by a bottom trawler at a depth of 90 m. This record represents the first to be registered since the last reported catch of *M. asterias*° in the early 1980s by Gücü and Bingel (1994). In the same area (Iskenderun Bay), a single female specimen of the pelagic stingray (*Pteroplatytrygon violacea*) was incidentally caught on a sandy/muddy bottom at a depth of approximately 40 m by a commercial bottom trawler in 2016 (Ergüden *et al.*, 2018).

During a broader investigation of Turkish waters (northeastern Mediterranean), Gökçe, Saygu and Eryaşar (2016) analysed catch composition and diversity in Mersin Bay, an important fishing ground for demersal trawls. A total of 182 hauls were carried out by a commercial trawler between September 2009 and April 2013. Elasmobranchs represented 5.1 percent of the total catch in terms of CPUE (kg per hour) and 0.09 percent in terms of number per hour. Overall, twelve species of elasmobranchs were identified, including sandbar shark (*Carcharhinus plumbeus*°), nursehound (*Scyliorhinus stellaris*), smooth-hound (*Mustelus mustelus*°), common stingray (*Dasyatis pastinaca*), Tortonese's stingray (*D. tortonesei*), spiny butterfly ray (*Gymnura altavela*°), thornback ray (*Raja clavata*), brown ray (*R. miraletus*), blackchin guitarfish (*Rhinobatos rhinobatos*°),

6. Rays, sawfishes, guitarfishes, skates and stingrays.

angular roughshark (*Oxynotus centrina*°), marbled electric ray (*Torpedo marmorata*) and electric ray (*T. nobiliana*) (Table 3).

In another study conducted in the northeastern Mediterranean (Turkey), Başusta and Başusta (2019) analysed the occurrence of the longnosed skate (*Dipturus oxyrinchus*) as bycatch from commercial trawl fishing at depths of 300–410 m and 360–400 m in Antakya Bay and recorded the first record of egg capsules and juveniles of the longnosed skate in this area. In addition, Başusta (2016) also reported the occurrence of neonate and juvenile sharks of three rare species, the sharpnose sevengill shark (*Heptranchias perlo*°), sawback angelshark (*Squatina aculeata*°) and velvet belly (*Etmopterus spinax*), captured as bycatch by a commercial trawler fishing at depths between 360 and 430 m in the same area. It was the first time that two neonates of *H. perlo*°, five neonates of *E. spinax* and one juvenile of *S. aculeata* were identified in this region.

In the central Aegean Sea, Eronat and Özaydın (2014) carried out a study on the length–weight relationship parameters of 2 511 specimens of 30 cartilaginous fish species (11 sharks, 18 batoids and 1 chimaera) caught from depths of 0 to 500 m by a research vessel and a commercial trawler between 2008 and 2009 in Izmir and Sığacık Bay. During the operations, a traditional bottom trawl (48 mm mesh size in codend) and cover net were used, while hauls were limited to 30 mn and the average speed was 2.5 knots. The most abundant species were the small-spotted catshark (*Scyliorhinus canicula*) (1 210 individuals), longnose spurdog (*Squalus blainville*) (308 individuals), blackmouth catshark (*Galeus melastomus*) (235 individuals), thornback ray (*Raja clavata*) (137 individuals), common stingray (*Dasiatys pastinaca*) (78 individuals), nursehound (*Scyliorhinus stellaris*) (19 individuals) and rough ray (*R. radula*) (16 individuals); the few priority-conservation species noted as bycatch during these surveys are reported in Table 3.

Elsewhere, along the southern Aegean coast, the catch composition of a shrimp trawl fishery was analysed from December 2009 to November 2010 (Bilge *et al*., 2014); among the elasmobranchs recorded during 68 hauls, the following species and abundances were noted: *Mustelus mustelus*° (74 individuals), *M. punctulatus*° (52 individuals), *Squalus blainville* (80 individuals), *Raja radula* (38 individuals), *R. miraletus* (62 individuals), *Torpedo marmorata* (57 individuals), *T. nobiliana* (73 individuals), *Scyliorhinus stellaris* (92 individuals) and *Scyliorhinus canicula* (144 individuals). Likewise, data collected from 11 scientific bottom trawling operations in 2009 and 2010 off the Turkish coast of the southern Aegean Sea were used to describe the distribution and abundance of chondrichthyan species (Filiz, Yapıcı and Bilge, 2018): the most abundant species were *Mustelus mustelus*°*, Dasyatis pastinaca, Raja miraletus and Raja radula*.

In another study, from Edremit Bay in the northern Aegean Sea, length-weight relationships were calculated for nine chondrichthyan species. (Türker, Zengin and Tünay, 2019). Samples were collected at depths ranging from 20 to 100 m at monthly sampling intervals from June 2007 to June 2009 using a commercial bottom trawler employing deep trawl nets with a 24 mm codend mesh size; tow duration was restricted to 30 mn. The 286 elasmobranchs caught consisted of *Dasyatis pastinaca* (10 individuals), *Mustelus mustelus*° (60 individuals), *Myliobatis aquila* (12 individuals), *Raja clavata* (33 individuals), *R. miraletus* (13 individuals), *R. radula* (23 individuals), *Scyliorhinus stellaris* (8 *individuals*), *S. canicula* (108 *individuals*) *Torpedo marmorata* (9 *individuals*), *Carcharodon carcharias*° (1 individual), *Cetorhinus maximus*° (1 individual), *Galeorhinus galeus*° (2 individuals), *Gymnura altavela*° (1 individual), *Leucoraja naevus* (1 individual), *Rostroraja alba*° (2 individuals) and *Squalus acanthias*° (2 individuals).

One of the first studies investigating the demography and reproductive biology of the blackmouth catshark (*Galeus melastomus*) in the eastern Mediterranean was carried out by Metochis *et al.* (2016), based on 452 individuals incidentally caught. The sampled population mainly consisted of immature catsharks (77 percent), predominantly trawled in the northwest Aegean and the Gulf of Corinth during winter and autumn. In addition, an investigation from the eastern part of the Aegean Sea by Bengil *et al.* (2019) onboard a commercial bottom trawler operating at depths between 150 and 550 m and studying the feeding habits of four elasmobranch species (carried out in 2008 and 2014) sampled a total of 2 174 specimens belonging to the velvet belly (*Etmopterus spinax*) (129 individuals), blackmouth catshark (*G. melastomus*) (441 individuals), longnose spurdog (*Squalus blainville*) (308 individuals) and small-spotted catshark (*Scyliorhinus canicula*) (1 296 individuals). The importance of this latter species, *S. canicula*, in the catch composition was recorded also during an investigation of commercial trawling operations conducted between March 2012 and May 2014 along the southeastern part of the Turkish coast, with a total of 1 150 individuals (562 females, 588 males) caught (Özcan and Başusta, 2018a).

Elsewhere, off the southern Turkish coast in Antalya Bay, Bulguroğlu *et al.* (2014) reported, in their study on elasmobranch parasites, that a thornback ray (*Raja clavata*) and an angelshark (*Squatina squatina*°) were captured by commercial trawl vessels as non-target species at a depth of 50 m in April and July 2013 as a result of low trawl mesh selectivity. The angelshark was returned to the sea after the parasites had been collected. Recently, also in Antalya Bay, Kabasakal and Bayrı (2019) reported a female specimen of the smalltooth sandtiger shark (*Odontaspis ferox*°) (4 m TL), incidentally caught in March 2019 by a commercial bottom trawler while towing at depths between 100 to 120 m.

Furthermore, along the Syrian coast, a total of 8 035 elasmobranchs, comprising 17 species belonging to 11 families, were recorded in bycatch at a main landing site between November 2014 and October 2015. The species caught by trawl nets were *Mustelus mustelus*° (418 individuals), *Galeus melastomus* and *Squalus blainville* (Alkusairy and Saad, 2018) (Table 3).

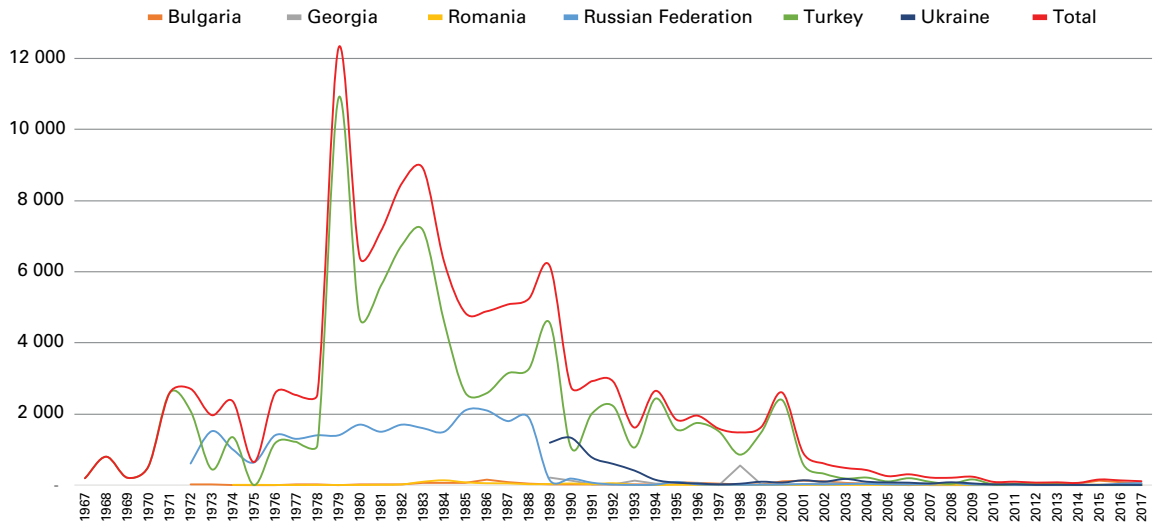
In the Marmara Sea, chondrichthyan bycatch was surveyed seasonally between October 2011 and February 2013 during 117 tows of the beam trawl fishery targeting deep-water rose shrimp (*Parapenaeus longirostris*); the bycatch per unit of effort are provided for each elasmobranch species: *Raja clavata* (0.47 kg/hour), *Raja miraletus* (0.051 kg/hour), *Dasyatis pastinaca* (0.093 kg/hour), *Scyliorhinus stellaris* (0.022 kg/hour), *Scyliorhinus canicula* (0.051 kg/hour), *Torpedo marmorata* (0.032 kg/hour), *Squalus acanthias*° (0.002 kg/hour) and *Oxynotus centrina*° (0.02 kg/hour) (İşmen *et al.*, 2013).

In the MEDLEM database, about 65 percent of the available records for elasmobranch bycatch come from bottom trawlers in the eastern Mediterranean. This high value is due, however, to a peak in bramble shark (*Echinorhinus brucus*) records (75 individuals) caught incidentally by Egyptian trawlers. The records of priority-conservation species are presented in Table 3.

Black Sea

Among the landings of small species of sharks and rays, the landings of piked dogfish (*Squalus acanthias*°) and thornback ray (*Raja clavata*) have been analysed from six countries bordering the Black Sea (Bulgaria, Georgia, Romania, Russian Federation, Turkey and Ukraine). Indeed, these two species are found in the incidental catch of the trawl fleet targeting turbot, red mullet, anchovy and whiting, among other fishes (STECF, 2017; GFCM, 2018a). Other types of fishing gear, such

FIGURE 2
Piked dogfish (*Squalus acanthias*) landings by Black Sea bottom trawlers (1967–2017)



Source: STECF, 2015; GFCM, 2018a.

as purse seines, longlines and gillnets, contribute to bycatch, but with a lower impact. Catches of *S. acanthias*° in bottom trawls have allowed for a long period of information to be analysed for this species (Figure 2) (STECF, 2015). Since 2016, Turkey has protected the piked dogfish *S. acanthias*° (STECF, 2017; GFCM, 2018a).

Due to the very low presence of *S. acanthias*° in catches in the Black Sea and a strong decrease in its biomass over recent years, the population of *S. acanthias*° is considered depleted in this subregion, and fishing mortality should be reduced by more than 90 percent (GFCM, 2018b).

Yıldız and Karakulak (2017) have estimated the discards of target and non-target species in the Black Sea from bottom trawlers (using a rhombic and 40 mm codend mesh size nets). Onboard sampling was conducted off the southwestern coast of the Black Sea in the Turkish fishing ports of Rumelifeneri and Igneada on a total of 66 hauls conducted by two commercial bottom trawlers from October 2012 to April 2013 and from October 2013 to April 2014. A total of 25 species of fish were identified, and the elasmobranchs included *Dasyatis pastinaca* (7 individuals), *Raja clavata* (157 individuals) and *Squalus acanthias*° (18 individuals).

Along the southern coast of the Black Sea, Bat *et al.* (2018) carried out a study during the fishing periods of 2013–2014 in order to evaluate certain fish agglomerations within 3 nautical miles (i.e. 4.8 km) of the coastal area in the Sinop-Inceburun Region (Turkey). Data were collected from five trawl operations at depths of 20 to 39 m at five different locations. During these surveys, 16 teleost species from 15 families, and two elasmobranch species from two families were recorded: *Raja clavata* (28 individuals) and *Dasyatis pastinaca* (2 individuals).

Among the large elasmobranchs, the MEDLEM database reports the capture of one blackchin guitarfish (*Rhinobatos cemiculus*°) and eight individuals of the bluntnose sixgill shark (*Hexanchus griseus*). Very little information about *H. griseus* is available from the Black Sea and more detailed studies on the biology of this species in this area should be carried out.

Table 3 – Incidental catch of conservation-priority elasmobranch species in bottom trawlers (data from literature 2008–2019)

Bibliographic reference	Reference years	Gear	GFCM subregion	Country	Species	SPA/BD Protocol Annex	Reported individuals in bycatch events	Source of data
Barría *et al.* (2015)	2011–2013	OTB	Western Mediterranean	Spain/France	*Centrophorus granulosus*	III	3	Onboard observations and experimental fishing
Barría *et al.* (2015)	2011–2013	OTB	Western Mediterranean	Spain/France	*Oxynotus centrina*	II	3	Onboard observations and experimental fishing
Barría *et al.* (2015)	2011–2013	OTB	Western Mediterranean	Spain/France	*Squalus acanthias*	III	2	Onboard observations and experimental fishing
Guallart, Morey and Bartolì (2019)	2018	OTB	Western Mediterranean	Spain	*Heptranchias perlo*	III	1	Onboard observations
MEDLEM	2008–2018	OTB	Western Mediterranean	-	*Alopias* spp.	II	3	-
MEDLEM	2008–2018	OTB	Western Mediterranean	-	*Cetorhinus maximus*	II	4	-
MEDLEM	2008–2018	OTB	Western Mediterranean	-	*Galeorhinus galeus*	II	1	-
MEDLEM	2008–2018	OTB	Western Mediterranean	-	*Prionace glauca*	III	5	-
MEDLEM	2008–2018	OTB	Western Mediterranean	-	*Gymnura altavela*	II	8	-
MEDLEM	2008–2018	OTB	Western Mediterranean	-	*Rostroraja alba*	II	2	-
Hamdaoui (2009)	2009	OTB	Central Mediterranean	Tunisia	*Heptranchias perlo*	III	22	Observation at landing sites
Hamdaoui (2009)	2009	OTB	Central Mediterranean	Tunisia	*Galeorhinus galeus*	II	1	Observation at landing sites
Hamdaoui (2009)	2009	OTB	Central Mediterranean	Tunisia	*Mustelus asterias*	III	8	Observation at landing sites
Hamdaoui (2009)	2009	OTB	Central Mediterranean	Tunisia	*Mustelus mustelus*	III	426	Observation at landing sites
Hamdaoui (2009)	2009	OTB	Central Mediterranean	Tunisia	*Mustelus punctulatus*	III	125	Observation at landing sites
Hamdaoui (2009)	2009	OTB	Central Mediterranean	Tunisia	*Carcharhinus plumbeus*	III	58	Observation at landing sites
Hamdaoui (2009)	2009	OTB	Central Mediterranean	Tunisia	*Squatina aculeata*	II	7	Observation at landing sites
Hamdaoui (2009)	2009	OTB	Central Mediterranean	Tunisia	*Squatina oculata*	II	3	Observation at landing sites
Hamdaoui (2009)	2009	OTB	Central Mediterranean	Tunisia	*Squatina squatina*	II	2	Observation at landing sites
Hamdaoui (2009)	2009	OTB	Central Mediterranean	Tunisia	*Carcharodon carcharias*	II	6	Observation at landing sites
Hamdaoui (2009)	2009	OTB	Central Mediterranean	Tunisia	*Gymnura altavela*	II	19	Observation at landing sites
Hamdaoui (2009)	2009	OTB	Central Mediterranean	Tunisia	*Rhinobatos rhinobatos*	II	192	Observation at landing sites
Hamdaoui (2009)	2009	OTB	Central Mediterranean	Tunisia	*Rhinobatos cemiculus*	II	271	Observation at landing sites
El Kamel-Moutalibi *et al.* (2014)	2014	OTB	Central Mediterranean	Tunisia	*Heptranchias perlo*	III	2	Observations at landing sites
MEDLEM	2008–2018	OTB	Central Mediterranean	-	*Carcharodon carcharias*	II	2	-
MEDLEM	2008–2018	OTB	Central Mediterranean	-	*Galeorhinus galeus*	II	1	-
MEDLEM	2008–2018	OTB	Central Mediterranean	-	*Rostroraja alba*	II	2	-
Ćetković (2018)	2016–2018	OTB	Adriatic Sea	Montenegro	*Oxynotus centrina*	II	2	Onboard and landing site observations
Ćetković (2018)	2016–2018	OTB	Adriatic Sea	Montenegro	*Mustelus mustelus*	III	5	Onboard and landing site observations

Table 3 (continued)

Bibliographic reference	Reference years	Gear	GFCM subregion	Country	Species	SPA/BD Protocol Annex	Reported individuals in bycatch events	Source of data
Bargione *et al.* (2019)	2012–2013 2016	OTB	Adriatic Sea	Italy	*Squalus acanthias*	III	326	Onboard and landing site observations
MEDLEM	2009–2018	OTB	Adriatic Sea	-	*Cetorhinus maximus*	II	1	-
MEDLEM	2009–2018	OTB	Adriatic Sea	-	*Prionace glauca*	III	2	
FAO (2018d)	2017	OTB	Adriatic Sea	Croatia	*Mustelus mustelus*	III	11	-
FAO (2018d)	2017	OTB	Adriatic Sea	Croatia	*Mustelus punctulatus*	III	2	-
FAO (2018d)	2017	OTB	Adriatic Sea	Croatia	*Squalus acanthias*	III	1	-
Kabasakal and Bayrı (2019)	2019	OTB	Eastern Mediterranean	Turkey	*Odontaspis ferox*	II	1	Landing observation
Moftah *et al.* (2011)	2008	OTB	Eastern Mediterranean	Egypt	*Mustelus mustelus*	III	8	Observations at landing sites
Moftah *et al.* (2011)	2008	OTB	Eastern Mediterranean	Egypt	*Mustelus punctulatus*	III	6	Observations at landing sites
Moftah *et al.* (2011)	2008	OTB	Eastern Mediterranean	Egypt	*Squalus acanthias*	III	5	Observations at landing sites
Moftah *et al.* (2011)	2008	OTB	Eastern Mediterranean	Egypt	*Squatina squatina*	II	3	Observations at landing sites
Moftah *et al.* (2011)	2008	OTB	Eastern Mediterranean	Egypt	*Oxynotus centrina*	II	1	Observations at landing sites
Bulguroğlu *et al.* (2014)	2013	OTB	Eastern Mediterranean	Turkey	*Squatina squatina*	II	1	Onboard observations
Eronat and Özaydın (2014)	2008–2009	OTB	Eastern Mediterranean	Turkey	*Mustelus mustelus*	III	41	Onboard observations
Eronat and Özaydın (2014)	2008–2009	OTB	Eastern Mediterranean	Turkey	*Mustelus punctulatus*	III	6	Onboard observations
Eronat and Özaydın (2014)	2008–2009	OTB	Eastern Mediterranean	Turkey	*Rostroraja alba*	II	10	Onboard observations
Eronat and Özaydın (2014)	2008–2009	OTB	Eastern Mediterranean	Turkey	*Heptranchias perlo*	III	1	Onboard observations
Eronat and Özaydın (2014)	2008–2009	OTB	Eastern Mediterranean	Turkey	*Galeorhinus galeus*	II	1	Onboard observations
Eronat and Özaydın (2014)	2008–2009	OTB	Eastern Mediterranean	Turkey	*Oxynotus centrina*	II	2	Onboard observations
Eronat and Özaydın (2014)	2008–2009	OTB	Eastern Mediterranean	Turkey	*Dipturus cf. batis*	II	2	Onboard observations
Eronat and Özaydın (2014)	2008–2009	OTB	Eastern Mediterranean	Turkey	*Gymnura altavela*	II	4	Onboard observations
Türker, Zengin and Tünay (2019)	2007-2009	OTB	Eastern Mediterranean	Turkey	*Mustelus mustelus*	III	60	Onboard observations
Türker, Zengin and Tünay (2019)	2007–2009	OTB	Eastern Mediterranean	Turkey	*Carcharodon carcharias*	II	1	Onboard observations
Türker, Zengin and Tünay (2019)	2007–2009	OTB	Eastern Mediterranean	Turkey	*Cetorhinus maximus*	II	1	Onboard observations
Türker, Zengin and Tünay (2019)	2007–2009	OTB	Eastern Mediterranean	Turkey	*Galeorhinus galeus*	II	2	Onboard observations
Türker, Zengin and Tünay (2019)	2007–2009	OTB	Eastern Mediterranean	Turkey	*Gymnura altavela*	II	1	Onboard observations
Türker, Zengin and Tünay (2019)	2007–2009	OTB	Eastern Mediterranean	Turkey	*Rostroraja alba*	II	2	Onboard observations
Türker, Zengin and Tünay (2019)	2007–2009	OTB	Eastern Mediterranean	Turkey	*Squalus acanthias*	III	2	Onboard observations
Başusta (2016)	2015	OTB	Eastern Mediterranean	Turkey	*Squatina aculeata*	II	1	Onboard observations
Başusta (2016)	2015	OTB	Eastern Mediterranean	Turkey	*Heptranchias perlo*	III	2	Onboard observations
Yemisken, Dalyan and Eryilmaz (2014)	2010	OTB	Eastern Mediterranean	Turkey	*Mustelus mustelus*	III	1	Onboard observations

Table 3 (continued)

Bibliographic reference	Reference years	Gear	GFCM subregion	Country	Species	SPA/BD Protocol Annex	Reported individuals in bycatch events	Source of data
Yemisken, Dalyan and Eryilmaz (2014)	2010	OTB	Eastern Mediterranean	Turkey	*Carcharhinus plumbeus*	III	2	Onboard observations
Yemisken, Dalyan and Eryilmaz (2014)	2010	OTB	Eastern Mediterranean	Turkey	*Rhinobatos cemiculus*	II	1	Onboard observations
Yemisken, Dalyan and Eryilmaz (2014)	2010	OTB	Eastern Mediterranean	Turkey	*Gymnura altavela*	II	203	Onboard observations
Özbek, Çardak and Kebapçioğlu (2016)	2009–2010	OTB	Eastern Mediterranean	Turkey	*Gymnura altavela*	II	172	Onboard observations
Gökçe, Saygu and Eryaşar (2016)	2009–2013	OTB	Eastern Mediterranean	Turkey	*Gymnura altavela*	II	26	Onboard observations
Gökçe, Saygu and Eryaşar (2016)	2009–2013	OTB	Eastern Mediterranean	Turkey	*Carcharhinus plumbeus*	III	1	Onboard observations
Gökçe, Saygu and Eryaşar (2016)	2009–2013	OTB	Eastern Mediterranean	Turkey	*Mustelus mustelus*	III	16	Onboard observations
Gökçe, Saygu and Eryaşar (2016)	2009–2013	OTB	Eastern Mediterranean	Turkey	*Rhinobatos rhinobatos*	II	160	Onboard observations
Gökçe, Saygu and Eryaşar (2016)	2009–2013	OTB	Eastern Mediterranean	Turkey	*Oxynotus centrina*	II	1	Onboard observations
Yeldan *et al.* (2013)	2008–2011	OTB	Eastern Mediterranean	Turkey	*Gymnura altavela*	II	56	Onboard observations
Yeldan *et al.* (2013)	2008–2011	OTB	Eastern Mediterranean	Turkey	*Rhinobatos rhinobatos*	II	62	Onboard observations
Ergüden and Bayhan (2015)	2014	OTB	Eastern Mediterranean	Turkey	*Squatina aculeata*	II	1	-
Başusta, Turan and Başusta (2015)	2014	OTB	Eastern Mediterranean	Turkey	*Oxynotus centrina*	II	2	-
Kapiris *et al.* (2014)	2014	OTB	Eastern Mediterranean	Turkey	*Mustelus asterias*	III	1	-
Bilge *et al.* (2014)	2009–2010	OTB	Eastern Mediterranean	Turkey	*Mustelus mustelus*	III	74	Onboard observations
Bilge *et al.* (2014)	2009–2010	OTB	Eastern Mediterranean	Turkey	*Mustelus punctulatus*	III	52	Onboard observations
Ergüden *et al.* (2020)	2014	OTB	Eastern Mediterranean	Turkey	*Cetorhinus maximus*	II	1	Landing observations
Alkusairy and Saad (2018)	2014–2015	OTB	Eastern Mediterranean	Syrian Arab Republic	*Mustelus mustelus*	III	418	Landing observations
MEDLEM	2009–2018	OTB	Eastern Mediterranean	-	*Alopias* spp.	II	1	-
MEDLEM	2009–2018	OTB	Eastern Mediterranean	-	*Carcharodon carcharias*	II	1	-
MEDLEM	2009–2018	OTB	Eastern Mediterranean	-	*Squatina aculeata*	II	4	-
MEDLEM	2009–2018	OTB	Eastern Mediterranean	-	*Rostroraja alba*	II	33	-
FAO (2018d)	2017	OTB	Eastern Mediterranean	Greece	*Mustelus mustelus*	III	3	-
FAO (2018d)	2017	OTB	Eastern Mediterranean	Greece	*Squalus acanthias*	III	9	-
FAO (2019)	2018	OTB	Eastern Mediterranean	Greece	*Squalus acanthias*	III	224	-
FAO (2019)	2018	OTB	Eastern Mediterranean	Greece	*Mustelus mustelus*	III	13	-
FAO (2019)	2018	OTB	Eastern Mediterranean	Greece	*Leucoraja melitensis*	II	1	-
FAO (2019)	2018	OTB	Eastern Mediterranean	Greece	*Centrophorus granulosus*	III	1	-
Yıldız and Karakulak (2017)	2012–2014	OTB	Black Sea	Turkey	*Squalus acanthias*	III	18	Onboard observations
MEDLEM	2009–2018	OTB	Black Sea	-	*Rhinobatos cemiculus*	II	1	-

Note: OTB = bottom otter trawl.

3.3.2 Small-scale fisheries

Fishing with artisanal gear is common throughout the Mediterranean and the Black Sea. Small-scale fisheries account for more than 80 percent of the Mediterranean and Black Sea fleet and probably represent the most complex vessel group, including many types of fishing gear – mostly static nets (e.g. trammel nets and gillnets), traps and longlines (both set and drifting) – and characterized by a variety of fishing grounds, seasons and target species (FAO, 2018c, 2020a). The Mediterranean and Black Sea elasmobranch species are largely coastal and benthic; some inhabit the continental shelf, making them vulnerable to small-scale fishing activities concentrated mainly along the coast (Bradai, Saidi and Enajjar, 2012; Le Direach *et al.*, 2013).

Across the whole Mediterranean, small-scale fishing gear is occasionally used to target sharks (Bradai, Saidi and Enajjar, 2012; Murua *et al.*, eds, 2013). These fisheries operate mainly on the basis of the seasonal abundance of elasmobranch species, meaning that the catch composition by species varies regionally (Ceyhan, Hepkafadar and Tosunoglu 2010; Echwikhi *et al.*, 2013). Furthermore, in some coastal communities, sharks provide a subsistence fishery between more profitable fishing seasons for teleosts, molluscs and crustaceans (Echwikhi *et al.*, 2013). Bradai, Saidi and Enajjar (2012) report limited use of gillnets targeting elasmobranch species such as *Mustelus*°spp. and *Squalus* spp. in the northern Adriatic Sea and *Mustelus*°spp., sandbar sharks (*Carcharhinus plumbeus*°) and *Rhinobatos*° spp. in the Gulf of Gabès. Stingrays and skates were the most captured species in the Balearic Islands, Corsica and the Aegean Sea. However, in general, few studies have been undertaken to assess the impacts of these fisheries on elasmobranchs.

The data reported officially by countries to the GFCM are presented in Table 4 (FAO, 2017, 2018d, 2019).

Data gathered in the MEDLEM database indicate that the elasmobranchs most frequently caught incidentally by small-scale fisheries are demersal species, notably *Mustelus*°spp. and batoids (i.e. rays, skates and their relatives), though occasionally some large pelagic elasmobranchs, such as *Carcharhinus* spp., basking sharks (*Cetorhinus maximus*°), thresher sharks (*Alopias* spp.), spintail devil ray (*Mobula mobular*°) and blue sharks (*Prionace glauca*°) are caught, as well as the great white shark (*Carcharodon carcharias*°).

Table 4 includes information on the incidental catch of conservation-priority shark and batoid species from sources individually reporting the elasmobranchs caught by small-scale fisheries. In this sense, Table 4 provides only an indicative overview, as some of the other studies cited below lack this information.

Western Mediterranean

Along the eastern Spanish coast, off the Valencian Community, Chaumel *et al.* (2018) carried out a survey from January to December 2017 on 63 sets laid by 14 vessels, gathering data through a combination of onboard observations and sampling at three harbours in order to analyse the bycatch in trammel nets. All the species caught were demersal species, totalling 424 batoid specimens belonging to five families: Torpedinidae, Rajidae, Myliobatidae, Dasyatidae and Gymnuridae, with the most common being common torpedo (*Torpedo torpedo*) (108 individuals, 25.5 percent), marbled electric ray (*Torpedo marmorata*) (101 individuals, 25.8 percent), rough ray (*Raja radula*) (67 individuals, 15.8 percent) and common stingray (*Dasyatis pastinaca*) (22 individuals, 5.2 percent).

In another study, conducted off western Corsica (France), a twelve-year seasonal survey (from 2001 to 2012) of the artisanal fishery provided data on the catch and discards of elasmobranchs in gillnets and trammel nets (Le Direach *et al.*, 2013). Among the elasmobranchs, the most frequently discarded species were *Scyliorhinus canicula* and *S. stellaris*, followed by *Dasyatis pastinaca* and *Torpedo* spp. The occurrence of *Myliobatis aquila* and *Squalus blainville* was rare, and these species were mainly encountered in the spring. An unidentified species belonging to the genus *Squatina*° was also observed only on one occasion.

Along the Algerian coast, a one-year (May 2013 to April 2014) investigation monitoring 1 330 fishing trips and 1 613 fishing operations (mainly gillnets and trammel nets) across 16 fishing grounds recorded the following species in bycatch: *Squalus acanthias*° (1 135 tonnes), *Scyliorhinus canicula* (750 tonnes) and *Torpedo* spp. (75 tonnes) (Boubekri *et al.*, 2018).

In the MEDLEM database, 14 percent of the records note small-scale fisheries bycatch in the western Mediterranean Sea. Among these, 45 percent of the records describe four large pelagic shark species, including common thresher shark (*Alopias vulpinus*°) and basking shark (*Cetorhinus maximus*° (Table 4), while bycatch of the common stingray (*Dasyatis pasticata*) alone represents 33 percent of the records.

Central Mediterranean

Along the Tunisian coast in recent years, sandbar sharks (*Carcharhinus plumbeus*°) and blackchin guitarfish (*Rhinobatos cemiculus*°) have become the object of directed artisanal fisheries using a special gillnet (stretched mesh size of 240–340 mm) locally known as a *kallabia*. Sandbar sharks (*Carcharhinus plumbeus*°) are targeted from April through June, and the guitarfishes *Rhinobatos*° spp. throughout the summer months (Echwikhi *et al.*, 2013). The study reported that over 45 fishing trips (conducted from April to June of 2007 and 2008), *R. cemiculus*° (4.6 individuals/km^2 of net per day) and the smooth-hound *Mustelus mustelus*° (2.2 individuals/km^2 of net per day) were the most important species. In comparison, the blackspotted smooth-hound *Mustelus punctulatus*° (0.7 individuals/km^2 of net per day), the common guitarfish *R. rhinobatos*° (0.6 individuals/km^2 of net per day) and the rough ray *Raja radula* (0.6 individuals/km^2 of net per day) presented lower values. Though the size composition of the catch varied by species, mature, mainly gravid, females were usually abundant.

Another study, conducted off the southern Tunisian coast, evaluated the potential impacts of the trammel net fishery on elasmobranchs (Saidi, Enajjar and Bradai, 2016). Data were based on 191 shrimp trammel net sets (40 mm stretched mesh size), conducted throughout May, June and July of 2009, onboard artisanal boats associated with the ports of Sfax, Mahres, Gabés and Zarat and targeting shrimps at depths ranging from 5 to 40 m. Five species of small coastal elasmobranchs, *Mustelus mustelus*° (706 individuals), *Mustelus punctulatus*° (117 individuals), *Dasyatis pastinaca* (54 individuals), *Dasyatis marmorata* (1 individual) and *Torpedo torpedo* (35 individuals), and two large coastal shark species, *Carcharhinus plumbeus*° (11 individuals) and *Carcharhinus brevipinna* (2 individuals), were recorded as bycatch in this fishery. Smooth-hound sharks *Mustelus*° spp. (*Mustelus mustelus*° – 3.7 individuals per trip, 1.2 individuals/1 000 m of net per day – and *M. punctulatus* – 0.6 individual per trip) were by far the most important (88.9 percent of the total elasmobranch catch), reflecting their abundance in the area. For the other species, CPUE varied between 0.2 and 0.003 individual per 1 000 m of net per day. Additionally, about 50 percent of the skates (*Torpedo torpedo* and *Dasyatis pastinaca*) were mature, while there was a high density of

neonates and small juvenile *M. mustelus*° in the Sfax zone, suggesting that these nearshore waters provide nursery grounds for smooth-hound sharks *Mustelus*° spp.

Along the coast of Sicily (central Mediterranean Sea), Tiralongo, Messina and Lombardo (2018) recently evaluated elasmobranch discards in the trammel net fishery targeting the common cuttlefish (*Sepia officinalis*). In 2017, during the peak *S. officinalis* fishing season (February–May), four batoid species (*Raja radula*, *Dasyatis pastinaca*, *Torpedo marmorata* and *Torpedo torpedo*) accounted for the total elasmobranch catch over the 16 survey days. In another study by the same authors, off the southeast coast of Sicily (Ionian Sea), a total of 164 specimens of *T. torpedo* were collected from fishers using trammel nets between March and May 2019 (Tiralongo, Messina and Lombardo, 2020).

The MEDLEM data on small-scale fisheries bycatch in the central Mediterranean represent 72 percent of the archive; these largely describe the demersal species *Mustelus mustelus*° and *M. punctulatus*° (74 percent combined), while the pelagic species include *Prionace glauca*° (7 percent) and *Mobula mobular*° (7 percent) (Table 4).

Adriatic Sea

Few studies report elasmobranch bycatch in small-scale fisheries in this subregion, though captures of large pelagic species are occasionally reported.

In the central Adriatic, in July 2010 and August 2011, two porbeagle sharks (*Lamna nasus*°), a rare species in the Adriatic Sea, were caught by small-scale fishing vessels using gillnets in the area of the Jabuka/Pomo Pit (Scacco *et al.*, 2012). Within the CIESM forum "In Search of Rare Shark Species," Soldo, Briand and Rassoulzadegan (2014) reported the capture of a specimen of bluntnose sixgill shark (*Hexanchus griseus*) in 2009 and two thresher sharks (*Alopias vulpinus*°) in 2012, in Croatian gillnets. More recently, Keramidas *et al.* (2019) reported that in September 2018, an individual of *L. nasus*° was incidentally caught and landed by a small-scale fisher using drifting longlines with sardines as bait. The specimen was captured near Čiovo Island, in the Split Channel, at a depth of 60 m. The total length was approximately 80 cm and the weight around 7 kg. The authors also referred to a specimen of porbeagle shark (*Lamna nasus*°) reported for the first time in Slovenian waters as bycatch in 2016 (Lipej *et al.*, 2016), but no information on the fishing gear was available.

Furthermore, in the Adriatic Sea, Pranovi *et al.* (2016) assessed the role played by artisanal fisheries in providing an important source of employment and income to many coastal communities, as well as a major cultural and traditional identity factor at the regional level. The study analysed a wide range of data collected from 2012 to 2014 in the Veneto region (Italy) from small-scale vessels fishing with trammel nets, gillnets, pots and traps. Among other aspects, the artisanal fleet in question appeared to show very low bycatch and discard rates, while the commercial catch in gillnets and trammel nets included smooth-hounds (*Mustelus mustelus*°).

In a recent study on Montenegrin fisheries, Ćetković (2018) presented data on the composition and abundance of shark bycatch from 2016 to 2018, gathered through observations made onboard and at landing sites, as well as from interviews with fishers. The bycatch of *Prionace glauca*° (7 individuals), *Carcharhinus plumbeus*° (1 individual) and *Mustelus mustelus*° (1 individual) in set gillnets targeting medium-sized pelagic fish such as bonitos (*Sarda sarda*), amberjacks (*Seriola*

dumerili) and false albacores (*Euthynnus alletteratus*) in Montenegro is reported. Such nets are described as being usually much taller than others, often above 7 or 8 m in height. In addition, the study showed that trammel net bycatch included *Scyliorhinus canicula* (5 individuals) and *Hexanchus griseus* (1 individual).

In southern Albania, in 2017, a bigeyed sixgill shark (*Hexanchus nakamurai*) was landed by a professional fishing vessel. The shark (230 cm TL) was accidentally caught in a gillnet set at a depth of 550 m (Save Our Seas, 2018).

MEDLEM data on small-scale fisheries bycatch in the Adriatic Sea represent only 2 percent of the archive; the data include records of the bycatch of ten basking sharks (*Cetorhinus maximus*°).

Eastern Mediterranean

As part of a study undertaken along the Lebanese coast in 2013, 225 specimens of cartilaginous fish (i.e. 11 shark and 14 batoid species), caught by three types of artisanal fishing gear (gillnets, trammel nets and longlines), were collected during experimental fishing, observations at landing sites and onboard observations (Lteif *et al.*, 2015). The majority of the sharks sampled were represented by *Centrophorus granulosus*°, *Galeus melastomus, Squalus blainville, Mustelus mustelus*° and *Carcharhinus obscurus*, while the majority of the batoids consisted of *Rhinobatos rhinobatos*°, *Rhinobatos cemiculus*°, *Torpedo marmorata, Tetronarce nobiliana, Raja miraletus* and *Raja clavata* (Table 4). These cartilaginous fish specimens were caught at depths ranging from 10 to 600 m; the gear responsible for the greatest catch was longlines, followed by trammel nets, while gillnets accounted for the least. 66.7 percent of all individuals were observed at depths less than 150 m, 18.2 percent from 150 to 400 m, and 10.6 percent from 450 to 600 m.

In the same Lebanese study, Lteif *et al.* (2015) also recorded that demersal species, such as *Raja clavata, Raja miraletus, Torpedo marmorata* and *Tetronarce nobiliana*, were principally caught by trammel nets, whereas *Rhinobatos rhinobatos*° and *Rhinobatos cemiculus*° were only caught by longlines, while species such as *Squatina oculata*°, *Squatina aculeata*°, *Mustelus mustelus*° and *Isurus oxyrincus*° were only caught by gillnets (Table 4). Additionally, the batoid species *Rhinobatos rhinobatos*° and *Rhinobatos cemiculus*°, the shark species *Hexanchus griseus* and sharks from the family Carcharhinidae were shown to be of commercial importance in some of the ports (i.e. Tripoli in northern Lebanon, and Sidon in southern Lebanon). In another study off the Lebanese coast, Lteif *et al.* (2016a) reported the capture of 235 elasmobranch specimens from December 2012 to October 2014 by small-scale vessels using long lines, trammel nets and gillnets: *Centrophorus uyato*° (38 individuals), *Squalus blainville* (11 individuals), *Galeus melastomus* (14 individuals), *Rhinobatos rhinobatos*° (70 individuals), *R. cemiculus*° (31 individuals), *Raja clavata* (19 individuals), *Raja miraletus* (30 individuals) and *Torpedo marmorata* (22 individuals).

An investigation from Syrian waters of the Levantine basin indicated that noteworthy elasmobranch incidental catch was occurring there as well. Alkusairy and Saad (2018), in their review of shark bycatch and composition in Syrian fisheries carried out between 2014 and 2016, reported *Carcharhinus plumbeus*° (1 135 individuals) and *Heptranchias perlo*° (267 individuals) as bycatch of "nets-longlines" and "trawls-nets," each of the two groups representing an aggregation of the corresponding types of gear (Table 4). In addition, off Raas Albassit, in northern Syria, Ali *et al.* (2012) reported the capture of a female basking shark (*Cetorhinus maximus*°) in April 2012 in gillnets stretching from the beach 150 m out to sea, at a depth of approximately 10 m. Similarly, according to a report published on a local news website (in May 2013), another 4 m-long *Cetorhinus maximus*°

was caught by an unspecified set net off Famagusta harbour (Cyprus, eastern Mediterranean Sea) (LGC News, 2013).

In Mersin Bay (Turkey), in 2011, a study was carried out to evaluate the effects on discard reduction of rigging prawn trammel nets with a guarding net (Gökçe, Saygu and Eryaşar, 2016). Over a total of 15 fishing trips using both the commercial net and the alternative experimental net, the capture of the common guitarfish (*Rhinobatos rhinobatos*°) (55 individuals) and eagle ray (*Myliobatis aquila*) (3 individuals) were also recorded. Likewise, on the Turkish coast, Kabasakal (2013) recorded the capture of a basking shark (*Cetorhinus maximus*°) measuring 2.3 m TL in a gillnet. Indeed, all basking sharks *C. maximus*° recorded off the Turkish coast, as well as some noted off Syrian and Israeli coasts, have been caught in shallow coastal waters by gillnets. In one case, in the northeast Aegean Sea, an adult male *C. maximus*°, around 10 m TL, was incidentally caught in a set net by local fishers (Kabasakal, 2009).

Additionally, in the northern Aegean Sea in 2008, a new-born great white shark (*Carcharodon carcharias*°), 125.5 cm TL, was captured by a commercial gillnetter (Kabasakal and Özgür Gedikoğlu, 2008). In 2016, a female great white shark *C. carcharias*° became entangled in a coastal stationary net in the Bay of Edremit (northeastern Aegean Sea). The total length of the shark was 175 cm. In 2018, another female *C. carcharias*° was captured by a coastal stationary netter, off the İzmir coast (central Aegean Sea) (Kabasakal, Bayrı and Ataç, 2018). In another study in the Aegean Sea, Akyol and Ceyhan (2012) investigated a traditional pelagic gillnet fishery[7] targeting swordfish based out of the ports of Sivrice and Sığacık, near Izmir, from June 2008 to August 2010. A total of 12 species belonging to nine families were caught. Four vulnerable species, the loggerhead sea turtle (*Caretta caretta*), the pelagic stingray (*Pteroplatytrygon violacea*) (9 individuals), the spintail devil ray (*Mobula mobular*°) (2 individuals) and one sunfish (*Mola mola*), were thrown back into the sea, while the others were retained for their commercial value. Furthermore, Kabasakal and Bilecenoğlu (2014) reported the bycatch of two individuals of the rare bramble shark (*Echinorhinus brucus*) by commercial gillnetters in Turkey: the first was a female of 220 cm TL and 300 kg weight, caught in the Marmara Sea at a depth of 300 m in 2010; the second individual was also a female of 200 cm TL and 140 kg in weight, but it was caught in the Aegean Sea, in 2013. Also in the Aegean Sea, along the coast south of Athens, two basking sharks *Cetorhinus maximus*° (both over 7 m TL and weighing roughly 2 000 kg) were caught incidentally by an unspecified set net in 2009 (Shark Alliance, 2009).

Elsewhere in the Aegean Sea, Kabasakal, Dalyan and Yurtsever (2011) reported the bycatch of two individuals of the rare bigeye thresher shark (*Alopias superciliosus*) in a stationary net set at a depth of nearly 100 m (off the coast of Sivrice in 2006) and in a trammel net (inner mesh 30 mm, outer mesh 120 mm) on a mixed bottom of sand and pebbles at a depth of 110 m (off the coast of Fethiye in 2011). The first was a male of 400 cm TL, while the second was a female of 450 cm TL and weighing 300 kg. In the coastal waters of Edremit Bay (Turkey), Kabasakal (2010) reported that two individuals of blue shark (*Prionace glauca*°) were caught by trammel nets in 2008 and 2009; the individuals were females – one juvenile and one adult – of 98 cm and 3 kg, and 350 cm and 100 kg, respectively. In April 2013, two specimens of the blackchin guitarfish (*Rhinobatos*

7. The Europeant Union, the GFCM and the International Commission for the Conservation of Atlantic Tunas (ICCAT) enforced, in 2005, recommendations prohibiting the use of driftnets in the Mediterranean. In 2006, driftnetting was also banned in Turkey. As a result, pelagic gillnetting tended to decrease. However, the Turkish fisheries authority and ICCAT gave limited permission for traditional pelagic gillnetting in Turkish seas until July 2011, when this fleet stopped its activity (Akyol and Ceyhan 2012).

cemiculus°) were captured by trammel nets (between 60 and 72 mm mesh size) in İzmir Bay at a depth of between 6 and 8 m on a sandy bottom (Akyol and Capapé, 2014).

A recent paper by Ergenler, Turan and Turan (2019) reported the capture of a male specimen of the sawback angelshark (*Squatina aculeata*°) in a trammel net at a depth of 47 m on 19 February 2019, off the coast of Konacık, Iskenderun Bay. The specimen was 117 cm TL and 3.69 kg in total weight. In addition, in the waters off northern Cyprus, Akbora *et al.* (2019) reported the bycatch of a rare smalltooth sand tiger shark (*Odontaspis ferox*°) at a depth of 41 m in a coastal fishery (the fishing gear is not reported in the study) targeting the greater amberjack (*Seriola dumerili*).

In the MEDLEM database, records of elasmobranch bycatch in the eastern Mediterranean by small-scale fisheries account for 12 percent of the total records for this vessel group. Most of the records refer to the angelshark (*Squatina squatina*°) (41 percent) and to the spintail devil ray (*Mobula mobular*°) (17 percent) (Table 4). Other rare elasmobranch species reported in the MEDLEM database are the copper shark (*Carcharhinus brachyurus*) (2 individuals) and dusky shark (*C. obscurus*) (2 individuals).

Black Sea

As for the bottom trawlers, small-scale fisheries in the Black Sea capture piked dogfish (*Squalus acanthias*°) and thornback ray (*Raja clavata*) above all else, and, more rarely, the common stingray (*Dasyatis pastinaca*) as bycatch (GFCM, 2018a; Filiz and Togulga, 2002; Düzgüneş *et al.*, 2006). In Ukrainian and Romanian waters, *S. acanthias*° is caught mainly in the spring and autumn by small-scale fisheries (gillnets and set longlines) (STECF, 2017; GFCM, 2018a). The total landings of *S. acanthias*° in Ukranian small-scale fisheries from 2008 to 2012 were 79.1 tonnes (2008), 46.5 tonnes (2009), 26.6 tonnes (2010), 30.5 tonnes (2011), 8.5 tonnes (2012) (191.2 tonnes in total) (GFCM, 2014b).

Table 4 – Incidental catch of conservation-priority elasmobranch species in small-scale fisheries (data from literature 2008–2019)

Bibliographic reference	Reference years	Gear	GFCM subregion	Country	Species	SPA/BD Protocol Annex	Reported individuals in bycatch events	Source of data
MEDLEM	2008–2019	Set net	Western Mediterranean	-	*Alopias vulpinus*	III	26	-
MEDLEM	2008–2019	Set net	Western Mediterranean	-	*Alopias superciliosus*[1]	III	1	-
MEDLEM	2008–2019	Set net	Western Mediterranean	-	*Carcharhinus plumbeus*	III	2	-
MEDLEM	2008–2019	Set net	Western Mediterranean	-	*Carcharodon carcharias*	II	3	-
MEDLEM	2008–2019	Set net	Western Mediterranean	-	*Cetorhinus maximus*	II	25	-
MEDLEM	2008–2019	Set net	Western Mediterranean	-	*Galeorhinus galeus*	II	3	-
MEDLEM	2008–2019	Set net	Western Mediterranean	-	*Isurus oxyrinchus*	II	18	-
MEDLEM	2008–2019	Set net	Western Mediterranean	-	*Lamna nasus*	II	3	-
MEDLEM	2008–2019	Set net	Western Mediterranean	-	*Odontaspis ferox*	II	1	-
MEDLEM	2008–2019	Set net	Western Mediterranean	-	*Prionace glauca*	III	25	-
MEDLEM	2008–2019	Set net	Western Mediterranean	-	*Sphyrna zygaena*	II	2	-

Table 4 (continued)

Bibliographic reference	Reference years	Gear	GFCM subregion	Country	Species	SPA/BD Protocol Annex	Reported individuals in bycatch events	Source of data
MEDLEM	2008–2019	Set net	Western Mediterranean	-	*Gymnura altavela*	II	3	-
MEDLEM	2008–2019	Set net	Western Mediterranean	-	*Mobula mobular*	II	18	-
MEDLEM	2008–2019	Set net	Western Mediterranean	-	*Rostroraja alba*	II	2	-
FAO (2019)	2018	GTR	Western Mediterranean	France	*Squalus acanthias*	III	1	-
FAO (2019)	2018	GNS	Western Mediterranean	France	*Squatina squatina*	II	1	-
FAO (2019)	2018	GTR	Western Mediterranean	France	*Squatina squatina*	II	5	-
Echwikhi *et al.* (2013)	2007–2008	GNS	Central Mediterranean	Tunisia	*Rhinobatos cemiculus*	II	313	-
Echwikhi *et al.* (2013)	2007–2008	GNS	Central Mediterranean	Tunisia	*Rhinobatos rhinobatos*	II	41	-
Echwikhi *et al.* (2013)	2007–2008	GNS	Central Mediterranean	Tunisia	*Mustelus mustelus*	III	151	-
Echwikhi *et al.* (2013)	2007–2008	GNS	Central Mediterranean	Tunisia	*Mustelus punctulatus*	III	48	-
Echwikhi *et al.* (2013)	2007–2008	GNS	Central Mediterranean	Tunisia	*Carcharhinus plumbeus*	III	27	-
Saidi, Enajjar and Bradai (2016)	2009	GTR	Central Mediterranean	Tunisia	*Mustelus mustelus*	III	706	Onboard observations
Saidi, Enajjar and Bradai (2016)	2009	GTR	Central Mediterranean	Tunisia	*Mustelus punctulatus*	III	117	Onboard observations
Saidi, Enajjar and Bradai (2016)	2009	GTR	Central Mediterranean	Tunisia	*Carcharhinus plumbeus*	III	11	Onboard observations
FAO (2019)	2019	Set net	Central Mediterranean	Tunisia	*Alopias vulpinus*	III	2	-
FAO (2018d)	2017	GTR	Central Mediterranean	Tunisia	*Carcharodon carcharias*	II	1	-
FAO (2019)	2019	GNS	Central Mediterranean	Tunisia	*Cetorhinus maximus*	II	1	-
FAO (2019)	2019	Set net	Central Mediterranean	Tunisia	*Isurus oxyrinchus*	II	1	-
FAO (2019)	2019	GNS	Central Mediterranean	Tunisia	*Mustelus mustelus*	III	11	-
FAO (2019)	2019	GNS	Central Mediterranean	Tunisia	*Rhinobatos rhinobatos*	II	2	-
FAO (2019)	2019	Set net	Central Mediterranean	Tunisia	*Mustelus mustelus*	III	1	-
MEDLEM	2008–2019	Set net	Central Mediterranean	-	*Alopias vulpinus*	III	4	-
MEDLEM	2008–2019	Set net	Central Mediterranean	-	*Alopias superciliosus*[1]	III	2	-
MEDLEM	2008–2019	Set net	Central Mediterranean	-	*Carcharhinus plumbeus*	III	18	-
MEDLEM	2008–2019	Set net	Central Mediterranean	-	*Carcharodon carcharias*	II	2	-
MEDLEM	2008–2019	Set net	Central Mediterranean	-	*Cetorhinus maximus*	II	7	-
MEDLEM	2008–2019	Set net	Central Mediterranean	-	*Isurus oxyrinchus*	II	5	-
MEDLEM	2008–2019	Set net	Central Mediterranean	-	*Mustelus mustelus*	III	706	-
MEDLEM	2008–2019	Set net	Central Mediterranean	-	*Mustelus punctulatus*	III	117	-

Table 4 (continued)

Bibliographic reference	Reference years	Gear	GFCM subregion	Country	Species	SPA/BD Protocol Annex	Reported individuals in bycatch events	Source of data
MEDLEM	2008–2019	Set net	Central Mediterranean	-	*Prionace glauca*	III	81	-
MEDLEM	2008–2019	Set net	Central Mediterranean	-	*Squatina aculeata*	II	1	-
MEDLEM	2008–2019	Set net	Central Mediterranean	-	*Squatina squatina*	II	2	-
MEDLEM	2008–2019	Set net	Central Mediterranean	-	*Mobula mobular*	II	73	-
Scacco *et al.* (2012)	2010–2011	GNS	Adriatic Sea	Italy	*Lamna nasus*	II	2	Onboard observations
Soldo, Briand and Rassoulzadegan (2014)	2012	GNS	Adriatic Sea	Croatia	*Alopias vulpinus*	III	2	-
Keramidas *et al.* (2019)	2018	LL	Adriatic Sea	Croatia	*Lamna nasus*	II	1	Interviews with fishers
Ćetković (2018)	2016–2018	GNS	Adriatic Sea	Montenegro	*Prionace glauca*	III	7	Onboard observations, observations at landing sites, interviews with fishers
Ćetković (2018)	2016–2018	GNS	Adriatic Sea	Montenegro	*Carcharhinus plumbeus*	III	1	Onboard observations, observations at landing sites, interviews with fishers
Ćetković (2018)	2016–2018	GNS	Adriatic Sea	Montenegro	*Mustelus mustelus*	III	1	Onboard observations, observations at landing sites, interviews with fishers
MEDLEM	2008–2019	Set net	Adriatic Sea	-	*Alopias vulpinus*	III	5	-
MEDLEM	2008–2019	Set net	Adriatic Sea	-	*Alopias superciliosus*[1]	III	1	-
MEDLEM	2008–2019	Set net	Adriatic Sea	-	*Carcharhinus plumbeus*	III	2	-
MEDLEM	2008–2019	Set net	Adriatic Sea	-	*Cetorhinus maximus*	III	10	-
MEDLEM	2008–2019	Set net	Adriatic Sea	-	*Isurus oxyrinchus*	II	1	-
MEDLEM	2008–2019	Set net	Adriatic Sea	-	*Lamna nasus*	II	1	-
MEDLEM	2008–2019	Set net	Adriatic Sea	-	*Prionace glauca*	III	1	-
MEDLEM	2008–2019	Set net	Adriatic Sea	-	*Mobula mobular*	II	1	-
Ali *et al.* (2012)	2012	GNS	Eastern Mediterranean	Syria	*Cetorhinus maximus*	III	1	Survey at sea
LGC News (2013)	2013	Set net	Eastern Mediterranean	Cyprus	Cetorhinus maximus	II	1	-
Akbora *et al.* (2019)	2018	-	Eastern Mediterranean	Cyprus	Odontaspis ferox	II	1	Landing observation
Lteif *et al.* (2015)	2013	LL	Eastern Mediterranean	Lebanon	*Centrophorus granulosus*	III	18	Experimental fishing, observations at landing sites, and onboard observations
Lteif *et al.* (2015)	2013	GTR	Eastern Mediterranean	Lebanon	*Centrophorus granulosus*	III	12	Experimental fishing, observations at landing sites, and onboard observations
Lteif *et al.* (2015)	2013	GTR	Eastern Mediterranean	Lebanon	*Heptranchias perlo*	III	3	Experimental fishing, observations at landing sites, and onboard observations

Table 4 (continued)

Bibliographic reference	Reference years	Gear	GFCM subregion	Country	Species	SPA/BD Protocol Annex	Reported individuals in bycatch events	Source of data
Lteif *et al.* (2015)	2013	LL	Eastern Mediterranean	Lebanon	*Heptranchias perlo*	III	1	Experimental fishing, observations at landing sites, and onboard observations
Lteif *et al.* (2015)	2013	GNS	Eastern Mediterranean	Lebanon	*Heptranchias perlo*	III	1	Experimental fishing, observations at landing sites, and onboard observations
Lteif *et al.* (2015)	2013	GNS	Eastern Mediterranean	Lebanon	*Isurus oxyrinchus*	II	1	Experimental fishing, observations at landing sites, and onboard observations
Lteif *et al.* (2015)	2013	GNS	Eastern Mediterranean	Lebanon	*Mustelus mustelus*	III	1	Experimental fishing, observations at landing sites, and onboard observations
Lteif *et al.* (2015)	2013	LL	Eastern Mediterranean	Lebanon	*Rhinobatos cemiculus*	II	21	Experimental fishing, observations at landing sites, and onboard observations
Lteif *et al.* (2015)	2013	LL	Eastern Mediterranean	Lebanon	*Rhinobatos rhinobatos*	II	43	Experimental fishing, observations at landing sites, and onboard observations
Lteif *et al.* (2015)	2013	GNS	Eastern Mediterranean	Lebanon	*Squatina aculeata*	II	1	Experimental fishing, observations at landing sites, and onboard observations
Lteif *et al.* (2015)	2013	GNS	Eastern Mediterranean	Lebanon	*Squatina oculata*	II	1	Experimental fishing, observations at landing sites, and onboard observations
Lteif *et al.* (2016a)	2012–2014	Set nets/ LL	Eastern Mediterranean	Lebanon	*Rhinobatos cemiculus*	II	31	Observations at landing sites
Lteif *et al.* (2016b)	2012–2014	Set nets/ LL	Eastern Mediterranean	Lebanon	*Rhinobatos rhinobatos*	II	70	Observations at landing sites
Akyol and Capapè (2014)	2013	GTR	Eastern Mediterranean	Turkey	Rhinobatos cemiculus	II	2	Observations at landing sites
Alkusairy and Saad (2018)	2014–2016	OTB/Set nets	Eastern Mediterranean	Syrian Arab Republic	*Heptranchias perlo*	III	267	Observations at landing sites
Alkusairy and Saad (2018)	2014–2016	Set nets/ LL	Eastern Mediterranean	Syrian Arab Republic	*Carcharhinus plumbeus*	III	1 135	Observations at landing sites
Akyol and Ceyhan (2012)	2008–2010	Pelagic gillnet	Eastern Mediterranean	Turkey	*Mobula mobular*	II	2	Onboard observations
Kabasakal, Dalyan and Yurtsever (2011)	2011	GTR	Eastern Mediterranean	Turkey	*Alopias superciliosus*[1]	-	2	-
Kabasakal (2009)	2009	Set net	Eastern Mediterranean	Turkey	*Cetorhinus maximus*	II	1	Landing observation
Kabasakal (2010)	2008–2009	GTR	Eastern Mediterranean	Turkey	*Prionace glauca*	III	2	Landing observations
Kabasakal (2013)	2012	GNS	Eastern Mediterranean	Turkey	*Cetorhinus maximus*	II	1	Landing observation
Shark Alliance (2009)	2009	-	Eastern Mediterranean	Greece	*Cetorhinus maximus*	II	2	Landing observations
Kabasakal and Özgür Gedikoğlu (2008)	2008	GNS	Eastern Mediterranean	Turkey	*Carcharodon carcharias*	II	1	Landing observation
Gökçe *et al.* (2016)	2011	GTR	Eastern Mediterranean	Turkey	*Rhinobatos rhinobatos*	II	55	Catch observation
Kabasakal, Bayrı and Ataç (2018)	2016	Set net	Eastern Mediterranean	Turkey	*Carcharodon carcharias*	II	1	Landing observation

Table 4 (continued)

Bibliographic reference	Reference years	Gear	GFCM subregion	Country	Species	SPA/BD Protocol Annex	Reported individuals in bycatch events	Source of data
Kabasakal, Bayrı and Ataç (2018)	2018	Set net	Eastern Mediterranean	Turkey	*Carcharodon carcharias*	II	1	Landing observation
Ergenler, Turan and Turan (2019)	2019	GTR	Eastern Mediterranean	Turkey	*Squatina aculeata*	II	1	-
FAO (2018d)	2017	GTR	Eastern Mediterranean	Greece	*Centrophorus granulosus*	III	13	-
FAO (2017)	2016	Set net	Eastern Mediterranean	Cyprus	*Galeorhinus galeus*	II	1	-
FAO (2018d)	2017	GTR	Eastern Mediterranean	Greece	*Mustelus mustelus*	III	1	-
FAO (2018d)	2017	GTR	Eastern Mediterranean	Cyprus	*Isurus oxyrinchus*	II	1	-
FAO (2019)	2018	GTR	Eastern Mediterranean	Greece	*Mustelus mustelus*	III	2	-
FAO (2018d)	2017	Set net	Eastern Mediterranean	Cyprus	*Rhinobatos rhinobatos*	II	1	-
FAO (2018d)	2017	GTR	Eastern Mediterranean	Greece	*Squalus acanthias*	III	40	-
MEDLEM	2008–2019	Set net	Eastern Mediterranean	-	*Alopias vulpinus*	III	9	-
MEDLEM	2008–2019	Set net	Eastern Mediterranean	-	*Alopias superciliosus*[1]	-	6	-
MEDLEM	2008–2019	Set net	Eastern Mediterranean	-	*Carcharhinus plumbeus*	III	25	-
MEDLEM	2008–2019	Set net	Eastern Mediterranean	-	*Carcharodon carcharias*	II	6	-
MEDLEM	2008–2019	Set net	Eastern Mediterranean	-	*Cetorhinus maximus*	II	11	-
MEDLEM	2008–2019	Set net	Eastern Mediterranean	-	*Isurus oxyrinchus*	II	8	-
MEDLEM	2008–2019	Set net	Eastern Mediterranean	-	*Odontaspis ferox*	II	1	-
MEDLEM	2008–2019	Set net	Eastern Mediterranean	-	*Prionace glauca*	III	2	-
MEDLEM	2008–2019	Set net	Eastern Mediterranean	-	*Squatina aculeata*	II	1	-
MEDLEM	2008–2019	Set net	Eastern Mediterranean	-	*Squatina squatina*	II	79	-
MEDLEM	2008–2019	Set net	Eastern Mediterranean	-	*Mobula mobular*	II	34	-

Notes:

GNS = set gillnet; GTR = trammel net; LL = longline.

1. *Alopias superciliosus* is not listed in Annex II or III of SPA/DB Protocol, but due to its morphological similarity to *A. vulpinus*°, bycatch events reported for this species were included in the table.

3.3.3 Purse seiners

Interactions between elasmobranchs and purse seiners appear to be limited, compared to other types of fishing gear, across the entire Mediterranean and Black Sea region. Purse seines are usually used to target schools of small (anchovies and sardines) and large pelagic fish (tuna and tuna-like species). However, during the detection of schools of fish and encircling operations, non-target species, mainly large predators (e.g. sharks and dolphins) may be attracted by high fish density and retained within the net (Bonanomi *et al.*, 2017).

The data reported officially by countries to the GFCM are presented in Table 5 (FAO, 2018d, 2019).

Table 5 includes information on the incidental catch of conservation-priority shark and batoid species from sources individually reporting the elasmobranchs caught by purse seiners.

Western Mediterranean

The MEDLEM database on purse seine bycatch in the western Mediterranean report two individuals of thresher shark (*Alopias vulpinus*°).

Central Mediterranean

In the central Mediterranean, the only recent data available regard the Tunisian coast, where purse seiner bycatch, from 2017 and 2019, records *Mobula mobular*° (10 individuals), *Carcharodon carcharias*° (2 individuals) and *Alopias vulpinus*° (3 individuals) (FAO, 2018d, 2019).

Adriatic Sea

Soldo, Briand and Rassoulzadegan (2014) reported the capture of a thresher shark (*Alopias vulpinus*°) (250 cm, 75 kg) in 2011 and a bluntnose sixgill shark (*Hexanchus griseus*) (4.5 m, 500 kg) in 2013 by Croatian purse seiners.

Eastern Mediterranean

There are reports of a fishery targeting spintail devil ray (*Mobula mobular*°) in specific locations of this subregion, where this species is opportunistically fished by local *shanshula* (purse seines) (Abudaya *et al*., 2017). Boats ranging from 4.5 to 21 m in length, operate over a very short seasonal window to supplement the tuna fisheries. A total of 304 *M. mobular*° (over 90 percent males) were landed and recorded from 2014 to 2016, most of which were mature and appeared to be reproductively active (i.e. over 90 percent of the males had sperm-filled claspers). In 2013, the highest number of specimens landed (370) was recorded. The evidence suggests that this fishing activity probably occurs during the reproductive period of the species and points to the importance of the Levantine basin as a mating ground for *M. mobular*°, thus providing critical insights for management and conservation. According to Abudaya *et al.* (2017), the meat from *M. mobular*° is exclusively sold at local markets for consumption. It was also reported that all fishers interviewed in Gaza were unaware of the "Endangered" status of *M. mobular*° and the Mediterranean-wide protection of this species.

Kabasakal, Dalyan and Yurtsever (2011) reported the bycatch of a bigeye thresher shark (*Alopias superciliosus*°), a female of 250 cm TL weighing 65 kg, by a commercial purse seine on 2 July 2011, off the coast of Silivri in the northern Marmara Sea. Ergüden, Gurlek and Turan (2013) also reported the bycatch of a young shortfin mako shark (*Isurus oxyrinchus*°) in a purse seine from Iskenderun Bay, Turkey, in 2010. Likewise, a young male specimen of *I. oxyrinchus*°, 69.8 cm TL and 2.2 kg total weight, was caught by a purse seine boat in March 2010, at a depth of 54 m off the coast of Samandag, south of Iskenderun Bay (Bilecenoğlu *et al.*, 2013). In 2014, a single male thresher (*Alopias vulpinus*°), measuring 392 cm TL and weighing about 180 kg, was incidentally captured by a purse seiner operating in Iskenderun Bay (Ergüden, Gurlek and Turan, 2015). In the same year, an individual of bluntnose sixgill shark (*Hexanchus griseus*) was captured as bycatch in a commercial purse seine fishery at a depth of 60 to 70 m in Iskenderun Bay (Başusta and Başusta, 2015). Furthermore, a total of 94 bull rays (*Aetomylaeus bovinus*) (approximately 50 percent females and 50 percent males, ranging from 29.5 to 129.2 cm disc width and weighing 0.27 to

33.6 kg), were collected as bycatch by commercial fishers using trawls and purse seines between September 2010 and December 2012, in Mersin and Iskenderun Bays (Başusta and Aslan, 2018).

More recently, Kabasakal, Bayrı and Ataç (2018) reported a male great white shark (*Carcharodon carcharias*°) measuring 200 cm TL and weighing 60 kg, captured by a commercial purse-seiner off the Didim coast (central Aegean Sea) in June, 2017.

The MEDLEM database on purse seine bycatch in the eastern Mediterranean reports four records: one individual of *Alopias vulpinus*°, one of *Carcharodon carcharias*°, one of *Isurus oxyrinchus*° and one of the rare smooth hammerhead (*Sphyrna zygaena*°).

Black Sea

Purse seiners operating in the Black Sea target mainly anchovy (*Engraulis encrasicolus*), sprat (*Sprattus sprattus*), horse mackerel (*Trachurus* spp.) and bonito (*Sarda sarda*). Between 2009 and 2010, a discard monitoring programme (Şahin, Ceylan and Kalaycı 2015), carried out monthly onboard commercial purse seiners operating along the southeastern coast of the Black Sea in Turkey, recorded the presence of *Squalus acanthias*°, *Dasyatis pastinaca* and *Raja clavata* in the catch composition, though these represented only 0.0003, 0.003 and 0.009 percent of the catch, respectively. All the elasmobranch bycatch was discarded at sea.

The MEDLEM database on purse seine bycatch in the Black Sea includes records of two individuals of *Alopias vulpinus*°, one of *A. superciliosus*, two *Hexanchus griseus*, and one of *Gymnura altavela*°.

Table 5 – Incidental catch of conservation-priority elasmobranch species in purse seiners (data from literature 2008–2019)

Bibliographic reference	Reference years	Gear	GFCM subregion	Country	Species	SPA/BD Protocol Annex	Reported individuals in bycatch events	Source of data
MEDLEM	2008–2019	PS	Western Mediterranean	-	*Alopias vulpinus*	III	2	-
FAO (2018d)	2017	PS	Central Mediterranean	Tunisia	*Carcharodon carcharias*	II	1	-
FAO (2019)	2019	PS	Central Mediterranean	Tunisia	*Mobula molar*	II	10	-
FAO (2019)	2019	PS	Central Mediterranean	Tunisia	*Carcharodon carcharias*	II	1	-
FAO (2019)	2019	PS	Central Mediterranean	Tunisia	*Alopias vulpinus*	III	3	-
Soldo, Briand and Rassoulzadegan (2014)	2011	PS	Adriatic Sea	Croatia	*Alopias vulpinus*	III	1	-
Abudaya *et al.* (2017)	2009	PS	Eastern Mediterranean	Palestine Territories	*Mobula mobular*	II	7	Landing survey and interviews with fishers
Abudaya *et al.* (2017)	2013	PS	Eastern Mediterranean	Palestine Territories	*Mobula mobular*	II	370	Landing survey and interviews with fishers
Abudaya *et al.* (2017)	2014	PS	Eastern Mediterranean	Palestine Territories	*Mobula mobular*	II	30	Landing survey and interviews with fishers
Abudaya *et al.* (2017)	2015	PS	Eastern Mediterranean	Palestine Territories	*Mobula mobular*	II	85	Landing survey and interviews with fishers
Abudaya *et al.* (2017)	2016	PS	Eastern Mediterranean	Palestine Territories	*Mobula mobular*	II	160	Landing survey and interviews with fishers
Kabasakal, Dalyan and Yurtsever (2011)	2011	PS	Eastern Mediterranean	Turkey	*Alopias superciliosus*[1]	III	1	-
Bilecenoğlu *et al.* (2013)	2010	PS	Eastern Mediterranean	Turkey	*Isurus oxyrinchus*	II	1	Catch data

Table 5 (continued)

Bibliographic reference	Reference years	Gear	GFCM subregion	Country	Species	SPA/BD Protocol Annex	Reported individuals in bycatch events	Source of data
Ergüden, Gurlek and Turan (2013)	2010	PS	Eastern Mediterranean	Turkey	*Isurus oxyrinchus*	II	1	-
Ergüden, Gurlek and Turan (2015)	2014	PS	Eastern Mediterranean	Turkey	*Alopias vulpinus*	III	1	Catch data
Kabasakal, Bayrı and Ataç (2018)	2017	PS	Eastern Mediterranean	Turkey	*Carcharodon carcharias*	III	1	Landing observation
MEDLEM	2008–2019	PS	Eastern Mediterranean	-	*Alopias vulpinus*	III	1	-
MEDLEM	2008–2019	PS	Eastern Mediterranean	-	*Carcharodon carcharias*	II	1	-
MEDLEM	2008–2019	PS	Eastern Mediterranean	-	*Isurus oxyrinchus*	II	1	-
MEDLEM	2008–2019	PS	Eastern Mediterranean	-	*Sphyrna zygaena*	II	1	-
MEDLEM	2008–2019	PS	Black Sea	-	*Alopias vulpinus*	III	2	-
MEDLEM	2008–2019	PS	Black Sea	-	*Alopias superciliosus*[1]	III	1	-
MEDLEM	2008–2019	PS	Black Sea	-	*Gymnura altavela*	II	1	-

Notes: PS = purse seine.

1. *Alopias superciliosus* is not listed in Annex II or III of SPA/DB Protocol, but due to its morphological similarity to *A. vulpinus*°, bycatch events reported for this species were included in the table.

3.3.4 Longliners

Generally, two types of longlines are used in the Mediterranean Sea: drifting longlines (sometimes also called surface or pelagic longlines), used in the water column at variable depths, and set longlines (sometimes also called bottom or demersal longlines), deployed on the sea bottom.

Drifting longliners in the Mediterranean and the Black Sea target, according to hook size and immersion depth, swordfish (*Xiphias gladius*), albacore (*Thunnus alalunga*) and bluefin tuna (*Thunnus thynnus*), and can incidentally capture different species of pelagic sharks (e.g. *Prionace glauca*°, *Isurus oxyrinchus*°, *Alopias vulpinus*°, *Galeorhinus galeus*°, *Lamna nasus*°, *Alopias superciliosus*, *Sphyrna zygaena*°, *Hexanchus griseus*, *Carcharhinus plumbeus*° and *Cetorhinus maximus*°). These species often end up representing relevant fractions of the total caught biomass; the importance of sharks in terms of catch composition varies according to the type of longline and the area (Gabr and El-Haweet, 2012; Ceyhan and Akyol, 2014; Bradai, Saidi and Enajjar, 2012; Echwikhi, Saidi and Bradai, 2014; Soldo, Briand and Rassoulzadegan, 2014; Murua *et al.*, eds, 2013). However, in all areas studied, the blue shark (*P. glauca*°) seems to be the species most represented in the catch, followed by the shortfin mako (*I. oxyrinchus*°) (Bradai, Saidi and Enajjar, 2012, 2018; Murua *et al.*, eds, 2013).

The bycatch of set longliners, targeting mainly demersal fish species (*Dentex dentex*, *Epinephelus* spp., *Pagellus* spp., *Merluccius merluccius*, etc.), consists mainly of batoids and demersal elasmobranch species (*Squalus blainville*, *Mustelus*° spp. *Carcharhinus plumbeus*°, *Torpedo* spp., *Raja radula*, *R. clavata and R. miraletus*, as well as guitarfish of the genus *Rhinobatos*°) (Bradai, Saidi and Enajjar, 2012, 2018; Bradai *et al.*, 2016).

The data reported officially by countries to the GFCM are presented in Table 6 (FAO, 2017, 2018d, 2019)

PLATE 3
A great white shark with a longline hook in its mouth

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Table 6 includes information on the incidental catch of conservation-priority shark and batoid species from sources individually reporting the elasmobranchs caught by longliners. As such, Table 6 provides only an indicative overview, as some of the other studies cited below lack this information.

Western Mediterranean

Biton-Porsmoguer and Lloret (2018) carried out a study between 2012 and 2016 on the Spanish longline fleets operating in certain areas of the Spanish Mediterranean (e.g. Andalusia, the Balearic Islands, Valencia, Murcia and Catalonia) and reported an increasing fishing impact on blue sharks (*Prionace glauca*°). During this period, the landings of *Prionace glauca*° in the Spanish Mediterranean ports totalled, on average, more than 58 tonnes per year. Meanwhile, the size of the fishing fleet involved in the Spanish Mediterranean remained stable over the investigated period (74 boats in 2012 and 73 in 2016).

Previously, Báez *et al.* (2016) reported that the bycatch of elasmobranchs from the Spanish drifting longline fleet consisted almost entirely of the pelagic stingray (*Pteroplatytrygon violacea*). Between 2000 and 2013, 3 007 longline fishing operations were monitored and 57 574 individuals of pelagic stingray recorded as bycatch. Two gear types were involved in 96 percent of the pelagic stingray bycatch observed: traditional surface longlines targeting swordfish and surface drifting longlines targeting albacore. The authors noted that despite these high bycatch numbers and the fact that the species largely dominates the drifting longline bycatch in several areas, *P. violacea* is not considered an endangered species ("Least Concern" in the IUCN Red List).

De Loyola Fernández *et al.* (2017) reported captures of the rare kitefin shark (*Dalatias licha*) (49 individuals) and the little sleeper shark (*Somniosus rostratus*) (24 individuals) over a four-year period from 2009 to 2013 in the bycatch of the commercial drifting longline fishery targeting tuna and swordfish in the Spanish Mediterranean Sea. Lanteri, Castellano and Garibaldi (2017) also reported the bycatch of a female bigeye thresher shark (*Alopias superciliosus*) in the northwestern Mediterranean Sea (Ligurian Sea, Italy) by the mesopelagic swordfish longline fishery. However, only the head was recovered, probably due to predatory/scavenging activity of other shark species. The importance of this record owes to the rarity of the species in the Mediterranean Sea and, more specifically, in Italian waters.

The MEDLEM archive does not provide specifications on type of longline (set vs drifting). However, in the western Mediterranean, the blue shark (*P. glauca*°) and the shortfin mako (*I. oxyrinchus*°) are the most reported bycatch species in longlines, accounting for 42 and 27 percent of the records, respectively. Other conservation-priority species reported in the MEDLEM database were *Alopias vulpinus*° (7 individuals), *Carcharhinus plumbeus*° (1 individual), *Carcharodon carcharias*° (1 individual) and *Gymnura altavela*° (4 individuals). Regarding non-conservation-priority species, the MEDLEM database also reports the bycatch of a *Carcharhinus obscurus* and four individuals of *Hexanchus griseus*.

Central Mediterranean

Longline fisheries targeting sharks are reported from Tunisia and Libya. Declines in swordfish catch in the area have led drifting longliners to shift towards targeting elasmobranchs, particularly the sandbar shark (*Carcharhinus plumbeus*°) (Bradai, Saidi and Enajjar, 2012, 2018; Echwikhi, Saidi and Bradai, 2014; Bradai *et al.*, 2016).

Along the Tunisian coast, *C. plumbeus*° is fished by commercial longliners from July to October. During 2007–2008, 48 sets of commercial drifting longlines (corresponding to 35 950 hooks deployed) were observed (Echwikhi, Saidi and Bradai, 2014; Bradai, Saidi and Enajjar, 2018). A total of 581 elasmobranchs were caught. The sandbar shark *C. plumbeus*° (around 15.2 individuals per1 000 hooks), was the species most represented in the bycatch, accounting for 94.2 percent of the number of elasmobranchs catch. The spinner shark *Carcharhinus brevipinna* (3.8 percent) and the pelagic ray *Pteroplatytrygon violacea* (2.1 percent) comprised minor components of the drifting longliner catch (Echwikhi, Saidi and Bradai, 2014) (Table 6).

In the same study, the bycatch composition of the set longlines was also analysed, with a total of 392 elasmobranch specimens recorded over 38 bottom longline sets (48 020 hooks deployed). Among the catch of elasmobranch species, the blackchin guitarfish (*Rhinobatos cemiculus*°) was the most abundant (31.4 percent), followed by *C. plumbeus*° (21.2 percent), the smooth-hound (*Mustelus mustelus*°) (15.8 percent) and the blackspotted smooth-hound (*M. punctulatus*°), at 13.5 percent (Echwikhi, Saidi and Bradai, 2014) (Table 6). *Rhinobatos rhinobatos*° (11.2 percent), *Raja radula* (4.1 percent) and *Carcharhinus brevipinna* (2.1 percent) represented minor components of the elasmobranch catch composition.

A new survey of set and drifting longline fisheries targeting groupers and swordfish was carried out in the Gulf of Gabès in 2016 and 2017 in order to evaluate the elasmobranch catch of two consecutive fishing seasons (July–September of 2016 and 2017) (Bradai *et al.*, 2016; Enajjar *et al.*, 2018). In the set longline fishery, the elasmobranchs represented about 50 percent of the total catch (batoids – 25.6 percent; sharks – 24.5 percent) (Bradai *et al.*, 2016; Enajjar *et al.*, 2018). Among the batoids, *Rhinobatos cemiculus*° (0.84 individuals/1 000 *h*ooks) was the species caught most frequently. The other species in this group consisted of *Dasyatis* spp. (0.39 individual/1 000 hooks), round fantail stingray (*Taeniurops grabatus*) (0.2 individual/1 000hooks) *Aetomylaeus bovinus* (0.13 *individual*/1 000 hooks), *Raja radula* (0.03 individual/1 000 hooks), *R. clavata* (0.31 *individual*/1 000 hooks), *R. miraletus* (0.01 *individual*/1 000 *hooks*), *Gymnura altavela*° (0.03 individual/1 000 hooks). Sharks were also represented by a variety of species, *Carcharhinus plumbeus*° (0.43 individual/1 000 hooks), *C. brevipinna* (0.02 individual/1 000 hooks), *Squalus megalops* (0.72 individual/1 000 hooks), *Heptranchias perlo*° (0.11 individual/1 000 hooks), *Mustelus punctulatus*° (0.08 individual/1 000 hooks), *Scyliorhinus canicula* (0.05 individual/1 000 hooks) and *Carcharodon carcharias*° (0.003 individual/1 000 hooks). *M. mustelus*° was the shark species caught most frequently (around 0.86 individual/1 000 hooks) (Table 6).

Over the same period (i.e. July–September of 2016 and 2017), the catch composition of drifting longlines, mainly targeting swordfish, was investigated, (Bradai *et al.*, 2016; Enajjar *et al.*, 2018). In the drifting longline fishery, elasmobranchs represented almost 92 percent of the total catch (batoids 2.2 percent, sharks 89.6 percent); 96 sets were examined, and *Carcharhinus plumbeus*° came out to be the species corresponding to the highest percentage in terms of both the catch composition (82.5 percent of the total catch) and catch rates (8.79 individuals/1 000 hooks). Other elasmobranch species included *C. brevipinna* (0.20 individual/1 000 hooks), *Isurus oxyrinchus*° (0.48 individual/1 000 hooks), *Pteroplatytrygon violacea* (0.09 individual/1 000 hooks), *Mustelus*

mustelus° (0.11 individual/1 000 hooks), *Rhinobatos cemiculus*° (0.03 individual/1 000 hooks), *Aetomylaeus bovinus* (0.02 individual/1 000 hooks), *Taeniurops grabatus* (0.09 individual/1 000 hooks) and *Raja clavata* (0.03 individual/1 000 hooks) (Bradai *et al.*, 2016; Enajjar *et al.*, 2018).

The above results were confirmed by Saidi *et al.* (2019), who investigated in depth the status of shark populations exploited by the shark drifting longline fishery in the Gulf of Gabès, comparing the respective species compositions and catch rates of different survey periods. They based their findings off of catch data from 48 longlines set and analysed over the first period of 2007–2008 by Echwikhi, Saidi and Bradai (2014) and from 96 longlines set and analysed over the second period of 2016–2017 (Bradai *et al.*, 2016; Enajjar *et al.*, 2018). In both periods, elasmobranch species dominated the catch, corresponding to 94 percent (2016–2017) and 99.3 percent (2007–2008) of the number of specimens (Table 6). The sandbar shark (*Carcharhinus plumbeus*°) was the predominant species in the total catch (more than 84 percent of all species caught) during both periods. Over the second period of the study (2016–2017), three other species of sharks, *Isurus oxyrinchus*° (4.6 percent of total catch), *C. brevipinna* (1.9 percent) and *Mustelus mustelus*° (1.07 percent), were also relatively common. Among the batoids, the pelagic stingray (*P. violacea*) was the most numerous, accounting for 0.9 percent in number, while other species such as *Rhinobatos cemiculus*° (0.25 percent), *Aetomylaeus bovinus* (0.16 percent) and *Taeniurops grabatus* (0.82 percent) represented a minor component. In addition, size distribution analyses revealed that the fishery may be operating opportunistically in mating and nursery areas, with impacts on the main species during most of their life stages.

In Maltese waters, Murua *et al.* (2013) reported the mean size and sample size for four species caught by drifting longlines in GSA 15 between 2008 and 2011: *Prionace glauca*°, *Galeorhinus galeus*°, *Lamna nasus*° and *Alopias* spp. (Table 6).

In southern Italy, Cambiè *et al.* (2013) analysed the bycatch species composition of surface longlines and mid-water longlines targeting swordfish during the summers of 2007, 2010 and 2011 (surface longlines) and the summers of 2010 and 2011 (mid-water longlines). They found, among the elasmobranch bycatch, specimens of *Pteroplatytrygon violacea* (around 8 percent of total catch composition in number) and *Prionace glauca*° (around 2 percent of total catch composition in number), though absolute numbers were not reported in the study.

It is worth highlighting that Tobuni *et al.* (2016) documented, for the first time, the presence of a tiger shark (*Galeocerdo cuvier*) in the Mediterranean Sea: two individuals were accidentally caught by a drifting longline targeting swordfish in Libyan waters.

In the MEDLEM database for the central Mediterranean, the blue shark (*Prionace glauca*°) is by far the most commonly bycaught species (60 percent) (see Table 6 for the other conservation-priority species). Regarding other species, the MEDLEM database also reports the bycatch of four individuals of *Carcharhinus obscurus*, one *Hexanchus griseus* and 78 *Pteroplatytrygon violacea*.

Adriatic Sea

Recently, Ćetković (2018) presented data on the composition and abundance of shark bycatch in Montenegrin fisheries, collected between 2016 and 2018 through observations made onboard and at landing sites, as well as from interviews with fishers. In the catch composition of drifting longliners targeting swordfish and tuna, the presence of *Prionace glauca*° (17 individuals), *Isurus oxyrinchus*° (5 individuals) and *Alopias vulpinus*° (1 individual) was recorded.

In the MEDLEM database, only a few specimens are reported from the Adriatic Sea and they consist of only conservation-priority species.

It is worth mentioning the ongoing WWF SafeSharks project (WWF, 2021) that began in 2018, carried out along the Apulian Adriatic coast in southern Italy. The project aims to provide important information on bycatch in the long-established Monopoli longline swordfish fishery (about 26 boats); preliminary analysis indicates that the fishery captures large elasmobranchs, including blue sharks *Prionace glauca*°, thresher sharks *Alopias* spp., spintail devil ray *Mobula mobular*° and shortfin mako *Isurus oxyrinchus*° sharks, on a daily basis. However, the fishers release almost all caught specimens back into the sea still alive, only retaining a few large individuals for sale. Preliminary data for the fishing period of 2019 (August through October) indicate that 65 individuals of *Prionace glauca*° were caught over 34 fishing days by the local longline swordfish fishery (WWF, 2021, unpublished data).

Eastern Mediterranean

Along the Syrian coast, a total of 114 spiny butterfly rays (*Gymnura altavela*°) were caught from July 2010 through March 2013, either in trawls or set longlines operating on sandy and rocky bottoms, at depths ranging from 5 to 60 m (Alkusairy *et al*., 2014), though the data do not specify which gear was responsible for each catch. Similarly, Alkusairy and Saad (2018), in their review of shark bycatch and its composition in Syrian fisheries carried out between 2014 and 2016, reported the sandbar shark (*Carcharhinus plumbeus*°) (1 135 individuals) as bycatch in nets–longlines (Table 6) and the gulper shark (*Centrophorus granulosus*°) (360 individuals) as bycatch in trawl–longlines. The study also recorded shark species diversity and the presence of possible nurseries along the Syrian coast.

Between December 2012 and January 2014, 67 individuals of the common guitarfish (*Rhinobatos rhinobatos*°) were caught in coastal Lebanese waters at depths ranging from 10 to 110 m by set longliners based out of different ports (Lteif *et al*., 2016b).

In Egypt, Gabr and El-Haweet (2012) conducted a survey of the drifting longline fishery during the albacore (*Thunnus alalunga*) fishing season between June and July of 2010. The composition of the discards included between five and ten pelagic stingrays (*Pteroplatytrygon violacea*) per fishing day per boat. Additionally, in Egyptian waters, a single bigeye thresher shark (*Alopias superciliosus*) was caught in June 2015 by a drifting longline (Farrag, 2017).

In Antalya (Turkey), Gokoglu reported the bycatch of a single individual of each of *Alopias vulpinus*° and *A. superciliosus* in 2014 from the drifting longline fishery targeting swordfish (Soldo, Briand and Rassoulzadegan, 2014).

Likewise, a survey carried out by Ceyhan and Akyol (2014) in Turkish waters along the Aegean coast, monitoring 50 surveyed operations of swordfish longlines during the fishing seasons from 2008 to 2013, assessed the percentage contribution, in terms of total biomass, of cartilaginous fish. The target swordfish accounted for the highest share of the catch both in number (78.6 percent) and in biomass (73.3 percent). Nevertheless, the biomass ratio of cartilaginous fish came to around 18 percent and included specimens of *Prionace glauca*° (4 individuals), *Isurus oxyrinchus*° (4 individuals), *Alopias vulpinus*° (3 individuals) *Carcharhinus plumbeus*° (2 individuals) and *Mobula mobular*° (2 individuals) (Table 6). The authors reported that one specimen of each of *P. glauca*° and *M. mobular*° was released alive, while the rest were retained due to their commercial value.

In the northern Aegean Sea, in 2008, it was also reported that a new-born great white shark (*Carcharodon carcharias*°) (145 cm TL) was captured by a set longliner (Kabasakal and Özgür Gedikoğlu, 2008). Elsewhere, in the southern Aegean Sea (Turkish coast), a single specimen of blackchin guitarfish (*Rhinobatos cemiculus*°) (925 mm TL) was caught in 2015 by a set longline on a sandy bottom at a depth of approximately 20 m (Filiz *et al.*, 2016).

In a more recent fishing experiment conducted on set longlines by Gönülal (2017) from March to August 2016, at depths of between 500 and 900 m in the northern Turkish Aegean Sea, the presence of different elasmobranch species was recorded: *Alopias vulpinus*° (1 individual), *Dalatias licha* (4 individuals), *Dipturus oxyrinchus* (2 individuals), *Hexanchus griseus* (3 individuals), *Pteroplatytrygon violacea* (1 individuals), *Etmopterus spinax* (12 individuals), *Prionace glauca*° (6 individuals), *Mustelus mustelus*° (11 individuals), *Galeus melastomus* (39 individuals) and *Scyliorhinus stellaris* (28 individuals).

Özcan and Başusta (2018b), in their study on the age, growth and reproduction of the smooth-hound (*Mustelus mustelus*°) inhabiting the Gulf of Iskenderun, in the northeastern Mediterranean, reported that between March 2012 and October 2015, a total of 155 *M. mustelus*° were caught in gillnets and set longlines.

In Cyprus in 2015, Kleitou *et al.* (2017) observed two longlines targeting swordfish (*Xiphias gladius*) over a total of six fishing days along the island's territorial waters. During this short period, the longlines caught 10 individuals of bigeye thresher shark (*Alopias superciliosus*). These captures not only confirmed the presence of this species in the area, but clearly showed, for the first time such a large abundance of *A. superciliosus* captured in the eastern Mediterranean basin by such a low fishing effort. Additional bycatch records of *A. superciliosus* (2 individuals) were recorded again in 2016 (Kleitou *et al.*, 2017).

In the MEDLEM database, for the eastern Mediterranean, 67 bycatch records are reported and mostly include conservation-priority species (Table 6), as well as *Carcharhinus brevipinna* (1 individual), *Pteroplatytrygon violacea* (10 individuals) and *Hexanchus griseus* (10 individuals).

Black Sea

Based on an FAO report (2018d), the bycatch composition of longlines operating in the Black Sea region is composed exclusively of the piked dogfish (*Squalus acanthias*°).

Table 6 – Incidental catch of conservation-priority elasmobranch species in longlines (data from literature 2008–2019)

Bibliographic reference	Reference years	Gear	GFCM subregion	Country	Species	SPA/BD Protocol Annex	Reported individuals in bycatch events	Source of data
Lanteri, Castellano and Garibaldi (2017)	2015	LLD	Western Mediterranean	Italy	*Alopias superciliosus*[1]	-	1	Landing observation
FAO (2019)	2017	LLD	Western Mediterranean	Algeria	*Prionace glauca*	III	1	-
FAO (2019)	2018	LLD	Western Mediterranean	France	*Isurus oxyrinchus*	II	1	-
MEDLEM	2008–2019	LL	Western Mediterranean	-	*Alopias vulpinus*	III	7	-
MEDLEM	2008–2019	LL	Western Mediterranean	-	*Alopias superciliosus*[1]	-	1	-
MEDLEM	2008–2019	LL	Western Mediterranean	-	*Carcharhinus plumbeus*	III	1	-

Table 6 (continued)

Bibliographic reference	Reference years	Gear	GFCM subregion	Country	Species	SPA/BD Protocol Annex	Reported individuals in bycatch events	Source of data
MEDLEM	2008–2019	LL	Western Mediterranean	-	*Carcharodon carcharias*	II	1	-
MEDLEM	2008–2019	LL	Western Mediterranean	-	*Cetorhinus maximus*	II	1	-
MEDLEM	2008–2019	LL	Western Mediterranean	-	*Isurus oxyrinchus*	II	17	-
MEDLEM	2008–2019	LL	Western Mediterranean	-	*Prionace glauca*	III	27	-
MEDLEM	2008–2019	LL	Western Mediterranean	-	*Gymnura altavela*	II	4	-
FAO (2018d)	2017	LLD	Central Mediterranean	Tunisia	*Carcharhinus plumbeus*	III	84	-
FAO (2018d)	2017	LLD	Central Mediterranean	Tunisia	*Isurus oxyrinchus*	II	19	-
FAO (2018d)	2017	LLD	Central Mediterranean	Tunisia	*Mustelus mustelus*	III	2	-
FAO (2019)	2019	LLD	Central Mediterranean	Tunisia	*Mustelus mustelus*	III	8	-
FAO (2019)	2019	LLD	Central Mediterranean	Tunisia	*Prionace glauca*	III	1	-
Echwikhi, Saidi and Bradai (2014)	2007–2008	LLS	Central Mediterranean	Tunisia	*Rhinobatos cemiculus*	II	123	Onboard observations
Echwikhi, Saidi and Bradai (2014)	2007–2008	LLS	Central Mediterranean	Tunisia	*Rhinobatos rhinobatos*	II	44	Onboard observations
Echwikhi, Saidi and Bradai (2014)	2007–2008	LLD	Central Mediterranean	Tunisia	*Carcharhinus plumbeus*	III	547	Onboard observations
Echwikhi, Saidi and Bradai (2014)	2007–2008	LLS	Central Mediterranean	Tunisia	*Mustelus punctulatus*	III	53	Onboard observations
Echwikhi, Saidi and Bradai (2014)	2007–2008	LLS	Central Mediterranean	Tunisia	*Mustelus mustelus*	III	62	Onboard observations
Bradai *et al.* (2016)	2016–2017	LLS	Central Mediterranean	Tunisia	*Carcharhinus plumbeus*	III	1 132[2]	Onboard observations
Bradai *et al.* (2016)	2016–2017	LLD	Central Mediterranean	Tunisia	*Carcharhinus plumbeus*	III	3 795[2]	Onboard observations
Bradai *et al.* (2016)	2016–2017	LLD	Central Mediterranean	Tunisia	*Mustelus mustelus*	III	48[2]	Onboard observations
Bradai *et al.* (2016)	2016–2017	LLS	Central Mediterranean	Tunisia	*Mustelus mustelus*	III	2 265[2]	Onboard observations
Bradai *et al.* (2016)	2016–2017	LLS	Central Mediterranean	Tunisia	*Mustelus punctulatus*	III	218[2]	Onboard observations
Bradai *et al.* (2016)	2016–2017	LLS	Central Mediterranean	Tunisia	*Heptranchias perlo*	III	299[2]	Onboard observations
Bradai *et al.* (2016)	2016–2017	LLS	Central Mediterranean	Tunisia	*Carcharodon carcharias*	II	8[2]	Onboard observations
Bradai *et al.* (2016)	2016–2017	LLS	Central Mediterranean	Tunisia	*Rhinobatos cemiculus*	II	2 216[2]	Onboard observations
Bradai *et al.* (2016)	2016–2017	LLD	Central Mediterranean	Tunisia	*Rhinobatos cemiculus*	II	11[2]	Onboard observations
Bradai *et al.* (2016)	2016–2017	LLS	Central Mediterranean	Tunisia	*Gymnura altavela*	II	81[2]	Onboard observations
Bradai *et al.* (2016)	2016–2017	LLD	Central Mediterranean	Tunisia	*Isurus oxyrinchus*	II	208[2]	Onboard observations
Saidi *et al.* (2019)	2016–2017	LLD	Central Mediterranean	Tunisia	*Isurus oxyrinchus*	II	56	Onboard observations
Saidi *et al.* (2019)	2016–2017	LLD	Central Mediterranean	Tunisia	*Mustelus mustelus*	III	13	Onboard observations
Saidi *et al.* (2019)	2016–2017	LLD	Central Mediterranean	Tunisia	*Carcharhinus plumbeus*	III	1 024	Onboard observations
Murua *et al.*, eds (2013)	2008–2011	LLD	Central Mediterranean	Malta	*Prionace glauca*	III	240	-
Murua *et al.*, eds (2013)	2008–2011	LLD	Central Mediterranean	Malta	*Galeorhinus galeus*	II	4	-

Table 6 (continued)

Bibliographic reference	Reference years	Gear	GFCM subregion	Country	Species	SPA/BD Protocol Annex	Reported individuals in bycatch events	Source of data
Murua *et al.*, eds (2013)	2008–2011	LLD	Central Mediterranean	Malta	*Lamna nasus*	II	59	-
Murua *et al.*, eds (2013)	2008–2011	LLD	Central Mediterranean	Malta	*Alopias* spp.	-	14	-
MEDLEM	2008–2019	LL	Central Mediterranean	-	*Alopias vulpinus*	III	4	-
MEDLEM	2008–2019	LL	Central Mediterranean	-	*Carcharodon carcharias*	II	1	-
MEDLEM	2008–2019	LL	Central Mediterranean	-	*Galeorhinus galeus*	II	19	-
MEDLEM	2008–2019	LL	Central Mediterranean	-	*Isurus oxyrinchus*	II	8	-
MEDLEM	2008–2019	LL	Central Mediterranean	-	*Lamna nasus*	II	2	-
MEDLEM	2008–2019	LL	Central Mediterranean	-	*Mustelus mustelus*	III	1	-
MEDLEM	2008–2019	LL	Central Mediterranean	-	*Mustelus punctulatus*	III	1	-
MEDLEM	2008–2019	LL	Central Mediterranean	-	*Prionace glauca*	III	206	-
MEDLEM	2008–2019	LL	Central Mediterranean	-	*Mobula mobular*	II	18	-
Ćetković (2018)	2016–2018	LLD	Adriatic Sea	Montenegro	*Prionace glauca*	III	17	Onboard observations, observations at landing sites, interviews with fishers
Ćetković (2018)	2016–2018	LLD	Adriatic Sea	Montenegro	*Isurus oxyrinchus*	II	5	Onboard observations, observations at landing sites, interviews with fishers
Ćetković (2018)	2016–2018	LLD	Adriatic Sea	Montenegro	*Alopias vulpinus*	III	1	Onboard observations, observations at landing sites, interviews with fishers
MEDLEM	2008–2019	LL	Adriatic Sea	-	*Alopias vulpinus*	III	1	-
MEDLEM	2008–2019	LL	Adriatic Sea	-	*Isurus oxyrinchus*	II	1	-
MEDLEM	2008–2019	LL	Adriatic Sea	-	*Prionace glauca*	III	3	-
WWF, 2021 (unpublished data)	2019	LLD	Adriatic Sea	Italy	*Prionace glauca*	III	65	Onboard observations and fisher's logbook records
Alkusairy *et al.* (2014)	2010–2013	LL/OTB	Eastern Mediterranean	Syria	*Gymnura altavela*	II	114	Observations at landing sites
Alkusairy and Saad (2018)	2014–2015	LL/OTB	Eastern Mediterranean	Syrian Arab Republic	*Centrophorus granulosus*	III	360	-
Lteif *et al.* (2016b)	2012–2014	LLS	Eastern Mediterranean	Lebanon	*Rhinobatos rhinobatos*	II	67	Observations at landing sites
Farrag (2017)	2015	LLD	Eastern Mediterranean	Egypt	*Alopias superciliosus*[1]	n/a	1	Catch composition analysis
Gokoglu *in* Soldo, Briand and Rassoulzadegan (2014)	2014	LLD	Eastern Mediterranean	Turkey	*Alopias supercilious*[1]	-	1	-
Gokoglu *in* Soldo, Briand and Rassoulzadegan (2014)	2014	LLD	Eastern Mediterranean	Turkey	*Alopias vulpinus*	III	1	-
Filiz *et al.* (2016)	2015	LL	Eastern Mediterranean	Turkey	*Rhinobatos cemiculus*	II	1	Observations at landing sites
Kabasakal and Özgür Gedikoğlu, 2008	2008	LLS	Eastern Mediterranean	Turkey	*Carcharodon carcharias*	II	1	Landing observation
Ceyhan and Akyol (2014)	2008–2013	LLD	Eastern Mediterranean	Turkey	*Alopias vulpinus*	III	3	Onboard observations

Table 6 (continued)

Bibliographic reference	Reference years	Gear	GFCM subregion	Country	Species	SPA/BD Protocol Annex	Reported individuals in bycatch events	Source of data
Ceyhan and Akyol (2014)	2008–2013	LLD	Eastern Mediterranean	Turkey	*Carcharhinus plumbeus*	III	2	Onboard observations
Ceyhan and Akyol (2014)	2008–2013	LLD	Eastern Mediterranean	Turkey	*Mobula mobular*	II	2	Onboard observations
Ceyhan and Akyol (2014)	2008–2013	LLD	Eastern Mediterranean	Turkey	*Prionace glauca*	III	4	Onboard observations
Ceyhan and Akyol (2014)	2008–2013	LLD	Eastern Mediterranean	Turkey	*Isurus oxyrinchus*	II	4	Onboard observations
Gönülal (2017)	2016	LLS	Eastern Mediterranean	Turkey	*Alopias vulpinus*	III	1	Experimental fishing
Gönülal (2017)	2016	LLS	Eastern Mediterranean	Turkey	*Prionace glauca*	III	6	Experimental fishing
Gönülal (2017)	2016	LLS	Eastern Mediterranean	Turkey	*Mustelus mustelus*	III	11	Experimental fishing
Özcan and Başusta (2018b)	2012–2015	LLD/ GNS	Eastern Mediterranean	Turkey	*Mustelus mustelus*	III	155	-
Kleitou *et al.* (2017)	2015–2016	LLD	Eastern Mediterranean	Cyprus	*Alopias superciliosus*[1]	-	12	Onboard observations
FAO (2019)	2018	LLD	Eastern Mediterranean	Cyprus	*Prionace glauca*	III	10	
FAO (2018d)	2017	LLD	Eastern Mediterranean	Cyprus	*Prionace glauca*	III	6	
FAO (2017)	2016	LLD	Eastern Mediterranean	Cyprus	*Prionace glauca*	III	1	
FAO (2017)	2016	LLD	Eastern Mediterranean	Cyprus	*Isurus oxyrinchus*	II	2	
FAO (2019)	2018	LL	Eastern Mediterranean	Greece	*Mustelus mustelus*	III	2	
FAO (2019)	2018	LL	Eastern Mediterranean	Greece	*Rostroraja alba*	II	1	
FAO (2018d)	2017	LL	Eastern Mediterranean	Greece	*Mustelus mustelus*	III	4	
FAO (2018d)	2017	LL	Eastern Mediterranean	Greece	*Squalus acanthias*	III	45	
FAO (2019)	2018	LL	Eastern Mediterranean	Greece	*Squalus acanthias*	III	8	
MEDLEM	2018–2019	LL	Eastern Mediterranean	-	*Alopias vulpinus*	III	30	-
MEDLEM	2018–2019	LL	Eastern Mediterranean	-	*A. superciliosus*[1]	-	26	-
MEDLEM	2018–2019	LL	Eastern Mediterranean	-	*Carcharhinus plumbeus*	III	2	-
MEDLEM	2018–2019	LL	Eastern Mediterranean	-	*Carcharodon carcharias*	II	1	-
MEDLEM	2018–2019	LL	Eastern Mediterranean	-	*Isurus oxyrinchus*	II	7	-
MEDLEM	2018–2019	LL	Eastern Mediterranean	-	*Prionace glauca*	III	5	-
MEDLEM	2018–2019	LL	Eastern Mediterranean	-	*Mobula mobular*	II	1	-

Notes:

LL = longline; LLS = set longline; LLD = drifting longline.

1. *Alopias superciliosus* is not listed in Annex II or III of SPA/DB Protocol, but due to its morphological similarity to *A. vulpinus*°, bycatch events reported for this species were included in the table.
2. Bycatch estimate referring to one fishing season of all set and drifting longline fisheries operating in the Gulf of Gabès, Tunisia.

3.3.5 Pelagic trawlers

Pelagic trawlers using large openings to target small pelagic fish (anchovies and sardines) operate almost exclusively in the Adriatic Sea and can incidentally catch pelagic sharks. Table 7 includes information on the incidental catch of conservation-priority shark and batoid species from sources individually reporting the elasmobranchs caught by pelagic trawlers. The data reported officially by countries to the GFCM are presented in Table 7 (FAO, 2018d)

Western Mediterranean

Some pelagic trawlers used to operate in the western Mediterranean, mainly in the Gulf of Lion (Farrugio and Cebrian, 2013).

In the MEDLEM database, the bycatch of 11 specimens belonging to four priority-conservation species is reported (Table 7).

Central Mediterranean

In the MEDLEM database, the bycatch of nine specimens belonging to three priority-conservation species is reported (Table 7).

Adriatic Sea

As mentioned, this type of fishing technique is mainly used in the Adriatic Sea. The largest fleet of pelagic trawlers is based in Italy, where they are commonly called *volanti* and are licensed to operate in pairs. Twin boats, usually of an overall length (LOA) greater than 18 m and nominal power between 150 and 900 kW mainly operate in the open sea, trawling a net around 150 m long, with a mouth opening of 15–18 m in width and 6–10 m in height and targeting anchovies, sardines and mackerel (Fortuna *et al.*, 2010).

A long bycatch monitoring programme in Italian pelagic trawlers, operating mainly in the northern central Adriatic, has provided the opportunity to collect information over a ten-year period (2006–2015) (Fortuna *et al.*, 2010; La Mesa *et al.*, 2016; Bonanomi *et al.*, 2018); qualified observers onboard 57 pelagic trawlers monitored all fishing operations and collected bycatch data for protected species (e.g. cetaceans) and species of conservation concern (e.g. elasmobranchs). While Fortuna *et al.* (2010) focused their study on cetacean bycatch, though they also collected information on bycatch of other vulnerable species over a three-year period (see Section 1.3), Bonanomi *et al.* (2018) assessed the impacts of the pelagic trawl fishery on four species of elasmobranchs: the common smooth-hound (*Mustelus mustelus*°), piked dogfish (*Squalus acanthias*°), common eagle ray (*Myliobatis aquila*) and pelagic stingray (*Pteroplatytrygon violacea*) by examining the incidental catch recorded in a longer data series (i.e. from 2006 to 2015). In fact, these species had already been initially identified by Fortuna *et al.* (2010) as the most impacted by pelagic trawlers in the Adriatic Sea.

According to Bonanomi *et al.* (2018), the *S. acanthias*° was the species of elasmobranch with the highest bycatch (2 160 individuals of *S. acanthias*° were caught, with an average frequency of 0.061 per fishing haul), followed by the common eagle ray (1 880 individuals *M. aquila*; average frequency of 0.054 per fishing haul), the common smooth-hound (833 *Mustelus mustelus*° individuals; average frequency 0.027), and the pelagic stingray (555 *P. violacea* individuals; average frequency 0.033). It was shown that depth, season and fishing area strongly influenced the bycatch of the above-mentioned species. Additionally, the presence of a nursery area identified in the northern Adriatic was probably a major factor affecting the bycatch of the *M. mustelus*° and *S. acanthias*°. The study also revealed that demersal elasmobranchs were caught by pelagic/midwater trawlers when these vessels operated in relatively shallow waters (<50 m). Table 7 reports the bycatch of the two priority-conservation species recorded from 2008 to 2015.

Analysing the same fishing data for the period 2006–2013, La Mesa *et al.* (2016) assessed the effects of spatiotemporal, environmental and operational factors on the catch of two myliobatids, the common eagle ray (*Myliobatis aquila*) and the bull ray (*Aetomylaeus bovinus*), by midwater trawlers operating in the north central Adriatic Sea. The proportion of positive hauls (i.e. hauls in which rays were caught) was 5.8 percent for common eagle rays and 1.3 percent for bull rays, corresponding to a total of 1 857 and 215 individuals, respectively. The major occurrences of common eagle rays and bull rays in the northern Adriatic Sea were observed between late spring

and early autumn. During winter, a southward shift in the catch was recorded for both species. In accordance with a significant effect noted for depth, common eagle rays were more likely to be caught in hauls conducted at depths between 10 and 60 m. The CPUEs of common eagle rays and bull rays declined significantly with haul duration and net vertical opening.

In the MEDLEM database, besides the data already mentioned above, the bycatch of *Carcharodon carcharias*° and *Mobula mobular*° are also reported for this vessel group in the Adriatic Sea (Table 7).

Eastern Mediterranean

A single individual of each of *Alopias superciliosus* and *Echinorhinus brucus* is reported as bycatch of pelagic trawlers in the eastern Mediterranean in the MEDLEM database.

Black Sea

No data available.

Table 7 – Incidental catch of conservation-priority elasmobranch species in pelagic trawlers (data from literature 2008–2019)

Bibliographic reference	Reference years	Gear	GFCM subregion	Country	Species	SPA/BD Protocol Annex	Reported individuals in bycatch events	Source of data
MEDLEM	2008–2019	PTM	Western Mediterranean	-	*Alopias vulpinus*	III	6	-
MEDLEM	2008–2019	PTM	Western Mediterranean	-	*Cetorhinus maximus*	II	2	-
MEDLEM	2008–2019	PTM	Western Mediterranean	-	*Galeorhinus galeus*	II	1	-
MEDLEM	2008–2019	PTM	Western Mediterranean	-	*Prionace glauca*	III	2	-
FAO (2018d)	2017	PTM	Western Mediterranean	Algeria	*Alopias vulpinus*	III	1	
MEDLEM	2008–2019	PTM	Central Mediterranean	-	*Alopias vulpinus*	III	1	-
MEDLEM	2008–2019	PTM	Central Mediterranean	-	*Isurus oxyrinchus*	II	1	-
MEDLEM	2008–2019	PTM	Central Mediterranean	-	*Prionace glauca*	III	7	-
Bonanomi *et al.* (2018)	2008–2015	PTM	Adriatic Sea	Italy	*Squalus acanthias*	III	2 068	Onboard observations
Bonanomi *et al.* (2018)	2008–2015	PTM	Adriatic Sea	Italy	*Mustelus mustelus*	III	758	Onboard observations
MEDLEM	2008–2019	PTM	Adriatic Sea	-	*Carcharodon carcharias*	II	1	-
MEDLEM	2008–2019	PTM	Adriatic Sea	-	*Mobula mobular*	II	1	-
MEDLEM	2008–2019	PTM	Eastern Mediterranean	-	*Alopias superciliosus*[1]	-	1	-

Notes: PTM = midwater pair trawl.

1. *Alopias superciliosus* is not listed in Annex II or III of SPA/DB Protocol, but due to its morphological similarity to *A. vulpinus*°, bycatch events reported for this species were included in the table.

3.3.6 Tuna seiners

This vessel group includes the large pelagic seiners and the few coastal tuna traps that remain active in the Mediterranean Sea (Storai *et al.*, 2011). Hall and Roman (2013) have provided a global review of the bycatch of the tuna purse seine fisheries. The major fishing grounds in which these types of vessels operate, with mostly the same fishing techniques and gear, are the eastern and western Pacific, the eastern Atlantic, and the western Indian Ocean; little information was provided for the Mediterranean and the Black Sea.

The data reported officially by countries to the GFCM are presented in Table 8 (FAO, 2018d). In the same table data coming from tuna trap bycatch records available in the MEDLEM archive are also reported. It is noteworthy that besides the conservation-priority species, rare large pelagic sharks have been recorded: the copper shark (*Carcharhinus brachyurus*, 1 individual) and the dusky

shark (*C. obscurus,* 1 individual) in the western Mediterranean, and the silky shark (*C. falciformis,* 1 individual) in the eastern Mediterranean.

Western Mediterranean

In 2015, news (Romagnoni, 2011) reported of five bycatch events of thresher sharks (*Alopias* spp.) in tuna fishing traps operating in the waters off Camogli (Ligurian Sea, Italy). According to the source, prior to the bycatch event that occurred in February 2015, other sharks had been caught in April and May 2008, June 2009, and April 2010.

Central Mediterranean

No data available.

Adriatic Sea

No data available.

Eastern Mediterranean

No data available.

Black Sea

No data available.

Table 8 – Incidental catch of conservation-priority elasmobranch species in tuna seiners (data from literature 2008–2019)

Bibliographic reference	Reference years	Gear	GFCM subregion	Country	Species	SPA/BD Protocol Annex	Reported individuals in bycatch events	Source of data
Romagnoni, 2011	2008–2015	-	Western Mediterranean	Italy	*Alopias* spp.	-	5	-
FAO (2018d)	2017	-	Eastern Mediterranean	Cyprus	*Prionace glauca*	III	5	-
MEDLEM	2008–2019	-	Western Mediterranean	-	*Alopias vulpinus*	III	10	-
MEDLEM	2008–2019	-	Western Mediterranean	-	*Carcharodon carcharias*	II	1	-
MEDLEM	2008–2019	-	Western Mediterranean	-	*Isurus oxyrinchus*	II	2	-
MEDLEM	2008–2019	-	Western Mediterranean	-	*Prionace glauca*	III	3	-
MEDLEM	2008–2019	-	Western Mediterranean	-	*Sphyrna zygaena*	II	1	-
MEDLEM	2008–2019	-	Western Mediterranean	-	*Mobula mobular*	II	1	-
MEDLEM	2008–2019	-	Central Mediterranean	-	*Alopias vulpinus*	III	1	-
MEDLEM	2008–2019	-	Central Mediterranean	-	*Alopias superciliosus*[1]	-	2	
MEDLEM	2008–2019	-	Central Mediterranean	-	*Carcharodon carcharias*	II	1	-
MEDLEM	2008–2019	-	Adriatic Sea	-	*Alopias vulpinus*	III	1	-
MEDLEM	2008–2019	-	Eastern Mediterranean	-	*Alopias superciliosus*[1]	-	1	-

Notes:

1. *Alopias superciliosus* is not listed in Annex II or III of SPA/DB Protocol, but due to its morphological similarity to *A. vulpinus*°, bycatch events reported for this species were included in the table.

3.3.7 Dredgers

No data available for this vessel group; these fisheries do not overlap with elasmobranch species.

3.4 Outlook

3.4.1 Results

Data on the bycatch of conservation-priority elasmobranch species in Mediterranean and Black Sea fisheries collected from around 2008 to the present from scientific literature, FAO reports and ad hoc archives (i.e. MEDLEM database, see Mancusi *et al.*, 2020) have been analysed to obtain qualitative evaluations by vessel group and subregion, as presented in Section 3.3.

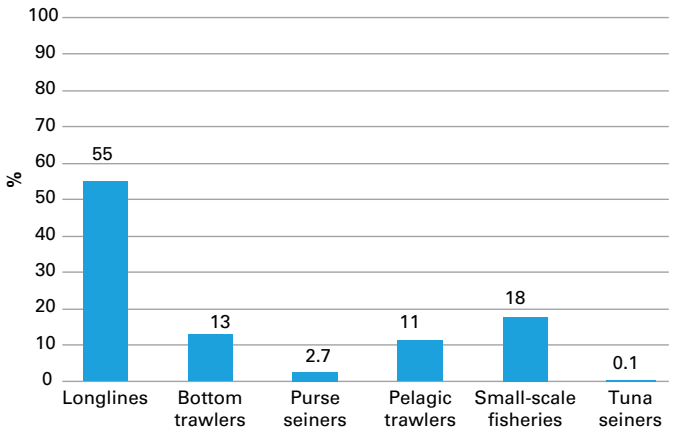
Focus is given to the conservation-priority species included in Annex II (24 species) and Annex III (9 species) of the SPA/BD Protocol and considered in Recommendations GFCM/36/2012/3 and GFCM/42/2018/2 (see Table 1). From 2013, according to these regional recommendations, a high level of protection from fishing activities shall be granted to the elasmobranch species listed in Annex II of the SPA/BD Protocol (List of endangered or threatened species). These species must be released live and unharmed, to the extent possible, and cannot be retained onboard, transhipped, landed, transferred, stored, sold, displayed or offered for sale. Species listed in Annex III of the SPA/BD Protocol (List of species whose exploitation is regulated) can be commercialized but detailed reporting of any catch must be reported.

It is worth noting that the geographical and historical coverage of the data analysed varies greatly and that only studies reporting individual values of elasmobranch bycatch were considered. Therefore, the data presented in this review are likely to underestimate the real values and the actual frequency of elasmobranch incidental catch in the Mediterranean and the Black Sea. However, this analysis could represent an important starting point for management considerations.

According to the data compiled, most of the reported conservation-priority elasmobranch bycatch comes from longliners (set and drifting considered together) (55 percent), followed by small-scale fisheries (18 percent), bottom trawlers (13 percent), pelagic trawlers (11 percent), purse seiners and tuna seiners (nearly 3 percent together) (Figure 3).

Small-scale fisheries are characterized by polyvalent gear vessels that may also operate with small longlines in coastal areas and, therefore, some of the bycatch records reported here under "Longlines" actually come from small-scale polyvalent vessels. In fact, in the Mediterranean and Black Sea, elasmobranch species are mainly coastal and benthic (around 80 percent of the species), making them vulnerable to fishing activities operating along the coasts (Bradai, Saidi and Enajjar, 2018).

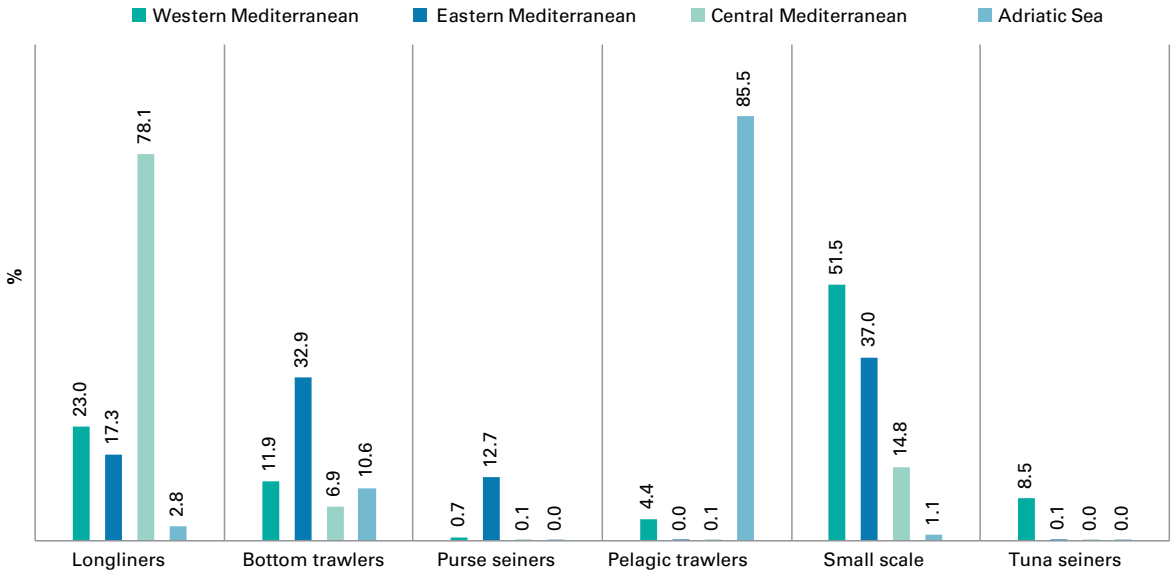
FIGURE 3
Reported incidental catch of elasmobranchs by fishing vessel group in the Mediterranean and the Black Sea (data from literature 2008–2019)



Number of individuals = 25 312

Quite different sets of impacts from the different vessel categories emerge when considering the various GFCM subregions (Figure 4). Most of the

FIGURE 4
Reported incidental catch of elasmobranchs by fishing vessel group by Mediterranean subregion (data from literature 2008–2019)



Note:
number of individuals = 270 western Mediterranean; 16 520 central Mediterranean; 3 309 Adriatic Sea; 5 190 eastern Mediterranean

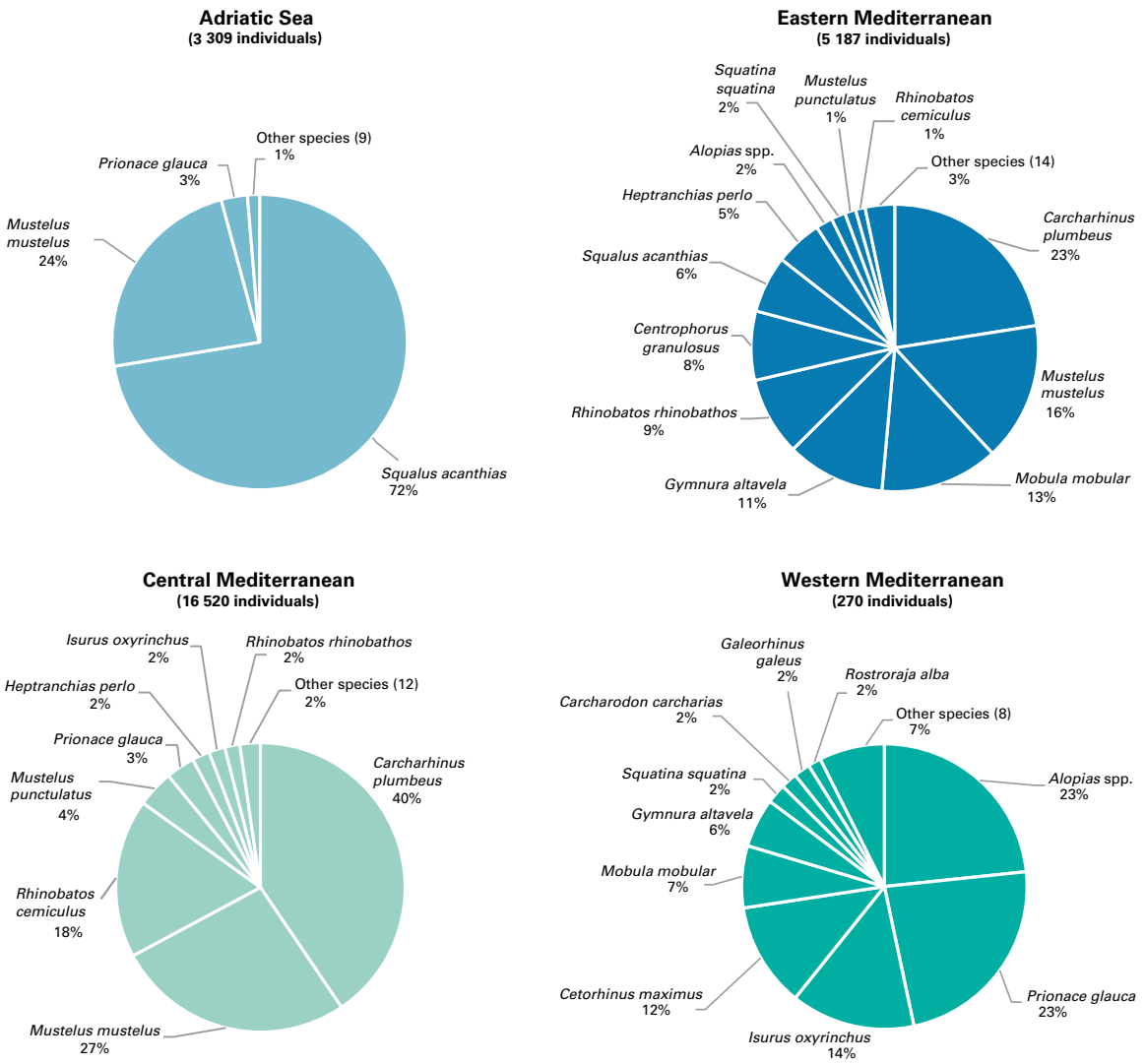
records from the Adriatic Sea come from pelagic trawlers, though it is worth noting that a specific multi-year observation campaign has been in place since 2006. Therefore, the data from this area probably reflect the extent and focuses of survey coverage, as well as the fact that, at the regional level, pelagic trawlers almost exclusively operate in the Adriatic subregion. Similarly, though traditional coastal purse seiners still used in the Levantine Sea are occasionally responsible for elasmobranch bycatch (see Table 5), elasmobranch bycatch in purse seines is rarely reported.

In the central Mediterranean, longliners are by far the most relevant fishing gear in terms of reported bycatch of conservation-priority elasmobranch species, with the absolute highest number of available records. In the eastern Mediterranean, elasmobranch bycatch is mostly reported from small-scale fisheries using a variety of set nets; bottom trawlers also seem to catch a considerable diversity of conservation-priority elasmobranch species in this subregion (see Table 3). In the western Mediterranean, most of the reported records come from small-scale fisheries, followed by longliners and bottom trawlers. It is interesting to note that almost all records of elasmobranch bycatch in tuna seiners, including tuna traps (i.e. a traditional type of gear that has almost disappeared from the Mediterranean basin), are reported from the western Mediterranean; the few remaining tuna traps are nevertheless able to incidentally catch large pelagic species of elasmobranchs (see Table 8).

Very few individual records of conservation-priority elasmobranch species could be found for the Black Sea (23 individuals), with these records coming largely from bottom trawlers (82 percent), followed by purse seiners (17.4 percent). No individual bycatch records from the other vessel groups could be found for this subregion, though small-scale fisheries targeting coastal fish such as turbot are known to incidentally catch the piked dogfish (*Squalus acanthias*°).

Regarding the conservation-priority species reported, notwithstanding differences in absolute numbers, the highest number of species reported as bycatch comes from the eastern Mediterranean (27 species), followed by the central (21 species) and the western Mediterranean (19 species), the Adriatic (13 species) and the Black Sea (4 species) (Figure 5). However, the large gap in reported individuals between the central Mediterranean Sea and the other subregions offers further evidence that the biomass of conservation-priority elasmobranch populations is still highest in the central Mediterranean, assuming that bycatch rates reflect the relative abundance of elasmobranchs, as well as the focus of scientific research. In accordance with these observations are the relevant contributions made to this review by recent studies on the incidental bycatch of elasmobranch species in the central (Tunisia) and in the eastern (Turkey) Mediterranean Sea (see for example, Kabasakal, 2019). These studies helped to expand the data pool from the historical overview (see Section 3.2) which includes data collected up to 2008–2009 mostly coming from studies carried out in the western Mediterranean and the Adriatic Sea and mainly in European countries.

FIGURE 5
Reported elasmobranch conservation-priority species by Mediterranean subregion (data from literature 2008–2019)



N.B. *Alopias vulpinus* and *A. superciliosus* records are pulled together as *Alopias* spp.

In the western Mediterranean, the five most reported species are all large pelagic elasmobranchs (around 80 percent of the records), and among the ten species most reported, eight are listed in Annex II of the SPA/BD Protocol. However, the pool of available data is scarce when compared to those of the other subregions (only 270 individuals), and most of the records come from the MEDLEM archive, as few relevant data could be found scientific literature. Nonetheless, the variety of species noted could reflect high elasmobranch diversity in the subregion (Bradai, Saidi and Enajjar, 2012; Coll *et al.*, 2010; Serena *et al.*, 2020).

In the central Mediterranean, the subregion with the highest number of records (16 520 individuals), the most common species reported as bycatch – mainly by Tunisian fisheries – are the sandbar shark *Carcharhinus plumbeus*° and the smooth-hound shark *Mustelus*°spp. (around 67 percent of the total records); both species are listed in Annex III of the SPA/BD Protocol. In the Adriatic Sea, despite the considerable number of records analysed (3 309 individuals), elasmobranch diversity seems to be lower than in the other subregions, with three species (listed in Annex III of the SPA/DB Protocol) accounting for around 98 percent of the reported bycatch events. The piked dogfish (*Squalus acanthias*°) is by far the most commonly reported conservation-priority species. This finding is in line with previous studies that already highlighted the impoverishment of elasmobranch populations in the Adriatic Sea, from both a quantitative and qualitative perspective (see Jukic-Peladic *et al.*, 2001; Ferretti *et al.*, 2013; Barausse *et al.*, 2014).

From the records analysed in the eastern Mediterranean, (5 190 individuals), the largest variety of species was found, with no peaks corresponding to any single one; this balance appears to be matched by the contributions of the different vessel groups in the subregion (Figure 4), as no fishing gear clearly prevails in terms of elasmobranch bycatch. This result could be due to the relatively high abundance and diversity of species that are still commonly found as bycatch in a variety of fishing gear in this subregion. Indeed, the eastern Mediterranean represents the subregion in which industrial fisheries have developed the least and in which the artisanal nature of fishing activities remains important. In addition, many studies in the eastern Mediterranean, especially from Turkish and Syrian coastal waters, reported the occurrence of shark and ray mating grounds and nurseries for many conservation-priority elasmobranch species, including those with pelagic habits.

In the Black Sea, the paucity of published studies reporting absolute values of elasmobranch species incidentally caught in fisheries stands out (only 23 individuals reported in total). However, it is well known and reported that the piked dogfish (*Squalus acanthias*°, Annex III of the SPA/BD Protocol) and the thornback ray (*Raja clavata*, not listed) comprise regular bycatch components of Black Sea small-scale vessels and bottom trawlers (see GFCM, 2016b, 2018a, 2018b; STECF, 2017; Demirhan, Engin and Can 2005; Ceylan, Şahin and Kalayci, 2013). Most of the data regarding the bycatch of these two species in Black Sea fisheries are often reported in tonnes and, therefore, could not be compared and used in this review. Due to its high bycatch rate, the piked dogfish *S. acanthias*° population in the Black Sea has been declared as depleted by the GFCM for a long time, and specific management measures were adopted in 2015, though the implementation of a full recovery plan is still advised (GFCM, 2018a, 2018b).

The data compiled and presented here also provide useful information on the recent (and reported) occurrence of rare elasmobranch species, as well as species reported to be locally extinct in specific areas. For example, incidental catch records of angel-sharks belonging to the genus *Squatina*° were found in the western, central and eastern Mediterranean, but not in the Adriatic

Sea. Of the three species of hammerhead sharks (*Sphyrna*° spp.) listed in Annex II of the SPA/BD Protocol, only four individuals of the smooth hammerhead (*Sphyrna zygaena*°) could be found as bycatch records (in the eastern and western Mediterranean). In addition, up to 46 individuals of the rare white skate (*Rostroraja alba*°) were reported as bycatch in eastern Mediterranean fisheries. Furthermore, only a few individuals of the demersal elasmobranchs the blue skate (*Dipturus cf. batis*°) (2 individuals), Maltese ray (*Leucoraja melitensis*°) (1 individual) and smalltooth sand tiger (*Odontaspis ferox*°) (3 individuals) were found in the various sources used for this review.

No recent bycatch records were found for the following Annex II species: sand tiger shark (*Carcharias taurus*°), sandy ray (*Leucoraja circularis*°), scalloped hammerhead (*Sphyrna lewini*°) great hammerhead (*S. mokarran*°), and the smalltooth (*Pristis pectinata*°) and common (*P. pristis*°) sawfish, which can be considered extinct in the Mediterranean Sea (Ferretti *et al.*, 2015; Serena *et al.*, 2020). However, in general, unreported data do not necessarily imply that certain species are not present and caught in a particular area. Therefore, while, in general, presence data can be considered valid, the same cannot be said of absence data, as it cannot be stated with certainty that these reflect the actual absence of a species from the area considered. On the other hand, bycatch records of rare elasmobranch species not included in Annex II and III of the SPA/BD Protocol, such as the bramble shark (*Echinorhinus brucus*), kitefin shark (*Dalatias licha*), copper shark (*Carcharhinus brachyurus*), dusky shark (*C. obscurus*), silky shark (*C. falciformis*), little sleeper shark (*Somniosus rostratus*) and tiger shark (*Galeocerdo cuvier*), were also found.

3.4.2 Future scenarios

The observed decline in elasmobranchs is of great concern across almost all the seas of the world, including the Mediterranean and the Black Sea (da Silva Rodrigues Filho and Bráullio de Luna Sales, 2017; Gallucci, McFarlane and Bargmann, eds, 2009; Coll, Navarro and Palomera, 2013; Başusta, Başusta and Özgürözbek, 2016; Bargnesi, Lucrezi and Ferretti, 2020; Myers *et al.*, 2007; Ferretti *et al.*, 2008; Heithaus *et al.*, 2008; Camhi *et al.*, 2009; Guisande *et al.*, 2013; Worm *et al.*, 2013; Barausse *et al.*, 2014; Dulvy *et al.*, 2014; Oliver *et al.*, 2015; Gordon *et al.*, 2017, 2019). The low resilience that elasmobranch species show with respect to human pressure (e.g. habitat loss, pollution, fisheries activities) due to their biological traits (such as late sexual maturity, production of few offspring, among other factors), as well as their vulnerability to incidental capture, which can occur at any growth stage, must be considered by fishery managers in order for effective solutions to be implemented to decrease elasmobranch fishing mortality (Cavanagh and Gibson, 2007; da Silva Rodrigues Filho and Bráullio de Luna Sales, 2017; Bargnesi, Lucrezi and Ferretti, 2020; Stevens *et al.*, 2000; Ferretti *et al.*, 2010; Oliver *et al.*, 2015; Dulvy *et al.*, 2016). The common management measures employed for bony fish have been shown to be ineffective, as the biological and morphological characteristics of cartilaginous fish populations cause them to be more markedly and rapidly impacted by fishing activity. For example, increases in the selectivity of fishing gear, based on the type of bony fish targeted, seldom have positive effects on elasmobranchs.

The data presented in this review highlight the need to implement, at the regional and national level, management and conservation measures aiming to avoid the incidental catch of elasmobranchs, including not only protected species with low or no commercial value, but also those that can be commercialized. Indeed, implementation of these measures is required to comply with the existing regional regulations/recommendations aimed at decreasing elasmobranch bycatch events in Mediterranean and Black Sea fisheries, especially those of protected species. Critical aspects concern the quality of data collection, reporting and fishing statistics with regard to those species

that can be commercialized, as the majority of the currently landed elasmobranchs are recorded at the level of family or species group, with most countries unable to record the catch at the species level (GFCM, 2012; Bradai, Saidi and Enajjar, 2012; Coll, Navarro and Palomera, 2013; Dulvy *et al*., 2014). As for other groups of vulnerable species, systematic onboard data collection on the bycatch of elasmobranch species should be ensured for all Mediterranean and Black Sea countries. Furthermore, for all vessel groups considered, regional, easy-to-use tools should be developed for fishers to record elasmobranch incidental catch. For example, the implementation and correct use of electronic logbooks onboard could contribute in a decisive manner toward this end. One of the issues related to assessing large sharks lies in species identification and knowledge of their conservation status. Simple tools should be provided for fishers to recognize protected species, enabling them to release captured specimens still alive, in order to contribute to the conservation of elasmobranch populations, as well as to avoid disciplinary sanctions.

In terms of fisheries management, the enforcement of relevant regulations is never an easy task, as reliable, basic information in relation to exploitable versus non-exploitable resources is always required. Complications arise particularly in consideration of the exploitation of elasmobranch species. In fact, some shark and ray species are included in several international legal instruments aimed at their protection (i.e. they are found in the annexes of various conventions, such as the Barcelona Convention (see Table 1), which is used as a reference both in the European regulations and GFCM recommendations), as well as for other charismatic large marine species like marine mammals, sea turtles and seabirds. On the other hand, elasmobranch species not included in the Barcelona Convention, yet sometimes assessed as regionally "Endangered" or "Critically Endangered" by the IUCN Red List (2016), can still be caught and commercialized (although for those listed in Annex III of the SPA/DB Protocol, special reporting should be undertaken). This scenario can create misunderstandings when it comes to distinguishing protected versus non-protected species, all of which may "look" the same. Such ambiguity can create further uncertainty or even errors in the assignment of a species to a particular (protection) category, thus leading to difficulties in the enforcement of the regulations among final users and administrations. In addition, a lack of general awareness of the current legislation could prevent effective implementation at the national level. For example, in many of the recent studies analysed in this review that concluded by invoking protection for selected "Endangered" or "Critically Endangered" species, no mention was made to the current regional protection framework already granted to the same elasmobranch species, listed in Annex II of the SPA/BD Protocol.

In general, all these difficulties of communication with final users, management and regulation enforcement can favour, especially in the case of elasmobranch bycatch, illegal, unreported and unregulated (IUU) fishing, which represents one of the most serious threats to the sustainability of fisheries. Different forms of IUU fishing can directly and indirectly affect elasmobranch species, particularly through the capture of protected shark and ray species, and include the use of banned types of fishing gear, fishing within restricted or closed areas (e.g. no-take zones or within three nautical miles of the coast or at depths of 50m or less) and fishing with towed gear beyond a depth of 1 000 m.

In conclusion, the management models considered to record and reduce the impact on elasmobranchs should not differ substantially from those procedures applied to other vulnerable species, such as marine mammals, sea turtles and seabirds, for which the highest levels of protection and conservation are expected. Potentially useful conservation measures for maintaining elasmobranch populations are already known and include fishing bans in nurseries and breeding/mating areas, as well as the release of all live specimens at sea, when the fishing gear allows,

as in the case of longliners, for which post-capture survival rates have been found to be high (Bradai *et al.*, 2016). The implementation of the precautionary approach is of special importance for elasmobranch species for whom data are limited and assessments of conservation status are often categorized as "Endangered," "Critically Endangered,"' or even "Data Deficient" in the IUCN Red List (IUCN, 2021 and Table 1b). It is therefore imperative to gather information from all the fisheries data collection framework programmes in place and to build a cooperative network of stakeholders, from local fishers and research scientists to national and international organizations. Only through collaboration and clear communication between these different groups with different interests from all the countries bordering the Mediterranean and Black Sea, can the decline of elasmobranch populations be reversed.

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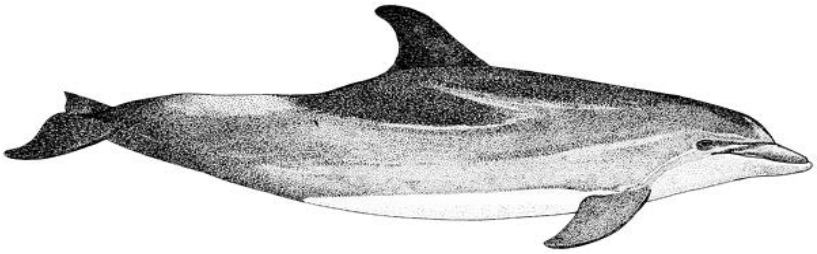
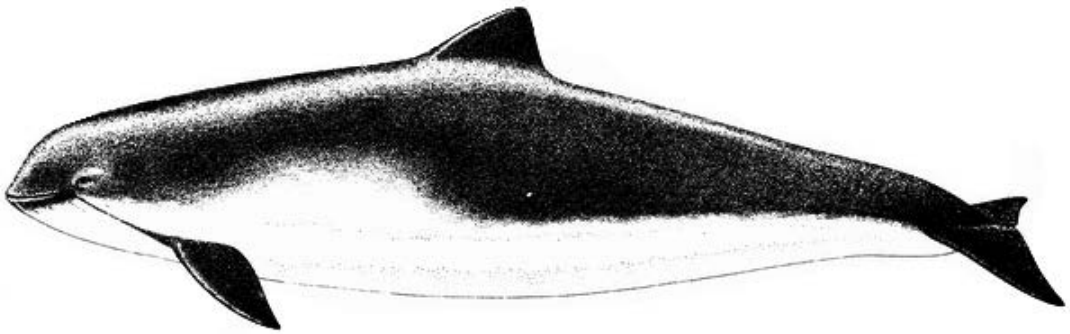
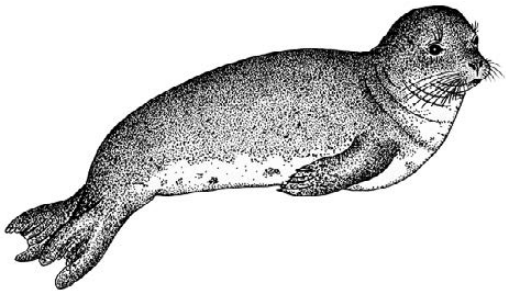
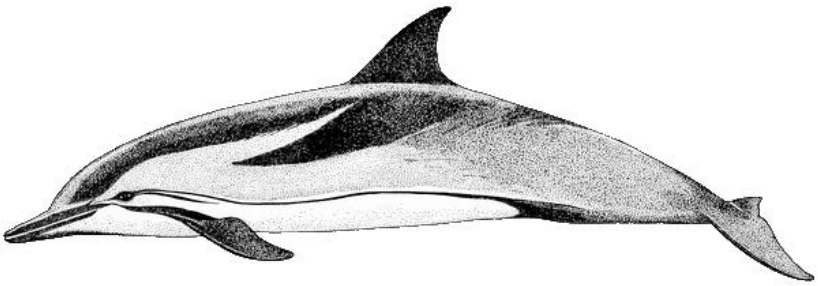


MARINE MAMMALS







Bottlenose dolphins (*Tursiops truncatus*)

4. Marine mammals

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Executive summary

The marine mammal species inhabiting the Mediterranean and the Black Sea belong to two different infraorders of the class Mammalia: Pinnipedia and Cetacea. At present, 18 different cetacean species and three subspecies have been sighted in the Mediterranean and Black Sea. The Mediterranean monk seal (*Monachus monachus*) is the only pinniped species inhabiting the Mediterranean region. Interactions between monk seals and fishers are well documented and described in literature and have always been of great conservation concern, especially in the past. In the Mediterranean, interactions between monk seals and fishing activities often lead to economic consequences for the fishers, such as damage done to fishing gear (for example, holes and ruptures) and loss of catch. Conversely, monk seals may remain entangled themselves when interacting with fisheries. Entrapment of monk seals in fishing gear has been reported from all areas of the species' distribution. The majority of interactions between monk seals and fisheries have been found to occur in coastal areas and especially involve small-scale fisheries using trammel nets, gillnets and longlines and whose activities overlap with Mediterranean monk seal habitats and target the same resources. Indeed, entanglement in gillnets and trammel nets has historically presented a major threat to the species in the absence of adequate management measures. Over recent years, reports on the mortality of Mediterranean monk seals due to fisheries are scarce, following the implementation of protection policies (for example, marine protected areas and closure to fisheries in those areas where monk seals occur) that have significantly helped to reduce the incidence of interactions with fisheries. Signs of population recovery, albeit minimal, have been recognized.

Interactions between cetaceans and different types of fishing gear (for example, trammel nets, gillnets and small-scale set longlines) have long represented a profound concern. Some cetacean species, mainly those inhabiting coastal areas, are attracted to fisheries, which offer them concentrations of "easy food" that can save them profitable energy. In the Mediterranean Sea, large-mesh driftnets targeting sizeable pelagic species, such as swordfish or tunas, represent the main sources of concern. Based on the high incidental catch rates and very high mortality rates of individuals entangled, researchers worldwide have arrived at a consensus around the severe impacts of these nets – resulting from their low selectivity – on cetacean populations, including large species. The intense use of drifting nets began in the Mediterranean in the mid-1980s. It was estimated during the late 1980s and early 1990s, which period corresponds to the peak of driftnet fishery activity, that up to 10 000 cetaceans were incidentally caught each year across the whole Mediterranean. An international moratorium on the use of driftnets to capture large pelagic species anywhere in the Mediterranean or Black Sea was issued in the early 2000s. Since about 2010, the number of new records and publications concerning surveys or studies of cetacean bycatch in different types of fishing gear, especially in the Mediterranean Sea, has drastically reduced. Formerly, at least up until the late 1990s, most cetacean bycatch occurred in large-mesh driftnets; in fact, once large driftnets were dismissed, cetacean bycatch considerably decreased, and currently concerns only sporadically medium-small cetacean species, such as the bottlenose dolphin (*Tursiops truncatus*) and the common dolphin (*Delphinus delphis*).

In contrast, depredation seems to be increasing compared to a few decades ago, now involving different and larger species of dolphins. Depredation can become a conservation issue if it results in an increased probability of bycatch or if it causes fishers to take retaliatory measures against marine mammals. It is therefore clear that the different types of interactions and the probability of entanglement depend on the characteristics of the fishing gear, such as mesh size, yarn strength, depth of deployment and fishing strategies, among other aspects. However, entanglements due to depredation are generally scarce. Recent information on cetacean bycatch has emerged from the Black Sea, where incidental catch of the three cetacean species endemic to the region continues in the context of the Black Sea coastal turbot bottom net fisheries. The high incidental catch mainly involves the Black Sea harbour porpoise (*Phocoena phocoena relicta*), which generally lives in coastal habitats and is impacted much more than the other cetacean species. From a technical point of view, this differential impact is probably due to a combination of both the size of the mesh used in the gillnets and/or trammel nets and the size of the Black Sea harbour porpoise, which is the smallest of the three cetacean species in the Black Sea.

Overall, though it has always been difficult to make reliable estimates of incidental catch, the literature and datasets analysed in this review indicate that in recent years (at least since 2008), the incidental catch of cetaceans in Mediterranean fisheries is decreasing with respect to the past. However, interactions (i.e. incidental catch and/or depredation) between marine mammals and fishing activities still occur, and in some areas (for example, Black Sea), still need to be carefully addressed in order to better understand and prevent any kind of conflict. Solid and standardized monitoring programmes would facilitate the application of emergency measures in areas where negative interactions continue to occur.

4.1 Description of the group

The marine mammal species inhabiting the Mediterranean and the Black Sea belong to two different infraorders of the class Mammalia: Pinnipedia and Cetacea. Taking into account the

great differences between these two groups, in terms of life traits, behaviour, interactions with fishers and different types of fishing gear, as well as, most importantly, incidental catch, they will be treated separately in each of the following sections.

4.1.1 Pinnipeds

Pinnipeds (*Pinnipedia*), commonly known as seals, are represented in the area by a single species, the Mediterranean monk seal, *Monachus monachus* (Hermann, 1779). Historically, this species was widely distributed all over the Mediterranean and the Black Sea, and its range extended into North Atlantic waters as well, from northern Morocco to northern Mauritania (Cabo Blanco), through the Canary Islands, Madeira Islands and the Azores (Israëls, 1992; Cebrian, 1998a; Ronald and Healey, 1976, 1982; Johnson and Lavigne, 1999; Brasseur, Reijnders and Verriopoulos, 1997; Johnson *et al.*, 2006). Over centuries, however, monk seals have disappeared from the majority of their range (Cebrian, 1998a, 2005, 2007). The Mediterranean seal population has faced the most severe contraction and fragmentation, beginning at the middle of the last century, as a result of several interrelated factors, such as pollution, human-induced death (e.g. incidental entrapment in fishing gear) and loss of habitat, mainly due to coastal urban development and mass tourism (Johnson and Lavigne, 1998).

Previous records indicate that *M. monachus* was widely distributed across the entire Black Sea area, along the coasts of the Russian Federation, Ukraine, Romania, Bulgaria and Turkey (Boulva, 1979). Some studies carried out since the 1960s have revealed that, beginning after the Second World War, the species' presence was progressively eradicated from the northern part of the basin and that subsequently, its distributional range was left concentrated only along the central Black Sea coast of Turkey (Mursaloğlu, 1964; Öztürk, 1994; Kıraç and Savaş, 1996; Sergeant *et al.*, 1978; Berkes *et al.*, 1979). Dobrovolov and Yoneva (1996) reported some sightings of monk seals along the southern Bulgarian coast, where Spiridonov and Spassov (1998) reported the presence of only two or three individuals. The survey carried out by Güçlüsoy *et al.* (2004) over the period 1994–1998 demonstrated that while 120 seal sightings were reported by interviews with fishers along the entire Turkish coast of the Black Sea, these sightings corresponded to a monk seal population of only two to three individuals surviving along the central coast of the Black Sea. Nowadays, though some individuals can still be found in the Marmara Sea (Inanmaz, Degirmenci and Gücü, 2014), *M. monachus* can be considered no longer present in the Black Sea (Kiraç, 2001).

With regard to the whole Mediterranean, the monk seal population as estimated by means of fieldwork (e.g. observations, questionnaires, etc.) was reported towards the end of the twentieth century as totalling a minimum of around 700 individuals, with the largest subpopulation found in Greece (around 235–300 seals) (Cebrian, 1998a).

Regular reproduction within the Mediterranean Sea is thought to persist currently only in a few breeding areas off Greece, and in parts of Turkey and Cyprus. As a whole, the eastern Mediterranean population is estimated to consist of about 350 mature individuals (Karamanlidis *et al.*, 2015). The most important assemblage, of 85 to 120 individuals, is found in the Cyclades Islands of Greece (southern Aegean Sea), where active reproduction and at least 24 yearly births have been verified across 30 caves (Cebrian, 1998a). Important populations were also identified in the northern part of the Sporades Islands (>35 seals) and at Zakynthos Island (15–22 seals) (Cebrian, 1998a, 2008). A review of the abundance and distribution of the monk seal population was prepared by Notarbartolo di Sciara and Kotomatas (2016) as an update to the work of Notarbartolo di Sciara

et al. (2009); they reported important breeding concentrations of monk seals in Greek waters: Gyaros Island (65–70 individuals); northern Sporades Islands (>50 individuals); Kimolos and Polyaigos Islands (<50 individuals); North Karpathos and Saria Islands (>20 individuals); Ionian Islands: Kefalonia, Lefkada, Ithaca and Zakynthos (about 20 individuals). Monk seals in Turkish Mediterranean waters are scattered from the Dardanelles to the border with Syria, with three main breeding concentrations known: in the northern Aegean (35 individuals), southern Aegean (<30 individuals) and on the Mediterranean coast (>40 individuals). In Cyprus, a small population of 3–17 individuals was judged to exist in 2006–2007 and evidence remains that pupping still occurs, even if the contribution from Cyprus is now minimal (<10 individuals) (Notarbartolo di Sciara and Kotomatas, 2016).

Between 2009 and 2016, 66 monk seal records were reported along the coast of Israel; while most sightings may refer to a single individual, there is evidence that at least two seals were present (Scheinin *et al.*, 2011; Bundone *et al.*, 2016).

Vagrant individuals have been episodically sighted elsewhere in the Mediterranean, suggesting a possible return to some of their formerly inhabited areas, such as Albania, Croatia, Egypt, Israel, Italy, Lebanon, Libya (particularly Cyrenaica), Spain and Syria (Cebrian, 1995, 2005; Monachus Guardian, 2010, 2012; Mo, 2011; Huber, 2014; Notarbartolo di Sciara and Kotomatas, 2016; Alfaghi *et al.*, 2013; Gomerčić *et al.*, 2011).

Outside the Mediterranean Sea, other subpopulations still exist in the Atlantic Ocean, around Cabo Blanco (over 360 individuals) and the Madeira Islands (Portugal) (less than 50 individuals) (Fundación CBD Habitat, 2020; Karamanlidis *et al.*, 2015). Conservation measures introduced over the last 30 years have helped to curb population decline, and there is evidence of recent small increases in these monitored subpopulations.

PLATE 1
Mediterranean monk seal (*Monachus monachus*)

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4.1.2 Cetaceans

Cetaceans (infraorder: Cetacea), namely whales, dolphins and porpoises, are represented in the Mediterranean Sea by at least 21 species (12 of which occur regularly, while the other eight only do occasionally) and three subspecies, endemic to the Black Sea: the Black Sea common dolphin (*Delphinus delphis ponticus*) (Barabasch-Nikiforov, 1935), the Black Sea bottlenose dolphin (*Tursiops truncatus ponticus*) (Barabash-Nikiforov, 1940) and the Black Sea harbour porpoise (*Phocoena phocoena relicta*) (Abel, 1905) (Table 1). The status of conservation and the range of size and distribution of the different cetacean populations in the Mediterranean and the Black Sea vary greatly, depending on the species and areas. To a greater or lesser extent, all cetacean species may interact with different fishing gears and fishing activities. For this reason, assessing the abundance and distribution of the different species is essential in order to better understand and evaluate the relative importance of various kinds of interactions with fishing activities and the impacts of incidental catch (Notarbartolo di Sciara, Podestà and Curry, 2016).

The striped dolphin (*Stenella coeruleoalba*) is the most abundant and widespread cetacean species in the whole Mediterranean basin, though it is generally more abundant in the western Mediterranean. In the past, and more recently, population estimates have been calculated in several areas using different methods (for example, through vessel and aerial surveys). Numbers show a high variability, from a few thousand in limited local populations to more than a hundred thousand at the basin scale (Aguilar, 2000; Forcada and Hammond, 1998; Forcada, Notarbartolo di Sciara and Fabbri, 1995a; Forcada *et al.*, 1994; Gómez de Segura *et al.*, 2006: Fortuna *et al.*, 2007; Panigada *et al.*, 2011, 2017; Laran *et al.*, 2017; Benmessaoud *et al.*, 2018).

The common bottlenose dolphin (*Tursiops truncatus*) is the most common species in coastal and neritic areas and, for this reason, is considered the species that interacts the most with small-scale fishing activities. Studies have been carried out on several populations along the Mediterranean coasts of Spain, Italy, Greece, Croatia (Bearzi, Fortuna and Reeves, 2009) and Tunisia (Benmessaoud *et al.*, 2018). The same phenomenon applies to the Black Sea subspecies, the Black Sea bottlenose dolphin (*Tursiops truncatus ponticus*).

The common dolphin (*Delphinus delphis*) has shown a steep decline in its abundance and distribution in the Mediterranean basin over the last hundred years due to the impacts of human activities – not only of fisheries, but also of pollution and habitat loss (Bearzi *et al.*, 2003, 2005). Currently, the most abundant populations occur in the Greek Ionian Sea, the Alboran Sea and off the northern coast of Africa.

Population estimates for all other cetacean species present in the Mediterranean are much more difficult to calculate and results are less reliable. However, these abundances are certainly lower than those of the species described above; for example, the estimate for the fin whale

PLATE 2
Black Sea dolphins

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Black Sea common dolphin (*Delphinus delphis ponticus*)

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Black Sea bottlenose dolphin (*Tursiops truncatus ponticus*)

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Black Sea harbour porpoise (*Phocoena phocoena relicta*)

Table 1 – Cetacean species in the Mediterranean and the Black Sea

Common name	Scientific name
Striped dolphin	*Stenella coeruleoalba* (Meyen, 1833)
Common bottlenose dolphin	*Tursiops truncatus* (Montagu, 1821)
Black Sea bottlenose dolphin	*Tursiops truncatus ponticus**
Common dolphin	*Delphinus delphis* (Linnaeus, 1758)
Black Sea common dolphin	*Delphinus delphis ponticus**
Black Sea harbour porpoise	*Phocoena phocoena relicta**
Risso's dolphin	*Grampus griseus* (G. Cuvier, 1812)
Rough-toothed dolphin	*Steno bredanensis* (Cuvier in Lesson, 1828)
Long-finned pilot whale	*Globicephala melas* (Traill, 1809)
Cuvier's beaked whale	*Ziphius cavirostris* (Cuvier, 1823)
Killer whale	*Orcinus orca* (Linnaeus, 1758)
Sperm whale	*Physeter macrocephalus* (Linnaeus, 1758)
Fin whale	*Balaenoptera physalus* (Linnaeus, 1758)
False killer whale	*Pseudorca crassidens* (Owen, 1846)
Common minke whale	*Balaenoptera acutorostrata* (Lacépède, 1804)
Humpback whale	*Megaptera novaeangliae* (Borowski, 1781)
Indian Ocean humpback dolphin	*Sousa plumbea* (Cuvier, 1829)
Sei whale	*Balaenoptera borealis* (Lesson, 1828)
North Atlantic right whale	*Eubalaena glacialis* (P.L.S. Müller, 1776)
Dwarf sperm whale	*Kogia sima* (Owen, 1866)
Northern bottlenose whale	*Hyperoodon ampullatus* (Forster, 1770)
Blainville's beaked whale	*Mesoplodon densirostris* (Blainville, 1817)
Gervais' beaked whale	*Mesoplodon europaeus* (Gervais, 1855)

Notes:
In grey, species recorded only occasionally (modified from Pace, Tizzi and Mussi, 2015).
*Endemic subspecies of the Black Sea.

(*Balaenoptera physalus*) comes to around one thousand individuals, the majority of which are found in the western Mediterranean (Panigada *et al.*, 2017), though seasonal variation and different estimates were reported by Laran *et al.* (2017). For all the other cetacean species, no estimates are available at the basin scale, only at the local level. A few hundred individuals have been estimated for each of the following species: Risso's dolphin (*Grampus griseus*), Cuvier's beaked whale (*Ziphius cavirostris*), long-finned pilot whale (*Globicephala melas*), false killer whale (*Pseudorca crassidens*) and sperm whale (*Physeter macrocephalus*) (Notarbartolo, Podestà and Curry, 2016). Finally, two other species occur unexpectedly at opposite sides of the Mediterranean: a small population of killer whales (*Orcinus orca*) – less than 40 individuals (Esteban *et al.*, 2016) – inhabits the area of the Strait of Gibraltar, while the elusive rough-toothed dolphin (*Steno bredanensis*) is present in the easternmost part of the Mediterranean, though its abundance is unknown (Kerem *et al.*, 2016).

In the Black Sea, human activities have strongly impacted the populations of the three cetacean subspecies inhabiting the basin. After the ban on direct hunting, several studies were carried out, mainly within the last 20 years, aimed at estimating cetacean abundance in the area by means of vessel and aerial surveys (Dede (cited in IWC, 2004); Krivokhizhin, 2009; Komakhidze and Goradze, 2005; Sokolov, Yashkin and Yukhov, 1997; Birkun *et al.*, 2002, 2003, 2004; Krivokhizhin *et al.*, 2006; Paiu *et al.*, 2019). The most recent estimates for population abundance of the three subspecies, based on surveys carried out along the western coasts of the basin, come to around 60 000 individuals for the Black Sea common dolphin (*Delphinus delphis ponticus*), 26 000 for the Black Sea bottlenose dolphin (*Tursiops truncatus ponticus*) and 29 000 for the Black Sea harbour porpoise (*Phocena phocena relicta*) (Birkun *et al.*, 2014).

In general, both the diversity and abundance of cetaceans are higher in the western Mediterranean basin. Interactions with fisheries, including incidental catch, depend on the habitat use, behaviour, size and abundance of the cetacean species involved. Similarly, each type of fishing gear represents a potential site of entanglement/entrapment, depending on the fishing gear characteristics (net mesh size, hook type), structure, surface area and time of displacement at sea, as well as fishing areas and strategies.

4.2 Historical records of interactions with fisheries

4.2.1 Pinnipeds

Interactions between Mediterranean monk seals (*Monachus monachus*) and fishers, fishing boats and fishing gear are well documented and described in the relevant literature and are of great conservation concern (Cebrian, 1998a, 2005, 2008; Güçlüsoy, 2008; Güçlüsoy and Savas, 2003; Karamanlidis *et al.*, 2008; Hale *et al.*, 2011). In the Mediterranean, interactions between monk seals as well as other marine mammals (see Section 4.3) with fishing activities often lead to economic consequences for the fishers, such as damage to fishing gear (for example, holes and ruptures), loss of catch, or depredation (Schultze-Westrum, 1976; Boulva, 1979; Berkes, 1982; Cebrian, 1998a; Ronald and Healey, 1974; Marchessaux and Duguy, 1977; Cebrian and Anagnostopoulou, 1995; Cebrian, Anagnostopoulou and Anagnostopoulou, 1995; Berkes *et al.*, 1979; Ríos *et al.*, 2017). The typical damage caused by seals consists of holes about 20 to 30 cm in diameter (Marchessaux and Duguy, 1977) and a characteristic triangular three-hole pattern, corresponding to the animal's mouth and fore-flippers (Goedicke, 1981; Johnson, 1988). On the other hand, when interacting with fisheries, monk seals may remain entangled themselves (Avellá, 1986; Harwood, 1987; Cebrian, 1998a; Öztürk, 1998b; Ronald and Duguy, 1979; Avellá and González, 1989; Cebrian and Vlachoutsikou, 1992; Öztürk and Dede, 1995; Panou, Jacobs and Panos, 1993; Berkes *et al.*, 1979). Incidental entanglement, coupled with increasing fishing effort and the introduction of new materials for fishing gear, has been considered one of the major problems facing monk seals in different Mediterranean areas (Öztürk, 1998a; Cebrian, 2005; Johnson and Lavigne, 1998, 1999; Cebrian, Anagnostopoulou and Anagnostopoulou, 1995; Androukaki *et al.*, 1999).

Entrapment of monk seals in fishing gear has been reported from all areas of the species' distribution. Although analysis of historical records shows that seals can be injured by many types of fishing gear, they appear to be most vulnerable to passive gear (i.e. stationary nets set on the bottom) and abandoned nets (i.e. the ghost fishing effect) (Tudela, 2004). The majority of interactions between monk seals and fisheries have been found to occur in coastal areas and especially involve small-scale fisheries using trammel nets, gillnets, longlines or traps, whose activities overlap with *M. monachus* habitats and target the same resources. Entanglements have been historically recorded on baited hooks in the Danube Delta (Schnapp, Hellwing and Chizelea, 1962), on tuna nets near Cassis, in southeastern France, in the 1930s and 1940s (Cheylan, 1974; Sergeant *et al.*, 1978), in trammel nets in the Bay of Tunis (Ben Othman, Mokhtar and Quignard, 1971) and in coastal gillnets in Greece (Northridge, 1984). Some authors have described other types of fishing gear as being responsible for entanglement including trawl nets and purse seines (Brusina, 1889; Harwood, 1987; Israëls, 1992; Cebrian, 1998a; Cebrian and Vlachoutsikou, 1992; Kiraç and Savas, 1996; Johnson and Karamanlidis, 2000; Panou, Beudels and Harwood, 1987; Panou, Jacobs and Panos, 1993; Güçlüsoy, Johnson and Karamanlidis, 2002), though these gear types have not been considered to present a problem for monk seals (Cebrian, 1998a; Cebrian and Vlachoutsikou, 1994). Young monk seals have also been reported as bycatch of *lampara* fisheries (a kind of purse seiner) and are

considered more vulnerable, as they are worse equipped to escape from entrapment than adult specimens (Panou, Beudels and Harwood, 1987).

In the western Mediterranean, the incidental catch of monk seals in trammel nets has been recorded commonly in Italy since the 1940s (Di Natale and Notarbartolo di Sciara, 1990), while captures were noted occasionally from coastal gillnets in Morocco (Maigret, 1990) and in Algeria (Di Natale and Notarbartolo di Sciara, 1990); eight specimens died in Algeria between 1987 and 1990 due to interactions with humans (Boutiba, 1996). A similar scenario was observed for the small colony of monk seals inhabiting a cave on Gorgona Island (Tyrrhenian Sea, Italy): eight individuals perished due to entanglement in the nets of a local fisher during the 1980s (Guarrera, 1999).

However, an analysis of historical data on the causes of death for monk seals in the eastern Mediterranean and along the North African coast from 1970 to 2000 reveals that entanglements in fisheries have progressively declined. Indeed, Ronald and Healey (1974), basing their findings on interviews with fishers conducted during 1971 and 1972 (Kos, Greece), estimated that only up to four seals were caught annually in local nets, dead or alive; some years later, Jacobs and Panou (1988) reported that only eight of 34 animals died due to incidental capture in nets in the Ionian Sea, while the other 26 died from undetermined causes.

A differential vulnerability to entanglement in nets has been suggested for adult and young monk seals in the Cilician basin, off Turkey (Yediler and Gücü, 1997). It was observed that both trammel and gill nets were not strong enough to trap adults, whereas some pups were found entangled in these types of fishing nets over a five-year period. Cebrian, Anagnostopoulou and Anagnostopoulou (1995) also reported several records of pups drowned in trammel nets in the Cyclades. Indeed, pups foraging together with their mothers likely learn to eat fish from nets, thus becoming vulnerable to entanglement (Cebrian, 1995, 1998a). Kiraç and Savas (1996), and Yediler and Gücü (1997) furthermore reported a total of 13 seal deaths between 1965 and 1994 in Mediterranean and Black Sea Turkish waters.

Interviews with fishers revealed that, with very few exceptions, seals were considered to represent competition for fishers themselves. Goedicke (1981) made an attempt to ascertain fishers' attitudes towards seals and to determine the extent of net damage and loss of fish attributable to seals. Estimates of net damage ranged between USD 215 and 380 annually per boat. Cebrian (1998a) considered that, due to the weakness and methodological mistakes in data collection from fishers' interviews, unreliable conclusions had been drawn in some cases regarding the interpretation of seal–fisheries interactions, thus exaggerating interactions with nets. This situation results from fishers tending to report every time they suffer damage to their nets, but not doing so when many fishing trips are carried out without incident. In fact, onboard observations confirmed that most net damage was due to other causes, especially contact and entanglement of the gear along the sea bottom.

An additional investigation to determine the extent of net damage caused by monk seals was made by Panou, Jacobs and Panos (1993). During a survey around the islands of Kefalonia, Ithaca and Lefkada in the Greek part of the Ionian Sea, they noted that out of 1 864 fishing trips monitored over the survey period, only 136 instances (7.3 percent) of reported damage were clearly caused by monk seals. Inshore trammel nets suffered the highest frequency of seal-related damages, followed by offshore trammel nets and gillnets. Conversely, set longlines sustained

the least damage, possibly because of the fine nylon lines used. Moreover, they reported, from interviews and literature, 34 cases of seal mortality between 1963 and 1987. Analysis of long-term field monitoring data in the southern Ionian Sea has also shown that monk seal interactions with static nets became much less frequent as nets were placed further away from an occupied cave. Indeed, net damage dropped to very low levels at distances along the coast greater than five nautical miles from seal caves, and all the way to insignificance at distances more than ten nautical miles from seal caves (Cebrian, 2008). Regarding seasonality, lower levels of interaction between seals and nets have been observed in the spring in the southern Ionian Sea (Cebrian, 1998b, 2008), which is probably related to monk seals fasting during this peak period of moulting and the consequent reduction in fish predation. In contrast, damage done by dolphins in the same area showed no seasonal difference.

Cebrian (1995) indicated that damage done by seals to fish traps was common in the past in Croatia, while damage to nets was reported as rare in the Adriatic when a monk seal population was still present there.

Androukaki *et al.* (1999) reported the results of a survey carried out in Greece between 1991 and 1995. Over this period, 59 dead monk seals were examined (25 by necropsy and 34 by different methods), while other information was added for 20 cases of dead seal strandings between 1985 and 1990. Considering all 79 cases, the most frequent cause of death (32 percent) was interactions with fisheries, followed by natural causes (16 percent) and other unspecified accidents (13.9 percent); however, for 30 individuals (38 percent) the cause of death could not be determined. In the same paper, an extensive review of the relevant literature was carried out, in which the authors critically revised the cause of death for 182 monk seals in Greek waters in previous years, prior to 1985. The results showed that interactions with fishing activities represented the cause of death in 65 percent of these cases (118 individuals).

Entrapment in fishing nets has also been implicated in the death of a monk seal pup in the Foça Specially Protected Area, located at the northeastern entrance of Izmir Bay, Turkey and in its immediate vicinity in February 1997 and of an adult seal found at Kaş in southwestern Turkey in 1999 (Johnson, ed., 1999; Güçlüsoy *et al.*, 2004).

The entanglement of seals in set fishing gear appeared to represent a constant issue for *M. monarchus* in all the studied regions, except the Black Sea and Marmara Sea (Güçlüsoy *et al.*, 2004). As stated already, the monk seal is probably almost extinct in the Black Sea, though occasional sightings have been recorded over the past 25 years along the central coast of Turkey and Bulgaria and some recent records exist from the Marmara Sea. Only Schnapp, Hellwing and Chizelea (1962) have reported some old cases of incidental catch of monk seals by longlines along the Bulgarian coast.

Entanglement in gillnets and trammel nets has historically been a major threat to *M. monachus* in the absence of related management measures, especially in certain areas with more robust populations, where drowning in nets surpassed 37.5 percent of the mortality records (see Table 5), as in the Cyclades, which are surrounded by shallow waters (Cebrian, Anagnostopoulou and Anagnostopoulou, 1995) and the eastern Aegean (Öztürk, 1998a).

4.2.2 Cetaceans

Though no whaling activities have regularly targeted large cetaceans in the Mediterranean Sea, except over limited periods in certain places (Cabrera, 1925; Sanpera and Aguilar, 1992; Aguilar and Borrell, 2007; Bernal-Casasola *et al.*, 2016), small cetaceans (as well as monk seals) have been caught for a variety of reasons in the past (Cebrian, 1998a; Bearzi, 2002; Bearzi, Holcer and Notarbartolo di Sciara, 2004; Androukaki *et al.*, 2006; Birkun *et al.*, 2014; Karamanlidis *et al.*, 2015), including for: museum collections and research (Richard, 1936); military target practice (Minà Palumbo, 1868; Cornalia, 1872; Parona, 1896, 1908; Anonymous, 1903; Cagnolaro, 1977; Littardi, Rosso and Wurtz, 2004); and hunting by fishers who perceived these animals as direct competitors (Lepri, 1914; Borri, 1927a, 1928b; Brunelli, 1932; Bolognari, 1949; Tamino, 1953; Cyrus, 1969; Avellà, 1979; Poggi, 1986; Öztürk, 1998a, 2007; Kiraç and Savaş, 1996; Dede, Tonay and Öztürk, 2015; Androukaki *et al.,* 1999; Notarbartolo di Sciara *et al.*, 2003; Danyer *et al.* 2013a).

In addition, interactions between cetaceans and different types of fishing gear (e.g. trammel nets, gillnets and small-scale set longlines) have long represented a profound concern. Some cetacean species, mainly those inhabiting the coastal areas, are attracted to fisheries, which offer them concentrations of "easy food," saving them profitable energy. This type of interaction (i.e. depredation, see Section 4.4), in addition to catch removal, can cause significant damage to set nets (such as holes and breakages) and generate economic losses for fishers.

As for the monk seal, information on the incidental catch of cetaceans in fishing gear in the Mediterranean used to be only anecdotally collected; beginning in the 1960s and 1970s, however, interest developed from a statistical point of view. Indeed, concerns about marine mammal conservation led to the implementation of scientific studies in this field, including more precise record-keeping, interviews with fishers, surveys and direct observations at sea, and assessments of the causes of stranding.

In the Black Sea, the regular recording of incidental catch began in the former Soviet Union in 1968 and lasted until 1993, during which period information on cetacean bycatch was partly collected in all the other countries of the Black Sea as well. Set nets targeting Black Sea turbot (*Scophthalmus maximus*) and piked dogfish (*Squalus acanthias*) were found to cause the greatest bycatch impacts on Black Sea cetaceans.

In the Mediterranean Sea, large mesh driftnets targeting sizeable pelagic species, such as swordfish (*Xiphias gladius*) or albacore tuna (*Thunnus alalonga*), represented the main sources of concern. Worldwide, researchers arrived at a consensus on the severe impacts of these nets on cetacean populations, including large species, based on the high incidental catch rates and very high mortality rates of individuals entangled. The intense use of drifting gillnets began in the Mediterranean in the mid-1980s (Di Natale, 1990a, 1990b, 1990c, 1990d, 1990e) and was introduced widely in Algeria, France, Greece, Malta, Morocco, Spain and Turkey (Di Natale and Notarbartolo di Sciara, 1994; Silvani, Gazo and Aguilar, 1999). As a result, the number of vessels rapidly expanded to over 1 000 by 1990 (IWC, 1994); for example, the Italian driftnet fleet was reported to be the biggest in the Mediterranean, increasing by 57 percent between 1987 and 1990, with up to about 700 boats. One of the main issues with driftnets targeting large pelagic fish species involves the nets' low selectivity, given that swordfish represented nearly 50 percent in weight of the Italian driftnet catch, but only 18 percent by number (Di Natale, 1996). Moreover, very few specimens of marine mammals caught were able to be disentangled and released alive;

furthermore, adults of the larger species (for example, sperm whales and pilot whales), though often still alive when the net was retrieved, were generally set adrift for days before death (Mussi *et al.*, 2004).

It was estimated at the end of the 1980s and beginning of the 1990s, which period corresponds to the peak of driftnet fishery activity, that a total of over 8 000 cetaceans were incidentally caught each year from Italian seas and up to 10 000 cetaceans across the whole Mediterranean (Di Natale 1990a, 1990b, 1990c, 1990d, 1990e, 1992; Notarbartolo di Sciara, 1990; IWC, 1994; UNEP and IUCN, 1994; Cagnolaro and Notarbartolo di Sciara, 1992; Di Natale and Notarbartolo di Sciara, 1994; Forcada and Hammond, 1998; Silvani, Gazo and Aguilar, 1999). Of these, the striped dolphin (*Stenella coeruleoalba*) was the most impacted species by number, though the effects were more severe on larger species, such as the sperm whale (*Physeter macrocephalus*) and the long-finned pilot whale (*Globicephala melas*), taking into account their population dynamics and abundance. In 1992, the United Nations General Assembly established an international moratorium prohibiting driftnets longer than 2.5 km. Moreover, a prohibition on catching certain pelagic fish species was introduced by the European Union for all its Member States' vessels on 1 January 2002. Afterwards, Recommendation GFCM/29/2005/3 prohibiting the use of driftnets for fisheries of large pelagic species adopted by the General Fisheries Commission for the Mediterranean (GFCM) (GFCM, 2021) and Resolution A/3.1 related to the use of driftnets adopted by the Agreement on the Conservation of Cetaceans in the Black Sea, Mediterranean Sea and contiguous Atlantic area (ACCOBAMS) (ACCOBAMS, 2021) introduced a prohibition on the use of driftnets of any length to capture large pelagic species anywhere in the Mediterranean or Black Sea. Despite these bans and recommendations, together with some programmes put in place in different countries addressing drifting gear replacement, driftnet fisheries continued operations for several years afterwards in certain Mediterranean areas (Cornax, 2009). Given the historical importance of this activity, and in order to paint a better picture of the importance of driftnets in cetacean bycatch in the Mediterranean, the main data collected from the relevant literature are presented in Table 2.

Table 2 – Incidental catch of cetaceans in pelagic driftnets

Bibliographic reference	Reference years	Gear	GFCM subregion	Country	Species	Reported individuals in bycatch events	Estimated bycatch events	Mortality rate/year	Fishing operations/ Number of interactions recorded
Di Natale and Mangano, 1981	-	GND	Western Mediterranean	Italy	*Balaenoptera acutorostrata*	4	-	-	-
Duguy *et al.*, 1983a, 1983b	-	GND	Western Mediterranean	France	*Balaenoptera acutorostrata*	1	-	-	-
Duguy *et al.*, 1983a, 1983b	-	GND	Western Mediterranean	France	*Stenella coeruleoalba*	4	-	-	-
Duguy *et al.*, 1983a, 1983b	-	GND	Western Mediterranean	Italy	*Tursiops truncatus*	1	-	-	-
Duguy *et al.*, 1983a, 1983b	-	GND	Western Mediterranean	Spain	*Tursiops truncatus*	1	-	-	-
Duguy *et al.*, 1983a, 1983b	-	GND	Western Mediterranean	Italy	*Grampus griseus*	1	-	-	-
Duguy *et al.*, 1983a, 1983b	-	GND	Western Mediterranean	Italy	*Physeter macrocephalus*	16	-	-	-
Di Natale and Mangano, 1983b	1978–1982	GND	Western Mediterranean	Italy	*Physeter macrocephalus*	20	-	-	-

Table 2 (continued)

Bibliographic reference	Reference years	Gear	GFCM subregion	Country	Species	Reported individuals in bycatch events	Estimated bycatch events	Mortality rate/year	Fishing operations/ Number of interactions recorded
Notarbartolo di Sciara, 1990	1986–1988	GND	Western Mediterranean	Italy	*Stenella coeruleoalba*	68	-	-	-
Notarbartolo di Sciara, 1990	1987–1988	GND	Western Mediterranean	Italy	*Physeter macrocephalus*	24	-	-	-
Notarbartolo di Sciara, 1990	1988–1988	GND	Western Mediterranean	Italy	*Tursiops truncatus*	13	-	-	-
Notarbartolo di Sciara, 1990	1988–1989	GND	Western Mediterranean	Italy	*Globicephala melas*	10	-	-	-
Notarbartolo di Sciara, 1990	1988–1990	GND	Western Mediterranean	Italy	*Grampus griseus*	5	-	-	-
Notarbartolo di Sciara, 1990	1988–1991	GND	Western Mediterranean	Italy	*Ziphius cavirostris*	2	-	-	-
Notarbartolo di Sciara, 1990	1988–1991	GND	Western Mediterranean	Italy	Unidentified	28	-	-	-
Podestà and Magnaghi, 1989	1988	GND	Western Mediterranean	Italy (Ligurian Sea)	*Stenella coeruleoalba*	18	-	-	-
Podestà and Magnaghi, 1989	1988	GND	Western Mediterranean	Italy (Ligurian Sea)	*Globicephala melas*	4 + 5[2]	-	-	-
Podestà and Magnaghi, 1989	1988	GND	Western Mediterranean	Italy (Ligurian Sea)	*Physeter macrocephalus*	3[2]	-	-	-
Podestà and Magnaghi, 1989	1988	GND	Western Mediterranean	Italy (Ligurian Sea)	*Grampus griseus*	2	-	-	-
Podestà and Magnaghi, 1989	1988	GND	Western Mediterranean	Italy (Ligurian Sea)	*Balaenoptera physalus*	1	-	-	-
Podestà and Magnaghi, 1989	1988	GND	Western Mediterranean	Italy (Ligurian Sea)	Unidentified	4	-	-	-
Reeves and Notarbartolo di Sciara, eds., 2006	1986–2000	GND	Western Mediterranean	Italy	*Physeter macrocephalus*	64	-	-	-
Silvani *et al.*, 1999	1992	GND	Western Mediterranean	Spain	*Delphinus delphis*	6	-	-	13 sets/6
Silvani *et al.*, 1999	1993	GND	Western Mediterranean	Spain	*Delphinus delphis*	6	-	-	27 sets/6
Silvani *et al.*, 1999	1993	GND	Western Mediterranean	Spain	*Stenella coeruleoalba*	5	-	-	27 sets/5
Silvani *et al.*, 1999	1994	GND	Western Mediterranean	Spain	*Stenella coeruleoalba*	15	-	-	54 sets/15
Silvani *et al.*, 1999	1994	GND	Western Mediterranean	Spain	*Delphinus delphis*	15	-	-	54 sets/15
Silvani *et al.*, 1999	1993	GND	Western Mediterranean	Spain	*Stenella coeruleoalba* *Delphinus delphis*	-	366/year	0.1/km	81 sets
Silvani *et al.*, 1999	1994	GND	Western Mediterranean	Spain	*Stenella coeruleoalba* *Delphinus delphis*	-	289/year	0.1/km	81 sets
Di Natale *et al.*, 1992; Di Natale, 1995	1990–1992	GND	Western Mediterranean	Italy	*Stenella coeruleoalba*	12 + 1[2]	-	0.015/km	100 trips/13
Di Natale *et al.*, 1992; Di Natale, 1995	1990–1992	GND	Western Mediterranean	Italy	*Globicephala melas*	1	-	-	100 trips/1

Table 2 (continued)

Bibliographic reference	Reference years	Gear	GFCM subregion	Country	Species	Reported individuals in bycatch events	Estimated bycatch events	Mortality rate/year	Fishing operations/ Number of interactions recorded
Di Natale *et al.*, 1992; Di Natale, 1995	1990–1992	GND	Western Mediterranean	Italy	*Ziphius cavirostris*	1[2]	-	-	100 trips/1
Di Natale, 1995	1990–1991	GND	Western Mediterranean	Italy	*Stenella coeruleoalba*	-	2 512/year	-	100 trips
Di Natale, 1995	1990–1991	GND	Western Mediterranean	Italy	*Globicephala melas*	-	234/year	-	100 trips
Di Natale, 1995	1992–1991	GND	Western Mediterranean	Italy	*Grampus griseus*	-	146/year	-	100 trips
Di Natale, 1995	1991–1993	GND	Western Mediterranean	Italy	*Tursiops truncatus*	-	65/year	-	100 trips
Di Natale, 1995	1991–1994	GND	Western Mediterranean	Italy	*Physeter macrocephalus*	-	18/year	-	100 trips
Di Natale, 1995	1991–1995	GND	Western Mediterranean	Italy	*Ziphius cavirostris*	-	4/year	-	100 trips
Di Natale, 1995	1991–1996	GND	Western Mediterranean	Italy	*Balaenoptera physalus*	-	2/year	-	100 trips
University of Barcelona, 1995	1993–1994	GND	Western Mediterranean	Spain	*Physeter macrocephalus*	9 + 3[2]	-	-	-
Làzaro and Martin, 1999	-	GND	Western Mediterranean	Spain	*Physeter macrocephalus*	15	-	-	-
Mussi *et al.*, 2004	2004	GND	Western Mediterranean	Italy	*Physeter macrocephalus*	5[2]	-	-	-
Reeves and Notarbartolo di Sciara, eds., 2006	1971–2004	GND	Western Mediterranean	Italy, France, Spain	*Physeter macrocephalus*	229	-	-	-
Tudela *et al.*, 2005	2002–2003	GND	Western Mediterranean	Morocco (Alboran Sea)	*Stenella coeruleoalba*	128	-	0.06/km	369 sets/128
Tudela *et al.*, 2005	2002–2003	GND	Western Mediterranean	Morocco (Alboran Sea)	*Delphinus delphis*	108	-	0.06/km	369 sets/108
Tudela *et al.*, 2005	2002–2003	GND	Western Mediterranean	Morocco (Alboran Sea)	*Stenella coeruleoalba* *Delphinus delphis*	-	3 110–4 184/year	-	369 sets
Tudela *et al.*, 2005	2003–2003	GND	Western Mediterranean	Strait of Gibraltar	*Stenella coeruleoalba* *Delphinus delphis*	-	11 189–15 127/ year	-	369 sets
Bănaru *et al.*, 2010	2000–2003	GND	Western Mediterranean	France	*Stenella coeruleoalba*	58	326/year (in 2000)	-	329 sets/58
Bănaru *et al.*, 2010	2000–2003	GND	Western Mediterranean	France	*Globicephala melas*	1	-	-	329 sets/1
David *et al.*, 2010	2002–2006	GND	Western Mediterranean	France	*Stenella coeruleoalba*	100	81–250/ year	0.034/km	459 sets/100
David *et al.*, 2010	2002–2006	GND	Western Mediterranean	France	*Globicephala melas*	2	-	-	460 sets/2
David *et al.*, 2010	2002–2006	GND	Western Mediterranean	France	*Grampus griseus*	1	-	-	461 sets/1
David *et al.*, 2010	2002–2006	GND	Western Mediterranean	France	*Delphinus delphis*	1	-	-	462 sets/1
David *et al.*, 2010	2004–2005	GND	Western Mediterranean	France	*Physeter macrocephalus*	1 + 3[2]	-	-	463 sets/4
Panou and Tselentis, 1989	1989	GND	Central Mediterranean	Greece	*Ziphius cavirostris*	1[2]	-	-	-
Bradai and Ghorbel, 1998	1995	GND	Central Mediterranean	Tunisia	*Balaenoptera acutorostrata*	1	-	-	-

Table 2 (continued)

Bibliographic reference	Reference years	Gear	GFCM subregion	Country	Species	Reported individuals in bycatch events	Estimated bycatch events	Mortality rate/year	Fishing operations/ Number of interactions recorded
Bradai and Bouain, 1994	-	GND	Central Mediterranean	Tunisia	*Megaptera novaeangliae*	1	-	-	-
Öztürk *et al.*, 2001	1999–2000	GND	Eastern Mediterranean	Turkey (Aegean Sea)	*Stenella coeruleoalba*	13	-	-	-
Öztürk *et al.*, 2001	1999–2000	GND	Eastern Mediterranean	Turkey (Aegean Sea)	*Delphinus delphis*	4	-	-	-
Öztürk *et al.*, 2001	1999–2000	GND	Eastern Mediterranean	Turkey (Aegean Sea)	*Grampus griseus*	2	-	-	-
Akyol *et al.*, 2005	2002	GND	Eastern Mediterranean	Turkey (Aegean Sea)	*Delphinus delphis*	18 + 5[2]	-	-	-
Öztürk and Dede, 2002	2002	GND	Eastern Mediterranean	Turkey (Aegean Sea)	*Physeter macrocephalus*	1[2]	-	-	-
Akyol and Cehyan, 2012[1]	2010–2011	GND	Eastern Mediterranean	Turkey (Aegean Sea)	*Stenella coeruleoalba*	2 + 5[2]	-	-	-

Notes: GND = driftnet.

In grey data collected before 2008.

1. The European Union, the GFCM and ICCAT enforced regulations prohibiting the use of driftnets in the Mediterranean. Afterwards, driftnetting in Turkey was banned in 2006 and, as a result, pelagic gillnetting tended to decrease. However, the Turkish fisheries authority and ICCAT gave limited permission for traditional pelagic gillnetting in Turkish waters until July 2011, when this fleet stopped its activity (Akyol and Ceyhan, 2012).
2. Number of individuals released alive.

In contrast, bottom trawls and midwater pair trawls appeared to present fewer risks to cetaceans (Northridge, 1984, 1991; Reeves, Read and Notarbartolo di Sciara, eds., 2001). From old records, Duguy *et al.* (1983a, 1983b) reported the incidental capture of one striped dolphin (*Stenella coeruleoalba*) and four common bottlenose dolphins (*Tursiops truncatus*) by trawlers in France, and of two short-beaked common dolphins (*Delphinus delphis*), three sperm whales (*Physeter macrocephalus*) and a few fin whales (*Balaenoptera physalus*) by trawlers in Italy, over a long period. Di Natale and Mangano (1983b) provided details for 448 sperm whales stranded in the central Mediterranean between 1978 and 1982; 25 specimens of *Physeter macrocephalus* were also captured incidentally by fishing activities, including three by trawlers, probably corresponding to the same individuals reported by Duguy *et al.* (1983a, 1983b). Much of the rare incidental catch of cetaceans in trawling nets resulted from depredation, particularly in cases involving the common bottlenose dolphin (*Tursiops truncatus*), which can be attracted by fish discards or by the concentration of food available in the trawl net mouth or codend (Bearzi, 2002). Di Natale and Mangano (1981, 1982) and Di Natale (1989) reported some incidental catch of common bottlenose dolphins in Italian waters up to the end of the 1980s, while Consiglio *et al.* (1992) found no evidence of incidental catch of *T. truncatus* in Sardinia.

In the area around the Balearic Islands, Silvani, Raich and Aguilar (1992) reported, based on information collected from fishers in 1991, the death of one common bottlenose dolphin incidentally caught by a trawler over the period 1989–1991. Massuti (unpublished data) monitored 460 commercial trawling trips off Majorca between 2001 and 2004 and did not report any dolphin bycatch despite the presence of several specimens (mainly *Tursiops truncatus*) swimming

near the trawler during observations. In the same area, Gonzalvo *et al.* (2008) observed a high rate of interactions between trawlers and bottlenose dolphins, probably due to the easily available discarded fish or access to fish from the net. As a result, during direct onboard observations of 79 trawling operations conducted between May 2004 and May 2005, though 55 interactions were observed, no incidental catch was recorded, nor was any incidental catch reported in interviews with more than 50 fishers. Elsewhere, in Tunisian waters, only two cases of dolphin bycatch by bottom trawlers were reported: one striped dolphin in 1988 (Bradai, 2000) and one bottlenose dolphin in 2004 (Bradai *et al.*, 2010).

Generally, the risk of incidentally capturing cetaceans within trawl nets has been very low across the Mediterranean; the only exception was recorded along the coast of Israel, where high mortality rates in bottom trawl nets were reported. In this area, out of 67 common bottlenose dolphins (*Tursiops truncatus*) found dead, stranded or adrift, between 1993 and 2004, 26 (39 percent) were incidentally caught in trawl nets (Goffman, Kerem and Spanier, 1995; Feingold *et al.*, 2005; Kent *et al.*, 2005). In the western Mediterranean, fishing activities carried out with midwater pair trawls, targeting small pelagic fish, has resulted in the bycatch of small cetaceans and, occasionally, of fin whales (*Balaenoptera physalus*) or killer whales (*Orcinus orca*) (Sacchi, 2008). However, the impacts of these fisheries remain relatively low compared to those of similar fisheries in the Atlantic region, given the small number of vessels involved in this activity and its low temporal and spatial coverage (i.e. limited fishing grounds and reduced duration of fishing operations).

In the Black Sea, before the 1990s, three Black Sea common dolphins (*Delphinus delphis ponticus*) were incidentally caught by pelagic trawlers targeting anchovy in Georgian territorial waters (BLASDOL, 1999), while two Black Sea common dolphins were recorded as bycatch in November 1995 in Ukrainian territorial waters from pelagic trawling operations for sprat (Birkun, 2002). A more detailed study undertaken in Ukraine in 2006 revealed some incidental catch of both Black Sea harbour porpoises (*Phocoena phocoena relicta*) and Black Sea common dolphins. Birkun *et al.* (2014) reported some data from surveys carried out on pelagic trawlers in 2006: over the course of 54 onboard observations in Bulgaria, no cetacean bycatch was recorded; meanwhile in Ukraine, over the course of 14 observations, the incidental catch of 18 common dolphins and two Black Sea harbour porpoises was reported. No cetacean catch has ever been reported in literature from the trawl fishery in Romanian coastal waters or from beam trawlers operating in Bulgaria and Eastern Turkey.

As far as small-scale fisheries, most vessels in the Mediterranean and Black Sea use set nets (for example, trammel nets and gillnets), representing over 80 percent of the whole fleet operating in the basin (FAO, 2018). Indeed, set nets are widely used along all coasts and are the main site of interactions between cetaceans and fishing gear. Information on incidental catch in this type of fishing gear suggests that set nets cause low mortality in coastal cetacean species, though the high number of sets deployed every day, paired with a scarcity of scientific data or surveys, make it difficult to assess past and current impacts on cetaceans.

Cetacean incidental catch in set nets has been reported from coastal waters throughout the Mediterranean and the Black Sea, both formerly and presently (Díaz López, 2006; Di Natale and Notarbartolo di Sciara, 1994; Brotons, Grau and Rendell, 2008; Birkun *et al.*, 2014). In the past, records of incidental catch described entanglements of sperm whales (*Physeter macrocephalus*), Risso's dolphins (*Grampus griseus*), common dolphins (*Delphinus delphis*) and bottlenose dolphins (*Tursiops truncatus*) in small-scale fixed nets (i.e. gillnets and trammel nets) in Italy, France and

Spain. Anecdotal information concerning four striped dolphins (*Stenella coeruleoalba*), three common dolphins, five bottlenose dolphins, six Risso's dolphins, two minke whales (*Balaenoptera acutorostrata*) and one sperm whale entangled in fixed nets was reported (Di Natale, 1983a, 1983b, 1983c; Di Natale and Mangano, 1983a, 1983b, 1983c; Duguy *et al.* 1983a, 1983b). Furthermore, Duguy and Cyrus (1973) reported the incidental catch of two rough-toothed dolphins (*Steno bredanensis*) along the French Mediterranean coast (1970–72), the first off Granier, near Aigues-Mortes and the second near Toulon. In addition, Duguy (1985, 1986, 1987, 1989) provided further information on cetacean bycatch from the French Mediterranean stranding records.

Around the Balearic Islands, interactions between coastal fisheries and the local bottlenose dolphin (*Tursiops truncatus*) population have been reported for decades, but the frequency of interactions has increased since 1990. Based on information collected from fishers in 1991, Silvani, Raich and Aguilar (1992) reported the death of 13 dolphins incidentally caught in gillnets between 1989 and 1991. In order to evaluate the impact of these interactions, involving mainly bottlenose dolphins in the Balearic Islands, 1 040 fishing trips were monitored by observers onboard nine different vessels between January 2001 and April 2003 (Brotons, Grau and Rendell, 2008; Brotons *et al.*, 2008). Although 139 instances of depredation by dolphins were reported, no incidental catch was recorded.

The common bottlenose dolphin (*Tursiops truncatus*) was regularly found throughout the year along the northern coast of Sardinia (Italy); the increasing use of bottom-set nets (mainly trammel nets) in coastal areas and the presence of fish farms led to a rise in interactions between bottlenose dolphins and human activities at sea (Díaz López, 2005; Díaz López, Marini and Polo, 2004). Two studies were carried out to evaluate the level of interaction between dolphins and bottom-set net fisheries in Sardinia. The first one was undertaken within the boundaries of the Gulf of Asinara marine protected area in 2002, northwest of Sardinia, by means of onboard observers; 88 fishing observations were conducted between October 1999 and October 2001, over the course of 24 different fishing days. However, although bottlenose dolphins were recorded interacting with fishing operations on 29 occasions out of 88, no incidental catch was observed (Lauriano *et al.*, 2004). The second study was carried out along the northeast coast of Sardinia between October 1999 and December 2004, combining direct onboard observations with interviews of fishers (Díaz López, 2006). A total of 744 interviews were carried out, covering about 20 percent of the local fleet; they reported that 2 556 days saw at least some gillnet damage caused by interactions with bottlenose dolphins, i.e. 68.7 percent of the total fishing days. Over 3 720 days of observations, three dolphins (one adult and two immature individuals) were captured (0.29 dolphin per year). Two of the entrapped dolphins were dead, but an immature dolphin was able to be rescued from the net and released alive. No other marine mammal bycatch was recorded. Combining the collected data with the fishing effort of the entire fleet in the area (30 boats) over the five-year period, and assuming a constant probability of incidental catch, the total estimated number of bottlenose dolphins caught annually in gillnets along the northeastern coast of Sardinia would be 1.47 (0.98 immatures, 0.49 adults) (Díaz López, 2006).

In the central and eastern Mediterranean, though no published data based on fishery surveys exist for cetacean bycatch, incidental captures in bottom-set nets have been reported on an anecdotal basis (Di Natale and Notarbartolo di Sciara, 1994). In Tunisia, a bottlenose dolphin entangled in November 1980 in a trammel net, north of Tunis, and a striped dolphin (*Stenella coeruleoalba*) caught in a trammel net were reported by Ktari-Chakroun (1981) and Bradai (1991), respectively. A fin whale (*Balaenoptera physalus*), 9.88 m long, was also incidentally caught in a gillnet in the

region of Sfax in August 2008 (Karaa *et al.*, 2012). Among the records of strandings in Tunisian waters, there are signs of interactions between bottlenose dolphins and fishing nets (Attia El Hili *et al.*, 2010).

In the Levant Sea, Kerem *et al.* (2012), in a review of cetacean strandings along the Israeli coast between 1993 and 2009, reported the incidental catch in gillnets of three rough-toothed dolphins (*Steno bredanensis*), two striped dolphins (*Stenella coeruleoalba*) and two common minke whale (*Balaenoptera acutorostrata*) calves. Generally, the death of a stranded dolphin is attributed to incidental catch when, on external examination, clear indications of entanglement are found, such as pieces of net still present around the body or the caudal fin, or impressions left by the net mesh on the skin. In some cases, death may be due to larynx strangulation during depredation rather than to entanglement. Gomerčić *et al.* (2009) noted that out of 120 dead stranded common bottlenose dolphins (*Tursiops truncatus*) found along the Croatian coast of the Adriatic Sea from 1990 through the beginning of 2008, 12 (10 percent) showed signs of larynx strangulation by gillnet parts, though only in a few cases were the causes of death identifiable through external examination alone. Therefore, cetacean mortality due to interactions with different kinds of small-scale fishing gear may be underestimated.

In the Black Sea, bottom gillnets targeting Black Sea turbot (*Scophthalmus maximums*) and piked dogfish (*Squalus acanthias*) were responsible for the large majority of known cetacean bycatch. The scientific literature available over the past 60 years reveals that the direct impact of set nets used in Black Sea fisheries mainly affects the Black Sea harbour porpoise (*Phocoena phocoena relicta*). The information on cetacean bycatch in Ukraine, Russia and Georgia was for a long time available only in strictly confidential internal annual reports or published in brief papers. Artov, Pavlov and Zhuravleva (1994), and Pavlov, Artov and Zhuravleva (1996) reported, between 1968 and 1993, the incidental catch of 1 695 Black Sea harbour porpoises (*Phocoena phocoena relicta*), 287 Black Sea common dolphins (*Delphinus delphis ponticus*) and 104 Black Sea bottlenose dolphins (*Tursiops truncatus ponticus*). Cetacean bycatch in set net fisheries was also monitored in Romania from 1984 to 1990 (Vasiliu and Dima, 1990), and from 2002 to 2006 (Radu, Anton and Radu, 2006). Overall, the surveys recorded an incidental catch of 2 991 cetaceans: 2 545 Black Sea harbour porpoises (85.1 percent), 326 Black Sea common dolphins (10.9 percent) and 120 Black Sea bottlenose dolphins (4.0 percent). Furthermore, a comprehensive investigation was carried out for two years (from February 1997 to January 1999) simultaneously in Bulgaria, Georgia and Ukraine (BLASDOL, 1999; Birkun *et al.*, 2002, 2009, 2014). In addition, studies undertaken between 1993 and 2003 provided data on the Turkish Black Sea coast (Tonay and Öz, 1999; Tonay and Öztürk, 2003; Öztürk, Öztürk and IWC, 2004). Ghost fishing, involving the capture of fish in abandoned gillnets, was found to be another issue affecting cetacean populations along the Romanian coast. Radu, Anton and Radu (2006) reported that 20 Black Sea harbour porpoises were caught in a set of 40 km-long abandoned turbot nets in 2005, estimating an incidental catch of about 50 cetaceans per 100 km of net (i.e. 0.5 individuals per km). Considering the quantity of ghost nets that are abandoned each year, the number of cetaceans incidentally entangled in these nets could be higher. The absolute numbers of annual population loss due to incidental catch have not been estimated for each Black Sea country; the only relevant figure comes from Öztürk, Öztürk and Dede (1999), who made an estimate of 2 000–3 000 harbour porpoises (*Phocoena phocoena relicta*) and 200–300 Black Sea bottlenose dolphins (*Tursiops truncatus ponticus*) incidentally caught in Turkey every year. Details of the different species by time period, country and fishing gear are reported in Table 3.

Drifting longlines are mainly used in the Mediterranean to target swordfish (*Xiphias gladius*), bluefin tuna (*Thunnus thynnus*), albacore (*Thunnus alalunga*) and other pelagic species (Di Natale, 1990a, 1990d). There are very few examples of interactions between cetaceans and this type of gear: in the majority of cases, individuals were released still alive, as long as no particular conditions or injuries were present. However, older data on the incidental capture and entanglement of striped dolphins (*Stenella coeruleoalba*), false killer whales (*Pseudorca crassidens*), Risso's dolphins (*Grampus griseus*), fin whales (*Balaenoptera physalus*) and sperm whales (*Physeter macrocephalus*) caught by surface longlines in Italian and Spanish waters have been reported (Di Natale and Mangano, 1983a, 1983b; Duguy *et al*., 1983b).

Di Natale and Mangano (1983b) gave details on 25 sperm whales, one of whom was caught by a pelagic longline, captured by Italian boats between 1978 and 1982. Di Natale (1989) also refers to the capture of two specimens of Risso's dolphin (*Grampus griseus*) and a Cuvier's beaked whale (*Ziphius cavirostris*) caught by a longline. Furthermore, Garibaldi (2015) reported another case of dolphin bycatch from the period 1990–2009; over the course of 187 fishing operations (employing around 98 000 hooks) of the professional swordfish fishery using surface longlines in the Ligurian Sea, the only cetacean bycatch he observed directly onboard involved a juvenile striped dolphin (*Stenella coeruleoalba*), which was caught on October 1990 and released still alive. In addition, Mussi *et al*. (1998), reporting on data collected between 1991 and 1995, noted a decomposed sperm whale (*Physeter macrocephalus*) found entangled in an abandoned drifting longline in the southern Tyrrhenian Sea.

Over the same period (1990–1995), it was estimated that between 12 and 32 cetaceans were incidentally caught annually by the Spanish pelagic longline fleet operating in the Mediterranean. This bycatch mainly consisted of common dolphins (*Delphinus delphis*), striped dolphins (*Stenella coeruleoalba*) and pilot whales (*Globicephala melas*) (University of Barcelona, 1995). Taking into account that the majority of cetaceans were able to be released still alive and estimating an at-vessel mortality rate of 10 percent, one to three individuals are likely to be caught dead yearly.

During a survey carried out between 1999 and 2000, Camiñas and Valeiras (2001) described bycatch rates of cetaceans in Spanish Mediterranean longline fisheries. Over the course of 291 longline sets observed in 1999 and 507 longline sets in 2000, three species of cetaceans were entangled in fishing lines: striped dolphin (*Stenella coeruleoalba*), with three and four specimens caught respectively in 1999 and 2000; Risso's dolphin (*Grampus griseus*) with seven specimens in 2000; and beaked whale (Ziphiidae), one of whom was caught in 2000, though the species was not identified.

The activity of more widespread purse seine fleets targeting small pelagic fish in the Mediterranean does not seem to have led to high incidental catch rates, even if high numbers of interactions with cetaceans were observed, especially with coastal dolphins, such as bottlenose dolphins (*Tursiops truncatus*), common dolphins (*Delphinus delphis*) and Risso's dolphins (*Grampus griseus*). Some old instances of incidental catch were reported along the coasts of southern Spain, southern Italy and northern Africa (Tudela, 2004; Aguilar *et al.*, 1991; Zahri *et al.*, 2007). In contrast, a report by the University of Barcelona (1995) described exceptionally high dolphin bycatch in the Alboran Sea at the beginning of the 1990s, though the majority of those caught were released alive, with an estimated annual mortality of 300 dolphins, mainly common dolphins (*Delphinus delphis*). This impact could partially explain the decline of the common dolphin populations along the Spanish Mediterranean coast and northern Africa. Moreover, the impact on other species, such as striped

dolphins (*Stenella coeruleoalba*), was estimated at 100 individuals caught/dead per year (University of Barcelona, 1995). In Tunisian waters, only two cases were reported: a bottlenose dolphin (*Tursiops truncatus*) caught by a purse seiner in October 1991 (Bradai, 1991) and an unidentified 8.5 m-long whale captured by a purse seiner from La Skhira in the Gulf of Gabès in September 1992 (Bradai and Ghorbel, 1998).

In the Black Sea, purse seine fisheries targeting small pelagics, such as Black Sea anchovies (particularly *Engraulis encrasicolus ponticus* and, to a lesser extent, *E. encrasicolus maeticus*), Black Sea sprats, pilchards, shads, bonitos and other small fish, are intensely active in Turkey, with a few boats also present in Ukraine. Despite this high activity, cetacean bycatch in purse seine fisheries has been rarely reported in the Black Sea area and records are scattered. Data reported by Birkun *et al.* (2014) and referring to 2006 revealed some cases of cetacean bycatch in Ukrainian waters: over the course of eight fishing observations, two Black Sea common dolphins (*Delphinus delphis ponticus*) and three Black Sea harbour porpoises (*Phocoena phocoena relicta*) were caught, while in Turkish Black Sea waters, 63 out of 194 direct onboard observations involved Black Sea common dolphins and 45 involved Black Sea harbour porpoises.

In Mediterranean waters, cetaceans are generally not caught by purse seiners targeting bluefin tuna (Table 3). However, a handful of records in the relevant literature refer to occasional bycatch in different Mediterranean regions; nevertheless, fishers themselves have also reported catching pilot whales (*Globicephala melaena*) and other small cetacean species sporadically (Di Natale, 1990d). Additionally, Duguy *et al.* (1983a, 1983b) reported the capture of three striped dolphins (*Stenella coeruleoalba*) in French waters before the 1980s; during the same period, Di Natale (1983a) described the incidental catch of 21 striped dolphins in two separate incidents in the Ligurian Sea, both involving tuna purse seine nets. In the same area, Magnaghi and Podestà (1987) observed directly onboard the incidental capture of eight striped dolphins off Sanremo (northwestern Italy) in 1986. Furthermore, within the framework of the Regional Observer Programme for Bluefin Tuna

Table 3 – Incidental catch of cetaceans in purse seiners

Bibliographic reference	Reference years	Gear	GFCM subregion	Country	Species	Reported individuals in bycatch events	Estimated bycatch events	Mortality rate/year	Fishing operations/ Number of interactions recorded
Duguy *et al.*, 1983a, 1983b	-	PS (for bluefin tuna)	Western Mediterranean	France	*Stenella coeruleoalba*	3	-	-	-
Di Natale, 1983a	-	PS (for bluefin tuna)	Western Mediterranean	Italy (Ligurian Sea)	*Stenella coeruleoalba*	21	-	-	-
Magnaghi and Podestà, 1987	1986	PS (for bluefin tuna)	Western Mediterranean	Italy (Ligurian Sea)	*Stenella coeruleoalba*	8	-	-	-
Fromentin and Farrugio, 2005	2003	PS (for bluefin tuna)	Western Mediterranean	France	*Stenella coeruleoalba*	3	-	-	-
University of Barcelona, 1995	1990–1994	PS	Western Mediterranean	Spain	*Delphinus delphis*	-	300/year	-	-
University of Barcelona, 1995	1990–1994	PS	Western Mediterranean	Spain	*Stenella coeruleoalba*	-	100/year	-	-
Bradai, 1991	1991	PS	Central Mediterranean	Tunisia	*Tursiops truncatus*	1	-	-	-
Bradai and Ghorbel, 1998	1992	PS	Central Mediterranean	Tunisia	*Megaptera novaeangliae*	1	-	-	-

Table 3 (continued)

Bibliographic reference	Reference years	Gear	GFCM subregion	Country	Species	Reported individuals in bycatch events	Estimated bycatch events	Mortality rate/year	Fishing operations/ Number of interactions recorded
Birkun *et al.*, 2014	2006	PS	Black Sea	Ukraine	*Delphinus delphis ponticus*	2	-	1	2/2
Birkun *et al.*, 2014	2006	PS	Black Sea	Ukraine	*Phocoena phocoena relicta*	3	-	0.8	4/3
Birkun *et al.*, 2014	2006	PS	Black Sea	Ukraine	*Tursiops truncatus ponticus*	0	-	-	2/0
Birkun *et al.*, 2014	2006	PS	Black Sea	Turkey	*Delphinus delphis ponticus*	63	-	0.7	91/63
Birkun *et al.*, 2014	2006	PS	Black Sea	Turkey	*Phocoena phocoena relicta*	45	-	1.2	37/45
Birkun *et al.*, 2014	2006	PS	Black Sea	Turkey	*Tursiops truncatus ponticus*	0	-	-	64/0

Notes: PS = purse seine.
In grey, data collected before 2008.

of the International Commission for the Conservation of Atlantic Tunas (ICCAT), three striped dolphins were caught in 2003 over the course of 190 fishing day trips on a French purse seiner operating in the Gulf of Lion (Fromentin and Farrugio, 2005).

Other types of fishing gear were responsible for the incidental catch of cetaceans in a very limited number of cases (Table 4). Traditional tuna traps targeting large bluefin tuna during their spawning migrations can sometimes trap cetaceans as well: on 18 June 1946, a minke whale (*Balaenoptera acutorostrata*) was caught in the small tuna trap of Camogli, near Genoa, in the Ligurian Sea (Cattaneo and Bava, 2009), and another specimen of minke whale was found in the tuna trap of Sidi-Daoud in 1976 (Ktari-Chakroun, 1980). Di Natale and Mangano (1983a) likewise refer to the capture of a killer whale (*Orcinus orca*) in a tuna trap in Sicily.

Table 4 – Incidental catch of cetaceans in various types of fishing gear

Bibliographic reference	Reference years	Gear	GFCM subregion	Country	Species	Reported individuals in bycatch events	Estimated bycatch events	Mortality rate/year	Fishing operations/ Number of interactions recorded
Cattaneo and Bava, 2009	1946	Tuna trap	Western Mediterranean	Italy	*Balaenoptera acutorostrata*	1	-	-	-
Ktari-Chakroun, 1980	1976	Tuna trap	Central Mediterranean	Tunisia	*Balaenoptera acutorostrata*	1	-	-	-
Di Natale and Mangano, 1983a	1983	Tuna trap	Western Mediterranean	Italy	*Orcinus orca*	1	-	-	-
Vasiliu and Dima, 1990	1988	Pound net	Black Sea	Romania	*Delphinus delphis ponticus*	8	-	-	-
Birkun *et al.*, 2014	2006	Pound net	Black Sea	Turkey	*Delphinus delphis ponticus*	5	-	-	-

Note:
In grey, data collected before 2008.

In the Black Sea, the entrapments of a number of cetaceans were attributed to pound nets, small traps targeting mixed pelagic and demersal fish. A group of eight Black Sea common dolphins (*Delphinus delphis ponticus*) entered pound nets installed by the Romanian Marine Research Institute in July 1988 (Vasiliu and Dima, 1990), while another case involving five Black Sea common dolphins in Turkey was reported by Birkun *et al.* (2014).

Interactions between handline fisheries and cetaceans were further recorded in some Mediterranean and Black Sea areas. Mussi *et al.* (1998) also reported the results of a five-year field survey conducted in Italian waters in the southern Tyrrhenian Sea, where the local cetaceans, i.e. striped dolphins (*Stenella coeruleoalba*), Risso's dolphins (*Grampus griseus*), long-finned pilot whales (*Globicephala melas*) and sperm whales (*Physeter macrocephalus*), were observed taking advantage of the handline squid fishery by depredating the squids that were attracted to the lights. However, cetacean bycatch was reported neither here nor in a survey carried out in Bulgarian waters, perhaps due to the short soaking time involved (Birkun *et al.*, 2014).

4.3 Analysis of recent data from literature (2008–2019)

4.3.1 Pinnipeds

Over the last years, reports on the mortality of Mediterranean monk seals (*Monachus monachus*) due to fisheries are scarce.

Only a few papers have been published as comprehensive reviews of the causes of death, based on different methods (such as interviews, direct observations and necropsies) and covering extended periods. For example, Danyer *et al.* (2018) have provided a brief summary of the details of the individuals found dead along the coast of Turkey; over the period 1994–2014, 32 entanglements and 49 directly human-induced deaths were reported in the relevant literature (Öztürk, 2007; Güçlüsoy *et al.*, 2004; Danyer *et al.*, 2013a, 2013b, 2014). Danyer *et al.* (2018) also updated the information on monk seal deaths recorded along the Mediterranean Turkish coast to include

Table 5 – Incidental catch of Mediterranean monk seal in various types of fishing gear

Bibliographic reference	Reference years	Gear	GFCM subregion	Country	Species	Number of dead individuals recorded	Direct human-induced deaths	Individuals found entangled in fishing gear	Reported individuals in bycatch events (%)	Individuals with unidentified causes of death
Županović, 1966	1907–1908	Tuna trap	Adriatic Sea	Croatia	*Monachus monachus*	2	0	2	100%	-
Županović, 1966	1886–1928	Tuna trap	Adriatic Sea	Croatia	*Monachus monachus*	15	15	0	0	-
Ronald and Healey, 1974	1900–1930	Tuna trap	Western Mediterranean	Spain (Balearic Islands)	*Monachus monachus*	26	19	7	26.9%	-
Avellà, 1979	1900–1970	-	Western Mediterranean	Spain (Balearic Islands)	*Monachus monachus*	50	26	24	48%	-
Guarrera, 1999	1980s	GNS	-	Italy (Tuscany)	*Monachus monachus*	8	0	8	100%	-
Boutiba, 1996	1987–1990	GNS	Western Mediterranean	Algeria	*Monachus monachus*	8	0	8	100%	-
Ronald and Healey, 1974	1971–1972	GNS	Eastern Mediterranean	Greece (Kos)	*Monachus monachus*	0	0	4/year	0	-
Jacobs and Panou, 1988	1980–1982	GNS	Central Mediterranean	Greece (Ionian Sea)	*Monachus monachus*	34	26	7	20.6%	-

Table 5 (continued)

Bibliographic reference	Reference years	Gear	GFCM subregion	Country	Species	Number of dead individuals recorded	Direct human-induced deaths	Individuals found entangled in fishing gear	Reported individuals in bycatch events (%)	Individuals with unidentified causes of death
Jacobs and Panou, 1988	1980–1982	LLS	Central Mediterranean	Greece (Ionian Sea)	*Monachus monachus*	34	26	1	2.9%	-
Avellà, 1987	1980s	-	Western and central Mediterranean	Tunisia, Algeria, Morocco	*Monachus monachus*	40	11	6	15%	23
Berkes *et al.*, 1979	1960s–1970s	-	Eastern Mediterranean	Turkey (Aegean Sea)	*Monachus monachus*	25	19	6	24%	-
Cebrian, 1993	1988–1990	GNS	Eastern Mediterranean	Greece (Halkidiki)	*Monachus monachus*	16	11	3	18.8%	2
Cebrian and Anagnostopoulou, 1992	1988–1992	-	Eastern Mediterranean	Greece (South Aegean Sea)	*Monachus monachus*	37	28	5	13.5%	4
Kiraç and Savaş, 1996; Yediler and Gücü, 1997	1965–1994	GNS	Eastern Mediterranean and Black Sea	Turkey (Med. and Black Sea)	*Monachus monachus*	13	11	2	15.4%	-
Cebrian *et al.*, 1990	1990	GNS	Eastern Mediterranean	Greece (Santorini)	*Monachus monachus*	1	0	1	0	-
Cebrian *et al.*, 1995	1986–1994	GNS	Eastern Mediterranean	Greece (Cyclades)	*Monachus monachus*	16	4	6	37.5%	6
Cebrian *et al.*, 1995	Before 1986	GNS	Eastern Mediterranean	Greece (Cyclades)	*Monachus monachus*	5	5	0	0	-
Cebrian and Vlachoutsikou, 1994	1988–1993	GNS	Central Mediterranean	Greece (southern Ionian Sea)	*Monachus monachus*	8	6	1	12.5%	1
Cebrian, 1998a	1987–1994	GNS	Eastern and central Mediterranean	Greece	*Monachus monachus*	61	34	11	18%	16
Panou *et al.*, 1993	1963–1987	GNS	Central Mediterranean	Greece (Ionian Sea)	*Monachus monachus*	34	21	8	23.5%	5
Panou *et al.*, 1993	before 1963	GNS	Central Mediterranean	Greece (Ionian Sea)	*Monachus monachus*	13	10	3	23.1%	-
Dede *et al.*, 2015	1986–1996	GNS/ LLS	Eastern Mediterranean	Turkey (Aegean Sea and Mediterranean coast)	*Monachus monachus*	24	12	6	25%	6
Öztürk, 1998a	1986–1996	GNS	Eastern Mediterranean	Turkey (Aegean Sea)	*Monachus monachus*	13	5	5	38.5%	3
Androukaki *et al.*, 1999	1985–1995	-	Eastern Mediterranean	Greece	*Monachus monachus*	79	25	11	13.9%	43
Androukaki *et al.*, 2006	up to 1995	-	Eastern Mediterranean	Greece	*Monachus monachus*	182	118	27	14.8%	37
Johnson, ed., 1999; Güçlüsoy *et al.*, 2004	1997 and 1999	GNS	Eastern Mediterranean	Turkey	*Monachus monachus*	2	0	2	0	-
Veryeri *et al.*, 2001, 2003	-	GNS	Eastern Mediterranean	Turkey (Aegean Sea)	*Monachus monachus*	7	0	7	0	-
Androukaki *et al.*, 2006	1986–2005	-	Eastern Mediterranean	Greece	*Monachus monachus*	203	37	12	6%	154
Karamanlidis *et al.*, 2008	1991–2007	-	Eastern Mediterranean	Greece	*Monachus monachus*	96	15	7	7.3%	74
Danyer *et al.*, 2018	1994–2014	-	Eastern Mediterranean	Turkey	*Monachus monachus*	81	49	32	39.5%	-
Danyer *et al.*, 2018	2012–2018	-	Eastern Mediterranean	Turkey	*Monachus monachus*	18	2	0	0	16

Notes: GNS = set gillnet; LLS = set longline.
In grey, data collected before 2008.

those occurring between 2012 and 2018. Out of 18 dead seals, five died due to natural causes, two in human-induced deaths, while for the other 11, it was not possible to determine the cause. A summary of the records available in the relevant literature is reported in Table 5.

Androukaki *et al.* (2006) published a complete review of the causes of death in the monk seal population in Greece between 1986 and 2005. Based on information and data collected from 203 stranded animals (full necropsies were performed on 86 specimens), death was attributed most commonly to various natural explanations (45 percent), followed by human-induced death (around 20 percent) and accidental death (8 percent); unknown causes of death were recorded for the remaining 27 percent of the cases. The results were also analysed dividing the period into two intervals (1986–1995 and 1996–2005) but no important differences were found in the patterns of mortality between them.

Another review of the Mediterranean monk seal data in Greek waters was undertaken by Karamanlidis *et al.* (2008), obtaining results similar to those of Androukaki *et al.* (2006). The research was carried out based on three different sources: a literature review, data on incidental catch collected through questionnaires and data from necropsies. The interviews registered the entanglement of 13 seals in fishing gear, 11 in gillnets and two in longlines. The two individuals caught by longlines were released still alive, as well as two seals entangled in gillnets. From 1991 to 2007, 200 dead monk seals were reported, and in 96 cases, full necropsies were performed. Natural causes, human-induced death, and entanglement corresponded to 41 percent (39 cases), 16 percent (15 cases) and 7 percent (7 cases) of the 96 seals examined, respectively, while the cause of death could not be determined for the remaining 36 percent (35 cases). Entanglement appeared to affect mainly sub-adult individuals (46 percent); in contrast, the most frequently recorded causes of mortality in adults and pups were human-induced death (50 percent) and natural causes (93 percent), respectively. In addition, incidental entanglement in fishing gear was determined to be the cause of death for seven female sub-adults found in Zakynthos (n = 2), Naxos, Samos, Evoia (n = 2) and Lavrio. Overall, the most frequently recorded cause of death, throughout the study period, was found to be non-human-induced. However, this finding is not consistent with what the authors noted when considering the different age classes: pups died mainly due to natural causes, whereas sub-adults and adults died due to interactions with fishing activities (for example, entanglement in fishing gear).

Veryeri, Güçlüsoy and Savas (2001) and Veryeri, Nurlu and Erdem (2003) stressed the large impact of nets on pups and juveniles, describing at least seven cases of entanglement clearly leading to death from the Turkish Aegean coast.

4.3.2 Cetaceans

Since about 2010, the number of new records and publications concerning surveys or studies of cetacean bycatch in different types of fishing gear has drastically reduced. Formerly, at least up until the late 1990s, most cetacean bycatch occurred in large-mesh driftnets; once these were banned, cetacean bycatch – and consequently mortality – in fishing gear dropped. Currently, large-mesh driftnets are officially banned from all countries in the GFCM area of application, though some anecdotal information and evidence (e.g. cetacean strandings showing typical signs of entanglement in large driftnets, images and videos on social networks, or news from online sources) occasionally surface, meaning that this activity may still be illegally practiced in some areas.

In particular, recent information on cetacean bycatch has emerged from the Black Sea, where incidental catch of the three cetacean species endemic to the region continues in the context of the Black Sea turbot bottom net fisheries. An update on the most recent studies available in the literature, examined according to vessel group and area, here follows.

4.3.2.1 Bottom trawlers

Bottom trawlers are widely distributed across the Mediterranean and the Black Sea (FAO, 2018, 2020) and have been historically considered as only a minor threat to cetaceans, even if a high number of interactions have been reported in recent years (Pace, Tizzi and Mussi, 2015). Based on the available data, incidental catch in trawl fisheries appears to be relatively uncommon in most Mediterranean areas (Table 6); only a few instances of incidental catch have been reported in the past, from the Mediterranean coast of Israel (Goffman, Kerem and Spanier, 1995; Kent *et al.*, 2005).

Table 6 – Incidental catch of cetaceans in bottom trawlers and midwater pair trawlers

Bibliographic reference	Reference years	Gear	GFCM subregion	Country	Species	Reported individuals in bycatch events	Estimated bycatch events	Mortality rate/year	Fishing operations/ Number of interactions recorded
Duguy *et al.*, 1983a, 1983b	-	OTB	Western Mediterranean	France	*Stenella coeruleoalba*	1	-	-	-
Duguy *et al.*, 1983a, 1983b	-	OTB	Western Mediterranean	Italy	*Delphinus delphis*	2	-	-	-
Duguy *et al.*, 1983a, 1983b	-	OTB	Western Mediterranean	France	*Tursiops truncatus*	4	-	-	-
Duguy *et al.*, 1983a, 1983b	-	OTB	Western Mediterranean	Italy	*Physeter macrocephalus*	3[1]	-	-	-
Di Natale and Mangano, 1983b	-	OTB	Western Mediterranean	Italy	*Physeter macrocephalus*	3[1]	-	-	-
Silvani *et al.*, 1992	1989–1991	OTB	Western Mediterranean	Spain (Balearic Islands)	unidentified dolphin	1	-	-	-
Massuti (unpublished data)	2001–2004	OTB	Western Mediterranean	Spain (Balearic Islands)	-	0	-	-	-
Gonzalvo *et al.*, 2008	2004–2005	OTB	Western Mediterranean	Spain (Balearic Islands)	-	0	-	-	79 sets/55
Bradai, 2000	1988	OTB	Central Mediterranean	Tunisia	*Stenella coeruleoalba*	1	-	-	-
Bradai *et al.*, 2010	2004	OTB	Central Mediterranean	Tunisia	*Tursiops truncatus*	1	-	-	-
Goffman *et al.*, 1995; Feingold *et al.*, 2005; Kent *et al.*, 2005	1993–2004	OTB	Eastern Mediterranean	Israel	*Tursiops truncatus*	26	-	-	-
Fortuna *et al.*, 2010a	2006–2008	PTM	Adriatic Sea	Italy (Adriatic Sea)	*Tursiops truncatus*	2 + 1[2]	22[3]	-	3 141 hauls/609
Fortuna *et al.*, 2010b	2009–2010	PTM	Adriatic Sea and Central Mediterranean	Italy	*Tursiops truncatus*	0[4]	-	-	2 254 hauls/-
Fortuna *et al.*, 2012	2011–2012	PTM	Adriatic Sea	Italy (Adriatic Sea)	*Tursiops truncatus*	3	72 (2001)	0.001	2 735 hauls/604
Morizur *et al.*, 2012a	2010	PTM	Western Mediterranean	France (Gulf of Lion)	*Stenella coeruleoalba*	4	-	-	-
Morizur *et al.*, 2012b	2011	PTM	Western Mediterranean	France (Gulf of Lion)	*Stenella coeruleoalba*	1	-	-	-

Table 6 (continued)

Bibliographic reference	Reference years	Gear	GFCM subregion	Country	Species	Reported individuals in bycatch events	Estimated bycatch events	Mortality rate/year	Fishing operations/ Number of interactions recorded
Morizur *et al.*, 2014	2012	PTM	Western Mediterranean	France (Gulf of Lion)	*Tursiops truncatus*	1	-	-	-
Sala *et al.*, 2013	2012–2013	PTM	Adriatic Sea	Italy (Adriatic Sea)	*Tursiops truncatus*	0[5]	-	-	144 hauls/31
Sala *et al.*, 2014	2013–2014	PTM	Adriatic Sea	Italy (Adriatic Sea)	-	0	-	-	202 hauls/49
Sala *et al.*, 2016	2015–2016	PTM	Adriatic Sea	Italy (Adriatic Sea)	*Tursiops truncatus*	1	2	0.002	1 797/587
Sala *et al*, 2018	2016-2017	PTM	Adriatic Sea and Central Mediterranean	Italy	*Tursiops truncatus*	3	-	0.05	1 571/438
BLASDOL, 1999	1997–1999	PTM	Black Sea	Georgia	*Delphinus delphis ponticus*	3	-	-	-
Birkun, 2002	1995	PTM	Black Sea	Ukraine	*Delphinus delphis ponticus*	2	-	-	-
Birkun *et al.*, 2014	2006	PTM	Black Sea	Ukraine	*Delphinus delphis ponticus*	18	68	1.8	14/18
Birkun *et al.*, 2014	2006	PTM	Black Sea	Ukraine	*Phocoena phocoena relicta*	2	25	0.5	14/2

Notes: OTB = bottom otter trawl; PTM = midwater pair trawl.

In grey data collected before 2008.

1. Same specimens probably.
2. Number of individuals released alive.
3. Value obtained from unreliable statistics.
4. Five specimens reported by fishers from other vessels not involved in the survey.
5. One specimen reported by fishers from other vessels not involved in the survey.

Western Mediterranean

No recent data are available from bottom trawlers operating in this subregion.

Central Mediterranean

No recent data are available from bottom trawlers operating in this subregion.

Adriatic Sea

No recent data are available from bottom trawlers operating in this subregion.

Eastern Mediterranean

No recent data are available from bottom trawlers operating in this subregion.

Black Sea

No recent data are available from bottom trawlers operating in this subregion.

4.3.2.2 Pelagic trawlers

Activity of pelagic trawlers, mainly targeting small pelagic fish such as anchovies (*Engraulis encrasicolus*), sardines (*Sardina pilchardus*), mackerel (*Scomber* spp.) and horse mackerel (*Trachurus* spp.), is not evenly distributed across the Mediterranean and the Black Sea. This fishery is active only in France and Italy for the western Mediterranean, in Tunisia and Malta for the central Mediterranean, in Montenegro and Italy for the Adriatic and in Turkey for the eastern Mediterranean and the Black Sea (Bulgaria, Ukraine, Romania and Georgia) (FAO, 2016; Birkun *et al.*, 2014).

Western Mediterranean

In the Gulf of Lion, in 2010, four striped dolphins (*Stenella coeruleoalba*) were caught by pelagic trawlers (Morizur *et al.*, 2012a, 2012b). In 2011, only one bottlenose dolphin (*Tursiops truncatus)* was incidentally caught by a pelagic trawler over the course of 200 days of fishing and 700 pelagic trawl operations, and a striped dolphin was also captured over 50 days of fishing activity and 150 pelagic trawling operations (Morizur *et al.*, 2012a, 2012b) (Table 6).

Central Mediterranean

No recent data are available for pelagic trawlers operating in this subregion.

Adriatic Sea

Pelagic trawlers targeting anchovies and sardines are active in Italian waters, mainly in the Adriatic Sea. Beginning in 2006, a project (Fortuna *et al.*, 2010b) was carried out to monitor the possible non-commercial incidental catch, including of protected species, occurring during pelagic trawling activities in the Adriatic Sea; pingers were used to test the influence of acoustic deterrent devices on the behaviour of cetaceans and other protected species, such as sea turtles. Between 2006 and 2008, the fishing operations of a subset of 27 fishing vessels (out of about 69 operating in the area) were monitored over 24 months (for a total of 745 successful fishing trips and 3 141 hauls); 609 groups of bottlenose dolphins (*Tursiops truncatus*) were sighted close to the nets, with dolphins present at over 30 percent of the hauls and often interacting with the fishing operations. Nevertheless, only three bottlenose dolphins were caught, one of which, entangled in the net by its caudal fin, was immediately released still alive. On the basis of these data, an estimate of the total annual incidental catch was considered statistically unreliable by Fortuna *et al.* (2010a). After this start, the survey was extended year by year and was carried out continuously until 2019 following the same sampling scheme: the results of the different extensions are summarized and reported in Table 6.

During the 2009–2010 survey, carried out also in Sicilian waters, 528 fishing days were monitored (2 254 hauls) and no cetacean bycatch was observed, though fishers reported the incidental catch of five bottlenose dolphins in the Adriatic by boats not involved in the monitoring programme (Fortuna *et al.*, 2010b). In 2011–2012, a total of 658 fishing days were monitored by onboard observers for a total effort of 2 735 hauls. Over the course of the survey, 604 interactions with bottlenose dolphins (*Tursiops truncatus*) were observed and the bycatch of three specimens was recorded. On the basis of these data, the estimated annual number of dolphins captured as bycatch for 2011 was estimated at 72; considering the entire period 2006–2011, a total estimate of 35 dolphins per year was calculated (Fortuna *et al.*, 2012). From May 2012 to May 2013, a less extensive survey was carried out (Sala *et al.*, 2013), monitoring the fishing activity of 15 boats in the central Adriatic Sea; onboard observers monitored 35 fishing days and 144 fishing operations. Over the course of the entire survey, 31 interactions with bottlenose dolphins (*Tursiops truncatus*) were recorded, but no incidental catch occurred; during the same period, the incidental catch of a bottlenose dolphin was reported by fishers in one of the 15 boats monitored without onboard observers.

In 2013–2014, 53 fishing days were monitored (202 hauls) and 49 interactions between fishing vessels and bottlenose dolphins were observed, though none involved any incidental catch (Sala *et al.*, 2014). Subsequently, another survey was carried out over the period from February 2015 to February 2016. Overall, 464 fishing trips were monitored for a total of 1 797 hauls; out of 587 bottlenose dolphin individuals interacting with fishing operations, only one incidental catch

was recorded, for an estimated catch rate of 0.002, corresponding to two expected catches per year (Sala *et al.*, 2018). The last available report of this project is referred to in the 2016–2017 survey. Overall, 397 fishing days (1 571 hauls) were monitored by onboard observers and 438 interactions between fishing boats and dolphins were observed; the bycatch of three bottlenose dolphins was recorded, but no estimate of the total annual bycatch was calculated.

Eastern Mediterranean

No recent data are available for pelagic trawlers operating in this subregion.

Black Sea

No recent data are available for pelagic trawlers operating in this subregion.

4.3.2.3 Small-scale fisheries

Small-scale fisheries represent more than 80 percent of the Mediterranean and Black Sea fleets as a whole (FAO, 2018, 2020). Passive bottom-set nets are widely used along all the coasts of the Mediterranean and the Black Sea, targeting several demersal species, including red mullet (*Mullus surmuletus*), common cuttlefish (*Sepia officinalis*), European hake (*Merluccius merluccius*), European spiny lobster (*Palinurus elephas*) and other commercially valuable species. According to the available data, passive bottom-set nets may represent the most common site of interactions between cetaceans and fishing gear. However, further analysis of the same data indicates low mortality of coastal cetacean species interacting with these types of gear across the whole Mediterranean. The many small boats docking in numerous ports, together with the multiple sets each deploys nearly every day and the scarcity of scientific data or surveys, make it difficult to assess and compare the past and current impacts of small-scale fisheries on coastal cetaceans.

Western Mediterranean

In the western Mediterranean Sea, only two surveys have been carried out recently to monitor interactions between cetaceans and small-scale fishing activities. The first one was dedicated to set nets hauled by coastal vessels in Corsica between March and September of 2011; over 164 days at sea, no cetacean bycatch was recorded (Morizur, Gaudou and Dermaneche, 2014; Morizur *et al.*, 2012a, 2012b). Another study was undertaken on a particular type of small-scale fishing gear, the so-called small-scale driftnet. These nets are traditional legal driftnets, with a small mesh size and moderate total length, that mainly target pelagic schooling species, such as anchovy (*Engraulis encrasicolus*), sardine (*Sardina pilchardus*), mackerel (*Scomber* spp.), horse mackerel (*Trachurus* spp.) and saddled seabream (*Oblada melanura*). In the past, their use was widespread all over the Mediterranean and presented no major environmental concern; in fact, no entanglement of cetaceans has ever been reported. In 2013, a project investigating the past and present activities of these small-scale fisheries collected data in 15 Italian fishing ports, where 98 vessels (plus two in Slovenia) were identified as using nine different types of small-scale driftnets. The project was based on interviews, direct measurements of the characteristics of the nets, and onboard observations. The findings generally indicated a high selectivity of these nets toward a well-defined range of small and medium pelagic species, and no incidental catch or interactions with cetaceans were recorded (Lucchetti *et al.*, 2017).

Central Mediterranean

Some recent data on cetacean bycatch were collected from an analysis of cetacean strandings occurring along the northern coast of Tunisia. Following necropsies, Attia El Hili *et al.* (2010) found that at least four out of seven bottlenose dolphins stranded over the period 2006–2008

died due to possible interactions with fisheries: two specimens in 2006 were found with their tails amputated, as well as one in 2007, while another specimen in 2008 showed the remains of a net in its mouth and/or around the epiglottis. More recently, using the same methodology, data collected from 2007 to 2017 revealed that at least five out of 25 stranded bottlenose dolphins showed the remains of fishing nets in their mouths, suggesting death by asphyxia following net ingestion during depredation activity (Attia El Hili *et al.*, 2018).

Adriatic Sea

No recent data are available for small-scale fisheries operating in this subregion.

Eastern Mediterranean

No recent data are available for small-scale fisheries operating in this subregion.

Black Sea

The most common types of fishing gear in the Black Sea are gillnets and trammel nets, used to catch Black Sea turbot (*Scophthalmus maximus*) and other demersal fish. The use of these types of gear is generally seasonal, depending on the target species, country and fishing grounds. Given the high level of cetacean incidental catch recorded in the past for these types of gear, several studies have been carried out over the last 10 to 15 years, involving more or less all the countries around the basin, in order to evaluate the impact of these fisheries on cetacean populations; for instance, it is reported that bottom-set gillnets caused 98 percent of cetacean bycatch in the northeastern Black Sea (Birkun and Krivokhizhin, 2011). In Ukraine, following the BLASDOL survey (BLASDOL, 1999), onboard observations were carried out yearly, between 2006 and 2009, monitoring 4 769 bottom-set gillnets (deploying a total of 354.1 km) targeting Black Sea turbot and piked dogfish. During these periods, the incidental catch of 515 Black Sea harbour porpoises (*Phocoena phocoena relicta*) and five Black Sea bottlenose dolphins (*Tursiops truncatus ponticus*) was recorded (Birkun and Krivokhizhin, 2011). Furthermore, Birkun *et al.* (2014) reported the results of various small surveys conducted along the Ukrainian coast (involving 543 vessels deploying 760 865 km of nets) and estimated an annual bycatch of 1 539 Black Sea harbour porpoises and 1 211 Black Sea bottlenose dolphins.

A more recent paper (Vishnyakova and Gol'din, 2015) described the results of an analysis carried out on Black Sea harbour porpoise (*Phocoena phocoena relicta*) strandings along the Azov Sea coastline between 1993 and 2013. Out of the 633 specimens examined, around 93 individuals (14.7 percent) showed evidence of incidental capture in fishing gear. In addition, direct monitoring onboard fishing vessels (covering 88.4 km of the central part of the Bulgarian coast) reported bycatch of 19 Black Sea harbour porpoises and two Black Sea bottlenose dolphins between April 2010 and July 2011 (Mihaylov, 2011). A monitoring survey, undertaken with the cooperation of 812 gillnet fishers (targeting Black Sea turbot), allowed Birkun *et al.* (2014) to calculate that at least 945 662 km of nets were annually deployed in Bulgarian waters and to estimate an annual incidental catch of 3 016 Black Sea harbour porpoises and 1 895 Black Sea bottlenose dolphins, resulting in respective catch per unit effort (CPUE) of 0.22 and 0.02. Since 2002, several surveys on cetacean bycatch and strandings have been regularly carried out along the Romanian coast. Radu and Anton (2014) reported that from 2002 to 2011, 129 Black Sea harbour porpoises and two Black Sea bottlenose dolphins were incidentally caught in fishing gear (i.e. gillnets, pound nets and pelagic trawls) used in Romanian fisheries. Moreover, the same authors reported that in 150 gillnets (with an average length of 60 m), the bycatch of Black Sea harbour porpoises totalled about seven individuals (CPUE 0.8/1 km).

In Romania, Anton, Cândea and Paiu, (2012) reported the results of a survey carried out in 2010 and 2011 along the Romanian Danube delta. The main cause of death was asphyxia for the majority of the 80 stranded cetaceans (73 Black Sea harbour porpoises, five Black Sea bottlenose dolphins and two Black Sea common dolphins) and was linked to incidental capture in gillnets or other fishing gear. The high vulnerability of the Black Sea harbour porpoise was confirmed by direct observations made onboard, which reported the bycatch of 54 Black Sea harbour porpoises (Anton, Cândea and Paiu, 2012). Furthermore, Radu and Anton (2014) recorded, from 2002 to 2011, 483 stranded cetaceans, comprising 259 Black Sea harbour porpoises, 20 Black Sea common dolphins, 44 Black Sea bottlenose and 160 unidentified dolphins; the presence of net marks and scars on their bodies indicated that more than 95 percent of these cetaceans had died due to being incidentally caught in gillnets or other fishing gear.

In their review on the state of knowledge of Black Sea cetaceans, Birkun *et al.* (2014) recorded, while observing some trips between 2002 and 2011, the incidental capture of 52 Black Sea harbour porpoises, with a high CPUE of 10.4/km. In addition, other data were obtained by interviews with fishers: 56 responses from 165 boats led to a bycatch estimate of 208 Black Sea harbour porpoises and one of zero for the other dolphin species. The authors estimate a potential bycatch of 2.71 porpoises per boat annually, assuming that responses were not biased (Birkun *et al.*, 2014).

One of the most recent studies on cetacean bycatch in Turkish Black Sea waters was published by Tonay (2016); over the course of two seasons (from April to July 2007 and from April to September 2008), a fishing vessel using trammel nets targeting Black Sea turbot (*Scophthalmus maximus*) was monitored on 629 and 584 fishing trips in 2007 and 2008, respectively. A total of 24 Black Sea harbour porpoises and one Black Sea bottlenose dolphin were recorded as bycatch (13 in 2007, 12 in 2008). Based on these results, the author estimated an incidental catch rate (number of specimens per km of fishing gear) of 0.18 for Black Sea harbour porpoises and 0.01 for Black Sea bottlenose dolphins in 2007, and 0.19 for Black Sea harbour porpoises in 2008. According to these data, and assuming that the incidental catch rate and the net and fishing characteristics are similar along the whole Turkish Black Sea coast, it could be estimated that around 2 011 (SE ± 742) Black Sea harbour porpoises were caught in 2007 and 2 294 (SE ± 806) in 2008, while 168 Black Sea bottlenose dolphins were caught (SE ± 156) in 2007.

Meanwhile, in another investigation, Bilgin, Kose and Yesilcicek (2018) concentrated their research effort along the Turkish coast in the southeastern Black Sea. They conducted surveys monthly between March 2010 and September 2011, monitoring 136 gillnet operations targeting Black Sea turbot. Seventy-one Black Sea harbour porpoises and four Black Sea common dolphins were incidentally caught over the study period. CPUE values were estimated as 0.09 ± 0.028 individuals per km daily in 2010 and 0.15 ± 0.032 individuals per km daily in 2011 for Black Sea harbour porpoises (CPUE 0.13 ± 0.023 individuals per km daily for the two years combined); for the Black Sea common dolphin, the CPUE figure was calculated as < 0.003 individuals per km daily for 2010 and 2011, as well as for both years combined. The authors remarked on the high seasonality of the incidental catch rate, especially of Black Sea harbour porpoises, given that they were caught mostly between April and June, both in 2010 and in 2011, with the highest CPUE value – of 0.26 individuals per km daily – occurring in April 2011.

The historical and recent data on cetacean bycatch in small-scale fisheries are summarized in Table 7.

Table 7 – Incidental catch of cetaceans in small-scale fisheries

Bibliographic reference	Reference years	Gear	GFCM subregion	Country	Species	Reported individuals in bycatch events	Estimated bycatch events	Mortality rate/year[1]	Fishing operations/ Number of interactions recorded
Duguy *et al.*, 1983a, 1983b	-	GN	Western Mediterranean	France	*Stenella coeruleoalba*	4	-	-	-
Duguy *et al.*, 1983a, 1983b	-	GN	Western Mediterranean	France	*Delphinus delphis*	1	-	-	-
Duguy *et al.*, 1983a, 1983b	-	GN	Western Mediterranean	Spain	*Delphinus delphis*	1	-	-	-
Duguy *et al.*, 1983a, 1983b	-	GN	Western Mediterranean	Italy	*Delphinus delphis*	1	-	-	-
Duguy *et al.*, 1983a, 1983b	-	GN	Western Mediterranean	Spain	*Tursiops truncatus*	1	-	-	-
Duguy *et al.*, 1983a, 1983b	-	GN	Western Mediterranean	France	*Tursiops truncatus*	4	-	-	-
Duguy *et al.*, 1983a, 1983b	-	GN	Western Mediterranean	Italy	*Grampus griseus*	2	-	-	-
Duguy *et al.*, 1983a, 1983b	-	GN	Western Mediterranean	France	*Grampus griseus*	4	-	-	-
Duguy *et al.*, 1983a, 1983b	-	GN	Western Mediterranean	Italy	*Physeter macrocephalus*	1	-	-	-
Duguy *et al.*, 1983a, 1983b	-	GN	Western Mediterranean	France	*Balaenoptera acutorostrata*	2	-	-	-
Granier, 1970	-	GN	Western Mediterranean	France	*Steno bredanensis*	1	-	-	-
Duguy and Cyrus, 1973	-	GN	Western Mediterranean	France	*Steno bredanensis*	1	-	-	-
Silvani *et al.*, 1992	1989–1991	GN	Western Mediterranean	Spain (Balearic Islands)	various species of dolphins	13	-	-	-
Brotons *et al.*, 2008, Brotons, Grau and Rendell, 2008	2001–2003	GN	Western Mediterranean	Spain (Balearic Islands)	-	0	-	-	1 040/139
Lauriano *et al.*, 2004	1999–2001	GN	Western Mediterranean	Italy (Sardinia)	-	0	-	-	88/29
Díaz López, 2006	1999–2004	GN	Western Mediterranean	Italy (Sardinia)	*Tursiops truncatus*	2 + 1[2]	-	1.47/year	3 720/2 556
Ktari-Chakroun, 1981	1980	GN	Central Mediterranean	Tunisia	*Tursiops truncatus*	1	-	-	-
Bradai, 1991	-	GN	Central Mediterranean	Tunisia	*Stenella coeruleoalba*	1	-	-	-
Karaa *et al.*, 2012	2008	GN	Central Mediterranean	Tunisia	*Balaenoptera physalus*	1	-	-	-
Karaa *et al.*, 2012	1937–2009	GN	Central Mediterranean	Tunisia	*Tursiops truncatus*	25	-	-	-
Gomerčić *et al.*, 2009	1990–2008	GN	Adriatic Sea	Croatia	*Tursiops truncatus*	12	-	-	-
Morizur *et al.*, 2012b; Morizur *et al.*, 2014	2011	GN	Western Mediterranean	France (Corsica)	-	0	-	-	164 hauls/0
Kerem *et al.*, 2012	1993–2009	GN	Eastern Mediterranean	Israel	*Stenella coeruleoalba*	2	-	-	-
Kerem *et al.*, 2012	1993–2009	GN	Eastern Mediterranean	Israel	*Steno bredanensis*	3	-	-	-
Kerem *et al.*, 2012	1993–2009	GN	Eastern Mediterranean	Israel	*Balaenoptera acutorostrata*	2	-	-	-
Attia El Hili *et al.*, 2010	2006–2008	GN/GTR	Central Mediterranean	Tunisia	*Tursiops truncatus*	4	-	-	-
Attia El Hili *et al.*, 2018	2007–2017	GN/GTR	Central Mediterranean	Tunisia	*Tursiops truncatus*	5	-	-	-

Table 7 (continued)

Bibliographic reference	Reference years	Gear	GFCM subregion	Country	Species	Reported individuals in bycatch events	Estimated bycatch events	Mortality rate/year[1]	Fishing operations/ Number of interactions recorded
Artov *et al.*, 1994; Pavlov *et al.*, 1996	1968–1993	GN	Black Sea	Russian Federation, Ukraine	*Phocoena phocoena relicta*	1 685	-	0.009/0.12	-
Artov *et al.*, 1994; Pavlov *et al.*, 1996	1968–1993	GN	Black Sea	Russian Federation, Ukraine	*Delphinus delphis ponticus*	297	-	0.009/0.12	-
Artov *et al.*, 1994; Pavlov *et al.*, 1996	1968–1993	GN	Black Sea	Russian Federation, Ukraine	*Tursiops truncatus ponticus*	104	-	0.009/0.12	-
Vasiliu and Dima, 1990	1984–1990	GN	Black Sea	Romania	*Phocoena phocoena relicta*	541	-	-	-
Vasiliu and Dima, 1990	1984–1990	GN	Black Sea	Romania	*Delphinus delphis ponticus*	22	-	-	-
Vasiliu and Dima, 1990	1984–1990	GN	Black Sea	Romania	*Tursiops truncatus ponticus*	3	-	-	-
Radu *et al.*, 2006	2002–2006	GN	Black Sea	Romania	*Phocoena phocoena relicta*	46	-	0.5	-
Radu *et al.*, 2006	2002–2006	GN	Black Sea	Romania	*Delphinus delphis ponticus*	3	-	-	-
Radu *et al.*, 2006	2002–2006	GN	Black Sea	Romania	*Tursiops truncatus ponticus*	2	-	-	-
Radu *et al.*, 2006	2005–2006	GN	Black Sea	Romania	*Phocoena phocoena relicta*	20	-	0.5	40 km/20
Öztürk *et al.*, 1999	1993–1997	GN	Black Sea	Turkey	*Phocoena phocoena relicta*	62	-	-	-
Öztürk *et al.*, 1999	1993–1997	GN	Black Sea	Turkey	*Delphinus delphis ponticus*	0	-	-	-
Öztürk *et al.*, 1999	1993–1997	GN	Black Sea	Turkey	*Tursiops truncatus ponticus*	1	-	-	-
Tonay and Öz, 1999	1999	GN/GTR	Black Sea	Turkey	*Phocoena phocoena relicta*	28	-	-	-
Tonay and Öz, 1999	1999	GN/GTR	Black Sea	Turkey	*Delphinus delphis ponticus*	0	-	-	-
Tonay and Öz, 1999	1999	GN/GTR	Black Sea	Turkey	*Tursiops truncatus ponticus*	0	-	-	-
Tonay and Öztürk, 2003	2002–2003	GN/GTR	Black Sea	Turkey	*Phocoena phocoena relicta*	40	-	-	875 nets (i.e. 94.5 km)/40
Tonay and Öztürk, 2003	2002–2003	GN/GTR	Black Sea	Turkey	*Delphinus delphis ponticus*	1	-	-	875 nets (i.e. 94.5 km)/1
Tonay and Öztürk, 2003	2002–2003	GN/GTR	Black Sea	Turkey	*Tursiops truncatus ponticus*	1	-	-	875 nets (i.e. 94.5 km)/1
BLASDOL, 1999	1997–1999	GN	Black Sea	Bulgaria	*Phocoena phocoena relicta*	13	-	-	-
BLASDOL, 1999	1997–1999	GN	Black Sea	Bulgaria	*Delphinus delphis ponticus*	0	-	-	-
BLASDOL, 1999	1997–1999	GN	Black Sea	Bulgaria	*Tursiops truncatus ponticus*	1	-	-	-
BLASDOL, 1999	1997–1999	GN	Black Sea	Georgia	*Phocoena phocoena relicta*	7	-	-	-
BLASDOL, 1999	1997–1999	GN	Black Sea	Georgia	*Delphinus delphis ponticus*	3	-	-	-
BLASDOL, 1999	1997–1999	GN	Black Sea	Georgia	*Tursiops truncatus ponticus*	1	-	-	-
BLASDOL, 1999	1997–1999	GN	Black Sea	Russian Federation/ Ukraine	*Phocoena phocoena relicta*	123	-	-	-
BLASDOL, 1999	1997–1999	GN	Black Sea	Russian Federation/ Ukraine	*Delphinus delphis ponticus*	0	-	-	-

Table 7 (continued)

Bibliographic reference	Reference years	Gear	GFCM subregion	Country	Species	Reported individuals in bycatch events	Estimated bycatch events	Mortality rate/year[1]	Fishing operations/ Number of interactions recorded
BLASDOL, 1999	1997–1999	GN	Black Sea	Russian Federation/ Ukraine	*Tursiops truncatus ponticus*	7	-	-	-
Mihaylov, 2011	2010–2011	GN	Black Sea	Bulgaria	*Phocoena phocoena relicta*	19	-	0.22	88.4 km/19
Mihaylov, 2011	2010–2011	GN	Black Sea	Bulgaria	*Tursiops truncatus ponticus*	2	-	0.02	88.4 km/2
Birkun *et al.*, 2014	-	GN	Black Sea	Bulgaria	*Phocoena phocoena relicta*	-	3 016	-	-
Birkun *et al.*, 2014	-	GN	Black Sea	Bulgaria	*Tursiops truncatus ponticus*	0	1 895	-	-
Birkun and Krivokhizhin, 2011	2006–2009	GTR	Black Sea	Russian Federation/ Ukraine	*Phocoena phocoena relicta*	355	-	1.42	250 km/355
Birkun and Krivokhizhin, 2011	2006–2009	GTR	Black Sea	Russian Federation/ Ukraine	*Tursiops truncatus ponticus*	5	-	0.02	250 km/5
Birkun and Krivokhizhin, 2011	2006–2009	GN	Black Sea	Russian Federation/ Ukraine	*Phocoena phocoena relicta*	159	-	1.51	104 km/159
Birkun and Krivokhizhin, 2011	2006–2009	GN	Black Sea	Russian Federation/ Ukraine	*Tursiops truncatus ponticus*	0	-	-	-
Birkun *et al.*, 2014	-	GN	Black Sea	Russian Federation/ Ukraine	*Phocoena phocoena relicta*	-	1 539	-	-
Birkun *et al.*, 2014	-	GN	Black Sea	Russian Federation/ Ukraine	*Tursiops truncatus ponticus*	-	1 211	-	-
Birkun *et al.*, 2014	2006–2009	GN	Black Sea	Russian Federation/ Ukraine	*Delphinus delphis ponticus*	2	-	0.09	23 km/2
Birkun *et al.*, 2014	2006–2009	GN	Black Sea	Russian Federation/ Ukraine	*Delphinus delphis ponticus*	29	-	0.95	31 km/29.5
Birkun *et al.*, 2014	2006–2009	GN	Black Sea	Russian Federation/ Ukraine	*Phocoena phocoena relicta*	2	-	1.0	2 km/2
Birkun *et al.*, 2014	2006–2009	GN	Black Sea	Russian Federation/ Ukraine	*Phocoena phocoena relicta*	0	-	-	18 km/0
Birkun *et al.*, 2014	2006–2009	GN	Black Sea	Russian Federation/ Ukraine	*Phocoena phocoena relicta*	68	-	2.8	24 km/68
Birkun *et al.*, 2014	2006–2009	GN	Black Sea	Russian Federation/ Ukraine	*Delphinus delphis ponticus*	81	-	2.4	34 km/81.5
Anton *et al.*, 2012	2010–2011	GN	Black Sea	Romania	*Phocoena phocoena relicta*	54	-	-	-
Radu and Anton, 2014	2002–2011	GN	Black Sea	Romania	*Phocoena phocoena relicta*	129	-	-	-
Radu and Anton, 2014	2002–2011	GN	Black Sea	Romania	*Tursiops truncatus ponticus*	2	-	-	-
Birkun *et al.*, 2014	2002–2011	GN	Black Sea	Romania	*Phocoena phocoena relicta*	52	-	10.4	5 sets/52
Birkun *et al.*, 2014	-	GN	Black Sea	Romania	*Phocoena phocoena relicta*	-	320	-	-
Gönener and Bilgin, 2009	March–April 2006	GTR	Black Sea	Turkey	*Phocoena phocoena relicta*	92	-	4.14	22 km of nets/92

Table 7 (continued)

Bibliographic reference	Reference years	Gear	GFCM subregion	Country	Species	Reported individuals in bycatch events	Estimated bycatch events	Mortality rate/year[1]	Fishing operations/ Number of interactions recorded
Gönener and Bilgin, 2009	March–April 2006	GTR	Black Sea	Turkey	*Phocoena phocoena relicta*	2	-	0.01	22 km/2
Birkun *et al.*, 2014	-	GN	Black Sea	Turkey	*Phocoena phocoena relicta*	-	6 477	-	-
Birkun *et al.*, 2014	-	GN	Black Sea	Turkey	*Tursiops truncatus ponticus & Delphinus delphis ponticus*	-	4 500	-	--
Tonay, 2016	2007–2008	GTR	Black Sea	Turkey	*Phocoena phocoena relicta*	24	1 269–3 100	0.18	130 km/24
Tonay, 2016	2007–2008	GTR	Black Sea	Turkey	*Tursiops truncatus ponticus*	1	12–324	0.01	130 km/1
Bilgin *et al.*, 2018	2010–2011	GN	Black Sea	Turkey	*Phocoena phocoena relicta*	71	-	0.13	136 nets/71
Bilgin *et al.*, 2018	2010–2011	GN	Black Sea	Turkey	*Delphinus delphis ponticus*	4	-	< 0.003	136 nets/4
Vishnyakova and Gol'din, 2015	1993–2013	-	Black Sea	Russian Federation/ Ukraine	*Phocoena phocoena relicta*	93	-	-	

Notes:
GN = gillnet not specified; GTR = trammel net
In grey, data collected before 2008.
1. n/year or CPUE=n/km nets
2. Number of individuals released alive.

4.3.2.4 Longliners

Generally, two types of longlines are used in the Mediterranean Sea: drifting longlines (sometimes also called surface or pelagic longlines) used in the water column at variable depths and set longlines (sometimes also called bottom or demersal longlines) deployed on the sea bottom.

a) Drifting longlines

Drifting longlines are one of the most widespread types of fishing gear globally, as well as in the Mediterranean, where they target mainly swordfish (*Xiphias gladius*), albacore (*Thunnus alalunga*), bluefin tuna (*Thunnus thynnus*) and some smaller tunas. They can be deployed on the continental shelf or in offshore waters at different depths (i.e. from the surface down to 600 m) and can reach 55 km in length, comprising up to 2 000–3 000 hooks. Depending on the target species, the hook size and shape can vary, ranging from 4 to 7 cm or more. In the past, the impact on cetaceans was low: only some cases were recorded, scattered across the Mediterranean and the Black Sea (Table 8).

Western Mediterranean

Between 2000 and 2009, an extensive survey was carried out in Spanish waters to assess the interactions between drifting longliners and cetaceans; 2 587 fishing sets were observed and a gross total of 5 398 297 hooks were monitored (Macías López *et al.*, 2012). Over this period, only in 52 cases (around 2 percent of the total fishing operations) were cetacean interactions recorded; these resulted in the capture of 57 individuals. The cetaceans belonged to four species: 33 Risso's dolphins (*Grampus griseus*), eight striped dolphins (*Stenella coeruleoalba*), six common dolphins (*Delphinus delphis*) and four long-finned pilot whales (*Globicephala melas*), plus six unidentified dolphins. Overall, 82 percent of the dolphins were released alive. The study showed significant differences in the

numbers of dolphins caught, according to the type of bait, the size of the hook, the soaking time (i.e. the time during which the fishing gear is actively in the water), the type of longline (i.e. traditional surface longline, Japanese longline, the American type longline with light sources to attract fish, the mesopelagic longline) and the depth of deployment (Table 8).

Central Mediterranean
No recent data are available for drifting longliners operating in this subregion.

Adriatic Sea
No recent data are available for drifting longliners operating in this subregion.

Eastern Mediterranean
No recent data are available for drifting longliners operating in this subregion.

Black Sea
No recent data are available for drifting longliners operating in this subregion.

b) Set longlines
Set longlines are not considered as a threat to cetaceans.

Western Mediterranean
No recent data are available for set longliners operating in this subregion.

Central Mediterranean
Bradai *et al.* (2018, unpublished data) report the entanglement of two bottlenose dolphins in Tunisia, both of which were released alive (Table 8).

Adriatic Sea
No recent data are available for set longliners operating in this subregion.

Eastern Mediterranean
No recent data are available for set longliners operating in this subregion.

Black Sea
No recent data are available for set longliners operating in this subregion.

4.3.2.5 Tuna seiners
Dolphins are rarely caught in purse seines targeting bluefin tuna and the impact of this type of fishery on cetaceans can be considered negligible (see Table 3).

Western Mediterranean
No recent data are available for tuna seiners operating in this subregion.

Central Mediterranean
No recent data are available for tuna seiners operating in this subregion.

Eastern Mediterranean
No recent data are available for tuna seiners operating in this subregion.

Table 8 – Incidental catch and estimated mortality rates of cetaceans in drifting longlines

Bibliographic reference	Reference years	Gear	Country	GFCM subregion	Species	Reported individuals in bycatch events	Estimated bycatch events	Mortality rate/year	Fishing operations/ Number of interactions recorded
Di Natale and Mangano, 1983b	1978–1982	LLD	Italy	Western Mediterranean	*Physeter macrocephalus*	1	-	-	-
Duguy *et al.*, 1983a, 1983b	-	LLD	France	Western Mediterranean	*Stenella coeruleoalba*	4	-	-	-
Duguy *et al.*, 1983a, 1983b	-	LLD	Spain	Western Mediterranean	*Tursiops truncatus*	1	-	-	-
Duguy *et al.*, 1983a, 1983b	-	LLD	Italy	Western Mediterranean	*Tursiops truncatus*	1	-	-	-
Duguy *et al.*, 1983a, 1983b	-	LLD	Italy	Western Mediterranean	*Grampus griseus*	1	-	-	-
Duguy *et al.*, 1983a, 1983b	-	LLD	Italy	Western Mediterranean	*Physeter macrocephalus*	16	-	-	-
Di Natale, 1989	-	LLD	Italy	Western Mediterranean	*Grampus griseus*	1	-	-	-
Di Natale, 1989	-	LLD	Italy	Western Mediterranean	*Ziphius cavirostris*	1	-	-	-
Garibaldi, 2015	1990	LLD	Italy	Western Mediterranean	*Stenella coeruleoalba*	1*	-	-	-
Mussi *et al.*, 1998	1991–1995	LLD	Italy	Western Mediterranean	*Physeter macrocephalus*	1	-	-	-
University of Barcelona, 1995	1991–1995	LLD	Spain	Western Mediterranean	all species	-	13–32	10%	-
Camiñas and Valeiras, 2001	1999	LLD	Spain	Western Mediterranean	all species	3	-	-	-
Camiñas and Valeiras, 2001	2000	LLD	Spain	Western Mediterranean	all species	12	-	-	-
Macías López *et al.*, 2012	2000–2009	LLD (for albacore)	Spain	Western Mediterranean	*Delphinus delphis*	1	-	0.002/1 000 hooks	-
Macías López *et al.*, 2012	2000–2009	LLD (for swordfish)	Spain	Western Mediterranean	*Delphinus delphis*	5	-	0.0015	-
Macías López *et al.*, 2012	2000–2009	LLD (for albacore)	Spain	Western Mediterranean	*Stenella coeruleoalba*	2	-	0.004	-
Macías López *et al.*, 2012	2000–2009	LLD (for swordfish)	Spain	Western Mediterranean	*Stenella coeruleoalba*	5	-	0.0016	-
Macías López *et al.*, 2012	2000–2009	LLD (for swordfish)	Spain	Western Mediterranean	*Stenella coeruleoalba*	1	-	0.003	-
Macías López *et al.*, 2012	2000-2009	LLD (for swordfish)	Spain	Western Mediterranean	*Globicephala melas*	2	-	0.0038	-
Macías López *et al.*, 2012	2000–2009	LLD (for swordfish)	Spain	W Mediterranean	*Globicephala melas*	2	-	0.0006	-
Macías López *et al.*, 2012	2000-2009	LLD (for swordfish)	Spain	Western Mediterranean	*Grampus griseus*	14	-	0.0246	-
Macías López *et al.*, 2012	2000–2009	LLD (for swordfish)	Spain	Western Mediterranean	*Grampus griseus*	10	-	0.0028	-
Macías López *et al.*, 2012	2000–2009	LLD (for swordfish)	Spain	Western Mediterranean	*Grampus griseus*	5	-	0.0087	-
Macías López *et al.*, 2012	2000–2009	LLD (for swordfish)	Spain	Western Mediterranean	*Grampus griseus*	4	-	0.012	-
Macías López *et al.*, 2012	2000–2009	LLD	Spain	Western Mediterranean	unidentified	6		-	-
Macías López *et al.*, 2012	2000–2009	LLD	Spain	Western Mediterranean	all species	47 + 10[1]	-	22% - 0.011/1 000 hooks	2 877 sets/52
Bradai *et al.*, unpublished data	2018	LLD (for swordfish)	Tunisia	Central Mediterranean	*Tursiops truncatus*	2	-	-	-

Notes: LLD = drifting longline.

In grey, data collected before 2008.

1. Number of individuals released alive.

Adriatic Sea
No recent data are available for tuna seiners operating in this subregion.

Black Sea
No recent data are available for tuna seiners operating in this subregion.

4.3.2.6 Dredges

Western Mediterranean
No recent data are available for dredges operating in this subregion.

Central Mediterranean
No recent data are available for dredges operating in this subregion.

Eastern Mediterranean
No recent data are available for dredges operating in this subregion.

Adriatic Sea

No recent data are available for dredges operating in this subregion.

Black Sea
No recent data are available for dredges operating in this subregion.

4.4 Depredation

Interactions between marine mammals and fisheries have a double effect: while marine mammals can be trapped by nets and hooks (incidental catch), they can also hurt fishers (depredation) in several ways. From a socio-economic perspective, marine mammal interactions with fisheries may have negative effects, including damage to fishing gear, reductions in catch size or quality, as well as loss of fishers' time, money or even gear. A number of studies have been carried out in the past on this issue, mainly involving the common bottlenose dolphin in many areas of the Mediterranean Sea (Díaz López, 2006; Cebrian, 2008; Mitra, Koutrakis and Milani, 2001; Fossa, Lammers and Orsi Relini, 2011; Pace, Tizzi and Mussi, 2015; Lauriano *et al.*, 2004; Pennino *et al.*, 2015; Benmessaoud *et al.*, 2018), but also on monk seals (Schultze-Westrum, 1976; Boulva, 1979; Berkes, 1982; Cebrian, 2008; Güçlüsoy, 2008; Ronald and Healy, 1974; Marchessaux and Duguy, 1977; Berkes *et al.*, 1979; Ríos *et al.*, 2017). Likewise, bottlenose dolphins also interact with fish farms at sea (Díaz López, 2006, 2017; Díaz López and Methion, 2017; Bearzi, Quondam and Politi, 2001; Piroddi, Bearzi and Christensen, 2011), sometimes resulting in incidental catch (Díaz López and Shirai, 2007).

Indeed, fishers have always viewed marine mammals as competitors for the same resources; furthermore, depredation by some species (such as monk seals and bottlenose dolphins) has always been the subject of complaints from fishers. In some cases, however, it appears that cetacean interactions with fishing activities, rather than having had only negative consequences, actually allowed for an increase in catch and fishing yields (CPUE), with the cetaceans incidentally foraging cooperatively with fishers (Benmessaoud *et al.*, 2018).

Depredation seems to be increasing in comparison to a few decades ago, involving different and larger species, such as sperm whales (Hanselman, Pyber and Peterson, 2018) and killer whales (Towers *et al.*, 2018). In the Mediterranean, one of the most notable cases is linked to the depredation by killer whales of the bluefin tuna small-scale fishery in the Strait of Gibraltar (de Stephanis, Cornulier and Verborgh, 2008; Guinet *et al.*, 2007; Esteban *et al.*, 2014, 2016). It is clear that the different types of interactions and the possibility of entanglement depend on the characteristics of the fishing gear, such as mesh size, yarn strength, depth of deployment and fishing strategies, among other aspects. However, entanglements due to depredation are generally scarce. The behaviour of depredation and the relative capacity to recognize and distinguish noises produced by the different phases of fishing activities (haulers, depth sounders, engines and so on) can be learned and passed down from generation to generation in cetacean populations (Díaz López, Bunke and Shirai, 2008; Pace, Pulcini and Triossi, 2011).

It is not easy to assess the actual damage, especially depending on the species and gear in question. Some attempts to estimate the damage and economic loss dealt by marine mammals, for example, Mediterranean monk seals (*Monachus monachus*), to fishers have been made in the past (see Goedicke, 1981). However, Cebrian (2008) remarked that seal damage reported by fishers in small-scale fisheries has generally been overreported, potentially distorting calculation values. Meanwhile, besides possibly overestimated damage to nets, monitoring of coastal fishing activities in Greek waters with important seal populations has revealed that monk seals may take an average of as little as 1 kg of fish from nets monthly per animal (Cebrian, 2008). More recently, however, Ríos *et al.* (2017) estimated possible economic loss due to depredation by monk seals in Greece at EUR 2 230 per fisher annually.

The cost of catch loss and net damage caused by common bottlenose dolphins (*Tursiops truncatus*) in the Balearic Islands between 2001 and 2003 was estimated as 6.5 percent of the total catch value and the annual loss as 3.4 percent of the total catch by weight (Brotons, Grau and Rendell, 2008). Another study conducted in the Balearic Islands between September and October of 2001 estimated the total economic damage caused by bottlenose dolphins as EUR 1 094 per trammel boat (Gazo, Gonzalvo and Aguilar, 2008). In addition, Lauriano *et al.* (2004) carried out an investigation in northeastern Sardinia and estimated that the catch loss from 1999 to 2001 came to about EUR 1 170 per trammel boat per fishing season, based on direct observations.

It is more difficult to quantify the damage done to other fishing activities, such as purse seiners targeting small pelagics. These fisheries are based on the concentration of fish, often in strictly coastal waters, and therefore also greatly attract marine mammals, especially cetaceans, often lured by the easy capture of their favourite prey, which allows them to save energy in the search for food in the process. The resulting arrival of the cetaceans disaggregates the schools of small pelagics, leading to delays, as well as losses of catch, for the fishers. Unpublished studies carried out in Morocco reported an annual economic loss due to bottlenose dolphins (*Tursiops truncatus*) in the purse seine fishery as high as 36 percent, with an annual loss per boat owner varying between 9 and 19 percent (Zahri *et al.*, 2004). More recently, Benmessaoud *et al.* (2018) estimated EUR 364 per month as the average costs of repairing nets damaged by dolphins in the area of Kelibia, Tunisia.

The situation for trawlers remains different. Interactions involving bottom trawlers frequently occur in the Mediterranean, as in other parts of the world, with the main species involved being the common bottlenose dolphin (Fertl and Leatherwood, 1997; Silvani, Raich and Aguilar, 1992;

Goffman, Kerem and Spanier, 1995; Trites, Christensen and Pauly, 1997; Consiglio *et al.*, 1992; Mussi *et al.*, 1998; Pace *et al.*, 1999; Bearzi *et al.*, 2008; Gonzalvo *et al.*, 2008). Indeed, foraging behind bottom trawlers provides cetaceans with an efficient strategy to save time and energy (Fertl and Leatherwood, 1997). Generally, cetaceans, such as bottlenose dolphins, feed on the fish that come out of the nets or on discards rejected by fishers at sea and therefore rarely cause any real physical damage. Only a few cases were reported of individuals catching prey fish in front of the mouth of the trawling net, thereby capitalizing on the higher fish concentrations. Under these circumstances, in addition to possibly doing economic damage to the fishers, such types of behaviour are dangerous for the dolphins themselves, potentially leading to capture or entanglement (Goffman *et al.*, 1995; Kent *et al.*, 2005).

4.5 Outlook

Marine mammals have always had a conflictual relationship with fishing activities/fishers, to a greater or lesser degree depending on the historical period, the type of fishing gear and species involved and socio-economic factors. Nevertheless, the literature and datasets analysed in this review indicate that in recent years (since 2008), the incidental catch of cetaceans in Mediterranean fisheries has begun to decrease with respect to past levels, i.e. when bycatch of marine mammals in pelagic driftnets was relevant, as well as of other groups of large marine vertebrate species. The use of these nets was banned in 2005 and since then, only a few studies have reported the bycatch of marine mammals from other fisheries in the Mediterranean Sea.

Generally, the types of fishing gear responsible for the most interactions with marine mammals are those used by small-scale fisheries in coastal areas, including bottom-set gillnets and trammel nets targeting several demersal species, such as red mullet (*Mullus surmuletus*), common cuttlefish (*Sepia officinalis*), and other neritic fish and cephalopod species in the Mediterranean Sea, and bottom-set gillnets for Black Sea turbot (*Scophthalmus maximus*). The marine mammal species most impacted in the Mediterranean are the Mediterranean monk seal (*Monachus monachus*), common bottlenose dolphin (*Tursiops truncatus*), common dolphin (*Delphinus delphis*) and harbour porpoise (*Phocoena phocoena*), along with three highly vulnerable species endemic to the Black Sea, the Black Sea bottlenose dolphin (*Tursiops truncatus ponticus*), the Black Sea common dolphin (*Delphinus delphis ponticus)* and the Black Sea harbour porpoise (*Phocoena phocoena relicta)* (Birkun, 2002; Reeves, McClellan and Werner, 2013; Birkun *et al.*, 2014).

The Mediterranean monk seal (*Monachus monachus*), given its biological and physiological characteristics, has always been extremely vulnerable to human activities; this species has seen its distribution area and population size dramatically drop since the last century. Its populations still present in the Mediterranean have now been reduced to a few hundred individuals, and it has been considered extinct in the Black Sea for over 20 years (Güçlüsoy *et al.*, 2004). Though historically, the main cause of death was related to direct interactions with humans, in more recent years, habitat disturbance and loss due to the expansion of human activities, including tourism, have been the main causes of death affecting monk seals, rather than incidental catch in coastal fisheries. Though it may not always be easy to understand the real causes of death, monk seal bycatch seems to have an impact primarily on calves and juveniles, rather than on adults (Androukaki *et al.* 1999, 2006). Currently, signs of population recovery, albeit minimal, have been offered by some authors; these positive trends are probably due to the protection policies implemented and above all to a better relationship between fishers and monk seals (Notarbartolo di Sciara and Kotomatas, 2016).

Considering cetacean bycatch in the Mediterranean basin from a strictly numerical point of view, mortality due to fishing reached high numbers only in large-mesh driftnets targeting large pelagic fish (Di Natale, 1989, 1995; Notarbartolo di Sciara, 1990; IWC, 1994; Di Natale and Notarbartolo di Sciara, 1994; Forcada and Hammond, 1998; Reeves and Notarbartolo di Sciara, eds., 2006; Tudela *et al.*, 2005). In fact, once large driftnets were banned and subsequently dismissed, cetacean bycatch considerably decreased, currently concerning only sporadically medium-small cetacean species, such as the bottlenose dolphin and the common dolphin.

PLATE 3
Common dolphin (*Delphinus delphis*)

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The situation in the Black Sea is quite different, as the coastal fisheries targeting Black Sea turbot still have an impact on the endemic cetacean populations (Birkun, 2002; Birkun *et al.*, 2014). The high levels of incidental catch mainly involve Black Sea harbour porpoises (*Phocoena phocoena relicta*), which generally live in coastal habitats and are impacted much more than the other cetacean species. From a technical point of view, this differential impact is probably due to a combination of both the size of the mesh used in the gillnets and/or trammel nets and the size of the Black Sea harbour porpoise, which is the smallest of the three cetacean species in the Black Sea (Birkun, 2002; Birkun *et al.*, 2014).

In general, however, it has always been difficult to make reliable estimates of total cetacean incidental catch. One of the main problems is that the methods used by researchers in different countries are not standardized, making it extremely difficult to compare the results obtained (Di Natale, 1995; Silvani *et al.*, 1999; Tudela *et al.*, 2005). Moreover, the parameters that should always be taken into account are numerous and difficult to evaluate; in order to make estimates more reliable, it is necessary to assume that observations made during surveys at sea (the best approach) are applicable to the entire fleet or vessel group throughout the year and during all seasons. The number of vessels involved in a certain fishery and the fishing effort (based on days at sea, kilometres of nets, number of hauls and number of hooks, among other criteria) should be considered, as well as cetacean behaviour (for example, time, area and species involved) and environmental parameters. Nevertheless, it is likewise complicated to obtain good estimates of the total incidental catch, even when surveys are carried out at sea. Moreover, collecting data in the field unfortunately consumes large amounts of time and money.

An example of the potential difficulties involved with this kind of approach comes from analysing gillnets targeting turbot (*Scophthalmus maximus*) in the Black Sea. This fishery has always impacted the local cetacean populations. Many estimates have been made in the past, some of which are more reliable than others. Based on surveys, onboard observations and interviews with fishers, Birkun *et al.* (2014) estimated the total effort of the turbot set net fishery in the Black Sea by country and the corresponding total cetacean bycatch for the Black Sea harbour porpoise (*Phocoena phocoena relicta*), as well as a combined figure for the other two endemic dolphin species, the Black Sea bottlenose dolphin (*Tursiops truncatus ponticus*) and the Black Sea common dolphin

Table 9 – Estimated number of vessels, fishing effort, stated catch rate and potential total incidental catch of cetaceans from the fishers' survey for the turbot gillnet fishery

Country	Number of vessels	Number of trips	Number of hauls	Km of net hauled	Km days of effort	Stated porpoise[1] bycatch per vessel/year	Stated dolphin[2] bycatch per vessel/year	Potential porpoise[1] bycatch per year	Potential dolphin[2] bycatch per year
Ukraine	543	16 154	96 926	760 865	3 660 110	2.83	2.23	1 539	1 211
Romania	118	2 931	12 777	95 824	716 058	2.71	0	320	0
Bulgaria	812	8 088	76 263	945 662	13 398 754	3.71	2.33	3 016	1 895
Turkey	1 119	7 553	26 856	306 158	3 348 608	5.79	4.02	6 477	4 500
Total	**2 592**	**34 726**	**212 821**	**2 108 510**	**21 123 528**			**11 351**	**7 606**

Source: modified from Birkun *et al.* (2014).

Notes:

1. Black Sea harbour porpoise (*Phocoena phocoena relicta*).
2. Could refers to both Black Sea bottlenose dolphin (*Tursiops truncatus ponticus*) and Black Sea common dolphin (D*elphinus delphis ponticus*).

Table 10 – Indicative incidental catch of vulnerable species in other types of fishing gear in the Black Sea

Gear	Country	Number of vessels	Porpoise bycatch rate per vessel	Dolphin bycatch rate per vessel	Estimated porpoise bycatch per year	Estimated dolphin bycatch per year
Gillnets	Ukraine	474	0.25	2.27	119	1 076
Gillnets	Turkey	3 148	3.11	1.62	9 799	5 104
Purse seine	Ukraine	21	1.15	1	24	21
Purse seine	Turkey	395	2.71	0.56	1 070	220
Pelagic trawl	Ukraine	49	0.50	1.38	25	68
Total					**11 037**	**6 489**

Source: modified from Birkun *et al.* (2014).

(*Delphinus delphis ponticus*). The same procedure was carried out for the other types of fishing gear used in the Black Sea as well; the results are reported in Table 9 and Table 10 and clearly show the difference between stated and potential bycatch in the Black Sea in relation to fishing effort.

Considering the incredibly high levels of incidental catch they came up with, the authors themselves cast some doubt on the reliability of these estimates, which, in some cases, even exceeded the actual abundance of the entire population of the species. They concluded that the main problems are linked to difficulties in obtaining robust estimates of incidental catch rates, which can then be extrapolated to produce a better estimate for the whole fleet. Indeed, it appears likely that the observations reported must have been far from representative of the overall fishing activities. In order to provide more accurate data, these types of errors can be corrected only by a higher coverage of monitoring activities.

PLATE 4
Black Sea bottlenose dolphin (*Tursiops truncatus ponticus*)

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Over the last two decades, as made clear by this review, studies on incidental catch have considerably declined, while

research on direct interactions (i.e. depredation) between marine mammals and fishing gear is increasing, often with the aim of quantifying its importance and, when possible, assessing the damage inflicted on fishers from an economic point of view (Díaz López, 2006; Radu, Anton and Dumitrache, 2008; Quero *et al.*, 2000; Bearzi *et al.*, 2008; Bradai *et al.*, 2010; Pennino *et al.*, 2015; Ríos *et al.*, 2017; Revuelta *et al.*, 2018).

However, it clearly remains very difficult to reduce interactions between marine mammals and fishing activities. A positive sign seems to come from the recent decreases in bycatch and lethal interactions, which depend on increased awareness of fishers and reductions in fishing effort, especially in the number of boats in some areas (FAO, 2016, 2018, 2020), as well as on the introduction of protection and mitigation measures. These measures can vary, depending on the types of fishing gear and strategies employed and the marine mammals involved. In order to reduce cetacean and monk seal bycatch (and mortality) and economic damage to fishers, controls could be implemented to limit fishing effort (i.e. closures at certain times and in specific areas) or to modify the different types of fishing gear and strategies used by fishers (i.e. gear designed to minimize bycatch, the introduction of devices able to prevent unwanted catch, such as grids for trawlers, and changes in fishing behaviour). Awareness campaigns should be implemented for fishers and all stakeholders involved in fishery activities, highlighting the important value of marine mammals in terms of natural cycles, biodiversity conservation, ecotourism, etc.

Acoustic deterrent devices are one of the most widespread measures used in attempt to mitigate interactions between marine mammals and fishing gear. Pingers (i.e. devices that transmit short, high-pitched signals) have been tested in a large variety of situations all over the world, but sometimes offer contradictory results. For example, pingers can function as a "dinner bell" for cetaceans (Bordino *et al.* 2002), who become rapidly habituated to the initial avoidance response (Imbert *et al.*, 2002, 2007). While in the GFCM area of application, it seems they could have a positive effect on reducing the bycatch of Black Sea harbour porpoises (*Phocoena phocoena relicta*) in the Black Sea turbot gillnet fishery (Gönener and Bilgin, 2009; Zaharieva, Spasova and Gavrilov, 2016), other areas showed different results. In the Adriatic Sea, pingers were used consistently from 2006 to 2018 during surveys carried out on midwater pair trawlers (Fortuna *et al.*, 2010a, 2010b). The objective was to test the effects of different types of acoustic deterrent devices on the behaviour of cetaceans and assess their real efficacy as a mitigation measure for this fishing activity. The first results seemed encouraging, but statistical analysis of the entire project revealed that the pinger influence on dolphin behaviour was not significant, highlighting a gradual reduction of the effects over time (De Carlo *et al.*, 2012; Sala *et al.*, 2018). Other studies provide good evidence for the effectiveness of pingers in reducing the incidental catch of some cetacean species (Gazo, Gonzalvo and Aguilar, 2008; Brotons *et al.*, 2008; Dawson *et al.*, 2013), but a definitive answer for achieving effective mitigation overall is still lacking (Zahri *et al.*, 2007; Buscaino *et al.*, 2009).

In conclusion, further studies are required to improve the collection of reliable data on fishing effort, fishing gear and fishing strategies, covering, to the greatest extent possible, all the coastal fisheries of the whole Mediterranean and the Black Sea region. Moreover, the standardization of survey methods and observer sampling protocols should be considered one of the top priorities in order to obtain robust estimates of marine mammal bycatch rates, of which so much remains unknown.

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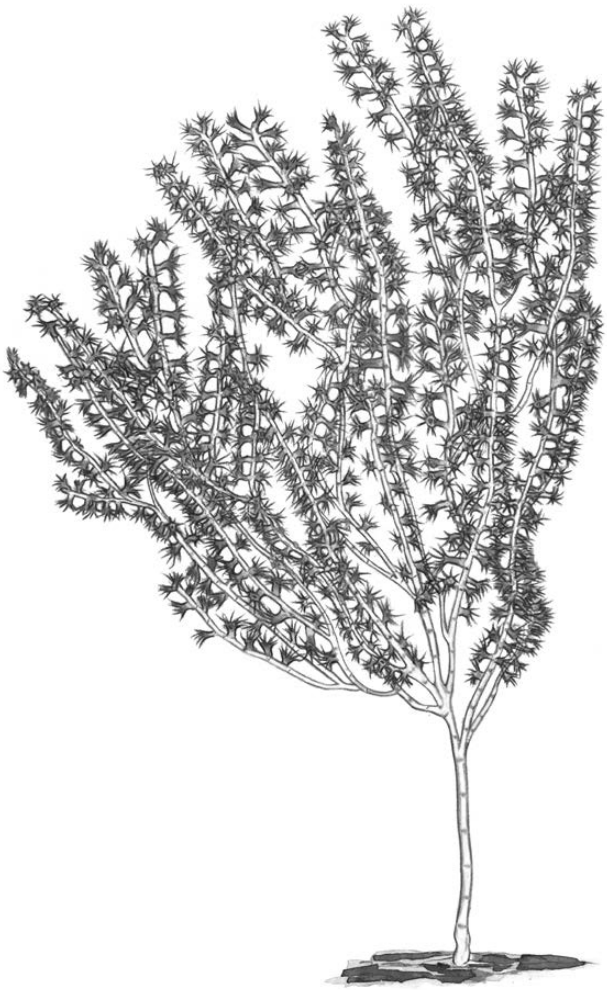
MACROBENTHIC INVERTEBRATES



The black coral (*Antipathella subpinnata*)

5. Macrobenthic invertebrates

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Executive summary

Macrobenthic invertebrates such as soft and hard corals, sponges, echinoderms, molluscs and other benthic organisms contribute to forming structured habitats that may constitute the so-called vulnerable marine ecosystems (VMEs). This review describes VMEs and their macrobenthic indicator taxa currently known in the Mediterranean Sea, and provides an overview of available information on the bycatch of these taxa from fishery-dependent and fishery-independent surveys. It presents a detailed analysis of available information on the incidental catch of VME indicator taxa at the lowest possible taxonomic level, by sub-basin and bottom-contact fishing gear (such as bottom trawlers set longliners and gillnets, as well as pot and traps generally used in small-scale fisheries). Nonetheless, bycatch data from commercial fisheries are often scarce or only refer to a few specific areas. In this respect, independent scientific surveys can provide insights into the bycatch of VME indicator taxa. Bottom trawls represent the most impactful fishing practice to VMEs. On the other hand, the extent of bycatch from set longlines and small-scale fisheries is almost unknown. For example, the use of a VME encounter protocol for deep-sea fisheries using bottom-contact gear, as well as fishery monitoring protocols based on onboard observers, could provide new information on the distribution of VME indicators in most of the Mediterranean areas not covered by scientific surveys. This would assist in identifying VME hotspot or priority areas for the implementation of conservation measures (such as fishery closure).

5.1 Vulnerable marine ecosystems

A wide variety of macro- and megabenthic species (0.5–20 mm and >20 mm, respectively) are present in the Mediterranean Sea. They can display an aggregative behaviour and constitute populations and communities which play a significant structural role in providing essential three-dimensional habitats for fish and invertebrate communities, acting as habitat formers, from the shallow to the deep-sea (e.g. Caddy, 2007; Bo *et al.*, 2011; Freiwald *et al.*, 2009; Buhl-Mortensen *et al.*, 2010; D'Onghia *et al.*, 2010, 2011; Bo *et al.*, 2012; Aguilar *et al.*, 2013; Chimienti *et al.*, 2019a). The biogenic habitats resulting from this aggregation host a rich fauna, including endangered and protected species as well as fish and crustacean species of high commercial value (D'Onghia, Sion and Capezzuto, 2019; Mastrototaro *et al.*, 2010, 2017; D'Onghia *et al.*, 2012, 2017; Rueda *et al.*, 2019; Sion *et al.*, 2019).

Because of the high abundance of commercial species, often with large-sized specimens, inhabiting them, these benthic habitats are usually targeted by commercial fisheries (Bo, Canese and Bavestrello, 2014; Bo *et al.*, 2014a; Cau *et al.*, 2017c; D'Onghia, 2019). However, they are particularly sensitive to certain types of bottom-contact fishing gear used in some fisheries, as well as to other human activities impacting the seabed. According to FAO (2009), vulnerable marine ecosystems (VMEs) are groups of species, communities, or habitats that may be vulnerable to impacts from fishing activities. Their vulnerability is linked to their likelihood of experiencing substantial alterations from short-term or chronic disturbances, as well as to their eventual recovery possibilities. Thus, a marine ecosystem is classified as vulnerable based on its uniqueness or rarity, its functional significance, its fragility (both physical and functional), its structural complexity and the life-history traits of the species that make its recovery difficult (for example, slow growth rate, late age of maturity, low or unpredictable recruitment and long-life expectancy).

Deep-sea ecosystems more generally present these traits and may hence be particularly vulnerable to the impacts of fishing gear (Danovaro *et al.*, 2010; Ramirez-Llodra *et al.*, 2011). Deep-sea fisheries, which make use of gear that comes into contact with the seafloor to catch benthic or demersal species, can affect the marine environment damaging VMEs and causing negative effects, known as significant adverse impacts. Several resolutions adopted by the United Nations General Assembly, namely Resolution 59/25 in 2004 (UNGA, 2004), Resolution 61/105 in 2006 (UNGA, 2006) and Resolution 64/72 in 2009 (UNGA, 2009), called upon regional fisheries management organizations to take urgent action to protect VMEs from significant adverse impacts in areas beyond national jurisdiction. Significant adverse impacts occur when the ecosystem function is impaired and the long-term natural productivity is degraded on more than a temporary basis, compromising the long-term integrity and function of VMEs as structurally complex communities and habitats.

Temporary impacts are those that are limited in duration and allow an ecosystem to recover over an acceptable time span. Ecosystem recovery is case-by-case dependent, but impacts are generally not considered temporary if the recovery takes more than 5 to 20 years, depending on the specific features of the populations and ecosystems (FAO, 2009). Moreover, impacts should be evaluated individually, in combination and cumulatively. Vulnerable marine ecosystems develop under specific topographical, hydrophysical and geological conditions, such as seamounts and volcanic ridges, canyons and trenches, steep slopes, submarine relief structures (for example, slumped blocks, ridges and cobble fields), cold seeps (including pockmarks, mud volcanoes, sediment under reducing conditions, anoxic pools and methanogenic hard bottoms), as well as hydrothermal

vents, collectively referred to as VME indicator features (FAO, 2009). In association with these features, several benthic species or groups of species can settle and live, representing a signal of VME occurrence, and are thus called VME indicator species or taxa.

The General Fisheries Commission for the Mediterranean (GFCM) defined Mediterranean VME indicator taxa, habitats and features (GFCM, 2017, 2018b). Vulnerable marine ecosystem indicator taxa include soft and hard corals, sponges, echinoderms, molluscs and other benthic organisms (Table 1, Table 2), most of which are included in relevant lists of protected species, such as the International Union for the Conservation of Nature (IUCN) Red List (IUCN, 2021). Nevertheless, no broad consensus exists about the depth range for the occurrence of VMEs or for restricting deep-sea fishery practices. Conventionally, from an ecological point of view, the deep sea is considered to be over 200 m depth and beyond the shelf break (Thistle, 2003), and the deep Mediterranean is regarded as roughly coinciding with the aphotic zone, from 150–200 m depth, where the direct influence of the sunlight is almost absent and the bathyal zone, as defined by Pérès and Picard (1964), generally begins. The mesophotic seabed of the so-called twilight zone (from 50 to 150–200 m depth), often targeted by fisheries, can host important and fragile animal communities too, and generally fits the definition of VMEs (Bo, Canese and Bavestrello, 2014; Cerrano *et al.*, 2010; Bo *et al.*, 2014a, 2015; Cau *et al.*, 2017c; Chimienti *et al.*, 2020b). In fact, in the North Atlantic, the ecological impacts on seabed communities are considered comparable to ocurring on shallower ecosystems (Clark and Koslow, 2007; Hall–Spencer, Allain and Fosså, 2002; Clark, Althaus and Schlacher, 2016; Gage *et al.*, 2005; Waller *et al.*, 2007), and this might also be the case at a global scale (Clark and Rowden, 2009; Koslow *et al.*, 2001; Althaus *et al.*, 2009). From a fishery management perspective, the concept of deep sea is linked to the occurrence of deep-sea fisheries (FAO, 2009), which in many regions of the world operate in areas beyond national jurisdiction, i.e. from the continental slope to depths of thousands metres. In light of this, the significant adverse impact on VMEs has been mostly associated with deep-sea fisheries in the international context.

Due to the oceanographic conditions characterizing the Black Sea (Özsoy and Ünlüata, 1997), no VME indicators are likely to occur in this basin below 200 m depth, though some fragile communities can occur in shallower waters. For instance, a rare garden of the gorgonian *Spinimuricea klavereni* was found in the Marmara Sea, which connects with the Black Sea (Figure 1), where unquantified trammel net fishing activities were reported (Topçu and Öztürk, 2016). However, no VME indicator taxa were reported in the invertebrate bycatch from commercial trawling along the Turkish coast in the southern Black Sea (Kasapoglu and Duzgunes, 2017), or from the shrimp beam trawl fishery in the Marmara Sea (Zengin and Akyol, 2009). Moreover, there are no data available on the incidental catch of VME indicator taxa from longline and small-scale fisheries in the Black Sea; therefore the following sections focus on the Mediterranean Sea.

BOX 1. Definitions

Alcyonacea: corals (Phylum: Cnidaria; Class: Anthozoa; Subclass: Octocorallia) that do not produce calcium carbonate skeletons, but only minute, thorny skeletal elements called sclerites. They include the so-called gorgonians.

Antipatharians: also known as black corals, an order of coral (Phylum: Cnidaria; Class: Anthozoa; Subclass: Hexacorallia) characterized by a black skeleton and an arborescent shape.

Aphotic zone: the portion of the seabed where there is very little or no sunlight. It is formally defined as the depths beyond which less than 1 percent of sunlight penetrates. In the Mediterranean Sea, it indicatively starts below 200 m depth and includes the bathyal zone.

Bathyal and abyssal zones: the portion of the seabed where the light is absent and plants and algae cannot live. In the oceans, the bathyal zone is followed by the abyssal zone, where the water temperature is less than 4°C. In the Mediterranean Sea, the bathyal zone indicatively starts below 200 m depth and has a temperature between 12.5 and 14.5°C, depending on the different locations in the basin.

Byssus: a bundle of protein filaments secreted by many species of bivalves that function to attach the mollusc to the substrate.

Cold seep: an area of the ocean floor, sometimes also called cold vent, where hydrogen sulphide, methane and other hydrocarbon-rich fluid seepage occurs, often in the form of a brine pool.

Deep-sea fisheries: Deep-sea fisheries are those that operate at great depths (up to 1 600 m). Deep-sea fisheries in the Mediterranean Sea are defined as: i) all fishing vessels above 15 m length overall (LOA) using bottom contact fishing gear to fish for giant red shrimp (*Aristaeomorpha foliacea*), blue and red shrimp (*Aristeus antennatus*) or golden shrimp (*Plesionika martia*); and ii) all fishing vessels above 15 m LOA using bottom contact gear (bottom trawls, longlines, gillnets and pots and traps) at depths deeper than 300 m or on offshore seamounts (FAO, 2020).

Ecosystem engineer: any organism that creates, significantly modifies, maintains or destroys a habitat.

Emergent fauna: an aggregation of individuals or colonies of benthic animal species that develop above the seabed, enhancing the three-dimensionality of the environment.

Epibiosis: any relationship between two organisms in which one lives on the other. Epibionts can usually settle on a coral when the latter is stressed, injured or dead.

Encounters and encounter rules: an encounter with vulnerable marine ecosystem (VME) indicator taxa is defined as any catch of VME indicator taxa by any deep-sea fishery. Encounter rules stipulate that, following an encounter, the captain of the vessel shall report the encounter to the flag State, completing an ad hoc form and providing the following information: i) the position of the vessel; ii) the fishing characteristics of the vessel; and iii) the groups of VME indicator taxa encountered and the best estimates of their live weight. Encounter rules were endorsed by the GFCM in 2018, and GFCM contracting parties and cooperating non-contracting parties are encouraged to use them when implementing measures to prevent significant adverse impacts of deep-sea fisheries on VMEs (Resolution GFCM/43/2019/6 on the establishment of a set of measures to protect vulnerable marine ecosystems formed by cnidarian (coral) communities in the Mediterranean Sea) (FAO, 2020).

BOX 1. (Continued)

Essential fish habitat: Habitats identified as essential to satisfying the ecological and biological requirements of critical life history stages of exploited fish (used as a collective term to include molluscs, crustaceans and any other aquatic animal that is harvested) species. These habitats may require special protection to improve the status of the stocks and secure their long-term sustainability (FAO, 2020).

Exploratory deep-sea bottom fishing protocols: exploratory (or new) deep-sea bottom fishing occurs during the initial development phase of a deep-sea fishery when it begins to either operate in areas that have not previously been fished or to fish again in familiar areas after significant changes in gear or effort. Exploratory deep-sea bottom fishing protocols are established to ensure that exploratory or new deep-sea fishing activities are only allowed to grow at a rate consistent with the knowledge and management of that fishery and while always respecting existing VMEs. Thus, vessels undertaking exploratory (or new) deep-sea bottom fishing shall be required to follow the exploratory deep-sea bottom fishing protocol, providing information on: i) the start and end points of each tow or set; ii) the fishing characteristics of the vessel, including the gear used; iii) the geographical subarea and the statistical grid where the exploratory deep-sea fishing occurred; iv) catch, bycatch, discards and fishing effort; and v) VME indicator taxa (if any) through the VME encounter protocol. These protocols were endorsed by the GFCM in 2018, and GFCM contracting parties and cooperating non-contracting parties are encouraged to use them when implementing measures to prevent significant adverse impacts of deep-sea fisheries on vulnerable marine ecosystems (Resolution GFCM/43/2019/6 on the establishment of a set of measures to protect vulnerable marine ecosystems formed by cnidarian (coral) communities in the Mediterranean Sea) (FAO, 2020).

Fishery-dependent surveys: surveys carried out as part of commercial fishing activities.

Fishery-independent surveys: surveys not carried out as part of commercial fishing but, for example, through ad hoc fishing campaigns or scientific/experimental surveys.

Mesophotic zone: also known as the circalittoral zone or twilight zone, the portion of the seabed from the limit of seagrass present to the limit of algae present (loss of net productivity at the level of irradiance <1 percent). In the Mediterranean Sea, it indicatively ranges between 50 and 200 m depth.

Methanogenic hard bottom: the production of methane from the seafloor which sometimes form a hard crust.

Osculum, oscula: an excretory structure in the living sponge, represented by a large opening through which the current of water exits after passing through the atrial cavity (spongocoel).

Precious corals: a term collectively describing the species of corals (species belonging to the Phylum Cnidaria with a skeleton made of calcium carbonate or limestone) whose skeletal axis is used as a gemstone to make ornaments and jewelry (FAO, 2020).

Pockmarks: circular to ellipsoid shallow craters on soft muddy sea floors, formed by sub-sea-floor fluid expulsion. The diameter of pockmarks can range from a few metres to >300 m. They can be locally very abundant, forming pockmark fields.

Table 1 – Vulnerable marine ecosystem indicator features, habitats and taxa present in the Mediterranean Sea

Mediterranean VME indicator features		
Seamounts and volcanic ridges		
Canyons and trenches		
Steep slopes		
Submarine relief structures (e.g. slumped blocks, ridges and cobble fields)		
Cold seeps (pockmarks, mud volcanoes, sediment under reducing conditions, anoxic pools and methanogenetic hard bottoms)		
Hydrothermal vents		
Mediterranean VME indicator habitats		
Cold-water coral reefs		
Coral gardens	Hard-bottom coral gardens	
	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		
Mediterranean VME indicator taxa		
Phylum	**Class**	**Subclass (order)**
Cnidaria	Anthozoa	Hexacorallia (Antipatharia, Scleractinia)
		Octocorallia (Alcyonacea, Pennatulacea)
		Ceriantharia
	Hydrozoa	Hydroidolina
Porifera	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 indicating the presence of a cold seep or hydrothermal vent are considered.

Source: GFCM, 2018b.

Table 2 – Examples of families, genera and species included in vulnerable marine ecosystem indicator taxa, and main references

VME indicator habitat	Family	Genus/species	Author	References
Cold-water coral reefs (section 5.1.1)	Order Scleractinia			
	Caryophylliidae	*Desmophyllum dianthus*	(Esper, 1794)	Tursi *et al.*, 2004; Taviani *et al.*, 2005, 2017; Freiwald *et al.*, 2009, 2011; Mastrototaro *et al.*, 2010; Angeletti *et al.*, 2014, 2020; D'Onghia *et al.*, 2015a; Chimienti, Angeletti and Mastrototaro, 2018; Chimienti *et al.*, 2019a
	Caryophylliidae	*Lophelia pertusa* (*Desmophyllum pertusum*)	(Linnaeus, 1758)	Tursi *et al.*, 2004; Taviani *et al.*, 2005, 2017; Schembri *et al.*, 2007; Freiwald *et al.*, 2009, 2011; Orejas *et al.*, 2009; Mastrototaro *et al.*, 2010; Gori *et al.*, 2013; Angeletti *et al.*, 2014, 2020; Fabri *et al.*, 2014; Addamo *et al.*, 2015; Chimienti, Angeletti and Mastrototaro, 2018; Chimienti *et al.*, 2019a
	Dendrophylliidae	*Dendrophyllia cornigera*	(Lamarck, 1816)	Tursi *et al.*, 2004; Orejas *et al.*, 2009; Mastrototaro *et al.*, 2010; Salomidi *et al.*, 2010; Gori *et al.*, 2013, 2014; Bo *et al.*, 2014a; D'Onghia *et al.*, 2016; Lastras *et al.*, 2016; Chimienti *et al.*, 2019a; Enrichetti *et al.*, 2019; Giusti *et al.*, 2019; Moccia *et al.*, 2021
	Scleractinia	*Madrepora oculata*	(Linnaeus, 1758)	Tunesi and Diviacco, 1997; Tursi *et al.*, 2004; Taviani *et al.*, 2005, 2017; Schembri *et al.*, 2007; Freiwald *et al.*, 2009, 2011; Orejas *et al.*, 2009; Mastrototaro *et al.*, 2010; Lo Iacono *et al.*, 2012; Gori *et al.*, 2013; Angeletti *et al.*, 2014, 2020; Fabri *et al.*, 2014; D'Onghia *et al.*, 2015a, 2016; Lastras *et al.*, 2016; Fanelli *et al.*, 2017; Chimienti, Angeletti and Mastrototaro, 2018; Chimienti *et al.*, 2019a
	Order Anthoathecata			
	Stylasteridae	*Errina aspera***	(Linnaeus, 1767)	Giacobbe, 2001; Álvarez–Pérez *et al.*, 2005; Giacobbe *et al.*, 2007; Salvati *et al.*, 2010; Chimienti *et al.*, 2019a
Mesophotic stony coral communities (section 5.1.2)	Order Scleractinia			
	Caryophylliidae	*Phyllangia americana mouchezii*	(Lacaze-Duthiers, 1897)	Zibrowius, 1980; Corriero *et al.*, 2019
	Caryophylliidae	*Polycyathus muellerae*	(Abel, 1959)	Zibrowius, 1980; Corriero *et al.*, 2019
	Dendrophylliidae	*Dendrophyllia ramea**	(Linnaeus, 1758)	Zibrowius, 1980; Ocaña *et al.*, 2000; Sánchez *et al.*, 2004; Salomidi *et al.*, 2010; Orejas *et al.*, 2017
Coral gardens (section 5.1.3)	**Hard-bottom coral gardens (section 5.1.3.1)**			
	Order Antipatharia			
	Antipathidae	*Antipathes dichotoma*	(Pallas, 1766)	Mastrototaro *et al.*, 2010; Bo *et al.*, 2011, 2014c, 2020b; Mytilineou *et al.*, 2014; Cau *et al.*, 2015; Chimienti *et al.*, 2019a ; Moccia *et al.*, 2021
	Leiopathidae	*Leiopathes glaberrima*	(Esper, 1788)	Deidun *et al.*, 2010, 2015; Mastrototaro *et al.*, 2010; Angeletti *et al.*, 2014; Mytilineou *et al.*, 2014; Bo *et al.*, 2015; Cau *et al.*, 2015; Ingrassia *et al.*, 2016; Massi *et al.*, 2018; Chimienti *et al.*, 2019a; Moccia *et al.*, 2021
	Myriopathidae	*Antipathella subpinnata*	(Ellis and Solander, 1786)	Bo *et al.*, 2008, 2009, 2012, 2014c; Cau *et al.*, 2015; Deidun *et al.*, 2015; Enrichetti *et al.*, 2019; Chimienti *et al.*, 2020b ; Moccia *et al.*, 2021
	Schizopathidae	*Parantipathes larix*	(Esper, 1788)	Bo *et al.*, 2012, 2014b; Cau *et al.*, 2015; Ingrassia *et al.*, 2016; Chimienti *et al.*, 2019a ; Moccia *et al.*, 2021

Table 2 (continued)

VME indicator habitat	Family	Genus/species	Author	References
	Order Alcyonacea			
	Acanthogorgiidae	*Acanthogorgia hirsuta*	(Gray, 1857)	Tursi *et al.*, 2004; Mastrototaro *et al.*, 2010; Bo *et al.*, 2012, 2014a; Moccia *et al.*, 2021
	Alcyoniidae	*Alcyonium acaule**	(Marion, 1878)	Ambroso *et al.*, 2013a; Fiorillo *et al.*, 2013
	Alcyoniidae	*Alcyonium coralloides*	(Pallas, 1766)	Groot and Weinberg, 1982; Quintanilla *et al.*, 2013
	Coralliidae	*Corallium rubrum*	(Linnaeus, 1758)	Rossi *et al.*, 2008; Deidun *et al.*, 2010; Santangelo and Bramanti, 2010; Costantini *et al.*, 2011; Bramanti *et al.*, 2013; Bavestrello *et al.*, 2014; Cau *et al.*, 2015; Knittweis *et al.*, 2016; Lastras *et al.*, 2016; Giusti *et al.*, 2019; Ferrigno *et al.*, 2020; Moccia *et al.*, 2021
	Dendrobrachiidae	*Dendrobrachia bonsai*	(López-González and Cunha, 2010)	López-González and Cunha, 2010; Sartoretto, 2012; Bo *et al.*, 2020b
	Ellisellidae	*Ellisella paraplexauroides*	(Stiasny, 1936)	Angiolillo *et al.*, 2012; Maldonado *et al.*, 2013; Grinyó *et al.*, 2016
	Ellisellidae	*Viminella flagellum*	(Johnson, 1843)	Giusti *et al.*, 2012; Lo Iacono *et al.*, 2012; Bo *et al.*, 2014a; Cau *et al.*, 2015, 2017c; Deidun *et al.*, 2015; Chimienti *et al.*, 2019a; Moccia *et al.*, 2021
	Gorgoniidae	*Eunicella cavolini*	(Koch, 1887)	Russo, 1985; Weinbauer and Velimirov, 1996a, 1996b; Cau *et al.*, 2015; Sini *et al.*, 2015; Enrichetti *et al.*, 2019; Giusti *et al.*, 2019; Moccia *et al.*, 2021
Coral gardens (section 5.1.3)	Gorgoniidae	*Eunicella singularis**	(Esper, 1791)	Skoufas *et al.*, 2000; Coma *et al.*, 2006; Gori *et al.*, 2007, 2011a, 2011b, 2012; Ribes *et al.*, 2007; Linares *et al.*, 2008; Ferrier–Pagès *et al.*, 2009;
	Gorgoniidae	*Eunicella verrucosa*	(Pallas, 1766)	Coz *et al.*, 2012; Bo *et al.*, 2014a; Enrichetti *et al.*, 2019; Giusti *et al.*, 2019; Chimienti, 2020
	Gorgoniidae	*Leptogorgia sarmentosa**	(Esper, 1789)	Mistri, 1995; Rossi and Gili, 2009; Gori *et al.*, 2011a
	Isididae	*Chelidonisis aurantiaca*	(Studer, 1890)	Bo *et al.*, 2020b
	Nidaliidae	*Chironephthya mediterranea*	(López-González, Grinyó and Gili, 2015)	López-González *et al.*, 2015
	Nidaliidae	*Nidalia studeri**	(Koch, 1891)	López-González *et al.*, 2012
	Plexauridae	*Bebryce mollis*	(Philippi, 1842)	Mastrototaro *et al.*, 2010; Bo *et al.*, 2012; Grinyó *et al.*, 2016; Moccia *et al.*, 2021
	Plexauridae	*Muriceides lepida*	(Carpine & Grasshoff, 1975)	Bo *et al.*, 2020a, 2020b
	Plexauridae	*Paramuricea clavata*	(Risso, 1826)	Bavestrello *et al.*, 1997; Cerrano *et al.*, 2005; Linares *et al.*, 2008; Linares and Doak, 2010; Gori *et al.*, 2011a; Mokhtar-Jamai *et al.*, 2011; Bo *et al.*, 2014a; Ponti *et al.*, 2018; Enrichetti *et al.*, 2019; Giusti *et al.*, 2019; Moccia *et al.*, 2021
	Plexauridae	*Paramuricea macrospina*	(Koch, 1882)	Mastrototaro *et al.*, 2010; Bo *et al.*, 2011, 2012; Angeletti *et al.*, 2014; Grinyó *et al.*, 2016; Enrichetti *et al.*, 2019
	Plexauridae	*Placogorgia coronata**	(Carpine and Grasshoff, 1975)	Cartes *et al.*, 2009; Enrichetti *et al.*, 2018
	Plexauridae	*Spinimuricea klavereni**	(Carpine and Grasshoff, 1975)	Vafidis *et al.*, 1994; Bo *et al.*, 2012; Topçu and Öztürk, 2013, 2015, 2016
	Plexauridae	*Swiftia dubia*	(Thomson, 1929)	Mastrototaro *et al.*, 2010; Mytilineou *et al.*, 2014; Grinyó *et al.*, 2016
	Plexauridae	*Villogorgia bebrycoides**	(Koch, 1887)	Bo *et al.*, 2012, 2014a, 2020a

Table 2 (continued)

VME indicator habitat	Family	Genus/species	Author	References
Coral gardens (section 5.1.3)	Primnoidae	*Callogorgia verticillata*	(Pallas, 1766)	Tursi *et al.*, 2004; Mastrototaro *et al.*, 2010; Pardo *et al.*, 2011; Bo *et al.*, 2012, 2014a, 2015, 2020a; Lo Iacono *et al.*, 2012; Angeletti *et al.*, 2014; Fabri *et al.*, 2014; Cau *et al.*, 2015, 2017c; Deidun *et al.*, 2015; Chimienti *et al.*, 2019a, 2020b; Moccia *et al.*, 2021
	Soft-bottom coral gardens (section 5.1.3.2)			
	Order Alcyonacea			
	Alcyoniidae	*Alcyonium palmatum**	(Pallas, 1766)	Ambroso *et al.*, 2013b; Enrichetti *et al.*, 2019
	Isididae	*Isidella elongata*	(Esper, 1788)	D'Onghia *et al.*, 2003; Maynou and Cartes, 2012; Bo *et al.*, 2014a, 2015; Fabri *et al.*, 2014; Mytilineou *et al.*, 2014; Pierdomenico *et al.*, 2016; Mastrototaro *et al.*, 2017; Chimienti *et al.*, 2019a; Gerovasileiou *et al.*, 2019; Carbonara *et al.*, 2020
Sea pen fields (section 5.1.4)	Order Pennatulacea			
	Funiculinidae	*Funiculina quadrangularis*	(Pallas, 1766)	Ocaña *et al.*, 2000; Tunesi *et al.*, 2001; Freiwald *et al.*, 2009; Porporato *et al.*, 2009; Pardo *et al.*, 2011; Bo *et al.*, 2012; Aguilar *et al.*, 2013; Cartes *et al.*, 2013; Fabri *et al.*, 2014; Pierdomenico *et al.*, 2016; Bastari *et al.*, 2018; Chimienti *et al.*, 2019a
	Kophobelemnidae	*Kophobelemnon stelliferum*	(Müller, 1776)	Gili *et al.*, 1987; Hebbeln *et al.*, 2009; Pardo *et al.*, 2011; Bo *et al.*, 2012; Mastrototaro *et al.*, 2013; Fabri *et al.*, 2014; Pierdomenico *et al.*, 2016; Chimienti *et al.*, 2019a
	Pennatulidae	*Pennatula phosphorea*	(Linnaeus, 1758)	Mytilineou *et al.*, 2014; Mastrototaro *et al.*, 2017
	Pennatulidae	*Pennatula rubra*	(Ellis, 1761)	Chimienti, Angeletti and Mastrototaro, 2018; Chimienti *et al.*, 2015, 2018; Enrichetti *et al.*, 2019
	Pennatulidae	*Pteroeides spinosum*	(Ellis, 1764)	Porporato *et al.*, 2011, 2012, 2014
	Veretillidae	*Veretillum cynomorium*	(Pallas, 1766)	
	Virguatiidae	*Virgularia mirabilis*	(Müller, 1776)	Ambroso *et al.*, 2013a; Deidun *et al.*, 2015
Deep-sea sponge aggregations (section 5.1.5)	**"Ostur" sponge aggregations (section 5.1.5.1)**			
	Order Tetractinellida			
	Geodiidae	*Geodia barretti**	(Bowerbank, 1858)	Cárdenas *et al.*, 2013
	Geodiidae	*Geodia conchilega**	(Schmidt, 1862)	Vacelet, 1961; Pulitzer-Finali, 1972, 1983; Saritas, 1973; Corriero *et al.*, 2000; Ben Mustapha *et al.*, 2003; Voultsiadou, 2005; Cárdenas *et al.*, 2013
	Geodiidae	*Geodia nodastrella**	(Carter, 1876)	Longo *et al.*, 2005
	Hard-bottom sponge gardens (section 5.1.5.2)			
	Order Dictyoceratida			
	Dysideidae	*Dysidea* spp.		Vacelet, 1959; Corriero *et al.*, 1997
	Irciniidae	*Sarcotragus foetidus*	(Schmidt, 1862)	Enrichetti *et al.*, 2020
	Order Haplosclerida			
	Chalinidae	*Haliclona* spp.		Bertolino *et al.*, 2013; Grenier *et al.*, 2018
	Petrosiidae	*Petrosia (Petrosia) ficiformis*	(Poiret, 1789)	Bertolino *et al.*, 2013; Grenier *et al.*, 2018

Table 2 (continued)

VME indicator habitat	Family	Genus/species	Author	References
Deep-sea sponge aggregations (section 5.1.5)	Order Poecilosclerida			
	Cladorhizidae	*Lycopodina hypogea**	(Vacelet and Boury-Esnault, 1996)	Vacelet and Boury-Esnault, 1996; Aguilar *et al.*, 2011; Fourt *et al.*, 2017; Grenier *et al.*, 2018
	Microcionidae	*Antho (Antho) dichotoma*	(Linnaeus, 1767)	Boury-Esnault *et al.*, 1994
	Order Suberitida			
	Halichondriidae	*Topsentia* spp.		Bertolino *et al.*, 2013; Grenier *et al.*, 2018
	Suberitidae	*Suberites* spp.*		Pansini and Musso, 1991; Bertolino *et al.*, 2013; Grenier *et al.*, 2018
	Order Tetractinellida			
	Axinellidae	*Phakellia hirondellei*	(Topsent, 1890)	Boury-Esnault *et al.*, 1994; Grenier *et al.*, 2018
	Axinellidae	*Phakellia robusta**	(Bowerbank, 1866)	Topsent, 1925; Maldonado, 1992; Boury-Esnault *et al.*, 1994; Calcinai *et al.*, 2013; de la Torriente *et al.*, 2014; D'Onghia *et al.*, 2015a; Grenier *et al.*, 2018
	Axinellidae	*Phakellia ventilabrum**	(Linnaeus, 1767)	Maldonado, 1992; Lo Iacono *et al.*, 2012; de la Torriente *et al.*, 2014
	Axinellidae	*Axinella* spp.		Enrichetti *et al.*, 2020
	Azoricidae	*Leiodermatium lynceus**	(Schmidt, 1870)	Boury-Esnault *et al.*, 1994; Magnino *et al.*, 1999; Longo *et al.*, 2005; Grenier *et al.*, 2018
	Azoricidae	*Leiodermatium pfeifferae**	(Carter, 1873)	Maldonado *et al.*, 2015; Bo *et al.*, 2020a
	Pachastrellidae	*Pachastrella monilifera*	(Schmidt, 1868)	Pulitzer-Finali, 1983; Maldonado, 1992; Longo *et al.*, 2005; Voultsiadou, 2005; Mastrototaro *et al.*, 2010; Bo *et al.*, 2012; Calcinai *et al.*, 2013; Angeletti *et al.*, 2014; D'Onghia *et al.*, 2015a; Grenier *et al.*, 2018; Moccia *et al.*, 2021
	Vulcanellidae	*Poecillastra compressa*	(Bowerbank, 1866)	Vacelet, 1976; Pansini, 1987a, 1987b; Boury-Esnault *et al.*, 1994; Longo *et al.*, 2005; Voultsiadou, 2005; Mastrototaro *et al.*, 2010; Bo *et al.*, 2012; Calcinai *et al.*, 2013; Angeletti *et al.*, 2014; D'Onghia *et al.*, 2015a; Fourt *et al.*, 2017; Grenier *et al.*, 2018; Moccia *et al.*, 2021
	Vulcanellidae	*Vulcanella gracilis*	(Sollas, 1888)	Calcinai *et al.*, 2013; Grenier *et al.*, 2018
	Soft-bottom sponge gardens (section 5.1.5.3)			
	Order Poecilosclerida			
	Cladorhizidae	*Cladorhiza abyssicola**	(Sars, 1872)	Boury-Esnault *et al.*, 1994; Fourt *et al.*, 2017; Mastrototaro *et al.*, 2017
	Order Suberitida			
	Stylocordylidae	*Stylocordyla pellita*	(Topsent, 1904)	Zibrowius and Taviani, 2005; Maldonado *et al.*, 2015; Fourt *et al.*, 2017; Grenier *et al.*, 2018; Bo *et al.*, 2020a
	Suberitidae	*Rhizaxinella* spp.		Pansini and Musso, 1991; Ilan *et al.*, 2003; Bertolino *et al.*, 2013; Grenier *et al.*, 2018
	Order Tetractinellida			
	Theneidae	*Thenea muricata*	(Bowerbank, 1858)	Sarà, 1958; Vacelet, 1969; Pansini, 1987b; Uriz and Rosell, 1990; Pansini and Musso, 1991; Ben Mustapha *et al.*, 2003; Voultsiadou, 2005; de la Torriente *et al.*, 2014; Fourt *et al.*, 2014, 2017; Evans *et al.*, 2016; Mastrototaro *et al.*, 2017; Grenier *et al.*, 2018

Table 2 (continued)

VME indicator habitat	Family	Genus/species	Author	References
Deep-sea sponge aggregations (section 5.1.5)	**Glass sponge communities (section 5.1.5.4)**			
	Order Amphidiscosida			
	Pheronematidae	*Pheronema carpenteri*	(Thomson, 1869)	Rice *et al.*, 1990; Barthel *et al.*, 1996; Boury-Esnault *et al.*, 2015; Grenier *et al.*, 2018
	Order Lyssacinosida			
	Rossellidae	*Asconema setubalense*	(Kent, 1870)	Aguilar *et al.*, 2011, 2013; Sitjà and Maldonado, 2014; Boury-Esnault *et al.*, 2015; Maldonado *et al.*, 2017
Tube-dwelling anemone patches (section 5.1.6)	Order Spirularia			
	Cerianthidae	*Cerianthus membranaceus*	(Gmelin, 1791)	Aguilar *et al.*, 2008; Lastras *et al.*, 2016
	Order Penicillaria			
	Arachnactidae	*Arachnanthus* spp.		Aguilar *et al.*, 2014
Crinoid fields (section 5.1.7)	Order Comatulida			
	Antedonidae	*Leptometra phalangium**	(Müller, 1841)	Laborel *et al.*, 1961; Vaissière and Carpine, 1964; Reyss and Soyer, 1965; Bourcier and Zibrowius, 1973; Kallianotis *et al.*, 2000; Smith *et al.*, 2000; Colloca *et al.*, 2004; Abelló and Sola, 2006; Fanelli *et al.*, 2007; Marin *et al.*, 2011a, 2011b; Pardo *et al.*, 2011; Gofas *et al.*, 2014
Oyster reefs and other giant bivalves (section 5.1.8)	Order Ostreida			
	Gryphaeidae	*Neopycnodonte cochlear**	(Poli, 1795)	de la Torriente *et al.*, 2014; Fabri *et al.*, 2014; Angeletti and Taviani, 2020; Cardone *et al.*, 2020
	Gryphaeidae	*Neopycnodonte zibrowii*	(Gofas, Salas and Taviani, 2009)	Beuck *et al.*, 2016; Taviani *et al.*, 2017, 2019
	Pinnidae	*Atrina fragilis*	(Pennant, 1777)	Zenetos, 1997; Alliani and Meloni, 1999; Šimunović *et al.*, 2001; Hiscock and Jones, 2004; Casellato and Stefanon, 2008; Papoutsi and Galinou-Mitsoudi, 2010; Pubill *et al.*, 2011; Fryganiotis *et al.*, 2013
Seep and vent communities (section 5.1.9)	**Polychaetes**			
	Order Sabellida			
	Siboglinidae	*Lamellibrachia* spp.		Olu–LeRoy *et al.*, 2004; Hughes and Crawford, 2008; Bayon *et al.*, 2009; Gambi *et al.*, 2011; Southward *et al.*, 2011; Taviani *et al.*, 2013
Other dense emergent fauna (section 5.1.10)	**Actinians**			
	Order Actiniaria			
	Hormathiidae	*Actinauge richardi*	(Marion, 1882)	Marano *et al.*, 1989; D'Onghia *et al.*, 2003
	Hydrozoans			
	Order Leptothecata			
	Aglaopheniidae	*Lytocarpia myriophyllum*	(Linnaeus, 1758)	Rossi, 1950; Di Camillo *et al.*, 2013; Cerrano *et al.*, 2015; Fourt *et al.*, 2017; Enrichetti *et al.*, 2019
	Brachiopods			
	Order Terebratulida			
	Terebratulidae	*Gryphus vitreus*	(Born, 1778)	Boullier *et al.*, 1986; Emig, 1989, 1997; Logan *et al.*, 2002; Taviani *et al.*, 2011; Gerovasileiou and Bailly, 2016

Table 2 (continued)

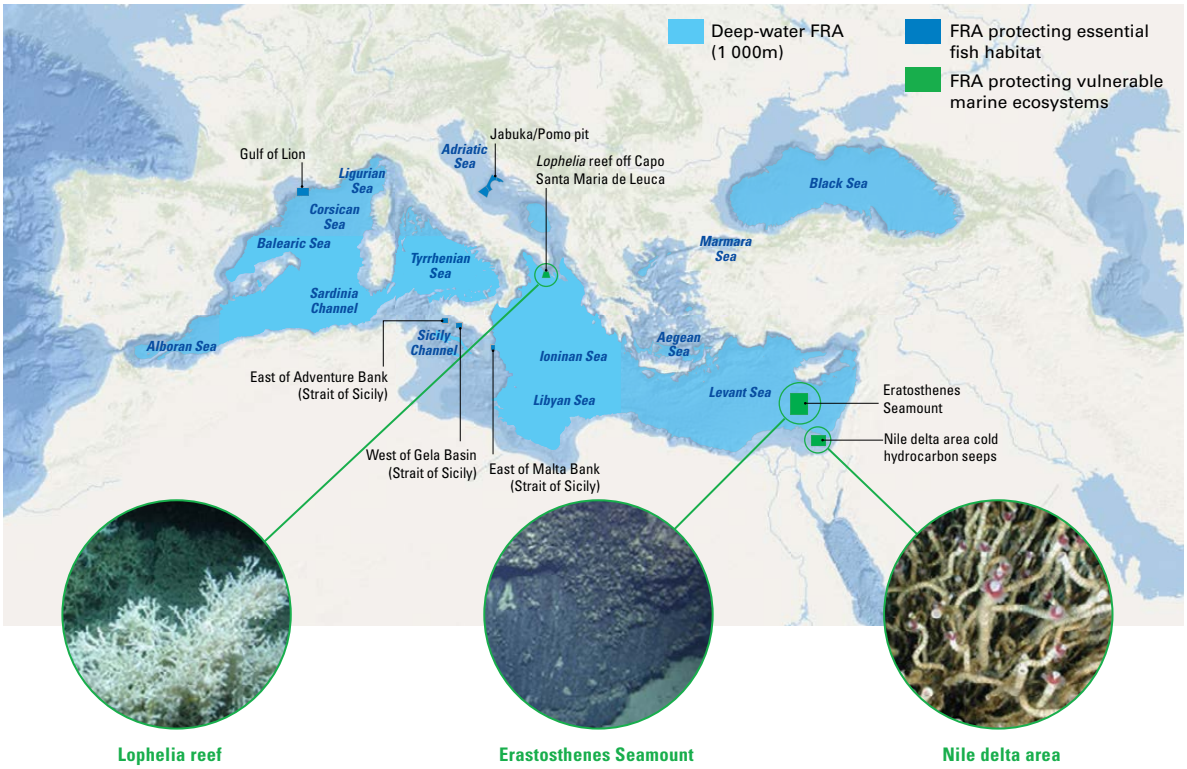
VME indicator habitat	Family	Genus/species	Author	References
Other dense emergent fauna (section 5.1.10)	**Bryozoans**			
	Order Cheilostomatida			
	Adeonidae	*Adeonella* spp.		Casoli *et al.*, 2020
	Bitectiporidae	*Pentapora* spp.		Enrichetti *et al.*, 2019; Casoli *et al.*, 2020
	Bugulidae	*Kinetoskias* spp.		Harmelin and d'Hondt, 1993; Aguilar *et al.*, 2013; Maldonado *et al.*, 2015; Mastrototaro *et al.*, 2017
	Celleporidae	*Celleporina* spp.		
	Celleporidae	*Turbicellepora* spp.		
	Myriaporidae	*Myriapora* spp.		Casoli *et al.*, 2020
	Phidoloporidae	*Reteporella* spp.		Casoli *et al.*, 2020
	Smittinidae	*Smittina* sp.		Casoli *et al.*, 2020
	Order Cyclostomatida			
	Horneridae	*Hornera* spp.		

* plasticity in the occupation of both hard bottoms or soft detritic bottoms.

** not a true coral, but a hydrocoral that may form reef-like structures.

FIGURE 1

GFCM Fisheries restricted areas for the conservation of fishery resources and marine habitats



Source: FAO, 2020.

5.1.1 Cold-water coral reefs

Cold-water coral reefs or frameworks are marine bioconstructions structuring important habitats of the deep Mediterranean Sea (Ingrosso *et al.*, 2018; Chimienti *et al.*, 2018c), identified as biodiversity hotspots (Mastrototaro *et al.*, 2010; Watling *et al.*, 2011) of considerable ecological and economic value (Foley, van Rensburg and Armstrong, 2010; Capezzuto *et al.*, 2018a). These habitats are mainly composed of the so-called white corals, namely the colonial species *Madrepora oculata* and *Lophelia pertusa* (currently renamed as *Desmophyllum pertusum*), as well as the solitary coral *Desmophyllum dianthus*. These species have a broad frame-building ability, being able to deposit calcium carbonate and build up durable biogenic substrata. In particular, the branched stony corals *M.oculata* and *L. pertusa* can create large bioconstructions (Plate 1), facilitating the formation of true deep-sea coral frameworks, while *D. dianthus* is a pseudo-colonial bank-building coral which can reach high local densities in the Mediterranean Sea, often in association with colonial corals (Freiwald *et al.*, 2009; Roberts *et al.*, 2009; Gori *et al.*, 2013; Angeletti *et al.*, 2014; Lo Iacono *et al.*, 2014; Chimienti *et al.*, 2018c, 2019a).

D'Onghia (2019) described the role of cold-water coral as shelter, feeding and life-history critical habitats for fish species in the Mediterranean Sea and in world oceans. Cold-water coral habitats provide a suitable ground for larval settlement and juvenile growth of benthic species and represent an important spawning and nursery area for vagile fauna, acting as essential fish habitat for several commercial and non-commercial fish and invertebrate species (D'Onghia, Sion and Capezzuto, 2019; Fabri *et al.*, 2014; D'Onghia *et al.*, 2015a, 2015b, 2016; Cau *et al.*, 2017b; Capezzuto *et al.*, 2018b, 2019; Sion *et al.*, 2019). For instance, D'Onghia *et al.* (2010) reported that a cold-water coral habitat in the central-eastern Mediterranean hosted large densities of reproducing fish individuals, such as the blackbelly rosefish (*Helicolenus dactylopterus*) and the blackspot seabream (*Pagellus bogaraveo*). In addition, cold-water corals act as nursery areas for the deep-water shark, the velvet belly lanternshark (*Etmopterus spinax*) and some important commercial fish species such as the European hake (*Merluccius merluccius*).

Other stony corals can occur in cold-water coral reefs, though their presence is not usually predominant. For instance, the yellow coral *Dendrophyllia cornigera* can occur with relatively high colony density on flat or gently sloping hard bottoms (Plate 1), as well as on flat muddy bottoms without any consistent anchorage, forming *D. cornigera* beds that significantly contribute to the three-dimensionality of the seabed (Bo *et al.*, 2014a; Enrichetti *et al.*, 2019; Chimienti *et al.*, 2019a). Solitary corals such as *Stenocyathus vermiformis*, *Javania cailleti*, *Anomocora fecunda* and cup-corals belonging to the genus *Caryophyllia* (especially *C. calveri*) can also be present in cold-water coral reefs, although they have not been reported so far with a relevant aggregative behaviour, and their role in the bioconstruction is minimal (Ocaña *et al.*, 2000). In addition, the hydrocoral *Errina aspera* can be considered among the Mediterranean habitat-formers due to its branched calcareous skeleton. Currently, this species is found in the Strait of Messina, at 80–230 m depth (Giacobbe, 2001; Giacobbe *et al.*, 2007), where it forms monospecific stands showing high densities similar to deep-sea coral reefs or frameworks (Salvati *et al.*, 2010). The Strait of Messina's population was the only one found so far in the Mediterranean Sea but other large populations of *E. aspera* probably occur deeper in the basin, as is the case in the Strait of Gibraltar (Álvarez-Pérez *et al.*, 2005; Chimienti *et al.*, 2019a).

5.1.2 Mesophotic stony coral communities

Some mesophotic stony corals do not belong to the so-called cold-water corals, but they can also structure communities and bioconstructions comparable to reefs, and similarly fit the definition of VME. This is the case of the scleractinians *Phyllangia americana mouchezii* and *Polycyathus muellerae* that were observed forming mesophotic coral reefs along the Adriatic coast of Apulia, in southern Italy, with mixed bioconstructions involving, among others, the bivalve *Neopycnodonte cochlear* and serpulids (Corriero *et al.*, 2019). Although these formations are assimilated to animal-dominated coralligenous bioconstructions (Ingrosso *et al.*, 2018), they represent unique habitats of the mesophotic zone, whose role is likely to be comparable to the cold-water coral reefs present in deeper waters. Similarly, the pink coral *Dendrophyllia ramea* (Plate 1), mainly found in isolated colonies on the hard and sedimentary bottoms of the Mediterranean Sea (Zibrowius, 1980; Sánchez, Demestre and Martin, 2004; Ocaña *et al.*, 2000; Salomidi *et al.*, 2010), can occasionally form patches of up to four or six colonies per square metre (Orejas *et al.*, 2017, 2019).

5.1.3 Coral gardens

Arborescent corals belonging to the subclasses Hexacorallia and Octocorallia can form large aggregations of colonies known as coral facies (as defined by Pérès and Picard, 1964), coral meadows, coral forests or coral gardens, due to their analogy with land habitats structured by plants. These coral aggregations can be monospecific or they can be present as mixed coral communities (Chimienti *et al.*, 2019a).

Coral gardens can develop on hard or soft substrata, depending on the habitat-forming species. Some species settle directly on rocky bottoms or use a small hard substratum for their settlement, thus also developing their presence on detritic bottoms, on soft substrata containing shells, coral rubble and pebbles or on small rocky scattered substrata. For this reason, though categorized as hard-bottom coral gardens (Table 2), these species can be also collected during trawling operations on muddy, sandy or coarse detritic bottoms.

5.1.3.1 Hard-bottom coral gardens

The typical garden-forming anthozoans on hard bottoms belonging to the orders Antipatharia and Alcyonacea. Antipatharians are present in the Mediterranean Sea with four main species, namely *Antipathes dichotoma*, *Parantipathes larix*, *Leiopathes glaberrima* and *Antipathella subpinnata* (Plate 1), all of them forming monospecific or multispecific forests (e.g. Bo, Bavestrello and Canese, 2011; Bo, Canese and Bavestrello, 2014b; Bo *et al.*, 2012, 2015; Cau *et al.*, 2017b; Chimienti *et al.*, 2019a, 2020b). Several fish species are often associated with these antipatharians (e.g. Mytilineou *et al.*, 2014; Bo *et al.*, 2015; Chimienti *et al.*, 2020b). Two other species may also occur in the basin, despite information on their presence being unclear: *Antipathella wollastoni*, an Atlantic species reported only in shallow waters close to the Strait of Gibraltar (Ocaña, Opresko and Brito, 2007) and likely to be present solely in the Alboran Sea, and *Antipathes fragilis*, considered taxonomically doubtful since it was found only once, when it was described, and the holotype was subsequently lost.

Alcyonaceans are present on Mediterranean Sea hard bottoms with several species, covering a wide bathymetric range. Typical garden-forming species in the bathyal zone are the whip-like gorgonian *Viminella flagellum* (Plate 1) and the fan-shaped gorgonian *Callogorgia verticillata*, both of them known to form large gardens from 100–500 m and 150–1 000 m depth, respectively (Chimienti *et al.*, 2019a). Other bathyal gorgonian species can locally contribute to structuring coral

gardens, such as *Villogorgia bebrycoides*, which may occasionally form monospecific populations, and *Bebryce mollis*, which does not form extensive monospecific gardens but is often present in mixed gorgonian communities (Bo *et al.*, 2012). Furthermore, *Dendrobrachia bonsai* and *Swiftia dubia* (also synonymised with *S. pallida*; Plate 1) are characterized by small colonies that can be locally abundant (Sartoretto, 2012; Grinyó *et al.*, 2016). Together with these strictly bathyal species, other hard-bottom alcyonaceans can form large colonial aggregations from shallow to deep waters, such as *Acanthogorgia hirsuta*, *Paramuricea macrospina*, *Placogorgia coronata*, as well as the precious red coral *Corallium rubrum*.

Shallower alcyonacean species, mainly present above 200 m depth, meet the criteria for VME indicator taxa, based on traits related to their functional significance, fragility, as well as to the life histories of component species with a slow recovery to disturbance, and thus are vulnerable to fishing practices. This is the case, for example, of the gardens formed by the gorgonians *Paramuricea clavata* (Plate 1), *Ellisella paraplexauroides*, *Leptogorgia sarmentosa* and *Eunicella* spp. (*E. cavolini*, *E. singularis* and *E. verrucosa*), sometimes mixed with the ectoparasitic Zoantharia *Savaglia savalia*. These gardens can host a large variety of species, playing an important ecological role, and therefore represent true VMEs in shallow waters (Gori *et al.*, 2007, 2011b, 2017; Linares *et al.*, 2008; Cerrano *et al.*, 2010; Linares and Doak, 2010; Ponti *et al.*, 2018). Nevertheless, in the case of *L. sarmentosa*, despite its tolerance for high-sedimentation environments and ability to appear even in harbours (e.g. Betti *et al.*, 2018), its role as an ecosystem engineer on trawlable grounds should be considered, as well as for the other gorgonian gardens.

Another coastal species worth noting is *Spinimuricea klavereni*, a rare Mediterranean endemic anthozoan, whose unique large population was found in the northeastern Marmara Sea, and which requires proper protection from the impact of fishing (Topçu and Öztürk, 2016). Hard-bottom soft corals representing VME indicator species also include the nidaliids *Chironephthya mediterranea* and *Nidalia studeri*, as well as the alcyoniids *Alcyonium acaule* and *Alcyonium coralloides*. These last two species can locally form large patches on rocky bottoms and, occasionally, on detritic bottoms characterized by shells or pebbles. The alcyoniid *Alcyonium palmatum* was included for the purpose of this review within the soft-bottom alcyonacean category because it mainly dwells on more or less detritic soft substrata, even though it can be present on hard bottoms (Ambroso *et al.*, 2013b).

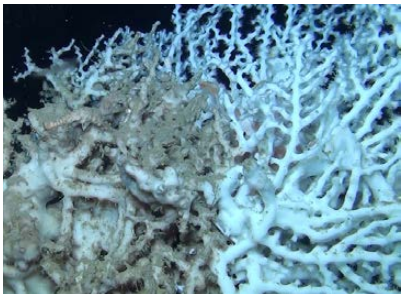
5.1.3.2 Soft-bottom coral gardens

On soft bottoms, true coral gardens can be structured by the alcyonaceans *Isidella elongata* and *A. palmatum*. The dead man's fingers, *A. palmatum*, can colonize both hard and soft bottoms, although it forms large aggregations, typically on bathyal soft bottoms (Ambroso *et al.*, 2013b). The bamboo- coral, *I. elongata* (Plate 1), forms dense gardens on bathyal compact mud between 110 and 1 600 m depth, on a relatively flat or gently inclined seabed (Chimienti *et al.*, 2019a). This candelabrum-shaped gorgonian is highly sensitive to fishing pressure, with high fragility and low recovery rates (Mastrototaro *et al.*, 2017; Carbonara *et al.*, 2020). Despite being very common in the past (Carpine, 1970), the presence of *I. elongata* gardens is essentially limited to areas where trawling does not occur due to: particular seabed features, such as large cold-water coral reefs nearby or sloping soft bottoms (Hebbeln *et al.*, 2009; Fabri *et al.*, 2014); fishing bans as a result of the presence of submarine cables (Mastrototaro *et al.*, 2017); and depths over 1 000 m representing deep refuges (up to 1 656 m depth), such as for the population of *I. elongata* along the Catalan coast (Maynou and Cartes, 2012). Moreover, where trawling occasionally occurs in certain coastal areas, for example on the upper slope of the eastern Ionian Sea (D'Onghia *et al.*, 2003) and along the

PLATE 1

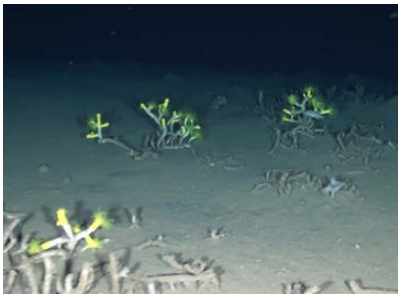
Examples of corals representing vulnerable marine ecosystem indicator taxa

Cold-water coral reefs



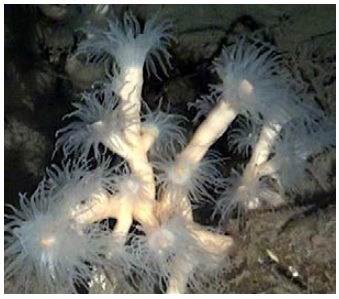
©Giovanni Chimienti

White coral
(*Madrepora oculata*)



©Oceana

Yellow coral
(*Dendrophyllia cornigera*)



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Pink coral
(*Dendrophyllia ramea*)

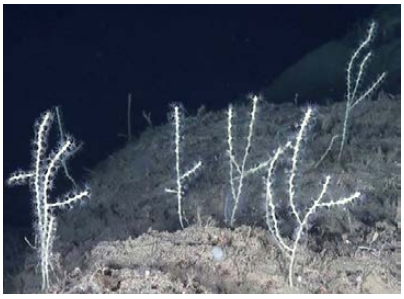
Hard-bottom coral gardens

©Giovanni Chimienti

Black coral
(*Antipathella subpinnata*)

©Giovanni Chimienti

Red gorgonian
(*Paramuricea clavata*)



©Oceana

Northern sea fan
(*Swiftia dubia*)

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Whip gorgonian
(*Viminella flagellum*)

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V. flagellum on a detritic bottom

Soft-bottom coral gardens

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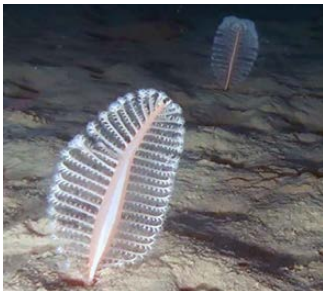
Bamboo coral (*Isidella elongata*)

Sea pen fields



©Giovanni Chimienti

Red sea pen (*Pennatula rubra*)

southwest Sardinian coast (Bo *et al.*, 2015), *I. elongata* can be present in shallow refuges (i.e. around 100 m depth). The overlapping of *I. elongata* hotspots with nursery and spawning areas of the deep-water red and blue shrimps *Aristaeomorpha foliacea* and *Aristeus antennatus* and the blackmouth catshark *Galeus melastomus* was investigated in the central Mediterranean (Carbonara *et al.*, 2020).

5.1.4 Sea pen fields

Pennatulaceans, commonly known as sea pens, are colonial octocorals characterized by a more or less distinct feather-like appearance; they are adapted to live on muddy, sandy or detritic bottoms, which can be subject to bottom-contact fishing activities. These soft corals can form dense aggregations, called sea pen fields, structuring the environment and attracting vagile fauna (Pardo *et al.*, 2011; Baillon *et al.*, 2012; Mastrototaro *et al.*, 2013; Chimienti *et al.*, 2018). In the Mediterranean Sea, the sea pens *Pennatula rubra* (Plate 1), *Pteroeides spinosum* and *Veretillum cynomorium* were found to form monospecific fields on the continental shelf (Chimienti, Tursi and Mastrototaro, 2018; Porporato *et al.*, 2014; Chimienti *et al.*, 2019b). Other species like *Pennatula phosphorea* and *Virgularia mirabilis* can occur from shallow to deep seabed, often in mixed aggregations with other soft-bottom anthozoans, while *Funiculina quadrangularis* and *Kophobelemnon stelliferum*, which are true deep-sea pennatulaceans, can form dense fields in the deep muddy bottoms of the Mediterranean Sea (Freiwald *et al.*, 2009; Mastrototaro *et al.*, 2013). It is assumed that other sea pens, namely *Cavernualria pusilla, Crassophyllum thessalonicae* and *Protoptilum carpenteri*, can form fields too, but only a few scattered occurrences were recorded in the basin, thus suggesting that these species are rare (Sezgin and Yüksek, 2015; Fryganiotis *et al.*, 2011; Mastrototaro *et al.*, 2015).

5.1.5 Deep-sea sponge aggregations

Deep-sea sponge aggregations have been identified as potential VMEs under the United Nations General Assembly Resolution 61/105 of 2006 (UNGA, 2006) and by FAO (2009); in addition, they are listed as "Threatened and/or declining species and habitats" by the Convention for the Protection of the Marine Environment of the North-East Atlantic (OSPAR Convention) (OSPAR, 2008). The ecological importance of deep-sea sponge aggregations, rich associated community and sensitivity to human pressures have been widely documented, and the United Nations Environment Programme (UNEP) has called for international engagement in mapping and modelling deep-sea sponge distribution to preserve these habitats (Hogg *et al.*, 2010). Deep-sea sponge aggregations developing under certain geological, hydrological and biological conditions and forming a three-dimensional habitat are known as sponge beds, sponge fields, sponge grounds, sponge associations, "ostur" and sponge reefs (Hogg *et al.*, 2010). In literature, all these terms are used either as synonyms or in reference to particular species and features, which makes their use rather confusing. However, Mediterranean sponge-dominated habitats can be broadly distinguished as: 1) "ostur" sponge aggregations; 2) hard-bottom sponge gardens; 3) soft-bottom sponge gardens; and 4) glass sponge communities.

These habitats can be structured by one or more species, with different morphologies influencing the structure and composition of the associated community (Beazley *et al.*, 2013). Sponge communities can also be found in association with cold-water corals, structuring a mixed coral-sponge habitat (e.g. Mastrototaro *et al.*, 2010; Angeletti *et al.*, 2014; D'Onghia *et al.*, 2015a).

Table 2 reports the Mediterranean VME indicator habitats structured by sponges and the main VME indicator sponge taxa, with a non-exhaustive list of species and genera. In fact, due to the

complex taxonomic identification of many sponge species, data are often only available for higher systematic levels, such as family or order.

5.1.5.1 "Ostur" sponge aggregations

"Ostur" sponge habitats were first described off the Faroe Islands, between the North Atlantic and the Norwegian Sea, where fishers defined the large aggregations of massive sponges as "ostur", which literally means cheese bottom and refers to the size, form and consistency of these sponges as well as the smell of broken specimens (Klitgaard and Tendal, 2001). Ostur-type sponge aggregations in the Mediterranean Sea are mainly built up by species of the genus *Geodia* (Table 2). These massive, hard sponges can have a variety of shapes, from irregular to convoluted masses, with young specimens, usually sub-spherical. They settle on gravel, pebbles or other small hard substrata, incorporating gravel into their cortex in order to anchor more strongly to the seafloor and to resist faster current speeds (Klitgaard and Tendal, 2001). "Ostur" sponge aggregations typically develop on gravelly or detritic bathyal bottoms, where the sponges grow to include the hard substratum in their body on which they originally settled.

5.1.5.2 Hard-bottom sponge gardens

The deep hard bottoms of the Mediterranean Sea can host complex sponge-dominated habitats, mainly structured by Demospongiae belonging to the orders Dictyoceratida, Haplosclerida, Poecilosclerida, Suberitida and Tetractinellida (Table 2). This latter order usually includes larger species such as the stalked, fan-shaped sponges of the genus *Phakellia*, the lamellate rock sponges *Leiodermatium lynceus* and *L. pfeifferae*, or the laterally-flat white and orange sponges *Pachastrella monilifera* and *Poecillastra compressa* both displaying an extensive distribution in the Mediterranean Sea, reaching densities of up to ten individuals per square metre, and forming mixed communities with the cold-water corals *Madrepora oculata* and *Lophelia pertusa* in several areas of the Mediterranean (Longo, Mastrototaro and Corriero, 2005; Bo *et al.*, 2012; Calcinai *et al.*, 2013; Angeletti *et al.*, 2014; Maldonado *et al.*, 2017). On mesophotic bottoms, Demospongiae belonging to the genus *Haliclona* can form extensive sponge gardens on rocky habitats (Plate 2), thus acting as habitat formers. Moreover, other species such as *Sarcotragus foetidus*, *Spongia lamella* and *Axinella polypoides* are known to form sponge aggregations on flat, patchy and highly silted hardgrounds between 40 and 70 m depth (Enrichetti *et al.*, 2020).

Some of the taxa included in this VME indicator habitat can settle on small rocks or pebbles, and thrive not only on rocky bottoms but also on mixed substrata.

5.1.5.3 Soft-bottom sponge gardens

On Mediterranean soft bottoms, the presence of sponge aggregations is limited to a few species. Sponge-based VME indicator taxa are broadly represented by the carnivorous pine-tree sponge *Cladorhiza abyssicola*, the lollipop sponges *Stylocordyla pellita* and *Rhizaxinella* spp. (mainly *R. pyrifera*), and the globular sponge *Thenea muricata*. In particular, *S. pellita* has a smooth and flexible stalk and is often attached to small hard substrata by means of a rounded disc, while *R. pyrifera* has an occasionally knobbed or branched rigid stalk and a branching root-like structure to settle on soft sediment and detritic bottoms, including mud volcanoes (Olu-Le Roy *et al.*, 2004). The globular sponge *T. muricata* is anchored to muddy bottoms by means of its rooting structures, and can form as a result monospecific or mixed communities with other sponges, as well as with the bamboo-coral *Isidella elongata* and/or sea pens (de la Torriente *et al.*, 2014; Fourt *et al.*, 2014; Evans *et al.*, 2016; Mastrototaro *et al.*, 2017).

5.1.5.4 Glass sponge communities

Hexactinellids, also known as glass sponges, represent a predominantly deep-sea group, with only nine representatives in the Mediterranean Sea. Among them, two main species are known to form sponge aggregations. The barrel-shaped *Pheronema carpenteri* lives on soft or mixed deep bottoms, where it is anchored by rooting tufts of long spicules. It is also known as the bird's nest sponge due to its hairy surface, forming an intricate network of spicules, and its globular/subcylindrical shape with a wide and deep atrial cavity and a large apical osculum. This species forms extensive populations from the south of Iceland to the western Mediterranean, forming aggregations of up to six individuals per square metre with a wet weight biomass of 1.1 kg per square metre (Rice, Thurston and New, 1990; Barthel *et al.*, 1996; Boury-Esnault *et al.*, 2015). The second species is the large funnel-shaped *Asconema setubalense*, living mainly on deep gravel and stones, as well as on soft or mixed substrata (Plate 2). It is called the felt vase sponge due to its thin fiberglass-like wall, folding outwards at the top. This species was documented as forming aggregations of up to five individuals per square metre in the Alboran Sea, although details of its distribution, biomass and population densities are still unknown (Aguilar *et al.*, 2013; Boury-Esnault *et al.*, 2015; Maldonado *et al.*, 2017).

5.1.6 Tube-dwelling anemone patches

Tube anemones or cerianthids can reach high densities on both detritic and muddy bottoms. *Cerianthus membranaceus* is the most common and widespread species known so far in the Mediterranean Sea, with populations of many colonies forming cerianthid patches, often on sloping soft bottoms or around canyons (Aguilar, Torriente and Garcia, 2008; Lastras *et al.*, 2016). Species belonging to the genus *Arachnanthus* can form groups of thousands of individuals, even though they tend to be slightly separated from each other (Marin *et al.*, 2011a; Aguilar *et al.*, 2014).

5.1.7 Crinoid fields

The crinoid *Leptometra phalangium* forms extensive crinoid fields, playing an important role in the structuring of soft bottoms (Plate 2). These fields develop particularly along shelf-break and canyon-head areas under bottom currents, where *L. phalangium* can reach a density of 50 individuals per square metre (Vaissière and Carpine, 1964; Reyss and Soyer, 1965; Bourcier and Zibrowius, 1973; Fanelli, Colloca and Ardizzone, 2007; Laborel *et al.*, 1961; Kallianotis *et al.*, 2000; Gofas *et al.*, 2014). Despite being a vagile species, *L. phalangium* can form habitats hosting a rich associated community and supporting high abundances of recruits and juveniles of important commercial species, such as the European hake (*Merluccius merluccius*), the greater forkbeard (*Phycis blennoides*), and the deep-water rose shrimp (*Parapenaeus longirostris*) (Ordines and Massutí, 2009; Colloca *et al.*, 2004). In fact, the fields of *L. phalangium* represent an indicator of highly productive areas, particularly along the Mediterranean shelf break (Colloca *et al.*, 2004), where this species can be present not only on muddy bottoms, but also on hard bottoms and cold-water coral frameworks (Pardo *et al.*, 2011). Occasionally, the crinoid *Antedon mediterranea* can also reach high densities and form crinoid fields in coastal waters.

5.1.8 Oyster reefs and other giant bivalves

Oysters belonging to the Gryphaeidae family, such as *Neopycnodonte cochlear* and *Neopycnodonte zibrowii*, can grow with their valves cemented onto each other, forming durable aggregations known as oyster reefs. These bioconstructions contribute to significantly increasing the habitat

heterogeneity and biodiversity. In particular, *N. cochlear* reefs (Plate 2) can develop in both mesophotic and aphotic zones, from the circalittoral to the bathyal zone (Pérès and Picard, 1964), on both hard and soft detritic bottoms (de la Torriente *et al.*, 2014; Fabri *et al.*, 2014; Angeletti and Taviani, 2020; Cardone *et al.*, 2020). In contrast, *N. zibrowii* develops mainly on the deep seabed, on rocky bottoms from 350 m to more than 1 000 m depth, in locations where escarpments, seamounts and canyons are present and where it was found to reach a density of around 20 individuals per square metre (Beuck *et al.*, 2016; Taviani *et al.*, 2019).

In addition, species of the genus *Atrina* have the narrow half of their shells anchored in the sediment by means of a byssus, with a large part of the fragile shell protruding from the sea floor, making them highly vulnerable to damage by bottom trawls. The fan mussel, *Atrina fragilis*, is present on sandy and detritic bottoms throughout the basin (Zenetos, 1997; Alliani and Meloni, 1999; Hiscock and Jones, 2004; Casellato and Stefanon, 2008; Papoutsi and Galinou-Mitsoudi, 2010; Šimunović *et al.*, 2001; Pubill *et al.*, 2011). In a few areas, this species can form more or less extended patches of specimens, generally from 30 to 100 m depth and, occasionally, down to 600 m depth (Poutiers, 1987; Fryganiotis, Antoniadou and Chintiroglou, 2013; Šimunović *et al.*, 2001). Although there is very little information available, the rare congeneric comb pen shell, *Atrina pectinata,* can probably play a similar role on the circalittoral and bathyal seabed.

5.1.9 Seep and vent communities

Assemblages of certain bivalve species belonging to the families Lucinidae (e.g. *Lucinoma kazani*, *Loripes orbiculatus* and *Myrtea spinifera*), Mytilidae (e.g. *Idas modiolaeformis*), Thyasiriidae (e.g. *Thyasira flexuosa*) and Vesicomyidae (e.g. *Isorropodon perplexum*), and of polychaetes belonging to the genera *Lamellibrachia* and *Siboglinum* can develop in areas rich in sulphur and methane (Taviani, 2014), such as the Eratosthenes Seamount in the Levant Sea (Figure 1). These chemosynthetic taxa live in association with archaean communities and microbial mats (Pachiadaki and Kormas, 2013; Pachiadaki *et al.*, 2010; Brissac *et al.*, 2011; Giovannelli *et al.*, 2016), usually indicating the presence of cold seeps, hydrothermal vents or other reducing environments (Taviani, 2014), but they can also be present sometimes on wrecks with an unclear energy source for the obligate symbiotic bacteria (Hughes and Crawford, 2008; Gambi, Schulze and Amato, 2011; Dando *et al.*, 1992). These communities occur down to more than 3 000 m in depth, in proximity of submarine volcanic apparatuses, pockmark fields, fluid seepage areas and mud volcanoes (Southward, Andersen and Hourdez, 2011; Olu-Le Roy *et al.*, 2004; Dupré *et al.*, 2007; Hilário *et al.*, 2011; Taviani *et al.*, 2013) (Plate 2). Furthermore, seep and vent communities host peculiar associated species, such as the ghost shrimps of the genus *Calliax*, thus representing an important source of primary production in the deep sea (Taviani *et al.*, 2013).

5.1.10 Other dense emergent fauna

Other animal species form dense aggregations in the mesophotic and aphotic zones of the Mediterranean Sea, acting as habitat-formers, and are particularly sensitive to bottom fishing pressures. This is the case, for example, of the mud sea anemone *Actinauge richardi*, which can occur in abundant populations on bathyal bottom sediments throughout the basin. This sea anemone has a typically invaginated base, forming a rounded cavity, which encloses a ball of mud or sand for anchoring onto soft bottoms, though it is also able to adhere to solid substrata such as rocks, pebbles and even plastic litter.

PLATE 2
Examples of vulnerable marine ecosystem habitats

©Oceana

Haliclona sp. sponge garden

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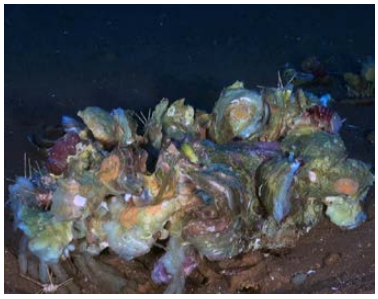
Asconema setubalense sponge garden

©Oceana

Leptometra phalangium crinoid field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Neopycnodonte cochlear oyster reef

©Oceana

Cold seep on muddy seabed

©Ocean Exploration Trust

Siboglinids (*Lamellibrachia anaximandri*) in a hydrothermal area

Another example, the leptomedusan hydroid *Lytocarpia myriophyllum*, can form dense aggregations of up to seven colonies per square metre on muddy detritic bottoms, often rich in biogenic mineral detritus and characterized by a high terrigenous supply (Rossi, 1950; Di Camillo *et al.*, 2013; Cerrano *et al.*, 2015; Enrichetti *et al.*, 2019). The populations of *L. myriophyllum* act as habitat-formers by enhancing the complexity of the seabed and hosting a rich associated fauna, but remain highly vulnerable to trawling activities.

In addition, the brachiopod *Gryphus vitreus* can form large facies (Pérès and Picard, 1964) on soft bottoms, mainly on the continental slope, where the species can reach up to 800 individuals per square metre on sandy mud with bottom currents (Emig, 1989, 1997; Boullier *et al.*, 1986).

Erect bryozoans can usually form mixed aggregations with other benthic species, including cold-water corals. Nevertheless, some species can comprise true bryozoan beds on both hard or soft bottoms in deep Mediterranean areas, such as escarpments, seamounts and pockmark fields (Bellan-Santini *et al.*, eds., 2002; Aguilar *et al.*, 2010; de la Torriente *et al.*, 2014; Enrichetti *et al.*, 2019). These beds are ecologically relevant in providing a substratum for epizoans and refuge for several organisms, including ophiuroids and small fish (Smith *et al.*, 2001). On hard bottoms and/or on gravelly sedimentary bottoms, bryozoan communities include the branched genera *Adeonella*, *Hornera*, *Myriapora*, *Pentapora* and *Reteporella*, as well as the massive genera *Celleporina* and *Turbicellepora*, while on muddy bottoms the stalked genus *Kinetoskias* was found to be locally abundant (Harmelin and D'Hondt, 1993; Aguilar *et al.*, 2013; Maldonado *et al.*, 2015; Mastrototaro *et al.*, 2017; Enrichetti *et al.*, 2019). Erect byozoans can reach high densities and form important benthic communities at mesophotic depth, similar to coralligenous bioconstructions (Casoli *et al.*, 2020).

5.2 Incidental catch of vulnerable marine ecosystem indicator taxa

Bycatch is the part of the catch that is unintentionally caught during a fishing operation in addition to the target species. It refers to the catch of other commercial species that are landed, commercial species that cannot be landed (for instance, undersized or damaged individuals), non-commercial species, as well as the incidental catch of endangered, vulnerable or rare species (for example, sea turtles, shark, marine mammals and seabirds) (FAO, 2020). Discard is the part of the catch that is not retained onboard and is instead returned to the sea, dead or alive. It can include target species or any other species (both commercial and non-commercial) that has been discarded at sea (GFCM, 2018a). Vulnerable marine ecosystem indicator taxa can represent a relevant part of the catch, but information from fishery-dependent surveys is lacking and, to date, their overall contribution to bycatch in the Mediterranean and Black Sea is not clear yet.

Some information can be gathered from observer programmes of fishing activities (Sánchez, Demestre and Martin, 2004; D'Onghia *et al.*, 2017), as well as from fishery-independent surveys, such as experimental fishing campaigns aimed at assessing demersal resources (Bertrand *et al.*, 2002). Although the scale of bycatch is not exhaustively understood and is mostly unquantified, the physical damage and the mortality it causes can be observed, in addition to the loss of fishing gear entangled on rocks or on benthic organisms. The impact of demersal fishing on VMEs has been recognized as a major environmental concern, causing not only the direct removal of species, but also several secondary effects, such as tissue abrasion and consequent vulnerability to epibiosis, damage due to resuspension of the sediments and the interruption of reproduction in stressed or injured species (Hinz, 2017; Clark, Althaus and Schlacher, 2016; Bavestrello *et al.*, 1997; Hogg *et al.*, 2010; Bo *et al.*, 2014a; Cau *et al.*, 2017a; D'Onghia *et al.*, 2017; Gori *et al.*, 2017). In fact, visual techniques such as remotely operated vehicles (ROVs) and towed cameras allow documenting the physical impact of fisheries on VMEs, though it cannot be comprehensively quantified yet. In addition, derelict fishing gear, from set nets to set longlines, is particularly common on bioconstructions, seamounts, banks, mounds and canyons in both the Mediterranean Sea and the North Atlantic Ocean, representing on average 34 percent of the total benthic litter (Pham *et al.*, 2014b).

5.2.1 Bottom trawlers

Bottom trawls are commonly used throughout the Mediterranean and routinely remove most of the benthic fauna, resulting in declines of faunal biodiversity, cover and abundance. However, the incidental catch of VME indicator taxa is difficult to assess as data are lacking, since commercial vessels do not report the bycatch of benthic invertebrates. Quantitative data from scientific surveys are rarely available in the literature (e.g. D'Onghia *et al.*, 2003; Carbonara *et al.*, 2020), since they are often observed as unquantified catch, but not reported. Despite a lack of bycatch data, trawling impacts are nevertheless well documented as a result of experimental trawl fishing operations and ROV surveys.

Soft-bottom coral gardens and sea pen fields have been historically impacted by trawl fishing, as higher coral densities support higher abundance and biomass of crustacean species. In fact, some commercially important species such as the deep-water red shrimps *Aristeus antennatus*, *Aristaeomorpha foliacea* and *Plesionika martia* reach their maximum abundance in the bamboo-coral (*Isidella elongata*) gardens, while the Norway lobster (*Nephrops norvegicus*) and the deep-water rose

shrimp (*Parapenaeus longirostris*) usually coexist with fields of the sea pen *Funiculina quadrangularis* (Pérès, 1967; Pérès and Picard, 1964; Cartes *et al*., 2004; Maynou *et al*., 2006).

Western Mediterranean

Bycatch from commercial trawling on the northern Alboran Sea continental shelf and slope includes the soft coral *Alcyonium palmatum* and the sea pen *Pennatula rubra*, with retrieved quantities of 0.07 ± 0.02 and 0.1 ± 0.04 kg per hour of trawling (Abad *et al*., 2007). In addition, Gofas *et al*. (2014) observed the sea pen *Kophobelemnon stelliferum* and the sponge *Thenea muricata* being caught, together with many specimens of the crinoid *Leptometra phalangium*, during a single experimental beam trawl in the Alboran Sea.

Cnidaria, including the VME indicator species *Alcyonium palmatum*, represent 1.6 percent by mass of the total catch from commercial otter trawling off the Catalan coast, characterized by high fishing intensity (Sánchez *et al*., 2007). Similarly, Gili, Ros and Pagès (1987) reported a long list of anthozoans, including many VME indicator species collected from trawling grounds in the same area. In particular, *A. palmatum* and the sea pen *Veretillum cynomorium* are notably common in the trawl catch of this area, together with isolated or few colonies of stony corals (*Dendrophyllia ramea*, *Caryophyllia smithii*, *Madrepora oculata*), gorgonians (*Eunicella* spp., *Leptogorgia sarmentosa*, *Isidella elongata*), antipatharians (*Parantipathes larix*) and sea pens (*Pteroeides spinosum*, *Cavernularia pusilla*, *Virgularia mirabilis*, *Pennatula phosphorea*, *Funiculina quadrangularis* and *Kophobelemnon stelliferum*).

Based on four scientific trawl surveys carried out between 1985 and 2008, Maynou and Cartes (2012) reported in the northwestern Mediterranean the collection of many colonies of *Isidella elongata*, together with the cold-water coral *Desmophyllum dianthus*, the sea pen *Funiculina quadrangularis* and the brachiopod *Gryphus vitreus*. In addition to providing data about the distribution of *I. elongata* gardens and the relevant number of fish and invertebrate species associated with this habitat, the authors highlighted the impacts of bottom trawls on this VME. In particular, they reported 97.63 ± 73.83 kg per square kilometre of *I. elongata* being collected along the continental margin of the Iberian Peninsula, with a maximum of 28 kg (1 292 kg per square kilometre) in a single haul at 626 m depth. Crustacean species richness, abundance and biomass positively correlated with the density of *I. elongata*, especially in the case of the blue and red shrimp *Aristeus antennatus* and the golden shrimp *Plesionika martia* (Maynou and Cartes, 2012). Further evidence was provided by the high density of trawl tracks, which demonstrated that the continental margin along the Catalan coast is intensely fished down to 900 m depth (Company, Ramirez-Llodra and Sardà, 2012). Indeed, observers onboard commercial trawlers on the continental shelf and platform along the same coast were able to detect a relevant commercial discard, including, among others, the stony corals *Dendrophyllia ramea* (0.19 kg per hour) and *Dendrophyllia cornigera* (0.25 kg per hour), the sea pens *Pteroeides spinosum* (0.17 kg per hour) and *Veretillum cynomorium* (0.5 kg per hour), as well as the crinoid *Leptometra phalangium* (0.06 kg per hour) (Sánchez, Demestre and Martin, 2004).

Experimental trawling in the Balearic basin indicated a large amount of incidental catch of corals, such as *Isidella elongata*, *Desmophyllum dianthus*, *Paramuricea macrospina*, *Placogorgia coronata and Funiculina quadrangularis*, and sponges, including *Thenea muricata* (Cartes *et al*., 2009). Among the VME indicator taxa, Massutì and Reñones (2005) reported the bycatch of the soft coral *Alcyonium palmatum*, sea pens and the brachiopod *Gryphus vitreus* during experimental trawling around the Balearic archipelago. Although such bycatch was not quantified, the authors highlighted the negative effects of trawling which can lead to the removal of soft-bottom habitat formers and cause consequent changes in the benthic community of the area, as mentioned by Gili, Ros and Pagès (1987).

In the Gulf of Lion canyon system, Madurell *et al.* (2012) highlighted that the areas where little trawling occurs coincide with areas of high ecological interest featuring VMEs, thus indicating the impact of trawling on benthic habitats (Gili *et al.*, 2011). Elsewhere, Relini, Peirano and Tunesi (1986) reported the bamboo-coral *Isidella elongata* as a common element of the commercial trawling bycatch in the Ligurian Sea together with several other VME indicator species, while Fusco (1967) identified cold-water coral reefs off Punta Mesco, also in the Ligurian Sea, based on the catch from trawling. In the same basin, the gorgonian *Placogorgia coronata* often occurred among the discards of the bottom trawl fishery targeting red shrimps, with an average estimated catch rate of about 18 live colonies per year per fisher (Enrichetti *et al.*, 2018). In addition, Arena and Li Greci (1973) reported historical records of living colonies of the black coral *Leiopathes glaberrima* collected during trawling operations in the Sardinia Channel and the Tyrrhenian Sea, as well as along the coast of Sicily. Furthermore, through observers onboard commercial vessels in the northern Tyrrhenian Sea, Sartor, Sbrana and Reale (2003) reported the presence of the soft coral *Alcyonium palmatum* and the red sea pen *Pennatula rubra* as a common fraction of the bycatch, although catches were less than 0.1 kg per hour.

In the Sardinia Sea, Carbonara *et al.* (2020) reported the occurrence of *Isidella elongata* in 2 percent of the trawl hauls carried out between 200 and 800 m depth, indicating the overall rarity of this species.

In the central Tyrrhenian Sea, the same authors reported the presence of *Isidella elongata* in 30 percent of the trawl hauls (Carbonara *et al.*, 2020). Regarding the crinoid *Leptometra phalangium*, Fanelli, Colloca and Ardizzone (2007) estimated a density of 12–15 individuals per square metre collected during experimental bottom trawls, while Colloca *et al.* (2004) observed that about 300 kg of this species (around 200 000 individuals) can be collected during one hour of bottom trawls, which represents the only quantitative information available concerning the heavy impact of trawling on crinoid fields.

Remotely operated vehicle surveys in the western Mediterranean (for example, the Alboran Sea, Balearic Islands and Gulf of Lion) highlighted how soft-bottom anthozoans such as *Isidella elongata* and sea pens are present with high densities in areas where trawling is not carried out, while they are hardly present or totally absent where trawl marks are more evident (Chimienti *et al.*, 2019a). In particular, *I. elongata* seems to be still present in a few areas, with dense aggregations thriving in places more or less accidentally protected from fishing pressure. This is the case, for example, of the populations found in shallow-water inaccessible refuges (e.g. Bo *et al.*, 2015), in deep-water refuges greater than 1 000 m depth (e.g. Maynou and Cartes, 2012), on sloping soft bottoms where trawling is difficult (e.g. Fabri *et al.*, 2014) or where the presence of submarine cables does not allow fishing activities (e.g. Mastrototaro *et al.*, 2017). Like *I. elongata*, sea pen fields remain only in areas where the fishing pressure is generally low, whereas they have disappeared from areas where they were formerly found due to trawling (Hebbeln *et al.*, 2009; Bo *et al.*, 2012; Fabri *et al.*, 2014; Mastrototaro *et al.*, 2015, 2017; Chimienti *et al.*, 2019a). Lost trawling nets were also documented in the Gulf of Saint Eufemia (southern Tyrrhenian Sea), impacting some hard-bottom coral gardens and sponge aggregations (Bertolino *et al.*, 2013).

Central Mediterranean

Incidental trawl catch in the central Mediterranean revealed the presence of true cold-water coral reefs, such as the coral communities of Santa Maria di Leuca in the northern Ionian Sea and South Malta in the Strait of Sicily (Chimienti, Angeletti and Mastrototaro, 2018; Tursi *et al.*,

2004; Schembri *et al.*, 2007; Mastrototaro *et al.*, 2010). This suggests that, occasionally, trawls can directly impact cold-water coral reefs and other hard-bottom VMEs due to trawling operations that should not have been carried out in these areas (e.g. by positioning errors or trying to exploit new areas). In addition, the presence of stony corals is generally known to the local fishers, who experience gear damage and losses, although they often fish close to these areas with the aim to obtain greater catch and larger specimens. In fact, side-scan sonar and underwater video images show the characteristic seabed scars of otter trawls ploughing through the coral banks (D'Onghia *et al.*, 2010, 2017).

Except for occasional trawling on hard bottoms, trawling in the central Mediterranean mostly impact detritic- and muddy-bottom VMEs. Based on scientific trawl survey data, Lauria *et al.* (2017) modelled the presence of the bamboo coral *Isidella elongata* in the Strait of Sicily, and found a negative linear relationship with fishing effort, suggesting a rapid decline of *I. elongata* abundance as fishing activity increased, until its disappearance due to intense trawling. Along the Tunisian coast, Azouz (1972) also highlighted the close relationship between red shrimps and *I. elongata*, with the latter usually collected as unquantified bycatch. Recent experimental trawl fishing operations highlighted the presence of *I. elongata* in 6 percent of the trawl hauls carried out in the Ionian Sea (Carbonara *et al.*, 2020). Likewise, off Malta, Terribile *et al.* (2016) reported that during experimental trawling, several VME indicator taxa were caught, including sponges, anthozoans and crinoids. Among the corals, the presence of *Lophelia pertusa* and *I. elongata* was noted, although both were identified with low densities (0.1 and 1.1 colonies per square kilometre, respectively), while *Funiculina quadrangularis* was particularly abundant in the trawling catch, with 324 colonies collected per square kilometre (Terribile *et al.*, 2016). Despite being sensitive to trawling impacts, *F. quadrangularis* populations seem to be generally more resilient and present nevertheless in areas exploited by trawl fisheries, although they do not reach high densities (Lauria *et al.*, 2017).

The bycatch of sea pen fields in the central Mediterranean may include *Kophobelemnon stelliferum*, whose large population was sampled with fishing gear towed off Santa Maria di Leuca in the northern Ionian Sea (Mastrototaro *et al.*, 2013), confirming the vulnerability of this species. Moreover, an estimated bycatch of the red sea pen *Pennatula rubra*, with up to 9 492 colonies per square kilometre, was reported from scientific trawl surveys off the Calabrian coast in the Ionian Sea, where this species showed a mean density of 0.7 ± 0.1 colonies per square metre (Chimienti, Bo and Mastrototaro, 2018; Chimienti *et al.*, 2015). Furthermore, in the northern Ionian Sea, D'Onghia *et al.* (2003) reported, among the benthic catch from scientific trawl surveys, the stony corals *Caryophyllia smithii* and *Desmophyllum dianthus*, the sea pens *F. quadrangularis*, *K. stelliferum* and *P. rubra*, the bamboo-coral *I. elongata* and the brachiopod *Gryphus vitreus*, all with very low densities (0.1–0.5 specimens per hour). Remotely operated vehicle explorations off Santa Maria di Leuca (Ionian Sea) enabled recent trawling traces, such as trawl door scars and lost nets, to be observed both inside and outside the fisheries restricted area (FRA) established by the GFCM in 2006 to protect these habitats from bottom trawlers, providing evidence of fishing activities occurring in the FRA (Savini *et al.*, 2014; D'Onghia *et al.*, 2017).

Adriatic Sea

Past scientific trawl surveys along the Italian coast of the southern Adriatic Sea revealed the bamboo coral *Isidella elongata*, sea pens and sponges as common bycatch, together with consistent amounts of the sea anemone *Actinauge richardi*, the soft coral *Alcyonium palmatum*, the crinoid *Leptometra phalangium* and the brachiopod *Gryphus vitreus* (Marano, Ungaro and Vaccarella, 1989; D'Onghia *et al.*, 2003). An extensive *I. elongata* garden was collected in the same basin during

a scientific trawl survey off Otranto, with large amounts of colonies sampled (Spedicato *et al.*, 2017). In the southern Adriatic, Carbonara *et al.* (2020) reported the occurrence of *I. elongata* in 23 percent of the trawl hauls. Two large fields of the sea pen *Funiculina quadrangularis* and one of the crinoid *L. phalangium* were also sampled along the Adriatic coast of Apulia during a scientific trawl survey (Spedicato *et al.*, 2017), even though no quantitative information is available to date.

On the opposite side of the Adriatic Sea, along the continental shelf and slope off Montenegro, Petović *et al.* (2016) reported the catch of some VME indicator taxa during scientific trawl surveys aiming to assess demersal resources. In particular, the soft coral *Alcyonium palmatum* was mostly caught at shallow depths, with 96 colonies per square kilometre and 0.6 kg per square kilometre within 50 m depth, 34 colonies per square kilometre and 0.6 kg per square kilometre at 50–100 m depth, and 36 colonies per square kilometre with 0.2 kg per square kilometre at 100–200 m depth. In contrast, at 200–500 m depth, the occurrence of *A. palmatum* as bycatch was only five colonies per square kilometre and 0.02 kg per square kilometre.

Petović *et al.* (2016) also documented sea pens, with *Pennatula rubra* mainly caught within 100 m depth, with 80–96 colonies per square kilometre and 0.8–0.9 kg per square kilometre; *Pteroeides spinosum* caught at 50–100 m and 500–800 m depth with 0.3 and 0.1 kg per square kilometre, respectively, and a density of 11 colonies per square kilometre; and *Funiculina quadrangularis* caught at 200–500 m depth with five colonies per square kilometre and 1.3 kg per square kilometre. In addition, the hydrozoan *Lytocarpia myriophyllum* was also reported in the catch within 50 m depth (96 colonies per square kilometre and 1.3 kg per square kilometre) and at 50–100 m depth (23 colonies per square kilometre and 0.05 kg per square kilometre).

It has been estimated that the phylum Cnidaria, including the VME indicator species *Alcyonium acaule* and *Alcyonium palmatum*, and the sea pen *Virgularia mirabilis*, represents 0.2 percent of the total catch from the commercial otter trawl fishery in the central Adriatic grounds, which are characterized by high fishing intensity (Sánchez *et al.*, 2007). In addition, in the northern Adriatic Sea, trawl survey bycatch data identified vulnerable sea pen fields and reefs of the bivalve *Neopycnodonte cochlear* in the in the Pomo/Jabuka Pit FRA (GFCM, 2017) (Figure 1). The rare giant bivalve *Atrina fragilis* was also reported as a dominant component of commercial "rapido" trawl bycatch in some areas of the northern Adriatic Sea, with most of the individuals being highly damaged by this fishing practice (Pranovi *et al.*, 2001).

Eastern Mediterranean

Reef-forming cold-water corals such as *Madrepora oculata*, *Lophelia pertusa* and *Desmophyllum dianthus* were reported as occasional catch during scientific trawling in the northern Aegean Sea (Vafidis, Koukouras and Voultsiadou-Koukoura, 1997), while some *Isidella elongata* colonies were collected from experimental trawl surveys in the eastern Mediterranean (Gerovasileiou *et al.*, 2019). Elsewhere, in the Levant Sea, the incidental catch of the phosphorescent sea pen *Pennatula phosphorea* was recorded during scientific trawl surveys along the Turkish coast (Gücü, 2012).

During experimental beam trawl surveys along the northern coast of Crete (Aegean Sea), a marked reduction of the crinoid *Leptometra phalangium* was observed in trawled areas, associated with a decrease in the richness, abundance and biomass of benthic species (Smith, Papadopoulou and Diliberto, 2000), confirming the impact of commercial trawling on the crinoid fields present in the area. Likewise, in the Gulf of Thermaikos (Aegean Sea), a great variety of VME indicator taxa were reported as discards from commercial otter trawling (Voultsiadou *et al.*, 2011). In particular,

Demospongiae species (i.e. the most diverse class of sponges) were caught in 5–38 percent of the commercial hauls, depending on the sponge species. Alcyonaceans and sea pens represented common components of discards, with a high collection frequency for certain species, such as *Alcyonium palmatum* (100 percent), *Pennatula rubra* (95 percent), *Pteroeides spinosum* (29 percent), *Veretillum cynomorium* (29 percent) and *Funiculina quadrangularis* (5 percent).

Bivalves belonging to the genus *Atrina* also were found to be part of the bycatch from commercial otter trawling in the Aegean Sea, and thus considered endangered, mainly due to habitat degradation and intensive bottom trawling (Fryganiotis, Antoniadou and Chintiroglou, 2013). In fact, *Atrina pectinata* was present in 81 percent of the otter trawling hauls carried out in the Gulf of Thermaikos (Voultsiadou *et al.*, 2011). Commercial otter trawling resulted in 0.03–0.22 individuals of *A. fragilis* per square metre caught in the routinely trawled areas, while experimental trawl surveys in a comparable area of the Gulf of Thermaikos, where trawling is prohibited, revealed a catch of 4.60–6.27 individuals of *A. fragilis* per square metre (Fryganiotis, Antoniadou and Chintiroglou, 2013). Finally, the cylinder tube anemone *Cerianthus membranaceus*, a large, tube-dwelling anemone, was also caught as bycatch in 5 percent of the trawl hauls in the area (Voultsiadou *et al.*, 2011).

5.2.2 Set longliners

Set longlines are widely used in the Mediterranean Sea to catch, among others, dentex (*Dentex* spp.), seabreams (*Diplodus* spp., *Pagellus* spp.) and groupers (*Epinephelus* spp.). This gear can also be used in areas of complex bottom topography and not accessible to trawling, to catch the Atlantic wreckfish (*Polyprion americanus*), the greater forkbeard (*Phycis blennoides*), the blackbelly rosefish (*Helicolenus dactylopterus*) and the blackspot seabream (*Pagellus bogaraveo*) (D'Onghia *et al.*, 2010, 2012, 2016; Sion *et al.*, 2019). Set longlines can sweep the seabed (when the gear is hauled up) and, in the process, they can catch benthic species (Welsford and Kilpatrick, 2008; Hogg *et al.*, 2010; Sampaio *et al.*, 2012; Mytilineou *et al.*, 2014). Intensive longline fishing, while having much less impact compared to bottom trawling (Pham *et al.*, 2014a), may over time cause significant adverse impacts to VMEs (Ragnarsson *et al.*, 2017). Indeed, benthic VME indicator taxa can often be damaged or caught by demersal lines and hooks, resulting in a substantial bycatch (D'Onghia *et al.*, 2012). Longlines can also cause mechanical injuries to benthic species when drifting on the sea floor, leading to the accumulation of debris on the sea bottom due to lost gear, thus altering habitats (e.g. Hinz, 2017; Company, Ramirez-Llodra and Sardà, 2012; Reed *et al.*, 2005; Orejas *et al.*, 2009; Bo *et al.*, 2014a).

Western Mediterranean

No data are available for longline incidental catch of VME indicator taxa in the western Mediterranean. However, some lost longlines were documented by means of ROV as laying on cold-water coral reefs and on the gardens of the fan-shaped gorgonian *Callogorgia verticillata* in the Gulf of Lion, as well as on the singular lithistid demosponge (*Leiodermatium pfeifferae)* formations occurring in the Balearic Sea, thus confirming the presence of non-quantified impacts on VMEs (Fabri *et al.*, 2014; Maldonado *et al.*, 2015). In the same area, Orejas *et al.* (2009) recorded approximately 200 lost longlines in the Cap de Creus cold-water coral community, representing 0.06–0.22 longlines per square metre, demonstrating a positive correlation between the occurrence of lost fishing gear and cold-water corals.

In the Ligurian Sea, injury by longlines is the major cause of mortality for the red gorgonian *Paramuricea clavata* and the yellow gorgonian *Eunicella cavolini* (Bavestrello *et al.*, 1997; Betti *et al.*,

2020). Similarly, the dominant type of debris observed in the Ligurian and Tyrrhenian Sea (79 and 62.5 percent, respectively) is represented by lost longlines, which become entangled in the hard-bottom gardens of the black coral *Antipathella subpinnata* and the gorgonians *P. clavata*, *Paramuricea macrospina*, *Eunicella cavolini*, *Corallium rubrum*, *Viminella flagellum* and *Callogorgia verticillata* (Angiolillo *et al.*, 2015; Bo *et al.*, 2020b; Ferrigno *et al.*, 2020). Furthermore, Bo *et al.* (2014a) reported longlines as being the most widespread derelict gear found on hard bottom coral gardens in the Tyrrhenian Sea, and in fact, they were present in almost 100 percent of the video frames analysed from four of the five different localities studied. In particular, at Mantice Shoal and Santa Lucia Bank (northern Tyrrhenian Sea), these authors reported 32 and 17 m of lines per 100 square metres, respectively.

In the Vedove Shoal (central Tyrrhenian Sea), although longlines were present in fewer video frames (35 percent), there was an estimated density of 70 m of lines per 100 square metres of sea floor (Bo *et al.*, 2014a). Likewise, in the southern Tyrrhenian Sea, unquantified longlines were recorded as being entangled in colonies of the gorgonians *Bebryce mollis*, *Callogorgia verticillata*, *Eunicella cavolini* and *Paramuricea clavata* in the Gulf of Saint Eufemia, and were observed in 4–10 percent of the analysed images (Bo *et al.*, 2012), while about 28 m of lines per 100 square metres were documented on the Marco Bank (Bo *et al.*, 2014a). In this last location, longlines were entangled on about 29 ± 6 percent and 32 ± 3 percent of the colonies of the black coral *Leiopathes glaberrima* and the whorled tree coral *C. verticillata*, respectively, while all the observed colonies of *C. verticillata* with entangled lines had lost the flabellate shape typical of healthy specimens and had broken branches (Bo *et al.*, 2014b). Elsewhere, low fishing impacts were reported for the hard-bottom coral gardens in southwestern Sardinia, where Bo *et al.* (2015) observed lost longlines in 2.2 percent of the video frames, mostly impacting *C. verticillata* and *L. glaberrima* colonies.

Central Mediterranean

Stony corals (*Desmophyllum dianthus*), black corals (*Antipathes dichotoma*, *Leiopathes glaberrima*), alcyonaceans (*Isidella elongata*, *Swiftia dubia*, *Villogorgia bebrycoides*) and sea pens (*Pennatula phosphorea*) were among the benthic bycatch observed during experimental longline surveys targeting fish assemblages off the southwestern coast of Kefalonia Island in the Ionian Sea (Mytilineou *et al.*, 2014). Living colonies of these VME indicator taxa were reported as occurring in most longline sets (72 percent) with 2–4 species per longline, and with a variable abundance. Mytilineou *et al.* (2014) estimated that about 100 and 130 living colonies of black corals and *I. elongata*, respectively, were caught by each fishing boat every year in the eastern Ionian Sea, representing the most common coral bycatch. In contrast, a lower occurrence (55 percent), though a similar number of coral species (four), were reported by D'Onghia *et al.* (2012) as being caught by longlines in the northern Ionian Sea, probably due to the dominant presence of stony corals forming robust cold-water coral reefs, likely to be more resistant to hook removal than coral forests. As such, these results represent one of the few indications of the potential impact of set longlines on VMEs. Furthermore, the incidental catch of the corals *Madrepora oculata*, *Lophelia pertusa*, *Dendrophyllia cornigera* and *L. glaberrima* was documented from the commercial longline fisheries in the northwestern Ionian Sea through an ad hoc interview campaign amongst fishers (D'Onghia *et al.*, 2016). Moreover, ROV exploration both inside and outside the Lophelia Reef FRA (Santa Maria di Leuca) provided images of lost fishing lines entangled on the seabed or on the coral colonies (Freiwald *et al.*, 2009; Savini *et al.*, 2014; D'Onghia *et al.*, 2017).

Adriatic Sea

No quantitative information about longline incidental catch of VME indicator taxa in the Adriatic Sea is available. However, D'Onghia *et al.* (2016) reported the presence of the corals *Madrepora*

oculata, *Lophelia pertusa* and *Leiopathes glaberrima* in the bycatch from commercial longline fishers in the southern Adriatic Sea (data gathered through ad hoc interviews among fishers). Moreover, 0.03 items per square metre (15 longlines over 600 square metre) were reported within a forest of *Callogorgia verticillata* in Montenegrin waters (Chimienti *et al.*, 2020a), and 0.12 items per square metre (39 longlines over 320 square metre) within a forest of *Antipathella subpinnata* at the Tremiti Islands marine protected area (Chimienti *et al.*, 2020b).

Eastern Mediterranean

No data are available for the longline incidental catch of VME indicator taxa in the eastern Mediterranean. However, the incidental catch of the bamboo-coral *Isidella elongata* by bottom longlines was reported in the literature (Mytilineou *et al.*, 2014; Gerovasileiou *et al.*, 2019), indicating the vulnerability of this species to this type of fishing gear.

5.2.3 Small-scale fisheries

Small-scale fisheries were generally assumed to have a low or negligible discard rate, comprising around 3.7 percent of total catch on the global scale (Kelleher, 2005). However, some studies suggest that a wide variation in bycatch rates may exist, with some small-scale fisheries showing levels of bycatch that could potentially wipe out some populations of marine megafauna, such as seabirds, sharks and turtles (e.g. Voges, 2005; Peckham *et al.*, 2007). In the Mediterranean Sea, demersal small-scale fisheries could also have a significant impact on megabenthic communities considering the large number of vessels involved, accounting for 83 percent of the fishing fleet in the basin (FAO, 2018, 2020). Small-scale fisheries employ a wide variety of bottom-contact fishing gear, including gillnets, baited traps and pots, which can be deployed from shallow to deep waters and varying in the way they interact with marine ecosystems (Morgan and Chuenpagdee, 2003; Shester and Micheli, 2011). For instance, dragging traps on the seafloor causes damage to the benthic species significantly more frequently than crushing, particularly on corals (Shester and Micheli, 2011). Furthermore, gillnets and trammel nets can easily remain entangled on the hard bottoms and on the VME indicator taxa, thus damaging these habitats and/or remaining abandoned on the seabed.

The issues of incidental catch and impacts of small-scale fisheries have been hardly addressed worldwide (Breen, 1989; ICES, 1995; Quandt, 1999; Stephan, Peuser and Fonseca, 2000; Erzini *et al.*, 1997; Appeldoorn *et al.*, 2000; Eno *et al.*, 2001), and the consequences, including in the Mediterranean Sea, remain difficult to quantify.

Western Mediterranean

No data are available concerning the incidental catch of VME indicator taxa by small-scale fisheries in the western Mediterranean. Nevertheless, as an example, lost gillnets and severe tissue abrasion due to small-scale fisheries were observed in the rare and vulnerable candelabrum coral *Ellisella paraplexauroides* garden in the Alboran Sea (Maldonado *et al.*, 2013), where about half of the colonies (44.6 percent) originally growing in certain areas were dead, and about 82 percent of the surviving colonies showed substantial signs of injury (e.g. broken branches, tissue abrasion, intense epibiosis).

In the Gulf of Lion canyon system (Figure 1), Madurell *et al.* (2012) noted that the best preserved benthic communities coincided with the least overlap of artisanal fishing. In some canyons of the western Ligurian Sea, derelict fishing nets from small-scale fisheries represented 57 percent of the

anthropogenic objects present on the seafloor (Giusti *et al.*, 2019). Lost gillnets were also observed in the Tyrrhenian Sea, where Bo *et al.* (2014a) reported 8 and 0.5 square metres of nets per 100 square metres on the sea floor at Mantice Shoal and Santa Lucia Bank, respectively, and they were recorded in 3 percent on average of the analysed images on the hard-bottom coral gardens in the Gulf of Saint Eufemia (Bo *et al.*, 2012). Indeed, nets and pots are among the most common debris impacting hard-bottom coral gardens in the Tyrrhenian Sea, representing 24.4 percent and 2.1 percent of the total debris, respectively (Angiolillo *et al.*, 2015). Furthermore, the canyons along the upper Sardinian slope were shown to be major repositories for derelict fishing gear, mainly from small-scale fisheries (Cau *et al.*, 2017a). Derelict nets and other small-scale fishing gear were documented as common within a population of *Corallium rubrum* in the Tyrrhenian Sea (Ferrigno *et al.*, 2020).

Central Mediterranean

No data are available concerning the incidental catch of VME indicator taxa by small-scale fisheries in the central Mediterranean.

Adriatic Sea

No data are available concerning the incidental catch of VME indicator taxa by small-scale fisheries in the Adriatic Sea. A few nets (possibly gillnets or trammel nets) were observed entangled within an *Antipathella subpinnata* forest at the Tremiti Islands, with 0.02 items per square metre (Chimienti *et al.*, 2020b).

Eastern Mediterranean

No quantitative data are available concerning the incidental catch of VME indicator taxa by small-scale fisheries in the eastern Mediterranean. However, in the Gulf of Thermaikos (Aegean Sea), the bycatch of Demospongiae species was reported to be frequent, representing 14–43 percent of the discards from fishing hauls in small-scale fisheries, depending on the sponge species (Voultsiadou *et al.*, 2011). Part of the bycatch was also represented by the soft corals *Alcyonium palmatum* and *Veretillum cynomorium*, which were collected in 29 percent and 14 percent of the hauls, respectively. Likewise, bivalves belonging to the genus *Atrina* can occasionally be harvested or occur as bycatch in small-scale fisheries in the Aegean Sea (Poutiers, 1987). In the western Aegean Sea, Gökçe and Metin (2007) also conducted an observer-based survey on the commercial prawn trammel net fishery in Izmir Bay, Turkey. Based on data from three fishing boats, these authors reported a low bycatch rate of benthic species. The only VME indicator species recorded was *V. cynomorium*, collected in about 18 percent of the hauls, with one or two colonies each.

5.3 Outlook

5.3.1 Interactions between fisheries and VMEs

Bottom trawling represents the fishing practice with the highest impact on VMEs (Rogers, 1999; Maynou and Cartes, 2012; Probert, McKnight and Grove, 1997; Eigaard, Bastardie and Hintzen, 2017; Murillo *et al.*, 2011; Puig *et al.*, 2012). Its role in the degradation of VMEs is both direct, by scraping the seabed, resuspending the sediments and destroying habitat-formers, and indirect, by inducing long-term changes in the benthic community, reducing habitat complexity and affecting ecosystem functioning (Jones, 1992; Roberts, 2002; Hinz, 2017; Jennings and Kaiser, 1998; Watling and Norse, 1998; Maynou and Cartes, 2012; Colloca *et al.*, 2004; Gray *et al.*, 2006). Although bycatch data from commercial fisheries are lacking, scientific trawl surveys can provide

an insight into understanding the bycatch of VME indicator taxa (e.g. Gili, Murillo and Ros, 1989; Chimienti, Bo and Mastrototaro, 2018; Petović *et al*., 2016; Terribile *et al*., 2016).

Despite the fact that quantification remains unclear for the incidental catch of VME indicator taxa, there is sufficient scientific evidence linking trawling practices to the impacts and particular environmental changes caused, suggesting that the higher the frequency of trawling, the greater the likelihood of permanent changes. In fact, considering the slow growth rate of many VME indicator taxa, the recovery of these fragile habitats may take decades or centuries after direct and indirect damage inflicted on them by bottom trawlers (e.g. Jones, 1992; Hinz, 2017; Fosså, Mortensen and Furevik, 2002; Bo *et al*., 2015), thus resulting in long-term changes in the environment.

In general, hard bottom VMEs such as cold-water coral reefs and coral gardens are not directly affected by the mechanical impacts of trawling, although recent fishing technologies enable trawling to be carried out very close to them. However, together with occasional incidental catch, hard-bottom VMEs can be damaged by the resuspension of sediment and other indirect effects caused by trawling. In contrast, soft-bottom VMEs are more sensitive to trawling pressures due to the direct destruction of the habitat, particularly for fragile organisms (such as the bamboo-coral *Isidella elongata*, the sea pens *Funiculina quadrangularis* and *Kophobelemnon stelliferum*, the crinoid *Leptometra phalangium* and the fan-mussel *Atrina fragilis*). Moreover, the three-dimensionality and consistency of the body also play a significant role in the catchability of VME indicator taxa. For instance, the catch efficiency of trawling on sponge-based communities (for example, "ostur" sponge aggregations, soft-bottom sponge gardens and glass sponge communities) can easily reach 100 percent, while the efficiency on sea pen fields can be about 3–10 percent, depending on the pennatulacean species (Chimienti, Bo and Mastrototaro, 2018; Kenchington *et al*., 2011).

Although the efficiency of fishing gear can be low, incidental mortality can be very high. In fact, as clearly shown, higher soft coral concentrations are generally located in areas characterized by low or no fishing activity (Heifetz, Stone and Shotwell, 2009; Murillo *et al*., 2010, 2018). In particular, comparative studies found significantly lower densities of sea pens and alcyonaceans in areas of high trawling intensity (Engel and Kvitek, 1998; Hixon and Tissot, 2007), indicating an inability to recover after frequent fishing pressure. Because of its slender structure and peculiar aggregative behaviour, the tall sea pen *Funiculina quadrangularis* is often present as bycatch, although in declining abundance (Arena and Li Greci, 1973; Relini, Peirano and Tunesi, 1986; Colloca *et al*., 2003; Voultsiadou *et al*., 2011; Bastari *et al*., 2018), and the formerly common *F. quadrangularis* fields have almost completely disappeared from many Mediterranean areas due to trawling (D'Onghia *et al*., 2003; Sardà *et al*., 2004; Chimienti *et al*., 2019a). Data from other sea pen species in trawling discard are variable and are overall unquantified (Massutì and Reñones, 2005; Chimienti, Maiorano and Mastrototaro, 2015; Chimienti, Bo and Mastrototaro, 2018; Abad *et al*., 2007; Bastari *et al*., 2018).

Information about the incidental catch of VME indicator taxa by longlines is very scarce, and the impacts caused by longlines are difficult to detect, since they can be easily masked by natural events or disturbances created by other fishing gear types (Heifetz, Stone and Shotwell, 2009). As for bottom trawls, the mortality can be higher than the catchability because benthic species damaged by set longlines may not be removed from the seabed or may be simply lost in the water column during hauling operations (Welsford and Kilpatrick, 2008; Edinger *et al*., 2007). Thus, the amount of VME indicator taxa bycatch may be a poor indicator of the actual magnitude of

the damage caused by longlines, hence underestimating the scale of impacts on VMEs, while data to accurately estimate the spatial overlap between longline fishing effort and VMEs are generally lacking (Ragnarsson *et al.*, 2017).

Remotely operated vehicle surveys have provided clear information about the high-impact potential of set longlines on VMEs, based on findings of entangled longlines on arborescent habitat-formers, mainly corals, both on hard and soft bottoms (Bo *et al.*, 2012, 2014a, 2014c, 2015; Deidun *et al.*, 2015; Fanelli *et al.*, 2017). The frequency of coral bycatch can vary depending on the density of colonies, as well as their three-dimensional structure and resistance to anchoring. In general, antipatharians and the bamboo-coral *Isidella elongata* show the highest catchability, due to a highly branched structure. Moreover, *I. elongata* has a weak anchoring apparatus, while large antipatharians are often collected with part of the small rocks or the biogenic substratum they are settled on. Other alcyonaceans and stony corals display a lower catchability, probably due to their anchoring on hard bottoms, even though entanglement may cause the loss of longlines to occur more frequently (Bo *et al.*, 2014a; Cau *et al.*, 2017a). Finally, sea pens are broadly less affected because of their soft consistency. No data are available about the catchability of other VME indicator taxa, but their presence as part of longline bycatch is likely to be limited to the branched or morphologically complex species.

The extent of VME indicator taxa bycatch from small-scale fisheries in the Mediterranean Sea is almost unknown. However, the effects of these fishing activities are clear, since they can remove or severely damage (for example, through the breakage of branches and tissue abrasion) corals, sponges and other VME indicator taxa. Other indirect effects of the different types of fishing gear include increased vulnerability to epibiosis, parasitism and predation, especially for corals damaged and detached from the seafloor, as well as the interruption of reproduction in injured corals due to a reallocation of energy reserves for tissue repair and regeneration (e.g. Mortensen *et al.*, 2005). However, a small amount of information is available on the response of VME indicator taxa to specific fishing activities (Bo *et al.*, 2014a; Kaiser *et al.*, 2018) and quantitative data on their commercial bycatch from small-scale fisheries are scarce and limited to a few areas (e.g. Gökçe and Metin, 2007).

There are few data available on the effects of trapping and potting in deep waters, but the fact that these types of equipment are larger and heavier compared to those used in inshore waters suggests that they may have greater impacts. If deployed on VMEs, they are likely to cause physical damage during setting and retrieval when dragged over the seafloor. Therefore, it is reasonable to assume that a certain, though still unquantified, bycatch of VME indicator taxa likely occurs. For instance, Troffe *et al.* (2005) found that prawn traps had a 0–5 percent efficiency in catching whip-like sea pens at two bays on Clio Channel, southcentral coast of British Columbia, Canada, while in the offshore area, Risk, MacAllister and Behnken (1998) reported that a pot fishery caused damage to hard-bottom alcyonaceans of the genus *Primnoa*.

Considering gillnets, despite a lack of data about incidental catch, evidence provided by visual surveys clearly revealed the high impact on VMEs, notably lost nets and extensive damage of benthic communities (e.g. Bo *et al.*, 2012, 2014a). Although the effects of gillnets are mostly visible at shallower depths in comparison to trawl nets and set longlines, they may still play an important role in the bycatch and impact on mesophotic VMEs, such as hard-bottom coral gardens structured by black corals and alcyonaceans. For instance, Shester and Micheli (2011) found that the overall damage by gillnets caused by the removal of arborescent corals can be comparable to

that of bottom trawls in certain areas of Baja California, Mexico. Thus, the ecological impacts of small-scale fisheries can be severe and even comparable to those of large-scale industrial fisheries on the basis of catch per unit effort (Shester and Micheli, 2011).

5.3.2 Future scenarios

Combining commercial fishery, scientific surveys and fisher interview data represents a key step to understand the extent of the incidental catch of VME indicator taxa, and consequently the conservation of VMEs likely to occur in fished areas. In order to obtain a comprehensive estimate of the scale of fishing impacts on VMEs, commercial bycatch data, integrated with results from experimental fishing surveys, as well as with ROV imaging, are necessary. Soft-bottom VMEs are mainly affected by bottom trawls, and only secondarily by set longlines and small-scale fisheries. In contrast, lost longlines and gear from small-scale fisheries represent the majority of the marine litter recorded in the proximity of rocky sea bottoms, confirming the impact of these fishing practices on hard-bottom VMEs.

The precautionary approach for managing demersal fisheries with respect to VMEs should be adopted, including a VME encounter protocol for bottom-contact fisheries aimed at avoiding the risk of significant adverse impacts. Management measures to protect VMEs from bottom-contact fishing gear include commercial fishery monitoring protocols through onboard observers, vessel monitoring systems data, assessment of commercial bycatch rates, scientific surveys and the closure of strategic areas (Hourigan, 2009; Aguilar, Perry and López, 2017; Thompson *et al.*, 2016). The presence of trained observers onboard commercial fishing vessels is crucial to understanding the scale of incidental catch of VME indicator taxa by fishing fleets, since fishing gear and practices on commercial fishing vessels sometimes differ from experimental fishing surveys. This solution could also offer an additional means to control the catch quotas of sensitive benthic species. For example, observers onboard fishing boats targeting the precious red coral *Corallium rubrum* along western Sardinia reported the occurrence of undersized colonies, underestimated weight catches on the logbooks, as well as amounts of harvested corals above the limits imposed by the local regulations (Carugati *et al.*, 2020).

Effective fishing closures represent useful spatial management measures to prevent the bycatch of VME indicator taxa by commercial bottom fishing and thus mitigate adverse impacts on marine ecosystems. In order to ensure the conservation of VMEs, appropriate fishery policy mechanisms are required; they should involve stakeholders and include a credible system for monitoring, control and surveillance. Urgent action is needed to protect VME indicators, particularly the last living gardens of the bamboo-coral *Isidella elongata*, considered to be common until fifty years ago, but now critically endangered due to decades of commercial trawling (Mastrototaro *et al.*, 2017; Chimienti *et al.*, 2019a). This very important VME indicator species was classified as "Critically Endangered" in the IUCN Red List of Threatened Species (IUCN, 2021), which is the maximum risk category before extinction (Otero *et al.*, 2017), thus representing a conservation priority for the entire basin. While there is a need to gather more information from commercial and scientific fishing surveys, literature data already provide useful insights to identify strategic areas for the conservation of *I. elongata* and many other vulnerable benthic species.

An increasing amount of information exists about VME occurrences throughout the Mediterranean basin, based on non-destructive visual surveys, but the eastern basin and the Black Sea are certainly less covered by scientific studies. Involving fishers in the collection of

data on macrobenthic invertebrate bycatch could represent an appropriate solution to help to fill knowledge gaps regarding the incidental catch of VME indicator taxa. The implementation of data collection programmes onboard commercial vessels would also provide a useful means to quantify the magnitude of fishing impacts on VMEs. Until such solutions are put in place, the adoption of the precautionary approach is necessary to preserve vulnerable habitats and species.

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Glossary

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.

Bathyal and abyssal zones: The portion of the seabed where light is absent and the life of plants and algae is impossible. In the oceans, it is followed by the abyssal zone, in which the water temperature is below 4°C. In the Mediterranean Sea, it indicatively starts below 200 m depth and has a temperature of between 12.5°C and 14.5°C, according to different locations of the basin.

Beam trawling: A fishing practice using a net attached to a steel beam and dragged along the sea bottom behind a towing vessel. The mouth of the net is held open by the beam which is attached to two solid metal plates called shoes, welded to the ends of the beam.

Biomass index: The weight of fish per square kilometre (kg/km²).

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, seabirds).

Catch: The amount of marine biological resources that are caught by fishing gear and reach the deck of the fishing vessel. This includes individuals of the target species, which are usually kept onboard and retained, as well as bycatch, which refers to species with or without commercial value that are not targeted by the fishery.

Density index: The number of fish per square kilometre (n/km²).

Depredation: An interaction between marine animals (e.g. cetaceans, seabirds, sea turtles, sharks and rays) with different types of fishing gear considered to be a source of food. Depredatory behaviour can have consequences on fisheries through the removal of bait or caught fish from hooks, nets or traps, thereby reducing commercial catches (i.e. income) or damage done to fishing gear. Depredation can also impact animals, who can suffer mortality and injuries from these interactions. Impacts caused by damages to fishing gear and the loss of catches can lead to hostile dynamics between fishers and those groups of species.

Discard: The part of the catch that is not retained onboard and is returned to sea, dead or alive. It may include target species or any other species (both commercial and non-commercial) discarded at sea.

Epipelagic species: Species living in the upper portion of both the neritic and oceanic waters, where photosynthesis occurs.

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.

Fishing trip: In the simplest cases, a fishing vessel leaves the port, goes 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". 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 unit of time. 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.

Fleet segment: A group of fishing vessels of the same size category and using the same gear type for more than 50 percent of their time at sea over the course of a year.

Hanging ratio: The ratio between the length of the headrope and the length of the netting. This term can describe the horizontal slackness of a set net.

Incidental catch or accidental catch: Non-target species captured during their attempts to take bait or other species already caught by fishing gear or taken simply through proximity to the fishing gear. See bycatch.

Landing: The part of the catch that is retained onboard and brought ashore.

Mesopelagic longlines: Longlines that are set in deeper waters (150–200 m), usually for a longer period, and have a lower number of hooks per set, compared with a traditional surface longline.

Mesophotic zone: Also known as circalittoral zone or twilight zone, the mesophotic zone is the portion of the seabed from the final limit of the presence of seagrass to the initial limit of the presence of algae (loss of net productivity at level of irradiance <1 percent). In the Mediterranean Sea, it indicatively ranges between 50 and 200 m depth.

Neritic zone: A shallow marine environment generally corresponding to the continental shelf, characterized by relatively abundant nutrients and biologic activity due to its proximity to land

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.

Otter trawling: A fishing practice using a large net dragged along the sea bottom behind a towing vessel. The mouth of the net is held open by two large otter boards (also known as doors) which are attached to either side of the net and drag on the seabed before the net.

Semipelagic longline: The main line of a semipelagic longline is positioned at a depth of 150 m or more, while the main line of a surface longline targeting swordfish is usually set at a depth less than 100 m.

Soaking time: The time during which the fishing gear is actively in the water.

Total length: The length of a fish measured from the tip of the snout to the tip of the longer lobe of the caudal fin, usually measured with the lobes compressed along the midline. It is a straight-line measure, i.e. not measured over the curve of the body.

Vessel group: Fishing vessels, regardless of their size, using the same gear for more than 50 percent of their time at sea over the course of a year.

Vulnerable marine ecosystem (VME): A marine ecosystem that has the characteristics referred to in paragraph 42 and elaborated in the annex of the FAO *International Guidelines for the Management of Deep-Sea Fisheries in the High Seas* (FAO, 2009). Vulnerable marine ecosystems (VMEs) include groups of species, communities, or habitats that may be vulnerable to impacts from fishing activities.

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 macrobenthic invertebrate species pertaining to VMEs have been used.

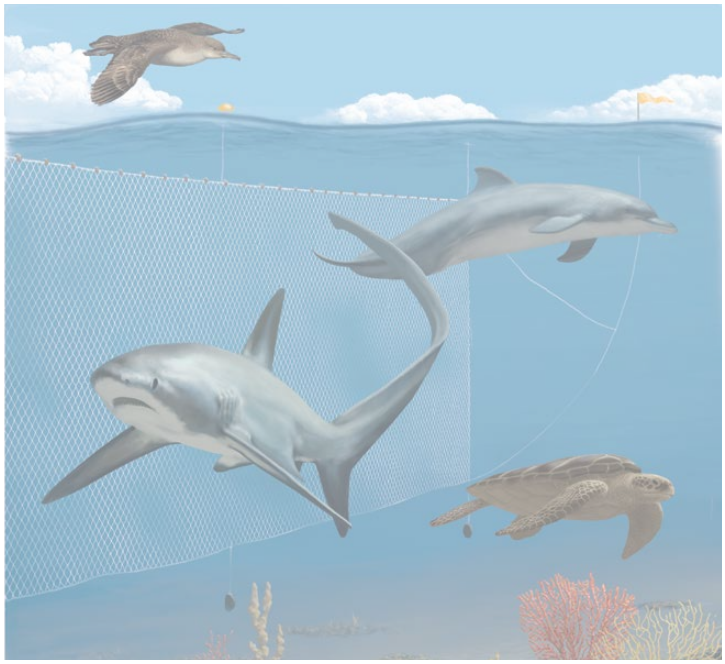
INCIDENTAL CATCH OF VULNERABLE SPECIES IN MEDITERRANEAN AND BLACK SEA FISHERIES A REVIEW

Bycatch – a term widely used to refer to part of the catch unintentionally caught during a fishing operation, in addition to target species, and consisting of the discards and incidental catch 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. Understanding the bycatch issue and adopting effective measures in order to reduce bycatch rates are essential steps towards minimizing the impacts on vulnerable species and ensuring both a sustainable fisheries sector and healthy seas.

In the Mediterranean and the Black Sea, the incidental catch of vulnerable species – namely seabirds, sea turtles, elasmobranchs, marine mammals and macrobenthic invertebrates – represents one of several challenges for the industrial, semi-industrial and small-scale fisheries that coexist in the region, as well as for the diverse and sensitive ecosystems impacted. Typically, data on this issue have been collected in an opportunistic manner and in ways that make comparisons difficult. The annual absolute values of incidental catch of vulnerable species are not available: studies cover only a small portion of the total fishing activity and often present important knowledge gaps for many types of fishing gear, countries and/or subregions, as well as on temporal scales, for example, to establish reliable baselines. The result is that little is known of the scope of the problem, despite incidental catch being a significant pressure on the populations of vulnerable species, as well as a concern for fishers.

This regional review is an attempt to compile, in one single document, all available data and historical records on the incidental catch of vulnerable species in the Mediterranean and Black Sea fisheries, obtained from existing literature, databases and other grey sources, and collated in a standardized and comparable way. The main objective is to provide comprehensive baseline information, earmark the main data gaps, as well as identify the most impacting types of fishing gear by taxonomic group.

This work is a reminder of the importance of standardized data collection and the need to have baseline information in order to support decision-making in the identification of appropriate bycatch mitigation techniques, thus enabling analysis of their effectiveness and comparison over time and space, as well as facilitating the implementation of relevant conservation and/or management measures at the national, subregional and regional levels.



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MEDIAS HANDBOOK

(Version: April, 2021)

Common protocol for the MEDIterranean International Acoustic Survey (MEDIAS)

The geographical areas that are covered by the MEDIAS surveys and the respective days at sea per survey are presented in the following Table 1 and Figure 1. References can be found on MEDIAS website: http://www.medias-project.eu/medias/website/

Table 1. The size of the geographical area that is covered by each Institute in the Mediterranean Sea and in the Black Sea. (Note that it should be updated on an annual basis).
NM = nautical miles

Country	Institute	Geographical area	Size of area	Standard number of days
Greece	HCMR	Aegean Sea	9000 NM^2	40
Greece	HCMR	Eastern Ionian Sea	2800 NM^2	30
France	IFREMER	Gulf of Lion	3300 NM^2	30
Slovenia	CNR-IRBIM/FRIS	Adriatic Sea (Slovenia)	117 NM^2	1
Italy	CNR-IRBIM	Adriatic Sea (Italy)	13200 NM^2	40
Italy	CNR-IAS	Sicily Channel*	4300 NM^2	16
Italy	CNR-IAS	Tyrrhenian and Ligurian Sea	6644 NM^2	30
Spain	IEO	Iberian coast	8829 NM^2	33
Croatia	IOF	Adriatic Sea (Croatia)	13578 NM^2	30**
Bulgaria	IO-BAS	Black Sea	3400 NM^2	20
Romania	NIMRD	Black Sea	4300 NM^2	20

Note: * This area includes both GSA 16 (South of Sicily) and part of GSA 15 (Malta Island)
** - not sufficient, as proved in surveys in 2019 and 2020; should be increased.

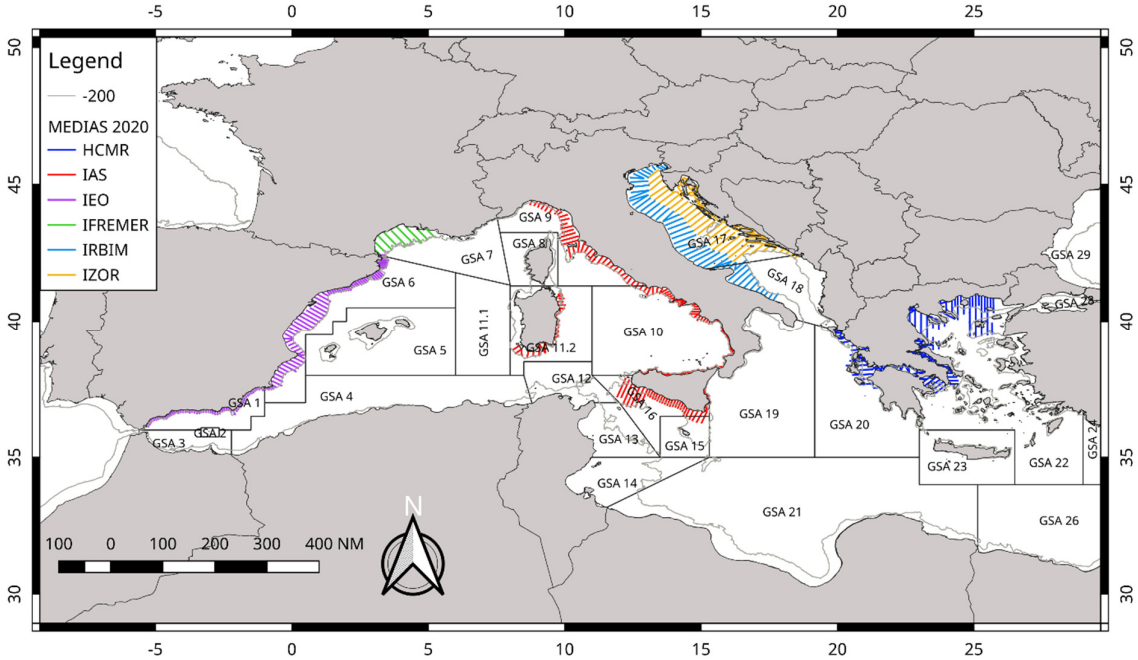

Figure 1: Surveys design in the MEDIAS 2020.

Survey Identity

In the report of the DCF each Institute should report, the geographical area, the size of the area covered, the days at sea, as well as the period and dates in which the survey took place. In addition, the following vessel characteristics should be reported: Name of vessel, vessel length and vessel HP.

Echo sounder parameters

A variety of equipments with specific characteristics could be considered as adequate for the assessment of small pelagics. A split beam echo–sounder should be used for the echo–sampling. The angle beam, Athwart Beam Angle (in degrees), Along Beam Angle, and Ping rate of the echo–sounder should be reported. The frequency for assessment should be the 38 kHz, while the 18, 70, 120, 200 and 333 kHz can operate as complementary frequencies, depending on the research vessel used.

The pulse duration should be 1 ms; a pulse duration of 0.5 ms will be used only in case of Target Strength specific experiments. The threshold for assessment should be -70 to

-60 dB depending on the survey and the ecosystem and should be reported. As the main objective is the optimum discrimination between fish and plankton, the background noise should be removed and in a next step, based on the available frequencies used in each survey, a frequency response-based mask should be developed to split the acoustic backscattering between fish and plankton. Whenever this cannot apply, the threshold for assessment should be set at -70 to -60 dB, depending a) on noise

level (-60 dB in case of high noise); b) the peculiarities of each area regarding school morphology and plankton density (-60 when plankton is dense, but -70 dB when small schools dominate the area); c) echo-sounder features; d) time of day that echo acquisition is carried out.

The ping rate should be set as fast as possible depending on depth, in order to assure good echo discrimination. At least one calibration of echo-sounder should be held per survey based on the procedure described in the manual of each echo-sounder and according to the principles described by Demer *et al.* (2015). The calibration parameters and the results of the acoustic equipment should be reported by survey according to the following Table 2. In principle, one calibration per survey is suggested.

Table 2. Calibration report

Calibration report	
Frequency (kHz)	
Echo-sounder type	
Transducer serial no.	
Vessel	
Date	
Place	
Latitude	
Longitude	
Bottom depth (m)	
Temperature (°C) at sphere depth	
Salinity (psu) at sphere depth	
Speed of sound (ms^{-1})	
TS of sphere (dB)	
Pulse duration (s)	
Equivalent 2-way beam angle (dB)	
Default TS transducer gain	
Iteration no.	
Time	
Range to sphere (m)	
Ping rate	
Calibrated TS transducer gain	
Time (GMT)	
RMS	
sA correction	

Survey Design

The survey design for the acoustic sampling should consider the characteristics of the spatial structures of small pelagic fish in each area as well as the peculiarities in the topography of each area. Transects should be run along the greatest gradients in fish density, which is often related to gradients in bottom topography, meaning that transects will normally run perpendicular to the coastline/bathymetry. Inter-transect distance should be adjusted to achieve the minimization of the coefficient of variation of the acoustic estimates for the target species in each area but also take into account survey duration. In cases that topography is complex like in the case of semi-closed gulfs transect design could be decided otherwise. The survey design in each area should be reported. Based on some preliminary studies of the spatial structure characteristics of small pelagics in the Mediterranean Sea (WKACUGEO 2010; MEDIAS 2011) the inter-transect distance should not exceed 12 NM.

Specifically, within certain common workshops that were held in the framework of the AcousMed project (Anonymous, 2012) and past MEDIAS meetings, the existing survey design at different areas has been reviewed along with area peculiarities (e.g. size of the area, topography, survey duration). In the framework of these workshops, geostatistical analysis was applied on historical acoustic data under a common protocol and different survey designs were evaluated towards optimization, considering the spatial characteristics of small pelagic fish aggregations. The optimum inter-transect distance in each area has been identified and proposed. The results have been adopted at the 5th MEDIAS coordination meeting. However, in order to evaluate the survey performances in each area, a dedicated session with this specific Terms of Reference should be held when needed within the framework of the MEDIAS annual meetings.

Vessel speed during acoustic sampling should be adjusted depending on vessel noise as set by the ICES-WGFAST (WGFAST 2006). The working group agreed that vessel speed of 8-10 knots is adequate for a split beam echo sounder of 38 kHz. At higher speeds, problems might be encountered with engine noise or propeller cavitation.

It was strongly recommended that if species identification depends on the recognition of schools based on the echograms, the survey will have to take place only during day- time, being interrupted during periods in the 24-hour cycle when the schools disperse.

Otherwise, if available survey time does not permit this, echo sampling might be extended. In this case, echo allocation into species will not be based on school shape identification and justification should be given in the report that this does not affect the accuracy of the estimations. In the framework of the AcousMed project appropriate acoustic data from daytime and nighttime have been analyzed in order to determine the degree of error. Results from recent study (in press) indicated that night estimates can be higher or lower compared to daytime estimates largely depending on the area peculiarities and especially the local plankton and fish densities. However, results showed that correction is possible and it is advisable when night sampling is inevitable.

Transects should be extended as close to the coast as possible in order to cover adequately the spatial distribution of sardine. The minimum distance from the shore largely depends on the size of the research vessel used. In any case, the Distance of acoustic sampling from the coast in respect to the Bottom depth should whenever this is possible reach the 10 m isobath. In each case the minimum

bottom depth of each survey should be reported. The maximum echo-sounding depth should be 200 m and the minimum echo-sounding depth should be reported as it depends on the draught of the research vessel.

The Elementary Distance Sampling Unit (EDSU) for echo integration should be 1 nautical mile (NM), excluding "bad data". In the case of parallel transect designs, the acoustic energy in the inter-transect tracks will not be considered for assessment purposes. The working group concluded that the target species of the survey will be anchovy (*Engraulis encrasicolus*) and sardine (*Sardina pilchardus*).

The echo partitioning into species should be based on echogram visual scrutinization. This will be done either by direct allocation based on the identification of individual schools and/or allocation on account of representative fishing stations.

Target Strength (TS) equations: in the Mediterranean Sea, different species TS equations are currently applied depending on the area. The application of common TS equations should ideally derive from *in situ* estimations of TS, preferably based on acoustic data from the Mediterranean Sea. For this purpose, specific workshops were held in the framework of AcousMed project as well as DCF and MEDIAS coordination meetings but largely based on the analysis of available historical data. Based on these results, the 5th MEDIAS coordination meeting agreed to apply for sardine the following TS-TL equation this point forward:

$$TS=20\log(TL)-72.6 \text{ dB}$$

where TS=Target Strength, TL=Total Length. The Steering Committee at its 14th annual meeting also agreed that in addition to use previous TS equation for sardine (with b20= -72.6 dB), IFREMER also will continue to use a b20=-71.2 dB in the Gulf of Lions, for compatibility reasons to the long time-series available, as well as because the available data analyzed from the area of Gulf of Lion were very limited.

Analysis results concerning anchovy indicated large differences between areas. For this purpose, MEDIAS partners concluded that further analysis using more data from all areas is needed and agreed not to propose a single TS equation and b_{20} value for anchovy. It was suggested that the work regarding anchovy TS should continue within the framework of specific MEDIAS workshops, using available data from additional areas, such as Croatia. Thus, it was agreed that for the time being, the historical Target Strength equations for anchovy will be maintained in each area and the applied TS equation should be reported.

Acoustic data processing for the assessment of the target species, Echoview or alternative Movies 3D software should be used for acoustic data analysis and the estimation of abundance. For compatibility reasons, raw data should be available into a common *.hac file format. Due to the large file size raw data will be stored within the responsibility of each Institute. The common *hac format will be also available for the requirements of the Data Collection Framework (DCF) upon request.

A script in R to calculate geostatistical CV associated with biomass estimates from acoustic survey, based on Walline et al. (2007), has been created by Marco Barra (CNR) and tested by all MEDIAS groups. This procedure is considered mandatory to calculate geostatistical CV to be provided along with acoustic estimates.

Workflow for acoustic data processing

During the 6th MEDIAS meeting the Steering Committee agreed on a common workflow for acoustic data processing, which is structured in the following four steps:

a) Load and view data

b) The acoustic data acquired by echo-sounder during the survey are loaded in a software environment for visual exploration in terms of echograms and maps.

c) Calibrate

d) The results of calibration procedure, carried out on board the vessel, are installed in order to convert the raw acoustic data into absolute backscattering measurements. Such step includes also the installation of correct settings of transducers position referred to GPS antenna.

e) Remove background noise

f) Before analyzing the acoustic data any ambient noise present in the underwater environment has to be removed.

g) Detect and filter

The step includes the use of grids, lines, regions and mathematical operators for excluding from the collected acoustic data any backscattering signal not linked to the presence of fish and/or plankton.

<u>Specific aspects are:</u>

1. Intermittent noise removal;
2. Evaluate possible interferences that may produce artefacts in the echograms, and adopt a procedure for removing them;
3. Surface and seafloor exclusions;
4. Use lines for correctly separating the backscattering signals from surface and bottom;
5. Single targets estimation;
6. In case of organisms scattered in the water column, typical of night-time data acquisition, adopt the necessary procedure for separating fishes from planktonic organisms;
7. Schools estimation;
8. Use regions and/or mathematical operators for estimating backscattering signal due to fish aggregations.

Abundance indices

The following abundance indices should be estimated and reported in the DCF within the framework of MEDIAS:

The Total fish NASC per EDSU, as well as Point maps of total fish NASC should be available.

The target species of MEDIAS for assessment purposes will be anchovy (*Engraulis encrasicolus*) and sardine (*Sardina pilchardus*). The abundance indices estimated by all MEDIAS parties provided in the DCF report should include both NASC and Biomass estimations, for the whole area. Specifically, for the two target species abundance estimates provided in the report are: NASC/EDSU; Biomass/EDSU; Number of fish/EDSU; Number/age and per length class; Biomass/age and per length class. Point maps of anchovy and sardine in NASC/mile; Biomass/mile should also be available. In addition, abundance indices could be given for all pelagic species in the community which are important in each area.

The catch compositions of the hauls: pie-charts indicating percentage by weight per species and/or group of species should be available also.

Fish sampling

According to the standard methodology followed in acoustics, species allocation of the acoustic records is impossible if trawl information is not available. Fish sampling is required to collect representative samples of the fish population in order to identify echoes. The main objectives of trawling in an acoustic survey are a) to obtain a sample from the school or the layer that appears as an echo trace on the sounder for echo trace identification and allocation into species and b) to get biological information and evaluation of the size distribution of each species. Therefore, the trawling gear used is of no importance as long as it is suitable to catch a representative sample of the target-school or layer. In the framework of the AcousMed project available past data from different areas in the Mediterranean were analyzed based on a common protocol. Results showed no significant differences between day and night sampling (Machias et al., 2013). The coordination meeting based on these results concluded that samples collected during both day and night in the same survey could be merged and used for the necessary estimations.

In addition, the sampling intensity of the hauls cannot be pre-determined because of the objectives of the acoustic survey *per se*. The sampling intensity in an acoustic survey depends on the size of the area covered, the frequency of occurrence of different echo traces on the sounder screen and the spatial characteristics of fish aggregations. In addition, the geographical coordinates or the sampling depth of the hauls cannot be pre-determined because pelagic species execute extended horizontal and vertical movements. Schools morphometry and energetic characteristics might change depending on the area, the time interval or even the fishing pressure. Therefore, the sampling strategy has to be adaptive depending on the school characteristics per area, time period and year.

Considering that, within a common protocol, the different research vessels used and the peculiarities of each area the following points have been agreed:

- A pelagic trawl will be used in all areas for biological sampling.
- Maximum codend mesh size should be equal to 24 mm (side of mesh equal to 12 mm). The codend and the trawl characteristics used in each area will be reported. If codend cover is used it should be reported and not to be used for LFD of target species.
- The vertical opening of the pelagic hauls along with the netsounder used should be reported.
- The duration of hauls should be no less than 30 min for unknown echoes and when multi-species scattered echoes are being fished.
- Vessel speed during fishing should be 3.5–4.5 knots.
- It is widely accepted that in the framework of an acoustic survey a standard total number of hauls cannot be set because this depends on the fish distribution and abundance found in each survey. However, in any case the hauls number must be adequate in order to a) ensure identification of echo traces; b) obtain a representative length structure of the population for each target species; c) obtain species composition and biological samples.
- Target species of the MEDIAS surveys are anchovy and sardine, but biological data for all species in the pelagic community regarding length frequency distribution and Length-Weight relationships should also be acquired.

Biological and oceanographic parameters

The following biological parameters should be estimated in each survey:

- The Length frequency distribution (0.5 cm) should be estimated from a representative sample for each fish species per haul. Total length will be measured for all species. The Length–Weight relationship for all pelagic species will be estimated and reported. The size of each sample should be set at minimum the one described in the respective protocol of the Data Collection Framework (DCF).
- For the target species, anchovy and sardine, the mean Total Length at age should be estimated, as well as the Age-Length-Key used for the conversion of abundance indices to abundance-at-age. Data should be provided according to the DCF instructions.
- Otolith reading criteria for anchovy and sardine should be in accordance with ICES WKARA2 report (2017) and follow the recommendation of that meeting. In particular the 1st of January should be considered the birthdate for anchovy from an assessment point of view in relation to time-steps in the assessment. Mean TL at age should be reported.

- It is strongly recommended the use of ICES WKSPMAT report (2008) scale during the lab processing for classifying the reproductive phase for anchovy and sardine, particularly for identifying mature/immature which are very relevant to stock assessment purposes, in order to obtain the L_{50} estimation. This scale allows reaching a higher accuracy since it has been developed specifically for small pelagics (indeterminate spawners).
- Since the environmental parameters are very important for small pelagic fish, a minimum of 3 CTD stations should be held per transect or a grid of stations with density adequate to describe the oceanography of the surveyed area. Temperature and salinity are the hydrographic parameters that should be measured in the entire water column at each station.

Furthermore, the need for a common database has been concluded. The need for collaboration with the respective surveys in the Atlantic region (e.g. Bay of Biscay) has also been discussed and agreed. In the framework of this collaboration, information and experience will be exchanged.

Database

In the framework of the AcousMed project as well as a MEDIAS workshop, a common database design has been decided for all MEDIAS surveys (See: MEDIAS proposals in Annex VII). The 5th MEDIAS coordination meeting agreed to use this data base framework to store acoustic and biological data collected within the acoustic surveys in the Mediterranean Sea.

Ecosystem indices related to acoustic surveys

The abilities of currently applied MEDIAS surveys to contribute towards an ecosystem-based management approach in relation to the current and the future DCF requirements was extensively discussed by the MEDIAS partners. In the following Table 3 the ecosystem indices that can derive from acoustic surveys (based on data regularly collected and analyzed) are reported.

Table 3. Ecosystem indices that could be derived from acoustic surveys.

Good Environmental Status indices	Spatial/temporal strata	Spatial strata	GSA				
			Acoustic survey				
		Time periods	Season (Summer/Autumn depending on the area)				
	Taxonomic levels	Community	Pelagic fish (Species composition, occurrence in pelagic hauls)				
		Target Species	Adult	Anchovy			
				Sardine (for Mediterranean)			
				Sprat (for Black Sea)			
	Indices	Biodiversity	Species	Population size	Acoustic estimates	Total biomass & abundance estimates for target species	
						Estimation error (CV) (i.e. as agreed based on a common estimation procedure, see ToRs)	
				Population condition	Biomass & abundance estimate per size/age	Anchovy, Sardine, Sprat (Black Sea)	
					Recruitment index	Sardine (i.e. Number at Age 0 of the population based on summer surveys)	
				Habitats	Habitat condition	Hydrological condition	Temperature (i.e. SST: average at 10m, estimated as the interpolated mean value for the whole area)
							Salinity (i.e. SSS: average at 10m, estimated as the interpolated mean value for the whole area))
			Community	Fish Community condition	Community Synthesis	Total pelagic fish NASC	
					Species composition (i.e. percentage in terms of weight of pelagic trawls per hour)*		
			Age and size distribution	95% percentile of the population length distribution for the target species			
				Proportion of fish larger than L50 (length at first maturity estimated based on collected data or defined based on literature)			

Tables for DCF Data Call

The common templates (e. g. https://datacollection.jrc.ec.europa.eu/dc/medbs/templates), currently used for submission of MEDIAS results to Data Calls by MS, provided by JRC, are the following:

Abundance (in numbers per species per sex and length class)	xxx_Abundance
Biomass (biomass per species per sex and length class)	xxx_Biomass
Abundance biomass (abundance and biomass per species per sex and age class)	xxx_Abund_Biom

Common format for presentations at MEDIAS Coordination Meetings

- GSA number and general information on the GSA; map and general information on the acoustic survey
- Type of echosounder and frequencies in use
- Calibration results
- Survey design
- Number of nautical miles effectively processed for biomass estimation
- Biomass estimation results in tons by GSA and graphs in terms of biomass density (time series of average t/nm^2)
- Headline, footrope length of the pelagic net, sidelines dimensions, mesh size
- CTD stations map
- Biomass per length classes (0.5 cm) and per age classes in tons
- Graphs of Age Length Keys (in %, with total No. otoliths, by length clases)
- Maps of anchovy and sardine spatial distribution (proportional maps of NASC values - bubble plots)
- Map with pie charts reporting percentages in weight of anchovy, sardine and other species

Other results of interest from acoustic surveys could be also reported but they are not mandatory.

Data accessibility

As the MEDIAS Steering Committee acknowledges the need for MEDIAS data and output accessibility it was agreed to:

-MEDIAS results per survey are presented in the Annual MEDIAS report which is freely available in the MEDIAS website
-Overall biomass and abundance estimates are available through the DCF Data Call
-Include annual distribution maps of NASC per species along with the respective metadata information in a GEOportal.
Detailed data per EDSU could be available to third parties through the GEOportal. The third party should send a request and present to the Steering Committee the type of data requested, the purpose for which data are needed and exchange ideas for collaboration.

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Summary table of the common protocol for the Pan-MEDIterranean Acoustic Survey (MEDIAS).

Survey Identity	
Geographic area	Should be reported
GSA area	Should be reported
Size of Area to be covered (NM^2 / km^2)	Should be reported
Days at sea	Should be reported
Vessel	Should be reported
Vessel length	Should be reported
Vessel HP	Should be reported
Period of survey	Should be reported
Echo sounder parameters	
Echo sounder	Split beam
Frequency for assessment (kHz)	38
Complementary frequencies (kHz)	18, 70, 120, 200, 333 kHz depending on availability.
Pulse duration (ms)	0.5 or 1 ms, should be reported
Beam Angles (degrees) Athw. Beam Angle, Alog. Beam Angle	Should be reported
Ping rate	Maximum depending on depth
Calibration (No per survey)	A calibration report should be given One calibration per survey
Threshold for acquisition (dB)	-80
Threshold for assessment (dB)	-70 to -60 (reported)
Survey design	
Transects design	Perpendicular to the coastline/bathymetry, otherwise depending on topography The survey design according to the MEDIAS conclusion for each area and should be reported.
Inter-transect distance (NM)	Max <=12 NM. The inter-transect distance should be according to the MEDIAS conclusion for each area and should be reported
Time of day for acoustic sampling	Day time. Otherwise, in cases of time limitation and if echo allocation into species does not depend on school shape identification (in this case justification of the accuracy of results will be presented)

EDSU (nm)	1 NM
Distance from the coast according to the Bottom depth (min, m)	Bottom depth should whenever this is possible reach the 10 m isobath
Echo sounding depth (min, m)	Depending on the draught of RV. Should be reported
Echo sounding depth (max, m) recording.	200 m
Vessel speed	8-10 knots
Software for analysis	Movies and/or Echoview
File format	*.hac
Inter - transect	Acoustic energy in the inter-transect track will not be taken into account
Applied TS (dB)	Sardine: -72.6 dB, See also hand book Other species: Keep historical TS equations.
Echo partitioning into species	Echo trace classification based on echogram visual scrutinisation • Direct allocation and • allocation on account of representative fishing station
Abundance estimates	
Abundance indices estimated	ν Total fish NASC per EDSU ν Anchovy, Sardine NASC per EDSU ν Anchovy, Sardine Biomass per EDSU ν Anchovy, Sardine Numbers per EDSU ν Anchovy, Sardine Number/age and per length class ν Anchovy, Sardine Biomass/age and per length class
Maps and charts	ν Point maps of total fish NASC ν Point maps of target species in NASC/mile; biomass / mile. ν Catch compositions of the hauls, pies charts indicating biomass per species
Fish sampling	
Target species	Anchovy, Sardine
Other species	Biological data for all species in the pelagic community: Length-Weight relationships; Length distribution.

Fishing gear, codend mesh size	Pelagic trawl, Codend and trawl characteristics should be reported. Max Codend mesh size = 24 mm (side of mesh = 12 mm).
Vertical opening of the pelagic trawl	Should be reported
Netsounder used	Should be reported
Duration of haul	Minimum 30 min for unknown echoes
Time of sampling	Both daytime and night time biological samples from the same survey will be used.
Vessel speed during fishing	3.5 – 4.5 knots
Sampling intensity, no of hauls	The total number of hauls has to be adequate to: • ensure identification of echo traces; • obtain length structure of the population; • obtain species composition; • get biological samples.
Biological and oceanographic parameters	
Length	All species: Total length (TL), Length frequency distribution (0.5 cm)
Age readings, ALK	Sardine, Anchovy: Mean TL at age Sample sizes according to the new DCF.
Length - Weight	All pelagic species
Oceanographic. Parameter (CTD)	Minimum 3 CTD per transect or grid of stations with density adequate to describe the oceanography of the surveyed area. Minimum variables: T, S

International bottom trawl survey in the Mediterranean

Instruction manual

Version 9

2017

MEDITS-Handbook. Version n. 9, 2017, MEDITS Working Group : 106 pp.

The MEDITS programme is conducted since 2002 in compliance with the European framework for the collection and management of fisheries data (Regulation EC 1543/2000). This framework was first reformed in 2008 (Regulation EC 199/2008) resulting in the Data Collection Framework (DCF) and lastly in 2017 (Regulation EU 2017/1004 - recast). Under this framework the Member States collect, manage and make available a wide range of fisheries data needed for scientific advice. The financial support to the MEDITS programme is from the European Commission (DG MARE) and from the Member States.

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Preamble

The MEDITS project started in 1994 within the cooperation between several research Institutes from four Mediterranean Member States (France, Greece, Italy, Spain) of the European Union. Along the time, till to the advent of the European framework for the collection and management of fisheries data, new partners from Slovenia, Croatia, Albania, Montenegro, Malta and Cyprus joined the MEDITS project.

The target was to conduct a common bottom trawl survey in the Mediterranean in which all the participants use the same gear, the same sampling protocol and the same methodology.

A first manual with the major specifications was prepared at the start of the project. The manual was revised in 1995, following the 1994 survey and taking into account the methodological improvements acquired during the first survey. Along the years, several improvements were introduced. A new version of the manual was issued each time it was felt necessary to make improvements to the previous protocol. In any case, each time the MEDITS Co-ordination Committee ensured that amendments did not disrupt the consistency of the series. The third version of this manual was edited in 1999, while the fourth one served as a manual for the surveys carried out between 2000 and 2006. The fifth version, although issued in 2007, included improvements adopted by the MEDITS group since 2005, and was the protocol followed from 2005 until 2011 surveys.

In 2012 the revision 6 was issued, which included substantial modifications to the MEDITS manual, though not affecting the main characteristics of the protocol regarding the sampling scheme, methods and gear. This new version included changes in the list of target species and faunistic categories, which were both expanded. In addition, the protocol for otolith sampling and measurements of biological parameters was included, while adjusting the storage data formats accordingly.

The version number 7, in continuity with the previous ones, was amending and innovating some aspects, while incorporating more specific and standardised gear checks and proposing a common protocol for the voluntary collection of data on marine litters, in agreements with the requirements of the Marine Strategy Directive Framework (Directive 2008/56/EC).

The version 8 introduced more details on the checks of the MEDITS gear and on the aspects related to the taxonomic list and categories.

To ease the MEDITS Handbook consultation, the present version 9 separates out the TM list from the MEDITS Handbook and makes the former available in an electronic format only at the web site: http://www.sibm.it/MEDITS%202011/principale%20project.htm.

Co-ordination of the MEDITS program (2017)

Co-ordination

Since 2017 the MEDITS program is co-ordinated at international level by George Tserpes (HCMR, Greece).

The MEDITS group is currently composed as in table 1. The members of the Steering Committee are indicated by the letter N in the same table.

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R= Regional Coordinator; N=National Coordinator; I=International Coordinator

Contents

INTRODUCTION 9

[1] SPECIFICATIONS OF THE SAMPLING GEAR 11

1.1 THE TRAWL 11

1.2 THE RIGGING 12

1.3 THE DOORS (OTTER BOARDS) 12

1.4 WARP DIAMETER AND LENGTH 13

1.5 COMPLEMENTARY EQUIPMENT AND MONITORING SYSTEMS 13

[2] SAMPLING METHODOLOGY 14

2.1 VESSEL CHARACTERISTICS 14

2.2 PERIOD OF THE SURVEY 14

2.3 HAULS LOCALISATION 14

2.4 OPERATING THE GEAR 14

2.4.1 SAMPLING PERIOD IN THE DAY 14
2.4.2 HAUL SPEED AND DURATION 15
2.4.3 HAUL START AND END DEFINITION 15
2.4.4 HAUL ORIENTATION 15
2.4.5 MANAGING THE END OF SHOOTING OPERATIONS AND THE START OF THE HAUL 15
2.4.6 TRAWL GEOMETRY WHILE FISHING 16
2.4.7 WEAR OF THE TRAWL 16
2.4.8 CHECKS OF THE SAMPLING EQUIPMENT 17

[3] TREATMENT OF THE CATCHES 18

3.1 SAMPLINGS 18

3.2 BIOLOGICAL PARAMETERS 19

3.2.1 MEASUREMENT UNITS 19
3.2.2 SEX AND MATURITY 19
3.2.3 OTOLITH, WEIGHT AND MATURITY STAGE AT INDIVIDUAL LEVEL 20

3.3 OTHER PARAMETERS 20

[4] INTER-CALIBRATION OF THE WORK AT SEA 22

[5] DATA EXCHANGE FORMATS 23

5.1 GENERAL INFORMATION 23

5.2 FILES TYPE 23

5.3 FILES STRUCTURE AND INFORMATION CODING 23

[6] GEAR STANDARDIZATION AND MONITORING 24

[7] THE PROTOCOL FOR MONITORING MARINE LITTER **25**

[8] OTHER ASPECTS (MEDITS RULES) **26**

FIGURES OF GEAR SPECIFICATIONS 27

[9] ANNEXES **34**

I. CODES FOR COUNTRIES, VESSELS AND GEAR **35**

II. STRATIFICATION SCHEME (BY STRATUM NUMBER) (STRATUM: POSITION 125-129 IN THE FILE A) **37**

III. TARGET NUMBER OF HAULS BY AREA (BASED ON 2002 ONWARDS RECORDS) **42**

IV. CODES FOR RECORDED SPECIES, OF THE OBSERVATIONS ON HAULS AND OF QUADRANTS **43**

V. CODES OF TAXONOMIC CATEGORIES. FORM TO INTRODUCE NEW SPECIES CODES **44**

VI. LIST OF THE REFERENCE SPECIES **46**

VII. STANDARD LENGTH MEASUREMENT FOR CRUSTACEANS, CEPHALOPODS AND FISH **50**

VIII. CODES OF SEXUAL MATURITY FOR FISH, CRUSTACEANS AND CEPHALOPODS **53**

IX. PROTOCOL FOR CONVERSION OF MATURITY SCALES FROM THE SCALES PROPOSED AT THE WORKSHOPS ON MATURITY STAGES AND THE MEDITS SCALES **58**

X. FORMAT OF THE TYPE A FILES (DATA ON THE HAUL) **60**

ANNEX X.A 61

XI. FORMAT OF THE TYPE B FILES (CATCHES BY HAUL) **62**

XII. FORMAT OF TYPE C FILES (LENGTH AND AGGREGATED BIOLOGICAL PARAMETERS) **63**

XIII.A. FORMAT OF TYPE E FILES (BIOLOGICAL PARAMETERS AT INDIVIDUAL LEVEL) **64**

XIII.B. FORMAT OF TYPE L FILES (LITTER RECORDING) **65**

XIV. PROTOCOL FOR SAMPLING OTOLITHS, INDIVIDUAL WEIGHT AND MATURITY STAGES OF MEDITS TARGET SPECIES **66**

OBJECTIVES 66
SAMPLING FRAME 66
SAMPLING REQUIREMENTS AND SIZE 67
ESTIMATES OF ABUNDANCE INDICES AT AGE 69
REFERENCES 70

XV. TM LIST OF SPECIES CODES **71**

TM MEDITS LIST (2017 UPDATED) 74

XVI - TECHNICAL SPECIFICATIONS AND QUALITY CHECK OF THE MEDITS GEAR 75

XVI.1 - GUIDELINES FOR THE GEAR QUALITY CONTROL 75
XVI.2 - QUALITY TIME-0 CONTROL CHECKLIST 84
XVI.3. QUALITY PERIODIC/ANNUAL CONTROL CHECKLIST AND GEAR MAINTENANCE 91
XVI.4. - GLOSSARY OF TERMS AND REFERENCES TO THE ACRONYMS USED IN THE CURRENT MEDITS HANDBOOK 96
XVI.5. - LIST OF GEAR METRICS 98

XVII - PROTOCOL FOR MONITORING MARINE LITTER ON A VOLUNTARY BASIS 99

XVIII. INTERNAL RULES OF THE MEDITS GROUP 104

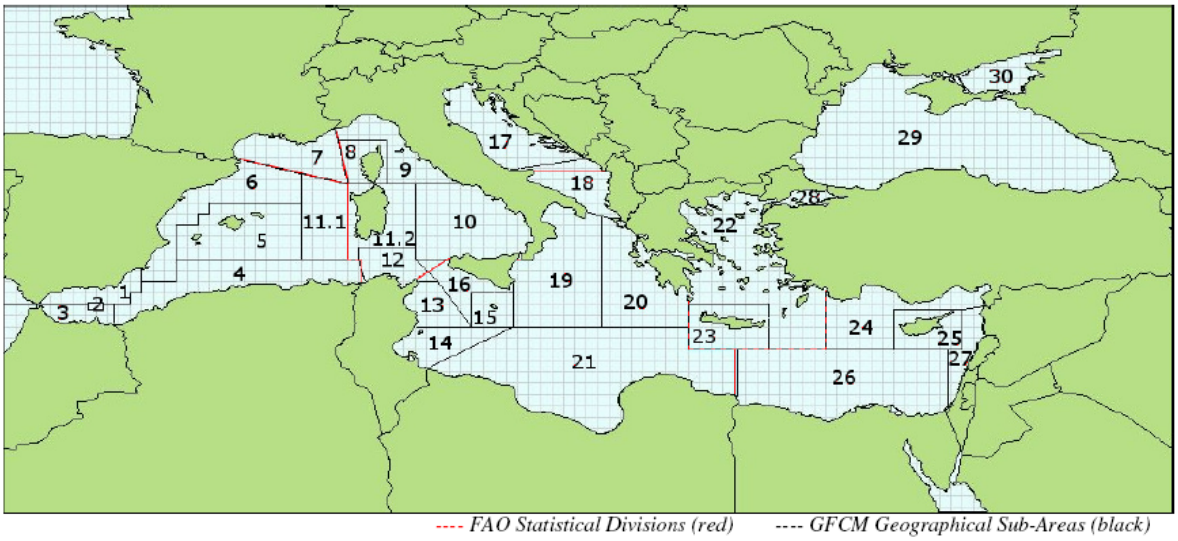
1.OBJECTIVE OF THE DOCUMENT 104
2.THE MEDITS SURVEY INITIATIVE 104
3.THE MANDATE OF THE MEDITS GROUP 104
4.COMPOSITION OF THE MEDITS GROUP 104
5. INTERNAL RULES OF THE GROUP 105
6. DATA POLICY 106

Introduction

This document is the ninth version of the first manual elaborated in the frame of the MEDITS international project to harmonise the sampling of demersal resources in the Mediterranean Sea.

It is the reference document for research institutes and teams contributing to the MEDITS surveys on the continental shelves and slopes in the Mediterranean (Fig. 1).

GFCM Geographical Sub-Areas (GSAs) (GFCM, 2009)



---- *FAO Statistical Divisions (red)* ---- *GFCM Geographical Sub-Areas (black)*

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

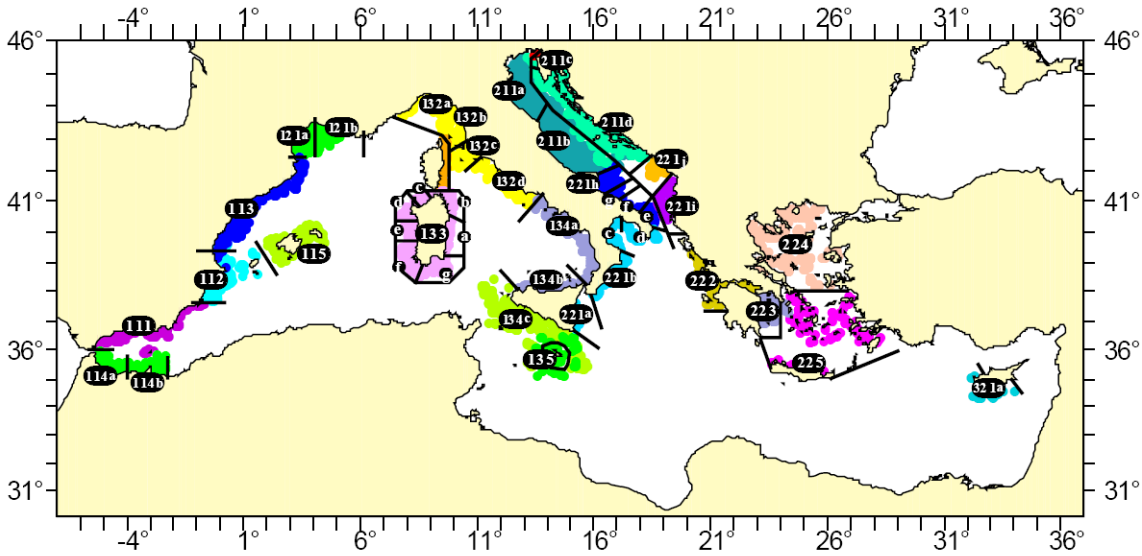


Fig. 1. General map of the area covered by the programme. Top: the GFCM GSAs (RES-GFCM/33/2009/2). Down: the MEDITS strata. Coloured: areas covered by the MEDITS surveys. The designations used and the presentation of cartographic data imply no line as for the juridicial status of the various areas neither as for the border lines between countries.

The manual describes the sampling gear characteristics (feature and handling), the design of the survey, the sampling methodology and the processing of samples. Finally, it gives the specifications of the data files for data storage and exchange.

This manual includes amendments and improvements to the MEDITS protocol as agreed by the MEDITS Co-ordination Committee up to the 2017 annual meeting. Considering the need for progressing towards new objectives (e.g common data-base) and amendments to be considered in the future, updates to this manual will be carried out as necessary.

The present version of the MEDITS Manual also includes the work performed in the **M**ultidisciplinary **G**roup on **G**ear **P**erformance and Standardization of Gear Data Processing (MGGP) established at the MEDITS coordination meeting in Ljubljana (Slovenia, 6-8 March 2012). The MGGP ToRs related to the Technical specifications and quality check of the Medits gear were finalised during the MEDITS Coordination Meeting of 2013 (Heraklion, Greece, March 12-14, 2013). Thus, a new regularly check of the MEDITS gears (trawl, rigging, doors) and of the protocol-abiding has been plenary proposed and accepted. This protocol, updated in 2014 and further revised in 2015, to fix some technical details, is in the Annex XVI to the present handbook version 9 (2017).

In addition, the common protocol for the voluntary collection of data on Marine Litters, in agreements with the requirements of the Marine Strategy Directive Framework (Directive 2008/56/EC), is reported in the Annex XVII. This protocol was agreed at the MEDITS Coordination Meeting of 2013 (Heraklion, Greece, March 12-14, 2013) and further improved in 2014 and 2015.

[1] Specifications of the sampling gear

According to Bertrand et al. (1997) the adopted gear constitutes a compromise between different constraints. To increase the catch of demersal species, it has been designed with a vertical opening slightly superior to the most common professional gears used in the Mediterranean when the MEDITS survey started. The design of the gear has been drawn up by fishery technologists from specifications defined by the biologists.

1.1 The trawl

The sampling gear is a bottom trawl made of four panels.

Figure 2 shows a schematic drawing of this trawl (IFREMER reference GOC73).

This gear should be operated by a vessel with a towing power of at least 368 kW (500 HP) and 4.5 tons of bollard pull.

The most important gear specifications were:

- to be able to work in all the areas and at all the depths specified by the programme (10-800 m);
- to have a selectivity as low as possible so as to have good images of the populations sampled.

In practice the last requirement was the opposite of what is normally asked to the fishermen, which is to use good selective gears so as to allow the small size individuals to escape. This goal is generally obtained by imposing to all the commercial gears a minimum size for the meshes used. For the Mediterranean the present minimum legal mesh opening for the demersal trawl gears is currently a square-mesh of 40 mm or a diamond-mesh of 50 mm opening, but for the sampling gear to be used during the MEDITS surveys it was decided to limit the mesh size of the codend to **10 mm of mesh side**, which corresponds to about 20 mm of mesh opening.

Even if other sampling gears for survey purposes exist in the world (e.g. the GOV – *Grande OuvertureVerticale* trawl used in the North Sea surveys), it was decided to design a new trawl to better follow the required specifications and for a better adaptation to the particular characteristics of the Mediterranean Sea above mentioned.

For all the report and figures, the mesh side value, or half mesh, will be used to indicate the mesh dimensions. The mesh side is defined by the International Organization for Standardization (**ISO 1107-1974 - Mesh Measurements, definitions**) as:

- the distance between two sequential knots, measured from centre to centre when the yarn between those points is fully extended.

In some cases, the values of mesh opening, or inside measurement, will also be used, but only after an explicit declaration. For knotted netting, the opening of the mesh is defined by the same ISO standard, as the distance between two opposite knots in the same mesh when fully extended in the N-direction, which is the fore-aft direction along the net. For knotless netting it is defined as the distance between two opposite joints in the same meshes when fully extended along its longest possible axis.

On the plan in figure 2 the mesh sizes are indicated in bar length. The mesh numbers in height correspond to well finished and joined netting sections; the joining mesh should then be subtracted when cutting. The numbers of mesh in width do not include the side seams and these should then be added when cutting.

The nets should be made from good quality polyamide netting (nylon). It will however not be possible for the net manufacturer always to obtain sheet netting of exactly the same length as

specified in this manual. Thorough care must be taken to obtain materials with properties as close as possible to the ones specified in figure 2.

The headline should have **40 floats** resisting to an immersion of 1,300 m depth. Their diameter should be around 20 cm, their individual buoyancy of 2.7 kgf (± 5%), the total buoyancy of the 40 floats being around 108 kgf (± 5%). The 40 floats should be distributed along the headline as follows (figures 3 and 8):

- from the end of each wing, one float every 1.50 m, 5 times;
- one pair of floats every 1.50 m on the whole remaining length;
- in the headline bosom a small adjustment of the spacing is necessary.

With this number of floats the vertical opening of the trawl should reach 2.4 to 2.6 m depending on the horizontal opening.

A weighting chain (*ballast chain*) of 120 kg (Nr. 3 × 40) should be secured to the foot rope at 17 cm intervals (with a hanging height of at most 8 cm).

A supplementary chain (only one chain) of 15 kg (around 6.50 m and a diameter of 10 mm) should in addition be secured symmetrically on both parts of the belly bosom in the same way as the first one (garland of 17 cm in length).

1.2 The rigging

The general drawing of the rigging is given in figure 3.

Various details of mounting and connecting are shown in figure 4.

The upper bridle length is 30 m; the lower bridle length is 29 m, plus the adjustment chain of 1 m (the adjustement chain is only found on the lower legs).

To maintain the geometry of the trawl as constant as possible, **two bridle lengths are defined according to the depth**. They are given in the following table:

Depth (in meters)	10 - 200	201 - 800
Bridles length (in meters)	100	150

Following the results of an experiment carried out on board the RV/L'Europe in June 2000, it is recommended to increase the bridle length to 200 m at depths deeper than -500 m. This modification, even though not compulsory, may favour a better and faster contact of the trawl with the seabed.

1.3 The doors (Otter Boards)

The doors are also normalised. They are of type **MorgereWH S** (figures. 5 and 6). The adopted doors correspond to the size number 8. The warp is shackled in the fore hole of the bracket sheet (see arrow 1 in figure 2). The short parts of the external crowfoot are shackled in the most back part of the backside sheets, upper and lower (see arrow 2 in figure 2). The length of the backstrops (shackles not included) are as follow:

long external back-strops: 1.60 m

short upper and lower back-strops: 0.65 m (± 10%).

1.4 Warp diameter and length

Taking the characteristics of the trawl and the rigging into account, the warps should have a diameter of 16 mm, with a minimum thickness of 14 mm and a maximum of 22 mm.

The length of warps to be shot is determined by the operating depth.

The recommended relationship between depth and warp length is given in figure 7. The table in figure 7 gives different warp lengths for a range of warp constructions given by diameter (12-22 mm). The relationships are calculated based on the specifications of the net and doors. Also it is recommended that the warp length should not be less than 200 meters as it will decrease considerably the door spread and increasing the door instability.

Although in certain particular circumstances some adaptations can be made to this relationship, it is recommended to respect the depth/warp length ratio as far as possible.

For the vessels which are not equipped with a device to measure the length of warp shot, it is recommended to standardise the position of the last mark on the warp, for example at the most back warp block.

1.5 Complementary equipment and monitoring systems

The systematic use of a device (**SCANMAR, SIMRAD or other sensors**) to control the trawl geometry (vertical and horizontal openings, contact with the bottom) is highly recommended.

If this is not possible, measurements of the trawl geometry should be taken at various depths on board each vessel at the beginning of the survey to establish relationship between horizontal and vertical opening with parameters easy to measure, like depth and/or warp length.

The sensors should be positioned on the net as shown in figure 8.

Data of the net horizontal and vertical opening measured *in situ* or estimated for each haul, will be included in the TA data file, as specified further on in this manual.
Reliable models of horizontal- and vertical-net opening related to measured parameters or to some other available parameters (i.e. warp length, depth, etc.) will be used to estimate values of net openings and applied when necessary.

A net safety recovery system (**the pennant**) allowing the retrieval of the trawl by the codend can be installed. As far as possible, it is recommended to secure the line as shown in figure 8 and to take care of its fixations. The pennant must be sewed every 3.6 m at the starboard strengthening lacing. Rules for the use of the pennant must be adopted in order to avoid deformations of the gear geometry and drag. Ropes attached to the codend and terminating with a float must be avoided. Ropes starting from the codend and terminating to the wing tip are allowed only if connected to the strengthening lacing at regular intervals (every 1-1.5 m; figure 8).

[2] Sampling methodology

2.1 Vessel characteristics

The vessels used for the MEDITS surveys should have an engine of at least 370 kW to be able to tow the standard sampling gear (traction at ground run: 4.5 tons). It is strongly recommended that as far as possible the same vessel and crew be used every year in each area so as to reduce variations between years due to vessel effect. The list of the vessels used since the beginning of the survey series is given in the **Annex I**.

2.2 Period of the survey

The period of the MEDITS survey is **centred around June** (from May to July). It is strongly recommended to keep the sampling period consistent among years in order to reduce the time of the survey effect on the time series.

2.3 Hauls localisation

The hauls are positioned following a **depth stratified sampling scheme** with **random drawing of the positions within each stratum**. The number of positions in each stratum is proportional to the area of these strata. Except in the case of peculiar problems (damages noted in previous years, etc.), the hauls are made in the same position from year to year. The decision to make a haul in a given place should not be influenced by the presence of fish shoals detected with the sounder or the sonar.

The following depths are fixed in all areas as strata limits:

10 - 50 m,

51 - 100 m,

101 - 200 m,

201 - 500 m,

501 - 800 m.

Furthermore the strata are limited by lines more or less perpendicular to the coast, depending on the geographical characteristics of each area.

The adopted stratification schemes has been shown in figure 1, while strata are described in **Annex II**. The target number of hauls by area is given in **Annex III**.

It is strongly recommended to maintain the same scheme between years.

The *Posidonia sp.* meadows are excluded from the sampling scheme and should never be trawled.

2.4 Operating the gear

2.4.1 Sampling period in the day

The hauls must be performed only during **daylight**. The daylight period is defined as the time between 30 minutes after sunrise and 30 minutes before sunset.

2.4.2 Haul speed and duration

The standard fishing **speed is 3 knots** on the ground. This recommended speed is very important in order to ensure the best trawl geometry. The actual speed as well as the covered distance should be monitored and recorded.

It is highlighted that a speed lower than 2.8 knots can have a negative effect on the verticality and the stability of the doors which can lie down and get stucked into the mud. In deep waters a speed greater than 3.2 knots can cause the lifting of the gear out of the bottom and must be avoided.

The haul duration is fixed at 30 minutes on depths less than -200 m and at 60 minutes at depths more than -200 m. In case during the fishing operations the haul should be stopped before the completion of the standard duration, **the haul can be considered valid if at least 2/3 of the time or of the distance have been successfully attained**.

2.4.3 Haul start and end definition

The start of the haul is defined as the moment at which the trawl geometry (vertical and horizontal) is stabilised (cf. § 2.4.5).

The end of the haul is defined as the moment at which warp hauling begins.

The haul start and end times should be recorded in UT time (GMT) and not in the local time.

2.4.4 Haul orientation

In general, hauls should be performed at constant depth. The depth variations during the haul should not exceed ± 5% relative to the initial depth. The discrepancies to this target should be recorded. In case of a significant difference between the depth under the vessel as recorded by the eco-sounder onboard and the depth at which the trawl is, the recorded depth should be taken as the latter.

As far as possible and in respect of the previous constraints, the hauls should be rectilinear. If for some reasons that is not possible, the turning circle must be as wide as possible so as not to disrupt the trawl geometry. In all cases the fields "COURSE" and "DISTANCE" of the "TA" data file (see § 5.2 and **Annex X**) should be precisely documented.

2.4.5 Managing the end of shooting operations and the start of the haul

It is important that the gear stays in good contact with the seabed during the whole haul. This should be regularly checked either by an acoustic device during the haul, by the observation of the chains wear and by the observation of benthic organisms in the catches after the haul.

At deeper waters (more than 200 m) some difficulties might be encountered in MEDITS gear setting on the bottom, therefore particular attention must be paid to the shooting operations. In order to decrease the setting time the following recommendations must be considered:

- after the complete shooting of the warps and the winch stopped, a relatively high speed (5-6 knots) should be maintained for around 1 minute, in order to stretch the gear and open the doors ;
- the speed should then be strongly reduced (even to 0) allowing the doors to reach the seabed. The time required varies depending on the vessel and the depth; for example 2-3 minutes at 500 m.
- once the doors are on the seabed, a speed lower than the normal one (2.5-2.7 knots) should be maintained in order to allow the net to reach the bottom.
- once the net is well stabilised the speed will be increased towards the standard speed (3 knots); this moment is defined as the real start of the haul.

The above procedure should be respected as precisely as possible, except in some particular

situations where minor adaptations may be absolutely necessary.

For those vessels using a device such as a SCANMAR Trawl Sensor or SIMRAD or other equivalent equipment, the trawl can be considered well stabilised as soon as its vertical opening is between 2 and 3 m.

For the vessels without such a device, preliminary trials shall be made before the survey. The aim of these trials is to determine ship by ship the setting time needed to operate correctly from one vessel to another, taking into consideration the approach of each individual skipper, as well as the best predicting models of the MEDITS behaviour (e.g. horizontal and vertical net openings by warp length).

2.4.6 Trawl geometry while fishing

The trawl is designed to have a vertical opening between 2 and 3 meters at the various depths if the above mentioned adjustments are respected.

When a device like the SCANMAR Trawl Sensor or SIMRAD is used, the vertical and horizontal (between the wings) opening should be checked as often as possible, once the trawl is stabilised. The average values of these two parameters (disregarding the obviously aberrant values) will be reported in the data file for each haul.

When appropriate instruments to control the gear behaviour are not regularly used, reliable models of horizontal and vertical net opening related to some other available parameters (i.e. warp length, depth, etc.) should be used. So that estimated values of net openings can be derived and applied when necessary. Nevertheless the use of these instruments is highly recommended because they give exact information on the gear behaviour. From one side they give the measure of the horizontal and vertical net openings in all the conditions, even when some external and unpredictable effect (i.e. part of the net entangled or damaged, particular types of the bottom) can influence the above parameters and make the possible estimates inaccurate. From the other side, the knowledge of the gear behaviour could improve the setting operations and the determination of the exact tow duration also at high depths.

For each Operative Unit, some specific models of MEDITS gear behavior were produced from the data collected during the project *"Intercalibration des campagnes internationales de chautage démersal en Méditerranée central"* (IRPEM-CE project MED/93/015).

Modelization has also progressed within the MGGP WG, as reported in the Annex 4 - Exercise on the potential impact of different methods to estimate the wing opening on the abundance indices of the Report of the MEDITS Coordination Meeting 2013 held in Heraklion.

During trawl survey, if it will be not possible to use the gear monitoring system due to risky hauls (e.g. rocks, relicts, etc.), such models should be used to interpolate any missing values.

General quantitative predictions of MEDITS gear geometry (e.g. horizontal and vertical openings) from other known parameters (e.g. warp length, bottom depth, bridles length, etc.) can be derived using the approach described in the above mentioned exercise (Annex 4 of the Report of the 2013 MEDITS Coordination Meeting. The new MEDITS Units or Units without any gear monitoring system are recommended to adopt these new general models consistently throughout the years in order to keep eventual errors constant in the time series.

All the Operative Units should follow a common standardization of data-processing of the technological parameters (haul duration, horizontal- and vertical-net opening). The data-process must be consistent throughout the years, keeping eventual errors constant in the time series.

2.4.7 Wear of the trawl

Since no system has been developed to prevent the bosom of the trawl from rubbing against the seabed it is recommended that affected sections of the trawl (in particular the lower net panel) be replaced as needed, particularly when they have lost their initial resistance characteristics.

2.4.8 Checks of the sampling equipment

During use, the trawls must be checked at regular intervals by taking a number of check measurements on the geometry of the trawl.

The net should be regularly checked for wear and tear and all damages shall be repaired upon discovery. The net will eventually stretch under normal fishing conditions. The overall status for the net should be checked at the beginning of every cruise. Every year a detailed check should be made of all net and rope dimensions.

The check guide reported in the Annex XVI can be used.

Special attention should be given to ensure that the relationship (difference) between the length of the netting sections in the top and bottom panels are maintained. Lower sections are of the same length than the top sections. These similar lengths have to be maintained by monitoring the net at regular intervals. In the case that the difference is larger than 1 mesh size the longer section must be shortened to the proper size. Also the relationship between the length of the framing ropes and the nets in the wings and arms must be retained.

The percentage the net is stretched on the headline and footrope is given in the specification (figure 2). When the netting after a period of use loses its stretch, the headline and footrope must be cut off, the net in the wings and arms shortened and remounted on the ropes again.

The trawl consists of four panels: top, bottom and side panels. Each panel has several sections. It is necessary to check the relative length of each netting section. They are all compared with the corresponding sections in the other panels in the way that the top and bottom panel sections are checked against the side panel sections. The best method to compare two sections is to let two persons – one in each end of the section – take around 10 meshes from the centre line of one section in one hand and hold it against 10 meshes from the centre line of the other section in the other hand. The sections must then be stretched and the difference in length observed. Length of side, top and lower panel sections must be equal. The procedure is repeated for each section. In case any difference is detected, a skilled net maker should be consulted to evaluate a possible adjustment.

The length of the groundrope and headline must be compared by holding the two together. The length is adjusted by means of the adjustment chain on the groundrope. The groundrope (40 m) must be 4.30 m longer than the headline (35.70 m).

[3] Treatment of the catches

3.1 Samplings

On board the vessel, the catches are split into the categories and sub-categories as reported in **Annex V** and **XV** of this manual.

For each species the total weight and number of individuals should be collected, excluding the taxonomic category V, G, H for which only the total weight should be collected.

For taxonomic categories D and E the number of individuals is not mandatory.

When the catch of a given species or a fraction of a given species (e.g. juveniles) is too abundant to be measured *in extenso* it is reasonable to take a representative sub-sample of the catch. This sub-sample should be not less than 100 individuals.

The common coding system adopted for the complete set of species (**Annex XV**) is a RUBIN like coding system as defined in the NCC standard[1], even if this international coding system has been no longer maintained for some years. This coding system appears to be a very practical one and it would be very easy in the future to build a correspondence table with any new coding system. In respect to the NCC recommendations and as the MEDITS coding is not strictly identical to the RUBIN one (different use, species not referenced to in the RUBIN code), the "name" of this code has been changed and is for the purpose of the MEDITS called "TM list" (Taxonomic list, formerly FM, i.e. Faunistic list).

The species identifications are made following Fisher *et al*., 1987[2]. For the fish species not included in this work, the descriptions from Whitehead *et al*, 1984[3] have been used. Furthermore, a correspondence with the most updated revisions by international bodies (e.g. Fishbase[4] for fish) is given.

The 2012 review of the species list is based on the checklist of Fauna and Flora of Italian seas. Nevertheless, the species coding is to be strictly kept identical in the data base, even if the scientific species name has been changed, in order to keep the time series consistant.

It is important to precise the extent of species recorded from the catch. Coding for this information is given in **Annex IV**.

Since 2012, the MEDITS reference list of target species (**Annex VI)** includes 82 species, of which 32 are Elasmobranches. The list also includes all species of the *Epinepheus* and *Scomber* genera, for which length measurements should be taken.

For all the 82 species and the two genera mentioned above (*Epinepheus* and *Scomber*) and reported in **Annex VI,** the total number of individuals, the total weight and the individual length should be collected.

This list has been further split in two groups:

- MEDITS G1 includes 41 species with 9 demersal (3 fish, 4 crustaceans and 2 cephalopods) and 32 Selachians. For these species the total number of individuals, the total weight, the individual length and also biological parameters including sex, maturity,

[1] NCC: Nordic code centre (Stockholm).

[2] Fisher W., M.L., Bauchaud et M. Shneider (rédact.), 1987. Fiches FAO d'identification des espèces pour les besoins de la pêche (révision 1). Méditerranée et mer Noire (volumes I et II). Projet GCP/INT/422/EEC. *FAO*, Rome: 1530 p.

[3] Whitehead P.J.P., M.L. Bauchot, J.C. Hureau, J. Nielsen, E. Tortonese, 1984. Poissons de l'Atlantique du nord-est et de la Méditerranée (3 volumes). *UNESCO*, Paris.

[4] Froese R. & D. Pauly eds, 2002. FishBase. World Wide Web electronic publication. www.fishbase.org.

individual weight and age (age has been proposed only for the teleosteans of the Group 1) should be collected;

- MEDITS G2 includes 43 species for which only total number of individuals, total weight and individual length should be collected.

If a live specimen of a rare species or a species subject to conservation measures is caught, efforts should be made to obtain length, weight and sex data and return the specimen back to the sea unharmed, giving it a chance for survival. The specimens should be returned at sea preferably within 4-5 minutes.

3.2 Biological parameters

3.2.1 Measurement units

For fish (Osteichthyes and Elasmobranches) the total length with the tail fully extended should be recorded. The measurement unit is the lower half centimetre. Only for past data (initial years of the survey) measurements at the lower centimetre are allowed.

For crustaceans the cephalo-thoracic length at the lower millimetre should be measured, while for cephalopods, the dorsal mantle length at the lower half centimetre should be obtained. For octopods the measure is taken along the line passing through the eyes.

Sketches of the standard measurements to be obtained are reported in the **Annex VII**.

If a given team wishes to make complementary observations on other species or of another nature, for its own works, it is kindly invited to inform the MEDITS Group (Co-ordination and Steering Committees) to eventually allow to normalise the methodology with other research teams.

For Octopus species, it has been suggested to measure both dorsal and ventral mantle lengths and to confront them, fitting a linear model to the data so that both measurements can be standardized.

For species which tails are often damaged after catch also it is suggested to take other measures, as body length or disc length or disc width (see **Annex VII**) and then compare measures.

3.2.2 Sex and maturity

The sex is defined following four categories: male, female, undetermined (impossible to determine it by eye) and not determined (the individual has not been examined).

Sex data is presented at individual level in the TE file (**Annex XIIIa**) and at aggregated level in the TC file (**Annex XII**). The latter is necessary for estimating the sex ratio of the target species, given that the sampled individuals in TE are sistematically stratified in the length classes and so cannot be used for sex-ratio estimates.

The sexual maturity is defined using the maturity scales given in the **Annex VIIIa to VIIIe** for fish, crustaceans and cephalopods. **The staging reported in the blue column must be adopted**.

The individuals of hermaphroditic species, undergoing a change in sex when observed, are qualified into the sex showing the more developed gonads.

The former MEDITS scale for the description of elasmobranch maturity stages was referred only to oviparous species (Rayadae and Scyliorhinidae). However the majority of elasmobranchs are viviparous or ovoviparous which have a great diversity in ovarian cycles and gestation periods. The examination of male maturity does not present particular problems, considering that they are classified according to the relative sizes and development of claspers and internal spermiducts. For females it is necessary to apply the dissection of the individual to

observe the presence of oocytes and the formation of egg-cases in mature oviparous individuals. For this reason it is better to use a specific scale for the viviparous and ovoviviparous species usually fished in the Mediterranean sea as *Squalus acanthias*, *Squalus brainvillei*, *Etmopterus spinax*, *Torpedo* spp., *Dasyatis* spp. for which the reproductive biology is less investigated in several Mediterranean areas. For these reasons the maturity scale for viviparous elasmobranches adopted at WKMSEL 2010 (ICES, 2010) is reported in the **Annex VIIIc**.

While all maturity stages during the MEDITS survey, should be reported using the MEDITS maturity scales**,** a conversion of these maturity scales to the scales proposed at the Workshops on Maturity stages is provided in **Annex IX** in case needed.

Reference

ICES. 2010. Report of the Workshop on Sexual Maturity Staging of Elasmobranches (WKMSEL), 11-15 October 2010, Valletta, Malta. ICES CM 2010/ACOM:48. 132 pp.

3.2.3 Otolith, weight and maturity stage at individual level

The MEDITS meeting held in Nantes on 15-17 March 2011 agreed to increase the information recorded during the MEDITS survey, including the monitoring of new biological variables such as the age of bony fish species coded G1 in the new list of target species (**Annex XIV**), and the individual weight of all the species coded G1 in the same list. Data on the Maturity Stages for the same species should also be collected.

Otoliths of routinely assessed species should also be collected for age determination, useful to estimate, *inter alia*, the probability reaction norm of maturation (PRNM) i.e. the indicator n. 4 of Data Collection Framework (Commission Decisions n. 949/2008 and SEC(2008) 449).

The above decisions were also approved by the 8th Regional Coordination Meeting of the Mediterranean and Black Sea held in Ljubljana (Slovenia) on May 10-13, 2011.

The decisions taken during the MEDITS coordination meeting in Ljubljana (March, 6-8, 2012) based on the above mentioned document are reported in **Annex XIV** that represents the sampling protocol to collect the biological information related to otoliths, individual weight and maturity stage by sex from MEDITS survey 2012 and onwards.

Due to these changes, a new file type; the TE file (**Annex XIIIa**), was introduced in order to store individual data. Consequently, new specifications were also introduced in the TC file (**Annex XII**).

It is reccommended that individual weight of *Nephrops norvegicus* is only measured when individuals still have both claws.

If Operative Units would like to collect biological parameters also for species other than G1 species, they are invited to follow the common protocol both for data collection and data storage.

3.3 Other parameters

The bottom water temperature should be recorded at the start and the end of each haul. This information should be stored in the TA exchange file with the format defined in the **Annex X**. Thus the information formerly included in TD file has been incorporated in TA file format.

The former recommended sensor was the Vemco minilog TDR –5 to 35°C, however this sensor is currently out of production. It can be replaced by other devices such as the one produced by Star-Oddi.

The sensor should be fixed on the bosom head line. It is important that the clock of the computer which receives the data from the sensor is exactly set accordingly with the UT time

(GMT) to have the same times as in the TA file. The temperatures from all the hauls (beginning and end) should be kept and reported in the TA file. These temperature data should correspond to the official time of beginning and end of the haul, assuming that the trawl begins and stops to work properly at these official times.

It is reccomended that when a device for recording temperature or other parameters is replaced by a different system a calibration should be accomplished.

Given that the new sensors collect additional parameters besides temperature a column is added to the TA file for salinity (in ppt).

[4] Inter-calibration of the work at sea

Two possibilities are recommended for the inter-calibration of the working methods between the various vessels:

- an exchange of scientists on board the vessels.
- a co-ordinated trawling operation by the two vessels at the border of the areas covered by these two vessels.

To favour the exchange of scientists one place will be reserved on board of each vessel for the eventual boarding of a scientist from another team. In addition, each co-ordination group will do its best to send a scientist from their own team on board to other vessels participating in the project. It is expected that the reports of these boardings help to identify eventual differences in the working methodology.

Where and when different teams are in charge of adjacent working areas, even though rather difficult and time consuming, they are invited to try and organise some common hauls in parallel to reach an inter-calibration between the two vessels.

[5] Data exchange formats

5.1 General information

Standard formats are defined for the storage and to facilitate the exchange of the data produced by the MEDITS surveys. The exchange files are in .csv format, using semicolon as field separator.

5.2 Files type

Five file types are defined in order to store and exchange the data:

Type A: Characteristics of haul (**Annex X**) - this file includes the data on bottom temperature and stratification, formely included in TD and TT type files;

Type B: Catches by haul (**Annex XI**);

Type C: Length, sex, and maturity at aggregated level (**Annex XII**);

Type E: Age weight and maturity by length at individual level (**Annex XIIIa**).

Type L: collection of marine litter data (**Annex XIIIb**)

The file names are defined as follow:

Position	Variable	Possible values
Character 1-2	Files type	**TA** (haul characteristics) T**B** (catch by haul) T**C** (biological parameters at aggregated level) T**E** (biological parameters at individual level); T**L** (litter categories)
Character 3-5	Country	**MLT**, **ESP**, **FRA**, **ITA**, **SVN**, **HRV**, **ALB**, **MON**, **MOR**, **ML**, **GRC, CYP**
Character 6-7	GSA	**See Annex III**
Character 8-11	Year	**2000**, **2001**, etc.
Character 12	Separator	**.** (point)
Character 13-15	Extension	**csv**

example TAITA192012.csv

5.3 Files structure and information coding

The exchange files format are described in **Annexes X to XIIIa, b**.

Complementary coding tables used to fill in the data files are given in the annexes referred above.

[6] Gear standardization and monitoring

At the MEDITS coordination meeting in Ljubljana (Slovenia, March 6-8, 2012), it was decided to include in this manual further technical specifications regarding the sampling gear (e.g. gear parameters, quality checks related to the gear), as well as to establish a multidisciplinary working group to progress in the harmonization of the MEDITS samplings in the Mediterranean Sea.

The ToRs of this WG can be synthesised as follows:

1) preparing a clear, commented and documented (e.g. using photos, sketches, etc..) checklist for the quality control of the technical characteristics of the MEDITS gear, in order to avoid the use of a gear that has not exactly the same characteristics from year to year;
2) preparing a clear and standard procedure, easy to apply in the field even by non technologists, for the monitoring and collection of the data on the gear performance;
3) evaluate and make available tools that enable, using the same methodological approach, the estimate of the parameters of the gear performance.

More detailed Terms of References are reported in the report of the MEDITS coordination meeting held in Ljubljana (Slovenia, 6-8 March 2012).

In this version of the MEDITS Handbook the **Quality periodic/annual control checklist, the Glossary of terms and references to the acronyms and the List of gear metrics** have been introduced (see **Annex XVI**). In addition, progresses regarding the point 3) listed above are included in the report of the MEDITS coordination meeting held in Heraklion (Greece, March 12-14, 2013).

[7] The protocol for monitoring Marine Litter

A common protocol for the voluntary collection of data on Marine Litters, in agreements with the requirements of the Marine Strategy Directive Framework (Directive 2008/56/EC) is reported in the **Annex XVII**.

This protocol was agreed at the MEDITS Coordination Meeting of 2013 (Heraklion, Greece, March 12-14, 2013).

[8] Other aspects (MEDITS Rules)

MEDITS internal rules were adopted during the MEDITS meeting, Split (Croatia), 15-16/06/2010 and reviewed during MEDITS meeting in Malta 13-14.04.2016. MEDITS internal rules are reported in the ***Annex XVIII****.*

Figures of Gear specifications

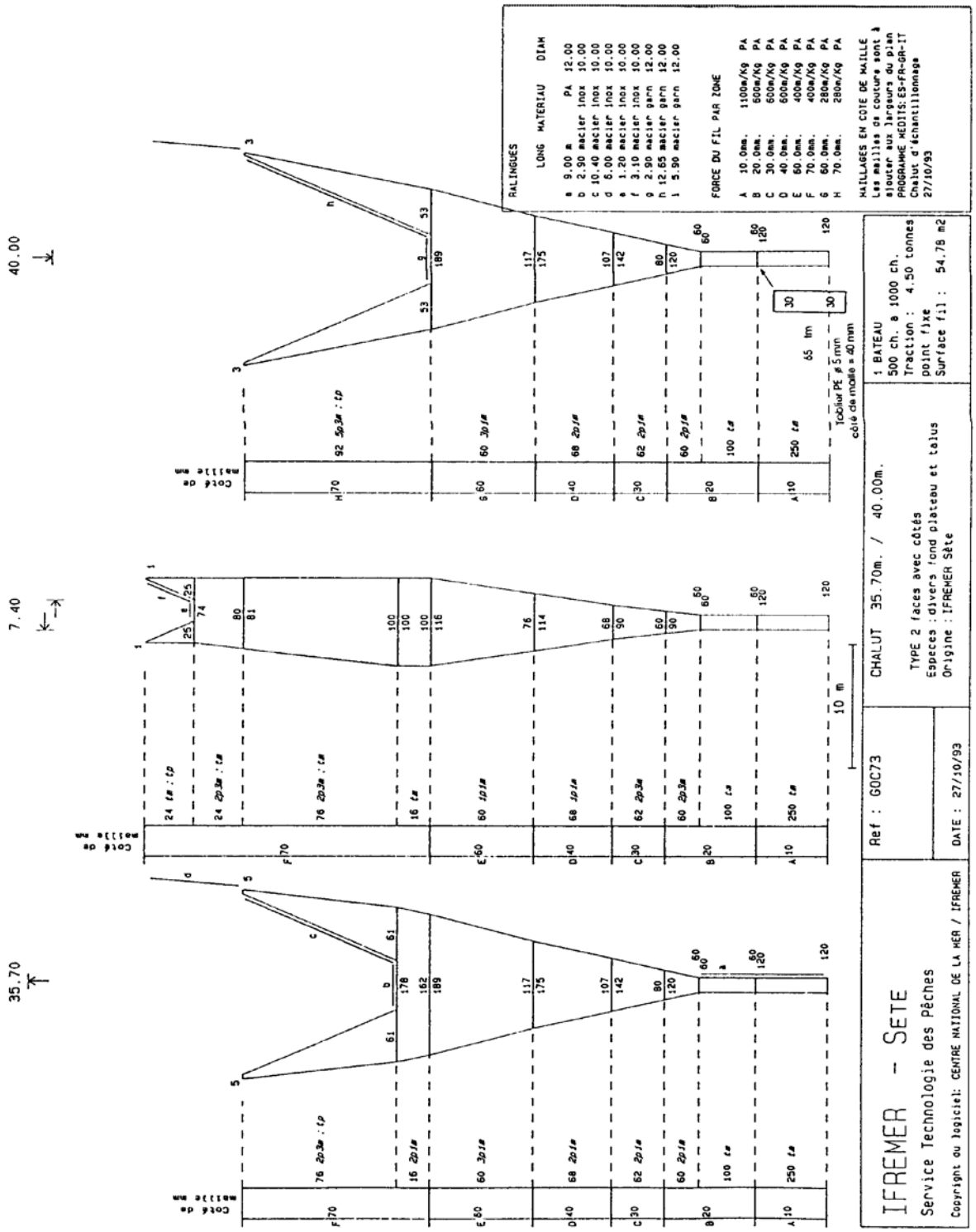


Fig. 2. Design of the GOC 73 trawl used for the MEDITS survey. It is very important to maintain the original relationship (hanging ratio, difference in length) between the netting lengths and the framing ropes along the headline and footrope.

Note to netmakers: The numbers of meshes shown for netting panel widths do not include selvedge meshes. Five meshes (six knots) per selvedge must be added where indicated . Conversely to obtain panel depths one row (1/2 mesh) must be subtracted from each panel as the joining row is included inm the number of meshes deep.

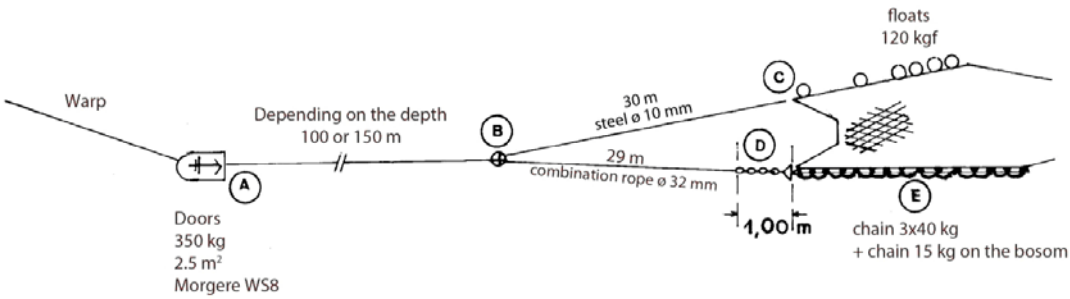


Fig. 3. Gear rigging details adopted for the MEDITS trawl. For the letter A, B, C, D and E refer to Figure 4.The length of the 1 m chain (D) must be adjusted in order to obtain the upper- (steel) and the lower-bridle (combination rope + chain) of the same length (30 m). See Figure 4 for further details.

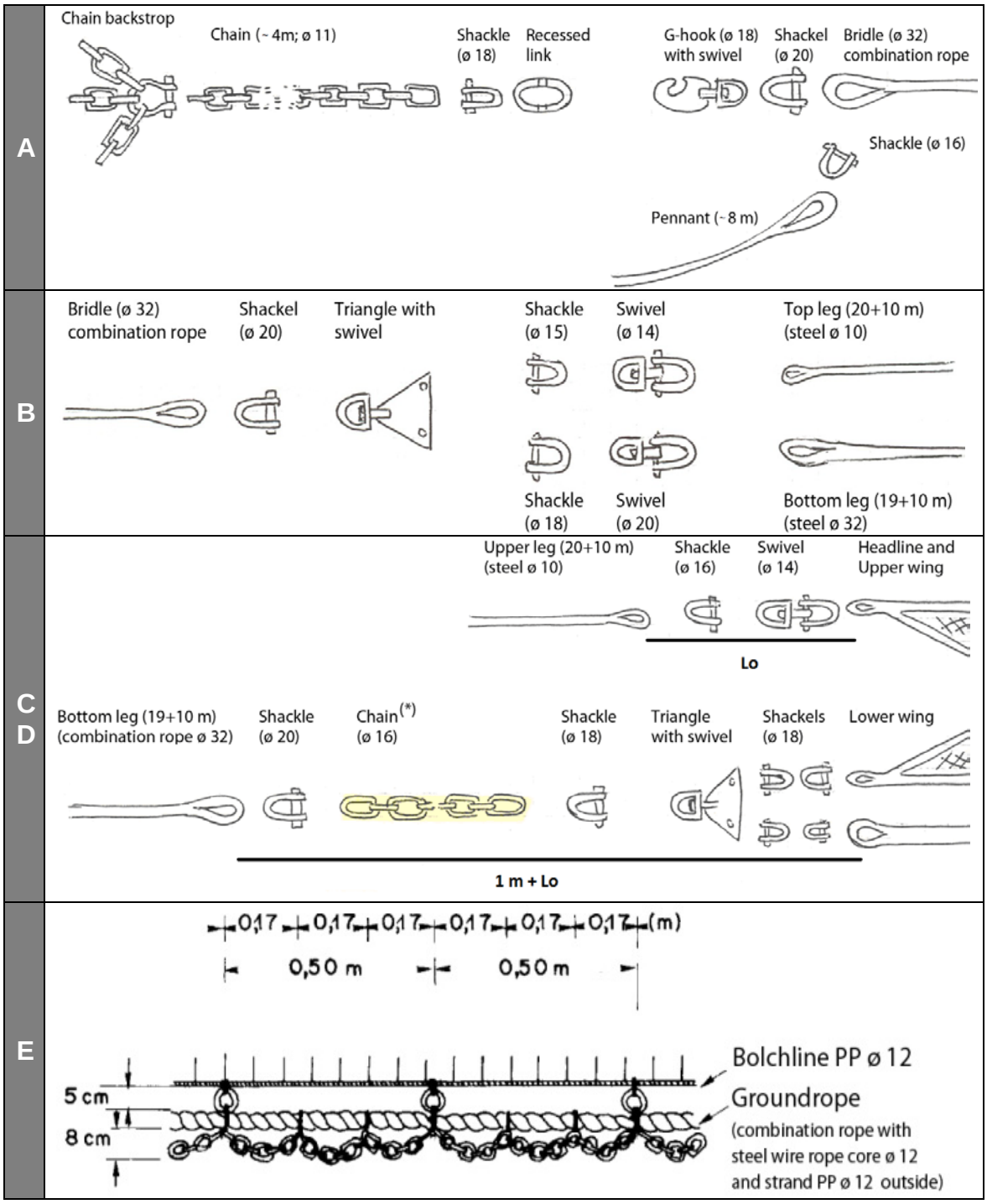
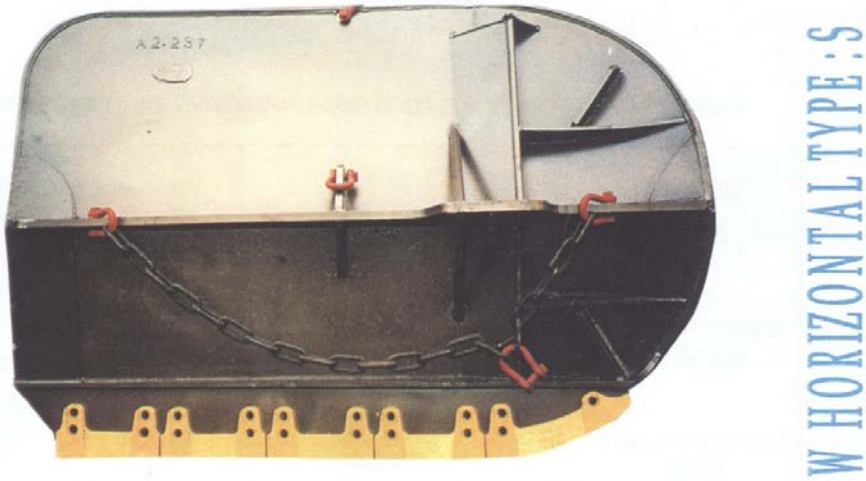


Fig. 4. Various details of the MEDITS trawl gear rigging. The length of the chain (*) must be adjusted in order to obtain the upper- (steel) and the lower-bridle (combination rope + chain) of the same length (30 m). The ballast chain must be rigged at the tip of the lower-bridle.



The otterboard WH can be equipped with chain or with fixed bracket.
In the back side, the otterboard can be equipped with 2 or 3 chains backstrop.

TYPE	DIMENSIONS	SURFACE M2	WEIGHT KG	TYPE	DIMENSIONS	SURFACE M2	POIDS KG
WS 0	1 050 X 750	0.70	60 – 100	WS 14	2 650 X 1 700	4.34	1 000 – 1 200
WS 1	1 300 X 850	1.00	100 – 130	WS 15	1 750 X 1 750	4.62	1 150 – 1 300
WS 2	1 500 X 900	1.12	110 – 150	WS 16	2 800 X 1 800	4.90	1 250 – 1 350
WS 3	1 600 X 1 000	1.36	150 – 180	WS 17	2 900 X 1 900	5.20	1 300 – 1 400
WS 4	1 700 X 1 050	1.62	200 – 240	WS 18	3 050 X 2 000	5.70	1 400 – 1 600
WS 5	1 750 X 1 100	1.74	230 – 280	WS19	3 200 X 2 100	6.10	1 500 – 1 700
WS 6	1 900 X 1 150	1.96	250 – 300	WS 20	3 400 X 2 200	6.60	1 700 – 1 900
WS 7	2 000 X 1 200	2.23	320 – 350	WS 21	3 500 X 2 300	7.30	1 900 – 2 100
WS 8	2 050 X 1 250	2.46	350 – 400	WS 22	3 600 X 2 400	7.58	2 000 – 2 300
WS 9	2 150 X 1 300	2.62	380 – 500	WS 23	3 750 X 2 500	8.82	2 300 – 2 700
WS 10	2 300 X 1 350	2.82	500 – 700	WS 24	4 000 X 2 700	9.31	2 300 – 3 000
WS 11	2 400 X 1 400	2.93	600 – 700	WS 25	4 300 X 2 900	11.10	2 500 – 4 000
WS 12	2 500 X 1 500	3.30	750 – 900	WS 26	4 600 X 3 200	13.00	3 000 – 5 000
WS 13	2 600 X 1 600	3.70	900 – 1 000	WS 27	5 000 X 3 500	15.80	4 000 – 6 000

Fig. 5. Main characteristics of the Morgere W Horizontal (WH) otterboards. For the MEDITS program it was selected the WS8 type. The otterboard weight refers to without- and with-plates in the shoe.

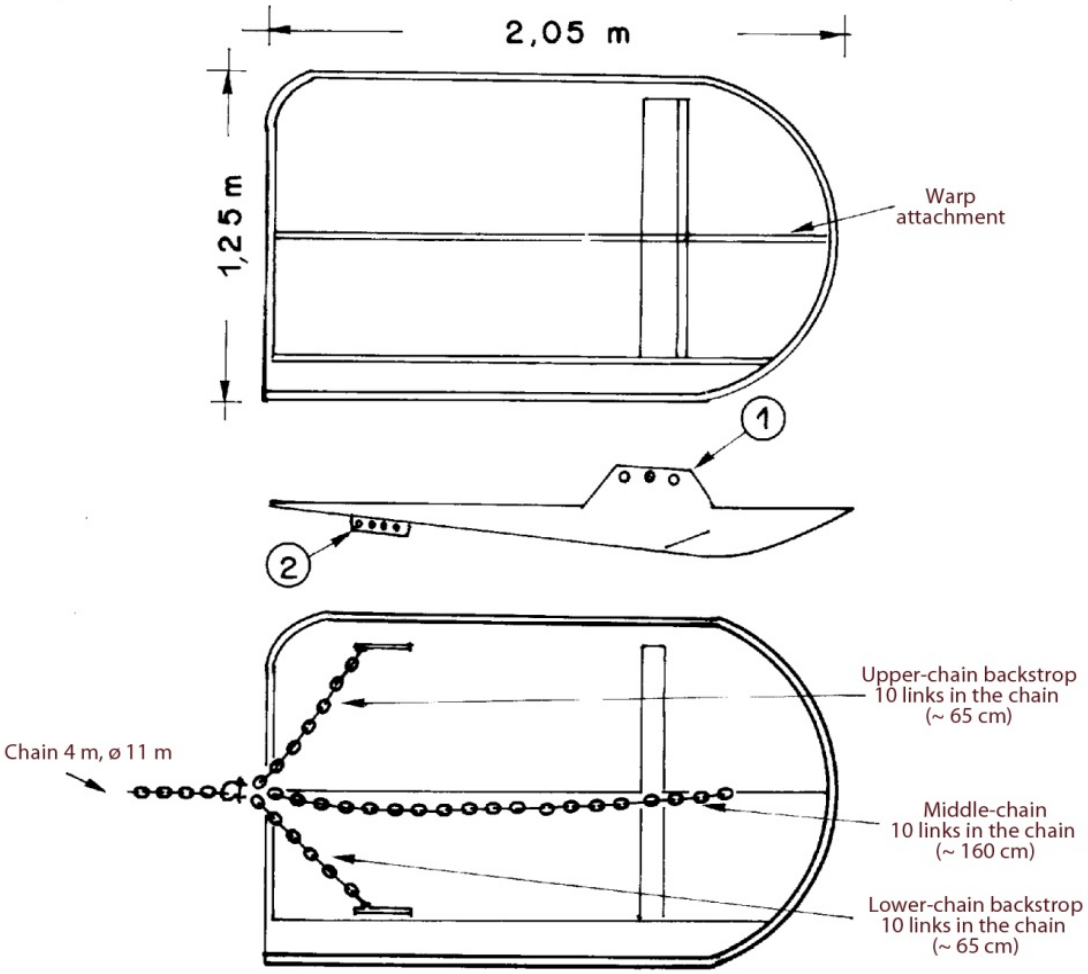
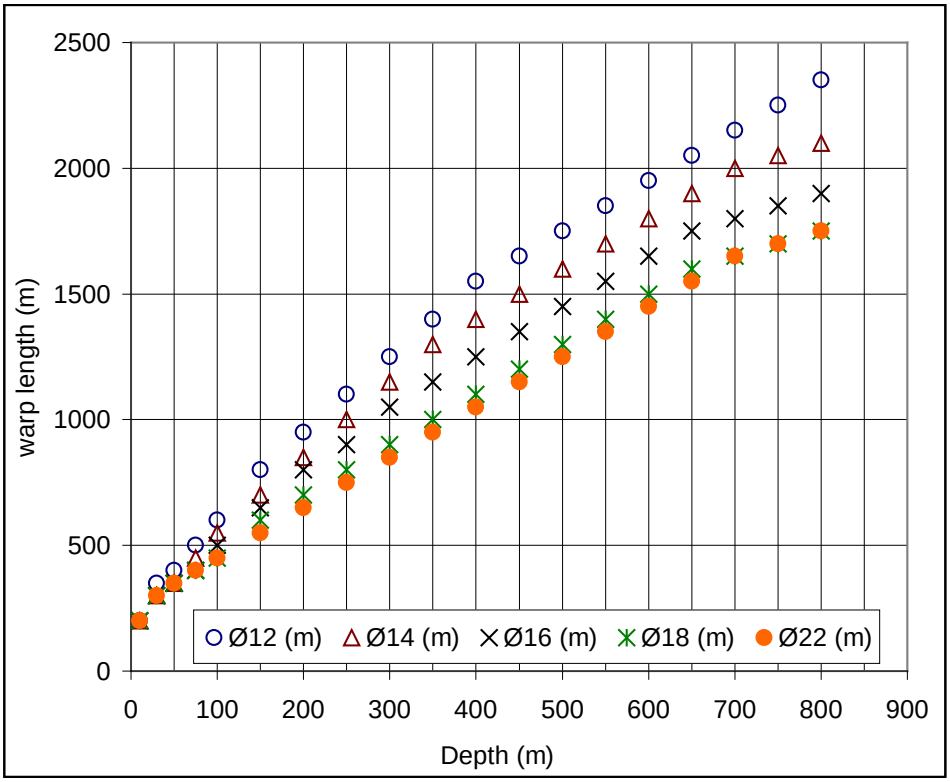


Fig. 6. Morgere WS8 (350 kg; 2.5 m^2). The lengths of the backstrop chains are indicated without the shackles. The warp is shackled in the fore hole of the bracket sheet (see arrow 1). The short parts of the external crowfoot are shackled in the most back part of the backside sheets, upper and lower (see arrow 2).



Relationship between depth (m) and warp length (m) at different warp length diameter (mm)

Depth	**Ø12**	**Ø14**	**Ø16**	**Ø18**	**Ø22**
(m)	*(m)*	*(m)*	*(m)*	*(m)*	*(m)*
10	200	200	200	200	200
30	350	300	300	300	300
50	400	350	350	350	350
75	500	450	400	400	400
100	600	550	500	450	450
150	800	700	650	600	550
200	950	850	800	700	650
250	1100	1000	900	800	750
300	1250	1150	1050	900	850
350	1400	1300	1150	1000	950
400	1550	1400	1250	1100	1050
450	1650	1500	1350	1200	1150
500	1750	1600	1450	1300	1250
550	1850	1700	1550	1400	1350
600	1950	1800	1650	1500	1450
650	2050	1900	1750	1600	1550
700	2150	2000	1800	1650	1650
750	2250	2050	1850	1700	1700
800	2350	2100	1900	1750	1750

Fig. 7. Relationship between depth and warp length for the trawl GOC 73.

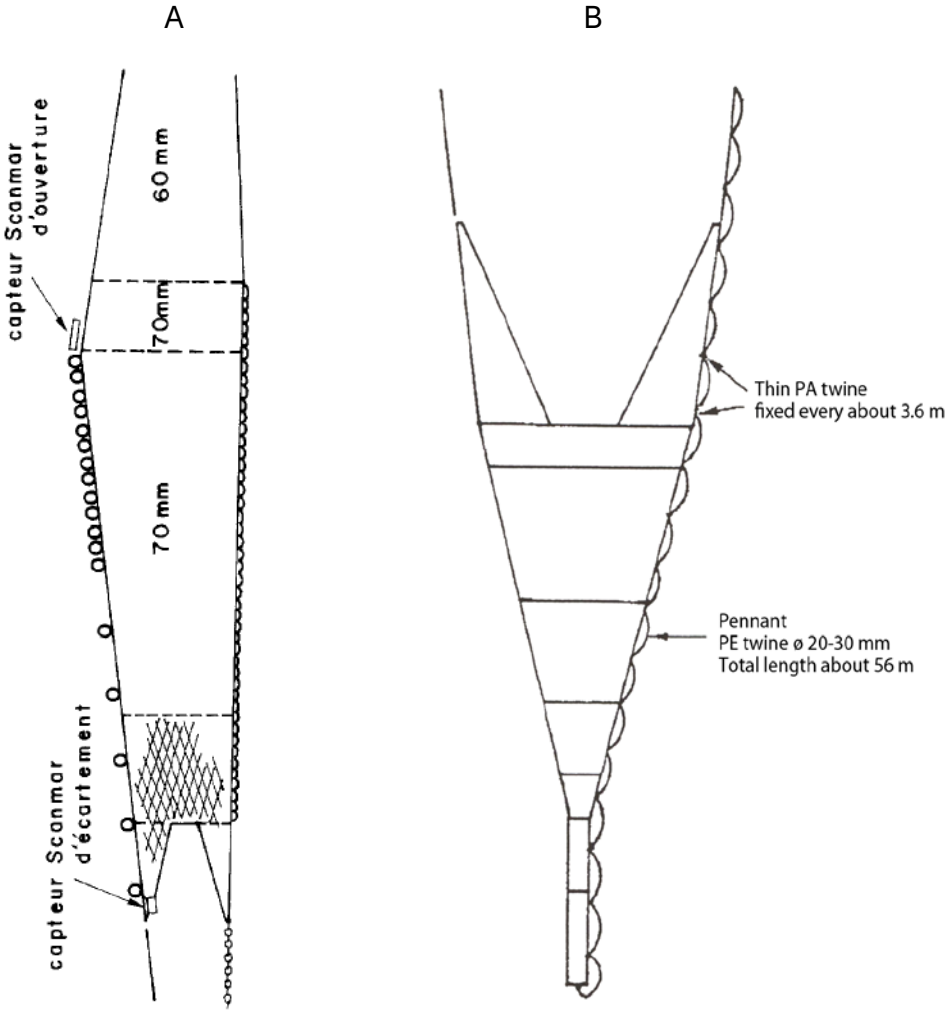


Fig. 8. A. Position of the geometry sensors. B. Details of the pennant adopted for the MEDITS trawl. The pennant must be fixed both at the wing tip and at the codend closure. The pennant must be sewed every 3.6 m at the starboard strengthening lacing.

[9] Annexes

I. Code of countries, vessels and gear

II. Stratification scheme

III. Target number of hauls by area

IV. Code of recorded species, of general observations on hauls and of quadrants

V. Code of faunistic categories. Form to introduce new species

VI. List of reference species

VII. Standard length measurement for Crustaceans, Cephalopods bony fish and Elasmobranches

VIII. Codes of sexual maturity for Fish, Crustaceans and Cephalopods

IX. Protocol for Conversion of maturity scales from the scales proposed at the Workshops on Maturity stages and the MEDITS scales

X. Format of the type A files (Data on hauls)

XI. Format of the type B files (Catches by haul)

XII. Format of the type C files (Length, sex and maturity at aggregated level)

XIIIa. Format of the type E files (Age, weight and maturity by length at individual level)

XIIIb. Format of the type L files (Litter Categories)

XIV. Protocol for sampling otoliths, individual weight and maturity stage of MEDITS target species

XV. TM list of species codes

XVI. Technical specifications and quality check of the Medits gear

XVII. Protocol for monitoring Marine Litter on a voluntary basis

XVIII. Internal rules of the MEDITS group

I. Codes for countries, vessels and gear

Codes for countries (Position 3-5 in the file A)

Code	*Country*
ALB	*Albania*
CYP	*Cyprus*
ESP	*Spain*
FRA	*France*
GRC	*Greece*
HRV	*Croatia*
ITA	*Italy*
MLT	*Malta*
MOR	*Morocco*
MON	*Montenegro*
SVN	*Slovenia*

Vessel codes and characteristics (Vessel code: Position 8-10 in the file A)

Vessel code	Vessel Name	Type	Length (m)	Tonnage (TJB)	Year	Material	Power (kW)	Warp diam (mm)	Warp length (m)
AND	Andrea	R	29.5	211	1998	aluminium	1300	14	2250
BIM	Bianca Maria	P	26.81	116	1988	wood	485	12	3000
BIO	BIOS DVA	R	36.3	336	2009	steel	895	14	1500
CHA	Charif Alidrissi	R	41	397	1986	steel	808	22	3000
COR	Cornide de Saavedra	R	66.7	1524	1970	steel	1651	29	2700
MOL	Miguel Oliver*	R	70	2495	2014	steel	2x1000	20	4000
DAP	Dalla Porta	R	35.3	285	2000	steel	809	14	2500
DEG	Degre	P	23.95	106.46	1996	steel	538	14	3100
DEM	Demetrios	P	27.77	78.24	1991	steel	537	12	3000
EGU	Elisa Guidotti	P	29	69	1991	bois	330	14	2500
EVA	Evagelistria	P	29.1	59.45	2000	steel	497	12	1800
FRP	Francesco Padre	P	25	88	1984	steel	660	14	3000
FUL	Fulmine	P	29	147.2	0	wood	736	14	2500
GAB	Gabriella	P	23	64	1970	wood	441	12	3500
GIS	Gisella	P	29.3	168	1999	iron	432	15	3000
IGO	Igor	P	22.5	102	1979	iron	345	14	2500
IRO	Ioannis Rossos	P	26.3	115.75	1986	iron	368	12	3000
LEU	L'Europe	R	29.6	259.69	1993	aluminium	690	16	2700
LIB	Libera	P	22.3	69	1987	wood	441	14	2500
MEG	Megalochari	P	33	150	2005	steel	367	12	2000
NAU	Nautilos	P	28.4	138	1991	iron	600	14	2500
NAV	Francisco Paula Navarro	R	30.5	178	1987	wood	750	18	2200
NUS	Nuovo Splendore	P	29.45	134.51	1967	wood	685	16	2450
PAR	Kapetan Paraschos	P	26.1	85.71	1989	wood	386	12	2000
PEC	Pasquale e Cristina	P	33.06	158.77	1996	wood	923	16	2500
PRI	Principessa I	P	32	165	1995	steel	403	14	2500
ROS	Roselys	R	0	0	0	wood	0	0	0
SAN	Sant'Anna	P	32.2	97.06	1981	steel	1357	14	3100
TAM	Takis-Mimis	P	28.97	161.70	2002	steel	367	12	2500

*http://www.magrama.gob.es/es/pesca/temas/buques-secretaria-general-pesca/buque-oceanografico-miguel-oliver/default.aspx

Codes for the gear (MEDITS code: Position 11-23 in the file A)

Nature	Gear	MEDITS code	Comments
Trawl	Large opening and 4 faces	GOC73	Standard for all vessels
Rigging	With legs	GC73	Standard for all vessels
Doors	Morgère WH S8	WHS8	Standard for all vessels

II. Stratification scheme (by stratum number) (Stratum: Position 125-129 in the file A)

GSA	Country	Stratum		Depth (m)	Surface (km²)	Area
1	Spain	11101	a	10-50	510	Alboran Sea
1	Spain	11102	a	50-100	1951	
1	Spain	11103	a	100-200	1086	
1	Spain	11104	a	200-500	3461	
1	Spain	11105	a	500-800	4912	
2	Spain	11106	b	10-50	0	Alboran Island
2	Spain	11107	b	50-100	130	Alboran Island
2	Spain	11108	b	100-200	132	
2	Spain	11109	b	200-500	221	
2	Spain	11110	a	500-800	350	
3	Morocco	11401	a	10-50	355	West Morocco
3	Morocco	11402	a	50-100	444	
3	Morocco	11403	a	100-200	487	
3	Morocco	11404	a	200-500	3580	
3	Morocco	11405	a	500-800	1108	
3	Morocco	11406	b	10-50	878	East Morocco
3	Morocco	11407	b	50-100	1098	
3	Morocco	11408	b	100-200	938	
3	Morocco	11409	b	200-500	3507	
3	Morocco	11410	b	500-800	1446	
5	Spain	11501	a	10-50	0	West Baleares
5	Spain	11502	a	50-100	1170	West Baleares
5	Spain	11503	a	100-200	1773	
5	Spain	11504	a	200-500	1123	
5	Spain	11505	a	500-800	2030	
5	Spain	11507	b	50-100	2255	East Baleares
5	Spain	11508	b	100-200	1472	
5	Spain	11509	b	200-500	1518	
5	Spain	11510	b	500-800	1315	
6	Spain	11201	a	10-50	1130	Valenciana
6	Spain	11202	a	50-100	4095	
6	Spain	11203	a	100-200	3302	
6	Spain	11204	a	200-500	4242	
6	Spain	11205	a	500-800	3159	
6	Spain	11301	a	10-50	1896	Tramontana
6	Spain	11302	a	50-100	7219	
6	Spain	11303	a	100-200	3587	
6	Spain	11304	a	200-500	2477	
6	Spain	11305	a	500-800	1399	
7	France	12101	a	10-50	1482	West Gulf of Lions
7	France	12102	a	50-100	3911	
7	France	12103	a	100-200	819	
7	France	12104	a	200-500	709	
7	France	12105	a	500-800	660	
7	France	12106	b	10-50	696	East Gulf of Lions
7	France	12107	b	50-100	2610	
7	France	12108	b	100-200	1734	
7	France	12109	b	200-500	653	
7	France	12110	b	500-800	586	
8	France	13101	a	10-50	0	North East Corsica
8	France	13102	a	50-100	521	North East Corsica
8	France	13103	a	100-200	234	
8	France	13104	a	200-500	920	
8	France	13105	a	500-800	867	

GSA	Country	Stratum		Depth (m)	Surface (km²)	Area
8	France	13106	b	10-50	0	South East Corsica
8	France	13107	b	50-100	524	South East Corsica
8	France	13108	b	100-200	153	
8	France	13109	b	200-500	383	
8	France	13110	b	500-800	960	
9	Italy	13201	a	10-50	657	North Ligurian Sea
9	Italy	13202	a	50-100	729	
9	Italy	13203	a	100-200	658	
9	Italy	13204	a	200-500	1737	
9	Italy	13205	a	500-800	2093	
9	Italy	13206	b	10-50	2053	East Ligurian Sea
9	Italy	13207	b	50-100	1598	
9	Italy	13208	b	100-200	3186	
9	Italy	13209	b	200-500	2449	
9	Italy	13210	b	500-800	879	
9	Italy	13211	c	10-50	945	North Tyrrhenian Sea
9	Italy	13212	c	50-100	1506	
9	Italy	13213	c	100-200	2732	
9	Italy	13214	c	200-500	2828	
9	Italy	13215	c	500-800	3071	
9	Italy	13216	d	10-50	2107	Central Tyrrhenian Sea
9	Italy	13217	d	50-100	2159	
9	Italy	13218	d	100-200	4302	
9	Italy	13219	d	200-500	3573	
9	Italy	13220	d	500-800	3148	
10	Italy	13401	a	10-50	1194	South East Tyrrhenian Sea
10	Italy	13402	a	50-100	1224	
10	Italy	13403	a	100-200	2095	
10	Italy	13404	a	200-500	3238	
10	Italy	13405	a	500-800	5248	
10	Italy	13406	b	10-50	622	South West Tyrrhenian Sea
10	Italy	13407	b	50-100	1003	
10	Italy	13408	b	100-200	1224	
10	Italy	13409	b	200-500	1966	
10	Italy	13410	b	500-800	2441	
11	Italy	13301	a	10-50	822	South East Sardinia
11	Italy	13302	a	50-100	382	
11	Italy	13303	a	100-200	351	
11	Italy	13304	a	200-500	589	
11	Italy	13305	a	500-800	502	
11	Italy	13306	b	10-50	910	North East Sardinia
11	Italy	13307	b	50-100	1592	
11	Italy	13308	b	100-200	839	
11	Italy	13309	b	200-500	765	
11	Italy	13310	b	500-800	855	
11	Italy	13311	c	10-50	627	North Sardinia
11	Italy	13312	c	50-100	796	
11	Italy	13313	c	100-200	512	
11	Italy	13314	c	200-500	500	
11	Italy	13315	c	500-800	242	
11	Italy	13316	d	10-50	431	North West Sardinia
11	Italy	13317	d	50-100	541	
11	Italy	13318	d	100-200	896	
11	Italy	13319	d	200-500	471	
11	Italy	13320	d	500-800	335	
11	Italy	13321	e	10-50	1096	West Sardinia
11	Italy	13322	e	50-100	446	

GSA	Country	Stratum		Depth (m)	Surface (km²)	Area
11	Italy	13323	e	100-200	927	
11	Italy	13324	e	200-500	412	
11	Italy	13325	e	500-800	260	
11	Italy	13326	f	10-50	783	South West Sardinia
11	Italy	13327	f	50-100	987	
11	Italy	13328	f	100-200	2335	
11	Italy	13329	f	200-500	1620	
11	Italy	13330	f	500-800	1041	
11	Italy	13331	g	10-50	705	South Sardinia
11	Italy	13332	g	50-100	350	
11	Italy	13333	g	100-200	768	
11	Italy	13334	g	200-500	1060	
11	Italy	13335	g	500-800	1227	
15	Malta	13501	a	10-50	152	Malta
15	Malta	13502	a	50-100	1473	
15	Malta	13503	a	100-200	3076	
15	Malta	13504	a	200-500	3353	
15	Malta	13505	a	500-800	2526	
16	Italy	13411	c	10-50	3145	Strait of Sicily
16	Italy	13412	c	50-100	6610	
16	Italy	13413	c	100-200	9866	
16	Italy	13414	c	200-500	13424	
16	Italy	13415	c	500-800	15653	
17	Italy	21101	a	10-50	17300	North Adriatic Sea
17	Italy	21102	a	50-100	8200	
17	Italy	21103	a	100-200	0	
17	Italy	21104	a	200-500	0	
17	Italy	21105	a	500-800	0	
17	Italy	21106	b	10-50	4700	Central Adriatic Sea
17	Italy	21107	b	50-100	10350	
17	Italy	21108	b	100-200	14950	
17	Italy	21109	b	200-500	3900	
17	Italy	21110	b	500-800	950	
17	Slovenia	21111	c	10-50	184	North Adriatic-Slovenia
17	Slovenia	21112	c	50-100	0	
17	Slovenia	21113	c	100-200	0	
17	Slovenia	21114	c	200-500	0	
17	Slovenia	21115	c	500-800	0	
17	Croatia	21116	d	10-50	7308	North East Adriatic-Croatia
17	Croatia	21117	d	50-100	14785	
17	Croatia	21118	d	100-200	7225	
17	Croatia	21119	d	200-500	2409	
17	Croatia	21120	d	500-800	0	
18	Italy	22121	e	10-50	261	South West Adriatic Sea
18	Italy	22122	e	50-100	509	
18	Italy	22123	e	100-200	1348	
18	Italy	22124	e	200-500	332	
18	Italy	22125	e	500-800	860	
18	Italy	22126	f	10-50	329	South West Adriatic Sea
18	Italy	22127	f	50-100	599	
18	Italy	22128	f	100-200	1809	
18	Italy	22129	f	200-500	472	
18	Italy	22130	f	500-800	350	
18	Italy	22131	g	10-50	290	South West Adriatic Sea
18	Italy	22132	g	50-100	689	
18	Italy	22133	g	100-200	1214	
18	Italy	22134	g	200-500	260	

GSA	Country	Stratum		Depth (m)	Surface (km²)	Area
18	Italy	22135	g	500-800	336	
18	Italy	22136	h	10-50	1702	South West Adriatic Sea
18	Italy	22137	h	50-100	1307	
18	Italy	22138	h	100-200	1407	
18	Italy	22139	h	200-500	707	
18	Italy	22140	h	500-800	492	
18	Albania	22141	i	10-50	568	South East Adriatic-Albania
18	Albania	22142	i	50-100	2231	
18	Albania	22143	i	100-200	2186	
18	Albania	22144	i	200-500	1840	
18	Albania	22145	i	500-800	1910	
18	Montenegro	22146	j	10-50	280	South Adriatic-Montenegro
18	Montenegro	22147	j	50-100	1100	
18	Montenegro	22148	j	100-200	1700	
18	Montenegro	22149	j	200-500	1150	
18	Montenegro	22150	j	500-800	770	
19	Italy	22101	a	10-50	412	North-Western Ionian Sea (East Sicily)
19	Italy	22102	a	50-100	377	
19	Italy	22103	a	100-200	334	
19	Italy	22104	a	200-500	650	
19	Italy	22105	a	500-800	641	
19	Italy	22106	b	10-50	326	North-Western Ionian Sea (South Calabria)
19	Italy	22107	b	50-100	225	
19	Italy	22108	b	100-200	257	
19	Italy	22109	b	200-500	939	
19	Italy	22110	b	500-800	1370	
19	Italy	22111	c	10-50	599	North-Western Ionian Sea (North Calabria)
19	Italy	22112	c	50-100	321	
19	Italy	22113	c	100-200	393	
19	Italy	22114	c	200-500	1327	
19	Italy	22115	c	500-800	1190	
19	Italy	22116	d	10-50	787	North-Western Ionian Sea (Apulia)
19	Italy	22117	d	50-100	778	
19	Italy	22118	d	100-200	1680	
19	Italy	22119	d	200-500	1439	
19	Italy	22120	d	500-800	2302	
20	Greece	22201	a	10-50	2916	East Ionian Sea
20	Greece	22202	a	50-100	4365	
20	Greece	22203	a	100-200	2536	
20	Greece	22204	a	200-500	3158	
20	Greece	22205	a	500-800	3848	
22	Greece	22301	a	10-50	2467	Argosaronikos
22	Greece	22302	a	50-100	587	
22	Greece	22303	a	100-200	7143	
22	Greece	22304	a	200-500	6074	
22	Greece	22305	a	500-800	8645	
22	Greece	22401	a	10-50	8645	North Aegean Sea
22	Greece	22402	a	50-100	8489	
22	Greece	22403	a	100-200	15823	
22	Greece	22404	a	200-500	19774	
22	Greece	22405	a	500-800	15426	
22	Greece	22501	a	10-50	4206	South Aegean Sea
22	Greece	22502	a	50-100	3436	
22	Greece	22503	a	100-200	12407	
22	Greece	22504	a	200-500	15630	
22	Greece	22505	a	500-800	19579	
23	Greece	22506	a	10-50	712	Crete (Cretan Sea)
23	Greece	22507	a	50-100	654	
23	Greece	22508	a	100-200	862	
23	Greece	22509	a	200-500	2470	
23	Greece	22510	a	500-800	2645	
25	Cyprus	32101	a	10-50	796	Cyprus

25	Cyprus	32102	a	50-100	717
25	Cyprus	32103	a	100-200	918
25	Cyprus	32104	a	200-500	2245
25	Cyprus	32105	a	500-800	6430

III. Target number of hauls by area (based on 2002 onwards records)

Country	GSA	Strata	Surface (km²)	No Hauls	Area
Spain	1, 2	111	12753	35	Northern Alboran Sea
Morocco	3	114	13841		Southern Alboran Sea
Spain	5	115	12656	53	Balearic Islands
Spain	6	112-113	32506	82	Northern Spain
France	7, 8	121, 131	18422	88	Gulf of Lions & Corsica*
Italy	9	132	42410	120	Ligurian, North and Central Tyrrhenian Sea
Italy	10	134a-b	20255	70	Central and Southern Tyrrhenian Sea
Italy	11	133	26975	101	Sardinia
Malta	15	135	10580	44	Malta
Italy	16	134c	48698	120	Strait of Sicily
Italy	17	211a-b	60350	120	Northern Adriatic Sea
Slovenia	17	211c	184	2	Northern Adriatic Sea
Croatia	17	211d	31727	60	Northern Adriatic Sea
Italy	18	221e-h	15273	53	Southern Adriatic Sea
Albania	18	221i	8735	27	Southern Adriatic Sea
Montenegro	18	221j	5000	10	Southern Adriatic Sea
Italy	19	221a-d	16347	70	North-Western Ionian Sea
Greece	20	222	16823	36	Eastern Ionian Sea
Greece	22	223	24916	23	Aegean Sea (Argosaronikos)
Greece	22	224	68157	65	Aegean Sea (North)
Greece	22	225	62601	40	Aegean Sea (South)
Greece	23	225	7343	20	Cretan Sea
Cyprus	25	321	11106	26	Cyprus

*23 hauls in GSA8 and 65 in GSA7

IV. Codes for recorded species, of the observations on hauls and of quadrants

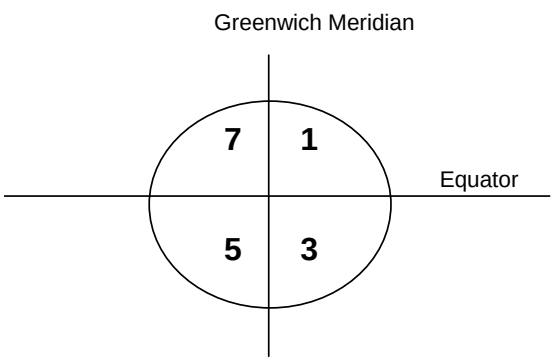
Codes of recorded species (Position 85 in the file A)

MEDITS code	Nature	Comments
0	No standard species recorded	
1	Only the species of the reference list are recorded	See Annex VI
2	The species of the reference list plus some others are recorded	
3	All the caught species are recorded	See Annex XV
4	Species from a national list	

Coding of the observations (Position 112 in the file A)

MEDITS code	Nature	Comments
0	No problem	
1	Slight plugging of the net	
2	Heavy plugging of the net	
3	High abundance of jellyfish	
4	High abundance of plants in the net	
5	Tears of the net	
6	High abundance of benthos	
7		
8		
9	Other	

Coding of the quadrants (Positions 41 and 63 in the file A)



V. Codes of Taxonomic categories. Form to introduce new species codes

Codes of taxonomic categories (Position 24 in the file B)

MEDITS code	Nature	Years of use/introduction
A	Fish	1994-2011
Aa	Fish Agnatha	2014÷
Ae	Fish Chondrichthyes	2012÷
Ao	Fish Osteichthyes	2012÷
B	Crustaceans (Decapoda)	1994-2014
Bam	Amphipoda	2012÷
Bci	Cirripeda	2012÷
Beu	Euphausiacea	2012÷
Bis	Isopoda	2012÷
Bst	Stomatopoda	2012÷
C	Cephalopods	1994-2012÷
D	Other commercial (edible) species	1994-2011
Dec	Echinodermata	2012÷
Dmb	Mollusca Bivalvia	2012÷
Dmg	Mollusca Gastropoda	2012÷
Dmo	Mollusca Opistobranchia	2012÷2014
Dtu	Tunicata (Ascidiacea)	2012÷
E	Other animal species but not commercial (not edible)	1994-2011
Ean	Annellida	2014÷
Eba	Brachiopoda	2012÷
Ebr	Bryozoa	2012÷
Ech	Echiura	2014÷
Ecn	Cnidaria	2012÷
Ect	Ctenophora	2012÷
Eec	Echinodermata	2012÷
Ehi	Hirudinea	2012÷
Emb	Mollusca Bivalvia	2012÷
Emg	Mollusca Gastropoda	2012÷
Emo	Mollusca Opistobranchia	2012÷
Emp	Mollusca Polyplacophora	2014÷
Ene	Nemertea	2014÷
Epo	Polychaeta	2012÷
Epr	Priapulida	2014÷
Esi	Sipuncula	2012÷
Esc	Scaphopoda	2012÷
Esp	Porifera (Sponges)	2012÷
Etu	Tunicata (Ascidiacea)	2012÷
G	portions or products of animal species (shell debris, eggs of gastropods, selachians, etc.)	2012÷
H	portions or products of vegetal species (e.g. leaves of sea grasses, of terrestrial plants, etc.)	2012÷
M	Mammalia (mammals)	2014÷
O	Aves (birds)	2014÷
R	Reptilia (Turtles)	2014÷
V	Plantae (vegetals)	2012÷

Form to introduce new species codes

Name of scientist: GSA:				Date:	
Proposed Code		Scientific name	Reference for scientific name description	Geographical position	Stratum
Genus	Species				

Sheet to be send to:

prof. Giulio Relini
Centro di Biologia Marina del Mar Ligure
Dip.Te.Ris. biolmar@unige.it

VI. List of the reference species

The MEDITS reference list (since 2012) includes 82 species, of which 32 are Elasmobranches. The list also includes all species of the *Epinepheus* and *Scomber* genera.

For all the 82 species and all species of the *Epinepheus* and *Scomber* genera, the total number of individuals, the total weight and the individual length should be collected.

This list is further split in two groups:

- MEDITS G1 includes 41 species with 9 demersal (3 fish, 4 crustaceans and 2 cephalopods) and 32 Selachians. For these species the total number of individuals, the total weight, the individual length, and also biological parameters including sex, maturity, individual weight and age (age has been proposed only for the teleosteans of the Group 1) should be collected;
- MEDITS G2 includes 42 species for which only total number of individuals, total weight and individual length and should be collected.

The new list of reference species (Tot. No=total number of individuals in the haul; Tot. W= total weight of the individuals in the haul; the number 1 in the column* MEDITS G1 *and* MEDITS G2 *indicates that the species has been selected for some measurements; the column date indicates when the species has been introduced in the list of target species, the symbol > followed by the year indicates that the species was excluded by the list in that year)

No	Medit LIST proposal 2011	Species group DCF	MEDITS G1	MEDITS G2	Group	Old MEDITS list	Tot. No	Tot. W	Ind. Length	Sex	Mat. stage	Age	Ind. weight	Date	CODE	English common name
	Teleosteans															
1	*Aspitrigla cuculus*	G3		1	Fish	1	x	x	x					1998	ASPI CUC	Red gurnard
2	*Boops boops*	G2		1	Fish	1	x	x	x					2006	BOOPBOO	Bogue
3	*Citharus linguatula*	G3		1	Fish	1	x	x	x					1994	CITH MAC	Spotted flounder
4	*Diplodus annularis*	G3		1	Fish		x	x	x					2012	DIPLANN	Annular seabream
5	*Diplodus puntazzo*	G3		1	Fish		x	x	x					2012	DIPLPUN	Sharpsnout seabream
6	*Diplodus sargus*	G3		1	Fish		x	x	x					2012	DIPLSAR	White sea bream
7	*Diplodus vulgaris*	G3		1	Fish		x	x	x					2012	DIPLVUL	Common two-banded seabream

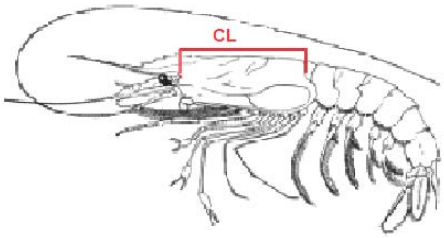
8	*Engraulis encrasicolus*	G1		1	Fish		x	x	x					2012	ENGRENC	Anchovy
9	*Epinephelus spp.**	G3		1	Fish		x	x	x					2012	EPINSPP	Grouper
10	*Eutrigla gurnardus*	G2		1	Fish	1	x	x	x					1994	EUTR GUR	Grey gurnard
11	*Helicolenus dactylopterus*	G3		1	Fish	1	x	x	x					1994	HELI DAC	Rockfish
12	*Lepidorhombus boscii*	G3		1	Fish	1	x	x	x					1994	LEPM BOS	Four-spotted megrim
13	*Lithognathus mormyrus*	G3		1	Fish		x	x	x					2012	LITH MOR	Striped seabream
14	*Lophius budegassa*	G2		1	Fish	1	x	x	x					1994	LOPH BUD	Black-bellied angler
15	*Lophius piscatorius*	G2		1	Fish	1	x	x	x					1994	LOPH PIS	Angler
16	***Merluccius merluccius***	**G1**	**1**		**Fish**	**1**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**1994**	**MERL MER**	**European hake**
17	*Micromesistius poutassou*	G2		1	Fish	1	x	x	x					1994	MICM POU	Blue whiting
18	***Mullus barbatus***	**G1**	**1**		**Fish**	**1**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**1994**	**MULL BAR**	**Red mullet**
19	***Mullus surmuletus***	**G1**	**1**		**Fish**	**1**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**1994**	**MULL SUR**	**Striped red mullet**
20	*Pagellus acarne*	G3		1	Fish	1	x	x	x					1994	PAGE ACA	Axillary seabream
21	*Pagellus bogaraveo*	G3		1	Fish	1	x	x	x					1994	PAGE BOG	Blackspot seabream
22	*Pagellus erythrinus*	G2		1	Fish	1	x	x	x					1994	PAGE ERY	Common pandora
23	*Pagrus pagrus*	G3		1	Fish		x	x	x					> 1996	SPAR PAG	Common seabream
24	*Phycis blennoides*	G3		1	Fish	1	x	x	x					1994	PHYI BLE	Greater forkbeard
25	*Polyprion americanus*	G3		1	Fish		x	x	x					2012	POLY AME	Wreckfish
26	*Psetta maxima*	G2		1	Fish		x	x	x					2012	PSET MAX	Turbot
27	*Sardina pilchardus*	G1		1	Fish		x	x	x					2012	SARD PIL	Sardine
28	*Scomber spp.**	G2		1	Fish		x	x	x					2012	SCOM SPP	mackerel
29	*Solea vulgaris*	G1		1	Fish	1	x	x	x					1994	SOLE VUL	Common sole
30	*Spicara flexuosa*	G3		1	Fish	1	x	x	x					1994	SPIC FLE	Picarel
31	*Spicara maena*	G3		1	Fish		x	x	x					2012	SPIC MAE	Blotched picarel
32	*Spicara smaris*	G2		1	Fish	1	x	x	x					1998	SPIC SMA	Picarel
33	*Trachurus mediterraneus*	G2		1	Fish	1	x	x	x					1994	TRAC MED	Mediterranean horse mackerel
34	*Trachurus trachurus*	G2		1	Fish	1	x	x	x					1994	TRAC TRA	Atlantic horse mackerel
35	*Trigla lucerna*	G2		1	Fish	1	x	x	x					2006	TRIGLUC	Tub gurnard

36	*Trigloporus lastoviza*	G3		1	Fish	1	x	x	x				1998	TRIP LAS	Streaked gurnard
37	*Trisopterus minutus capelanus*	G3		1	Fish	1	x	x	x				1994	TRIS CAP	Poor-cod
38	*Zeus faber*	G3		1	Fish	1	x	x	x				1994	ZEUS FAB	John dory
	Elasmobranches														
39	*Centrophorus granulosus*	G1	1		Elasmob.		x	x	x	x	x	x	2012	CENT GRA	Gulper shark
40	*Dalatias licha*	G1	1		Elasmob		x	x	x	x	x	x	2012	SCYM LIC	Kitefin shark
41	*Dipturus batis*	G1	1		Elasmob		x	x	x	x	x	x	2012	RAJA BAT	Skate
42	*Dipturus oxyrinchus*	G1	1		Elasmob		x	x	x	x	x	x	2012	RAJA OXY	Longnosed skate
43	*Etmopterus spinax*	G1	1		Elasmob		x	x	x	x	x	x	2012	ETMO SPI	Velvet belly
44	*Galeorhinus galeus*	G1	1		Elasmob		x	x	x	x	x	x	2012	GALE GAL	Tope shark
45	*Galeus melastomus*	G1	1		Elasmob	1	x	x	x	x	x	x	1999	GALU MEL	Blackmouth catshark
46	*Heptranchias perlo*	G1	1		Elasmob		x	x	x	x	x	x	2012	HEPT PER	Sharpnose sevengill shark
47	*Hexanchus griseus*	G1	1		Elasmob		x	x	x	x	x	x	2012	HEXA GRI	Bluntnose sixgill shark
48	*Leucoraja circularis*	G1	1		Elasmob		x	x	x	x	x	x	2012	RAJA CIR	Sandy ray
49	*Leucoraja melitensis*	G1	1		Elasmob		x	x	x	x	x	x	2012	RAJA MEL	Maltese ray
50	*Mustelus asterias*	G1	1		Elasmob		x	x	x	x	x	x	2012	MUST AST	Starry smoothhound
51	*Mustelus mustelus*	G1	1		Elasmob		x	x	x	x	x	x	2012	MUST MUS	Smoothhound
52	*Mustelus punctulatus*	G1	1		Elasmob		x	x	x	x	x	x	2012	MUST MED	Blackspotted smoothhound
53	*Myliobatis aquila*	G1	1		Elasmob		x	x	x	x	x	x	2012	MYLI AQU	Common eagle ray
54	*Oxynotus centrina*	G1	1		Elasmob		x	x	x	x	x	x	2012	OXYN CEN	Angular rough shark
55	*Raja asterias*	G1	1		Elasmob		x	x	x	x	x	x	2012	RAJA AST	Starry ray
56	*Raja clavata*	G1	1		Elasmob	1	x	x	x	x	x	x	1999	RAJA CLA	Thornback ray
57	*Raja miraletus*	G1	1		Elasmob		x	x	x	x	x	x	2012	RAJA MIR	Brown ray
58	*Raja polistigma*	G1	1		Elasmob		x	x	x	x	x	x	2012	RAJA POL	Speckled ray
59	*Raja undulata*	G1	1		Elasmob		x	x	x	x	x	x	2012	RAJA UND	Undulate ray
60	*Rhinobatos cemiculus*	G1	1		Elasmob		x	x	x	x	x	x	2012	RHIN CEM	Blackchin guitarfish
61	*Rhinobatos rhinobatos*	G1	1		Elasmob		x	x	x	x	x	x	2012	RHIN RHI	Common guitarfish
62	*Rostroraja alba*	G1	1		Elasmob		x	x	x	x	x	x	2012	RAJA ALB	White skate
63	*Scyliorhinus canicula*	G1	1		Elasmob	1	x	x	x	x	x	x	1999	SCYO CAN	Smallspotted

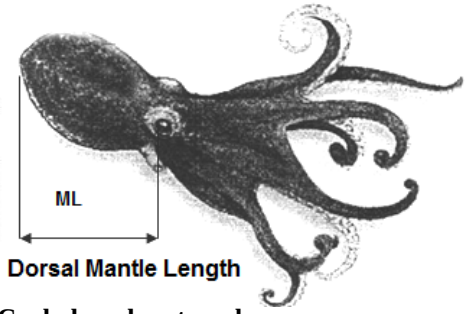
																catshark
64	*Scyliorhinus stellaris*	G1	1		Elasmob		x	x	x	x	x		x	2012	SCYO STE	Nursehound
65	*Squalus acanthias*	G1	1		Elasmob		x	x	x	x	x		x	2012	SQUA ACA	Piked dogfish
66	*Squalus blainvillei*	G1	1		Elasmob		x	x	x	x	x		x	2012	SQUA BLA	Longnose spurdog
67	*Squatina aculeata*	G1	1		Elasmob		x	x	x	x	x		x	2012	SQUT ACU	Sawback angelshark
68	*Squatina oculata*	G1	1		Elasmob		x	x	x	x	x		x	2012	SQUT OCL	Smoothback angelshark
69	*Squatina squatina*	G1	1		Elasmob		x	x	x	x	x		x	2012	SQUT SQU	Angelshark
70	*Torpedo marmorata*	G1	1		Elasmob		x	x	x	x	x		x	2012	TORP MAR	Marbled electric ray
	Crustaceans															
71	***Aristaeomorpha foliacea***	**G1**	**1**		**Cru**	**1**	**x**	**x**	**x**	**x**	**x**		**x**	**1994**	**ARIS FOL**	**Giant red shrimp**
72	***Aristeus antennatus***	**G1**	**1**		**Cru**	**1**	**x**	**x**	**x**	**x**	**x**		**x**	**1994**	**ARIT ANT**	**Blue and red shrimp**
73	***Nephrops norvegicus***	**G1**	**1**		**Cru**	**1**	**x**	**x**	**x**	**x**	**x**		**x**	**1994**	**NEPR NOR**	**Norway lobster**
74	***Parapenaeus longirostris***	**G1**	**1**		**Cru**	**1**	**x**	**x**	**x**	**x**	**x**		**x**	**1994**	**PAPE LON**	**Deep-water pink shrimp**
75	*Palinurus elephas*	G3		1	Cru		x	x	x					2012	PALI ELE	Spiny lobster
76	*Melicertus kerathurus*	G2		1	Cru		x	x	x					2012	PENA KER	Caramote prawn
77	*Squilla mantis*	G2		1	Cru		x	x	x					2012	SQUI MAN	Spottail mantis squillids
	Cephalopods															
78	*Eledone cirrhosa*	G2		1	Cef	1	x	x	x					1994	ELED CIR	Horned octopus
79	*Eledone moschata*	G2		1	Cef	1	x	x	x					1997	ELED MOS	Musky octopus
80	***Illex coindettii***	**G2**	**1**		**Cef**	**1**	**x**	**x**	**x**	**x**	**x**		**x**	**1994**	**ILLE COI**	**Broadtail squid**
81	***Loligo vulgaris***	**G2**	**1**		**Cef**	**1**	**x**	**x**	**x**	**x**	**x**		**x**	**1994**	**LOLI VUL**	**European squid**
82	*Octopus vulgaris*	G2		1	Cef	1	x	x	x					1994	OCTO VUL	Common octopus
83	*Sepia officinalis*	G2		1	Cef	1	x	x	x					1994	SEPI OFF	Common cuttlefish
84	*Todarodes sagittatus*	G2		1	Cef		x	x	x					2012	TODA SAG	Arrow squid

*not all *Epinephelus* and *Scomber* species are listed but the single species should be considered as target

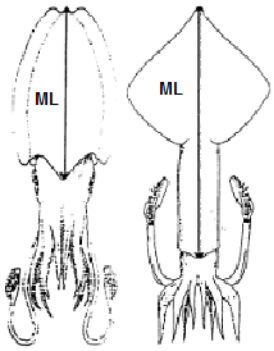
VII. Standard length measurement for Crustaceans, Cephalopods and Fish



Crustaceans
CL: cephalo-thoracic length

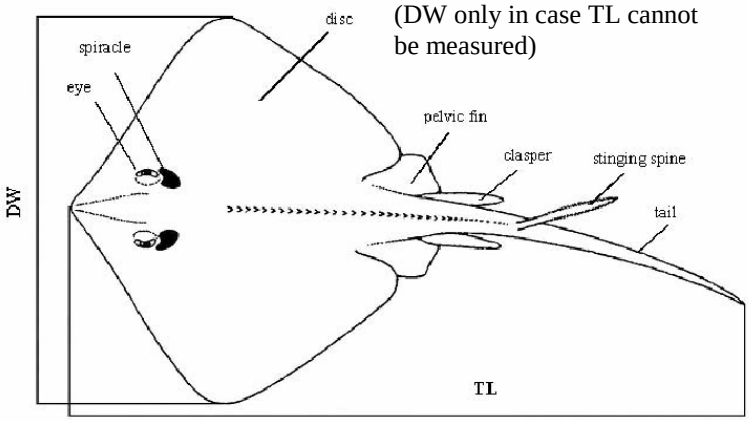


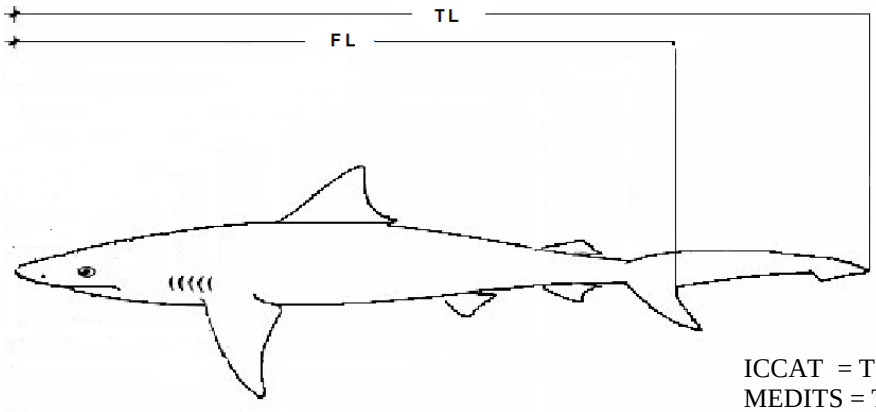
Cephalopods octopoda
Dorsal Mantle Length



Cephalopods decapoda
ML=Dorsal Mantle Length

ICCAT = Disk Width DW
MEDITS = Total LengthTL
(DW only in case TL cannot be measured)

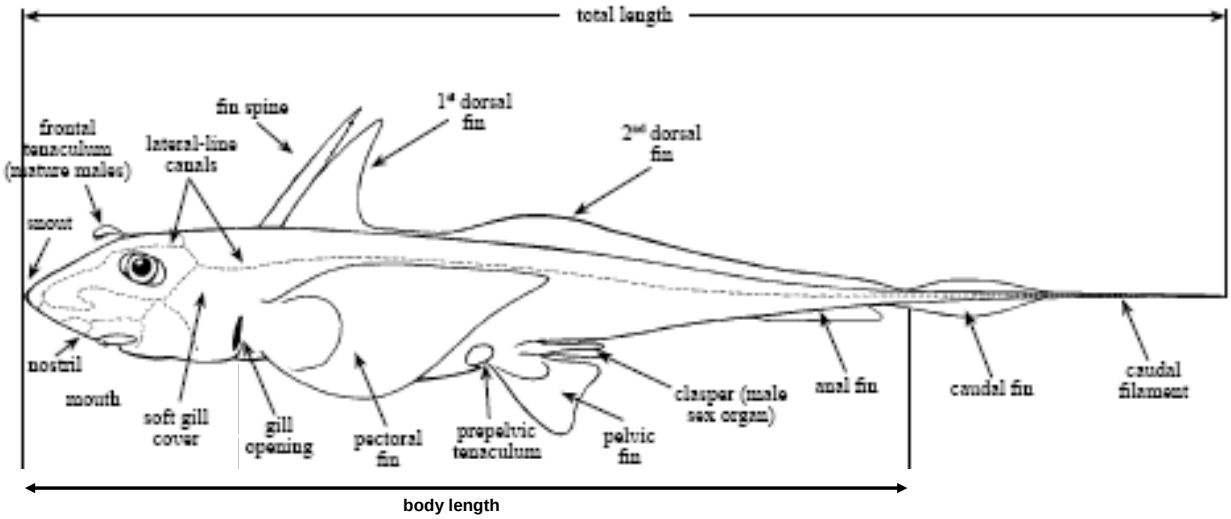




ICCAT = Total Length TL
MEDITS = Total Length TL
(Fork length FL in case TL cannot be taken; e.g. damaged fins)

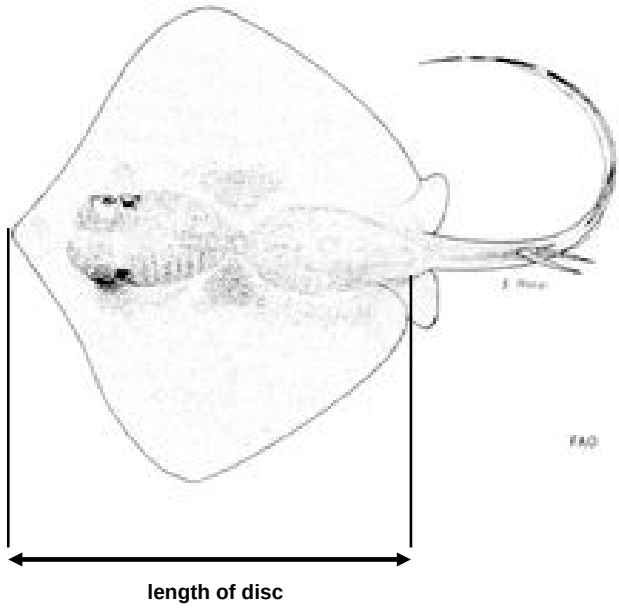
Note: rule to take TL of Elasmobranches holds also for bony fish

- For *chimaeroids* species the total length often is difficult to measure, because the caudal filament can easily be cut. The body length (snout to posterior end of supracaudal fin) is then a preferred measurement. Taking both measures on not damaged specimens can allow to confront both measures fitting a linear model to the data.



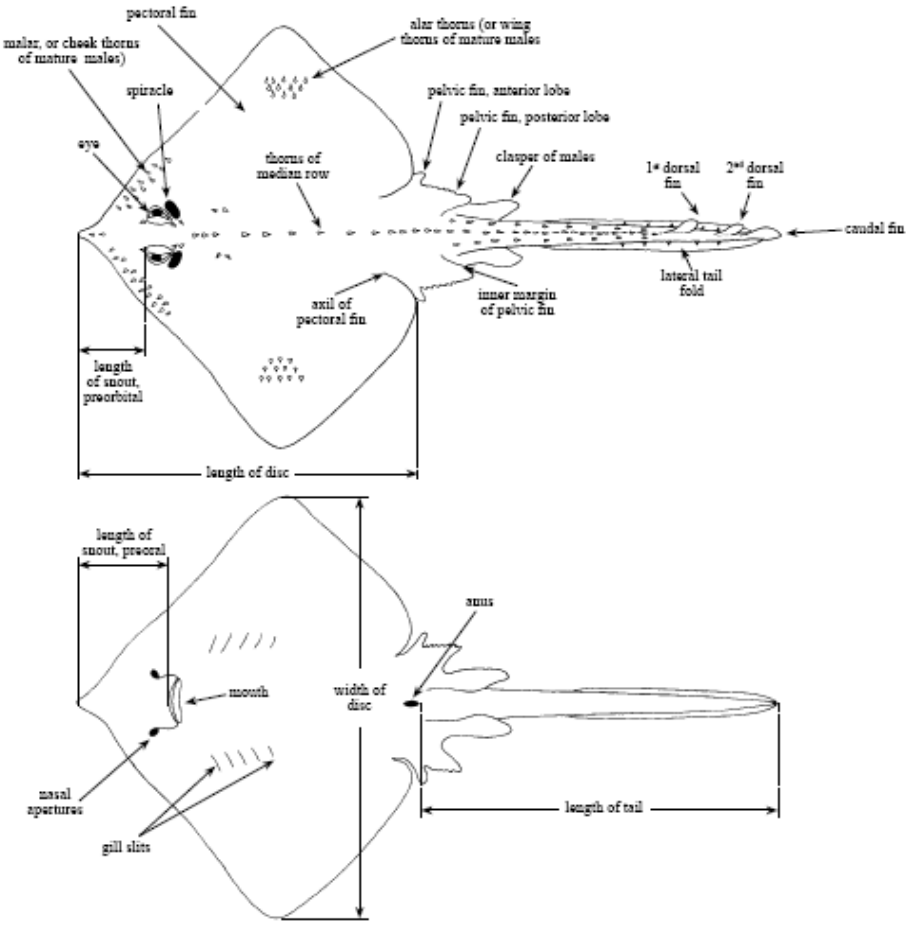
The body length in *chimaeroids* species

- For the same reason in Myliobatidae, Dasyatidae and Rhinopteridae the length of disc can be taken.



Length of disc in the Myliobatidae, Dasyatidae and Rhinopteridae species

- For Rajidae and Torpenidae it is recommended to take other measurements as length and width of the disc.



Length and width of the disc for the Rajidae and Torpenidae species

VIII. Codes of sexual maturity for Fish, Crustaceans and Cephalopods

VIII.A Bony Fish

SEX	GONAD ASPECT	MATURATION STATE	STAGE	MEDITS
I	Sex not distinguished by naked eye. Gonads very small and translucid, almost transparent. Sex undetermined.	UNDETERMINED	0	0
F	Small pinkish and translucent ovary shorter than 1/3 of the body cavity. Eggs not visible by naked eye.	IMMATURE=VIRGIN	1	1
M	Thin and withish testis shorter than 1/3 of the body cavity.			
F	Small pinkish/reddish ovary shorter than ½ of e body cavity. Eggs not visible by naked eye.	VIRGIN-DEVELOPING*	2a	2
M	Thin withish testis shorter than 1/2 of the body cavity.			
F	Pinkish-reddish/ reddish-orange and translucent ovary long about ½ of the body cavity. Blood vessels visible. Eggs not visible by naked eye.	RECOVERING*	2b	
M	Withish/pinkish testis, more or less symmetrical, long about ½ of the body cavity			
F	Ovary pinkish-yellow in colour with granular appearance, long about 2/3 of the body cavity. Eggs are visible by naked eye trough the ovaric tunica, which is not yet translucent. Under light pressure eggs are not expelled.	MATURING	2c	
M	Withish to creamy testis long about 2/3 of the body cavity. Under light pressure sperm is not expelled.			
F	Ovary orange-pink in colour, with conspicious superficial blood vessels, long from 2/3 to full length of the body cavity. Large transparent, ripe eggs are cleary visible and could be expelled under light pressure. In more advanced conditions, eggs escape freely.	MATURE/SPAWNER	3	3
M	Whitish-creamy soft testis long from 2/3 to full length of the body cavity. Under light pressure, sperm could be expelled. In more advanced conditions, sperm escapes freely.			
F	Reddish ovary shrunked to about 1/2 length of the body cavity. Flaccid ovaric walls; ovary may contain remanants of disintegrating opaque and/or translucent eggs.	SPENT	4a	4
M	Bloodshot and flabby testis shrunken to about 1/2 length of the body cavity			
F	Pinkish and translucent ovary long about 1/3 of the body cavity. Eggs not visible by naked eye.	RESTING*	4b	
M	Whitish/pinkish testis, more or less simmetrical, long about 1/3 of the body cavity.			

be careful, these stages can be easily confused

Adult specimens

VIII.B
Elasmobranchs oviparous

SEX	GONAD ASPECT	MATURATION STATE	STAGE	MEDITS
I	Sex not distinguished by naked eye.	UNDETERMINED	0	0
F	Ovary is barely discernible with small isodiametric eggs. Distal part of oviducts is thick-walled and whitish. The nidamental glands are less evident.	IMMATURE/VIRGIN	1	1
M	Claspers are small and flaccid and do not reach the posterior edge of the pelvic fins. Spermducts not differentiated. Testis small and narrow .			
F	Whitish and/or few yellow maturing eggs are visible in the ovary. The distal part of oviducts (uterus) is well developed but empty. The nidamental glands are small.	MATURIN*G	2	2
M	Claspers are larger, but skeleton still flexible. They extend to the posterior edge of the pelvic fins. Spermducts well developed eventually beginning to meander.			
F	Ovaries contain yellow eggs (large yolk eggs). The nidamental glands are enlarged and oviducts are distended.	MATURE	3a	3
M	Claspers extends well beyond the posterior edge of the pelvic fin and their internal structure is generally hard and ossified. Testis greatly enlarged. Spermducts meandering over almost their entire length.			
F	Ovary walls transparent. Oocytes of different sizes, white or yellow. Nidamental glands large. Egg-cases more or less formed in the oviducts (Extruding Stage).	MATURE/EXTRUDING-ACTIVE	3b	
M	Clasper longer than tips of posterior pelvic fin lobes, skeleton hardened with axial cartilages hardened and pointed. Spermducts largely. Sperm flowing on pressure from cloaca (Active Stage).			
F	Ovary walls transparent. Oocytes of different sizes, white or yellow. Oviducts appear much enlarged, collapsed and empty. The nidamental glands diameter are reducing.	RESTING	4a	4
M	Clasper longer than tips of posterior pelvic fin lobes, skeleton hardened with axial cartilages still hardened. Spermducts empty and flaccid.			
F	Ovaries full of small follicles similar to stage 2, enlarged oviducal glands and uterus	REGENERATING*	4b	

be careful, these stages can be easily confused

Adult specimens

VIII.C **Elasmobranchs viviparous**

VIVIPAROUS ELASMOBRANCHES (RAYS AND SHARKS)				
Sex	**GONAD ASPECT**	**MATURATION STATE**	**MATURITY**	**STAGE**
I	**Sex not distinguished by naked eye.**	**UNDETERMINED**	**IMMATURE**	**0**
M	**Claspers flexible and shorter than pelvic fins. Testes small (in rays, sometimes with visible lobules). Sperm ducts straight and thread-like.**	**IMMATURE**	**IMMATURE**	**1**
F	**Ovaries barely visible or small, whitish; undistinguishable ovarian follicles. Oviducal (nidamental) gland may be slightly visible. Uterus is thread-like and narrow.**			
M	**Claspers slightly more robust but still flexible. Clasp-ers as long as or longer than pelvic fins. Testes enlarged; in sharks testes start to segment; in rays lobules clearly visible but do not occupy the whole surface. Sperm ducts developing and beginning to coil (meander).**	**DEVELOPING**	**IMMATURE ***	**2**
F	**Ovaries enlarged with small follicles (oocytes) of dif-ferent size. Some relatively larger yellow follicles may be present. Ovaries lack atretic follicles. Developing oviducal gland and uterus.**			
M	**Claspers fully formed, skeleton hardened, rigid and generally longer than pelvic fins. Testes greatly enlarged; in sharks testes are fully segmented; in rays filled with developed lobules. Sperm ducts tightly coiled and filled with sperm.**	**SPAWNING CAPABLE**	**MATURE**	**3a**
F	**Large ovaries with enlarged yolk follicles all of about the same size so that they can be easily distinguished. Oviducal gland and uterus developed without yolky matter, embryos and not dilated.**	**CAPABLE to RE-PRODUCE**		
M	**Description similar to stage 3a, however with clasper glands dilated, often swollen and reddish (occasion-ally open). Sperm often present in clasper groove or glans. On pressure sperm is observed flowing out of the cloaca or in the sperm ducts.**	**ACTIVELY SPAWNING**	**MATURE**	**3b**
F	**Uteri well filled and rounded with yolk content (usually candle shape). In general segments cannot be distinguished and embryos cannot be observed.**	**EARLY PREGNANCY**	**MATERNAL**	
F	**Uteri well filled and rounded, often with visible segments. Embryos are always visible, small and with a relatively large yolk sac.**	**MID PREGNANCY**	**MATERNAL**	**3c**
F	**Embryos fully formed, yolk sacs reduced or absent. Embryos can be easily measured and sexed.**	**LATE PREGNANCY**	**MATERNAL**	**3d**
M	**Claspers fully formed, similar to stage 3. Testes and spermducts shrunken and flaccid.**	**REGRESSING**	**MATURE**	**4**
F	**Ovaries shrunken without follicle development and with atretic (degenerating) follicles. The oviducal glands diameter may be reducing. Uterus appears much enlarged, collapsed, empty and reddish.**	**REGRESSING**	**MATURE**	**4a**
F	**Ovary with small follicles in different stages of de-velopment with the presence of atretic ones. Uterus enlarged with flaccid walls. Oviducal gland distinguishable.**	**REGENERATING (mature)**	**MATURE ***	**4b**

be careful, these stages can be easily confused

Adult specimens

VIII.D **Crustaceans**

SEX	REPRODUCTIVE APPARATUS ASPECT	COLOURING OF FRESH OVARY	MATURATION STATE	STAGE	MEDITS
I	Sex not distinguished by naked eye. Sex undetermined	translucid	UNDETERMINED	0	0
F	Ovary hardy visible in transparence. After dissection of the tegument ovary is small and lobes are flaccid, stringy and poorly developed. *A. foliacea* and *A. antennatus* no sphermatophores on thelycum.	Whitish or traslucid	IMMATURE = VIRGIN *	1	1 FEMALE
M	Petasma is not much visible, and there are not spermatic masses (emi-spermatophores) on the seminal ammpullae, located on side of the V pair of pereiopods. *A. foliacea* and *A. antennatus* : long rostrum.				
F	Ovary status to develop. Cephalic and lateral lobes are small but distinguishable by naked eye. Abdominal extension are thin and just visible.	*A. foliacea* : flesh coloured; *A. antennatus:* Ivory coloured with orange pink-violet dotting. *N. norvegicus* : cream. *P. longirostris* : cream orange.	VIRGIN DEVELOPING **	2a	2 FEMALE
M	Petasma appears visible and nearly or completely joined, but there are no spermatic masses in the seminar ammpullae. *A. foliacea* & *A. antennatus* : long or intermediate rostrum.				
F	Ovary status to re-develop. Cephalic and lateral lobes are small but distinguishable by naked eye. Abdominal extension are thin and just visible. Occasionally presence of spermatophores in *A. foliacea* and *A. antennatus* .	*A. foliacea* : flesh coloured; *A. antennatus* : Ivory coloured with orange pink-violet dotting. *N. norvegicus* : cream. *P. longirostris* : cream orange.	RECOVERING**	2b	
M	Petasma appears completely joined, but there are no spermatic masses in the seminar ampullae. *A. foliacea* & *A. antennatus* : short rostrum.				
F	Ovary developed and occupies almost entirely the dorsal portion. The cephalic and lateral lobes are much developed and have a turgid consistence.	*A. foliacea* : light and dark grey; *A. antennatus* : lilla; *N. norvegicus* : light green; *P. longirostris* : light green or grey green.	MATURING OR ALMOST MATURE	2c	
M					
F	Turgid ovary extends to the whole dorsal portion, covery the organs below. Lobes and extensions well developed, in particular the abdominal extention are much evident. Oocytes well visible.	*A. foliacea* : black; *A. antennatus* : violet; *N. norvegicus* : dark grey; *P. longirostris* : brigth green or olive green.	MATURE	2d	
M	Petasma is perfectly visible and completely joined. Spermatic masses in seminar ampullae. *A. foliacea* & *A. antennatus* : small rostum.				
F	Resting ovary. Presence of spermatophores in *A. foliacea* and *A. antennatus* .	Uncoloured.	RESTING ADULT*	2e	
F (*N. norvegicus*)	Eggs on pleiopods		BERRIED	3	3 *N. norvegicus* , FEMALE

Adult specimens

*, ** : WARNING ! Be careful.These stages could be confused each other.

VIII.E **Cephalopods**

SEX	REPRODUCTIVE APPARATUS ASPECT	EGGS SIZE (mm)	SPERMATOPHORES DEVELOPMENT	MATURATION STATE	STAGE	MEDITS
I	Sex not distinguished by naked eye. Sex undetermined.	Total absence of eggs.	Total absence of spermatophores.	UNDETERMINED	0	0
F	Small and translucid Nidamental Glands (NG) / Oviducal Glands (OG). Ovary is semi-transparent, stringy and lacking granular structure Small semi-transparent NG / OG. Oviduct meander not visible.	*L. vulgaris & I. coindetii:* no eggs *S.officinalis:* Ø <2mm *E. moschata:* Ø <4mm *E. cirrhosa* Ø <2mm *O. vulgaris* Ø <1mm	Total absence of spermatophores	IMMATURE = VIRGIN	1	1
M	Testis small. Spermatophoric complex (SC) semi-transparent with not visible Vas deferens. Penis appears as a small prominence of SC.					
F	NG / OVG enlarged. NG covering some internal organs. Whitish ovary with granular structure clearly visible, not reaching the posterior half of the mantle cavity. Oviduct meander clearly visible.	Very small eggs	Absence of spermatophores	DEVELOPING	2a	2
M	Enlarged testis with structure not clearly visible. The Vas deferens whitish or white and the spermatophoric organ with white streak.					
F	Large NG covering the viscera below. Ovary occupies the whole posterior half of mantle cavity, containing reticulated oocytes of all sizes tightly packed and probably a few ripe ova at its proximal part. Oviducts fully developed but empty.	*L. vulgaris & I. coindetii* : maturing eggs visible by naked eye. *S.officinalis:* 2,1mm< Ø<4mm *E. moschata:* 4mm<Ø<11mm *E. cirrhosa:* 2mm<Ø<5mm *O. vulgaris:* 1mm<Ø<2mm	*L. vulgaris, I. coindetii* and *S.officinalis* : few immature spermatophores in Needham's sac. *E. moschata, E. cirrhosa, O. vulgaris* : few spermatophores, barelly developed and not functional	MATURING	2b	
M	The Vas deferens white, meandering, enlarged. The Needham's sac (SS) with structureless whitish particles inside. Normally the Needham's sac is without funtional spermatophores but sometimes some immature/abortive ones could occur. The testis tight, crispy, with visible structure.					
F	Large NG as previously. Ovary containing higher percentage of large reticulated eggs and some large ripe ova with smooth surface. In Teuthoidea ripe ova in oviducts.	*L. vulgaris & I. coindetii* : amber- colored and isodiametric eggs in oviducts and in part of the ovary (Ø =2mm in *Loligo* and Ø =1mm in *Illex*). *S.officinalis* : medium eggs (4,1mm< Ø<6,0mm) and big eggs (6,1mm<Ø<8mm) *E. moschata* : Ø >11mm (striped eggs). *E. cirrhosa* : Ø >5mm *O. vulgaris* : Ø >2mm	Well developed spermatophores	MATURE	3a	3
M	Testis as before. Spermatophores packed in the Needham's sac.					
F	NG/OG large but soft and running. Ovary shrinked and flaccid, with only immature oocytes attached to the central tissue and a few loose large ova in the coelom. In Teuthoidea oviduct may contain some mature ova but is no longer packed.	Few large ova	Disintegrating spermatophores	SPENT	3b	
M	Disintegrating spermatophores in the Needham's sac and the penis.					

Adult specimens

IX. Protocol for Conversion of maturity scales from the scales proposed at the Workshops on Maturity stages and the MEDITS scales

Adopted during the MEDITS meeting, Nantes (France), 15-17/03/2011 and amended during the MEDITS meeting in Heraklion (12-14/03/2013)

The protocol for conversion of maturity scales adopted during the MEDITS Coordination meeting, Nantes (France), 15-17/03/2011 is here reported with some editorial changes .

Conversion of maturity scale for *Merluccius merluccius*

MEDITS SCALE		WKMAT SCALE	
0	INDETERMINED		
1	IMMATURE /VIRGIN	1	IM - VIRGIN
2A	VIRGIN DEVELOPING	1	IM - VIRGIN
2B	RECOVERING	4	SP/RE - SPENT RECOVERY
2C	MATURING	2	MI - MATURING
3	MATURE/SPAWNER	3	MA - SPAWNING
4A	SPENT	4	SP/RE - SPENT RECOVERY
4B	RESTING	4	SP/RE - SPENT RECOVERY
5		5	OS - OMITTED SPAWNING *(shrunken and greyer gonads sexually mature, not contributing to the SSB)*

Notes:

- The WKMAT scale has a unique stage for "Spent/recovery" while in the MEDITS scale these stages are divided in 2B (Recovering), 4A (Spent) and 4B (Resting).
- During the MEDITS meeting in Nantes, it was suggested to include stage 5 (omitted spawning) in the MEDITS scale. However, a better understanding and a feedback from experts using the WKMAT scale to better apply the classification of this stage and to recognize how it can be macroscopically recognized, is necessary.

Conversion of maturity scale for *Lophius spp.*

MEDITS SCALE		WKMAT SCALE	
0	INDETERMINED		
1	IMMATURE /VIRGIN	1	IMMATURE
2A	VIRGIN DEVELOPING	2	DEVELOPING RESTING
2B	RECOVERING	2	DEVELOPING RESTING
2C	MATURING	3	MATURING/PRE SPAWNING
3	MATURE/SPAWNER	4	SPAWNING
4A	SPENT	5	POST-SPAWNING
4B	RESTING	2	DEVELOPING RESTING

Notes:

- The WKMAT scale has a unique stage for "Developing Resting" while in the MEDITS scale these stages are divided in 2A (Virgin developing), 2B (Recovering) and 4B (Resting).

Crustacean maturity scale key

MEDITS SCALE		WKMSC SCALE	
0	INDETERMINED	0	UNDETERMINED
1	IMMATURE VIRGIN	1	IMMATURE
2a	VIRGIN DEVELOPING	2	DEVELOPING/RECOVERING
2b	RECOVERING		
2c	MATURING OR ALMOST	3	MATURING

2d	MATURE	4	MATURE
2e	RESTING ADULT	5	SPENT
3	BERRIED (only for *Nephrops*		

Notes:

- A lot of similarities have been found between the WKMSC and MEDITS scales. Only the stages 2a (Virgin developing) and 2b (Recovering) of the MEDITS scale have been joined into a unique stage 2 (developing/recovering) in the WKMSC one, since differences cannot be found by a macro and micro point of view.
- In the MEDITS scale, for *Nephrops norvegicus* females, there is also a stage 3 (Berried). However, in the WS only ovary stages were analyzed and it wasn suggested to always consider the stage of the ovaries even for females with the eggs in the pleiopods. However the problem remains for the old data: the stage 3 could in fact be either 2B and 2E stages. During the meeting in Nantes it was decided that in case of comparing MEDITS data of *N. norvegicus* with maturity data from the WKMSC scale, the 3 (Berried) stage (MEDITS scale) will be considered as the 5 (Spent) of the WKMSC scale.

Elasmobranches maturity scale key

MEDITS SCALE		**WKMSEL SCALE**	
0	INDETERMINED	0	UNDETERMINED
1	IMMATURE VIRGIN	1	IMMATURE
2	MATURING	2	DEVELOPING
3a	MATURE	3a	SPAWNING CAPABLE
3b	MATURE/EXTRUDING-ACTIVE	3b	ACTIVELY SPAWNING
4a	REGRESSING	4a	REGRESSING
4b	REGENERATING*	4b	REGENERATING*

Notes: *Only for females

- For the Elasmobranches, the first 5 stages present many common points between the two scales (WKMSEL and MEDITS). In the WKMSEL, another stage, 4b (regenerating) for females, has been added. It is similar to stage 2 but with enlarged oviductal glands and uterus. It should be added also in the MEDITS scale.
- The WKMSEL scale regards only the oviparous species. During the WS, a new scale for the viviparous species has been created and is being adopted as part of this manual.

Cephalopods maturity scale key

MEDITS SCALE		**WKMCEPH SCALE**	
0	INDETERMINED	0	UNDETERMINED
1	IMMATURE VIRGIN	1	IMMATURE VIRGIN
2a	DEVELOPING	2a	DEVELOPING
2b	MATURING	2b	MATURING
3a	MATURE	3a	MATURE/SPAWNING
3b	SPENT	3b	SPENT

Notes:

No particular differences have been identified between the WKMCEPH scale and the MEDITS one for the cephalopods.

X. Format of the type A files (Data on the haul)

Name	Type	Position	Range	Comments
TYPE_OF_FILE	2A	1 - 2	TA	Fixed value
COUNTRY	3A	3 - 5	See Annex I	ISO Code
AREA	**2N**	6 - 7	**See Annex III**	**GFCM Code**
VESSEL	3A	8 - 10	See Annex I	MEDITS Code
GEAR	5AN	11 - 15	See Annex I	MEDITS Code
RIGGING	4AN	16 - 19	See Annex I	MEDITS Code
DOORS	4AN	20 - 23	See Annex I	MEDITS Code
YEAR	4N	24 - 27		e.g. 2000
MONTH	2N	28 - 29	1 to 12	
DAY	2N	30 - 31	1 to 28/29/30/31	
HAUL_NUMBER	3N	32 - 34	1 to 999	One series by vessel/year
CODEND_CLOSING	1A	35 - 35	S, C	S: without; C: controlled
PART_OF_THE_CODEND	**1A**	36 - 36	**A, M, P, S**	**Mandatory if codend closing = C; A: anterior, M: middle; P: posterior; S sum of the 3 parts**
SHOOTING_TIME	4N	37 - 40	0 to 2400	In UT Ex: 7 h 25 min > 725
SHOOTING_QUADRANT	1N	41 - 41	1, 3, 5, 7	See Annex IV
SHOOTING_LATITUDE	7N	42 - 48	3400 to 4600	Ex: 36° 40,22' > 3640,22.
SHOOTING_LONGITUDE	7N	49 - 55	0 to 3500	Ex: 4° 19,84' > 419,84
SHOOTING_DEPTH	3N	56 - 58	0, 10 to 800	At the trawl position, in meters; unknown: 0
HAULING_TIME	4N	59 - 62	0 to 2400	In UT Ex: 7 h 25 min > 725
HAULING_QUADRANT	1N	63 - 63	1, 3, 5, 7	See Annex IV
HAULING_LATITUDE	7N	64 - 70	3400 to 4600	Ex: 36° 40,22' > 3640,22.
HAULING_LONGITUDE	7N	71 - 77	0 to 2900	Ex: 4° 19,84' > 419,84
HAULING_DEPTH	3N	78 - 80	0, 10 to 800	At the trawl position, in meters; unknown: 0
HAUL_DURATION	2N	81 - 82	5 to 90	In minutes
VALIDITY	1A	83 - 83	V, I	V: valid; I: invalid.
COURSE	1A	84 - 84	R, N	R: rectilinear; N: not rectilinear
RECORDED_SPECIES	2N	85 - 86	See Annex IV	MEDITS code
DISTANCE	4N	87 - 90	1000 to 9999	Distance over ground in meters
VERTICAL_OPENING	3N	91 - 93	10 to 100	In decimeters
WING_OPENING	3N	94 - 96	50 to 250	In decimeters
GEOMETRICAL_PRECISION	1A	97 - 97	M, E	M: measured; E: estimated.
BRIDLES_LENGTH	3N	98 - 100	100, 150 or 200	In meters
WARP_LENGTH	4N	101 - 104	100 to 2200	In meters
WARP_DIAMETER	2N	105 - 106	10 to 30	In millimeters
HYDROLOGICAL_STATION	5A or 2A	107 - 111		National coding or NA if not available
OBSERVATIONS	1N	112 - 112	0 to 9	MEDITS code (Annex IV)
BOTTOM_TEMPERATURE_BEGINNING	**5N or 2A**	113 - 117	**0 to 30**	**in °C with two decimals; NA if not available**
BOTTOM_TEMPERATURE_END	**5N or 2A**	118 - 122	**0 to 30**	**in °C with two decimals; NA if not available**
MEASURING_SYSTEM	**2A**	123 - 124	**see Annex X.a**	**see Annex X.a; NA if not available**
NUMBER_OF_THE_STRATUM	**6AN**	125 - 130	**see Annex II**	
BOTTOM_SALINITY_BEGINNING	**5N or 2A**	131-135	**0 to 50**	**in ppt with two decimals; NA if not available**
BOTTOM_SALINITY_END	**5N or 2A**	136-140	**0 to 50**	**in ppt with two decimals; NA if not available**
MEASURING_SYSTEM	**2A**	141-142	**see Annex X.a**	**see Annex X.a; NA if not available**

Legend
A: alphabetic field; N: numerical field; AN alpha-numeric field
Before the type of the field there is the number of digit allowed for the field (e.g. 2N: numeric field with length 2)
(1) For the invalid hauls (I), no information on species

Annex X.a

System	Code	Notes
Vemco- Minilog TDR -5 to +35 C°	VA	
Star Oddi temperature sensor	SO	
XBT	XA	
SCANMAR	SA	
SIMRAD	SI	
CTD probe	CT	
SBE 56	SB	Temperature logger introduced by GSA19 in 2013
CTD probe SBE 37	CD	

Note: In case a different system is used this should be communicated to the coordinator to get a code.

XI. Format of the type B files (Catches by haul)

Name	Type	Position	Range	Comments
TYPE_OF_FILE	2A	1 - 2	TB	Fixed value
COUNTRY	3A	3 - 5	See Annex I	ISO Code
AREA	**2N**	6 - 7	**See Annex III**	**GFCM Code**
VESSEL	3A	8 - 10	See Annex I	MEDITS Code
YEAR	4N	11 - 14		e.g. 2000
MONTH	**2N**	**15 - 16**	**1 to 12**	
DAY	**2N**	**17 - 18**	**1 to 28/29/30/31**	
HAUL_NUMBER	3N	19 - 21	1 to 999	One series by vessel/year
CODEND_CLOSING	1A	22 - 22	S, C	S: without; C: controlled
PART_OF_THE_CODEND	1A	23 - 23	A, M, P, S	Mandatory if Codend closing = C; A: anterior, M: middle; P: posterior; S sum of the 3 parts
FAUNISTIC_CATEGORY	**3A**	**24 - 26**	**See Annexe V**	**MEDITS code**
GENUS	4A	27 - 30	See Annex XV	Following the Reference List
SPECIES	3A	31 - 33	See Annex XV	Following the Reference List
NAME_OF_THE_REFERENCE_LIST	2A	34 - 35	See Annex XV	NCC or MEDITS FM list
TOTAL_WEIGHT_IN_THE_HAUL	7N	36 - 42	0 to 9999999	For the given species, in grams
TOTAL_NUMBER_IN_THE_HAUL	7N	43 - 49	0 to 9999999 *	For the given species. Should be equal to the sum of the 3 following fields.
NB_OF_FEMALES	7N	50 - 56	0 to 9999999*	
NB_OF_MALES	7N	57 - 63	0 to 9999999 *	
NB_OF_UNDETERMINED	7N	64 - 70	0 to 9999999 *	Undetermined or not determined

Legend
A: alphabetic field; N: numerical field; AN alpha-numeric field
Before the type of the field there is the number of digit allowed for the field (e.g. 2N: numeric field with length 2)
*Not mandatory for faunistic category V,G,H, D, and E, in this case the number will be 0.

Note: the fields, NB_OF_FEMALES, NB_OF_MALES, are mandatory for the years 1994-2011 for the MEDITS target species, while since 2012 NB_OF_FEMALES, NB_OF_MALES are mandatory for the MEDITS G1 species list, unless the individuals are all UNDETERMINED (in TC as well).
In case the species was not a target in 1994-2011 or is not a G1 species since 2012, the field NB_OF_UNDETERMINED should be always filled and should be equal to the field TOTAL_NUMBER_IN_THE_HAUL. The fields, NB_OF_FEMALES and NB_OF_MALES will be 0.

XII. Format of type C files (length and aggregated biological parameters)

Name	Type	Position	Range	Comments
TYPE_OF_FILE	2A	1 - 2	TC	Fixed value
COUNTRY	3A	3 - 5	See Annex I	ISO Code
AREA	**2N**	6 - 7	**See Annex III**	**GFCM Code**
VESSEL	3A	8 - 10	See Annex I	MEDITS Code
YEAR	4N	11 - 14		e.g. 2000
MONTH	**2N**	**15 - 16**	**1 to 12**	
DAY	**2N**	**17 - 18**	**1 to 28/29/30/31**	
HAUL_NUMBER	3N	19 - 21	1 to 999	One series by vessel/year
CODEND_CLOSING	1A	22 - 22	S, C	S: without; C: controlled
PART_OF_THE_CODEND	1A	23 - 23	A, M, P, S	Mandatory if Codend closing = C; A: anterior, M: middle; P: posterior; S sum of the 3 parts
FAUNISTIC_CATEGORY	**3A**	**24 - 26**	**See Annexe V**	**MEDITS code**
GENUS	4A	27 - 30	See Annex XV	Following the Reference List
SPECIES	3A	31 - 33	See Annex XV	Following the Reference List
LENGTH_CLASSES_CODE	1A or 1N	34 - 34	m, 0, 1#	Type of classes: m: 1 mm; 0: 0.5 cm; 1: 1cm
WEIGHT_OF_THE_FRACTION	6N	35 - 40	0 to 999999	Weight of the fraction in the whole haul in grams
WEIGHT_OF_THE_SAMPLE_MEASURED	6N	41 - 46	0 to 999999	Weight of the sample really measured for length, sex and maturity stages (in grams)
SEX	1A	47 - 47	M, F, I, N	M: male; F: female; I: indetermined; N: not determined
NO_OF_INDIVIDUAL_OF_THE_ABOVE_SEX_MEASURED	6N	48 - 53	1 to 999999	Number of individuals of the above sex measured in the sample
LENGTH_CLASS	4N	54 - 57	1 to 9999	Identifier: lower limit of the class in mm; e.g. 30.5-31 cm ->305 (LENGTH_CLASS_CODE:0)
MATURITY	**1N or 2A**	58 - 59	0 to 4; **ND***: Not Determined (allowed from 2012)**	**See Annexes VIIIa-VIIIe. Maturity codes are according to the blue column since 2007 onwards; ND: Not Determined (allowed from 2012 for species G2 and for species G1 only in case staging is particularly difficult, despite the specimens are sexed)**
MATSUB##	**2A**	60 - 61	from A to E; **ND***: Not Determined (allowed from 2012)**	**introduced in 2007; See Annexes VIIIa-VIIIe maturity codes are according to the blue column since 2007 onwards; ND: Not Determined (allowed from 2012 for species G2 and for species G1 only in case staging is particularly difficult, despite the specimens are sexed).**
NUMBER_OF_INDIVIDUALS_IN_THE_LENGTH_CLASS_AND_MATURITY_STAGE	6N	62 - 67	1 to 999999	**No of individuals per maturity stage and length class for a given sex. The length classes without any individual are excluded from the file. The sum of No of individuals per class and sex is the No of individuals measured per sex. When maturiy stage is ND (since 2012) this field is the No per class and sex.**

Legend

A: alphabetic field; N: numerical field; AN alpha-numeric field

Before the type of the field there is the number of digit allowed for the field (e.g. 2N: numeric field with length 2)

* All numerical fields (N) are right justified; all alphanumeric fields (A) fields are left justified

** The word "Fraction" means any sub-group of individual from the total catch of a species (males, females, large sized individuals, small individuals, juveniles, etc.) on which it could be proceed to a sub-sample. For example: total weight = 1000 g which is divided into 100g of big individuals and 900 g of small. The big individuals will be entirely measured (WEIGHT_OF_THE_FRACTION = 100; WEIGTH_OF_THE_SAMPLED_MEASURED = 100). The small ones will be sub –sampled with a ratio of 1/10 (WEIGHT_OF_THE_FRACTION + 900; WEIGTH_OF_THE_SAMPLED_MEASURED = 90)

***Not Determined code (ND) was included in case length measures only were taken, as for the species coded MEDITS G2 in the Annex VI of this manual.

the class of 1 cm is allowed until 2012 as in the past years some species could have been measured at 1 cm.

##this field should be specified even when stage is 1 or 2 (in this case the field is NA) it cannot be 0 or empty.

XIII.A. Format of type E files (biological parameters at individual level)

Name	Type	Position	Range	Comments
TYPE_OF_FILE	2A	1 - 2	TE	Fixed value
COUNTRY	3A	3 - 5	See Annex I	ISO Code
AREA	**2N**	6 - 7	**See Annex III**	**GFCM Code**
VESSEL	3A	8 - 10	See Annex I	MEDITS Code
YEAR	4N	11 - 14		e.g. 2000
MONTH	**2N**	**15 - 16**	**1 to 12**	
DAY	**2N**	**17 - 18**	**1 to 28/29/30/31**	
HAUL_NUMBER	3N	19 - 21	1 to 999	One series by vessel/year
FAUNISTIC_CATEGORY	**3A**	**22 - 24**	**See Annexe V**	**MEDITS code**
GENUS	4A	25 - 28	See Annex XV	Following the Reference List
SPECIES	3A	29 - 31	See Annex XV	Following the Reference List
LENGTH_CLASSES_CODE	1A or 1N	32 - 32	m, 0	Type of classes: m: 1 mm; 0: 0.5 cm
SEX	1A	33 - 33	M, F, I, N	M: male; F: female; I: indetermined; N: not determined
NO_PER_SEX_MEASURED_IN_SUB_SAMPLE_FOR_OTOLITH	6N	34 - 39	0 to 999999	Number of individuals of the above sex measured in the sub-sample for otolith
LENGTH_CLASS	4N	40 - 43	1 to 9999	Identifier: lower limit of the class in mm; e.g. 30.5-31 cm ->305 (LENGTH_CLASS_CODE:0)
MATURITY	1N	44 - 44	0 to 4	See **Annexes VIIIa-VIIIe** maturity codes are according to the blue column
MATSUB	1A	45 - 45	from A to E or O	See **Annexes VIIIa-VIIIe** maturity codes are according to the blue column. The code O is used in case of omitted maturity sub-stage.
INDIVIDUAL_WEIGHT	6N or 2A	46 - 51	0.1 to 999999; ND: not determined	It is mandatory only for the species in List G1. See **Annex VI.** The weight is in grams and decimals are allowed (e.g. 2.5)
NO_PER_SEX_MEASURED_IN_SUB_SAMPLE_FOR_WEIGHT	6N	52 - 57	1 to 999999	Number of individuals of the above sex measured in the sub-sample for individual weight. In case otoliths are taken, individual weight should be reported
OTOLITH_SAMPLED	2A	58 - 59	Y or N* for Teleosts and NR for the other species	Y: otolith sampled; N: otolith not sampled; NR: not requested; for species in G1 list see **Annex VI**
NO_PER_SEX_MEASURED_IN_SUB_SAMPLE_FOR_AGEING	6N	60 - 65	0 to 999999	Number of individuals of the above sex measured in the sub-sample for ageing
OTOLITH_READ	2A	66 - 67	Y or N for Teleosts and NR for the other species	NR: not requested; Y: otolith read; N: otolith not read
AGE	4N or 2A	68 - 71	-1 to 99 for Teleosts, UR for unreadable, NR for the other species; -1 reading in progress or length class completed	Also decimal number for age (e.g. 10.5); NR: not requested; for species in G1 list see **Annex VI** UR unreadable otolith
OTOLITH_CODE	35AN	72 - 106	[Country][GSA][Vessel][Year][Haul][Genr_Spec][Stage][Sex][Length][individual code]	ITA10PEC2012100MULL_BAR2AM110_xxxxx
RECORD_NUMBER	N	107-113	0 to 100.000	Record identifier by year

Legend
A: alphabetic field; N: numerical field; AN alpha-numeric field
Before the type of the field there is the number of digit allowed for the field (e.g. 2N: numeric field with length 2)
NR species for which ageing is not requested
*in case, for example, the individual is sampled for the individual weight only
This table will be filled in only for specimens (already entered in TC) for which <u>individual</u> measures have been collected

Note: Otolith Code with underscore at the sub-maturity stage, if the maturity stage is only numerical.

Note: LENGTH_CLASSES_CODE and LENGTH_CLASS between TC and TE should be consistent.

XIII.B. Format of type L files (litter recording)

Name	Type	Position	Range	Comments
TYPE_OF_FILE	2A	1-2	TL	Fixed value
COUNTRY	3A	3-5	See Annex I	ISO Code
AREA	2N	6-7	See Annex III	GFCM Code
VESSEL	3A	8-10	See Annex I	MEDITS Code
YEAR	4N	11-14		e.g. 2000
MONTH	2N	15-16	1 to 12	
DAY	2N	17-18	1 to 28/29/30/31	
HAUL_NUMBER	3N	19-21	1 to 999	One series by vessel/year
LITTER_CATEGORY	2AN	22-23	from L1 to L9 and L0 (no litter)	See Annexe XVII
LITTER_SUB-CATEGORY	1A or 1N or 2A	24	from a to j or 0	See Annexe XVII or NA
TOTAL_WEIGHT_IN_THE_ CATEGORY_HAUL	7N or 2A	25-31	0 to 9999999	For the given category, in grams (facultative) or NA
TOTAL_NUMBER_IN_THE_CATEGORY_HAUL_	7N	32-38	1 to 9999999	For the given category
TOTAL_WEIGHT_IN_ THE_SUB-CATEGORY_ HAUL	7N or 2A	39-45	0 to 9999999	For the given sub-category, in grams (facultative) or NA
TOTAL_NUMBER_IN_ THE_SUB-CATEGORY_ HAUL	7N or 2A	46-52	0 to 9999999	For the given sub-category (facultative) or NA

XIV. Protocol for sampling otoliths, individual weight and maturity stages of MEDITS target species

Adopted during the MEDITS meeting, Ljubljana (Slovenia), 6-8/03/2012

A document with an overview on this subject was prepared by Maria Teresa Spedicato and circulated to the group. This document was discussed during the MEDITS coordination meeting (Ljubljana, Slovenia, 6-8/03/2012) and is attached as Annex 6 to this Coordination meeting report.

The decisions taken during the MEDITS coordination meeting in Ljubljana (Slovenia, 6-8/03/2012) based on the above mentioned document are reported in this annex and represent the sampling protocol to collect the biological information related to otoliths, individual weight and maturity stage by sex from MEDITS survey in 2012.

Objectives

The MEDITS meeting held in Nantes on 15-17 March 2011 agreed to increase the information recorded during the MEDITS survey, including the monitoring of new biological variables, such as age of bony fish species coded G1 in the new list of target species, and individual weight of all the species coded G1 in the same list. Data on the Maturity Stages for the same species should also be collected.

Age monitoring of bony fish, which implies otolith sampling, requires a common protocol to harmonise sampling technique, sample size, and information recording.

It is thus important to first identify the objectives of the new implementation.

Sampling otoliths can be aimed to:

1) estimate indices of abundance at age and monitoring of stock structure along the time;
2) monitor the spatial distribution of age groups;
3) use length at age data to estimate growth curves;
4) estimate structured survey indices to be used in tuning procedures for stock assessment;
5) use age data to estimate, in particular, the probability reaction norm of maturation (PRNM) i.e. the indicator n. 4 of the DCF.

Monitoring of individual weight can be aimed to:

1) estimate length-weight relationship of target species;
2) estimate growth curve in weight, if also otoliths are sampled;
3) estimate the condition factor of the sampled species as a welfare indicator of wild population;
4) use weight at length to estimate the ecosystem indicator that requires individual weight (as plarge in the DCF).

Monitoring of maturity can be aimed to:

1) estimate the indices of abundance, trends and spatial distribution by life stage (e.g. spawner).

Sampling frame

A sampling protocol that enables the simultaneous fulfilment of all these objectives is preferable, in terms of costs and sampling effort.

The group decided to adopt the ***length-stratified random sampling in which a fixed number of individuals are randomly collected from each length class by sex to take otoliths, individual weight and maturity stages.***

This let lean towards the ALK-like sampling, that is also the one adopted in the trawl surveys carried out in Europe, like in Evohe and IBTS.

Regarding the G1 species for which otoliths should not be sampled, the sample size for individual weight and maturity stages will be set according to a similar framework as for the species sampled for otoliths, as specified in the table 2. The precision of the body weight will be 0.1 grams.

Sampling requirements and size

The following criteria were taken into account to set the sample size for each length class:

- for the smallest size groups, that presumably contain only one age group, the number of otoliths per length class may be reduced. Conversely more otoliths per length are required for the larger length classes (see Tab. 1 as a general criterion);
- for estimating indicator n. 4, a number of 100 individuals by age class is required, mainly at maturity stages 2a, 2b, 2c and 3. Thus, to identify a criterion for balancing the number of individuals by length class, avoiding an oversampling of the juveniles, the $L_{m25\%}$ (length at 25% maturity) was chosen as a reference size (lower bound among different estimates if available) for collecting a higher number of individuals in the higher length classes, as these likely account for a larger portion of the length frequency distribution. If information of $L_{m25\%}$ is not available the criterion will be to take a higher sample if the portion of the length class is more than 5% (see Tab. 1).
- sex, maturity and individual weight data should be reported for all the target species for which otoliths and age data are collected and for all the G1 species of the MEDITS list;
- for individual weight and maturity stage samplings, the number of individuals per length class may be reduced for the smallest size groups, conversely more individuals per length are required for the larger length classes; by analogy with the second dash $L_{m25\%}$ can be a reference size for collecting a higher number of individuals. If information of $L_{m25\%}$ is not available the criterion will be to take an higher sample if the portion of the length class is more than 5% (see Tab. 1).
- targets should be set to ensure that data are collected from the entire survey area;
- participants are encouraged to collect age samples also from other commercially important species and any other species deemed important to the DCF.

The optimum number of otoliths per length class cannot be given in a universal form and the number of individual weight and maturity stage as well.
A description of the optimum sample size of age readings and length measurements dependent on a universal cost function is given in Oeberst (2000). According to Mandado and Vasquez (2011) a sample of 20 otoliths in a stratified sampling by length class was considered the optimum for a species with 30-40 length classes. Experiences gathered in the DCF for samplings of commercial catches in Italian GSAs evidenced an acceptable coefficient of variations (around 5%) when sampling 5 otoliths by sex per length class (0.5 or 1 cm depending on the species).
The analyses showed that the necessary number age readings in a length class depend on (AA.VV., 2011):

- the portion of the length class within the length frequency,
- the maximum variance of the portions of the age-groups within the length class.

The table 1 below gives for BITS (AA.VV., 2011) a criterion for establishing the minimum number of otoliths by length class.

Table 1 – Minimum number of otoliths by length class in BITS survey (AA.VV., 2011).

Criterion	Sample size
With probably only one age-group (age-group 0, 1)	**2 to 5**

With probably more than on age-group	
Portion of the length class less than 5%	**10**
Portion of the length class more than 5%	**20**

The above criteria hold also for establishing the minimum number for collecting individual weight and maturity stages data.

Therefore, the number of individuals suggested in the IBTS survey protocols (AA.VV., 2010a, b) for the same species as in MEDITS, or for species with comparable number of size classes, can be taken into consideration as a first approximation. In addition, the requirements for the calculation of the indicator n. 4 of DCF, for which a number of 100 otoliths per age class by sex can be considered suitable for the indicator estimate, should be also taken into account.

In the following table 2, a sample size is proposed for the MEDITS species coded as G1 in the new list of target species (Annex VI of this report).

Table 2 – Sample size by length class and sex proposed for otoliths, individual weight and maturity stages for the MEDITS species coded as G1 in the new list of target species. The spatial coverage is the GSA.

Species	**length class**	**sample size**	**sex**
Merluccius merluccius	**1 cm**	**5 otoliths**	**by sex (<Lm25%)**
		10 otoliths	**by sex (>=Lm25%)**
Mullus barbatus	**0.5 cm**	**6 otoliths**	**by sex (<Lm25%)**
		14 otoliths	**by sex (>=Lm25%)**
Mullus surmuletus	**0.5 cm**	**6 otoliths**	**by sex (<Lm25%)**
		14 otoliths	**by sex (>=Lm25%)**
Crustaceans	**1 mm**	**6 individuals**	**Juveniles ((<Lm25%) or portion of the length class less than 5%)**
		14 individuals	**by sex (>=Lm25%)**
Cephalopods*	**0.5 cm**	**6 individuals**	**Juveniles ((<Lm25%) or portion of the length class less than 5%)**
		30 individuals	**by sex (>=Lm25%)**
Elasmobraches	**1 cm**	**5 individuals**	**Juveniles ((<Lm25%) or portion of the length class less than 5%)**
		10 individuals	**by sex (>=Lm25%)**

*the number of individuals per length class is increased for cephalopods taking into account the higher variability of individual weight.

After analysing the characteristics of the G1 MEDITS species and the requirements of the indicator n. 4 of DCF, *P. erythrinus* has been excluded, because the sexual hermaphrodite pattern makes the attribution to a sex from year to year uncertain.

It is expected that for the species in table 2 the number of otoliths required for the estimation of indicator n.4 in the DCF should be fulfilled.

It is recommended that otoliths, individual weight and maturity stages are collected in each haul. This would avoid autocorrelation in the sample (e.g. individuals belonging to the same school).

For example 1-2 individuals should be taken per length class and haul, or 1 fish every 10 fish per length class and haul as in the Evhoe survey. However this specific approach will be adapted to the characteristics of each GSA. Otolith are then dried stored for later age determination.

Consequently, the number of fish selected for otolith extraction, should be equal to the number of fish for which individual weight, sex and maturity stage are obtained.

For those species for which otoliths are not taken, the number of fish selected for measuring individual weight, sex and maturity stage are equal to the numbers suggested for age reading.

In some vessels or in particular weather conditions during the MEDITS survey, individual weight cannot be measured accurately and the use of frozen samples is unavoidable. Thus, it is recommended to develop conversion factors between fresh and frozen samples.

Estimates of abundance indices at age

After the age distribution is allocated to the length distribution, the age based indices are calculated. The precision of the ALK can be estimated using the method of Baird (1983) or Oeberst (2000).

In the estimates of the abundance indices at age, it is necessary to compute the average numbers at length and associated variances as a first step.

The mean stratified standardization formulas by Souplet (1996) shall be used for the computation of average numbers at length and associated variances by stratum (formulas (1) and (2) below) and for the total area (formulas (3) and (4) below):

$$\bar{x}_{k,j} = \frac{\sum_{h=1}^{H} x_{h,k,j}}{\sum_{h=1}^{H} A_{h,k}} \qquad (1)$$

$$V(\bar{x}_{k,j}) = \frac{1}{H-1}\sum_{h=1}^{H} A_{h,k}\left(\frac{x_{h,k,j}}{A_{h,k}} - \bar{x}_{k,j}\right)^2 \qquad (2)$$

$$I_j = \sum_{k=1}^{K} W_k * \bar{x}_{k,j} \qquad (3)$$

$$V(I_j) = \sum_{k=1}^{K} \frac{W_k^2 S(\bar{x}_{h,j})^2}{\sum_{h=1}^{H} A_{h,k}}(1-f_k) \qquad (4)$$

where:

$x_{h,k,j}$ is the number of individuals in the haul *h* of the stratum *k* and length class *j*;

$A_{h,k}$ is the swept area of haul *h* in stratum *k;*

$\bar{x}_{k,j}$ is the average number at length *j* in the stratum *k;*

$V(\bar{x}_{k,j})$ is the variance of the average number at length *j* in the stratum *k;*

W_k is the stratum weight calculated as the area of stratum *k* divided by the GSA area;

I_j is the abundance index of the length class *j*;

$V(I_j)$ is the variance of the abundance index of the length class;

f_k is the finite population correction factor.

In a second phase, when building the age-length key, the computation of the proportions at age *i* per length class *j* and associated variances is computed as:

$$p_{i,j} = \frac{n_{i,j}}{n_j} \qquad (5)$$

$$V(p_{i,j}) = \frac{p_{i,j}(1-p_{i,j})}{n_j}$$ **Errore. Il segnalibro non è definito.**

(6)

where :

$n_{i,j}$ is the number of otoliths of age *i* in the length class *j*;

n_j is the total number of otolith in the length class *j*;

$p_{i,j}$ is the proportion of age *i* in the length class *j;*

$V(p_{i,j})$ is the variance of the proportion of age *i* in the length class *j*.

In a third phase, the computation of mean numbers at age and the associated variances are computed. The mean numbers at age are given by :

$$I_i = \sum_{j=1}^{J} I_j * p_{i,j} \qquad (7)$$

and the associated variance is:

$$V(I_i) = \sum_{j=1}^{J} \left[V(I_j) p_{i,j}^2 + I_j^2 V(p_{i,j}) + V(p_{i,j}) V(I_j) \right] \qquad (8)$$

where

I_i is the abundance index of the age class *i* and $V(I_i)$ its variance.

These computations are done by sex and the total age composition is given for each age *i* by:

$$Itot_i = Ima_i + Ife_i \qquad (9)$$

its variance is:

$$V(Itot_i) = V(Ima_i) + V(Ife_i) \qquad (10)$$

and the sampling being independent on sex the covariance is not considered.

References

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AA.VV. 2010b - ADDENDUM 2: IBTS MANUAL ON THE WESTERN AND SOUTHERN AREAS Revision III-Agreed during the meeting of the International Bottom Trawl Survey Working Group 22–26 March 2010, Lisbon. ICES web site: http://datras.ices.dk/Documents/Manuals/Manuals.aspx

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Oeberst R. 2000. An universal cost function for the optimization of the number of age readings and length measurements for Age-Length-Key-Tables (ALKT). Arch. Fish. Mar. Res. 48(1): 43–60.

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XV. TM list of species codes

TAXONOMIC LIST OF THE MEDITERRANEAN
to be used in the trawl surveys
Name of the list: TM

The present list is destined to code the marine species encountered in the Mediterranean. It has been built following the principle used in the Nordic Code Centre (Stockholm). For most of the species the codes are identical to those proposed by the NCC. However some species can be coded differently. In addition numerous Mediterranean species are not included in the NCC code and have been added. So the present list is specific. It has to be referred as the TM list (Taxonomic list not only Faunistic, FM list).

The first fish list has been established according to the following work:

Hureau J.-C. et Th. Monod (réd.), 1973. Catalogue des poissons de l'Atlantique du nord-est et de la Méditerranée. Unesco, Paris, Vol I, xxii + 683 p.; vol II, 331 p. [réimpression comprenant le *Supplément 1978*, par E. Tortonese et J. -C. Hureau (réd), en 1979]. The reference of the species following this work is reported as "C" (for Clofnam) in the column "Source" with number which is attributed to this species in the Catalogue in the column "Reference".

This list has been increased with reference to the following works:

- Fisher W., M.L., Bauchot et M. Schneider (rédact.), 1987. Fiches FAO d'identification des espèces pour les besoins de la pêche. (Révision 1). Méditerranée et mer Noire. Zone de pêche 37. Volume I. Végétaux et Invertébrés. Volume II. Vertébrés. Publication préparée par la FAO, résultat d'un accord entre la FAO et la Commission des Communautés Européennes (Projet GCP/INT/422/EEC) financée conjointement par ces deux organisations. Rome, FAO, 1530 p.

The reference of the species coming from this book are reported as "F" (for FAO) in the "Source" with the reference given to this species. Important reference are also the three volumes of FNAM: Whitehead *et al*., 1984, 1986 (W).

For most of the Invertebrates, the species have been named according to the following works:

- Zariquiey Alvarez R., 1968. Crustaceos decapodos ibéricos. Invest. Pesq. 32, 510 p.
- Riedl R., 1963. Fauna und flora der Adria. Paul Parey Ed. – 640 pp.

The references to these works are mentioned as Z and R respectively in the column "Source" (see other references below).

Until 2011 the source file of this list was located at the "Ecologie et modèles pour l'halieutique" department of Ifremer in Nantes.

In 2012 the list has been review by the Società Italiana di Biologia Marina (prof. Giulio Relini and dr. Alessandro Mannini) following the subdivision in the following main categories:

A fishes, B Crustaceans (Decapoda, Cirripedia, , Eufausiacea, Isopoda, Stomatopoda), C Cephalopods, D Other commercial (edible) species, E Other animal species but not commercial (not edible) for this classification the main references is Fisher *et al*. 1987, *Fiches FAO* d'*identification* des *espèces* pour les *besoins* de la *pêche*. *Méditerranée et mer Noire*. mimeo

Six more categories were added:

- G = portions or products of animal species (shell debris, eggs of gastropods, selachians, etc.);
- H = portions or products of vegetal species (e.g. leaves of sea grasses, of terrestrial plants, etc.);

- M = Mammalia (mammals);
- O = Aves (birds);
- R = Reptilia (turtles);
- V = Plantae (vegetals).

The categories A, B, D E were sub-divided in the following subcategories:

-Aa = Fish Agnata;
-Ae = Fish Chondrichthyes;
- Ao = Fish Osteichthyes;
- Bam = Amphipoda;
- Bci = Cirripedia;
- Bis = Isopoda;
- Beu = Euphausiacea;
- Bst = Stomatopoda
- Dec/ Eec = Echinodermata;
- Dmb/Emb = Mollusca Bivalvia;
- Dmg/Emg = Mollusca Gastropoda;
- Dmo/Emo = Mollusca Opisthobranchia;
- Dtu/ Etu = Tunicata;
- Ean = Annellida;
- Eba = Brachiopoda;
- Ebr = Bryozoa;
- Ech = Echiura;
- Ecn = Cnidaria;
- Ect = Ctenophora;
- Ehi = Hirudinea;
- Emp = Polyplacophora;
- Ene = Nemertea;
- Epo = Polychaeta;
- Epr = Priapulida;
- Esc = Scaphopoda;
- Esi = Sipuncula;
- Esp = Porifera (sponges).

In addition the following codes were added (column ‘Remarks’ in the list)

AL = alien species
Δ = species not yet recorded in the Italian Seas.
ΔΔ = species not yet recorded in the Mediterranean Sea

CODLON represents the Length classes code: m = 1 mm; 0 = 0,5 cm; 1 = 1 cm;

In the column “GSAs” are reported the GSAs in which the taxon was recorded.

In the column ‘Year’ of the table the year in which the species was recorded for the first time is reported,

Other new codes for new species could be added.

It was decided to not consider species lower than 1 cm like Isopoda, Amphipoda, small Polychaets etc. For the moment the species listed in the previous version (Relini *et al*., 2008) are maintained.

It was decided for the moment to maintain, when applicable, two codes for one species and to avoid the presence of the same code for different genus (the first 4 letters of the species code). The species (taxon) codes included in the data tables are based on the TM list. So, to maintain the consistency of the data series, they cannot be changed even if a species name is reviewed.

The codes are reported in alphabetical order in the list.

Codes of source column are:

C = Clofnam (Hureau and Monod, 1973);
F = Fisher *et al*., 1987;
G = Golani *et al*., 2002;
P = Guerra, 1992;
R = Riedl 1968 (Italian editions 1991) ;
T = Tortonese, 1965;
Y = Galil *et al*., 2002;
Z = Zariquiey 1968.

All the problems dealing with the list and in particular introduction of new species will be managed by the following WG: Giulio Relini (leader), Enric Massuti, Angelique Jadaud, Porzia Maiorano and Eugenia Lefkaditou. Proposals for new species will be sent to Giulio Relini (See **Annex V**).

To know the valid scientific name of species present in Italian seas the main reference is the checklist of Fauna and Flora of Italian seas (Relini, 2008; 2010). WoRMS (World Register of Marine Species) was checked for updating the scientific name, when applicable.

Regarding the alien species the recent papers by Galil (2011) and Zenetos et al. (2012) have been taken into account.

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TM MEDITS list (2017 updated)

The TM list updated to 2017 is available in electronic format at the following web site: http://www.sibm.it/MEDITS%202011/principale%20project.htm

XVI - Technical specifications and quality check of the Medits gear

by Antonello Sala (ISMAR, CNR, Italy).
This paper is presented for consideration by MEDITS Coordination group and may contain unpublished data, analyses, and/or conclusions subject to change. Data contained in this paper should not be cited or used for purposes other than the work of the MEDITS programme, or their subsidiary bodies without the permission of the originators/owners of the text.

XVI.1 - Guidelines for the gear quality control

XVI.1.1 - Towing cable

Check/measure with a calliper the warp diameter. It is important as the warp length/depth relationship must be in agreement with the table in Fig. 7 of this Handbook.

XVI.1.2 Otterboard

Assuming that the otterboard is the Morgere WS 8 type, measurement of the otterboard length and height can be easily carried out ashore, they must be 2050 and 1250 mm respectively.
See Figure 6 of this Handbook for the rigging, check the upper- and lower-backstrops they must be 65 cm, while the middle chain must be 160 cm. If you have to shorten the chain of one or some links in only one otterboard, it is recommended you replace the entire backstrops in both the otterboards.

XVI.1.3 Bridles and combination rope

To regularly check the respect of the protocol for all the components that could be altered by the use. For example the last protocol adopted provides that the upper- and lower-bridles have the same length. But because the lower one is a combination rope, it is subject to lengthen after some period of work at sea. The same is not true for the upper bridle which is made of steel. The result is that, after a certain period of time, the lower bridle could become longer than the upper one. The resulting extension affects the gear behaviour by decreasing the vertical net opening and increasing the bottom contact.
See Figure 2 of this Handbook. The combination rope (100 or 150 m and the lower bridle 29 m) is made of two parts: an external in PP and an internal part in steel. The nominal outer diameter should be 32 mm of PES 4 strands (see Figure 2) having an internal part (not defined before creating the current manual) of a metallic cross-section of approx. 36 mm^2. As also the internal diameter of the current combination ropes must be standardized, a check with your local company producer/manufacturer is required, take notes and communicate the values to the MEDITS coordinator. It is the internal part that is relevant for the weight of the rope, and the weight might affects the trawl openings. In the future such information will be included in the Handbook revision.

XVI.1.4. Floats

Detailed information on the floats is provided in the text of this manual.
The main checks are:
- check there are 40 floats on the headline;
- their diameter should be of around 20 cm;
- the 40 floats should be distributed along the headline:
  - from each wing tip, one float every 1.50 m for 5 times;
  - one pair of floats every 1.50 m on the whole remaining length;
  - in the headline (bosom) a small adjustment of the spacing might be necessary.

As specified at the section 1.1 of this Handbook, the individual buoyancy of the floats should

be 2.7 kgf (±5%), the total buoyancy of the 40 floats being around 108 kgf (±5%).

XVI.1.5. Bolchline, ballast chain

Bolsh- or bolchline. Rope attached along edge of lower wings and bosom netting (Figure XVI.1.1) for securing in bights to fishing line (ref. Multilingual dictionary of fishing gear, 1992). The bolchline and footrope must have the same length, that is 40 m, and can be measured as showed for the headline. The footrope is made of stainless steel covered by a twisted polypropylene (PP) rope and is connected in bights to the bolchline through metal rings. On the lower side of the footrope, the ballast chain (10 mm, 2 kg/m) is connected in bights to the footrope (Figure 3 of this Handbook).

The main checks required are:

- distance between the bolchline and the footrope must be 5 cm;
- the bightings between the bolchline and the footrope must have a distance of 50 cm;
- ballast chain has bightings every 17 cm and the inner height must be 8 cm;
- check (with the company manufacturer/provider) that the ballast chain is of 2 kg/m.

As the Operative Units have different number of hauls to perform each cruise and the differences in the ballast chain might affect the performance of the GOC73, it is highly recommended to have a new ballast chain at the beginning of every cruise in order to avoid any wear and tear effect on the chain.

Practical example for the calculation of the total ballast chain weight by respecting the standard MEDITS requirements:

Footrope length	40 m
Bight distance	17 cm (0.17 m)
Number of bights	40 / 0.17 = 235
Chain length for each bight	25.72 cm *(e.g. application of the arc formulae)*
Total ballast chain length	235 x 25.72 = 6044 cm (60.44 m)
Total ballast chain weight	60.44 x 2 kg/m = **120.88 kg**

The rigging of the ballast chain is important to keep constant the overall ballast chain weight. An example in the following table shows the effect of a small variation in the bight distance/height on the chain weight (e.g. *blue is the correct value*).

Bights distance [cm]	**20**	**20**	**17**	**17**
Bights height [cm]	8	10	8	10
Total chain length [cm]	55.30	62.80	60.44	70
Total chain weight [kg]	**110**	**125**	**120**	**140**

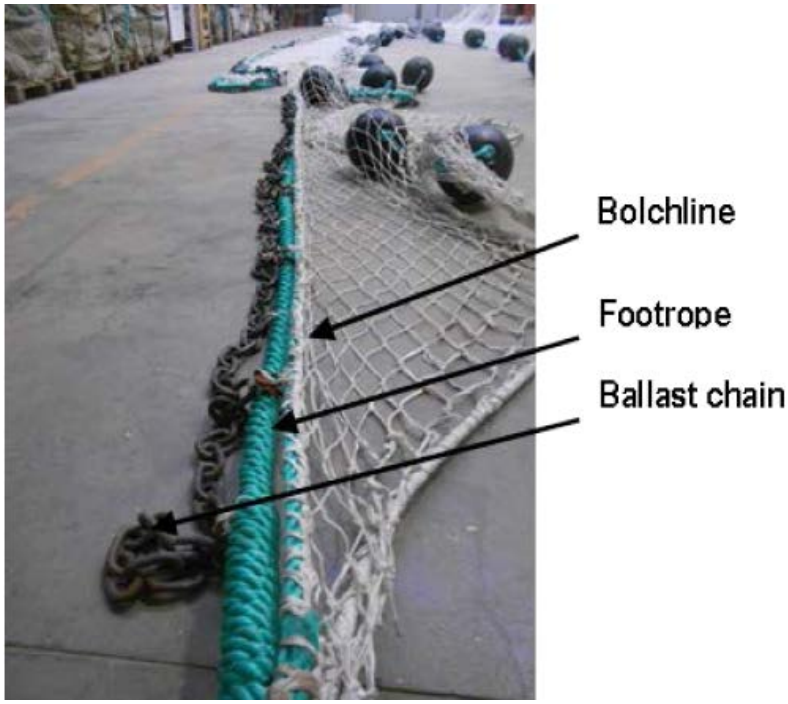


Figure XVI.1.1 - Particular of the bolchline, footrope and ballast chain in the GOC73.

Figure XVI.1.2. In (a) measurement of the distance between the bolchline and the footrope (5 cm) and (b) between the bightings on the bolchline (50 cm).

Figure XVI.1.3. In (a) Measurement of the distance between ballast chain bights (17 cm) and (b) of the inner height of the chain bightings (8 cm). Having such rigging the total weight of the chain must be around 120 kg. (c) supplementary chain (only one chain) of 15 kg (around 6.50 m and a diameter of 10 mm).

XVI.1.6. Headline, footrope and sideline

The main checks are:

- the groundrope (40 m) must be 4.30 m longer than the headline (35.70 m);
- the length of the groundrope and headline must be compared. The length is adjusted by means of the adjustment chain on the groundrope.

Both the headline and the groundrope must be measured by dividing the rope in three parts. Having Figure 1 of this Handbook as reference, for the headline we have 2.90 m (b) at the bosom, two pieces of 10.40 m (c) and 6.00 m (d) for a total of 35.70 m. While for the footrope, we have 2.90 m (g) at the bosom, two pieces of 12.65 m (h) and 5.90 m (i) for a total of 40.0 m. See Figure XVI.1.5, Figure XVI.1.6 and Figure XVI.1.8.

The weighting chain (*ballast chain*) of 120 kg (Nr. 3 × 40 m) should be secure to the footrope every 17 cm (with a hanging height of at most 8 cm). A supplementary chain (only one chain) of 15 kg (around 6.50 m and a diameter of 10 mm) should in addition been secured symmetrically on both parts of the belly bosom in the same way as the first one (garland of 17 cm in length).

Figure XVI.1.4. Measurement of the headline at the bosom level. We measured 1.46 m, which multiplied by two is 2.92 m.

Figure XVI.1.5. Measurement of headline at wings. The measurement should start from the end of the bosom (see the transversal seams) to the end of the wing. The headline in this part should be 10.40 m (c).

Figure XVI.1.6. Measurement of headline at wing tips. The measurement should start from the end of the wing to the end of the line. The headline in this part should be 6.00 m (d).

XVI.1.7. Trawl netting

Referring to the GOC73 acronyms in Figure XVI.1.8, the nettings in the upper-panel have been defined with the letter A, while the nettings in the side-panels with the letter B and with the letter C the nettings in the lower-panel. Furthermore, the number after the letters define the level of each netting: *e.g.* same number means same level and, as it can be seen in the GOC drawing of Figure XVI.1.8, the nettings with the same numbers have the same height.

The height of a netting (*H*) is calculated by multiplying the stretched mesh size (*MS*) of the netting by the number of meshes in height:

(*NH*): *H=MSxNH*.

In general the design of any trawl is conceived to distribute the net drag not homogeneously among the upper- (UP), lower- (LP) and side-panel (SP). In order to guarantee a correct trawl bottom contact, the UP has more drag than the LP, so that during towing the UP is more stretched while the LP is slacked. Despite the equal longitudinal number of meshes both in the UP and LP, the unequal drag distribution may cause a different stretching of the twines, resulting in a different effective panels length. For this reason, prior to any field cruise, all the nettings need to be measured in the longitudinal axis (N-direction), without considering seams. Normally, the different action of the drag on the three panels will cause that the upper nettings are more likely to be stretched; the lower nettings tend to shrink, and the side nettings are almost in a neutral situation.
Considering the schematic view of the GOC73 drawing with acronyms on pieces of netting provided in Figure XVI.1.8, the side nettings B6/B7/B8/B9 must be considered for the reasons abovementioned as reference nettings to be compared on with the respective upper- (A6/A7/A8/A9) and lower-nettings C6/C7/C8.

Before proceeding in explaining the procedures for the netting checks, it is important to define the transverse- and the longitudinal-seam meanings (Figure XVI.1.7).
The **transverse seams** join two nettings in the transverse direction (T), they are the references for the measurement of the netting height. While the **longitudinal seams** (strengthening lacing) join two nettings in the longitudinal direction (N) and they are rows of meshes laced together in order to strengthen the netting.

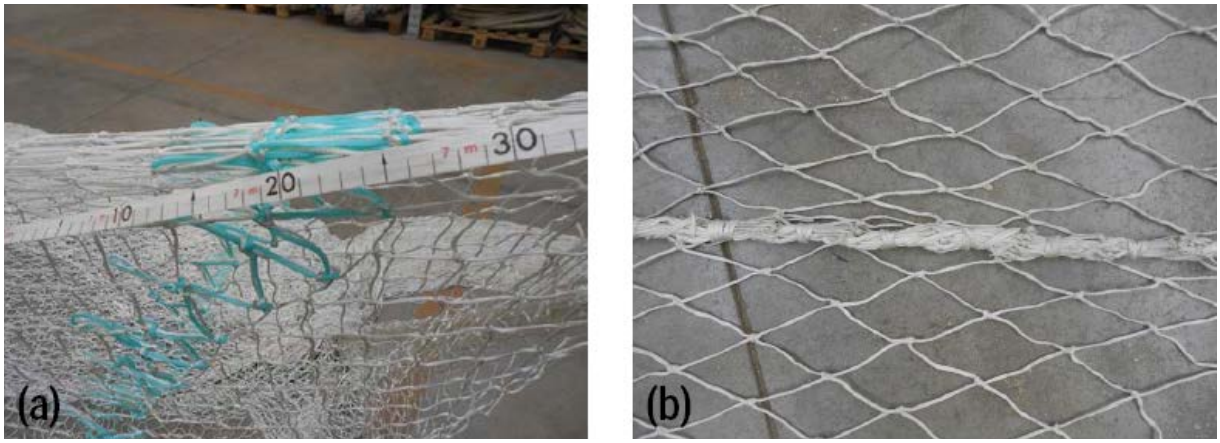


Figure XVI.1.7. The transverse seams (a) join two nettings in the transverse direction (T), they are the references for the measurement of the netting height. The longitudinal seams (b) or strengthening lacing join two nettings in the longitudinal direction (N). They are rows of meshes which may be laced together in order to strengthen the netting.

The main check is to check that all the nettings at the same level have the same height.
To speed up simplify the proceedure step-by-step for each netting from B6 to B8:

1. calculate the netting height of the side panel (B6): *H=NHxMS*, where *NH* is the number of meshes in height (N-direction) and *MS* is the stretched mesh size. For B6 is then: *H(B6)=60x120=7200 mm*.

2. After having verified the coherence of the height of the side netting (B6) with the design of the GOC 73 (Figure 1 of this Handbook), identify the beginning and the end of the netting you have to compare with (A6) by looking at the transverse seams and then align the transverse seams of A6 with those of B6. Always align the center part of the nettings and not the lateral part. To facilitate the comparison of the netting heights, you have another possibility, that is measuring with a meter

both the upper- and the lower- netting avoiding the abovementioned seams alignment procedure;

3. In case of differences we have two options:
   a. change the whole lower- or upper- netting. It allows to restore the original netting properties and it is the best solution with wear-and-tear nettings or when nettings have been fouled by obstructions on the sea bed. But it is more expensive than net mending;
   b. remove or add rows of meshes in the upper- or lower- panel (net mending). It is cheaper than replacing with a new netting (recommended only if a netting has been mended 1-2 times), but it results in a changing of the net drawing.

The total height of codend and extension nettings (A1+A2, see Figure XVI.1.1), must be equal to the length of the selvedge rope (line *a* in Figure XVI.1.1). Then it must be *H(A2+A1)=a=40x100+20x250=9000 mm*.

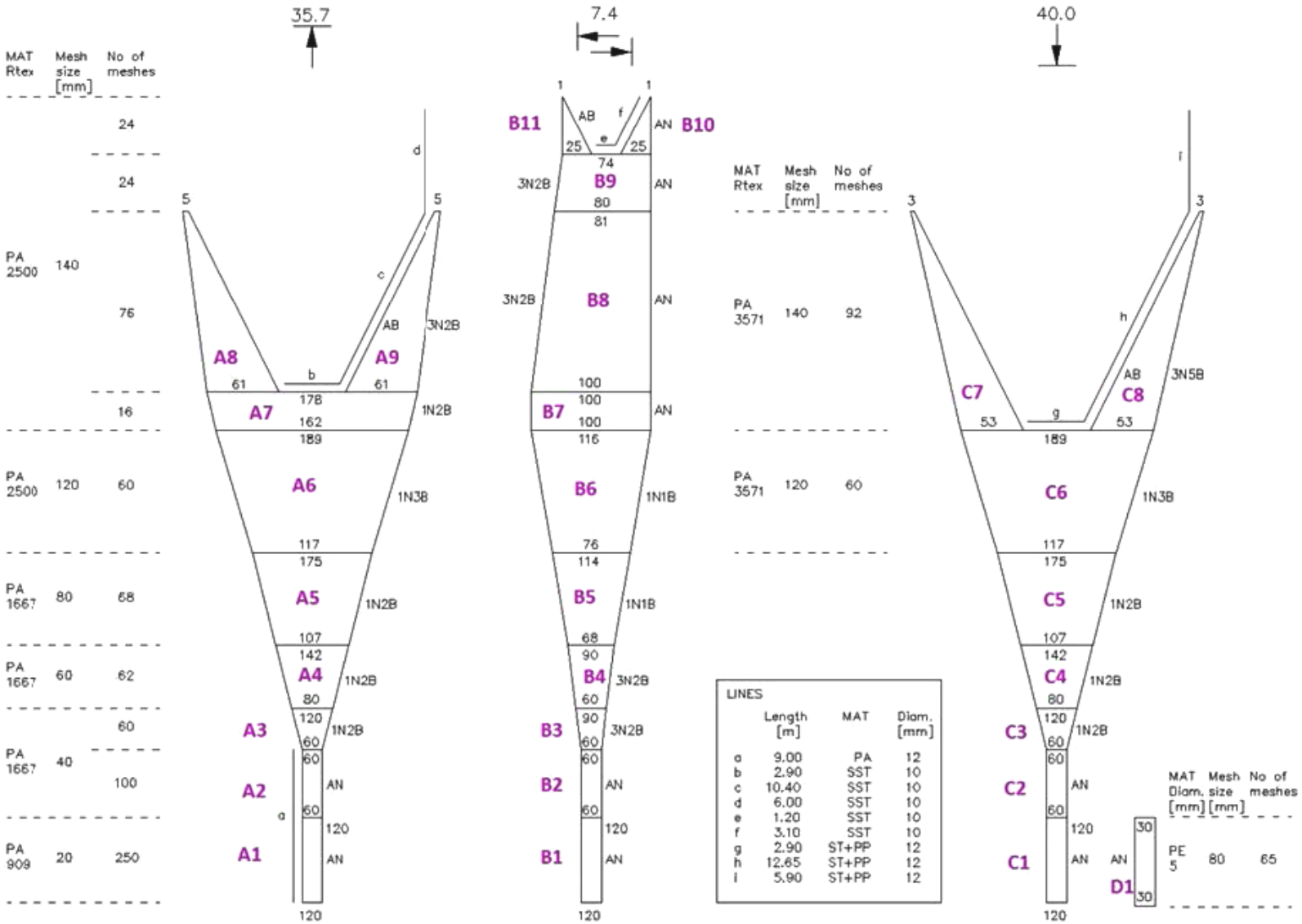


Figure XVI.1.8. Design of the GOC 73 trawl used for the MEDITS survey, with acronyms specified for each netting.

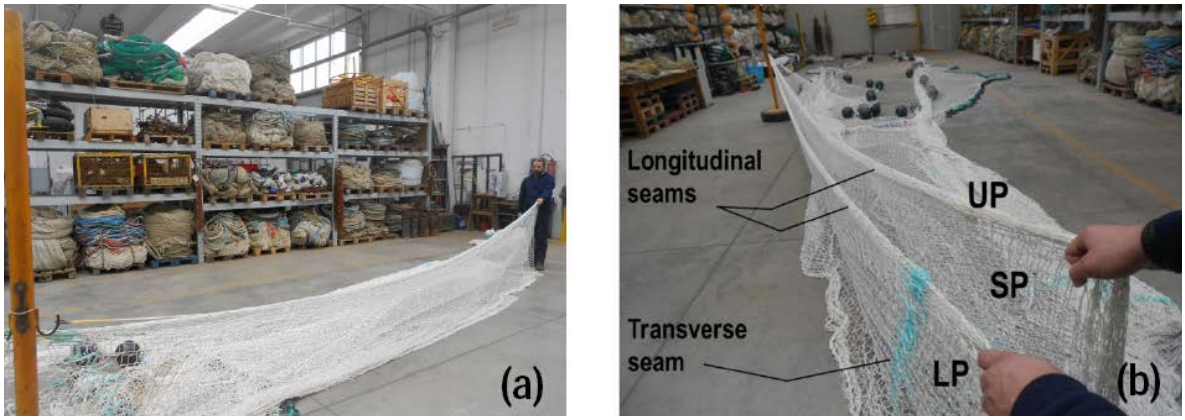


Figure XVI.1.9. Identification of the beginning and the end of each netting by looking at the transverse seams (a) and alignment of the transverse seams (b).

XVI.2 - Quality time-0 control checklist

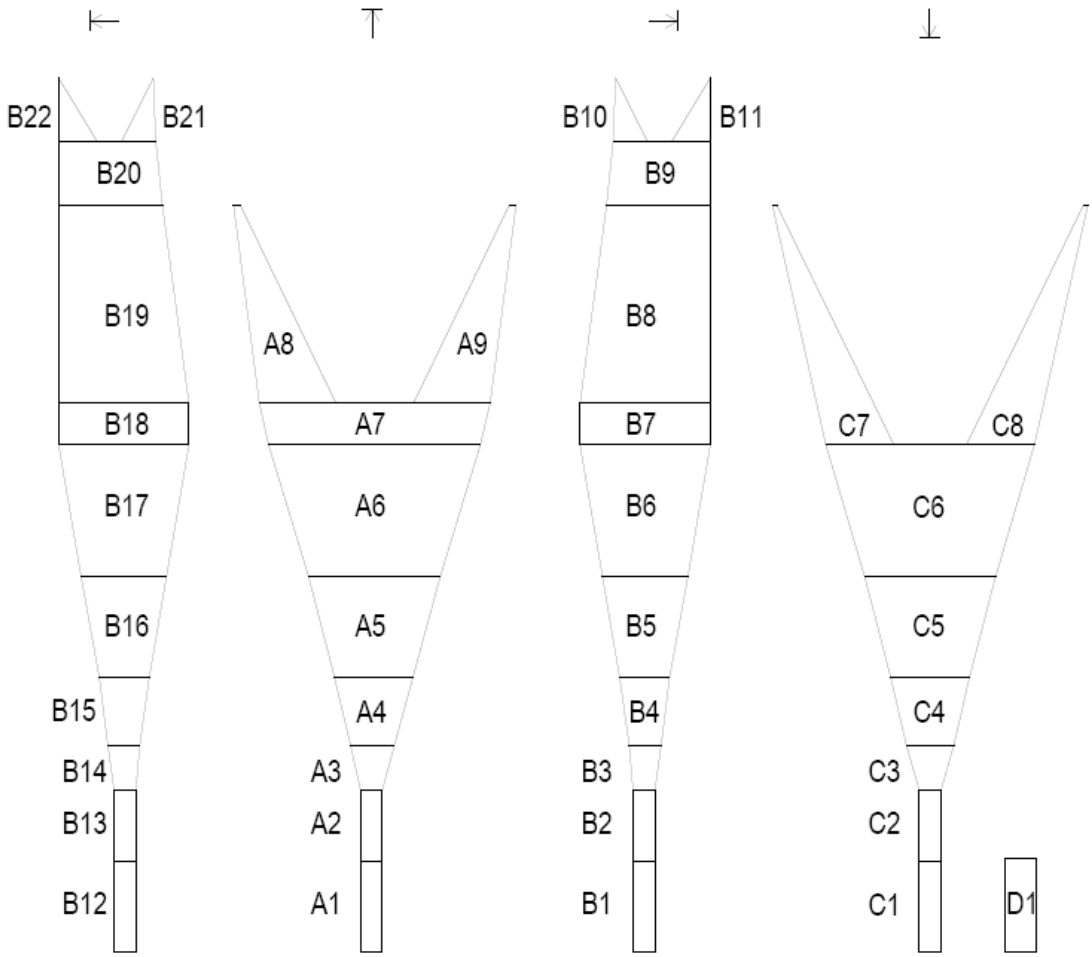
Time-0 checks are necessary both with a new trawl and when a Medits gear is measured for the first time (e.g. whenever measured).
The following modules have been developed in order to be printed out and form a sort of 'record book' for the quality certification of each Medits gear (e.g. GOC73, otterboard, and rigging parts).
It is recommended that each Medits trawl and otterboard are classified with the following rules of codification:

Trawl: **GOC73_OUXXX_YYYY_NN**
Otterboard: **WHS8_OUXXX_YYYY_NN**
where OUXXX stands for the Operative Unit number; YYYY is the year of trawl purchasing; and NN is an yearly progressive serial number (e.g. reset to 01 each year).

General information of the MEDITS gear inspection table

Operative Unit	
Inspection Nr.	
Date of inspection	
Name of the control operator	
GOC73 trawl code	
Otterboard code	

Top panel, Lower panel, Side panel (port), Side panel (starboard)



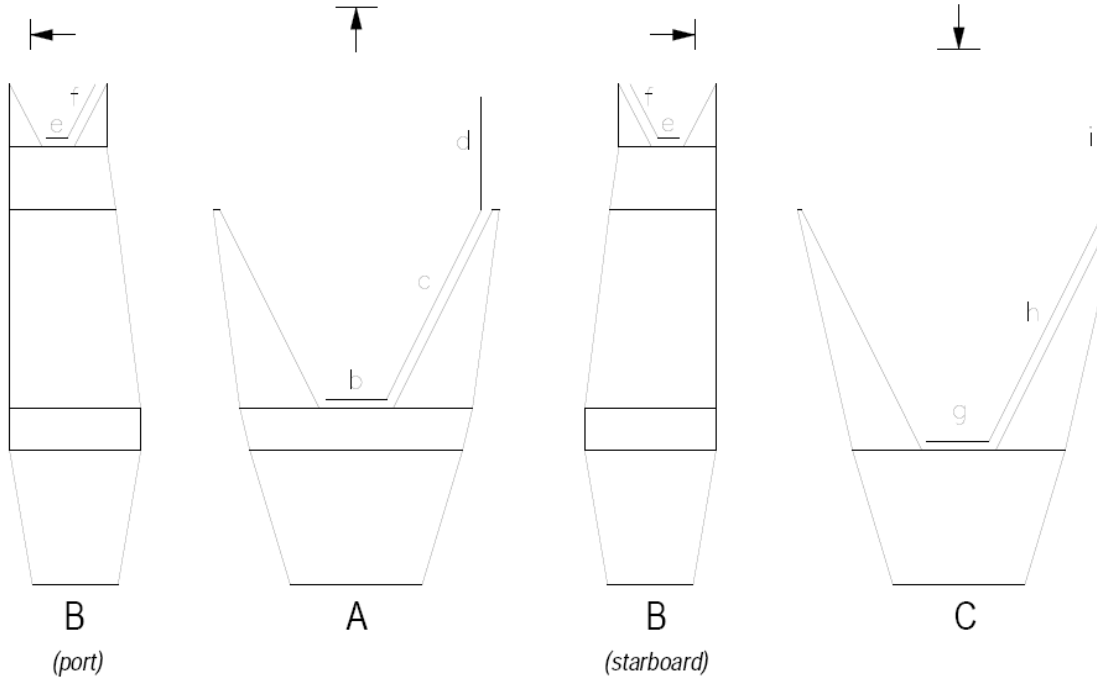
Top panel										
ID Netting	Mesh size [mm]		Netting Width				Netting Height			
			Mesh Fore (Nr)		Mesh Aft (Nr)		(Nr)		[m]	
	Nom	Eff	Nom	Eff	Nom	Eff	Nom	Eff	Nom	Eff
A1	20		120		120		250		5.00	
A2	40		60		60		100		4.00	
A3	40		120		60		60		2.40	
A4	60		142		80		62		3.72	
A5	80		175		107		68		5.44	
A6	120		189		117		60		7.20	
A7	140		178		162		16		2.24	
A8	140		5		61		76		10.64	
A9	140		5		61		76		10.64	

Lower panel										
ID Netting	Mesh size [mm]		Netting Width				Netting Height			
			Mesh Fore (Nr)		Mesh Aft (Nr)		(Nr)		[m]	
	Nom	Eff	Nom	Eff	Nom	Eff	Nom	Eff	Nom	Eff
C1	20		120		120		250		5.00	
C2	40		60		60		100		4.00	
C3	40		120		60		60		2.40	
C4	60		142		80		62		3.72	
C5	80		175		107		68		5.44	
C6	120		189		117		60		7.20	
C7	140		3		53		92		12.88	
C8	140		3		53		92		12.88	

Side panel *(port)*										
ID Netting	Mesh size [mm]		Netting Width				Netting Height			
			Mesh Fore (Nr)		Mesh Aft (Nr)		(Nr)		[m]	
	Nom	Eff	Nom	Eff	Nom	Eff	Nom	Eff	Nom	Eff
B12	20		120		120		250		5.00	
B13	40		60		60		100		4.00	
B14	40		90		60		60		2.40	
B15	60		90		60		62		3.72	
B16	80		114		68		68		5.44	
B17	120		116		76		60		7.20	
B18	140		100		100		16		2.24	
B19	140		81		100		76		10.64	
B20	140		74		80		24		3.36	
B21	140		1		25		24		3.36	
B22	140		1		25		24		3.36	

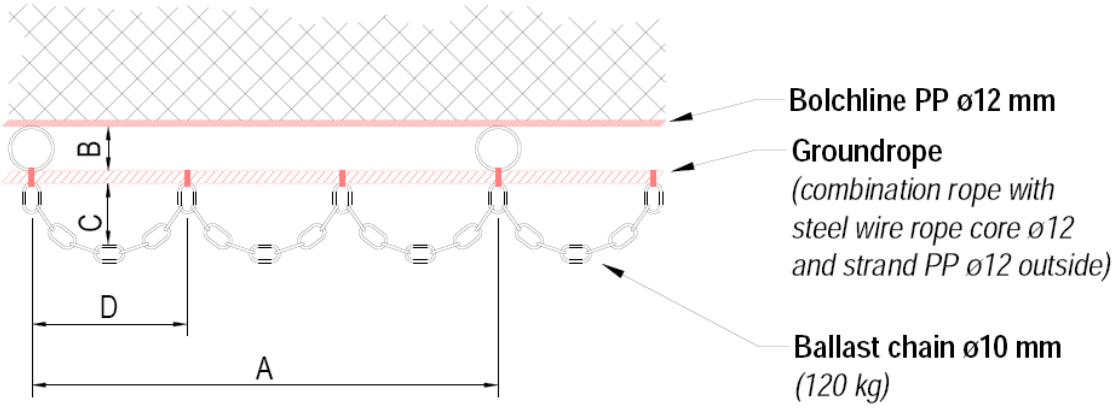
Side panel *(starboard)*										
ID Netting	Mesh size [mm]		Netting Width				Netting Height			
			Mesh Fore (Nr)		Mesh Aft (Nr)		(Nr)		[m]	
	Nom	Eff	Nom	Eff	Nom	Eff	Nom	Eff	Nom	Eff
B1	20		120		120		250		5.00	
B2	40		60		60		100		4.00	
B3	40		90		60		60		2.40	
B4	60		90		60		62		3.72	
B5	80		114		68		68		5.44	
B6	120		116		76		60		7.20	
B7	140		100		100		16		2.24	
B8	140		81		100		76		10.64	
B9	140		74		80		24		3.36	
B10	140		1		25		24		3.36	
B11	140		1		25		24		3.36	

Lines (Headline, sidelines, bolchline, footrope)



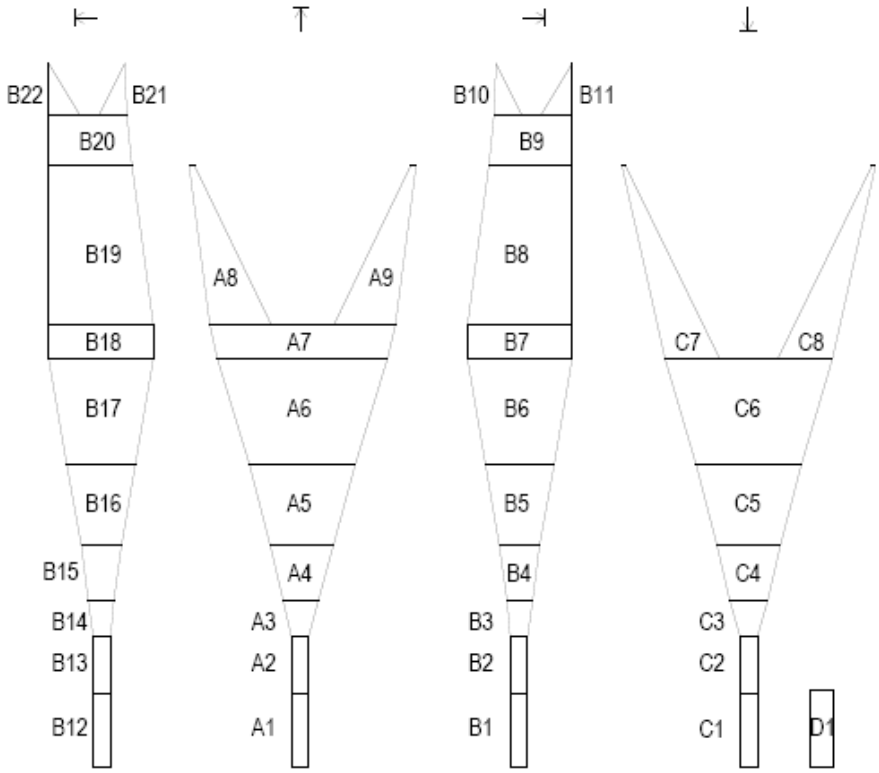
Lines *(headline, sidelines, bolchline, footrope)*												
ID Panel	Lines		Material		Diameter [mm]		Length [m]					
							Nom		Eff			
			Nom	Eff	Nom	Eff	Port	Starboard	Port	Starboard		
A	Headline	b	Steel		10		2.90					
		c	Steel		10		10.40	10.40				
		d	Steel		10		6.00	6.00				
B (port)	Sideline	e	Steel		10		1.20					
		f	Steel		10		3.10	3.10				
B (starboard)	Sideline	e	Steel		10		1.20					
		f	Steel		10		3.10	3.10				
C	Bolchline	g	PP		12		2.90					
		h	PP		12		12.65	12.65				
		i	PP		12		5.90	5.90				
	Footrope	g	Steel + PP		36		2.90					
		h	Steel + PP		36		12.65	12.65				
		i	Steel + PP		36		5.90	5.90				

Floats						
ID Float	Nr		Diameter [mm]		Distance [m]	
	Nom	Eff	Nom	Eff	Nom	Eff
1	1		200		1.5	
2	1		200		1.5	
3	1		200		1.5	
4	1		200		1.5	
5	1		200		1.5	
6	2		200		1.5	
7	2		200		1.5	
8	2		200		1.5	
9	2		200		1.5	
10	2		200		1.5	
11	2		200			
12	2		200			
13	2		200			
14	2		200			
15	2		200			
16	2		200		1.5	
17	2		200		1.5	
18	2		200		1.5	
19	2		200		1.5	
20	2		200		1.5	
21	1		200		1.5	
22	1		200		1.5	
23	1		200		1.5	
24	1		200		1.5	
25	1		200		1.5	



Groundgear		
Rigging	Measure [cm]	
	Nom	Eff
A	51	
B	5	
C	8	
D	17	
Ballast chain	Nom	Eff
Type	*Genovese*	
Diameter [mm]	10	
Pitch [mm]	40	
Linear density [kg/m]	2	
Total weight [kg]	120	

XVI.3. Quality periodic/annual control checklist and gear maintenance

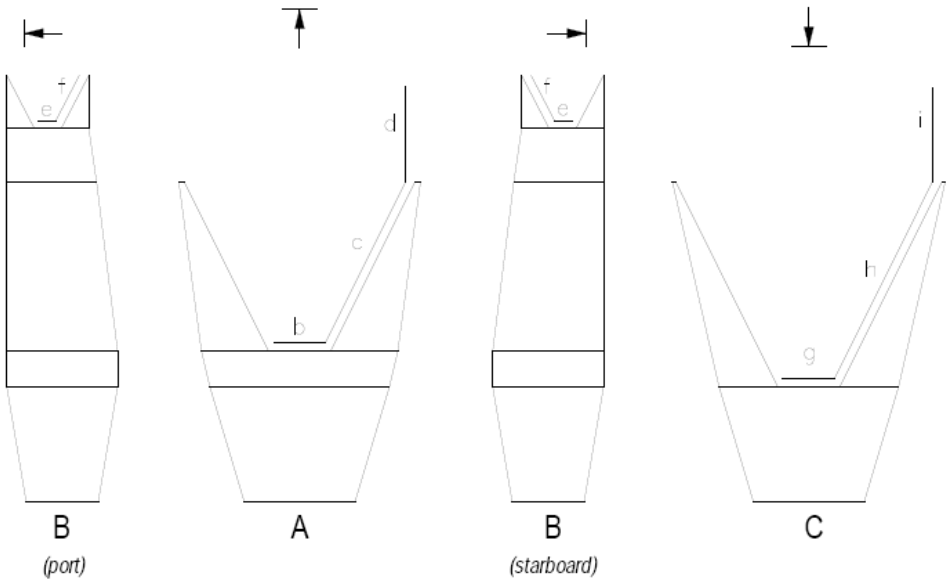


Top panel				
ID Netting	Mesh size [mm]		Netting Height [m]	
	Nom	Eff	Nom	Eff
A1	20		5.00	
A2	40		4.00	
A3	40		2.40	
A4	60		3.72	
A5	80		5.44	
A6	120		7.20	
A7	140		2.24	
A8	140		10.64	
A9	140		10.64	

Lower panel				
ID Netting	Mesh size [mm]		Netting Height [m]	
	Nom	Eff	Nom	Eff
C1	20		5.00	
C2	40		4.00	
C3	40		2.40	
C4	60		3.72	
C5	80		5.44	
C6	120		7.20	
C7	140		12.88	
C8	140		12.88	

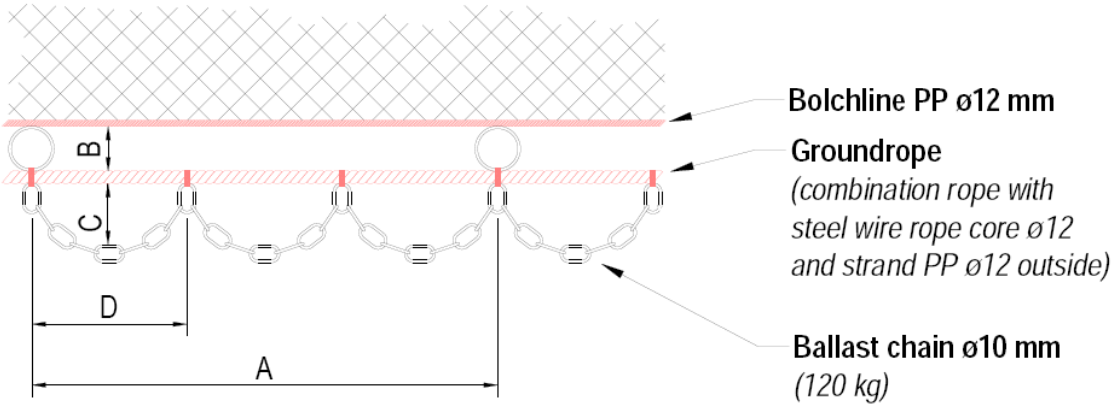
Side panel *(port)*				
ID Netting	Mesh size [mm]		Netting Height [m]	
	Nom	Eff	Nom	Eff
B12	20		5.00	
B13	40		4.00	
B14	40		2.40	
B15	60		3.72	
B16	80		5.44	
B17	120		7.20	
B18	140		2.24	
B19	140		10.64	
B20	140		3.36	
B21	140		3.36	
B22	140		3.36	

Side panel *(starboard)*				
ID Netting	Mesh size [mm]		Netting Height [m]	
	Nom	Eff	Nom	Eff
B1	20		5.00	
B2	40		4.00	
B3	40		2.40	
B4	60		3.72	
B5	80		5.44	
B6	120		7.20	
B7	140		2.24	
B8	140		10.64	
B9	140		3.36	
B10	140		3.36	
B11	140		3.36	



Lines *(headline, sidelines, bolchline, footrope)*						
ID Panel	Lines		Length [m]			
			Nom		Eff	
			Port	Starboard	Port	Starboard
A	Headline	b	2.90			
		c	10.40	10.40		
		d	6.00	6.00		
B (port)	Sideline	e	1.20			
		f	3.10	3.10		
B (starboard)	Sideline	e	1.20			
		f	3.10	3.10		
C	Bolchline	g	2.90			
		h	12.65	12.65		
		i	5.90	5.90		
	Footrope	g	2.90			
		h	12.65	12.65		
		i	5.90	5.90		

Floats				
ID Float	Nr		Distance [m]	
	Nom	Eff	Nom	Eff
1	1		1.5	
2	1		1.5	
3	1		1.5	
4	1		1.5	
5	1		1.5	
6	2		1.5	
7	2		1.5	
8	2		1.5	
9	2		1.5	
10	2		1.5	
11	2			
12	2			
13	2			
14	2			
15	2			
16	2		1.5	
17	2		1.5	
18	2		1.5	
19	2		1.5	
20	2		1.5	
21	1		1.5	
22	1		1.5	
23	1		1.5	
24	1		1.5	
25	1		1.5	



Groundgear		
Rigging	Measure [cm]	
	Nom	Eff
A	51	
B	5	
C	8	
D	17	
Ballast chain	Nom	Eff
Type	*Genovese*	
Diameter [mm]	10	
Pitch [mm]	40	
Linear density [kg/m]	2	
Total weight [kg]	120	

XVI.4. - Glossary of terms and references to the acronyms used in the current Medits Handbook

AB direction (AB). Direction parallel to a rectilinear sequence of mesh bars, each from adjacent meshes.

Bar cut (B). A cut parallel to a line of sequential mesh bars, each from adjacent meshes, and severing one or more bars.

Beam. Wood or steel spar which holds the net of a beam trawl open horizontally.

Beam trawl. The horizontal opening of this trawl is provided by a beam, made of wood or metal, which may be 10 long or more. Beam trawls are used mainly for flatfish and shrimp fishing.

Belly. Section of panel between wings and extension piece of the trawl.

Body. The centre which is usually the main part of a net or section of a trawl.

Bottom otter trawl. Trawl towed by a single boat. Its horizontal opening is obtained by the use of otterboards which are relatively heavy and equipped with a steel sole designed to withstand rough contact with the bottom.

Bottom trawl . Trawl designed and rigged to work near the bottom. According to the type used, one may distinguished: low opening trawls (specially designed for the capture of demersal species) such as beam trawls and shrimp, sole or nephrops trawls; and high opening trawls, suitable mainly for the capture of the semi. demersal or pelagic species.

Codend. Netting bag made up of one or more panels (pieces of netting) of the same mesh size attached to one another along their sides in the axis of the trawl by a seam where a side rope may also be attached.

Double rigging (double rig). In certain cases, the trawler can be specifically rigged with outriggers to tow two (or even four) trawls at the same time.

Dredge. An apparatus usually in the form of an oblong iron frame with an attached bag net.

Extension. Means the untapered section, made of one or more panels, between the trawl body and the codend.

Float. A buoyant unit used to give lift or to mark the position of a net, or both.

Headline (headrope). The principal upper frame rope of a net to which the netting is attached.

Horizontal cut (T). A cut parallel to the general course of the netting yarn just beyond the knots.

Lower panel. All the net sections of the lower part of the trawl net.

Lower wing. Net section extending forward from one side of the belly and usually joined to the adjacent top wing (two panel trawls) or adjacent side wing (four panel trawls).

Midwater otter trawl (pelagic one boat trawl). Trawl towed by a single boat. The horizontal opening of the net is controlled by otterboards, usually of a hydrodinamic shape, and which normally do not touch the ground.

Midwater pair trawl. Towed by two boats, thus ensuring the horizontal opening of the net, this net is designed and rigged to work in midwater.

Midwater trawl (pelagic trawl). Trawl usually much larger then bottom trawl, designed and rigged to work in midwater, including surface water. The front net sections are very often made with very large meshes or ropes, which heard the fish schools toward the net aft section. They may be towed by one or two boats.

Otterboard (trawl board, trawl door, board, door). Shearing device, two of which hold open horizontally the wings and mouth of a trawl.

Otter twin trawls. Gear comprising two identical trawl nets ("twin") working together, opened horizontally by a single pair of otterboards. The inner wings are attached to a sledge towed simultaneously with the otterboards from a common crowfoot.

Pennant. Handling wire connecting warp to bridle and allowing the bridle to by-pass the otterboard when shooting or hauling the gear.

Piece of netting. A section of netting consisting of a uniform size mesh

Pair trawling. Method in which the trawl is towed by two boats of similar power. The separation of the boats controls the opening of the net.

Rig. The process of fitting the necessary ropes and accessories so as to make a net ready for fishing.

Side wing. Lower or upper wing of side panel of a four panel trawl

Single rig. Gear consisting of a single trawl net.

Strengthening bag. A cylindrical piece of netting completely surrounding the codend of the trawl and which may be attached to the codend in intervals. It shall have at least the same dimensions (length and width) as the part of the codend to which it is attached.

Suberkrub otterboard. All steel cambered midwater otterboard with vertical aspect greater then its horizontal aspect.

Sweep. The rope usually of wire or combination rope, between otterboards and net.

Top panel. All the net sections of the upper part of the trawl.

Top wing (upper wing). Net section extending forward from one side of the square and usually joined to the adjacent lower wing (two panel trawls) or adjacent side wing (four panel trawls).

Vertical cut (N). A cut at right angles to the general course of the netting yarn just beyond the knots.

Warp. Long flexible steel rope connecting vessel to the trawl gear.

Wing. Tapered net section extending forward from one side of the main body of the net.

XVI.5. - List of gear metrics

In order to define main geometrical characteristics of the fishing gear, major gear metrics are listed below.

Lengths of the net. It Is the overall distance, along the longitudinal axis between, between the wings and the extension. When not specified, the codend is not included.

Headline length. It is the length of the upper combination rope, usually expressed in meters.

Footrope length. It is the length of the lower combination rope, usually expressed in meters.

Mouth horizontal opening. it is the horizontal distance between the ends of the headline.

Mouth vertical opening. It is the vertical distance (height) of the headline bosom from the ground.

Fishing circumference. Is the length, in meters, of the circumference obtained considering a vertical section of the net at the footrope bosom.

Door length. It is the horizontal overall distance between the forward and aft edges of the otterboard. On a cambered otterboard the length is measured along a direction parallel to the shoe.

Door weight. The weight, as usually indicated by manufacturers, is the weight in air. It should be noted that, when considering otterboard performance, the effective weight of the otterboard is the weight in water.

Horizontal door spread. It is the distance between the otterboards measured along a perpendicular at the trawling direction.

XVII - Protocol for monitoring Marine Litter on a voluntary basis

Proposal for collecting data on litter during MEDITS trawl surveys

Fabio Fiorentino, Evgenia Lefkaditou, Angelique Jadaud, Pier Luigi Carbonara, Giuseppe Lembo and Francois Galgani

This proposal is based on the document "Procédure pour l'observation des macro déchets au cours des campagnes halieutiques", version 1.0 (2012) prepared by Badts & Galgani (Ifremer). It was prepared taking into account the suggestions of Marine Litter Technical Recommendations for the Implementation of MSFD Requirement (Galgani et al., 2011), CEFAS protocol for the litter recording (ICES, 2012), as well as the results of a relevant study in the Tyrrhenian Sea (Serena et al., 2011).

Aim: This document concerns a protocol for data collection on macro litter in the framework of scientific fishery surveys. The procedure covers observations of macro-litter present in the catches of fishing gears used during fisheries surveys (trawl nets, drags, hand lines, etc.). The protocol does not concern observation of floating litter or non-fisheries surveys.

Definition of marine litter: In the framework of the directive for the Marine Strategy for the Good Environmental Status of the sea, marine litter consists of items that have been deliberately discarded, unintentionally lost or transported by winds and rivers into the sea and on beaches. It mainly consists of plastics, wood, metals, glass, rubber, clothing and paper. Land-based sources account for up to 80% of marine litter – these include tourism, sewage and illegal or poorly managed landfills. The main sea-based sources are shipping and fishing (EU, 2010).

Abstract: This protocol is aimed to standardize the procedure to collect data on litter caught during the MEDITS trawl surveys. Information on litter composition is recorded in terms of total weight of litter not yet separated into different categories and number and weight by litter categories. Thirty four (34) different typologies were identified including 9 main categories related to litter material and 25 sub-categories related to source and main litter findings. Litter data are reported in a specific form to be integrated with haul information included in TA files, in order to estimate a standardized index of total and by categories litter abundance per square kilometer, aiming to future recommendation depending on litter sources.

Procedure to collect litter data: On board the vessel, the litter collected is weighted as total and split into the categories and sub-categories as reported in the list below. It is mandatory to record or estimate total weight, regardless the categories and subcategories, and number of items for each main category: It is facultative to register weight by categories and number of items by sub-category. In case of large amount of litter in the catch, all big sized objects of litter must be recorded while a subsample could be analysed for small sized litter (e.g. lids). Litter should be coded as total, by category and sub-category. Detailed data on total weight and litter composition must be reported in the specific form on litter.
Qualitative and quantitative data on the litter have to be connected to data regarding the characteristics of the haul (Date, code of haul, the GPS positions of the haul (start and end), trawled distance, average speed, characteristics of the haul (horizontal opening), depth of haul etc.), contained in file TA.
Data related to the fishing set and gear performance allows calculating the sampled surfaces for each haul and estimating a standardized index of total and by categories litter abundance per square kilometer.

A photograph of total litter separated from fish catch in a haul, including a label with main haul data (Figure 1), is recommended as it might be used to future analysis of litter composition by Image Analysis Tools.
Organisms attached on litter might be also noted.

The list of the litter typology and codes :

L0 No litter in the net

L1 Plastic (including PVC, polypropylene, polyethylene)
- L1a. Bags
- L1b. Bottles
- L1c. Food wrappers
- L1d. Sheets (table-cover, etc.)
- L1e. Hard plastic objects (crates, containers, tubes, ash-trays, lids, etc.)
- L1f. Fishing nets
- L1g. Fishing lines
- L1h. Other fishing related (pots, floats, etc.)
- L1i. Synthetic ropes/strapping bands
- L1j. others

L2 Ruber
- L2a. Tyres
- L2b. Other (gloves, floats, boots/shoes, olskins, sanitaries)

L3 Metal
- L3a. Beverage cans
- L3b. Other food cans/wrappers
- L3c. Middle size containers (of paint, oil, chemicals)
- L3d. Large metalic objects (barrels, pieces of machinery, electric appliances)
- L3e. Cables
- L3f. Fishing related (hooks, spears, etc.)
- L3g. remnant from the war

L4 Glass / Ceramic/Concrete
- L4a. Bottles
- L4b. Pieces of glass
- L4c. Ceramic jars
- L4d. Large objects (ceramic basins, etc.)

L5 Cloth (textil) **/ Natural fibres**
- L5a. Clothing (clothes, shoes, etc.)
- L5b. Large pieces (carpets, mattresses, etc.)
- L5c. Natural ropes
- L5d. Sanitaries (diapers, cotton buds, etc.)

L6 Wood processed (palettes, crates, etc.)

L7 Paper and cardboard

L8 Other

L9 Unspecified

References

Badts V., & F. Galgani, 2012. Procédure pour l'observation des macro déchets au cours des campagnes halieutiques", version 1.0 (2012) (Ifremer).

European Union, 2010. Marine Litter: Time To Clean Up Our Act. http://ec.europa.eu/environment/marine/pdf/flyer_marine_litter.pdf

ICES. 2012. Manual for the International Bottom Trawl Surveys. Series of ICES Survey Protocols. SISP 1-IBTS VIII. 68 pp.

Galgani F., G.Hanke, S. Werner & H. Piha, 2011. Marine Litter Technical Recommendations for the Implementation of MSFD Requirement. MSFD GES Technical Subgroup Marine Litter. JRC Scientific and Technical Reports. EUR 25009 EN. ISSN 1831-9424. DOI 10.2788/92438 : 93 pp.

Serena F., A.J Abella., R.T.Baino, E. Cecchi, M. Ria , R. Silvestri & A. Voliani, 2011. Anthropogenic waste in the Marine Ecosystem. Biol. Mar. Mediterr. 18 (1): 161-164

Figure 1. Litter collected during a MEDITS haul in Argosaronikos Gulf (Aegean Sea).

Campaign: | | Date : | | | | Haul : | |

TOTAL weight of litter in the haul (kg) : | |

Type of Litter		Weight (kg) (mandatory for category and sub-category)	Number (facultative for subcategory)	Number (mandatory for category)
L0	No litter in the net			
L1 Plastic	**a**. Bags			
	b. Bottles			
	c. Food wrappers			
	d. Sheets (table covers, e.t.c.)			
	e. Hard plastic objects (crates, containers, tubes, ash-trays, lids, etc.)			
	f. Fishing nets			
	g. Fishing lines			
	h. Other fishing related (pots, floats, etc.)			
	i. Ropes/strapping bands			
	j others			
L2 Rubber	**a**. Tyres			
	b. Other (gloves, boots/shoes, olskins etc.)			
L3 Metal	**a**. Beverage cans			
	b. Other food cans/wrappers			
	c. Middle size containers (of paint, oil, chemicals)			
	d. Large metalic objects (barrels, pieces of machinery, electric appliances)			
	e. Cables			
	f. Fishing related (hooks, spears, etc.)			
	g. remnant from the war			
L4 Glass / Ceramic/ Concrete	**a**. Bottles			
	b. Pieces of glass			
	c. Ceramic jars			
	d. Large objects (specify)			
L5 Cloth (textil)/ natural fibres	**a**. Clothing (clothes, shoes)			
	b. Large pieces (carpets, mattresses, etc) (specify)			
	c. Natural ropes			
	d. Sanitaries (diapers, cotton buds, etc.)			
L6 Wood processed (palettes, crates, etc.)				
L7 Paper and cardboard				

L8 Other (specify)			
L9 Unspecified			

Responsible:

Remarks :

XVIII. Internal rules of the MEDITS group

Adopted at the MEDITS meeting, Split (Croatia), 15-16/06/2010 and updated in 2016 and 2017

1.Objective of the document

This document presents the way of working of the international group organised to coordinate the activity done by different countries to implement the MEDITS surveys.

2.The MEDITS survey initiative

Some Mediterranean countries have decided to join their efforts to carry out systematic bottom trawl surveys (acronym MEDITS) to produce basic information on benthic and demersal species in term of life history traits, population and community distribution and demographic structure.

The initiative started in 1993 and the first MEDITS survey was conducted by four countries in 1994. Since 2001, the European countries bordering the Mediterranean Sea are obliged to carry out MEDITS surveys yearly in the framework of the European Data Collection regulation. In 2010, ten Mediterranean countries collaborated in the project, and permanent links are maintained with the relevant bodies of the European Union and GFCM. All the information related to the MEDITS surveys is given in the MEDITS website.

All the countries interested to contribute to this challenge in view of extending the MEDITS survey coverage in the Mediterranean and Black Sea are warmly welcome in the MEDITS initiative.

3.The mandate of the MEDITS group

The MEDITS group has been created to coordinate the activity done in the MEDITS framework. Basically the aim of the group is to ensure consistency and coherence of the MEDITS surveys into space and time. With this goal, the group can review the standards defined to carry out the survey, including the sampling scheme, the gears used and the common observations to be done during the surveys. It can be entrusted with questions related to quality management of the surveys as well as about common management of the data. The group may also incite for the development of common research between the partners.

The terms of reference of the group include requests from the EU-RCM Med & BS, issues addressed by the GFCM, and questions from internal initiative.

4.Composition of the MEDITS group

The MEDITS group is open to all the scientists involved in the MEDITS surveys.

In each country participating in the MEDITS surveys, the contact point is the national coordinator of MEDITS. When relevant taking into account the national organisation of research activity and the characteristics of the surveyed area, regional coordinators may be identified near a national coordinator.

The activity of the group is managed by a steering committee.

4.1 The steering committee

The steering committee is the reference entity of the MEDITS group. The steering committee validates all the decisions taken in the name of the MEDITS group. It endorses the terms of reference, timings and agendas of the MEDITS sessions. It ratifies the conclusions and recommendations elaborated by the group.

The MEDITS steering committee is composed by scientists coming from the research groups involved in the MEDITS surveys, on the basis of one member by country. These scientists are the national coordinators of the MEDITS survey or their representative.

4.2 Chairpersonship

The MEDITS coordinator is in charge of animation of the MEDITS group, including the annual sessions of the group (preparation of the agenda, convening of the meeting, chair of the session, coordination and spreading of the report) and the in between activity (relationship with the other bodies, coordination of the tasks, management of the internal communication). The coordinator (or representative from the steering committee) participates in the RCM Med&BS upon request, for ensuring the link between the two Groups.

The mandate of the coordinator of the MEDITS group is for three years. The new coordinator is nominated by the steering committee at the end of an annual session, for immediate effect. One coordinator can be nominated for a maximum of two consecutive mandates. When the MEDITS coordinator is the national coordinator of one partner, a new national coordinator is nominated for this country.

5. Internal rules of the group

5.1 Annual session

The MEDITS group meets at least once a year. This meeting may include plenary sessions and sessions limited to the steering committee.

The plenary sessions of the MEDITS group are open to scientists from the member countries at the convenience of the relevant national coordinators. Furthermore, the MEDITS meetings are open to other scientists from invitation by the general coordinator.

In principle, date and place of the next annual meeting are defined by common agreement during the actual session. Nevertheless, they can be changed later by common agreement of the steering committee members, particularly to take into account the calendar of the reference bodies (GFCM and EU-RCM Med&BS). The place of the next meeting is decided from invitation given by the members.

The usual mode of working is elaboration of recommendations in the plenary meetings, then decision by consensus by the steering committee.

The requests submitted by external bodies (GFCM) must be transmitted to the MEDITS coordinator at least two months before the date of the next annual session.

5.2 Other activities

The MEDITS group may create ad hoc working groups in view of development of common activity on topics of interest in link with the MEDITS surveys (to progress on specific research questions, etc.). In this scope, the MEDITS group may incite and facilitate common publications at a global scale.

5.3 Website

A website presents the activity of the MEDITS group. It is managed by one of the members. The content of the website is validated by the steering committee. To facilitate exchanges between the members of the group, the group can open a private or a cooperative website.

6. Data Policy

The access to the MEDITS data was formerly regulated by the EU Reg. 199/2008 (Data Collection Framework) and currently by the regulation (EU) 2017/1004 (recast). Data that are made available for specific projects, like the preparation and publication of scientific papers/reports, or for the objectives of ad hoc working group, should be used only for these specific purposes (other uses are not allowed) and after the agreement of the MEDITS group. For that, it is recommended to present the proposals in the annual MEDITS coordination meetings. Another way to request this agreement could be through contact with the general and national coordinators.

Food and Agriculture Organization of the United Nations

General Fisheries Commission for the Mediterranean
Commission générale des pêches pour la Méditerranée

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640

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

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Methodology for data collection

By

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Rome, 2019

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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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Contents

Preparation of this document iii
Abstract iv
The Med bycatch project vi
Project partners viii
Contributors xii
Acknowledgements xiii
Abbreviations and acronyms xix
Definitions xx

1. INTRODUCTION 1

2. VULNERABLE SPECIES 3

2.1 What are vulnerable species? 3

2.1.1 Marine mammals 4

2.1.2 Sea turtles 4

2.1.3 Seabirds 5

2.1.4 Sharks and rays 6

2.1.5 Vulnerable benthic species 6

2.2 Why is bycatch of vulnerable species a problem? 7

2.3 Importance of collecting information on bycatch of vulnerable species 8

3. DATA SOURCES 9

3.1 Fishery-dependent data 11

3.1.1 Observer programmes 11

3.1.2 Interviews 12

3.1.3 Self-sampling 12

3.1.4 Stranding data 13

3.1.5 Remote electronic monitoring (REM) 14

3.2 Fishery-independent data 14

4. SAMPLING SCHEME 17

4.1 Designing an observer programme 17

4.2 Sampling stratification and allocation scheme 17

4.3 Assessing how much monitoring is required 19

4.4 Examples of sampling scheme 20

4.5 Training and identification guides 23

5. VULNERABLE SPECIES INCIDENTAL CATCH ESTIMATION 25

6. BENTHIC SPECIES 27

7. MARINE LITTER 31

REFERENCES **33**

ANNEXES

1. Vulnerable species **41**

1.a. Vulnerable species 41

1.b. Rare elasmobranch species 45

1.c. Vulnerable benthic species 46

2. GFCM geographical subareas (GSAs) and subregions **48**

3. Templates for observers on board **49**

3.a. On-board observation – vessel characteristics 49

3.b. On-board observation – general information by fishing trip 50

3.c. On-board observation – general information on vulnerable species 51

4. Templates for biological data **53**

4.a. Data on marine mammals 53

4.b. Data on sharks, rays and chimaeras 54

4.c. Data on sea turtles 55

4.d. Data on seabirds 56

5. Length measurements **57**

5.a. Cetaceans 57

5.b. Sharks, rays and chimaeras 59

5.c. Seabirds 61

5.d. Sea turtles 62

6. Vulnerable benthic species **64**

7. Questionnaire forms **65**

7.a. Questionnaire on fishing vessel characteristics 65

7.b. Questionnaire by fishing trip 67

7.c. Questionnaire on general information on bycatch of vulnerable species 69

8. Self-sampling **70**

8.a. Self-sampling – logbook for vessel characteristics and catch data 70

8.b. Self-sampling – logbook for data on vulnerable species 72

9. Stranding data **73**

10. Fleet segments **74**

11. Fishing gear **75**

12. Vulnerable species rate and estimation **77**

13. Template for marine macro-litter **78**

14. Weather conditions **79**

15. Equipment for on-board observations **80**

Sheet for reporting single fishing operation data **81**

Tables

Table 1. Summary of main characteristics of common monitoring strategies 9
Table 2. Example of conversion of fishing trips into fishing days for a given vessel 18
Table 3. Example of sampling scheme for a fleet composed of fishing vessels of 12–24 m 20
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 21
Table 5. Example of sampling scheme for a fleet composed of small-scale vessels 21
Table 6. Example of number of fishing trips to sample by year and coverage (%) for a fleet composed of small-scale fishing vessels 22
Table 7. Variables needed for estimation of total number of vulnerable specimens caught 25
Table 8. Vulnerable species estimation 26

Figures

Figure 1. Scheme representing diverse components of the catch as defined by the Data Collection Reference Framework 1
Figure 2. Sampling population, primary and secondary sampling units 17
Figure 3. Trawler performing several fishing hauls (b) during a fishing trip (a) 18
Figure 4. Relationship between cost of sampling programme, fishery size and precision of estimate 19
Figure 5. Benthic macroinvertebrates in the catch composition 27
Figure 6. Benthic species of sponges and corals 29
Figure 7. Species of macroinvertebrates present in the catch 30
Figure A1. Details of biological information (i.e. length and sex) for cetaceans 57
Figure A2. Other body measures that could be collected for cetaceans 58
Figure A3. Details of measuring sharks and rays 59
Figure A4. llustrations showing the sexual macroscopic determination of sex in elasmobranchs: A4a male, A4b female 60
Figure A5. Details of measuring seabirds 61
Figure A6. Curved carapace width and length measurements (A6a and A6b) and tail measurements (A6c) for sea turtles 62
Figure A7. Details of measuring sea turtles and some details of the carapace ‘scheme’ for diverse species 63

Box

Box 1. Mediterranean VME indicator: features (a), habitats (b) and taxa (c) 28

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):

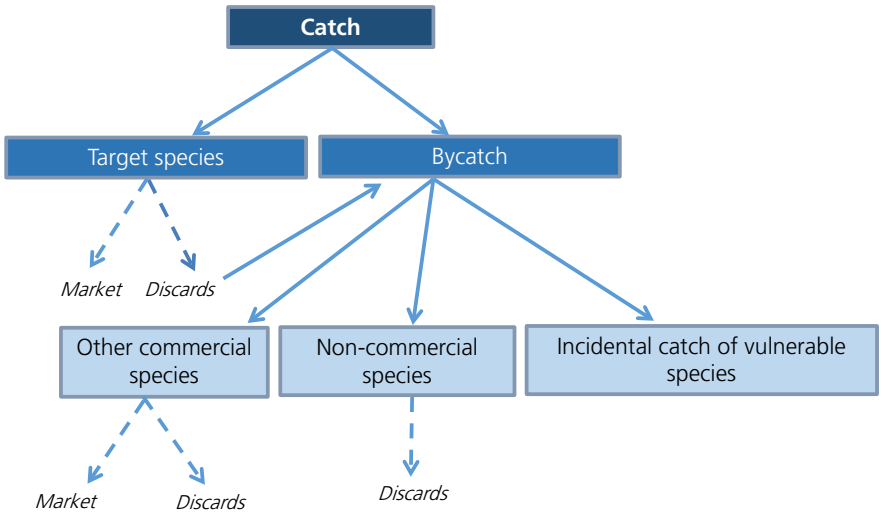
Active vessel:	In terms of its operational status, a vessel is considered active when it executes at least one fishing operation during the reference year in the GFCM area of application.
Bycatch:	The part of the catch that is unintentionally captured during a fishing operation in addition to the target 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.

[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.

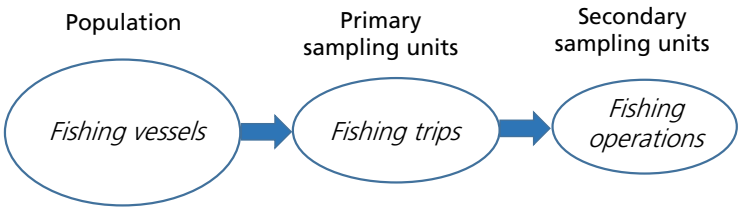
It is also important to consider previous information on the bycatch of vulnerable species for the diverse gear in the study area. If no information is available, the first approach would be to start a large survey of interviews (in ports or by telephone) to establish relationships with fishers and to 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).

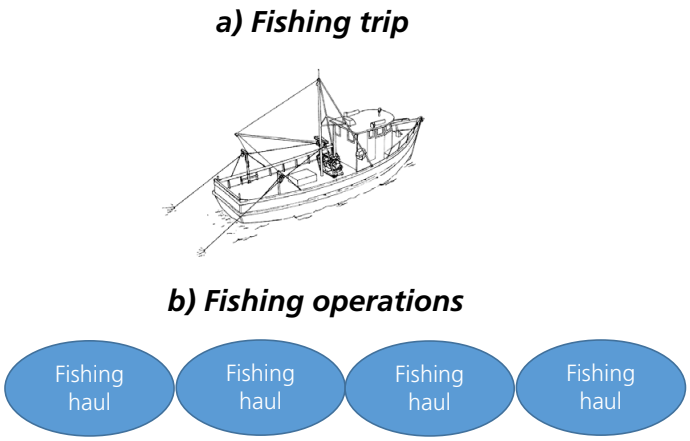
FIGURE 2
Sampling population, primary and secondary sampling units



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

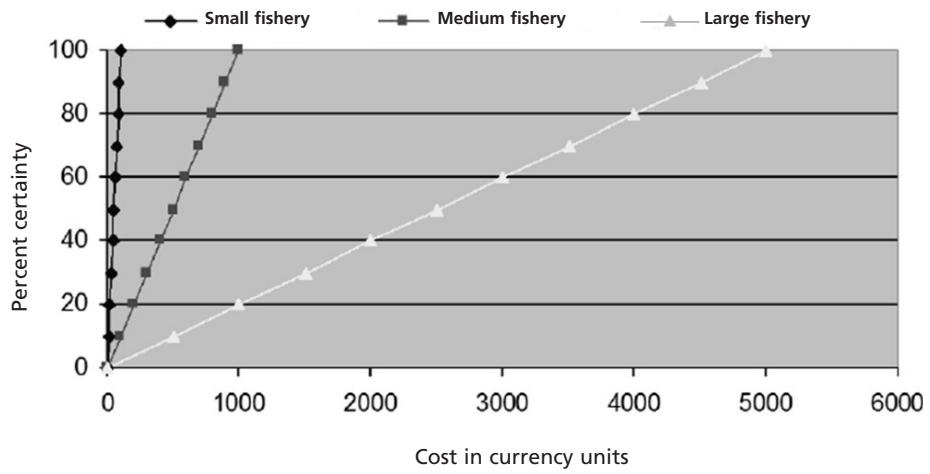
	Country 1	Country 2	Country 3
Number of fishing trips per year	60	125	50
Number of fishing days per fishing trip	2	1	3
Total number of fishing days during year	120	125	150

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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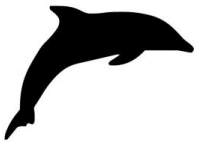
ANNEX 1. Vulnerable species

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

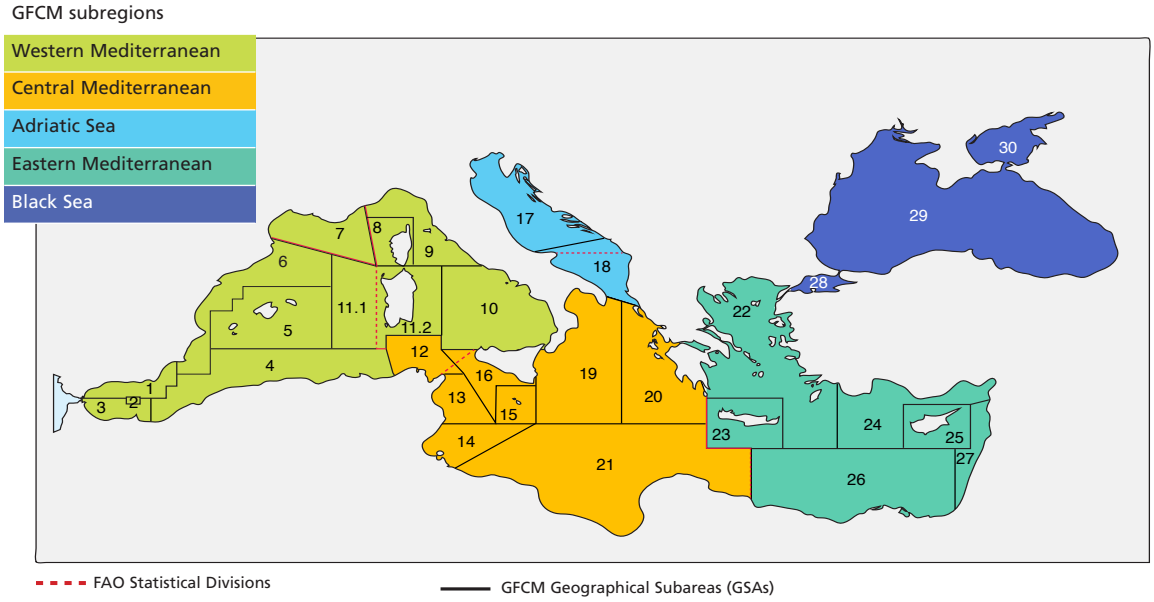
Group of rare species	Family	Species	Common name
Sharks, Rays, Chimaeras	Alopiidae	*Alopias superciliosus*	Bigeye thresher
	Hexanchidae	*Hexanchus nakamurai*	Bigeyed sixgill shark
	Echinorhinidae	*Echinorhinus brucus*	Bramble shark
	Squalidae	*Squalus megalops*	Shortnose spurdog
	Centrophoridae	*Centrophorus 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 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:

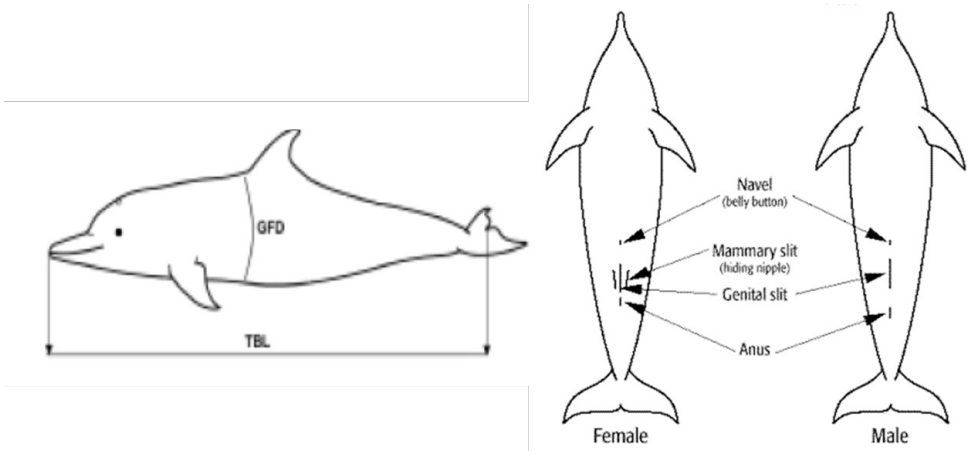
- Source: indicate source of data and then report code of:
- ID fishing trip: identification code assigned to each fishing trip (as in Annex 3.a).
  - ID fishing operation: identification code assigned to each fishing observation during a fishing trip (as in Annex 3.c).
  - ID self–sampling operation: 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



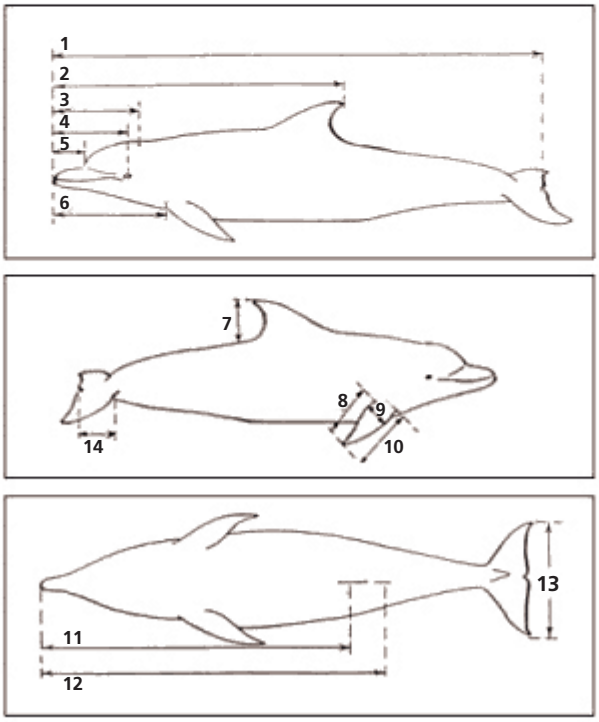
Source: MARE/2014/19, 2016.

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:



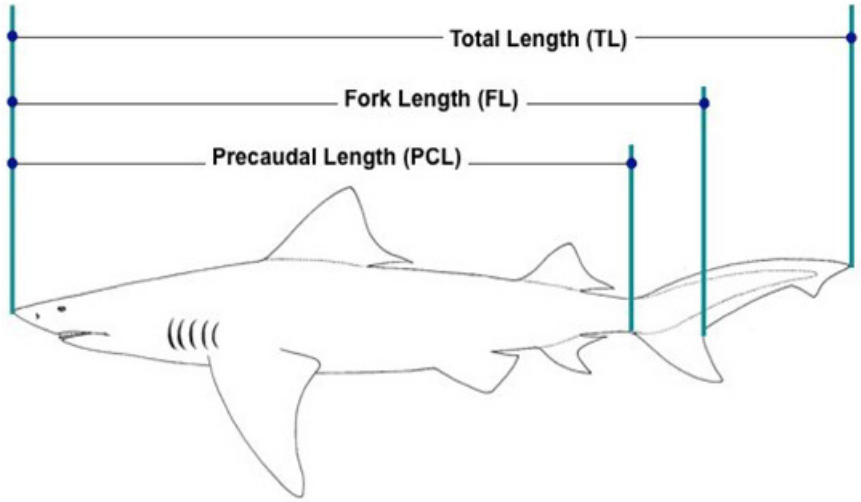
Source: UN Environment/MAP, 2008.

ANNEX 5.b. SHARKS, RAYS AND CHIMAERAS

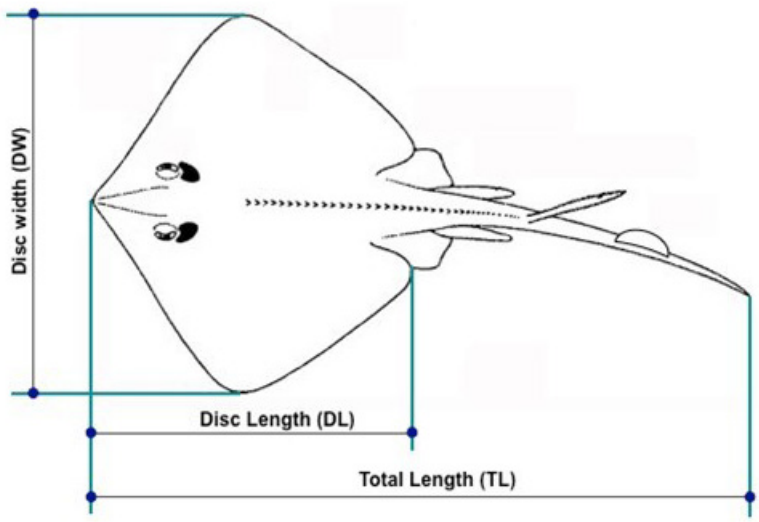
– Total length (cm, see Figure A3a): total body length (from the tip of the snout to the tip of the caudal fin) for sharks and rays, and anal length (from the tip of the snout to the anus) for chimaeras.
– Disc width (cm, see Figure A3b): width of the disc in rays.

FIGURE A3
Details of measuring sharks and rays

A3a



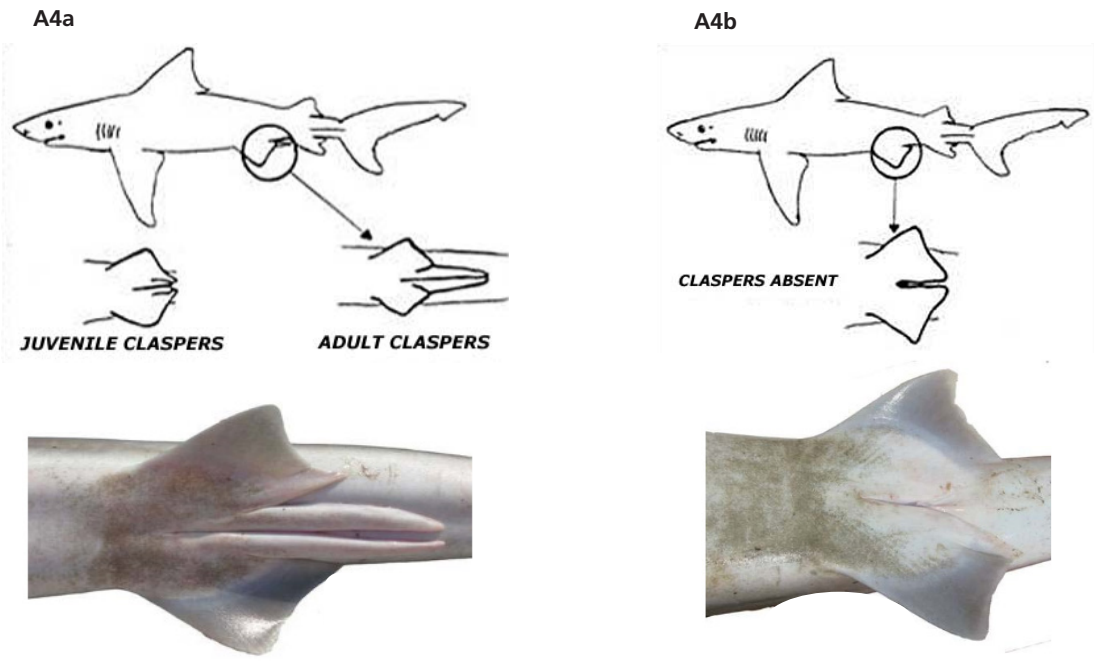
A3b



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

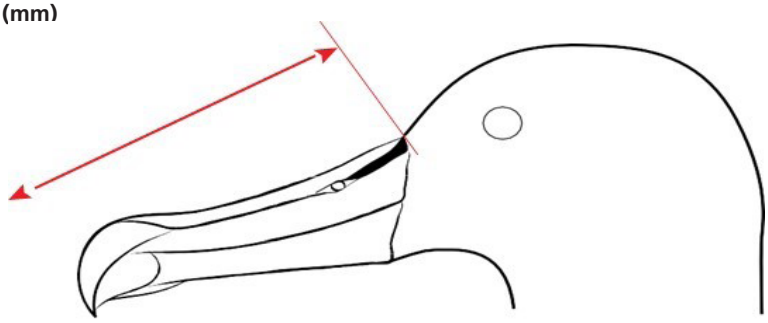


Source: Northeast Fisheries Science Center, National Oceanic and Atmospheric Administration (NOAA), U.S. Department of Commerce.

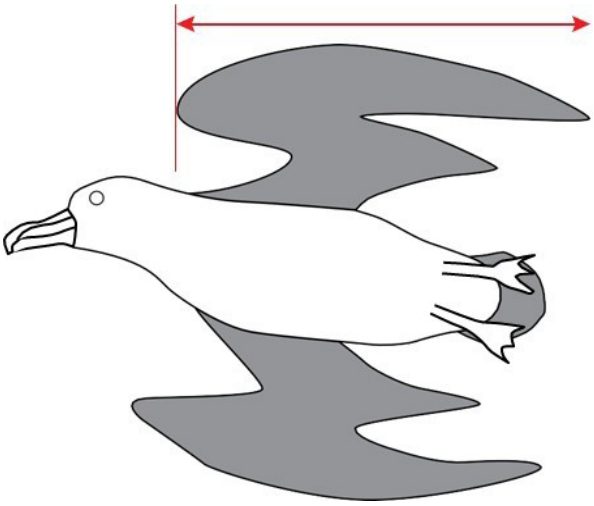
ANNEX 5.c. SEABIRDS

FIGURE A5
Details of measuring seabirds

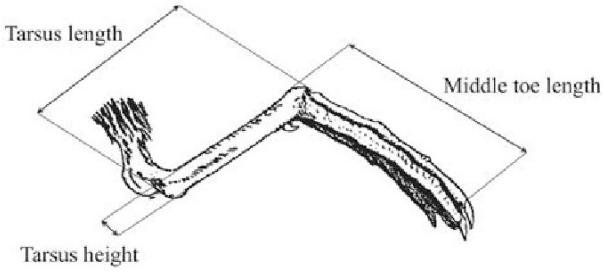
A5a – Bill length (mm)



A5b – Wing length (mm)



A5c – Tarsus length (mm)



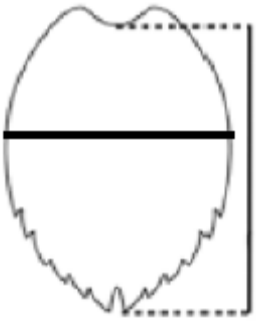
Note: Bill, wing and tarsus length measurements (in mm) may help identify the species.

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).

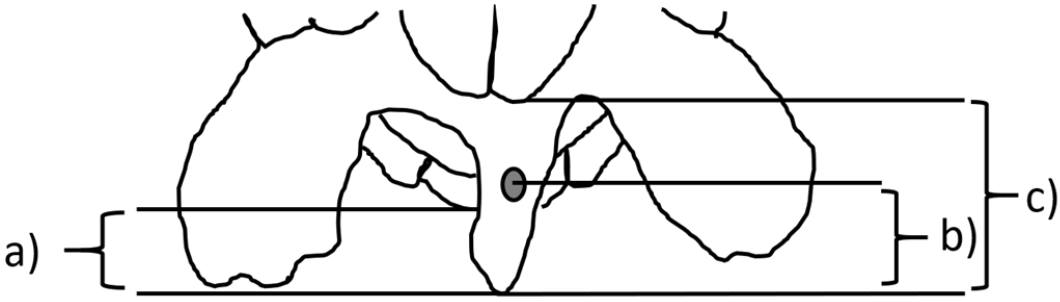
FIGURE A6
Curved carapace width and length measurements (A6a and A6b) and tail measurements (A6c) for sea turtles

A6a – Curved carapace width



A6b – Curved carapace length

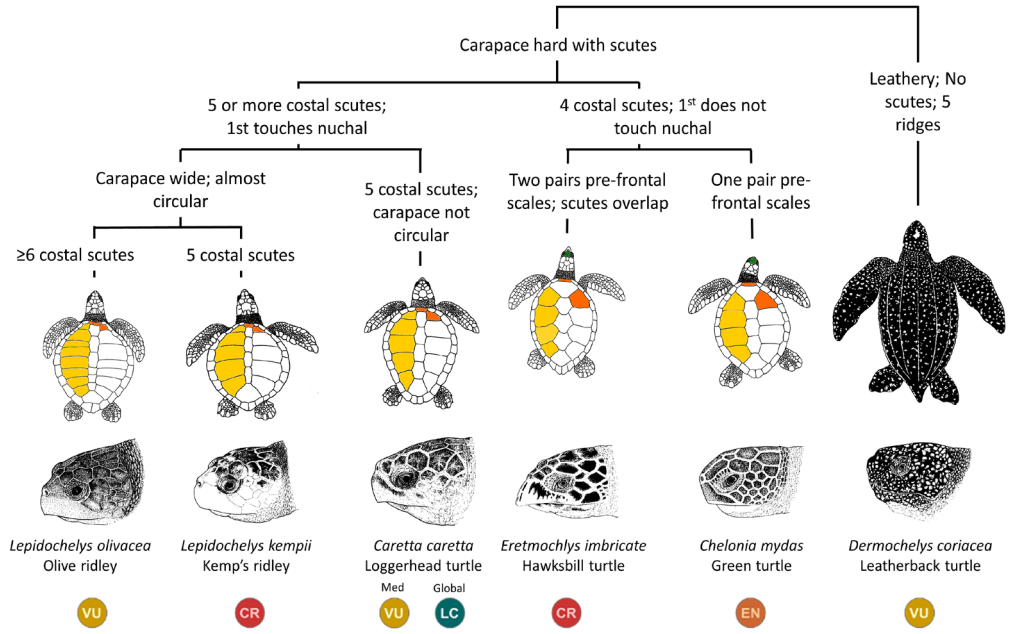
A6c – Tail measurements



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

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

* 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					

Condition at capture and at release	Capture	Release	Notes
Dolphins and whales			
Seals			
Sharks and rays			
Seabirds			
Sea turtles			

Benthic species composition			
Species or family/genus/order/taxa	Total weight (kg)	Total number	Notes/description

Additional comments

Annex 7.c. Questionnaire on general information on bycatch of vulnerable species						
Date of interview						
ID questionnaire						
Reference period						
Last week		Last month			Last year	
Did you catch any of the following group of vulnerable species? (Y/N)		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						
When more than one gear is used, please report name of gear						
How many are released alive? (insert a number or a percentage)						
Dolphins and whales						
Seals						
Sharks and rays						
Seabirds						
Sea turtles						
In which months or seasons do you most commonly catch vulnerable species?						
In general, in which location/area do you catch them (including distance offshore)?						
In general, when you do catch a vulnerable species, what do you do with it?						
What is your opinion on factors influencing bycatch and on how to mitigate interactions (if any)?						
Additional comments						

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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Procedures and sampling for demersal (bottom and beam) trawl surveys and pelagic acoustic surveys

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Preparation of this document

These guidelines have been prepared by the General Fisheries Commission for the Mediterranean (GFCM) of the Food and Agriculture Organization of the United Nations (FAO) to address the priorities identified by Mediterranean and Black Sea countries in the context of existing international commitments and regional strategies. In particular, Target 1 of the mid-term strategy (2017–2020) towards the sustainability of Mediterranean and Black Sea fisheries (mid-term strategy) aims at reversing the declining trend of fish stocks through strengthened scientific advice in support of management. This document contributes to the objective of this strategy aimed at enhancing knowledge on Mediterranean and Black Sea fisheries through regional surveys-at-sea, namely acoustic surveys for pelagic species and bottom and beam trawl surveys for demersal species.

As it is difficult to gather information on the status of fish stocks in the context of multispecies and multigear fisheries in the Mediterranean Sea, fisheries independent data sources obtained through scientific surveys are very useful to acquire direct information on the state and dynamics of fish stocks and ecosystems and to improve the assessments based on the analysis of fishery-dependent data. Standardized time series are essential to provide information on the spatial and temporal variations in the abundance of commercial and non-commercial species as well as on the demographic attributes and other ecological indices of these species.

Within the GFCM, the Scientific Advisory Committee on Fisheries (SAC) and the Working Group on the Black Sea (WGBS) have highlighted the lack of survey data for some areas in the Mediterranean and the Black Sea and the need to harmonize the production and collection of such data across the region. Building upon the protocols already in place in the European Union – namely the Mediterranean International Bottom Trawl Survey (MEDITS), the Solea Monitoring Survey (SoleMon) and the Mediterranean International Acoustic Survey (MEDIAS) – these technical guidelines provide a framework for the implementation of harmonized regional and subregional scientific surveys in the Mediterranean and the Black Sea using a standardized methodology aimed at producing comparable results.

Experts in bottom, beam trawl and acoustic surveys, namely Giuseppe Scarcella and Angelo Bonanno, were tasked with developing these guidelines under the overall coordination of Paolo Carpentieri, GFCM Fishery Resources Monitoring Specialist, who ensured consistency with the methodologies in place and with GFCM priorities as well as applicability across the GFCM area of application.

A coordination meeting for the implementation of scientific surveys in the Mediterranean, organized in 2017 by the GFCM in Slovenia, gathered preliminary elements on acoustic and bottom trawl surveys, based on national experiences and on the outcomes of similar initiatives both in the European Union and at the international level. Technical consultations with experts involved in the BlackSea4Fish project also led to the integration of a section on beam trawl surveys. The draft guidelines were reviewed on the occasion of a workshop on the harmonization of data collection in scientific surveys-at-sea, held in 2019 in Bulgaria. In parallel, they were also presented to the Regional Coordination Group for the Mediterranean and Black Sea of the European Commission and at the MEDITS and MEDIAS Steering Committee meetings. These consultations contributed to the set-up of appropriate coordination mechanisms and helped fine-tune the methodology and align it to current practices so that it could be useful and replicable in different countries and areas. GFCM national focal points

in Algeria, Egypt, Lebanon, Morocco and Tunisia already provided technical inputs as they prepared for the launch of their scientific surveys in 2019 and 2020, carried out with the support of the GFCM and the FAO regional projects and based on a standard methodology. Finally, the SAC and the WGBS reviewed and endorsed the final document for publication.

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, Lauriane Palopoli and Ysé Bendjeddou, GFCM Editing/Communications Interns. Barbara Hall served as language editor and Chorouk Benkabbour managed the graphic design and layout. Alberto Gennari produced and modified several illustrations based on existing materials.

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Abstract

There is increasing concern about species diversity, stock status and environmental conditions in ecology and conservation biology. Following investigations carried out in recent years at a local and regional scale, there is a growing need for large and multiscale data to increase knowledge on these aspects and determine how to maintain diversity. This is of particular importance in enclosed and semi-enclosed marine ecosystems such as the Mediterranean and the Black Sea, which are highly sensitive to human impacts.

In the Mediterranean and the Black Sea, demersal stocks are mainly assessed using data obtained through scientific demersal surveys (bottom and beam trawl), while pelagic stocks are assessed using data from acoustic surveys (i.e. using acoustic techniques together with mid-water trawling). These types of routine surveys provide essential information on many stocks and allow monitoring changes in species distribution and estimating annually the total mortality, growth parameters, sex ratios and average length at maturity of species so as to fine-tune assessments on the status of resources and to estimate indicators more precisely at the level of fish populations and communities.

However, scientific survey practices differ across subregions, each one having its own strengths and limitations, and there is still a lack of large-scale, standardized surveys devoted to analysing the diversity and distribution of the main demersal and pelagic species across the Mediterranean and the Black Sea. One solution to tackle this issue is to establish international scientific surveys covering the main demersal and pelagic stocks based on a common methodology.

The General Fisheries Commission for the Mediterranean (GFCM) has identified, among the main priorities of its mid-term strategy (2017–2020) towards the sustainability of Mediterranean and Black Sea fisheries (mid-term strategy), the need to develop a unique framework for the planning and implementation of regional demersal (bottom and beam) trawl and pelagic acoustic surveys based on existing protocols – namely the Mediterranean International Bottom Trawl Survey (MEDITS), the Solea Monitoring Survey (SoleMon) and the Mediterranean International Acoustic Survey (MEDIAS) that are being implemented in the European Union.

These technical guidelines aim at supporting this endeavour. Their use can serve different purposes: i) implementation of new surveys (applicable to areas where demersal trawl and/or pelagic acoustic surveys are not regularly carried out); ii) increasing comparability between existing surveys by standardizing methods, sampling of catches, and recording and analysis of data; and iii) definition of minimum requirements towards sustainability and management objectives (e.g. assessing the status of resources, establishment of management plans) at a regional and subregional scale. The guidelines cover Mediterranean and Black Sea priority species identified by the Scientific Advisory Committee on Fisheries (SAC) and the Working Group on the Black Sea (WGBS), based on the inputs of the Working Groups on Stock Assessment (WGSAs), and are in line with data collection requirements within the GFCM Data Collection Reference Framework (DCRF[1]). They provide a useful tool for the collection of relevant complementary information on the incidental catch of vulnerable species, vulnerable marine ecosystems and non-indigenous species. Furthermore, scientific surveys can represent a valuable source of information on marine litter.

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

Contents

Preparation of this document iii
Abstract v
Acknowledgements xi
Acronyms xii
Background xiii

1. DEMERSAL BOTTOM TRAWL SURVEYS 1
1.1 Aim 1
1.2 Vessel characteristics 2
1.3 Sampling gear 2
1.4 Survey design 6
1.5 Handling of the catch 10
1.6 Data reporting and exchange formats 16

2. PELAGIC ACOUSTIC SURVEYS 17
2.1 Aim 17
2.2 Vessel characteristics 18
2.3 Methodology 18
2.4 Period for and timing of pelagic acoustic surveys 18
2.5 Pelagic trawl 19
2.6 Oceanographic data 22
2.7 Data reporting and exchange formats 22

3. DEMERSAL BEAM TRAWL SURVEYS 25
3.1 Aim 25
3.2 Vessel characteristics 26
3.3 Sampling gear 26
3.4 Survey design 29
3.5 Handling of the catch 31
3.6 Data reporting and exchange formats 34

4. ECOSYSTEM DATA 35
4.1 Macrobenthos 35
4.2 Vulnerable species 38
4.3 Marine litter 39
4.4 Non-indigenous species 39

5. DATA POLICY 41

REFERENCES 43

ANNEXES 47

Annex 1. GFCM subregions and geographical subareas (GSAs) 49
Annex 2. List of priority species by subregion 50
Annex 3. Fishing haul information 53
Annex 4. Catch composition by fishing haul 55
Annex 5. Length data by fishing haul 56
Annex 6. Individual weight by species 58
Annex 7. Sex and maturity data 60
Annex 8. Maturity scales 64
Annex 9. Six-phase maturity stages for anchovies and sardines caught in pelagic surveys 70
Annex 10. Maturity scale conversion table for anchovy (*Engraulis encrasicolus*) and sardine (*Sardina pilchardus*) 71
Annex 11. Reporting templates for bottom and beam trawl demersal surveys 72
Annex 12. Reporting templates for pelagic acoustic surveys 77
Annex 13. List of vulnerable species 79
Annex 14. Data entry sheet for vulnerable species 84
Annex 15. Data entry sheet for marine macro-litter 85
Annex 16. Data entry sheet for macrobenthos 86
Annex 17. Scheme of the rapido trawl 87

Tables

Table 1. Relationship between depth (m) and warp length (m) for the trawl GOC 73 at different warp length diameters (mm) 7
Table 2. Depth strata (with surface in km^2) and number of planned hauls per stratum and GSA 8
Table 3. Proposed minimum number of otoliths by length class per survey 15
Table 4. Taxonomy of small pelagic species of potential interest in performing a pelagic acoustic survey 17
Table 5. Priority species of potential interest for which a BTS could provide primary and/or additional data for tuning indices, by GFCM subregion 32
Table 6. Subsampling of epibenthic and benthic species, and debris fraction 33

Figures

Figure 1. Main components of a demersal trawl net 2
Figure 2. GOC 73 trawl used for the MEDITS survey (acronyms specified for each netting) 3
Figure 3. Gear rigging details adopted for the MEDITS trawl 4
Figure 4. Main characteristics of the Morgere W horizontal (WH) otter board 5
Figure 5. Morgere WH S 8 6
Figure 6. Measurement of total (TL) and standard lengths (SL) in bony fish 12
Figure 7. Measurement of total (TL) and fork lengths (FL) in elasmobranchs 13
Figure 8. Measurement of carapace length (CL) for Decapoda crustacean 13
Figure 9. Measurement of dorsal mantle length (ML) of cephalopods 13
Figure 10. Example of an echogram acquired by a scientific split-beam echo-sounder (38 kHz) 19
Figure 11. Screenshots of a possible system for monitoring net sampling on small pelagic fish 20
Figure 12. Schematic representation and picture of the rapido trawl 27
Figure 13. Design of the rapido trawl net 28
Figure 14. Beam trawl scheme 28
Figure 15. Relationship between depth and warp length 29

Plates

Plate 1. Catch composition reaching a vessel deck (left) and sorting procedures (right) 11
Plate 2. Weighting and counting different species in the total catch 11
Plate 3. Invertebrates in catch composition (forming the megabenthos size > 2 cm) 11
Plate 4. Collection of total weight by species 14
Plate 5. Collection of individual weight 14
Plate 6. Results of a sampling activity by pelagic net 21
Plate 7. Results of biological sampling by pelagic net: species identification and separation 21
Plate 8. Measurement phases of biological samples 22
Plate 9. Catch reaching a vessel deck (left) and sorting procedures (right) 31
Plate 10. Various species of macroinvertebrates in a catch 36
Plate 11. Marine litter in catch composition 39

Boxes

Box 1.	Length data to be reported during a pelagic acoustic survey	23
Box 2.	Age data to be reported during a pelagic acoustic survey	23
Box 3.	The SoleMon survey in the northern Adriatic Sea (GSA 17)	26
Box 4.	Mediterranean VME indicator: features (a), habitats (b) and taxa (c)	37
Box 5.	Minimum set of data to be collected regarding the incidental catch of vulnerable species	38

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Acronyms

BTS	Beam trawl survey
CL	Carapace length
CPCs	Contracting parties and cooperating non-contracting parties (GFCM)
CTD	Conductivity, temperature and depth
DCRF	Data Collection Reference Framework (GFCM)
EDSU	Elementary distance sampling unit
FAO	Food and Agriculture Organization of the United Nations
FL	Fork length
GFCM	General Fisheries Commission for the Mediterranean
GSA	Geographical subarea (GFCM)
IFREMER	Institut Français de Recherche pour l'Exploitation de la Mer
IUCN	International Union for Conservation of Nature
MEDIAS	MEDiterranean International Acoustic Survey
MEDITS	MEDiterranean International bottom Trawl Survey
ML	Mantle length
NASC	Nautical area scattering coefficient
SAC	Scientific Advisory Committee on Fisheries (GFCM)
SL	Standard length
SOLEMON	SOLEa MONitoring survey
TL	Total length
UNCLOS	United Nations Convention on the Law of the Sea
VME	Vulnerable marine ecosystem
WGBS	Working Group on the Black Sea (GFCM)
WGSA	Working Group on Stock Assessment (GFCM)

Background

The establishment of pan-Mediterranean and Black Sea surveys has been motivated by the lack of comprehensive studies of the biological status of most demersal and pelagic fish stocks in some Mediterranean areas (GFCM, 2007; GFCM, 2017a, 2017b). To date, scientific surveys in the Mediterranean and the Black Sea have been carried out at an international scale, mainly covering European Union countries (Bertrand *et al*., 1997, 2002; AdriaMed, 2011; MEDITS, 2017; MEDIAS, 2019), with very few national surveys and varying degrees of comparability among surveys and countries. To effectively use survey information from all sources, the adoption of standard survey methods and stratification schemes is essential. Survey data throughout the Mediterranean and the Black Sea should be harmonized in order to capture the most relevant biological events and to allow for more accurate estimates of life history parameters such as mortality and growth. Since the boundaries of stock units are still not very well known for most Mediterranean species, the need for standardized indices of abundance and demography is a priority. Such data would provide valuable records to better assess the spatial occupation of the diverse components of stocks (e.g. seasonal distribution, spatial segregation, community structure and recruitment areas). This gain in accuracy would, in turn, sharpen the evaluation of variations in population indicators and input data/parameters for population and community modelling.

At a coordination meeting for the implementation of scientific surveys in the Mediterranean, organized by the GFCM in 2017 (GFCM, 2017d), it was decided that the existing manuals already in use among some GFCM countries (MEDIAS, 2015; 2017; 2019; MEDITS, 2016; 2017; SoleMon, 2017; 2019) and covering both demersal (bottom and beam) trawl and pelagic acoustic surveys should be considered as the main references. The proposal was endorsed by the Scientific Advisory Committee on Fisheries (SAC) (GFCM, 2017a) and the Working Group on the Black Sea (WGBS) (GFCM, 2016, 2017b, 2019b). In terms of target species, this document addresses priority species identified by the SAC and the WGBS, on the basis of the work carried out by the GFCM working groups on stock assessment (WGSAs) and in line with existing data collection requirements within the GFCM Data Collection Reference Framework (DCRF). The list of target species, which is based on the existing manuals, may be complemented at a later stage with other species of regional or subregional interest (GFCM, 2017d; 2018a).

1. DEMERSAL BOTTOM TRAWL SURVEYS

1.1 AIM

The aim of a demersal bottom trawl survey is to collect standardized fishery-independent data with a view to improving stock assessments. Demersal bottom trawl surveys should contribute to the characterization of fishery resources in a given area, in terms of population distribution (e.g. relative abundance indices) and demographic structure (e.g. length and sex distributions) as they collect data, including sex, maturity and weight, for the estimation of growth parameters of priority species. Thanks to the data obtained, it should be possible to compare catch composition in different areas, subregions and geographical subareas (GSAs) (GFCM, 2009; Annex 1) and to describe the spatial distribution pattern of all identified GFCM priority species (Annex 2), using the same gear specifications, to the extent possible.

The results of these surveys are crucial for the formulation of science-based advice on sustainable fisheries and conservation of stocks. In addition, the data collected should also be used for modelling the dynamics of the main target species in each GFCM subregion. Finally these surveys are also extremely useful to collect data on ecosystems (e.g. macrobenthos, several vulnerable marine species, and marine litter).

1.2 VESSEL CHARACTERISTICS

For the correct implementation of a standardized demersal bottom trawl survey, commercial and/or research vessels should be equipped with an engine of at least 370 kW (500 hp) to be able to tow the standard sampling gear (traction at ground run: 4.5 tonnes) (Section 1.3).

Trawl speed during each fishing operation should be of about 3 knots. This recommended speed is very important to ensure the best trawl geometry. A speed lower than 2.8 knots can have a negative effect on the vertical opening of the net mouth and the stability of the doors, which can descend and become stuck in the mud. In deep waters, a speed greater than 3.2 knots can cause the gear to lift off the bottom and must be avoided (MEDITS, 2017).

During the survey implementation, the main information on each fishing haul (e.g. latitude, longitude, depth, speed, etc.) should be monitored and reported (see Annexes 3).

1.3 SAMPLING GEAR

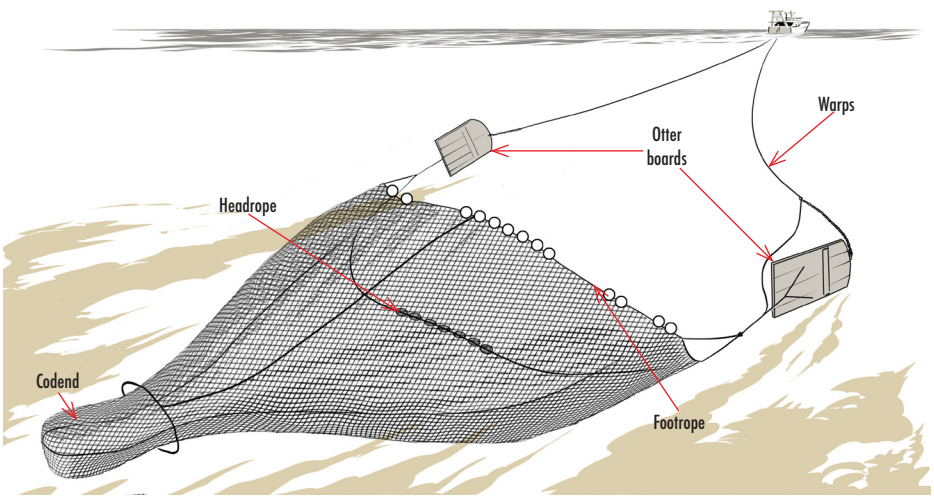
The sampling gear for demersal trawl surveys should correspond to the bottom trawl (i.e. GOC 73, see Section 1.3.1) used to carry out the MEDITS, including all its material and rigging from the doors to the codend of the net (Relini, Carpentieri and Murenu, 2008; MEDITS, 2017). This was agreed by the GFCM survey coordination meeting (GFCM, 2017d) and endorsed by the SAC (GFCM, 2017a) and the WGBS (GFCM, 2017b). The adoption of this standard gear would permit comparability of data and results among countries and GSAs.

This gear constitutes a good compromise between different constraints (Bertrand *et al.*, 1997, 2002): it has been planned with a vertical opening that is slightly superior to the most common commercial types of gear used in the Mediterranean and the Black Sea to increase the catch of demersal species (MEDITS, 2017).

Some general requirements and details regarding the mesh size, codend, otter boards and warps are provided in the following sections (a more detailed description of the gear is included in MEDITS, 2017).

For countries/GSAs where no demersal surveys have been previously carried out or where little information on sea bottom is available, it is suggested that exploratory fishing operations (e.g. fishing hauls/transects) should be carried out before the implementation of the standardized scientific survey with a commercial demersal trawl net (Figure 1). The bottom trawl used in this pre-survey should have a conical net bag with a wide mouth fitted with weights on the ground-rope and floats on the headrope.

FIGURE 1
Main components of a demersal trawl net



(Illustrator: Alberto Gennari)

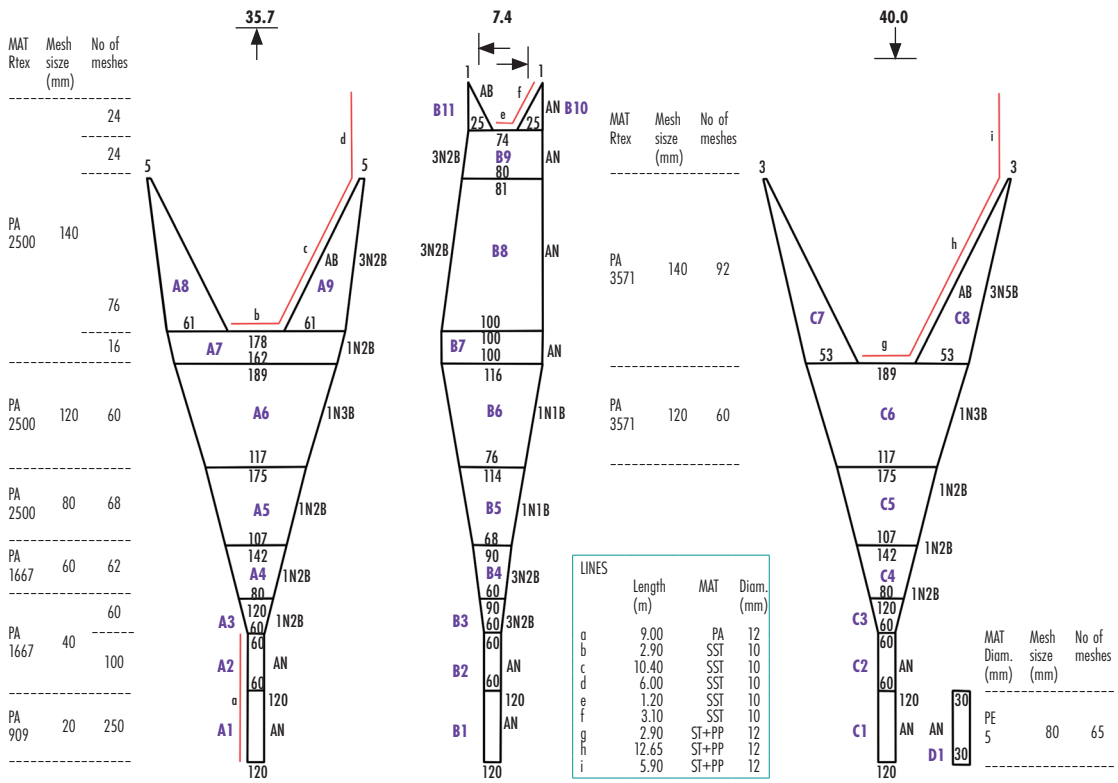
The use of a commercial trawl net would allow to better explore the bathymetry and the topography of the sea bottom. Based on the results of this pre-survey, the sampling scheme using the GOC 73 trawl gear (Section 1.3.1) designed by the Institut français de recherche pour l'exploitation de la mer (Ifremer) could then be used or modified.

1.3.1 GOC 73 trawl gear

All fishing hauls should be undertaken using a bottom otter trawl net with standard dimensions, i.e. the reference GOC 73 trawl designed for scientific purposes by Ifremer – width 22 m, height of vertical opening 2 m, length 40 m, stretched mesh size at codend 20 mm (Fiorentini and Dremière, 1996; Fiorentini *et al.*, 1999). Figure 2 shows a schematic drawing of the Ifremer GOC 73 trawl gear (MEDITS, 2017).

FIGURE 2

GOC 73 trawl used for the MEDITS survey (acronyms specified for each netting)



Source: Modified from MEDITS Survey – Instruction Manual, Version 9, 2017. (Illustrator: Alberto Gennari)

The most important specifications of this gear, also reported in the MEDITS manual (MEDITS, 2017), are the following:

- It is able to work from 10 to 800 m depth.
- It has low selectivity so as to have good images of the populations sampled, including recruits.

The mesh size of the codend should be 10 mm of mesh side, which corresponds to about 20 mm of mesh opening (stretch). In the International Organization for Standardization (ISO) 1107:2017, ISO defines the mesh side as "the distance between two sequential knots or joints, measured from centre to centre when the yarn between those points is fully extended".

The nets should be made of good-quality polyamide netting (nylon). The headrope should have around 40 floats, resisting to an immersion of 1 300 m depth. Their diameter should be about 20 cm, their individual buoyancy 2.7 kilograms-force per float (kgf) (± 5 percent), with the total buoyancy of the 40 floats being some 108 kgf (± 5 percent). The floats should be distributed along the headrope as follows:

– from the end of each wing, one float every 1.5 m, five times;
– one pair of floats every 1.5 m on the whole remaining length;
– in the headrope bosom, a small adjustment of the spacing is necessary.

Based on this number of floats, the vertical opening of the trawl should reach from 2.4 m to 2.6 m, being inversely related to the horizontal opening.

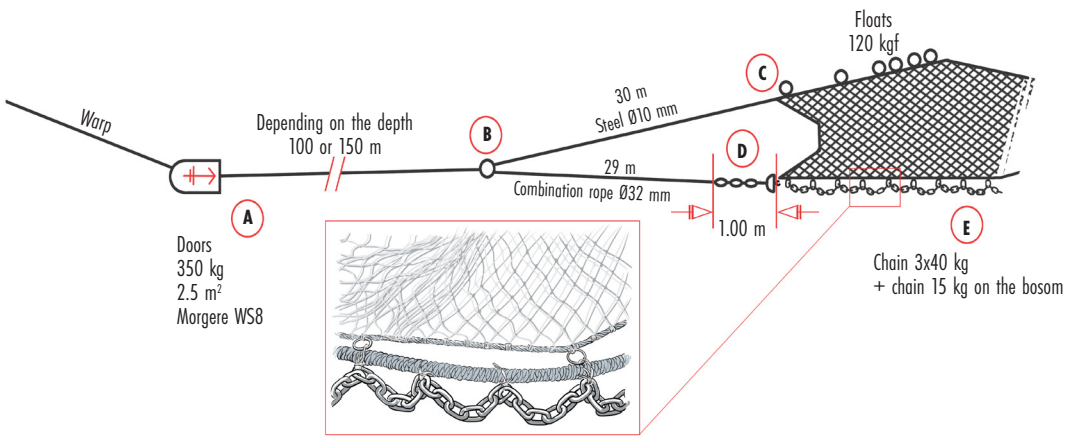
A weighting chain (ballast chain) of 120 kg (3 × 40 kg) should be secured to the foot rope at 17 cm intervals (with a hanging height of at most 8 cm).

In addition, a supplementary chain (one only) of 15 kg (about 6.5 m with a diameter of 10 mm) should be secured symmetrically on both parts of the belly bosom in the same way as the first chain (garland of 17 cm in length) (MEDITS, 2017).

1.3.2 Rigging

A general illustration of the rigging is presented in Figure 3 (MEDITS, 2017). The upper bridle length should be 30 m (C); the lower bridle length should be 29 m, plus the adjustment chain of 1 m (the adjustment chain is only found on the lower legs) (D).

FIGURE 3
Gear rigging details adopted for the MEDITS trawl



Note: The length of the 1 m chain (D) should be adjusted to obtain the upper (steel) and the lower bridle (combination rope + chain) of the same length (30 m).
Source: Modified from MEDITS Survey – Instruction Manual, Version 9, 2017. (Illustrator: Alberto Gennari)

In order to maintain the geometry of the trawl as constant as possible, two bridle lengths (MEDITS, 2017) are defined below according to the depth:

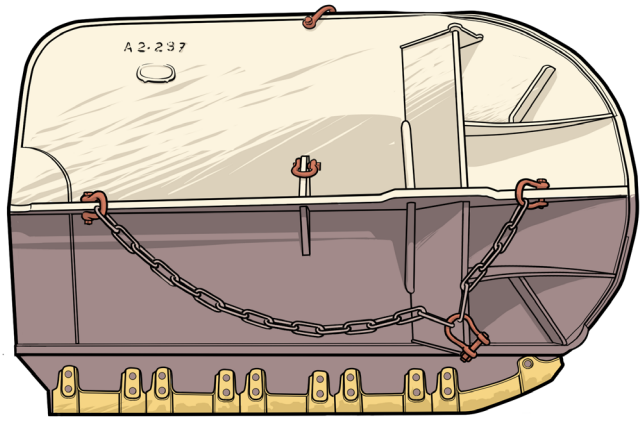
Depth (in metres)	10–200	201–800
Bridle lengths (in metres)	100	150

1.3.3 Doors

The doors should be of type Morgere W Horizontal: S (WH S, Figures 4 and 5), corresponding to size 8. The length of the backstops (shackles not included) should be as follows (MEDITS, 2017):

– long external backstrops: 1.60 m; and
– short upper and lower backstrops: 0.65 m (± 10 percent).

FIGURE 4
Main characteristics of the Morgere W horizontal (WH) otter board



W HORIZONTAL TYPE : S

The otter board WH can be equipped with chain or with fixed bracket.
In the backside, the otter board can be equipped with 2 or 3 chains backstrop

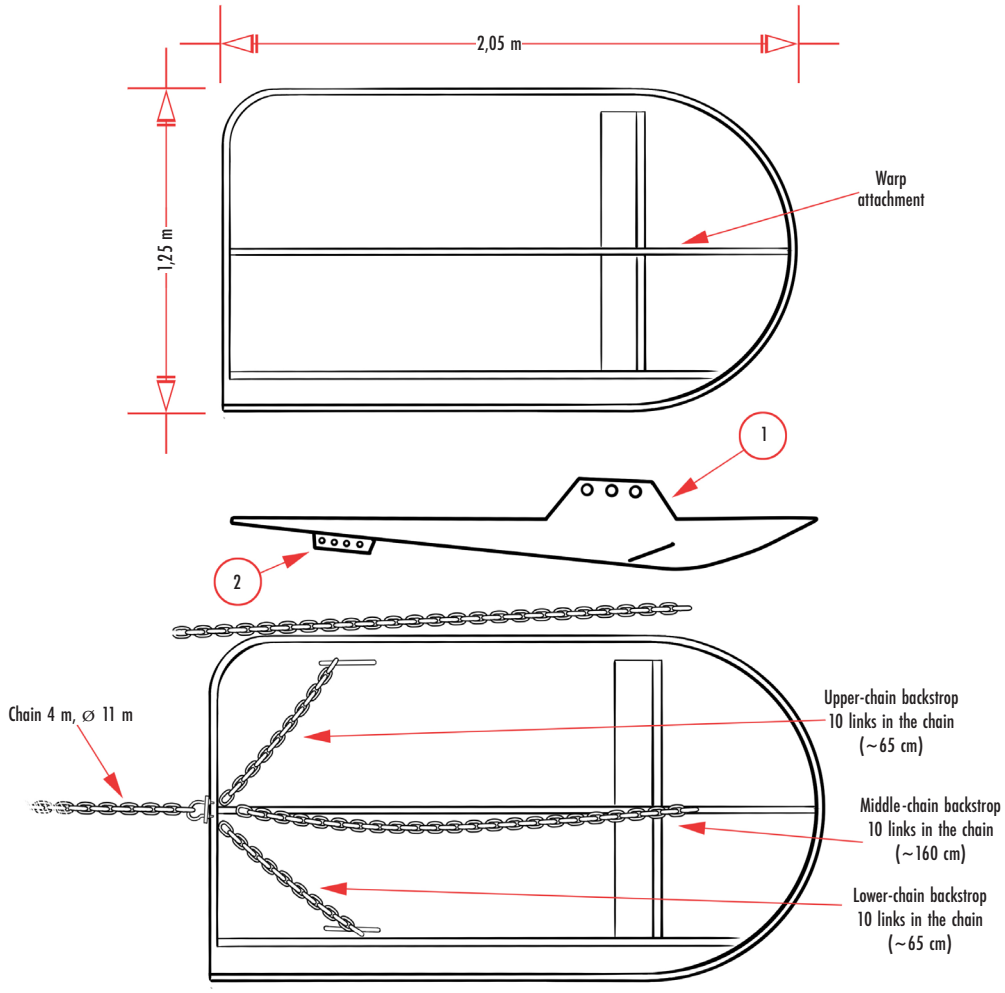
TYPE	DIMENSIONS	SURFACE M²	WEIGHT KG	TYPE	DIMENSIONS	SURFACE M²	WEIGHT KG
WS 0	1 050x750	0.70	60–100	WS 14	2 650x1 700	4.34	1 000–1 200
WS 1	1 300x850	1.00	100–130	WS 15	2 750x1 750	4.62	1 150–1 300
WS 2	1 500x900	1.12	110–150	WS 16	2 800x1 800	4.90	1 250–1 350
WS 3	1 600x1 000	1.36	150–190	WS 17	2 900x1 900	5.20	1 300–1 400
WS 4	1 700x1 050	1.62	200–240	WS 18	3 050x2 000	5.70	1 400–1 600
WS 5	1 750x1 100	1.74	230–250	WS 19	3 200x2 100	6.10	1 500–1 700
WS 6	1 900x1 150	1.96	250–300	WS 20	3 400x2 200	6.60	1 700–1 900
WS 7	2 000x1 200	2.23	320–350	WS 21	3 500x2 300	7.30	1 900–2 100
WS 8	2 050x1 250	2.46	350–400	WS 22	3 600x2 400	7.58	2 000–2 300
WS 9	2 150x1 300	2.62	380–500	WS 23	3 750x2 500	8.82	2 300–2 700
WS 10	2 300x1 350	2.82	500–700	WS 24	4 000x2 700	9.31	2 300–3 000
WS 11	2 400x1 400	2.93	600–700	WS 25	4 300x2 900	11.10	2 500–4 000
WS 12	2 500x1 500	3.30	750–900	WS 26	4 600x3 200	13.00	3 000–5 000
WS 13	2 600x1 600	3.70	900–1 000	WS 27	5 000x3 500	15.80	4 000–6 000

Note: For the MEDITS programme, the WS 8 type was selected. The otter board weight refers to without and with plates in the shoe.
Source: Modified from MEDITS Survey – Instruction Manual, Version 9, 2017. (Illustrator: Alberto Gennari)

1.3.4 Warp diameter and length

Taking the characteristics of the trawl and rigging into account, the warps should have a diameter ranging between a minimum of 14 mm and a maximum of 22 mm. The length of warps to be shot should be determined by the operating depth. Table 1 gives, by depth, different warp lengths to be shot at different depth in function of the warp diameter (from 12 to 22 mm). The relationships are calculated based on the specifications of the GOV 73 net and the WS 8 doors (MEDITS, 2017). In addition, it is recommended that the warp length not be less than 200 m, because this would considerably decrease the door spread, increasing door instability.

FIGURE 5
Morgere WH S 8



Note: The lengths of the backstrop chains are indicated without the shackles. The warp is shackled in the fore hole of the bracket sheet (arrow 1). The short parts of the external crowfoot are shackled in the furthest back part of the backside sheets, upper and lower (arrow 2).
Source: Modified from MEDITS Survey – Instruction Manual, Version 9, 2017. (Illustrator: Alberto Gennari)

Although in particular circumstances some adaptations can be made to this relationship, it is recommended that the depth/warp length ratio be respected as far as possible. For vessels not equipped with a device to measure the length of warp shot, it is recommended to put a mark every 50/100 m directly on the warp to know how much cable is dropped.

1.4 SURVEY DESIGN

The aim of a demersal trawl survey is to cover the main distribution area of the target species. Demersal abundance is highly variable and large-scale trends related to habitat features, bathymetric and hydrographic conditions are evident. To exploit these trends to improve the precision of abundance indices, it is important to correctly allocate the trawl stations.

A procedure for the allocation of stations should be established. A fixed grid of stations ensures maximum information on distribution throughout the area, but not necessarily the most precise estimate of biomass (Sparre and Venema, 1998). For an estimation of stock sizes, a completely randomized design or a stratified random sampling design should be preferred. In most cases, a stratified random sampling design should be chosen, because fish are seldom uniformly distributed, and in most cases, species occurrence and abundance is related to depth (Sparre and Venema, 1998).

TABLE 1
Relationship between depth (m) and warp length (m) for the trawl GOC 73 at different warp length diameters (mm)

Depth (m)	Ø12 mm	Ø14 mm	Ø16 mm	Ø18 mm	Ø22 mm
	Warp length (m)				
10	200	200	200	200	200
30	350	300	300	300	300
50	400	350	350	350	350
75	500	450	400	400	400
100	600	550	500	450	450
150	800	700	650	600	550
200	950	850	800	700	650
250	1 100	1 000	900	800	750
300	1 250	1 150	1050	900	850
350	1 400	1300	1 150	1 000	950
400	1 550	1 400	1 250	1 100	1 050
450	1 650	1 500	1 350	1 200	1 150
500	1 750	1 600	1 450	1 300	1 250
550	1 850	1 700	1 550	1 400	1 350
600	1 950	1 800	1 650	1 500	1 450
650	2 050	1 900	1 750	1 600	1 550
700	2 150	2 000	1 800	1 650	1 650
750	2 250	2 050	1 850	1 700	1 700
800	2 350	2 100	1 900	1750	1 750

Source: MEDITS Survey – Instruction Manual, Version 9, 2017.

A stratified random sampling scheme has several advantages over a purely random scheme:

- Sampling is spread out over the entire area of the survey (e.g. GSAs) by assuring the required number of trawl stations in each stratum (e.g. bathymetric range).
- Sampling rates, in terms of stations per unit area, can be varied to improve the precision of estimates for some key species, this being an advantage over systematic sampling.

Trawl station location, depending on the characteristics of each area (see Section 1.4.1), can be randomly selected within an identified bathymetric stratum (e.g. 10–50, 51–100, 101–200 m, etc.) prior to each survey. The number of stations within each stratum should be generally proportional to the area of the stratum and also include consideration of the overall variability in multispecies distribution among strata.

Generally, the use of stratified random sampling enables the size of the contribution of sampling error to be controlled and estimated, and avoids possible biases in station selection.

1.4.1 Survey area

A demersal trawl survey should cover the main geographical and bathymetric range of the main species within a given GSA or a combination of GSAs according to the stock boundaries of the target species. The total covered area should be stratified according to depth and geographical criteria and, if known, fish density. Fishing positions must be chosen randomly in a first survey, but may be maintained as fixed stations during subsequent surveys. Information about depth and type of bottom to point out trawlable areas and strata may be obtained also from a preliminary survey with echo-sounding. Information from local fishers may also

be valuable (Sparre and Venema, 1998). Information on seasonal winds, currents and migration patterns of fish stocks are important as well. Preferably, surveys in new areas should involve zones where commercial trawling is performed, using commercial hauls as a guide when deciding on sampling stations. This is essential due to the time constraints on performing the survey and also for safety reasons. Except in the case of particular problems (e.g. damages noted in previous years, etc.), once identified and selected, the same hauls position should be visited every year. According to Hilborn and Walters (1992) resorting the stations in each survey should allow a more accurate estimate of the standing stock in the investigated area, while keeping stations fixed over time should allow for more accurate information on time trends of relative abundance.

For conservation purposes, sensitive habitats (e.g. *Posidonia* spp. meadows, coralligenous beds), as well as vulnerable marine ecosystems (VMEs) (see Section 4.1) should be excluded from the sampling scheme and should never be trawled. All these aspects must be considered during the process of allocation of hauls to the different strata (Section 1.4.2).

1.4.2 Depth strata and sampling stations

Since bathymetry is the main factor affecting the distribution of demersal species, the trawl stations (or fishing hauls) should be allocated proportionally to the surface of each depth stratum, both over the shelves (0–200 m) and the upper slopes (> 200 m). Then, based on the MEDITS manual (Relini, Carpentieri and Murenu, 2008; MEDITS, 2017), fishing hauls should be allocated among five main depth strata (i.e. 10–50 m, 51–100 m, 101–200 m, 201–500 m, > 501 m). Within each identified stratum, the position of the stations should be then selected randomly in the first survey. Each country performing a new survey will have to adapt the allocation of the fishing hauls based on the morphological and ecological features of the sea bottom.

Generally, the target average sampling rate should be about one station per 60 square nautical miles in all areas (Bertrand *et al.*, 2002). To reduce or avoid covariance between fishing stations in adjacent strata, stations should be separated by at least 5–10 miles (ICES, 2010). Before the survey, it would be fundamental to set the surface area (in km^2) and number of fishing hauls by GSA and for each identified stratum (Table 2).

TABLE 2
Depth strata (with surface in km^2) and number of planned hauls per stratum and GSA

Stratum	Code	GSA	Surface area (km^2)	Number of planned hauls
10–50 m	A	.....	.....	.....
51–100 m	B	.....	.....	.....
101–200 m	C	.....	.....	.....
201–500 m	D	.....	.....	.....
> 501 m	E	.....	.....	.....

Note: This table, following stratification needs, should be prepared before survey implementation.

The following formula should be applied (modified from Sparre and Venema, 1998) and can be used to estimate how many fishing hauls can be carried out in a given period:

- number of fishing hauls per day = $T/(t_1+t_2+t_3)$; and
- total number of fishing hauls during the survey = (N)*(number of fishing hauls per day).

N	Total number of days available to perform the survey
t_1	Duration of one fishing haul (average, hrs)
t_2	Time used for shooting and hauling the trawl (average, hrs)
t_3	Time to cover distance between fishing hauls (average, hrs)
T	Number of hours available per fishing activity during the day (depending on crew, behaviour of investigated species, navigation, etc.)

It is important to standardize the length of a fishing haul throughout the survey, because the catchability of species and sizes can be affected by the duration of the haul (Section 1.4.3).

In general, fishing hauls should be performed at constant depth. The depth variations during the haul should not exceed ± 5 percent relative to the initial depth. As far as possible and in respect of the previous constraints, the hauls should be rectilinear.

The gear should stay in good contact with the seabed during the whole haul. This should be checked regularly by observation of chain wear, observation of benthic organisms in catches after the haul, and an acoustic device (if any) during the haul. The systematic use of a device (e.g. Scanmar, Simrad or other catch sensor) to control the trawl geometry (i.e. vertical and horizontal openings, contact with the bottom) is highly recommended.

When a device is not present, a proper contact could be indicated both by inspecting for chain/warp wear and for monitoring of warp widening and vibration. The measurements of the trawl geometry should be taken at various depths on board each vessel at the beginning of the survey to establish the relationship between the horizontal and vertical opening and parameters easy to measure, such as depth and/or warp length.

At deeper waters (i.e. more than 200 m), some difficulties might be encountered in gear setting on the bottom; thus particular attention must be paid to the shooting operations. In order to decrease the setting time, the following recommendations should be considered (MEDITS, 2017):

- After the complete shooting of the warps and once the winch is stopped, a relatively high speed (5–6 knots) should be maintained for about one minute to stretch the gear and open the doors.
- The speed should then be strongly reduced (even to 0), allowing the doors to reach the seabed. The time required varies depending on the vessel and the depth, for example 2–3 minutes at 500 m.
- Once the doors are on the seabed, a speed lower than normal (2.5–2.7 knots) should be maintained to allow the net to reach the bottom.
- Once the net is well stabilized, the speed will be increased towards the standard speed (3 knots); this moment is defined as the real start of the haul.

1.4.3 Survey period and timing of fishing operations

Demersal trawl surveys should be conducted annually, possibly during spring or summer (from 1 May to 30 September). This would permit greater comparability of data among GSAs and GFCM subregions (Annex 1). To properly carry out the survey, and based on the main biological aspects of the selected species (e.g. recruitments and spawning periods), the best month during this period should be selected.

Due to the different catchability of demersal resources according to the diel cycle, it is recommended to conduct trawling operations during daylight hours (i.e. between sunrise and sundown), although it is recognized that some institutes may wish to trawl

both during the day and at night. More specifically, the daylight period is defined as the time between 30 minutes after sunrise and 30 minutes before sunset. Fishing hauls should have a duration of 30 minutes on bottoms shallower than 200 m and 60 minutes on bottoms deeper than 200 m. For vessels using a device such as a SCANMAR Trawl Sensor or SIMRAD or other equivalent equipment, the start time of the haul is defined as the moment when vertical net opening and wing spread indicate that the net is in its stable fishing configuration (Engås *et al*., 2001; ICES, 2009; MEDITS, 2017). For the vessels without such a device, preliminary trials shall be made before the survey to determine the setting time needed to operate correctly for each vessel, taking into consideration the experience of each individual skipper, as well as the best predicting models of the net behaviour (e.g. horizontal and vertical net openings by warp length). Stop time is defined as the start of pull back (ICES, 2011). If the haul should be stopped before completion of the standard duration, it can be considered valid if at least two-thirds of the time or of the distance have been successfully attained (MEDITS, 2017).

It is strongly recommended that the sampling period of the survey is consistent yeartoyear to reduce the time-of-the-survey effect on the time series (ICES, 2012; MEDITS, 2017).

1.5 HANDLING OF THE CATCH

The organisation of work at sea mainly depends on the facilities available on board the vessel. Photos of whole catch should be systematically taken at each fishing haul. Wherever possible, the entire catch should be sorted (Plate 1), with all species (e.g. fish, cephalopods, crustaceans, etc.) identified to the lowest taxonomic level possible. However, as the level of taxonomic expertise on board vessels can be variable, and certain species can be hard to distinguish from one another, those could be reported by genus and/or higher taxonomic group (e.g. *Nezumia* spp. or Macrouridae).

Data on total catch composition (i.e. number and weight by species) for a single fishing haul can be collected and recorded as in Annex 4. For large catches, a representative subsample should be sorted. In some cases, the sample (e.g. non-identified species, a subsample of huge catch, etc.) can be taken and preserved on board, and the biological analyses carried out at laboratories.

After the catch has been sorted, for each species, the total weight and number of individuals should be recorded (Plate 2). Length measurements and some other biological data (i.e. sex, maturity and weight) should be taken, at least for all identified target species (Section 1.5.1).

With the exception of decapod crustaceans and cephalopods, which should be recorded according to the standard templates[1], the number and the total weight should be recorded for all other macroinvertebrates (Plate 3) (see Annex 16 and Section 4.1). In this sense, attention should be mainly focused on benthic species indicators of VMEs, as defined by the FAO (FAO, 2009; GFCM 2017a, 2017b; GFCM, 2018b, 2019a).

1.5.1 Target species

Although a scientific survey should aim to collect basic information on all species caught, the level of sampling requirements, based on time availability and human resources, will be different for all species observed in the survey. Hence, as a general principle, and in line with the requirements of the SAC and WGBS, the collection of basic data should be ensured to allow estimation of the distribution, abundance and key biological parameters (e.g. length, weight, sex and maturity) at least for all species of group 1 and group 2 (Annex 2) as requested by the DCRF (GFCM, 2018a).

[1] All the templates are available for consultation and download in electronic format at: http://www.fao.org/gfcm/data/en/

PLATE 1

Catch composition reaching a vessel deck (left) and sorting procedures (right)

PLATE 2

Weighting and counting different species in the total catch

PLATE 3

Invertebrates in catch composition (forming the megabenthos size > 2 cm)

For all other sampled species of fish, crustaceans, molluscs and other invertebrates, data collection depends on time availability, but at least the total number and total weight by species should always be collected.

Moreover, since in recent years non-indigenous species have been pointed out as one the most important direct drivers of biodiversity and ecosystem service changes both in the Mediterranean and the Black Sea, particular attention should also be paid to collecting biological data (i.e. length, weight, sex and maturity) on this group of species. Survey information on non-indigenous species could contribute to understanding their roles in the benthic and pelagic ecosystems, their impacts on their new colonised environment, including restructuring established food webs, and competition with native organisms for food and space (see also Section 4.4).

1.5.2 Biological parameters

In order to allow an exhaustive and accurate processing of collected materials, individual biological data (length, weight, sex, maturity and otoliths reading) can be recorded either on board or in laboratory according to the work conditions (e.g. trawl surveys carried out by using an oceanographic vessel or a hired commercial trawler).

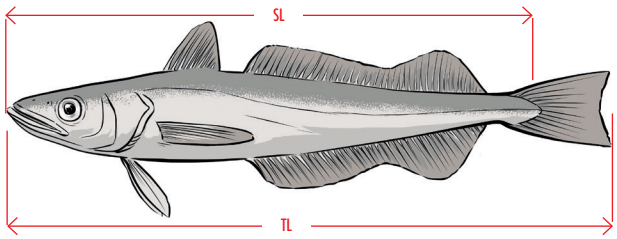
1.5.2a Length measurements

After sorting the catch into species, representative length distributions should be recorded for collected species (following the criteria described in Section 1.5.1), from high-priority species (i.e. group 1 and group 2 of Annex 2) to all others if time permits. Where the number of individuals is too high to measure them all, a representative subsample should be selected, from 50 to 100 specimens, depending on the species in each fishing haul. The length measurements to be taken depend on the group of species under study, and a proper representation of the given length distribution is key. Thus, attention must be given to a possible uneven distribution of species and/or size classes in the hold.

The methodology to be used for the collection and reporting of length data should follow the DCRF manual (GFCM, 2018a).

Bony fish and elasmobranchs – For bony fish, sharks, skates and rays, the length to be considered is total length (TL). The fish should be measured from the tip of the snout to the end of the caudal fin (Figures 6 and 7), to the lower half centimetre (e.g. 13.4 = 13 cm; 16.8 = 16.5 cm).

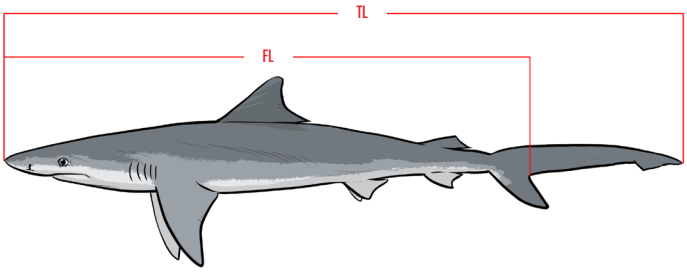
FIGURE 6
Measurement of total (TL) and standard lengths (SL) in bony fish



(Illustrator: Alberto Gennari)

For bony fish, the standard length (SL) could be also recorded, which is defined as the measurement taken from the tip of the lower jaw to the posterior end of the hypural bone (Figure 6). For elasmobranchs, fork length (FL) can be recorded when the caudal fin is damaged and the TL cannot be measured (Figure 7).

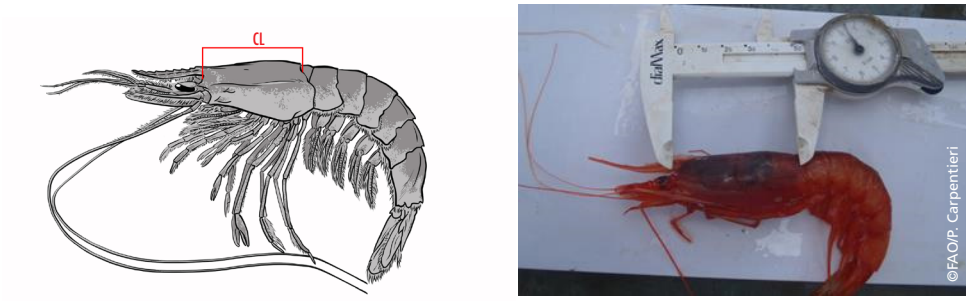
FIGURE 7
Measurement of total (TL) and fork lengths (FL) in elasmobranchs



(Illustrator: Alberto Gennari)

Crustaceans – For crustaceans, the cephalothorax (carapace) length in millimetres should be reported to the lowest millimetre (as a whole number, e.g. 1, 2, 3, 4, etc.) (Figure 8).

FIGURE 8
Measurement of carapace length (CL) for Decapoda crustacean

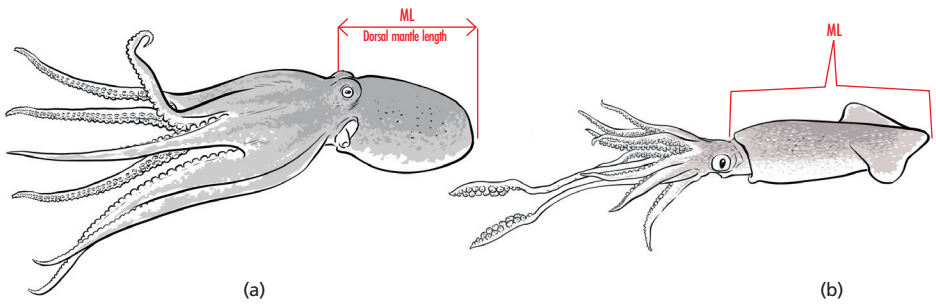


(Illustrator: Alberto Gennari)

Cephalopods – For cephalopods, the mantle length in centimetres should be collected and reported to the lower half centimetre (as a whole or half number, e.g. 0.5, 1.0, 1.5, etc.) (Figure 9). For Octopoda, measurement is taken along the median line, passing through the eyes to the apex of the mantle (Figure 9a). For Decapoda, measurement is made along the dorsal midline from the mantle margin to the posterior tip of the body, excluding long tails (Figure 9b).

Length data for different groups of species can be collected and reported using the forms in Annex 5.

FIGURE 9
Measurement of dorsal mantle length (ML) of cephalopods



Note: a) Octopoda and b) Decapoda.
(Illustrator: Alberto Gennari)

1.5.2b Weight

The total weight (in kg) of all species (Plate 4) in the catch should be collected and recorded (Annex 4).

PLATE 4
Collection of total weight by species

Individual weight should be collected and recorded (Plate 5) for at least all species of group 1 (Annex 6.1). The optimum number for individual weight per length class cannot be given in a universal form, but a minimum of five specimens per length class should be weighed.

PLATE 5
Collection of individual weight

The choice of weighing device (e.g. hanging balance, electronic balance) depends on the size of the sampling and working conditions (on board or at laboratory). For fish, elasmobranch and cephalopod species, the total weight of each individual could be reported to the nearest gramme, using an electronic balance. For crustaceans, the weight should be recorded to the nearest 0.1 g.

If it is impossible to measure individual weight, as a possible alternative, the number and total weight of a group of individuals with the same length should be recorded in order to calculate the mean weight of individuals in the length class (Annex 6.2).

Although the weighing of single individuals may prove more complex, depending on prevailing conditions in the workplace, it is important to collect this biological information to the extent possible.

1.5.2c Sex and maturity

The sex is defined following four categories, through macroscopic observation: male (M), female (F), undetermined (U – when, after dissection, it was not possible to determine the sex of different specimens with the naked eye), and not determined (ND – an individual that has not been examined). Sex and maturity data should be collected and reported (Annex 7) for the main priority species.

A large number of macroscopic maturation scales are available in the literature, varying from oversimplified scales comprising three to four stages to highly specific and relatively complicated scales (up to nine stages) (Follesa and Carbonara, 2019). For the purpose of this section, the maturity scales designed for scientific trawl surveys in other contexts should be used (MEDITS, 2017; see Annex 8)[2]. Using common maturity scales would simplify data sharing and data quality checks.

1.5.2d Otoliths

Otolith samples can be collected on a "by need" basis, depending on the countries participating in the survey and on regional and/or subregional working group requirements. However, otoliths of routinely assessed species should always be collected for age estimation.

The technique for cutting otoliths depends on the species. For descriptions of these techniques (i.e. otolith sampling, preparation and reading) it is recommended to consult the literature on the subject (Carbonara and Follesa, 2019). The optimum number of otoliths per species and length class cannot be given in a universal form. A description of the optimum sample size of age readings and length measurements dependent on a universal cost function is given in Oeberst (2000) and in the Manual for Baltic International Trawl Surveys (ICES, 2011). The analyses showed that the necessary number of age readings in a length class depends on:

– the portion of the length class within the length frequency; and
– the maximum variance of the portions of the age groups within the length class.

Table 3 proposes a minimum number of otoliths by length class that must be taken per survey and species, based on length distribution. For the smallest sized groups, which presumably contain only one age group, the number of otoliths per length class may be reduced. Conversely, more otoliths per length are required for the larger length classes.

TABLE 3
Proposed minimum number of otoliths by length class per survey

Criteria	Sample size
With probably only one age group (age group 0, 1)	From 2 to 5 individuals
With probably more than one age group:	
If the portion of any given length class is estimated as less than 5 percent of total catch per species	From 2 to 5 individuals
If the portion of any given length class is estimated as more than 20 percent of total catch per species	Minimum 10 individuals per length class

Source: ICES, 2011.

Otoliths may be sampled during the survey if proper facilities and experienced people are on board and stored in envelopes or other suitable containers. The whole fish or its head can be stored for later processing in laboratory. In both cases, it is important, when otoliths are removed, that each single container be labelled with the identification code of

[2] Collected maturity data, only for the purpose of the DCRF (GFCM, 2018a), should be submitted and reported with reference to the maturity scales based on DCRF rules and requirements (Recommendation GFCM/41/2017/6).

the species and date. For each specimen, length, individual weight, together with sex and the maturity stage, should be also collected. Annex 6.1 can be used to report these data.

1.5.3 Oceanographic data

As a minimum, the following hydrographical data should be collected at each fishing haul:

- seawater temperature and salinity in the surface layer; and
- seawater temperature, salinity and oxygen content in the bottom layer.

Whenever possible, other parameters (e.g. turbidity, transparency, and current among others) from the surface to the bottom should be recorded. Annex 3.2 can be used to report all these hydrographical data.

1.6 DATA REPORTING AND EXCHANGE FORMATS

The outcomes of demersal trawl surveys should satisfy different data requirements within the GFCM:

- Relevant information should comply with DCRF provisions (GFCM, 2018a).
- Useful information in compliance with existing GFCM recommendations should be reported to the GFCM by its contracting parties and cooperating non-contracting parties (CPCs).
- Information supporting stock assessment should be reported to the different Working Groups on Stock Assessments (WGSAs) through stock assessment forms.
- Other relevant information useful for regional analysis can be examined in dedicated expert groups.

Standard templates[3] are defined for the storage and exchange of data produced by demersal trawl surveys already conducted in some Mediterranean and Black sea countries (see also annexes from X to XIII in MEDITS, 2017). In order to have comparable and harmonized data, basic information on fishing hauls, catch and biological data should be reported, once collected, using these standard templates: i) Fishing hauls data (TA template; Annex 11.1); ii) Catch data by haul (TB template; Annex 11.2); iii) Biological data, length, sex, and maturity at aggregated species level (TC template; Annex 11.3); iv) Biological parameters at individual level (TE template; Annex 11.4) and v) Data on marine litter (TL template; Annex 11.5). The use of these standard templates should facilitate the exchange and analysis of the data produced by the demersal surveys among different countries.

In order to make proper use of the mentioned formats, ad hoc tool should be used and adapted (i.e. some fields should be revised, codifications are needed, among others) to the different needs of Mediterranean and Black Sea countries that are not currently involved in scientific surveys. Therefore, flexible routines for data conversion, from the input structure to the common formats (i.e. TA, TB, TC, TE and TL type formats), together with the complementary codification, will be made available to each country involved in a scientific survey.

This tool (i.e. MEDITS.Web application, COISPA Tecnologia & Ricerca, 2020), is conceived taking into account the long and consolidated experience of the MEDITS trawl survey (MEDITS, 2017), in terms of standardised protocols for data collection and data format. This approach is integrated by introducing a wide flexibility to allow applications in other areas taking into account the specificities at sub-regional level while maintaining a common minimum standard. MEDITS.Web application has been realized for data input, import/export, storage, check and sharing. Besides the needed flexibility other basic concepts associated to the MEDITS.Web application are the data quality control check, data elaboration, data check procedures, which would permit to highlight errors that could compromise further analysis and make them unreliable.

[3] All the templates are available for consultation and download in electronic format at: http://www.fao.org/gfcm/data/en/

2. PELAGIC ACOUSTIC SURVEYS

2.1 AIM

The main aim of a pelagic acoustic survey is to evaluate biomass and spatial distribution of the small pelagic fish species in given GSAs through the combined use of acoustic methods (Simmonds and MacLennan, 2005) and pelagic trawl. Consequently, data acquired during this survey should provide information on the pelagic fish community and on the pelagic environment.

The main species of the pelagic community, which could be sampled through the implementation of a pelagic acoustic survey in the Mediterranean and the Black Sea, are reported in Table 4.

TABLE 4
Taxonomy of small pelagic species of potential interest in performing a pelagic acoustic survey

Family	Scientific name	English common name	FAO code
Engraulidae	*Engraulis encrasicolus* (Linnaeus, 1758)	European anchovy	ANE
Clupeidae	*Sardina pilchardus* (Walbaum, 1792)	European pilchard	PIL
	Sardinella aurita (Valenciennes, 1847)	Round sardinella	SAA
	Sprattus sprattus (Linnaeus, 1758)	European sprat	SPR
Carangidae	*Trachurus trachurus* (Linnaeus, 1758)	Atlantic horse mackerel	HOM
	Trachurus mediterraneus (Steindachner, 1868)	Mediterranean horse mackerel	HMM
	Trachurus picturatus (Bowdich, 1825)	Blue jack mackerel	JAA
Scombridae	*Scomber scombrus* (Linnaeus, 1758)	Atlantic mackerel	MAC
	Scomber japonicus (Houttuyn, 1780)	Chub mackerel	MAS
Sparidae	*Boops boops* (Linnaeus, 1758)	Bogue	BOG

Note: this list of species could be subject to changes based on countries and regional/subregional needs.

2.2 VESSEL CHARACTERISTICS

It is highly recommended, whenever possible, that research vessel are used for acoustic surveying at sea. Vessels should be equipped with hull-mounted transducers for both the scientific echo-sounder and the net-sounder. Furthermore, vessels should be equipped with an engine capable of towing the sampling gear (maximum traction about 4.5 tonnes) (see Section 2.5).

2.3 METHODOLOGY

The survey design for acoustic sampling is strongly dependent on both the spatial structures of small pelagic fish and the topographic characteristics of the area to be investigated.

The survey should cover the sea area between the coastline and the limit of the continental shelf. The minimum bottom depth should be 20 m or less, reaching the 10 m isobaths whenever possible. The maximum echo-sounding depth should be 200 m. The intertransect distance to be adopted should be carefully determined based on the continental shelf extension and, if available, on specific knowledge of the ecological characteristics of the area.

2.4 PERIOD FOR AND TIMING OF PELAGIC ACOUSTIC SURVEYS

In the Mediterranean, pelagic acoustic surveys should be conducted annually, possibly during spring or summer (between May and September). In the Black Sea, surveys should be carried out in the period from spring to autumn (between April and November). Each Mediterranean and Black Sea country, based on the main biological aspects of the identified priority species (e.g. recruitments and spawning periods), should select the best month during these periods to carry out the survey. This would permit greater comparability of data among areas and GFCM subregions.

Acoustic surveys should only take place during daytime and should be interrupted at night, when fish schools disperse. This approach would prevent possible bias in the biomass estimation due to the different aggregation status of fish species. If available survey time does not permit acquisition of data only during daytime, echo sampling might be extended. Previous studies had indicated that night estimates can be higher or lower than daytime estimates, largely depending on the area characteristics and, especially, the local plankton and fish densities (Simmonds and MacLennan, 2005; Draštík *et al*., 2009). However, results showed that correction is possible and advisable when night sampling is inevitable. In this context, and depending on the available vessel time, it is good practice to identify specific test areas where acoustic data are recorded both in the daytime and at night. Test areas should be selected considering:

- the extension of the continental shelf;
- specific geographical characteristics (e.g. the presence of gulfs); and
- oceanographic processes such as the presence of specific enrichment processes driving the productivity of the area (e.g. upwelling events, river runoff, tidal mixing).

2.4.1 Analysis design

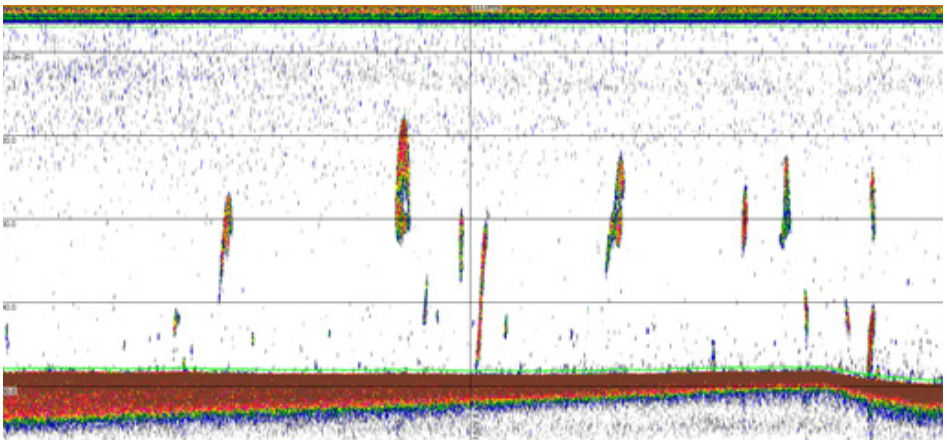
For countries/GSAs where acoustic surveys have been performed, the acoustic survey design is already established and, if necessary, could be adjusted to achieve minimization of the coefficient of variation of the acoustic estimates for the priority species in each area.

For countries/GSAs where no acoustic survey has been previously carried out, it is suggested that parallel transects be adopted along the depth gradients (i.e. bottom topography), which are normally perpendicular to the coastline/bathymetry. In cases of topographic complexity, as with semi-closed gulfs, riverine areas or islands, survey design could be decided in another manner (see Simmonds and MacLennan, 2005).

2.4.2 Echo sounder parameters

A scientific split-beam echo-sounder should be used for the acoustic survey (Figure 10). Pulse duration should be 0.5 or 1 millisecond (ms), depending on the technical specifications of each echo-sounder. The frequency for assessment should be 38 kilohertz (kHz), while other split beam transducers can operate as complementary frequencies (e.g. 18, 70, 120 and 200 kHz).

FIGURE 10
Example of an echogram acquired by a scientific split-beam echo-sounder (38 kHz)



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The threshold for assessment should be -70 to -60 dB, depending on the survey and the ecosystem. Background noise should be evaluated and removed. Since the main objective is optimum discrimination between fish and plankton, based on the available frequencies used in each survey, a frequency-response-based mask should be developed to split the acoustic backscattering between fish and plankton. Whenever this cannot apply, the threshold for assessment should be set at -70 to -60 dB, depending on: (a) noise level (-60 dB in the case of high noise); (b) the peculiarities of each area regarding school morphology and plankton density (-60 dB when plankton is dense, but -70 dB when small schools dominate the area); (c) echo-sounder features; and (d) time of day that echo acquisition is carried out.

The elementary distance sampling unit (EDSU) for echo integration should be one nautical mile (NM). The acoustic energy acquired in the inter-transect tracks should not be taken into account for assessment purposes.

At least one calibration of echo-sounder should be held per survey, based on the procedure reported in the manual of each echo-sounder and according to the principles described by Foote *et al.*, (1987) and Demer *et al.*, (2015).

2.5 PELAGIC TRAWL

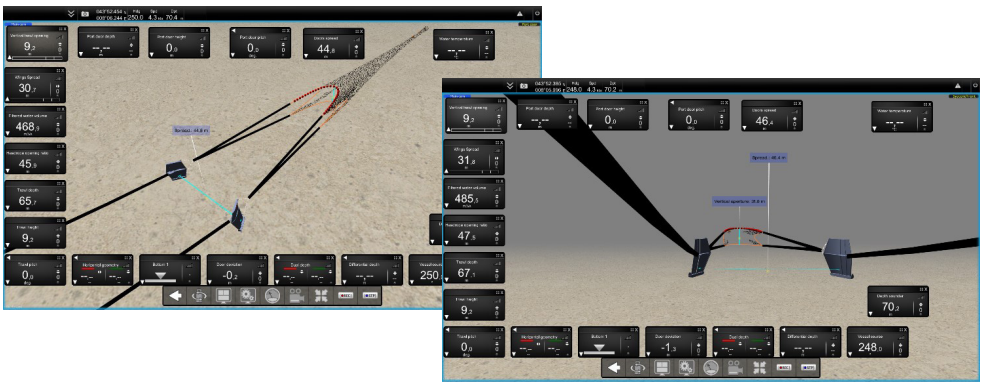
Implementing acoustic surveys means acquiring both acoustic data and net samplings of small pelagic fish with a pelagic trawl (i.e. pelagic fishing hauls). The details of each pelagic trawl haul (e.g. latitude, longitude, depth, time) should be monitored and reported as in Annex 3.1. Furthermore, temperature, salinity and other parameters from the surface to the bottom should be sampled. Annex 3.2 can be used to report these data.

The main objectives of trawling in an acoustic survey are to obtain a sample from the schools or layers that appear on the echograms and to acquire information on fish species composition and size distribution. Thus, it is important that the trawling gear be suitable for catching a representative sample of the target schools or layers.

In an acoustic survey, the sampling intensity for biological samples depends on the extent of the area covered, the frequency of occurrence of different echo traces on the echograms, and on the spatial characteristics of fish aggregations. The presence of specific behavioural effects, such as the spatial segregation between different age/length classes, should be considered in order to sample the whole fish population. In addition, the geographical coordinates or the sampling depth of the hauls cannot be predetermined, because pelagic species execute extended horizontal and vertical movements. School morphometry and energetic characteristics might change depending on the area, the time interval or even the fishing pressure. Thus, the sampling strategy has to be adaptive, depending on school characteristics per area, time of the survey and year.

It is recommended to use a net monitoring system (a net-sounder) during trawling operations (Figure 11).

FIGURE 11
Screenshots of a possible system for monitoring net sampling on small pelagic fish



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Given the fact that different research vessels are expected to be used in the GSAs in the Mediterranean and Black Sea, as a minimum, the following indications should be adopted:

- A standardized pelagic trawl net should be used in all areas for biological sampling.
- Maximum codend mesh size should be equal to 24 mm (mesh size equal to 12 mm).
- The vertical opening during the pelagic fishing hauls should be reported, along with the net-sounder used.
- The duration of fishing hauls should be no less than 30 minutes for unknown echoes and when multispecies scattered echoes are being fished.
- Vessel speed during fishing should be 3.5–4.5 knots.
- Sampling intensity must be adequate to ensure identification of echo traces, to obtain a representative length structure of the population for each small pelagic species, and to evaluate the species composition of the insonified target in the water column.

2.5.1 Handling of the catch

Once on board the vessel, the biological sample collected during each pelagic haul should be divided by species (Plate 6).

All species in the catch should be recorded. Data (i.e. length and weight) on total catch composition for single pelagic haul and by species should be collected and reported as in Annex 4. When the catch of a given species is too abundant, a representative subsample of the whole catch should be randomly selected (Plate 7).

PLATE 6
Results of a sampling activity by pelagic net

PLATE 7
Results of biological sampling by pelagic net: species identification and separation

This subsample should be not less than 100 individuals per species. The total length (TL) of each fish should be measured on board immediately, with the tail fully extended to the lower half centimetre. Length data for groups of species can be collected using the forms in Annex 5.

Individual weight (±0.01g) should be collected and recorded (Annex 6.1), at least for all pelagic species of group 1 (Annex 2 and Table 4). If it is impossible to determine individual weight, as a possible alternative, the number and total weight of a group of individuals with the same length should be recorded in order to calculate the mean weight of individuals in the length class (Annex 6.2).

Sex is defined following four categories, through macroscopic observation: male (M), female (F), undetermined (U – when, after dissection, it was not possible to determine the sex of different specimens with the naked eye), not determined (ND – an individual that has not been examined), and the spawning phases (Annexes 7 and 8). Based on the pelagic acoustic protocol in place (MEDIAS, 2017, 2019), for sardine (*Sardina pilchardus*) and anchovy (*Engraulis encrasicolus*) only,

a six-phase maturity scale, which would permit comparability of data among pelagic surveys, should be used (ICES, 2008; Annex 9)[4].

Otoliths of the target species can be collected for age determination at a laboratory (Plate 8) and reported in Annex 6.1.

PLATE 8
Measurement phases of biological samples

2.6 OCEANOGRAPHIC DATA

A multiparametric CTD probe should be used to acquire vertical profiles of the main oceanographic variables (e.g. pressure, temperature, and salinity) in the entire water column (MEDIAS, 2015, 2017). Taking into account the great importance of environmental parameters for small pelagic fish, a minimum of three CTD stations should be collected per transect or a grid of stations with density adequate to describe the oceanography of the surveyed area. The hydrographic parameters temperature and salinity should be measured at each station.

2.7 DATA REPORTING AND EXCHANGE FORMATS

The acoustic method for small pelagic fish biomass estimation is structured in two main phases to be performed, respectively, on board the vessel (acoustic data and biological samples collection) and at a ground-based laboratory (post-processing of acoustic data and analysis of biological samples). During the first phase, acoustic data collected both along the survey tracks and during the calibration procedure, should be stored in a specific format (e.g. *.raw or *.hac) in a mass storage unit.

The results of the second phase should be reported in specific tables or maps in terms of nautical area scattering coefficient (NASC) (MacLennan, Fernandes and Dalen, 2002) per EDSU, biomass per EDSU and numbers per EDSU (see Annex 12).

[4] Collected maturity data, only for the purpose of the DCRF (GFCM, 2018a), should be submitted and reported with reference to the maturity scales based on DCRF rules and requirements (Recommendation GFCM/41/2017/6) using the conversion table as in Annex 10.

In particular, the following abundance estimates, maps and charts are obtained:

Abundance indices	• Total fish NASC per EDSU • NASC per EDSU for each target species • Biomass per EDSU for each target species • Numbers per EDSU for each target species • Number/age per length class for each target species • Biomass/age per length class for each target species
Maps and charts	• Point maps of total fish NASC • Point maps of target species in NASC/mile; biomass/mile • Catch compositions of the fishing hauls, pies charts indicating biomass per species

Moreover, total biomass and total abundance (both by age class and by length class) should be estimated.

The minimum length and age data to be collected and reported during the implementation of a pelagic acoustic survey are summarized in Box 1 and Box 2.

BOX 1

Length data to be reported during a pelagic acoustic survey

- Country (country codes according to code list of FAO Member States, www.fao.org/countryprofiles/iso3list/en/)
- Year (year of survey in four-digit integer)
- Start day (starting day of survey in two-digit integer)
- End day (ending day of survey in two-digit integer)
- Start month (starting month of survey in two-digit integer)
- End month (ending month of survey in two-digit integer)
- GSA (area code according to Annex 1)
- Variable (abundance or biomass)
- Species (FAO 3-letter code)
- Sex (female = F, male = M, undetermined = U, not determined ND; combined = C)
- Unit (unit of length classes, mm = millimetre, cm = centimetre)
- Length classes 0 through 26 (numbers for abundance or tonnes for biomass, precision in thousands = three digits after comma)

Note: See annex 12.1 for complete list of fields.

BOX 2

Age data to be reported during a pelagic acoustic survey

- Country (country codes according to code list of FAO Member States, www.fao.org/countryprofiles/iso3list/en/)
- Year (year of survey in four-digit integer)
- Start day (starting day of survey in two-digit integer)
- End day (ending day of survey in two-digit integer)
- Start month (starting month of survey in two-digit integer)
- End month (ending month of survey in two-digit integer)
- GSA (area code according to Annex 1)
- Variable (abundance or biomass)
- Species (FAO three-alpha code)
- Sex (female = F, male = M, undetermined = U, not determined = ND, combined = C)
- Unit (unit of length classes, mm = millimetre, cm = centimetre)
- Age group 0 (numbers for abundance or tonnes for biomass, precision in thousands = three digits after comma)
- Age group 1 (numbers for abundance or tonnes for biomass, precision in thousands = three digits after comma)
- Age group 9 plus (numbers for abundance or tonnes for biomass, precision in thousands = three digits after comma)

Note: See Annex 12.2 for complete list of fields.

3. DEMERSAL BEAM TRAWL SURVEYS

3.1 AIM

The main aims for carrying out a standard and harmonized BTS are similar to those of a bottom trawl survey (Section 1). The main difference is that a BTS can supply fishery-independent indices and estimates of the age/length structure of target stocks that are not effectively sampled during a bottom trawl survey, such as flatfish, shellfish and other commercially-important benthic organisms.

In particular, in the different GSAs and/or GFCM subregions, a BTS can provide accurate information in terms of relative abundance/biomass, population distribution, demographic structure and biological parameters for target species such as common sole (*Solea solea*), cuttlefish (*Sepia officinalis*) and mantis shrimp (*Squilla mantis*), common in the Mediterranean Sea, but also turbot (*Scophthalmus maximus*) and Rapana whelk (*Rapana venosa*) common in the Black Sea.

Also, in coastal areas characterized by shallow waters and flat muddy bottoms, such as the Nile Delta, Iskenderun Bay, the inshore areas of the gulf of Lion and the Thracian Sea, a BTS can be a suitable technique for collecting fishery-independent data for different coastal benthic resources. In addition, a BTS can provide additional data for other demersal stocks already sampled during a standard bottom trawl survey (e.g. red mullet). These data can be functional in integrated approaches (e.g. SS3, a widely used statistical catch-at-age model), characterized by the use of more than one tuning index having a different selection pattern.

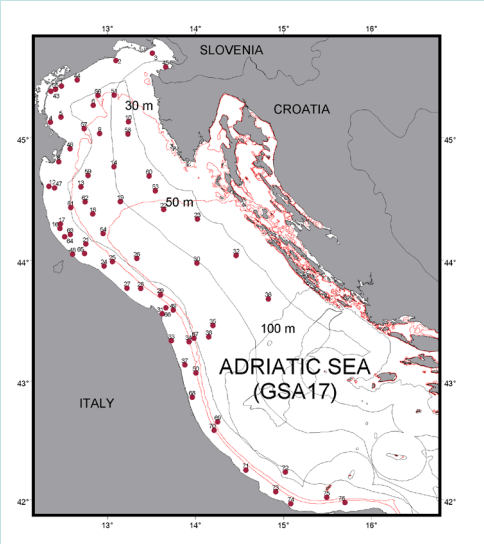
Similarly to standard bottom trawl surveys, a BTS can collect data on epibenthos assemblages as well as on VMEs (e.g. Pennatulacea). However, while in a standard bottom trawl survey, such data usually provide a qualitative indication of benthos assemblages, in a BTS, they can deliver quantitative data of benthos assemblages. Moreover, during the BTS, data on marine litter distribution and abundance can be collected.

Taking into consideration that, to date, the only BTS carried out regularly in the Mediterranean Sea is the SoleMon survey (SoleMon, 2017, 2019), which has been conducted since 2005 in the Adriatic Sea (see Box 3), it is recommended to use the same gear and methodology to have standard approaches and comparable results in other areas of the Mediterranean and Black Sea.

BOX 3

The SoleMon survey in the northern Adriatic Sea (GSA 17)

The SoleMon survey aims to collect data on distribution and relative abundance, with biological information on commercial fish species in GSA 17, to provide useful data for stock assessment and fishery management. The SoleMon survey programme is currently coordinated at the international level among Italy, Slovenia and Croatia, and since 2009 is harmonized in the framework of the ICES Working Group on Beam Trawl Surveys (WGBEAM). The primary target species is sole, with additional species including cuttlefish, scallop, queen scallops, mantis shrimp, turbot, brill, skates and caramote prawn.



3.2 VESSEL CHARACTERISTICS

Taking into account the sampling gear characteristics (Section 3.3) as well as the rigging, a BTS should be carried out with commercial and/or research vessels equipped with an engine of at least 298 kW (400 hp) to be able to tow the sampling gear with a correct speed. Trawl speed during each fishing operation should be from 4 to 5.5 knots. This recommended speed range is very important to ensure that the gear is always in contact with the seabed. A speed lower than 4 knots can have a negative influence on the penetration depth of a beam trawl into the seafloor. Therefore, the speed is an important factor determining catch efficiency, particularly for buried species, and also depends on the sediment type. It is recommended to monitor and report the speed of the trawl and to use the same speed every year.

During the survey implementation, details of each fishing haul (e.g. latitude, longitude, depth, speed, direction, etc.) should be monitored and reported as in Annex 3.1. Whenever possible, temperature, salinity and other parameters from the surface to the bottom should be sampled. Annex 3.2 can be used to report these data.

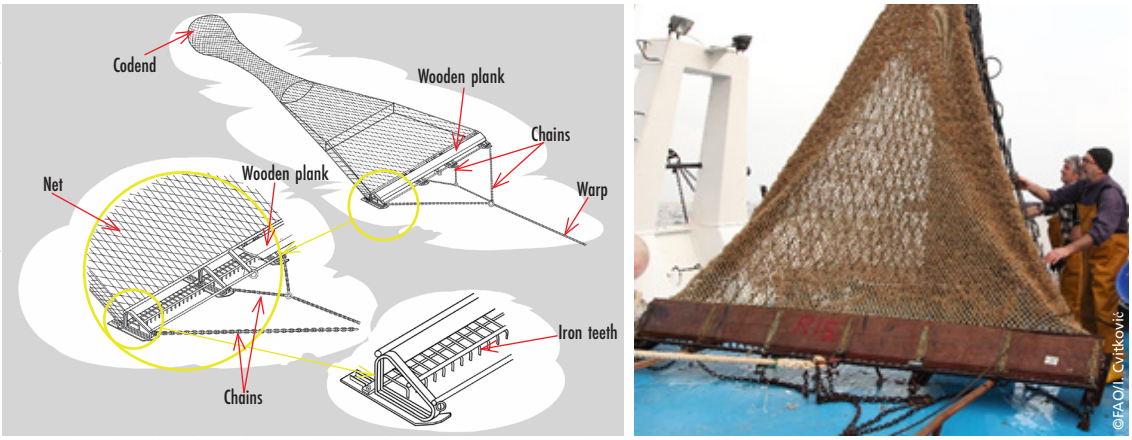
3.3 SAMPLING GEAR

A beam trawl is a kind of trawl characterized by the mouth, or opening of the net, that is kept open by a beam mounted at each end on guides or skids that travel along the seabed. The trawls should be adapted and made more effective by attaching tickler chains (for sand or mud) or heavy chain matting (for rough, rocky ground), depending on the type of ground being fished. These drag along the seabed in front of the net,

disturbing the fish in the path of the trawl, causing them to rise from the seabed into the oncoming net. Modern beam trawls range in size from 4 m to 12 m (weighing up to 7.5 tonnes in air) beam width, depending on the size and power of the operating vessel.

In implementing this survey in the Mediterranean and the Black Sea, a modified beam trawl called "rapido" should be used (SoleMon, 2017, 2019). This gear, commonly employed in the Adriatic subregion, was appositely designed to work on different types of soft bottoms. It consists of a modified beam trawl (Giovanardi *et al.*, 1998; Hall-Spencer *et al.*, 1999) with a rigid mouth fitted with 46 iron teeth (6–7 cm long) along the lower part. Joined to the iron frame there are four skids and a reinforced rubber diamond-mesh net in the lower part to protect the polyamide net bag (width: 3.59 m; height: 0.25; weight: around 225 kg; four 120-mm wide skids). The gear is always in contact with the seabed by an inclined wooden board (width: 3.60 m; length: 0.35 m; thickness: 0.03; weight: around 25 kg) fitted to the front of the iron frame, which acts as a spoiler and keeps the skids and the teeth tightly pushed down to the seafloor. The gear is joined to the warp with iron chains (long chain length: 2.10 m, short chain length: 1.00 m). A schematic representation of this gear is given in Figure 12 (drawings in Annex 17 schematize with more details all the different components).

FIGURE 12
Schematic representation and picture of the rapido trawl



In Figure 13, the mesh sizes are indicated in bar length. The mesh numbers in height correspond to well-finished and joined netting sections; the joining meshes are also shown. The length of the net is around 2.7 m. All fishing hauls should be undertaken using the rapido and the net as specified in the design.

The most important specifications of this gear are as follows:

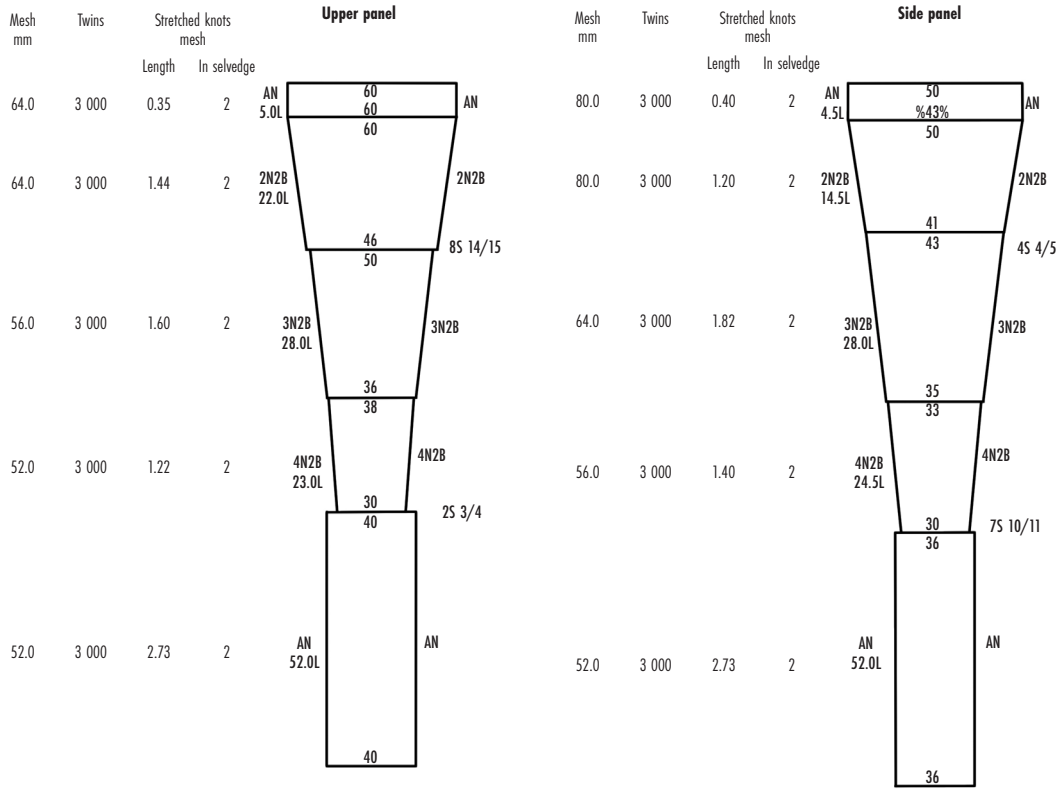
- It is able to work from 5 to 100 m depth.
- It has a selectivity as low as possible, so as to have good images of the populations sampled, including recruits.

The mesh size of the codend should be 26 mm of mesh side (stretch). The nets should be made of good-quality polyamide netting (nylon).

3.3.1 Rigging

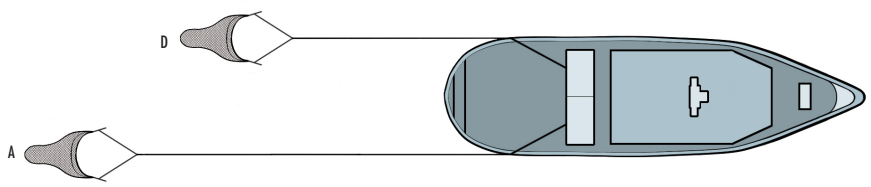
In implementing this survey, it is advisable that a vessel should be able to tow two fishing gear simultaneously, namely "beam A" on the right side of the vessel and "beam D" on the left side. (Figure 14). The gear positioned on the right side of the vessel should have 15 m more warp than the other in order to avoid possible interference between the two gear during the fishing haul.

FIGURE 13
Design of the rapido trawl net



Source: Modified from A. Sala. (Illustrator: Alberto Gennari)

FIGURE 14
Beam trawl scheme

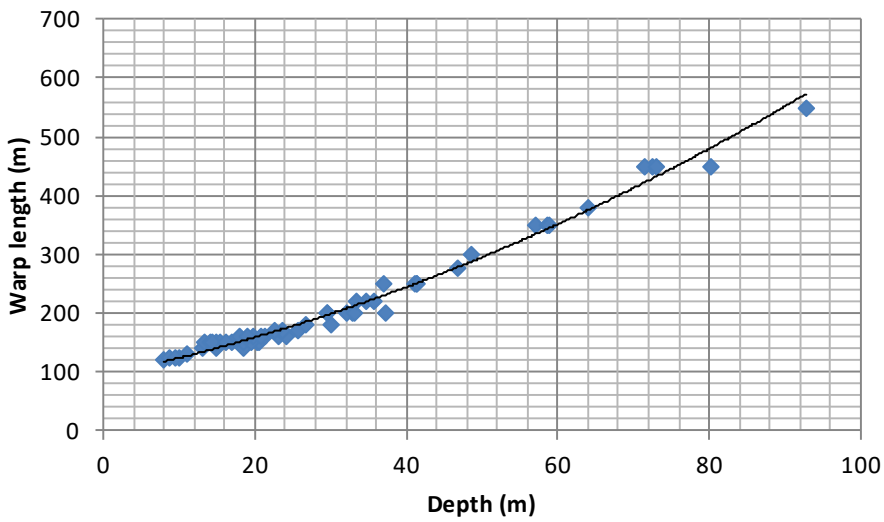


(Illustrator: Alberto Gennari)

3.3.2 Warp diameter and length

Taking the characteristics of the rigging and the gear into account, the warps should have a diameter of 14–16 mm. The length of warps to be shot is determined by the depth. The suggested relationship between depth and warp length is given in Figure 15. Although in certain peculiar circumstances some adaptations can be made to this relationship, it is recommended to respect the depth/warp length ratio as far as possible. Gear should be equipped with a DST (depth, salinity, temperature) recorder device. The use of this device, together with the fixed measures of mouth of the gear, should allow to know exactly the area explored by each gear.

FIGURE 15
Relationship between depth and warp length



3.4 SURVEY DESIGN

Similarly to a standard bottom trawl survey, during a BTS, one of the primary methods for estimating accurate indices reducing the variance of the estimates is to stratify the sampling frame into sets of sampling units with more homogeneous properties (Cochran, 1963). The overall variance is estimated as a weighted average of the within-stratum variances. If the strata have been defined appropriately, the stratified estimate of the variance will be smaller than that obtained from a simple random sample. When a BTS is carried out in the Mediterranean and the Black Sea, the sampling frame can be a GSA or a combination of GSAs according to the stock configuration of the target species, assuming as bathymetric limit the maximum depth beyond which a certain sampling gear (a beam trawl) is no longer efficient in sampling the target species.

For a BTS, a stratified random sampling design should be chosen, because fish and shellfish are seldom uniformly distributed, and in most cases, abundance is related to depth (Sparre and Venema, 1998). Therefore, a stratified random sampling scheme has several advantages over a purely random scheme, also for a BTS:

- sampling is spread out over the whole area of the survey (e.g. GSAs) by assuring the required number of fishing hauls in each stratum (e.g. bathymetric range); and
- sampling rates, in terms of fishing hauls per unit area, can be varied to improve the precision of estimates for some key species, this being an advantage over systematic sampling.

In a BTS, the fishing haul location, depending on the characteristics of each area (see Section 3.4.1), can be randomly selected within identified bathymetric stratum prior to each cruise. Importantly, the rapido trawl is efficient if used only at depths less than 100 m.

3.4.1 Survey area

The total area covered by a BTS should be stratified according to depth and geographical criteria, and if known, fish density. Fishing hauls positions should be chosen randomly in a first survey, but may be used as known and clear tow fishing hauls during subsequent surveys, except in the case of particular problems (e.g. area closures for military reasons). Regarding the standard bottom trawl survey as well as the BTS, it is advisable to control the bottom condition to understand if the area is trawlable.

This control can be carried out using an echo-sounder or information gathered from local fishers (Sparre and Venema, 1998).

For conservation purposes, sensitive habitats (e.g. *Posidonia* spp. meadows, coralligenous beds, etc.) should be excluded from the sampling scheme and should never be trawled. All these aspects should be considered during the process of allocating fishing hauls to the different depths. In particular, in the case of a BTS, it is advisable to carry out an explorative haul of a few minutes (from 2 to 5 minutes) in order to understand the nature of the substratum in term of granulometry and morphology. Should this explorative haul show a significant amount of rhodolite or phanerogams leaves, it is recommended to move away the fishing haul.

3.4.2 Depth strata and sampling stations

Before the survey, the surface area and number of fishing hauls by GSA and for each identified stratum should be identified. In absence of already available information about the density of target species by strata, the fishing hauls should be proportionally distributed over the shelves (from 0 to 100 m) according to the surface of each stratum and should follow a depth-stratified sampling scheme with a random drawing of the positions. For a given amount of sampling effort (e.g. 100 fishing hauls), based on several technical constraints (e.g. availability of funds, vessel), a greater degree of precision can be attained by increasing sampling in areas, or strata, of high abundance of target species.

Stratified sampling involves conducting a preliminary survey to identify different strata in the spatial distribution of the target species. These strata could be identified on the basis of information on biology of the target species. On the other hand, systematic pre-surveys could be carried out positioning the fishing hauls on fixed distances that could be considered the lower limit of the distribution pattern of many target species of the survey.

In order to decide on the number of fishing hauls inside each strata that maximize the precision in the estimate of the abundance of a pool of target species, a standard method based on the Neyman equation (Neyman, 1938) can be applied using the data of abundance and variances from the systematic survey to find a mathematical solution to the allocation problem. To reduce or avoid covariance between fishing hauls in adjacent strata, the distance between fishing hauls should be at least 5–10 miles (ICES, 2010).

Similarly to the standard bottom trawl survey, the length of a haul needs to be standardized, because the catchability of target species and sizes often depends on the duration of the haul. Moreover, fishing hauls should be performed at a constant depth. The depth variations during the haul should not exceed ± 5 percent relative to the initial depth. As far as possible and in respect of the previous constraints, the hauls should be rectilinear. The gear should stay in good contact with the seabed during the entire haul. This can be checked by the depth profile available from the minilog data logger and by observing the skids and teeth wear at the end of the haul.

During a BTS carried out with a rapido trawl, it is recommended to adjust the speed as follow:

- During the shooting of the warps, a relatively high speed (6-6.5 knots) should be maintained.
- The speed should then be reduced (to 3.5-4 knots) just before the rapido touches the sea bottom and is stopped.
- Once the rapido is on the seabed, a speed of 5–5.5 knots should be maintained to allow the gear to be in close contact with the sea bottom; this moment is defined as the real start of the fishing haul.

3.4.3 Survey period and timing of fishing operations

A BTS should be conducted every year during autumn, corresponding to the period of recruitment and/or spawning for most of the identified priority species (see Table 5). Each country, based on the main biological aspects of the selected species (e.g. recruitments and spawning periods), should choose the best month(s) during this period to carry out the survey. This will permit greater comparability of data among areas and GFCM subregions. It is strongly recommended that the sampling period of the survey be consistent year-to-year to reduce the time-of-the-survey effect on the time series (ICES, 2012).

It is also recommended to conduct fishing haul operations during daylight hours. The daylight period is defined as the time between 30 minutes after sunrise and 30 minutes before sunset. A fishing haul consists of 30 minutes of trawling two gear simultaneously during daytime, starting when the gear settles on the bottom and ending when hauling commences. Depending on the circumstances (e.g. great amount of shells and debris), a shorter period is allowed. Should the fishing haul be stopped before completion of the standard duration, it can be considered valid if at least two-thirds of the time or of the distance have been successfully attained.

3.5 HANDLING OF THE CATCH

The catch of the two gear towed simultaneously should be analysed separately for "beam A" and "beam D". The entire catch of each gear (Plate 9) should be sorted and weighted for all bony fish, rays, sharks, cephalopods and commercially important shellfish and crustaceans' species (Annex 4). For the whole catch (or a subsample) of the epibenthic/benthic species and debris (see Section 3.5.2), the weight and the total number should be recorded (fresh on board or in the lab) for each species identified to the lowest taxonomic level possible.

Length measurements (Annex 5), weight, otolith (Annex 6), sex and maturity (Annex 7), should be collected and reported for the main target species following the same approach defined for the bottom trawl survey (see also Section 1.5.2).

In Table 5, the priority species (Annex 2) for which a BTS can provide both primary and/or additional data for tuning indices are specified by subregion.

PLATE 9
Catch reaching a vessel deck (left) and sorting procedures (right)

TABLE 5
Priority species of potential interest for which a BTS could provide primary and/or additional data for tuning indices, by GFCM subregion

	GFCM subregions	Western Mediterranean Sea	Central Mediterranean Sea	Adriatic Sea	Eastern Mediterranean Sea	Black Sea
	GSA	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11	12, 13, 14, 15, 16, 19, 20, 21	17, 18	22, 23, 24, 25, 26, 27	28, 29, 30
Type of data	Countries	Algeria, France, Italy, Monaco, Morocco, Spain	Italy, Greece, Libya, Malta, Tunisia	Albania, Bosnia and Herzegovina, Croatia, Italy, Montenegro, Slovenia	Cyprus, Egypt, Greece, Israel, Lebanon, Syrian Arab Republic, Turkey	Bulgaria, Georgia, Romania, Turkey, Ukraine (Russian Federation)*
Beam trawl survey can provide primary data for tuning indices	*Eledone cirrhosa*	X		X		
	Eledone moschata			X		
	Marsupenaeus japonicus				X	
	Metapenaeus stebbingi				X	
	Octopus vulgaris	X	X	X	X	
	Raja asterias	X	X	X	X	
	Raja clavata	X	X	X	X	
	Raja miraletus	X	X	X	X	
	Rapana venosa					X
	Scophthalmus maximus					X
	Scyliorhinus canicula	X	X	X	X	X
	Scyliorhinus stellaris	X	X	X	X	
	Sepia officinalis	X	X	X		
	Solea solea			X	X	
	Squilla mantis			X		
	Torpedo marmorata	X	X	X	X	
	Torpedo torpedo	X	X	X	X	
Beam trawl survey can provide additional data for tuning indices	*Lophius budegassa*	X	X			
	Merluccius merluccius	X	X	X	X	
	Mullus barbatus	X	X	X	X	
	Nephrops norvegicus	X	X	X		
	Saurida lessepsianus				X	

3.5.1 Biological parameters

3.5.1a Length measurements

For fish (both bony fish and elasmobranches), the length is always the total length, the tail being extended following its longer dimension (see also Section 1.5.2a). The measurement unit (in cm) should be reported to the lower half centimetre (e.g. 13.4 = 13 cm; 16.8 = 16.5 cm).

For crustaceans, the length is measured in terms of cephalo-thoracic (carapace) length at the lowest millimetre (mm). For cephalopods, the length is the mantle length at the half centimetre (cm). For commercially important bivalves, the shell length at the lowest millimetre is recorded (Section 1.5.2a).

Subsampling by species may occur for the length measurements when the numbers are extremely high. Length data should be collected and reported as in Annex 5 at least for the main priority species, by GFCM subregion (Annex 2).

3.5.1b Sex and maturity

Also for BTS, sex is defined through macroscopic observation according to four categories: male (M), female (F), undetermined (U – when, after dissection, it was not possible to determine the sex of different specimens with the naked eye), and not determined (ND – an individual that has not been examined). Sex and maturity data should be collected and reported (Annex 7) for the main priority species.

When carrying out a demersal beam trawl, maturity scales designed for scientific trawl surveys with similar data (e.g. SOLEMON data) in other contexts should be used (e.g. MEDITS, 2017; see Annex 8)[5]. Using common maturity scales would simplify data sharing and data quality checks.

3.5.1c Otolith, weight at the individual level

Similar to demersal trawl surveys (see Section 1.5.2d), otoliths should be collected at least for the targets species of fish.

When otoliths are removed, the length, the individual weight, together with the sex and maturity stage of the sampled specimen, should be collected (Annex 6.1). For the target fish species, it is suggested to collect a minimum of ten otoliths per identified length class in each fishing haul.

3.5.2 Analysis of epibenthos, benthos, debris and marine litter

Sorting, counting and weighting epibenthic and benthic species (see Section 4.1), together with debris (i.e. shells, rocks, etc.) and marine litter items (see Section 4.3), should be carried out (whenever possible) directly on board on fresh material. Photos of epibenthic/benthic species, debris fraction and marine litter should be systematically taken at each fishing haul (see Annexes 15 and 16).

The subsampling should be carried out as follows:

- if the catch of epibenthic/benthic species and debris fraction in one rapido is around or less than 30 kg, all the species and debris items should be sorted directly without subsampling.
- If the catch of epibenthic/benthic species and debris fraction in one rapido is more than 30 kg, a subsample varying from 50 to 5 percent of the catches should be taken and sorted directly following the rules in Table 6.

TABLE 6
Subsampling of epibenthic and benthic species, and debris fraction

Weight of the portion of epibenthic/benthic species and debris fraction (kg)	Percentage to be sampled
≤ 30	100
> 30 ≥ 60	50
> 60 ≥ 500	20
> 500 ≥ 1500	10
> 1500	5

All the items of marine litter should be collected from one randomly chosen rapido and analysed. The fraction of epibenthic/benthic species and debris sorted for the rapido randomly chosen are assumed to correspond to the rapido that hasn't been analysed. The quantitative amount of the species assumed for the rapido not analysed are standardized on the basis of its overall catch weight, calculating the raising factor (RF) as follows:

$$\text{R.F.} = \frac{\text{(Sum of the weight of epibenthic-benthic species and debris from } \textit{Beam A} \text{ and } \textit{Beam D})}{\text{(Weight of the sample of epibenthic-benthic species and debris)}}$$

[5] Collected maturity data, only for the purpose of the DCRF (GFCM, 2018a), should be submitted and reported with reference to the maturity scales based on DCRF rules and requirements (Recommendation GFCM/41/2017/6).

3.5.3 Other parameters

During a single fishing haul, depth temperature throughout the tow should be recorded and monitored. A wide range of instruments can be been used to measure temperature and salinity.

At the end of a beam trawl fishing haul, a vertical cast with CTD should be made for temperature, salinity and turbidity.

3.6 DATA REPORTING AND EXCHANGE FORMATS

Similarly to demersal trawl surveys, BTS outcomes should satisfy different data requirements within the GFCM:

- Useful information in compliance with existing GFCM recommendations should be reported to the GFCM by its CPCs.
- Information supporting stock assessment should be reported to the WGSAs through stock assessment forms.
- Other relevant information for regional analysis should be examined in dedicated expert groups.

Standard formats are defined for the storage and exchange of data produced by a BTS. Once collected, the basic information on fishing hauls, catch and biological data should be reported using the templates[6] shown in Annex 11 (see also Section 1.6)

[6] All the templates are available for consultation and download in electronic format at: http://www.fao.org/gfcm/data/en/

4. ECOSYSTEM DATA

4.1 MACROBENTHOS

Fishing is the most widespread human activity exploiting the marine environment and has a direct impact not only on target species, but also on the entire marine community, including benthic organisms (plate 10) (GFCM, 2018b; FAO 2019a, 2019b). The importance of benthic habitats to ecological processes and as providers of key ecosystem services is unquestionable. In particular, macrobenthos or megabenthos (> 2cm), generally defined as a group of marine invertebrate organisms that live in (infauna) or on (epifauna) the sediment, due to their direct dependency on the sediment, become a valuable part of the ecosystem and are frequently used as bioindicators in ecological assessment (Pinto *et al.*, 2009).

Species distribution, abundance and diversity of benthic macroinvertebrate fauna as well as their relationship to environmental conditions are important in understanding the structure and functions of diverse ecosystems. Macrobenthos form the key element of the food web and serve as primary food source for fish and other higher organisms, also playing a major role in the maintenance, well-being and dynamics of the ecosystem.

Therefore, the collection of data through scientific surveys, such as surveys on the presence and abundance of different macrobenthic species, can provide a unique opportunity to increase knowledge of benthic assemblages and to produce basic information on their distribution within the Mediterranean and Black Sea region.

For the purpose of these guidelines, macrobenthos are considered as all organisms visible to the eye without the aid of a microscope and pertaining to major taxonomic phylum: Porifera (e.g. sponges), Cnidaria (e.g. corals), Briozoa, Echinodermata (e.g. sea stars, sea urchins, sea cucumbers), Crustacea, Mollusca (e.g. bivalves and gastropods), Annelida (e.g. polychaetes), Tunicata (e.g. ascidians) and others.

PLATE 10
Various species of macroinvertebrates in a catch

Ideally, macrobenthic individuals should be identified to the minimum taxonomic level, and species is obviously the basic taxonomic level to which to refer. However, since many species pertaining to the macrobenthos groups are difficult to identify (e.g. due a scarcity of taxonomic expertise on board), 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, among others – see FAO, 2017a; 2017b) may at times be unavoidable.

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, and cartilaginous) and form of benthic species. A minimum set of parameters, such as the total number of individuals caught per fishing haul and total weight (see Annex 16), should be always reported.

Furthermore, owing to the difficulty of collecting information for all macrobenthic species, attention should focus mainly on vulnerable benthic species that may form VMEs as defined by FAO (FAO, 2009; FAO, 2017a, 2017b; GFCM, 2018b, and 2019a). 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, 2009). 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.

The GFCM defined a series of VME indicators such as features, habitats and taxa for the Mediterranean Sea (Box 4), which, whenever possible, should be recorded and reported in Annex 16.

BOX 4

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.

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 seabottom features may display characteristics consistent with the possible occurrence of VMEs.

Once collected, all data on macrobenthic species could serve to produce basic information for different ecosystems in terms of species richness (i.e. number of species), abundance (the counts of individuals for every species) and biomass (i.e. weight).

4.2 VULNERABLE SPECIES

The incidental capture or bycatch of vulnerable and protected species (e.g. marine mammals, seabirds, sea turtles, sharks and rays, see Annex 13) has become an increasingly important aspect of fisheries management (FAO, 2019b). Limited or non-existent information from Mediterranean and Black Sea countries regarding bycatch rates for vulnerable species makes it impossible now to assess the likely conservation threat posed by total bycatch levels (FAO, 2016; 2018; GFCM, 2018a; FAO, 2019b). Moreover, the limited data available do not necessarily allow for accurate and realistic assessments of populations and of the impacts of incidental catch on them. More data collection and analyses will be required before it will be possible to produce robust total bycatch estimates for vulnerable species.

Therefore, when carrying out scientific surveys, it is important to collect a minimum set of data (e.g. number of individuals for each vulnerable species; Box 5) that could represent additional/alternative sources of information to provide guidance for any possible revision of incidental catches monitoring programmes. Data should be reported by GSA and by species group and/or family if the detailed information by species is not available (e.g. when an individual could not be identified at the species or genus level, as in the case of recording seabirds, which include a large number of possible species). It is also important to report the total number of individuals caught and whether they have been released alive, dead or in unknown status. When an individual is caught alive, the main goal is to facilitate a prompt release of the specimen through an appropriate handling (FAO and ACCOBAMS, 2018a, 2018b, 2018c, 2018d).

BOX 5

Minimum set of data to be collected regarding the incidental catch of vulnerable species

- Type of scientific survey
- Fishing gear
- Group of vulnerable species
- Family
- Species (identified as far as possible, or accompanied by photographs if identification is difficult)
- Total number of individuals caught
- Total weight of individuals caught
- Condition at capture and condition at release:
  - Number of individuals released alive
  - Number of dead individuals
  - Number of individuals released in unknown status

All the available information on vulnerable species should be collected and reported using the template[7] in Annex 14.

[7] All the templates are available for consultation and download in electronic format at: http://www.fao.org/gfcm/data/en/

4.3 MARINE LITTER

Litter in the marine environment (Plate 11) not only has negative environmental effects, but can also have negative economic and social impacts on fisheries (UNEP/MAP, 2015). So far, data on marine litter have been inconsistent and geographically restricted to some areas in the Mediterranean and the Black Sea, which explains why the understanding of these impacts is still limited. A standardized data collection protocol of marine litter data started within the framework of the MEDITS scientific survey (Fiorentino *et al*., 2013), allowing to produce over the years a first mapping of marine litter on trawling fishing grounds (Spedicato *et al*., 2019). Standardized research data for statistical purposes are still needed regarding the problem of litter in the whole region, and also in this case, bottom trawl and beam trawl surveys could be an important source of information on occurrence of litter on the sea bottoms.

During each survey it would be important to give a rough estimation of the quantity (weight) and quality (type) of any macro-litter material brought up by fishing operations (e.g. plastics, wood, metals, glass, rubber, clothing, fishing gear, petrochemicals). An indicative list of relevant data to be provided is reported in Annex 15. Registration of number and weight of items by categories and by subcategory is highly recommendable.

PLATE 11
Marine litter in catch composition

4.4 NON-INDIGENOUS SPECIES

In recent decades, non-indigenous species (i.e. any species introduced, either intentionally or unintentionally, outside its natural past or present distribution, also known as exotic or alien species) have been frequently caught by commercial fishing gear in different areas, accounting for a large share of the catch in some cases. In light of this rapid increase, there is a need to collect information in order to measure their impacts on fisheries and ecosystems. Scientific surveys could therefore

offer an opportunity to collect important and standardized data regarding not only the distribution of nonindigenous species as well as their quantitative and qualitative impacts, but also some biological information (e.g. length, weight, sex and maturity). All of this information, once collected, could contribute to an effective management strategy. When performing any kind of scientific survey, it is strongly encouraged to collect and report biological data on non-indigenous species, using the standard templates already provided (Annexes 5, 6 and 7).

5. DATA POLICY

Data from national scientific surveys should remain the property of the country executing the survey, and data and information transmitted by countries should be treated by the GFCM Secretariat in accordance with all necessary measures to comply with GFCM security and confidentiality provisions. People carrying out the work on board should not disclose any information without the permission of the flag country.

Each country will be responsible for the quality and completeness of the data. Collected data should be submitted by countries every year following the DCRF provisions (GFCM, 2018a) and requirements.

Data put at the disposal of dedicated expert groups will be treated in the same manner as data used by different WGSAs: all participants should have access to the data needed to address the objectives of the meeting.

Through its Secretariat, the GFCM will define and maintain high levels of protection for the data transmitted by countries complying with GFCM data submission requirements, as endorsed by the Commission. The use of shared data outside the framework of the GFCM or for purposes other than the agreed objectives should follow the existing GFCM data confidentiality rules.

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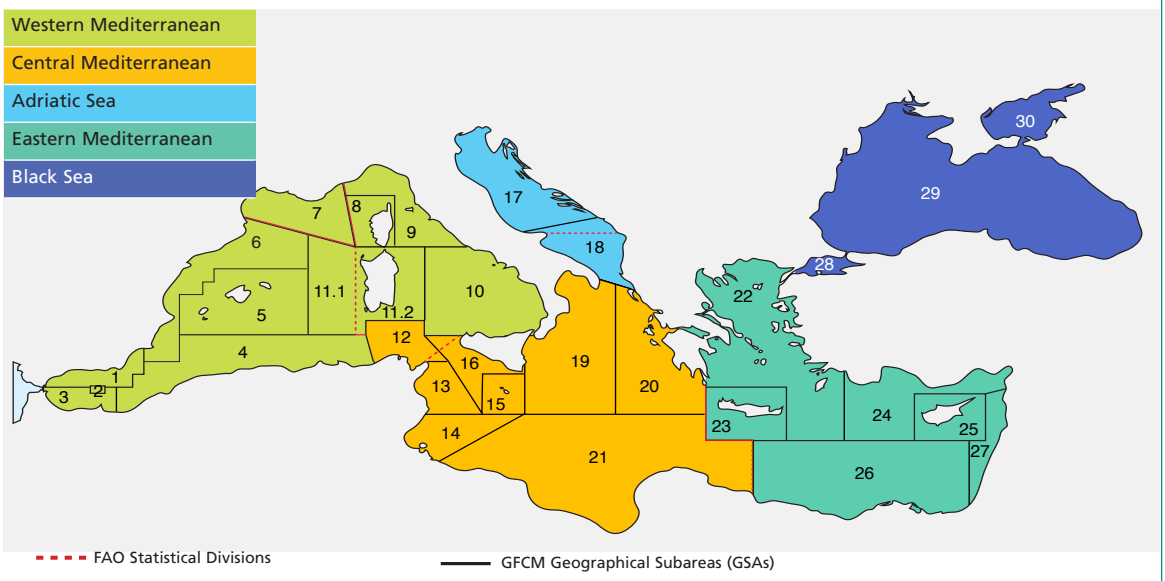
ANNEXES

ANNEX 1. GFCM SUBREGIONS AND GEOGRAPHICAL SUBAREAS (GSAS)

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 Sea
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 2. LIST OF PRIORITY SPECIES BY SUBREGION*

Annex 2.1. Group 1: species that drive the fishery and for which assessment is regularly carried out

		GFCM subregions ▶	Western Mediterranean Sea	Central Mediterranean Sea	Adriatic Sea	Eastern Mediterranean Sea	Black Sea
		GSAs ▶	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11	12, 13, 14, 15, 16, 19, 20, 21	17, 18	22, 23, 24, 25, 26, 27	28, 29, 30
		Countries ▶	Algeria, France, Italy, Monaco, Morocco, Spain	Italy, Greece, Libya, Malta, Tunisia	Albania, Bosnia and Herzegovina, Croatia, Italy, Montenegro, Slovenia	Cyprus, Egypt, Greece, Israel, Lebanon, Syrian Arab Republic, Turkey	Bulgaria, Georgia, Romania, Turkey, Ukraine[a]
Species	**Scientific name**	**FAO 3-letter code**					
Pelagics	*Engraulis encrasicolus*	ANE	X	X	X	X	X
	Sardina pilchardus	PIL	X	X	X	X	
	Sardinella aurita	SAA	X	X		X	
	Sprattus sprattus	SPR					X
	Trachurus mediterraneus	HMM					X
Demersal	*Aristaeomorpha foliacea*	ARS		X		X	
	Aristeus antennatus	ARA		X		X	
	Lagocephalus sceleratus	LFZ	X	X	X	X	
	Merlangius merlangius	WHG					X
	Merluccius merluccius	HKE	X	X	X	X	
	Mullus barbatus	MUT	X	X	X	X	
	Mullus surmuletus	MUR	X	X		X	
	Nephrops norvegicus	NEP	X	X	X		
	Pagellus bogaraveo	SBR	X				
	Parapenaeus longirostris	DPS	X	X	X	X	
	Pterois miles	UHQ	X	X	X	X	
	Rapana venosa	RPW					X
	Scophthalmus maximus	TUR					X
	Sepia officinalis	CTC			X		
	Solea solea	SOL			X		
	Squalus acanthias[b]	DGS					X
	Squilla mantis	MTS			X		
Additional species[c]	*Anguilla anguilla*	ELE	X	X	X	X	
	Corallium rubrum	COL	X	X	X	X	
	Coryphaena hippurus	DOL		X	X	X	
	Sarda sarda	BON					X
	Saurida lessepsianus[d]	SZX				X	

[a] All states, including GFCM non-contracting parties that are known to fish in the GFCM area of application, are encouraged to cooperate in joint actions undertaken in accordance with applicable international obligations (i.e. Article 63 of the United Nations Convention on the Law of the Sea [UNCLOS]).

[b] Species included in 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) – Protocol Concerning Specially Protected Areas and Biological Diversity in the Mediterranean.

[c] As identified by the mid-term strategy (2017–2020) towards the sustainability of Mediterranean and Black Sea fisheries (GFCM, 2016).

[d] The species is not currently present in the Aquatic Sciences and Fisheries Information System (ASFIS) list, and thus the 3-letter code of its genus (*Saurida* spp.) has been used.

* *Note*: The list of priority species (Groups 1, 2 and 3) is regularly updated by relevant GFCM subsidiary bodies, upon the approval of the GFCM at its annual sessions.

Annex 2.2. Group 2: species that are important in terms of landings and/or economic value at the regional and subregional levels and for which assessment is not regularly carried out

GFCM subregions ▶		Western Mediterranean Sea	Central Mediterranean Sea	Adriatic Sea	Eastern Mediterranean Sea	Black Sea
GSAs ▶		1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11	12, 13, 14, 15, 16, 19, 20, 21	17, 18	22, 23, 24, 25, 26, 27	28, 29, 30
Countries ▶		Algeria, France, Italy, Monaco, Morocco, Spain	Italy, Greece, Libya, Malta, Tunisia	Albania, Bosnia and Herzegovina, Croatia, Italy, Montenegro, Slovenia	Cyprus, Egypt, Greece, Israel, Lebanon, Syrian Arab Republic, Turkey	Bulgaria, Georgia, Romania, Turkey, Ukraine[a]
Scientific name	**FAO 3-letter code**					
Alosa immaculata	SHC					X
Aristeus antennatus	ARA	X				
Boops boops	BOG	X	X	X	X	
Chamelea gallina	SVE			X		
Diplodus annularis	ANN		X			
Eledone cirrhosa	EOI	X		X		
Eledone moschata	EDT			X		
Galeus melastomus	SHO	X				
Lophius budegassa	ANK	X	X			
Micromesistius poutassou	WHB	X				
Octopus vulgaris	OCC	X	X	X	X	
Pagellus erythrinus	PAC	X	X	X	X	
Raja asterias	JRS	X				
Raja clavata	RJC	X	X			
Saurida undosquamis	LIB				X	
Scomber japonicus	MAS	X			X	
Scomber scombrus	MAC	X	X			
Sepia officinalis	CTC	X	X			
Siganus luridus	IGU				X	
Siganus rivulatus	SRI				X	
Solea solea	SOL				X	
Sphyraena sphyraena	YRS		X			
Spicara smaris	SPC			X	X	
Trachurus mediterraneus	HMM	X				
Trachurus picturatus	JAA	X				
Trachurus trachurus	HOM	X	X		X	

[a] All states, including GFCM non-contracting parties that are known to fish in the GFCM area of application, are encouraged to cooperate in joint actions undertaken in accordance with applicable international obligations (i.e. Article 63 of UNCLOS).

Annex 2.3. Group 3: species under international/national management plans and recovery and/or conservation action plans; non-indigenous species with greatest potential impact

		Western Mediterranean Sea	Central Mediterranean Sea	Adriatic Sea	Eastern Mediterranean Sea	Black Sea
GFCM subregions ►						
GSAs ►		1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11	12, 13, 14, 15, 16, 19, 20, 21	17, 18	22, 23, 24, 25, 26, 27	28, 29, 30
Countries ►		Algeria, France, Italy, Monaco, Morocco, Spain	Italy, Greece, Libya, Malta, Tunisia	Albania, Bosnia and Herzegovina, Croatia, Italy, Montenegro, Slovenia	Cyprus, Egypt, Greece, Israel, Lebanon, Syrian Arab Republic, Turkey	Bulgaria, Georgia, Romania, Turkey, Ukraine[a]
Scientific name	FAO 3-letter code					
Dalatias licha	SCK	X	X	X	X	
Dipturus oxyrinchus	RJO	X	X	X	X	
Etmopterus spinax	ETX	X	X	X	X	
Galeus melastomus	SHO		X	X	X	
Hexanchus griseus	SBL	X	X	X	X	
Mustelus asterias[b]	SDS	X	X	X	X	
Mustelus mustelus[b]	SMD	X	X	X	X	
Mustelus punctulatus[b]	MPT	X	X	X	X	
Myliobatis aquila	MYL	X	X	X	X	
Prionace glauca[b]	BSH	X	X	X	X	
Pteroplatytrygon violacea	PLS	X	X	X	X	
Raja asterias	JRS		X	X	X	
Raja clavata	RJC			X	X	X
Raja miraletus	JAI	X	X	X	X	
Scyliorhinus canicula	SYC	X	X	X	X	X
Scyliorhinus stellaris	SYT	X	X	X	X	
Squalus acanthias[b]	DGS	X	X	X	X	
Squalus blainville	QUB	X	X	X	X	
Torpedo marmorata	TTR	X	X	X	X	
Torpedo torpedo	TTV	X	X	X	X	
Fistularia commersonii	FIO				X	
Marsupenaeus japonicus	KUP				X	
Metapenaeus stebbingi	MNG				X	
Scomberomorus commerson	COM				X	

[a] All states, including GFCM non-contracting parties that are known to fish in the GFCM area of application, are encouraged to cooperate in joint actions undertaken in accordance with applicable international obligations (i.e. Article 63 of UNCLOS).

[b] Species included in Annex III (species whose exploitation is regulated) of the Barcelona Convention – Protocol Concerning Specially Protected Areas and Biological Diversity in the Mediterranean.

ANNEX 3. FISHING HAUL INFORMATION

Annex 3.1. Data entry sheet: main characteristics of each fishing haul

Annex 3.1. Fishing haul information											
Country					Survey						
GSA					Year						
Gear											
Haul number	Haul identification code	Date	Coordinates				Depth (m)		Time		Average speed
			Start		End						
			Latitude	Longitude	Latitude	Longitude	Start	End	Start	End	(knots)
….	….	….	….	….	….	….	….	….	….	….	….

√ This template can be reproduced several times (depending on the number of fishing hauls).

Instructions

- **Survey:** insert the name of the survey.
- **GSA:** insert the code of the geographical subarea (GSA) as in annex 1.
- **Gear:** insert the type of gear (e.g. bottom trawl, pelagic trawl) and the main characteristics including the mesh size of the codend.
- **Haul number:** insert the identification number that should be assigned to each fishing haul (e.g. progressive numbers from 1 to 100). Fishing hauls are made in the same position from year to year, the same number should be associated to a fishing haul every year.
- **Haul identification code:** insert the identification code that is assigned yearly to each fishing haul (unique).
- **Coordinates:** latitude (start and end) – insert the latitude at the beginning and at the end of each fishing haul; data should be inserted in degrees, minutes and seconds (e.g. 40°51′59″N); longitude (start and end) – insert the longitude at the beginning and at the end of each fishing haul; data should be inserted in degrees, minutes and seconds (e.g. 124°4′58″W).
- **Depth (m):** insert the depth in metres at the beginning and at the end of each fishing haul.
- **Time:** insert the time at the beginning and at the end of each fishing haul.
- **Average speed:** insert the average speed maintained during the fishing haul.

Annex 3.2. Data entry sheet: oceanographic characteristics (when available) by single fishing haul

Annex 3.2. Oceanographic data											
Country				Survey							
GSA				Year							
Haul number	Haul identification code	Date	Sea surface				Sea bottom				Comments
			Temperature	Salinity	Other parameters		Temperature	Salinity	Other parameters		
....	....	....	....	....	....	....	....	....	....	....	....

Instructions

- **Survey:** insert the name of the survey.
- **GSA:** insert the code of the geographical subarea (GSA) as in annex 1.
- **Haul number:** insert the identification number that has been assigned to each fishing haul (as in annex 3.1).
- **Haul identification code:** insert the identification code that has been assigned to each fishing haul (as in annex 3.1).
- **Temperature:** insert an average value of the sea temperature (both recorded on the sea surface and on the bottom) in °C with two decimals; NA if not available.
- **Salinity:** insert an average value of the salinity (both recorded on the sea surface and on the bottom) in part per thousand ‰; NA if not available.

ANNEX 4. CATCH COMPOSITION BY FISHING HAUL

Annex 4. Catch composition by fishing haul				
Survey				
Country			**GSA**	
Haul identification code			**Date**	
Species	**Subsample (Y/N)**	**Multiplied by***	**Number**	**Weight (kg)**
....	....	....	....	....

*to be filled only when data have been collected for a subsample of the catch.

√ This template can be replicated several times (depending on the number of species caught during a single fishing haul)

Instructions

- **Survey:** Insert the name of the survey.
- **GSA:** Insert the code of the geographical subarea (GSA) as in annex 1.
- **Haul identification code:** Insert the identification code that has been assigned to the identified fishing haul (as in annex 3.1).
- **Species:** Insert the scientific name for all the species present in the catch composition.
- **Subsample (y/n):** For each species caught during the same fishing haul, indicate "Yes" if data (on weight and number) have been collected for a subsample; otherwise, indicate "No".
- **Multiplied by:** Indicate the number by the subsample should be multiplied.
- **Number:** Insert the total number of individuals present in the catch (or in the subsample) for the identified species
- **Weight (kg):** Insert the total weight (in kg) of the individuals present in the catch (or in the subsample) for the identified species.

ANNEX 5. LENGTH DATA BY FISHING HAUL

Annex 5.1. Data entry sheet: length data for fish, cephalopods and elasmobranchs

Annex 5.1. Length data (fish, cephalopods and elasmobranchs)							
Survey							
Country				**GSA**			
Haul identification code				**Date**			
TL (cm)	**Species**			**TL (cm)**	**Species**		
0				0			
0.5				0.5			
1				1			
1.5				1.5			
2				2			
2.5				2.5			
3				3			
3.5				3.5			
4				4			
4.5				4.5			
5				5			
5.5				5.5			
6				6			
6.5				6.5			
7				7			
7.5				7.5			
8				8			
8.5				8.5			
9				9			
9.5				9.5			
0				0			
....	....	....	....	....	....	....	....

√ This template should be duplicated for the different species caught during the same fishing haul and for which length data (in centimetres) should be collected.

Instructions

- **Survey:** insert the name of the survey.
- **GSA:** insert the code of the geographical subarea (GSA) as in annex 1.
- **Haul identification code:** insert the identification code that has been assigned to the identified fishing haul (as in annex 3.1).
- **Species:** insert the scientific name of the identified species.

Annex 5.2. Data entry sheet: length data for crustaceans

Annex 5.2. Length data (crustaceans)							
Survey							
Country				**GSA**			
Haul identification code				**Date**			
CL (mm)	**Species**			**CL (mm)**	**Species**		
0				0			
1				1			
2				2			
3				3			
4				4			
5				5			
6				6			
7				7			
8				8			
9				9			
10				10			
11				11			
12				12			
13				13			
14				14			
15				15			
16				16			
17				17			
18				18			
19				19			
20				20			
21				21			
22				22			
23				23			
24				24			
25				25			
26				26			
27				27			
28				28			
29				29			
30				30			
....				....			

√ This template should be duplicated for the different species caught during the same fishing haul and for which length data (in millimetres) should be collected.

Instructions

- **Survey:** insert the name of the survey.
- **GSA:** insert the code of the geographical subarea (GSA) as in annex 1.
- **Haul identification code:** insert the identification code that has been assigned to the identified fishing haul (as in annex 3.1).
- **Species:** insert the scientific name of the identified species.

ANNEX 6. INDIVIDUAL WEIGHT BY SPECIES

Annex 6.1. Data entry sheet: individual weight by species

Annex 6.1. Individual weight data					
Survey					
Country			**GSA**		
Haul identification code			**Date**		
Species					
Total weight in the catch			**Weight of the sample**		
Progressive number	Length (total L in cm, mantle L in cm or carapax L in mm)	Weight (g)	Sex* (F, M, U, ND)	Maturity stage*	Otoliths (Y/N)
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					
11					
12					
13					
14					
15					
16					
17					
18					
19					
20					
21					
22					
23					
24					
25					
26					
27					
28					
29					
30					
….	….	….	….	….	….

*if available

√ This template should be duplicated for the different species caught during the same fishing haul and for which individual weight (in grams) should be collected.

Instructions

- **Survey:** insert the name of the survey.
- **GSA:** insert the code of the geographical subarea (GSA) as in annex 1.
- **Haul identification code:** insert the identification code that has been assigned to the identified fishing haul (as in annex 3.1).
- **Species:** insert the scientific name of the identified species.
- **Length:** for each identified specimen, depending on the species, insert the total and/or the mantle length (in cm), or the carapax length (in mm).
- **Weight:** for each identified specimen, insert the total weight (in grams)
- **Length:** for each identified specimen, depending on the species, insert the total and/or the mantle length (in cm), or the carapax length (in mm).
- **Sex*:** if available, insert the sex of the identified specimen (M=male; F=female; U=undetermined; ND=not determined).
- **Maturity stage*:** if available, insert the maturity stage of the identified specimen following the maturity scales reported in annex 8 (in the case of anchovy and sardine caught during a pelagic survey, see annex 9).

Annex 6.2. Data entry sheet: weight by length class

Annex 6.2. Weight by length class			
Survey			
Country		**GSA**	
Haul identification code		**Date**	
Species			
Total weight in the catch		**Weight of the whole sample**	
Length class	Number of specimens by length class	Total weight by length class (g)	Mean weight per specimen
….	….	….	….

√ This template should be duplicated for the different species caught during the same fishing haul and for which information by length class should be collected.

Instructions

- **Survey:** insert the name of the survey.
- **GSA:** insert the code of the geographical subarea (GSA) as in annex 1.
- **Haul identification code:** insert the identification code that has been assigned to the identified fishing haul (as in annex 3.1).
- **Species:** insert the scientific name of the identified species.
- **Length class:** for the identified species, depending on the species in cm or mm, insert the identified length classes.
- **Number of specimens by length class:** for each identified length class, insert the total number of specimens.
- **Total weight by length class (g):** for each identified length class, insert the total weight of specimens present.
- **Mean weight per specimen:** for each identified length class, insert the mean weight of a single specimen (i.e. total weight divided the number of specimens).

ANNEX 7. SEX AND MATURITY DATA

Annex 7.1. Data entry sheet: sex and maturity data for fish

Annex 7.1. Sex and maturity data (fish)			
Survey			
Country		GSA	
Haul identification code		Date	
Species			

TL (cm)	Male							TL (cm)	Female							TL (cm)	Undetermined/ Not determined
	1	2			3	4			1	2			3	4			
	1	2a	2b	2c	3	4a	4b		1	2a	2b	2c	3	4a	4b		
0								0								0	
0.5								0.5								0.5	
1								1								1	
1.5								1.5								1.5	
2								2								2	
2.5								2.5								2.5	
3								3								3	
3.5								3.5								3.5	
4								4								4	
4.5								4.5								4.5	
5								5								5	
5.5								5.5								5.5	
6								6								6	
6.5								6.5								6.5	
7								7								7	
7.5								7.5								7.5	
8								8								8	
8.5								8.5								8.5	
9								9								9	
9.5								9.5								9.5	
0								0								0	
….								….								….	

√ This template should be duplicated for the different species caught during the same fishing haul and for which sex and maturity information should be collected

√ Maturity stages for the identified species should be reported following the maturity scales indicated in annex 8 (in case of species caught during a pelagic survey, see annex 9).

Instructions

- **Survey:** insert the name of the survey.
- **GSA:** insert the code of the geographical subarea (GSA) as in annex 1.
- **Haul identification code:** insert the identification code that has been assigned to the identified fishing haul (as in annex 3.1).
- **Species:** insert the scientific name of the identified species.

Annex 7.2. Data entry sheet: sex and maturity data for crustaceans

Annex 7.2. Sex and maturity data (crustaceans)			
Survey			
Country		**GSA**	
Haul identification code		**Date**	
Species			

CL (mm)	Males			CL (mm)	Females							CL (mm)	Undetermined Not determined
	0				1	2				3	4		
					1	2a	2b	2c	2d	2e	3		
0				0								0	
1				1								1	
2				2								2	
3				3								3	
4				4								4	
5				5								5	
6				6								6	
7				7								7	
8				8								8	
9				9								9	
10				10								10	
11				11								11	
12				12								12	
13				13								13	
14				14								14	
15				15								15	
16				16								16	
17				17								17	
18				18								18	
19				19								19	
20				20								20	
21				21								21	
22				22								22	
23				23								23	
24				24								24	
25				25								25	
26				26								26	
27				27								27	
28				28								28	
29				29								29	
30				30								30	

√ This template should be duplicated for the different species caught during the same fishing haul and for which sex and maturity information should be collected

√ Maturity stages for the identified species should be reported following the maturity scales as indicated in annex 8.

Instructions

- **Survey:** insert the name of the survey.
- **GSA: insert the code of the geographical subarea (GSA) as in annex 1.**
- **Haul identification code:** insert the identification code that has been assigned to the identified fishing haul (as in annex 3.1).
- **Species:** insert the scientific name of the identified species.

Annex 7.3. Data entry sheet: sex and maturity data for cephalopods

Annex 7.3. Sex and maturity data (cephalopods)													
Survey													
Country										**GSA**			
Haul identification code										**Date**			
Species													
ML (cm)	**Males**					ML (cm)	**Females**					ML (cm)	**Undetermined/ Not determined**
	1	2		3			1	2		3			
	1	2a	2b	3a	3b		1	2a	2b	3a	3b		
0						0						0	
0.5						0.5						0.5	
1						1						1	
1.5						1.5						1.5	
2						2						2	
2.5						2.5						2.5	
3						3						3	
3.5						3.5						3.5	
4						4						4	
4.5						4.5						4.5	
5						5						5	
5.5						5.5						5.5	
6						6						6	
6.5						6.5						6.5	
7						7						7	
7.5						7.5						7.5	
8						8						8	
8.5						8.5						8.5	
9						9						9	
9.5						9.5						9.5	
0						0						0	
….						….						….	

√ This template should be duplicated for the different species caught during the same fishing haul and for which sex and maturity information should be collected

√ Maturity stages for the identified species should be reported following the maturity scales as indicated in annex 8.

Instructions

- **Survey:** insert the name of the survey.
- **GSA:** insert the code of the geographical subarea (GSA) as in annex 1.
- **Haul identification code:** insert the identification code which has been assigned to the identified fishing haul (as in annex 3.1).
- **Species:** insert the scientific name of the identified species.

Annex 7.4. Data entry sheet: sex and maturity data for elasmobranchs

Annex 7.4. Sex and maturity data (elasmobranchs)			
Survey			
Country		**GSA**	
Haul identification code		**Date**	
Species			
Total length (cm)	Male (M), Female (F), Undetermined (U), Not Determined (ND)	Maturity stage	Notes
….	….	….	….
Comments			

√ This template should be duplicated for the different species caught during the same fishing haul and for which sex and maturity information should be collected

√ Maturity stages for the identified species should be reported following the maturity scales as indicated in annex 8.

Instructions

- **Survey:** insert the name of the survey.
- **GSA:** insert the code of the geographical subarea (GSA) as in annex 1.
- **Haul identification code:** insert the identification code which has been assigned to the identified fishing haul (as in annex 3.1).
- **Species:** insert the scientific name of the identified species.
- **Total length:** report in cm (to the lower half centimetre) the total length of each single specimen of elasmobranch measured.
- **Male (M), Female (F), Undetermined (U), Not Determined (ND):** insert the sex of the identified specimen (M=male; F=female; U=undetermined; ND=not determined).

ANNEX 8. MATURITY SCALES

Annex 8.1. Maturity scale for bony fish

Annex 8.1. Maturity scale (bony fish)			
Stages	**Maturation state**	**Reproductive apparatus aspect**	
0	UNDETERMINED	Sex not distinguished by naked eye. Gonads very small and translucent, almost transparent. Sex undetermined.	
		Females	**Males**
1	IMMATURE-VIRGIN	Small pinkish and translucent ovary shorter than 1/3 of body cavity. Eggs not visible to naked eye.	Thin and whitish testis shorter than 1/3 of body cavity.
2a	VIRGIN-DEVELOPING	Small pinkish/reddish ovary shorter than 1/2 of body cavity. Eggs not visible to naked eye.	Thin whitish testis shorter than 1/2 of body cavity.
2b	RECOVERING	Pinkish-reddish/reddish-orange and translucent ovary; length about 1/2 of body cavity. Blood vessels visible. Eggs not visible to naked eye.	Whitish/pinkish testis, more or less symmetrical; length about 1/2 of body cavity.
2c	MATURING	Ovary pinkish-yellow in colour with granular appearance; length about 2/3 of body cavity. Eggs are visible to naked eye through the ovaric tunica, which is not yet translucent. Under light pressure, eggs are not expelled.	Whitish to creamy testis; length about 2/3 of body cavity. Under light pressure, sperm is not expelled.
3	MATURE/SPAWNER	Ovary orange-pink in colour, with conspicuous superficial blood vessels; length from 2/3 to full length of body cavity. Large transparent, ripe eggs are clearly visible and could be expelled under light pressure. In more advanced conditions, eggs escape freely.	Whitish-creamy soft testis; length from 2/3 to full length of body cavity. Under light pressure, sperm could be expelled. In more advanced conditions, sperm escapes freely.
4a	SPENT	Reddish ovary shrunk to about 1/2 length of body cavity. Flaccid ovaric walls; ovary may contain remnants of disintegrating opaque and/or translucent eggs.	Bloodshot and flabby testis shrunk to about 1/2 length of body cavity.
4b	RESTING	Pinkish and translucent ovary; length about 1/3 of body cavity. Eggs not visible to naked eye.	Whitish/pinkish testis, more or less symmetrical; length about 1/3 of body cavity.

Source: MEDITS, 2017; see also Appendix G.1 of the DCRF manual (GFCM, 2018a).

Annex 8.2. Maturity scale for cephalopods

Annex 8.2. Maturity scale (cephalopods)			
Stages	Maturation state	Reproductive apparatus aspect	Sex
0	UNDETERMINED	Sex not distinguished by naked eye. Sex undetermined.	U
1	IMMATURE-VIRGIN	Small and translucent nidamental glands (NG)/oviducal glands (OG). Ovary is semi-transparent, stringy and lacking granular structure. Small semi-transparent NG/OG. Oviduct meander not visible. Total absence of spermatophores.	F
		Testis small. Spermatophoric complex (SC) semi-transparent; vas deferens not visible. Penis appears as a small prominence of SC.	M
2a	DEVELOPING	NG/OG enlarged. NG covering some internal organs. Whitish ovary with granular structure clearly visible, not reaching the posterior half of the mantle cavity. Oviduct meander clearly visible. Eggs very small. Absence of spermatophores.	F
		Enlarged testis with structure not clearly visible. Vas deferens is whitish or white and the spermatophoric organ has a white streak.	M
2b	MATURING	Large NG covering the viscera below. Ovary occupies the whole posterior half of mantle cavity, containing reticulated, tightly packed oocytes of all sizes and probably a few ripe ova at its proximal part. Oviducts fully developed, but empty. Maturing eggs visible to naked eye. Few spermatophores.	F
		Vas deferens is white, meandering, enlarged. Needham's sac with structure less whitish particles inside. Normally, the Needham's sac is without functional spermatophores, but sometimes some immature/abortive ones could occur. Testis tight, crispy, with visible structure.	M
3a	MATURE	Large NG as previously. Ovary containing higher percentage of large reticulated eggs and some large ripe ova with smooth surface. In Teuthoidea, ripe ova in oviducts. Eggs medium and large, and visible both in oviducts and in the ovary. Well-developed spermatophores.	F
		Testis as before. Spermatophores packed in the Needham's sac.	M
3b	SPENT	NG/OG large but soft and running. Ovary shrunk and flaccid, with only immature oocytes attached to the central tissue and a few loose large ova in the coelom. In Teuthoidea, oviduct may contain some mature ova, but they are no longer packed.	F
		Disintegrating spermatophores in the Needham's sac and the penis.	M

Source: MEDITS, 2017; see also Appendix G.2 of the DCRF manual (GFCM, 2018a).

Annex 8.3. Maturity scale for crustaceans

Annex 8.3. Maturity scale (crustaceans)				
Stages	**Sex**	**Maturation state**	**Reproductive apparatus aspect**	**Colouring of fresh ovary**
1	F	IMMATURE-VIRGIN*	The ovary is barely visible. After dissection of the tegument, the ovary is small, and lobes are flaccid, stringy and poorly developed. *A. foliacea* and *A. antennatus*: have no spermatophores on thelycum.	Whitish or translucid
	M		The petasma is not highly visible and there are no spermatic masses (emi-spermatophores) on the seminal ampullae located on the side of the fifth pair of pereiopods. *A. foliacea* and *A. antennatus* have a long rostrum.	
2a	F	VIRGIN DEVELOPING*	The ovary status is developing. Cephalic and lateral lobes are small but discernible to the naked eye. The abdominal extensions are thin and slightly visible.	*A. foliacea*: flesh-coloured; *A. antennatus*: ivory-coloured with orange pink-violet dotting; *N. norvegicus*: cream coloured;
	M		The petasma is visible and nearly or completely joined, but there are no spermatic masses in the seminar amplullae. *A. foliacea* and *A. antennatus*: long or intermediate rostrum.	*P. longirostris*: cream-orange coloured.
2b	F	RECOVERING*	The ovary is starting a new reproductive cycle. The cephalic and lateral lobes are small but discernible to the naked eye. The abdominal extensions are thin and slightly visible. Occasionally, there are spermatophores in *A. foliacea* and *A. antennatus*.	*A. foliacea*: flesh-coloured; *A. antennatus*: ivory-coloured with orange pink-violet dotting; *N. norvegicus*: cream coloured;
	M		The petasma appears completely joined but there are no spermatic masses in the seminar amplullae. *A. foliacea* and *A. antennatus*: short rostrum.	*P. longirostris:* cream-orange coloured.
2c	F	MATURING or ALMOST MATURE	The ovary is developed and occupies the dorsal portion almost entirely. The cephalic and lateral lobes are highly developed and have a turgid consistence.	*A. foliacea*: light and dark grey; *A. antennatus*: lilla; *N. norvegicus*: light green;
	M		-	*P. longirostris*: light green or grey green.
2d	F	MATURE	The turgid ovary extends to the whole dorsal portion, covering the organs below. The lobes and extensions are well developed; in particular, the abdominal extensions are highly visible. The oocytes are well developed.	*A. foliacea*: black; *A. antennatus*: violet; *N. norvegicus*: dark green;
	M		The petasma is perfectly visible and completely joined. There is a spermatic mass in the seminar ampullae. *A. foliacea* and *A. antennatus* have a small rostrum.	*P. longirostris*: bright green or olive green.
2e	F	RESTING ADULT*	It has a resting ovary. Spermatophores are present in *A. foliacea* and *A. antennatus*.	Uncoloured
3	F	BERRIED	Eggs are present on pleopods.	*N. norvegicus*

*these stages can be easily confused one with another.
Source: MEDITS, 2017.

Annex 8.4. Maturity scale for oviparous elasmobranchs

Annex 8.4. Maturity scale (oviparous elasmobranchs)			
Stage	**Sex**	**Maturation state**	**Gonad aspect**
1	F	IMMATURE VIRGIN	The ovary with small isodiametric eggs is barely discernible. The distal part of oviducts is thick-walled and whitish. The nidamental glands are less evident.
	M		The claspers are small and flaccid, and do not reach the posterior edge of the pelvic fins. The sperm ducts are not discernible. The testis is small and narrow.
2	F	MATURING*	The whitish and/or a few yellow maturing eggs are visible in the ovary. The distal part of the oviducts (uterus) is well developed but empty. The nidamental glands are small.
	M		The claspers are larger, but the skeleton is still flexible. They extend to the posterior edge of the pelvic fins. Sperm ducts are well developed and eventually begin to meander.
3a	F	MATURE	The ovary contains yellow eggs (large yolk eggs). The nidamental glands are enlarged, and oviducts are distended.
	M		The claspers extend well beyond the posterior edge of the pelvic fin, and their internal structure is generally hard and ossified. The testis is greatly enlarged. The sperm ducts meander over almost their entire length.
3b	F	MATURE/EXTRUDING-ACTIVE	The ovary walls are transparent. Oocytes are of different sizes, white or yellow. The nidamental glands are large. The egg cases are more or less formed in the oviducts (extruding stage).
	M		The claspers are longer than the tips of the posterior pelvic fin lobes; the skeleton has hardened and pointed axial cartilages. The sperm ducts are large. Sperm flows on pressure from the cloaca (active stage).
4a	F	RESTING	The ovary walls are transparent. The oocytes are of different sizes, white or yellow. The oviducts appear very enlarged, collapsed and empty. The diameter of the nidamental glands is reducing.
	M		The claspers are longer than the tips of the posterior pelvic fin lobes; the axial cartilages is still hardened. The sperm ducts are empty and flaccid.
4b	F	REGENERATING*	The ovary is full of small follicles similar to stage 2. The oviducal glands and uterus are enlarged.

*these stages can be easily confused one with another.
Source: MEDITS, 2017.

Annex 8.5. Maturity scale for viviparous elasmobranchs

Annex 8.5. Maturity scale (viviparous elasmobranchs)				
Stage	**Sex**	**Maturation state**	**Maturity**	**Gonad aspect**
1	F	IMMATURE	IMMATURE	The ovary is barely visible or small and whitish; the ovarian follicles are not visible. The oviducal (nidamental) gland may be slightly visible. The uterus is thread-like and narrow.
	M			The claspers are flexible and shorter than pelvic fins. The testis is small (in rays, sometimes with visible lobules). The sperm ducts are straight and thread-like.
2	F	DEVELOPING	IMMATURE*	The ovary is enlarged with small follicles (oocytes) of different sizes. Some relatively larger yellow follicles may be present. The ovary lacks atretic follicles. The oviducal gland and the uterus are developing.
	M			The claspers are slightly more robust but still flexible. They are as long as or longer than pelvic fins. The testis is enlarged; in sharks, testis starts to segment; in rays, lobules are clearly visible but do not occupy the whole surface. The sperm ducts are developing and beginning to meander.
3a	F	CAPABLE of REPRODUCING	MATURE	The large ovary has enlarged yolk follicles that are all roughly the same size, hence they can be easily distinguished. The oviducal gland and the uterus are developed. The uterus is not dilated and does not contain yolky matter and embryos.
	M	CAPABLE of REPRODUCING		The claspers are fully formed, and the skeleton is hardened and rigid and is generally longer than the pelvic fins. The testis is greatly enlarged; in sharks, the testis is fully segmented; in rays, it is filled with developed lobules. The sperm ducts are tightly coiled and filled with sperm.
3b	F	EARLY PREGNANCY	MATERNAL	The uteri are full and rounded with yolk content (usually candle-shaped). In general, the segments cannot be discernible, and embryos cannot be observed.
	M	ACTIVELY SPAWNING	MATURE	The description is similar to stage 3a, but with clasper glands dilated, often swollen and reddish (occasionally open). The sperm is often present in the clasper grooves or glands. Under pressure, sperm is observed flowing out of the cloaca or in the sperm ducts.
3c	F	MID-PREGNANCY	MATERNAL	The uteri are well filled and rounded, often with visible segments. The embryos are always visible and small, and with a relatively large yolk sac.
3d	F	LATE PREGNANCY	MATERNAL	The embryos are fully formed; the yolk sacs are reduced or absent. The embryos can be easily measured and sexed.
4a	F	REGRESSING	MATURE	The ovaries are shrunken without follicle development and with atretic (degenerating) follicles. The diameter of the oviducal glands may be decreasing. The uterus appears much enlarged, collapsed, empty and reddish.
4	M	REGRESSING	MATURE	The claspers are fully formed, similar to stage 3. The testis and sperm ducts are shrunken and flaccid.
4b	F	REGENERATING (mature)	MATURE*	The ovary has small follicles at different stages of development including atretic ones. The uterus is enlarged with flaccid walls. The oviducal gland is discernible.

*these stages can be easily confused one with another.
Source: MEDITS, 2017.

Annex 8.6. Maturity scale for stomatopods

Annex 8.6. Maturity scale (stomatopods)		
Maturation state	Stages	Reproductive apparatus aspect
Immature	0	Ovaries filamentous and hyaline; 6th–8th sternites hyaline.
Quiescent	1	Filamentous ovaries with evident brown dots (chromatophores), 6th–8th sternites hyaline.
Early Maturation	2	Narrow yellow ovaries, 6th–8th sternites whitish.
Maturation	3	Yellow ovaries extending up to half of abdomen width, not visible through cutile on ventral side of telson, 6th–8th sternites white.
Ripe	4	Yellow ovaries extending over half abdominal width, visible through cutile on ventral side of telson, 6th–8th sternites milky white.
Spent	5	Similar to quiescent ovaries, sometime with a few yellow dots, but 6th–8th sternites still white.

Note: see also Appendix G.5 of the DCRF manual (GFCM, 2018a).

ANNEX 9. SIX-PHASE MATURITY STAGES FOR ANCHOVIES AND SARDINES CAUGHT IN PELAGIC SURVEYS

Annex 9. Six-phase maturity stages for anchovies and sardines caught in pelagic surveys

Stage	Activity	Stage name	Female	Male
1	Inactive	Immature or resting	Invisible or very small ovaries (cord-shaped), translucent or slightly coloured (when resting).	Very small testis, translucent. Sex is very difficult to identify; small testis, colour orange-red (when resting).
2		Developing	Wider ovaries occupying 1/4 to 1/3 of body cavity; pinkish or yellow colour. Visible oocytes are not present.	The testis occupy approximately 1/3 of the abdominal cavity. White-greyish colour.
3	Active	Imminent spawning	Ovaries occupying 3/4 to almost fitting body cavity; opaque with yellow or orange colour. Opaque oocytes are visible.	Whitish to creamy testis about 2/3 of the body cavity. Under light pressure, sperm is not expelled.
4		Spawning	Large ovaries occupying the full body cavity; fully or partially translucent with gelatinous aspect. Hyaline oocytes are visible.	Whitish-creamy soft testis occupy the full body cavity. Under light pressure, sperm is expelled freely.
5		Partial post-spawning	Size from 1/2 to 3/4 of abdominal cavity; non-turgid ovaries with haemorrhagic zones. Blood coloured.	Deflated testicles occupy up to 2/3 of the body cavity. Brownish/reddish colour.
6	Inactive	Spent	Reddish ovary shrunken. Size less than 2/3 of abdominal cavity. Flaccid ovary. Some small opaque oocyte.	Flaccid and thin testicles with haemorrhagic aspect.

The following six-phase maturity scale should be used for sardine (*Sardina pilchardus*) and anchovy (*Engraulis encrasicolus)*, captured during pelagic surveys (ICES, 2008).
Source: ICES, 2008.

ANNEX 10. MATURITY SCALE CONVERSION TABLE FOR ANCHOVY (*ENGRAULIS ENCRASICOLUS*) AND SARDINE (*SARDINA PILCHARDUS*)

Annex 10. Maturity scales conversion table for anchovies and sardines				
	Pelagic survey maturity scale		DCRF maturity scale	
Status	Stage	Name of stage	Stage	Name of stage
	0	Undetermined	0	Undetermined
Inactive	1	Immature or resting	1	Immature-virgin
			2a	Virgin-developing
	2	Developing	2b	Recovering
Active	3	Imminent spawning	2c	Maturing
	4	Spawning	3	Mature/spawner
	5	Partial post-spawning	4a	Spent
Inactive	6	Spent	4b	Resting

For the purpose of the DCRF only (GFCM, 2018a), maturity data collected following the six-phase maturity scale (as in Annex 9) should be then converted and reported according to DCRF requirements (Recommendation GFCM/41/2017/6) using the conversion table below (ICES, 2008).

ANNEX 11. REPORTING TEMPLATES FOR BOTTOM AND BEAM TRAWL DEMERSAL SURVEYS

Annex 11.1. Demersal surveys: fishing haul data (TA file)

Annex 11.1. Demersal surveys: fishing haul data						
Type of file	Country	Area	Vessel	Gear	Rigging	Doors

Cont.

Year	Month	Day	Haul number	Codend closing	Part of the codend	Shooting time

Cont.

Shooting quadrant	Shooting latitude	Shooting longitude	Shooting depth	Hauling time	Hauling quadrant	Hauling latitude

Cont.

Hauling longitude	Hauling depth	Haul duration	Validity	Course	Recorded species	Distance

Cont.

Vertical opening	Wing opening	Geometrical precision	Bridle length	Warp length	Warp diameter	Hydrological station

Cont.

Observations	Bottom temperature beginning	Bottom temperature end	Measuring system	Number of the stratum	Bottom salinity beginning	Bottom salinity end

Cont.

Measuring system						

Note: to properly fill in the templates for bottom trawl demersal survey, see description in Section 1.6.
Source: MEDITS, 2017.

Annex 11.2. Demersal surveys: catch data (TB file)

Annex 11.2. Demersal surveys: catch data						
Type of file	Country	Area	Vessel	Year	Month	Day

Cont.

Haul number	Codend closing	Part of the codend	Faunistic category	Genus	Species

Cont.

Name of the reference list	Total weight in the haul	Total number in the haul	Number of females	Number of males	Number of undetermined

Note: to properly fill in the templates for bottom trawl demersal survey, see description in Section 1.6.
Source: MEDITS, 2017.

Annex 11.3. Demersal surveys: biological data (TC file)

Annex 11.3. Demersal survey: biological data by species per fishing haul							
Type of file	Country	Area	Vessel	Year	Month	Day	Haul number

Cont.

Codend closing	Part of the codend	Faunistic category	Genus	Species	Length class code	Weight of the fraction

Cont.

Weight of the sample measured	Sex	Number of individuals per sex measured	Length class	Maturity	Matsub	Number of individuals in the length class and maturity stage

Note: to properly fill in the templates for bottom trawl demersal survey, see description in Section 1.6.
Source: MEDITS, 2017.

Annex 11.4. Demersal surveys: individual biological data (TE file)

Annex 11.4. Demersal survey: individual biological data								
Type of file	Country	Area	Vessel	Year	Month	Day	Haul number	Faunistic category

Cont.

Genus	Species	Length class code	Sex	Number per sex measured in subsample for otoliths	Length class	Maturity	Matsub

Cont.

Individual weight	Number per sex measured in subsample for weight	Otoliths sampled	Number per sex measured in subsample for ageing	Otoliths read	Age	Otolith code	Record number

Note: to properly fill in the templates for bottom trawl demersal survey, see description in Section 1.6.
Source: MEDITS, 2017.

Annex 11.5. Demersal surveys: data on marine litter (TL file)

Annex 11.5. Demersal survey: individual biological data								
Type of file	Country	Area	Vessel	Year	Month	Day	Haul number	Litter category

Cont.

Litter subcategory	Total weight per haul	Total number per haul	Total weight in the subcategory per haul	Total number in the subcategory per haul

Note: to properly fill in the templates for bottom trawl demersal survey, see description in Section 1.6.
Source: MEDITS, 2017.

ANNEX 12. REPORTING TEMPLATES FOR PELAGIC ACOUSTIC SURVEYS

Annex 12.1. Pelagic acoustic surveys: length data

Annex 12.1. Pelagic acoustic surveys: length data							
Country	Year	Start day	End day	Start month	End month	GSA	Survey

Cont.

Variable*	Species	Sex	Unit	Length class 0	Length class 1	Length class 2	Length class 3

Cont.

Length class 4	Length class 5	Length class 6	Length class 7	Length class 8	Length class 9	Length class 10	Length class 11

Cont.

Length class 12	Length class 13	Length class 14	Length class 15	Length class 16	Length class 17	Length class 18	Length class 19

Cont.

Length class 20	Length class 21	Length class 22	Length class 23	Length class 24	Length class 25	Length class 26plus

Note: for "variable" insert abundance or biomass.

Annex 12.2. Pelagic acoustic surveys: age data

Annex 12.2. Pelagic acoustic surveys: age data						
Country	Year	Start day	End day	Start month	End month	Gsa

Cont.

Survey	Variable*	Species	Sex	Age group 0	Age group 1	Age group 2

Cont.

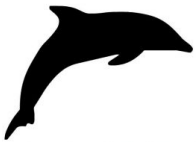
Age group 3	Age group 4	Age group 5	Age group 6	Age group 7	Age group 8	Age group 9plus

Note: for "Variable" insert abundance or biomass.

ANNEX 13. LIST OF VULNERABLE SPECIES

Annex 13.1. Vulnerable species included in Annex II and Annex III of the Barcelona Convention

List of vulnerable species 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). The list also contains the amendments of Annexes II and III of the Convention's Protocol Concerning Specially Protected Areas and Biological Diversity 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, adopted by the 17th 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 13.2 Rare elasmobranch species

This list reports elasmobranchs species that are included in the IUCN Red List of Threatened species (www.iucnredlist.org) or that are considered rare in the Mediterranean and the Black Sea (Bradai *et al.*, 2012; IUCN, 2016). (https://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 14. DATA ENTRY SHEET FOR VULNERABLE SPECIES

Annex 14. Data on vulnerable species			
Country			
GSA			
Survey			
Date			
Haul identification code			**Notes**
Time of starting operation			
Time of ending operation			
Latitude (start and end) of the fishing operation			
Longitude (start and end) of the fishing operation			
Depth (in m)			
Vulnerable species caught			
	Species 1	**Species 2**	**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			

*If available.

√ Data should be reported by species or by genus and/or family if the detailed information by species is not available.

√ This template could be duplicated if several vulnerable species are caught during the same fishing haul.

Instructions:

- **Survey:** insert the name of the survey.
- **GSA:** insert the code of the geographical subarea (GSA) as in annex 1.
- **Haul identification code:** insert the identification code that has been assigned to the identified fishing haul (as in annex 3.1).
- **Species:** insert the scientific name of the identified species (as in annex 13).
- **Latitude (start and end) of fishing operation:** insert the latitude at the beginning and at the end of each fishing operation (e.g. fishing hauls); data should be inserted in degrees, minutes and seconds (e.g. 40°51′59″N).
- **Longitude (start and end) of fishing operation:** insert the longitude at the beginning and at the end of each fishing operation (e.g. fishing hauls); data should be inserted in degrees, minutes and seconds (e.g. 124°4′58″W).
- **Depth (in m):** insert the depth in metres (m) of the fishing haul.
- **Photo (Y/N):** insert "yes" (Y) or "no" (N) if a photo of the specimen has been taken and, if "yes", assign an identification code to the photo.
- **Total weight of individual(s) caught:** whenever possible, for each group of vulnerable species caught, report the total weight in kilograms of the individual(s) caught, or insert an estimate.
- **Condition at capture and condition at release:** for each species, indicate the number of individuals that has been caught and released *alive*, *dead, almost dead,* or indicate that the state is *not known*.

ANNEX 15. DATA ENTRY SHEET FOR MARINE MACRO-LITTER

Annex 15. Data on marine macro-litter			
Country			
GSA			
Survey			
Date			
Haul identification code			**Notes**
Total quantity of marine litter (kg)			
Percentage (%) of marine litter in the catch			
Marine litter composition*	**kg**	**%**	**Notes**
Plastic			
Rubber			
Fishing gear			
Metal			
Glass			
Ceramic			
Cloth			
Wood processed			
Other (please specify)			
Comments:			

* If available.

Instructions:

- **Survey:** insert the name of the survey.
- **GSA:** insert the code of the geographical subarea (GSA) as in annex 1.
- **Haul identification code:** insert the identification code that has been assigned to the identified fishing haul (as in annex 3.1).
- **Total quantity of marine litter (kg):** insert the total weight in kilograms (or an estimate) of marine litter taken during a single fishing haul.
- **Percentage (%) of marine litter in the catch:** insert the total marine litter fraction (in percentage) accumulated during a single fishing haul.
- **Marine litter composition*:** whenever possible, insert the weight (or an estimate) in kilograms (kg) and the percentage of the different items contributing to the marine litter composition during a single fishing haul.

ANNEX 16. DATA ENTRY SHEET FOR MACROBENTHOS

16. Data on macrobenthos			
Country			
GSA			
Survey			
Date			
Haul identification code			
Total quantity of macroinvertebrates (estimation in kg)			
Percentage (% of macroinvertebrates in the total catch)			
	Feature*	Habitat*	Taxa*
VME Indicator*			

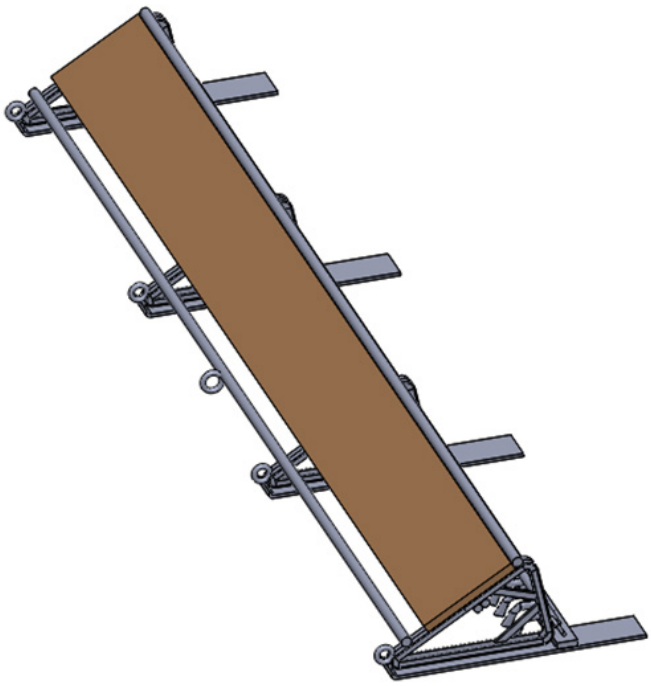
Composition by species*					
Species*	Family/Genus/Order/ Taxa/Morphological group	Total weight (kg)	Total number	Photo* (Y/N)	Notes

* If available.

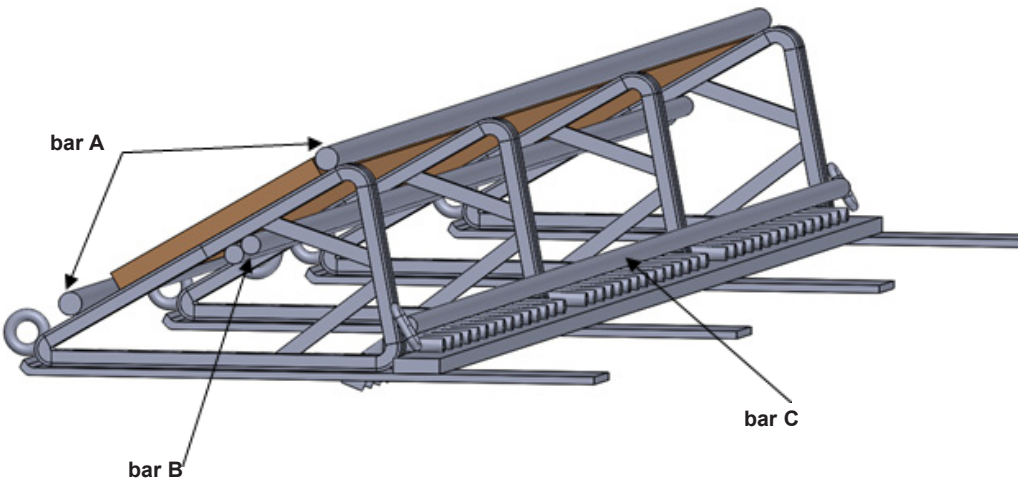
Instructions:

- **Survey:** insert the name of the survey.
- **GSA:** insert the code of the geographical subarea (GSA) as in annex 1.
- **Haul identification code:** Insert the identification code which has been assigned to the identified fishing haul (as in Annex 3.1).
- **Total quantity of macroinvertebrates (estimation in kg):** insert the total weight (or an estimate) of macroinvertebrates (macrobenthos) in kilograms taken during the same fishing trip or fishing operation.
- **Percentage of macroinvertebrates in the total catch (%):** insert the total macroinvertebrates fraction (in percentage) cumulated during a single fishing haul.
- **VME indicator (feature, habitat, taxa):** if possible, record this information for each fishing haul (please refer to Box 4 in Section 4.1).
- **Composition by species:** whenever possible, insert the name of the macrobenthic species. When the specimens cannot be identified at the species level, the genus, family, order or taxa should be indicated. In cases where species identification is not possible (especially for sessile taxa), organisms can be assigned to morphological groups according to their growth form (e.g. massive, tubular, globular, arborescent, stalked, fan-shaped, lollipop-shaped, cup-shaped) combined with information about their colour, consistency (e.g. hard/soft) and photographic documentation.
- **Total weight (kg):** insert the total weight in kilograms (or an estimate) for each identified species of benthic marine macroinvertebrates caught during the same fishing trip or fishing operation.
- **Total number:** insert the total number (or an estimate) for each identified species of benthic marine macroinvertebrates caught during the same fishing haul.
- **Photo (Y/N):** Insert "yes" or "no" if a photo of the specimen has been taken, and if "yes", assign an identification code to the photo.

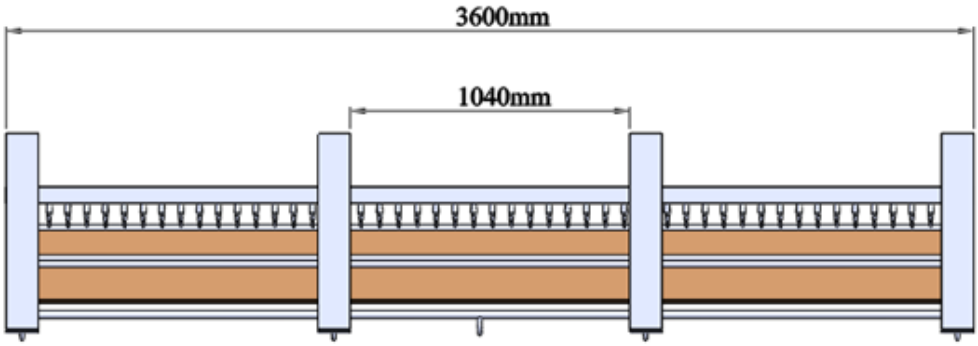
ANNEX 17. SCHEME OF THE RAPIDO TRAWL



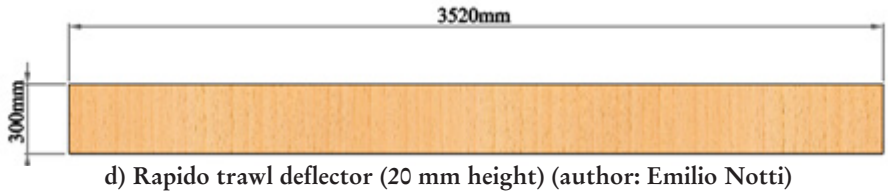
a) Rapido trawl frame upside (author: Emilio Notti)



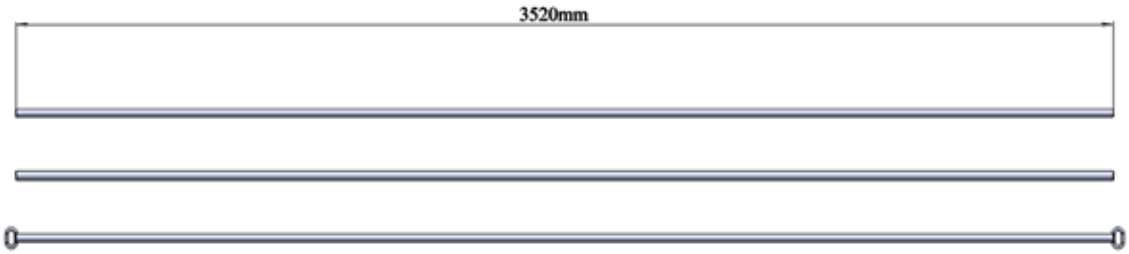
b) Rapido trawl frame lateral-back side. Bottom surface of central sledges 1 cm over the lateral sledges (author: Emilio Notti)



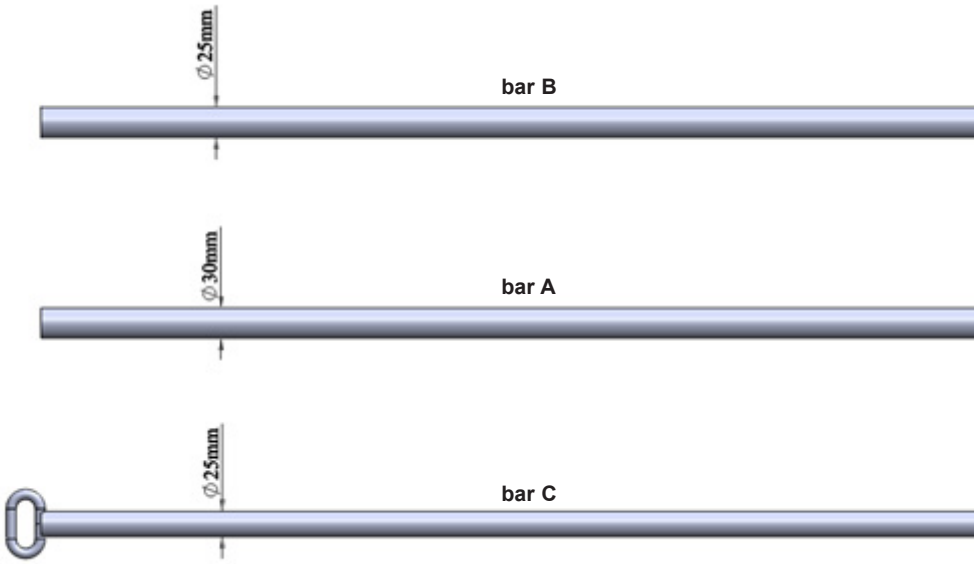
c) Rapido trawl frame bottom side (author: Emilio Notti)



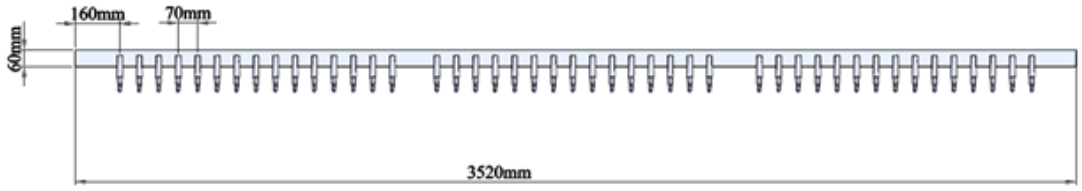
d) Rapido trawl deflector (20 mm height) (author: Emilio Notti)



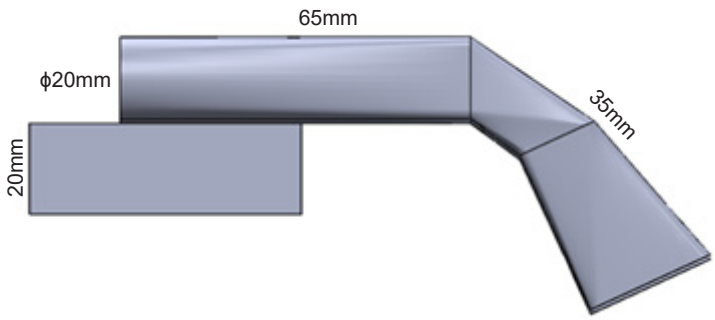
e) Rapido trawl bar lengths (author: Emilio Notti)



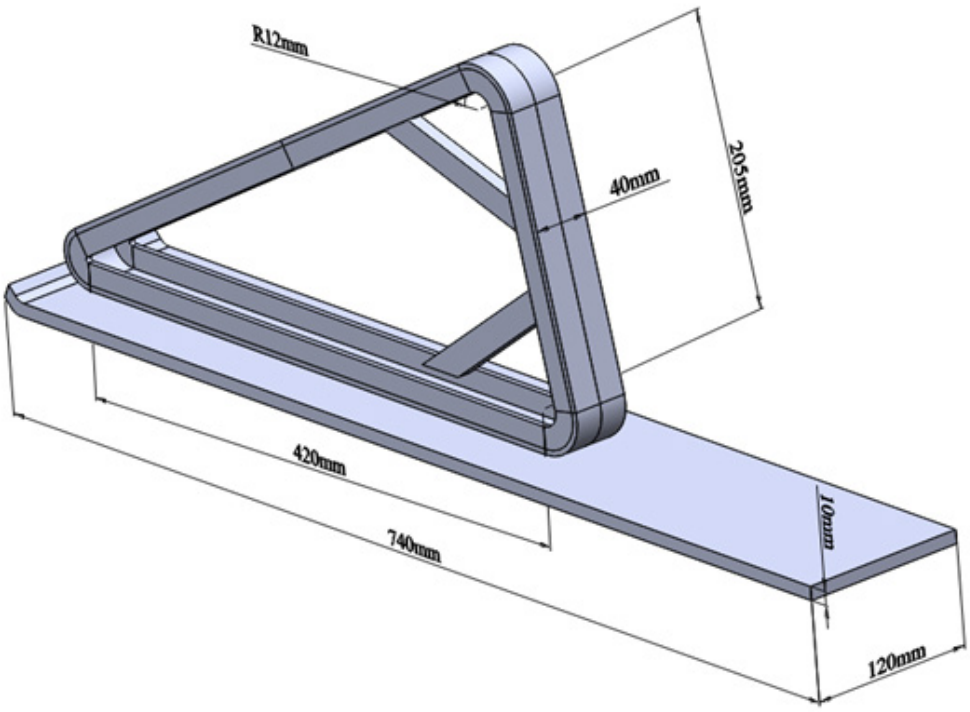
f) Rapido trawl bar diameters (author: Emilio Notti)



g) Rapido trawl blade scheme from above, 3 order of teeth 15 per order (author: Emilio Notti)



h) Rapido trawl blade from the side, square end of the knife 1 cm below the bottom plane of the sledge (author: Emilio Notti)



i) Rapido trawl frame, sledge dimensions (Author: Emilio Notti)

In the Mediterranean and the Black Sea, the assessment of demersal stocks mainly relies on scientific surveys (bottom and beam trawl) while the assessment of pelagic stocks is essentially based on acoustic surveys using acoustic techniques with mid-water trawling. These routine surveys-at-sea provide essential information to monitor changes in the distribution of species and to perform annual estimates of total mortality, growth parameters, sex ratio and average length-at-maturity, which in turn are crucial to fine-tune the assessments of the status of resources and to estimate more precisely indicators at the population and fish community levels. However, survey practices differ from one subregion to another, each approach having its own strengths and limitations. In addition, there is still a lack of large-scale standardized surveys aimed at analysing the diversity and distribution of the main demersal and pelagic species across the Mediterranean and the Black Sea. One way of tackling this issue is to carry out international scientific surveys covering the main demersal and pelagic stocks based on a common methodology. The methodology presented in this publication aims at supporting the planning and implementation of regional demersal (bottom and beam) trawl and pelagic acoustic surveys. It can be useful for the implementation of new surveys-at-sea in areas where demersal trawl and pelagic acoustic surveys are not regularly carried out. It can also contribute to increasing comparability between existing surveys thanks to the standardization of methods, sampling of catches and data recording and analysis. Finally, it represents a valuable tool to define minimum requirements towards sustainability and management objectives at the regional and subregional level.

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COMMISSION IMPLEMENTING DECISION (EU) 2019/909

of 18 February 2019

establishing the list of mandatory research surveys and thresholds for the purposes of the multiannual Union programme for the collection and management of data in the fisheries and aquaculture sectors

THE EUROPEAN COMMISSION,

Having regard to the Treaty on the Functioning of the European Union,

Having regard to Regulation (EU) 2017/1004 of the European Parliament and of the Council of 17 May 2017 on the establishment of a Union framework for the collection, management and use of data in the fisheries sector and support for scientific advice regarding the common fisheries policy and repealing Council Regulation (EC) No 199/2008 ([1]), and in particular the first and third subparagraphs of Article 4(1) thereof,

Whereas:

(1) Pursuant to Article 25 of Regulation (EU) No 1380/2013 of the European Parliament and of the Council ([2]), the Member States are to collect biological, environmental, technical and socioeconomic data necessary for fisheries management. The multiannual Union programme for the collection, management and use of data in the fisheries and aquaculture sectors (EU MAP) for the period 2017-2019 was adopted by Commission Implementing Decision (EU) 2016/1251 ([3]) and will expire on 31 December 2019.

(2) The multiannual Union programme is necessary for Member States to specify and plan their data collection activities in their national work plans. In accordance with Article 21 of Regulation (EU) No 508/2014 of the European Parliament and of the Council ([4]) these national work plans are to be submitted to the Commission by 31 October preceding the year from which the work plan is to apply.

(3) In order to prepare the review of the EU MAP after 2019, consultations with experts under the Scientific, Technical and Economic Committee on Fisheries, regional coordination groups, Member State representatives and other relevant stakeholders are ongoing and will be finalised only at the end of 2019. As a result, the new EU-MAP taking into account the outcomes of these consultations cannot be adopted before 2021.

(4) For the period from 2020 to 2021 it is, therefore, necessary to adopt the provisions on the list of mandatory research surveys at sea and thresholds below which it is not mandatory for Member States to collect data, included in the current EU MAP, on the basis of Regulation (EU) 2017/1004.

(5) This decision therefore establishes, in accordance with Article 4 of Regulation (EU) 2017/1004, the list of mandatory research surveys at sea and thresholds below which it is not mandatory for Member States to collect data based on their fishing and aquaculture activities or carry out surveys at sea, as referred to in Article 5(1)(b) and (c) of that Regulation. Detailed arrangements on the collection and management of biological, environmental, technical and socioeconomic data by Member States, as referred to in Article 5(1)(a) of that Regulation, are provided for by Commission Delegated Decision (EU) 2019/910 ([5]).

(6) For reasons of legal certainty, Implementing Decision (EU) 2016/1251 should be repealed.

(7) The measures provided for in this Decision are in accordance with the opinion of the Management Committee for Fisheries and Aquaculture,

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([1]) OJ L 157, 20.6.2017, p. 1.

([2]) Regulation (EU) No 1380/2013 of the European Parliament and of the Council of 11 December 2013 on the Common Fisheries Policy, amending Council Regulations (EC) No 1954/2003 and (EC) No 1224/2009 and repealing Council Regulations (EC) No 2371/2002 and (EC) No 639/2004 and Council Decision 2004/585/EC (OJ L 354, 28.12.2013, p. 22).

([3]) Commission Implementing Decision (EU) 2016/1251 of 12 July 2016 adopting a multiannual Union programme for the collection, management and use of data in the fisheries and aquaculture sectors for the period 2017-2019 (OJ L 207, 1.8.2016, p. 113).

([4]) Regulation (EU) No 508/2014 of the European Parliament and of the Council of 15 May 2014 on the European Maritime and Fisheries Fund and repealing Council Regulations (EC) No 2328/2003, (EC) No 861/2006, (EC) No 1198/2006 and (EC) No 791/2007 and Regulation (EU) No 1255/2011 of the European Parliament and of the Council (OJ L 149, 20.5.2014, p. 1).

([5]) Commission Delegated Decision (EU) 2019/910 of 13 March 2019 establishing the multiannual Union programme for the collection and management of biological, environmental, technical and socio-economic data in the fisheries and aquaculture sectors (see page 27 of this Official Journal).

HAS ADOPTED THIS DECISION:

Article 1

For the purposes of multiannual Union programme for the collection and management of data in the fisheries sector for the period 2020-2021, the list of mandatory research surveys at sea and thresholds below which it is not mandatory for Member States to collect data based on their fishing and aquaculture activities or carry out surveys at sea covering the parts of the multiannual Union programme referred to in points (b) and (c) of Article 5(1) of Regulation (EU) 2017/1004, is set out in the Annex to this Decision.

Article 2

Implementing Decision (EU) 2016/1251 is repealed with effect from 1 January 2020.

Article 3

This Decision shall enter into force on the day following that of its publication in the *Official Journal of the European Union*.

It shall apply from 1 January 2020.

Done at Brussels, 18 February 2019.

For the Commission

The President

Jean-Claude JUNCKER

ANNEX

CHAPTER I

Research surveys at sea

At least all research surveys at sea listed in the Table in this Annex (replacing Table 10 of Implementing Decision (EU) 2016/1251) shall be carried out, unless a review of surveys leads to the conclusion that a survey is no longer appropriate for informing stock assessment and fisheries management. On the basis of the same scientific review criteria, new surveys can be added to this list.

In the workplans referred to in Article 21 of Regulation (EU) No 508/2014, Member States shall set out the research surveys at sea to be carried out and shall be responsible for these surveys.

Member States contributing to international research surveys shall coordinate their efforts within the same marine region.

In their national work plans Member States shall guarantee continuity with previous survey designs.

This Chapter is replacing Chapter IV of Implementing Decision (EU) 2016/1251.

CHAPTER II

Thresholds

(1) This Chapter shall apply to Union fisheries and is replacing the provisions of Chapter V of Implementing Decision (EU) 2016/1251.

(2) No biological data have to be collected where, for a certain fish stock or species:

(a) a Member State's share of the related total allowable catch (TAC) is less than 10 % of the Union total, or

(b) where no TAC is fixed, the total landings of a Member State of a stock or species are less than 10 % of the average total EU landings in the previous 3 years, or

(c) the total annual landings of a Member State of a species is less than 200 tonnes. For species with a specific management need a lower threshold may be defined at marine region level.

When the sum of the relevant quotas of several Member States, whose share of a TAC is less than 10 %, is higher than 25 % of the share of the TAC for a certain stock, the 10 % threshold referred to under (a) shall not apply and Member States shall ensure task-sharing at regional level in order to ensure that the stock is covered by sampling in concordance with end-user needs.

No threshold shall apply to large pelagic species and anadromous and catadromous species.

(3) Without prejudice to more specific provisions relating to international obligations under Regional Fisheries Management Organisations, no biological data should to be collected where, for a certain internationally exploited fish stock other than stocks of large pelagic or highly migratory species, the Union's share is less than 10 %.

(4) Member States shall provide catch estimates from existing recreational fishery surveys, including those carried out under the Data Collection Framework or from an additional pilot study, within two years from the date on which this Decision takes effect. These surveys make it possible to assess the share of catches from recreational fisheries in relation to commercial catches for all species in a marine region for which recreational catch estimates are required under this multiannual Union programme. The subsequent design and extent of national surveys of recreational fisheries, including any thresholds for data collection, shall be coordinated at marine region level and shall be based on end user needs.

No threshold shall apply to recreational catches of fish stocks that are subject to recovery or multi-annual management plans such as those applying to large pelagic species and highly migratory species.

(5) No social and economic data on aquaculture need to be collected if the total production of the Member State is less than 1 % of the total Union production volume and value. No data need to be collected on aquaculture for species

accounting for less than 10 % of the Member State's aquaculture production by volume and value. Additionally, Member States with a total production of less than 2,5 % of the total Union aquaculture production volume and value may define a simplified methodology such as pilot studies with a view to extrapolate the data required for species accounting for more than 10 % of the Member States's aquaculture production by volume and value.

The reference data shall be the Member States' latest submission under Regulation (EC) No 762/2008 of the European Parliament and of the Council ([1]) and corresponding data published by Eurostat.

(6) No environmental data on aquaculture need to be collected where the total aquaculture production of the Member State is less than 2,5 % of the total Union aquaculture production volume and value.

The reference data shall be the Member States' latest submission under Regulation (EC) No 762/2008 and corresponding data published by Eurostat.

(7) A Member State's participation (physical or financial) in research surveys at sea listed in the list of surveys at sea of this Annex is not mandatory when its share of a Union TAC of the survey target species is below a threshold of 3 %. Where no TAC is set, a Member State's participation (physical or financial) in research surveys at sea is not mandatory when its share of the total Union landings of the preceding 3 years of a stock or species is below a threshold of 3 %. Thresholds for multispecies and ecosystem surveys may be defined at marine region level.

(8) Notwithstanding points 2 to 7, within the same marine region, Member States may agree on alternative thresholds.

List of research surveys at sea ([1])

Name of the survey	Acronym	Area	Period	Main targeted species
Baltic Sea				
Baltic International Trawl Survey	BITS Q1 BITS Q4	IIIaS, IIIb-d	1st and 4th Quarter	Cod and other demersal species
Baltic International Acoustic Survey (Autumn)	BIAS	IIIa, IIIb-d	Sep-Oct	Herring and sprat
Gulf of Riga Acoustic Herring Survey	GRAHS	IIId	3rd Quarter	Herring
Sprat Acoustic Survey	SPRAS	IIId	May	Sprat and herring
Rügen Herring Larvae Survey	RHLS	IIId	March-June	Herring
North Sea and Eastern Arctic (ICES areas I and II)				
International Bottom Trawl Survey	IBTS Q1 IBTS Q3	IIIa, IV	1st and 3rd Quarter	Haddock, Cod, Saithe, Herring, Sprat, Whiting, Mackerel, Norway pout.
North Sea Beam Trawl Survey	BTS	IVb,IVc,VIId	3rd Quarter	Plaice, Sole
Demersal Young Fish Survey	DYFS	Coasts of NS	3rd and4th Quarter	Plaice, sole, brown shrimp
Sole Net Survey	SNS	IVb, IVc	3rd Quarter	Sole, Plaice
North Sea Sandeels Survey	NSSS	IVa, IVb	4th Quarter	Sandeels
International Ecosystem Survey in the Nordic Seas	ASH	IIa	May	Herring, Blue whiting

([1]) Regulation (EC) No 762/2008 of the European Parliament and of the Council of 9 July 2008 on the submission by Member States of statistics on aquaculture and repealing Council Regulation (EC) No 788/96 (OJ L 218, 13.8.2008, p. 1).

Name of the survey	Acronym	Area	Period	Main targeted species
Redfish Survey in the Norwegian Sea and adjacent waters	REDNOR	II	August- September	Redfish
Mackerel egg Survey (Triennial)	NSMEGS	IV	May-July	Mackerel egg production
Herring Larvae survey	IHLS	IV,VIId	1st and 3rd Quarter	Herring, Sprat Larvae
NS Herring Acoustic Survey	NHAS	IIIa, IV,VIa	June, July	Herring, Sprat
Nephrops TVsurvey (FU 3&4)	NTV3&4	IIIA	2nd or 3rd Quarter	Nephrops
Nephrops TVsurvey (FU 6)	NTV6	IVb	September	Nephrops
Nephrops TVsurvey (FU 7)	NTV7	IVa	2nd or 3rd Quarter	Nephrops
Nephrops TVsurvey (FU 8)	NTV8	IVb	2nd or 3rd Quarter	Nephrops
Nephrops TVsurvey (FU 9)	NTV9	IVa	2nd or 3rd Quarter	Nephrops
North Atlantic (ICES Areas V-XIV and NAFO areas)				
International Redfish Trawl and Acoustic Survey (Biennial)	REDTAS	Va, XII, XIV; NAFO SA 1-3	June/July	Redfish
Flemish Cap Groundfish survey	FCGS	3M	July	Demersal species
Greenland Groundfish survey	GGS	XIV, NAFO SA1	October/November	Cod, redfish and other demersal species
3LNO Groundfish survey	PLATUXA	NAFO 3LNO	2nd and 3rd Quarter	Demersal species
Western IBTS 4th quarter (including Porcupine survey)	IBTS Q4	VIa, VII, VIII, IXa	4th Quarter	Demersal species
Scottish Western IBTS	IBTS Q1	VIa,VIIa	March	Gadoids, herring, mackerel
ISBCBTS September	ISBCBTS	VIIa f g	September	Sole, Plaice
WCBTS	VIIe BTS	VIIe	October	Sole, Plaice, Anglerfish, Lemon sole
Blue whiting survey		VI, VII	1st and 2nd Quarter	Blue whiting
International Mackerel and Horse Mackerel Egg Survey (Triennial)	MEGS	VIa, VII,VIII, IXa	January-July	Mackerel, Horse Mackerel egg production
Sardine, Anchovy Horse Mackerel Acoustic Survey		VIII, IX	March-April-May	Sardine, Anchovy, Mackerel, Horse Mackerel abundance indices

Name of the survey	Acronym	Area	Period	Main targeted species
Sardine DEPM (Triennial)		VIIIc, IXa	2nd and 4th Quarter	Sardine SSB and use of CUFES
Spawning/Pre spawning Herring/Boarfish acoustic survey		VIa, VIIa-g	July, Sept, Nov, March, Jan	Herring, Sprat
Biomass of Anchovy	BIOMAN	VIII	May	Anchovy SSB (DEP)
Nephrops UWTV survey (offshore)	UWTV (FU 11-13)	VIa	2nd or 3rd Quarter	Nephrops
Nephrops UWTV Irish Sea	UWTV (FU 15)	VIIa	August	Nephrops
Nephrops UWTV survey Aran Grounds	UWTV (FU 17)	VIIb	June	Nephrops
Nephrops UWTV survey Celtic Sea	UWTV (FU 20-22)	VIIg,h,j	July	Nephrops
Nephrops Survey Offshore Portugal NepS	UWTV (FU 28-29)	IXa	June	Nephrops
Mediterranean waters and Black sea				
Pan-Mediterranean Acoustic Survey ()	MEDIAS	GSA 1, 6, 7, 9, 10, 15, 16, 17, 18, 20, 22	Spring-summer (qtrs 2-3)	Small pelagic species
Bottom trawl survey in Black Sea,	BTSBS	GSA 29	Spring - autumn (qtrs 2,3,4)	Turbot
Pelagic trawl survey in Black Sea,	PTSBS	GSA 29	Spring-autumn (qtrs 2,3,4)	Sprat and Whiting
International bottom trawl survey in the Mediterranean (),	MEDITS	GSA 1, 2, 3, 5, 6, 7, 8, 9, 10, 11, 15, 16, 17, 18, 19, 20, 22, 23, 25	Spring-summer (qtrs 2-3)	Demersal species

(1) The list of research surveys at sea is replacing Table 10 of Implementing Decision (EU) 2016/1251.

COMMISSION DELEGATED DECISION (EU) 2019/910

of 13 March 2019

establishing the multiannual Union programme for the collection and management of biological, environmental, technical and socioeconomic data in the fisheries and aquaculture sectors

THE EUROPEAN COMMISSION,

Having regard to the Treaty on the Functioning of the European Union,

Having regard to Regulation (EU) 2017/1004 of the European Parliament and of the Council of 17 May 2017 on the establishment of a Union framework for the collection, management and use of data in the fisheries sector and support for scientific advice regarding the common fisheries policy and repealing Council Regulation (EC) No 199/2008 ([1]), and in particular the first and second subparagraphs of Article 4(1) thereof,

Whereas:

(1) Pursuant to Article 25 of Regulation (EU) No 1380/2013 of the European Parliament and of the Council ([2]), the Member States are to collect biological, environmental, technical and socioeconomic data necessary for fisheries management. The multiannual Union programme for the collection, management and use of data in the fisheries and aquaculture sectors (EU MAP) ([3]) for the period 2017-2019 was adopted by Commission Implementing Decision (EU) 2016/1251 ([4]) and will expire on 31 December 2019.

(2) The multiannual Union programme is necessary for Member States to specify and plan their data collection activities in their national work plans. In accordance with Article 21 of Regulation (EU) No 508/2014 of the European Parliament and of the Council ([5]) these national work plans are to be submitted to the Commission by 31 October preceding the year from which the work plan is to apply.

(3) In order to prepare the review of the current EU MAP after 2019, consultations with experts under the Scientific, Technical and Economic Committee on Fisheries, regional coordination groups, Member State representatives and other relevant stakeholders are ongoing and will be finalised only at the end of 2019. As a result, the new EU MAP taking into account the outcomes of these consultations cannot be adopted before 2021.

(4) For the period from 2020 to 2021 it is, therefore, necessary to adopt the provisions on the collection and management of biological, environmental, technical and socioeconomic data, included in the current EU MAP, on the basis of Regulation (EU) 2017/1004.

(5) This decision therefore establishes, in accordance with Article 4 of Regulation (EU) 2017/1004, detailed arrangements on collection and management of biological, environmental, technical and socioeconomic data by Member States as referred to in Article 5(1)(a) of that Regulation. The list of mandatory surveys at sea and thresholds below which it is not mandatory for Member States to collect data based on their fishing and aquaculture activities or carry out research surveys at sea, as referred to in Article 5(1)(b) and (c), are provided for by Commission Implementing Decision (EU) 2019/909 ([6]).

(6) For the purposes of legal certainty, Implementing Decision (EU) 2019/909 establishing the list of mandatory surveys and thresholds for the purposes of the multiannual Union programme for the collection and management of data in the fisheries and aquaculture sectors repeals Implementing Decision (EU) 2016/1251 with effect from 1 January 2020,

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([1]) OJ L 157, 20.6.2017, p. 1.
([2]) Regulation (EU) No 1380/2013 of the European Parliament and of the Council of 11 December 2013 on the Common Fisheries Policy, amending Council Regulations (EC) No 1954/2003 and (EC) No 1224/2009 and repealing Council Regulations (EC) No 2371/2002 and (EC) No 639/2004 and Council Decision 2004/585/EC (OJ L 354, 28.12.2013, p. 22).
([3]) OJ L 207, 1.8.2016, p. 113.
([4]) Commission Implementing Decision (EU) 2016/1251 of 12 July 2016 adopting a multiannual Union programme for the collection, management and use of data in the fisheries and aquaculture sectors for the period 2017-2019 (OJ L 207, 1.8.2016, p. 113).
([5]) Regulation (EU) No 508/2014 of the European Parliament and of the Council of 15 May 2014 on the European Maritime and Fisheries Fund and repealing Council Regulations (EC) No 2328/2003, (EC) No 861/2006, (EC) No 1198/2006 and (EC) No 791/2007 and Regulation (EU) No 1255/2011 of the European Parliament and of the Council (OJ L 149, 20.5.2014, p. 1).
([6]) Commission Implementing Decision (EU) 2019/909 of 18 February 2019 establishing the list of mandatory research surveys and thresholds for the purposes of the multiannual Union programme for the collection and management of data in the fisheries and aquaculture sectors (see p. 21 of this Official Journal).

HAS ADOPTED THIS DECISION:

Article 1

The multiannual Union programme for the collection, management and use of data in the fisheries sector for the period 2020-2021 covering the detailed list of data requirements as referred to in point (a) of Article 5(1) of Regulation (EU) 2017/1004, is set out in the Annex to this Decision.

Article 2

This Decision shall enter into force with its publication in the *Official Journal of the European Union* and shall apply from 1 January 2020.

Done at Brussels, 13 March 2019.

For the Commission

The President

Jean-Claude JUNCKER

ANNEX

CHAPTER I [1]

Definitions

For the purpose of this Annex, definitions in Regulation (EU) 2017/1004, Council Regulation (EC) No 1224/2009 [2], Commission Implementing Regulation (EU) No 404/2011 [3], and Regulation (EU) No 1380/2013 shall apply. In addition, the following definitions shall also apply:

(1) **active vessels**: vessels that have been engaged in any fishing operation (one day or more) during a calendar year. A vessel that has not been engaged in fishing operations during a year is considered 'inactive'.

(2) **anadromous species**: living aquatic resources with lifecycle starting by hatching in freshwater, migrating to saltwater, returning and finally spawning in freshwater.

(3) **catadromous species**: living aquatic resources with lifecycle starting by hatching in saltwater, migrating to freshwater, returning and finally spawning in saltwater.

(4) **catch fraction**: a part of the total catch, such as the part of the catch landed above the minimum conservation reference size, the part landed below the minimum conservation reference size, the part discarded below the minimum conservation reference size, de minimis discards or discards.

(5) **days at sea**: any continuous period of 24 hours (or part thereof) during which a vessel is present within an area and absent from port.

(6) **fishing days**: any calendar day at sea in which a fishing operation takes place, without prejudice to the international obligations of the Union and its Member States. One fishing trip can contribute to both the sum of the fishing days for passive gears and the sum of the fishing days for active gears on that trip.

(7) **fishing ground**: (group of) geographical units where fishing takes place. These units shall be agreed at marine region level on the basis of existing areas defined by Regional Fisheries Management Organisations or scientific bodies.

(8) **fleet segment**: group of vessels with the same length class (LOA, length overall) and predominant fishing gear during the year.

(9) **metier**: a group of fishing operations targeting a similar (assemblage of) species, using similar gear [4], during the same period of the year and/or within the same area and which are characterised by a similar exploitation pattern.

(10) **research surveys at sea**: trips carried out on a research vessel, or a vessel dedicated to scientific research for stock and ecosystem monitoring, and designated for this task by the body in charge of the implementation of the national workplan established in accordance with Article 21 of Regulation (EU) No 508/2014.

CHAPTER II [5]

Data collection methods

Data collection methods and quality shall be appropriate for the intended purposes defined in Article 25 of Regulation (EU) No 1380/2013 and shall follow the best practices and relevant methodologies advised by the relevant scientific bodies. To this end, the methods and the result of the application of the methods shall be examined at regular intervals by independent scientific bodies in order to verify that they are appropriate with respect to the management of the common fisheries policy.

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[1] This Chapter replaces Chapter I of Implementing Decision (EU) 2016/1251.

[2] Council Regulation (EC) No 1224/2009 of 20 November 2009 establishing a Community control system for ensuring compliance with the rules of the common fisheries policy, amending Regulations (EC) No 847/96, (EC) No 2371/2002, (EC) No 811/2004, (EC) No 768/2005, (EC) No 2115/2005, (EC) No 2166/2005, (EC) No 388/2006, (EC) No 509/2007, (EC) No 676/2007, (EC) No 1098/2007, (EC) No 1300/2008, (EC) No 1342/2008 and repealing Regulations (EEC) No 2847/93, (EC) No 1627/94 and (EC) No 1966/2006 (OJ L 343, 22.12.2009, p. 1).

[3] Commission Implementing Regulation (EU) No 404/2011 of 8 April 2011 laying down detailed rules for the implementation of Council Regulation (EC) No 1224/2009 establishing a Community control system for ensuring compliance with the rules of the Common Fisheries Policy (OJ L 112, 30.4.2011, p. 1).

[4] As specified in Annex XI of Regulation (EU) No 404/2011.

[5] This Chapter replaces Chapter II of Implementing Decision (EU) 2016/1251.

CHAPTER III [6]

Data requirements

1. **Data sets**

1.1. Under the workplans drawn up in accordance with Article 21 of Regulation (EU) No 508/2014, Member States shall establish the data to be collected amongst the following sets as specified in points 2 to 7 of this Chapter:

(a) biological data, by catch fraction, on stocks caught by Union commercial fisheries in Union and outside Union waters and by recreational fisheries in Union waters;

(b) data to assess the impact of Union fisheries on the marine ecosystem in Union waters and outside Union waters;

(c) detailed data on the activity of Union fishing vessels in Union waters and outside Union waters as reported under Regulation (EC) No 1224/2009;

(d) social and economic data on fisheries [7];

(e) social, economic and environmental data on aquaculture;

1.2. The data to be collected shall be established in accordance with Articles 4 and 5 of Regulation (EU) 2017/1004 taking into account the thresholds set out in Chapter II of the Annex of Implementing Decision (EU) 2019/909 establishing the list of mandatory surveys and thresholds for the purposes of the multiannual Union programme for the collection and management of data in the fisheries and aquaculture sectors.

1.3. Data shall be collected to enable valid estimates to be derived for the type of fisheries, temporal periods and areas based on end-user needs agreed at marine region level. The frequency of data collection is to be coordinated at marine region level, unless stated otherwise in this Annex and corresponding tables.

2. **Biological data on stocks caught by Union commercial fisheries in Union and outside Union waters and by recreational fisheries in Union waters.**

Such data shall consist of the following:

(a) Catch quantities by species and biological data from individual specimens enabling the estimation of:

(i) For commercial fisheries, volume and length frequency of all catch fractions (including discards and unwanted catches) for the stocks listed in Tables 1A, 1B and 1C, reported at the aggregation level 6 as set out in Table 2. The temporal resolution shall be coordinated at marine region level based on end-user needs;

(ii) For commercial fisheries, mean-weight and age distribution of catches of the stocks listed in Table 1A, 1B and 1C. The selection of stocks from which these variables have to be collected and the temporal resolution shall be coordinated at marine region level based on end-user needs;

(iii) For commercial fisheries, sex-ratio, maturity and fecundity data for stocks listed in Tables 1A, 1B and 1C of catches at frequencies needed for scientific advice. The selection of stocks from which these variables have to be collected and the temporal resolution shall be coordinated at marine region level based on end-user needs;

(iv) For recreational fisheries, annual volume (numbers and weights or length) of catches and releases for the species listed in Table 3 and/or the species identified at marine region level as needed for fisheries management purposes End user needs for age or other biological data as specified in paragraphs (i)-(iii) shall be evaluated for recreational fisheries at marine region level.

[6] This Chapter replaces Chapter III of Implementing Decision (EU) 2016/1251.
[7] Data on the processing industry may be collected on a voluntary base, in that case the segmentation and variable in Table 11 may be used.

(b) In addition to data collected under point (a), data on anadromous and catadromous species listed in Table 1E caught by commercial fisheries during the freshwater part of their lifecycle, irrespective of the way these fisheries are undertaken, as follows:

(i) stock-related variables (for individual specimens, on age, length, weight, sex, maturity and fecundity, by life stage, but further specified on a species and regional basis), and

(ii) annual catch quantities by age class or life stage.

(c) In addition:

as regards eel, information (e.g. data, estimates, relative trends, etc.) collected annually in at least one river basin per eel management unit on:

(i) the abundance of recruits,

(ii) the abundance of the standing stock (yellow eel), and

(iii) the number or weight and sex ratio of emigrating silver eels,

and as regards all wild salmon: information collected annually — unless agreed otherwise at regional level — on the abundance of smolt and parr and number of ascending individuals.

The designation of rivers to be monitored for eel and salmon shall be defined at regional level. The selection of stocks from which these variables have to be collected shall be coordinated at regional level based on end-user needs.

3. **Data to assess the impact of Union fisheries on marine ecosystems in Union waters and outside Union waters**

Such data shall consist of the following:

(a) For all types of fisheries, incidental by-catch of all birds, mammals and reptiles and fish protected under Union legislation and international agreements, including the species listed in Table 1D, including absence in the catch, during scientific observer trips on fishing ships or by the fishers themselves through logbooks.

Where data collected during observer trips are not considered to provide sufficient data on incidental by-catch for enduser needs, other methodologies, shall be implemented by Member States. The selection of these methodologies shall be coordinated at marine region level and be based on end-user needs.

(b) Data to assist in the assessment of the impact of fisheries in Union waters and outside Union waters on marine habitats.

The variables used for assessing the impact of fisheries on marine habitat shall be those recorded under Regulation (EC) No 1224/2009. Data shall be disagregated at fishing activity level 3 ([8]), unless a lower level of aggregation is required at regional level, in particular in the case of marine protected areas.

When data recorded under Regulation (EC) No 1224/2009 are not at the correct resolution or are not of sufficient quality or coverage for the intended scientific use, they shall be collected in an alternative way by using appropriate sampling methods. Data as recorded under Regulation (EC) No 1224/2009 are to be made available at the appropriate level of aggregation to the National Institutions implementing the workplans.

(c) Data for estimating the level of fishing and the impact of fishing activities on marine biological resources and on marine ecosystems, such as effects on non-commercial species, predator-prey relationships and natural mortality of fish species in each marine region.

Such data shall be first assessed within pilot studies. Based on the outcomes of these pilot studies, Member States shall determine future data collection specific for each marine region, coordinated at marine region level and based on end-user needs.

([8]) See Table 2

4. **Detailed data on the activity of Union fishing vessels** [9] **in Union waters and outside Union waters as recorded under Regulation (EC) No 1224/2009.**

Data to assess the activity of Union fishing vessels in Union waters and outside Union waters consist of the variables as indicated in Table 4. Data as recorded, reported and transmitted under Regulation (EC) No 1224/2009 are to be made available in the form of primary data to the national institutions implementing the workplans. When these data are not to be collected under Regulation (EC) No 1224/2009 or when data collected under Regulation (EC) No 1224/2009 are not at the correct resolution or are not of sufficient quality or coverage for the intended scientific use, they shall be collected in an alternative way by using appropriate sampling methods. These methods shall allow for the estimation of variables listed in Table 4 at the lowest relevant geographic level by fleet segment (Table 5a) and metier level 6 (Table 2).

5. **Social and economic data on fisheries to enable the assessment of the social and economic performance of the Union fisheries sector.**

Such data shall consist of the following:

(a) Economic variables as indicated in Table 5A according to the sector segmentation of Table 5B and according to the supraregions as defined in Table 5C.

The population shall be all active and inactive vessels registered in the Union Fishing Fleet Register as defined in Commission Regulation (EC) No 26/2004 [10] on December 31st of the reporting year and vessels that do not appear on the Register at that date but have fished at least one day during the reporting year

For inactive vessels only capital value and capital cost shall be collected.

In cases where there is a risk of natural persons and/or legal entities being identified clustering may be applied to report economic variables in order to ensure statistical confidentiality. Clustering may also be used if necessary to design a statistically sound sampling plan. Such clustering scheme shall be consistent over time.

Economic data shall be collected on an annual basis.

(b) Social variables as indicated in Table 6.

Social data shall be collected every three years starting in 2018.

Data on employment by education level and employment by nationality may be collected on the basis of pilot studies.

6. **Social, economic and environmental data on marine aquaculture, and optionally on freshwater aquaculture, to enable the assessment of the social, economic and environmental performance of the Union aquaculture sector.**

Such data shall consist of the following:

(a) Economic variables as indicated in Table 7 according to the sector segmentation set out in Table 9.

The population shall be all enterprises whose primary activity is defined according to the European Classification of Economic Activities NACE [11] codes 03.21 and 03.22 and who operate for profit.

Economic data shall be collected on an annual basis.

[9] Including specific requirements for RFMOs such as specified in Regulation (EU) No 1343/2011 of the European Parliament and of the Council of 13 December 2011 on certain provisions for fishing in the GFCM (General Fisheries Commission for the Mediterranean) Agreement area and amending Council Regulation (EC) No 1967/2006 concerning management measures for the sustainable exploitation of fishery resources in the Mediterranean Sea (OJ L 347, 30.12.2011, p. 44).

[10] Commission Regulation (EC) No 26/2004 of 30 December 2003 on the Community fishing fleet register (OJ L 5, 9.1.2004, p. 25).

[11] Regulation (EC) No 1893/2006 of the European Parliament and of the Council of 20 December 2006 establishing the statistical classification of economic activities NACE Revision 2 and amending Council Regulation (EEC) No 3037/90 as well as certain EC Regulations on specific statistical domains (OJ L 393, 30.12.2006, p. 1).

(b) Social variables as indicated in Table 6.

Social data shall be collected every three years starting in 2018.

Data on employment by education level and employment by nationality may be collected on the basis of pilot studies.

(c) Environmental data on aquaculture as indicated in Table 8 to enable the assessment of aspects of its environmental performance.

Environmental data may be collected on the basis of pilot studies and extrapolated to indicate totals relevant to the total volume of fish produced in the Member State.

Environmental data shall be collected every two years.

BIOLOGICAL DATA

Table 1A ([1])

Stocks in Union waters

Species (common name)	Species (scientific name)	Area (ICES ([2]), IBSFC ([3]) or FAO ([4]) area code) where the stock is located/stock code
East Arctic, Norwegian sea and Barentsz sea		
European Eel	*Anguilla anguilla*	I, II
Tusk	*Brosme brosme*	I, II
Atlanto-Scandian herring	*Clupea harengus*	I, II,
Cod	*Gadus morhua*	I, II
Capelin	*Mallotus villosus*	I, II
Haddock	*Melanogrammus aeglefinus*	I, II
Blue whiting	*Micromesistius poutassou*	I-II
Northern shrimp	*Pandalus borealis*	I, II
Saithe	*Pollachius virens*	I, II
Greenland halibut	*Reinhardtius hippoglossoides*	I, II
Salmon	*Salmo salar*	I, II
Mackerel	*Scomber scombrus*	II,
Golden Redfish	*Sebastes marinus*	I, II
Deep sea Redfish	*Sebastes mentella*	I, II
Horse mackerel	*Trachurus trachurus*	IIa,
Skagerrak and Kattegat		
Sand eel	*Ammodytidae*	IIIa
European Eel	*Anguilla anguilla*	IIIa
Herring	*Clupea harengus*	IIIa/22-24, IIIa
Roundnose grenadier	*Coryphaenoides rupestris*	IIIa

Species (common name)	Species (scientific name)	Area (ICES [2]), IBSFC [3]) or FAO [4]) area code) where the stock is located/stock code
Grey gurnard	*Eutrigla gurnardus*	IIIa
Red gurnard	*Aspitrigla cuculus*	IIIa,
Cod	*Gadus morhua*	IIIaN
Cod	*Gadus morhua*	IIIaS
Witch flounder	*Glyptocephalus cynoglossus*	IIIa
Dab	*Limanda limanda*	IIIa
Haddock	*Melanogrammus aeglefinus*	IIIa
Whiting	*Merlangius merlangus*	IIIa
Hake	*Merluccius merluccius*	IIIa,
Blue whiting	*Micromesistius poutassou*	IIIa
Norway lobster	*Nephrops norvegicus*	Functional unit
Northern shrimp	*Pandalus borealis*	IIIa
Plaice	*Pleuronectes platessa*	IIIa
Saithe	*Pollachius virens*	IIIa
Salmon	*Salmo salar*	IIIa
Turbot	*Psetta maxima*	IIIa
Mackerel	*Scomber scombrus*	IIIa
Brill	*Scophthalmus rhombus*	IIIa
Sole	*Solea solea*	IIIa
Sprat	*Sprattus sprattus*	IIIa
Norway pout	*Trisopterus esmarki*	IIIa
All commercial Sharks, rays & skates [5])	*Selachii, Rajidae*	IIIa
Baltic Sea —		
European Eel	*Anguilla anguilla*	22-32
Herring	*Clupea harengus*	22-24/25-29, 32/30/31/Gulf of Riga
Common Whitefish/houting	*Coregonus lavaretus*	IIId
Vendace	*Coregonus albula*	22-32
Cod	*Gadus morhua*	22-24/25-32
Dab	*Limanda limanda*	22-32
Perch	*Perca fluviatilis*	IIId

Species (common name)	Species (scientific name)	Area (ICES [2]), IBSFC [3]) or FAO [4]) area code) where the stock is located/stock code
Flounder	*Platichtys flesus*	22-32
Plaice	*Pleuronectes platessa*	22-32
Turbot	*Psetta maxima*	22-32
Salmon	*Salmo salar*	22-31/32
Sea trout	*Salmo trutta*	22-32
Pike-perch	*Sander lucioperca*	IIId
Brill	*Scophthalmus rhombus*	22-32
Sole	*Solea solea*	22
Sprat	*Sprattus sprattus*	22-32
North Sea and Eastern Channel		
Sand eel	*Ammodytidae*	IV
Catfish	*Anarhichas* spp.	IV
European Eel	*Anguilla anguilla*	IV, VIId
Argentine	*Argentina* spp.	IV
Grey gurnard	*Eutrigla gurnardus*	IV
Tusk	*Brosme brosme*	IV
Herring	*Clupea harengus*	IV, VIId
Common Shrimp	*Crangon crangon*	IV, VIId
Sea bass	*Dicentrarchus labrax*	IV, VIId
Grey gurnard	*Eutrigla gurnardus*	IV
Cod	*Gadus morhua*	IV, VIId
Witch flounder	*Glyptocephalus cynoglossus*	IV
Blue-mouth rockfish	*Helicolenus dactylopterus*	IV
Four-spot megrim	*Lepidorhombus boscii*	IV, VIId
Megrim	*Lepidorhombus whiffiagonis*	IV, VIId
Dab	*Limanda limanda*	IV, VIId
Black-bellied angler	*Lophius budegassa*	IV, VIId
Anglerfish	*Lophius piscatorius*	IV
Roughhead grenadier	*Macrourus berglax*	IV
Haddock	*Melanogrammus aeglefinus*	IV

Species (common name)	Species (scientific name)	Area (ICES [2]), IBSFC [3]) or FAO [4]) area code) where the stock is located/stock code
Whiting	*Merlangius merlangus*	IV, VIId
Hake	*Merluccius merluccius*	IV VII
Blue whiting	*Micromesistius poutassou*	IV, VIId
Lemon sole	*Microstomus kitt*	IV, VIId
Blue ling	*Molva dypterygia*	IV
Ling	*Molva molva*	IV
Red mullet	*Mullus barbatus*	IV, VIId
Striped red mullet	*Mullus surmuletus*	IV, VIId
Norway lobster	*Nephrops norvegicus*	all functional units
Northern shrimp	*Pandalus borealis*	IVa East/IVa/IV
Common scallop	*Pecten maximus*	VIId
Greater Forkbeard	*Phycis blennoides*	IV
Forkbeard	*Phycis phycis*	IV
Flounder	*Platichthys flesus*	IV
Plaice	*Pleuronectes platessa*	IV
Plaice	*Pleuronectes platessa*	VIId
Saithe	*Pollachius virens*	IV
Turbot	*Psetta maxima*	IV, VIId
Greenland halibut	*Reinhardtius hippoglossoides*	IV
Salmon	*Salmo salar*	IV, VIId
Mackerel	*Scomber scombrus*	IV, VIId
Brill	*Scophthalmus rhombus*	IV, VIId
Redfish	*Sebastes mentella.*	IV
Sole	*Solea solea*	IV
Sole	*Solea solea*	VIId
Sprat	*Sprattus sprattus*	IV/VIId
Horse mackerel	*Trachurus trachurus.*	IV, VIId
Tub gurnard	*Trigla lucerna*	IV
Norway pout	*Trisopterus esmarki*	IV
John Dory	*Zeus faber*	IV, VIId

Species (common name)	Species (scientific name)	Area (ICES [2]), IBSFC [3]) or FAO [4]) area code) where the stock is located/stock code
All commercial Sharks, rays & skates [5])	*Selachii, Rajidae*	IV, VIId
North East Atlantic and Western Channel		
Smoothhead	*Alepocephalus bairdii*	VI, XII
Sand eel	*Ammodytidae*	VIa
Boarfish	*Capros aper*	V, VI,VII
Scallop	*Pecten maximus*	IV, VI, VII
Queen scallop	*Aequipecten opercularis*	VII
Spider crab	*Maja squinado*	V, VI,VII
European Eel	*Anguilla anguilla*	all areas
Scabbardfish	*Aphanopus* spp.	all areas
Argentine	*Argentina* spp.	all areas
Meagre	*Argyrosomus regius*	all areas
Red gurnard	*Aspitrigla cuculus*	all areas
Alfonsinos	*Beryx* spp.	all areas, excluding X and IXa
Alfonsinos	*Beryx* spp.	IXa and X
Edible crab	*Cancer pagurus*	all areas
Herring	*Clupea harengus*	VIa/VIaN/ VIa S, VIIbc/VIIa/VIIj
Conger	*Conger conger*	all areas, excluding X
Conger	*Conger conger*	X
Roundnose grenadier	*Coryphaenoides rupestris*	all areas
Kitefin shark	*Dalatias licha*	All areas
Common stingray	*Dasyatis pastinaca*	VII, VIII
Birdbeak dogfish	*Deania calcea*	V, VI, VII, IX, X, XII
Sea bass	*Dicentrarchus labrax*	all areas, excluding IX
Sea bass	*Dicentrarchus labrax*	IX
Wedge sole	*Dicologlossa cuneata*	VIIIc, IX
Anchovy	*Engraulis encrasicolus*	IXa (only Cádiz)
Anchovy	*Engraulis encrasicolus*	VIII

Species (common name)	Species (scientific name)	Area (ICES [2]), IBSFC [3]) or FAO [4]) area code) where the stock is located/stock code
Velvet belly	*Etmopterus spinax*	VI, VII, VIII
Grey gurnard	*Eutrigla gurnardus*	VIId,e
Cod	*Gadus morhua*	Va/Vb/VIa/VIb/VIIa/VIIe-k
Witch	*Glyptocephalus cynoglossus*	VI, VII
Bluemouth rockfish	*Helicolenus dactylopterus*	all areas
Lobster	*Homarus gammarus*	all areas
Orange roughy	*Hoplostethus atlanticus*	all areas
Silver scabbardfish	*Lepidopus caudatus*	IXa
Four-spot megrim	*Lepidorhombus boscii*	VIIIc, IXa
Megrim	*Lepidorhombus whiffiagonis*	VI/VII, VIIIabd/VIIIc, IXa
Dab	*Limanda limanda*	VIIe/VIIa,f-h
Common squid	*Loligo vulgaris*	all areas, excluding VIIIc, IXa
Common squid	*Loligo vulgaris*	VIIIc, IXa
Black-bellied angler	*Lophius budegassa*	IV, VI/VIIb-k, VIIIabd
Black-bellied angler	*Lophius budegassa*	VIIIc, IXa
Anglerfish	*Lophius piscatorious*	IV, VI/VIIb-k, VIIIabd
Anglerfish	*Lophius piscatorious*	VIIIc, IXa
Capelin	*Mallotus villosus*	XIV
Haddock	*Melanogrammus aeglefinus*	Va/Vb
Haddock	*Melanogrammus aeglefinus*	VIa/VIb/VIIa/VIIb-k
Whiting	*Merlangius merlangus*	VIII/IX, X
Whiting	*Merlangius merlangus*	Vb/VIa/VIb/VIIa/VIIe-k
Hake	*Merluccius merluccius*	IIIa, IV, VI, VII, VIIIab/VIIIc, IXa
Wedge sole	*Microchirus variegatus*	all areas
Blue whiting	*Micromesistius poutassou*	I-IX, XII, XIV
Lemon sole	*Microstomus kitt*	all areas
Blue ling	*Molva dypterygia*	all areas, excluding X
Spanish ling	*Molva macrophthalma*	X
Ling	*Molva molva*	all areas
Striped red mullet	*Mullus surmuletus*	all areas

Species (common name)	Species (scientific name)	Area (ICES [2]), IBSFC [3]) or FAO [4]) area code) where the stock is located/stock code
Starry smooth-hound	*Mustelus asterias*	VI, VII, VIII, IX
Smooth-hound	*Mustelus mustelus*	VI, VII, VIII, IX
Blackspotted smooth-hound	*Mustelus punctulatus*	VI, VII, VIII, IX
Norway lobster	*Nephrops norvegicus*	VI Fuctional unit
Norway lobster	*Nephrops norvegicus*	VII Functional unit
Norway lobster	*Nephrops norvegicus*	VIII, IX Functional unit
Common octopus	*Octopus vulgaris*	all areas, excluding VIIIc, IXa
Common octopus	*Octopus vulgaris*	VIIIc, IXa
Blackspot sea bream	*Pagellus bogaraveo*	IXa, X
Pandalid shrimps	*Pandalus* spp.	all areas
Deepwater rose shrimp	*Parapenaeus longirostris*	IXa
Greater Forkbeard	*Phycis blennoides*	all areas
Forkbeard	*Phycis phycis*	all areas
Plaice	*Pleuronectes platessa*	VIIa/VIIe/VIIfg
Plaice	*Pleuronectes platessa*	VIIbc/VIIh-k/VIII, IX, X
Pollack	*Pollachius pollachius*	all areas except IX, X
Pollack	*Pollachius pollachius*	IX, X
Saithe	*Pollachius virens*	Va/Vb/IV, IIIa, VI
Saithe	*Pollachius virens*	VII, VIII
Wreckfish	*Polyprion americanus*	X
Turbot	*Psetta maxima*	all areas
Greenland halibut	*Reinhardtius hippoglossoides*	V, XIV/VI
Atlantic halibut	*Hippoglossus hippoglossus*	V, XIV
Salmon	*Salmo salar*	all areas
Sardine	*Sardina pilchardus*	VIIIabd/VIIIc, IXa
Spanish mackerel	*Scomber colias*	VIII, IX, X
Mackerel	*Scomber scombrus*	II, IIIa, IV, V, VI, VII, VIII, IX
Brill	*Scophthalmus rhombus*	all areas
Golden Redfish	*Sebastes marinus*	ICES Sub areas V, VI, XII, XIV & NAFO SA 2 + (Div. 1F + 3K).

Species (common name)	Species (scientific name)	Area (ICES [2]), IBSFC [3]) or FAO [4]) area code) where the stock is located/stock code
Deep sea Redfish	*Sebastes mentella*	ICES Sub areas V, VI, XII, XIV & NAFO SA 2 + (Div. 1F + 3K)
Cuttlefish	*Sepia officinalis*	all areas
Sole	*Solea solea*	VIIa/VIIfg
Sole	*Solea solea*	VIIbc/VIIhjk/IXa/VIIIc
Sole	*Solea solea*	VIIe
Sole	*Solea solea*	VIIIab
Sea breams (in plural)	*Sparidae*	all areas
Mediterranean horse mackerel	*Trachurus mediterraneus*	VIII, IX
Blue jack mackerel	*Trachurus picturatus*	VIII, IX, X
Horse mackerel	*Trachurus trachurus*	IIa, IVa, Vb, VIa, VIIa-c, e-k, VIIIabde/X
Horse mackerel	*Trachurus trachurus*	VIIIc, IXa
Pouting	*Trisopterus* spp.	all areas
John Dory	*Zeus faber*	all areas
All commercial Sharks, rays & skates [5])	*Selachii, Rajidae*	IV, VIId
Mediterranean Sea and Black Sea		
European Eel	*Anguilla anguilla*	all areas in the Med
Giant red shrimp	*Aristeomorpha foliacea*	all areas in the Med
Red shrimp	*Aristeus antennatus*	all areas in the Med
Bogue	*Boops boops*	1.3, 2.1, 2.2, 3.1, 3.2
Dolphinfish	*Coryphaena equiselis*	all areas in the Med
Dolphinfish	*Coryphaena hippurus*	all areas in the Med
Sea bass	*Dicentrarchus labrax*	all areas in the Med
Horned/curled octopus	*Eledone cirrhosa*	1.1, 1.3, 2.1, 2.2, 3.1
Musky octopus	*Eledone moschata*	1.3, 2.1, 2.2, 3.1
Anchovy	*Engraulis encrasicolus*	all areas in the Med
Anchovy	*Engraulis encrasicolus*	Black Sea GSA 29
Grey gurnard	*Eutrigla gurnardus*	2.2, 3.1

Species (common name)	Species (scientific name)	Area (ICES [2]), IBSFC [3]) or FAO [4]) area code) where the stock is located/stock code
Squid	*Illex* spp., *Todarodes* spp.	all areas in the Med
Billfish	*Istiophoridae*	all areas in the Med
Common squid	*Loligo vulgaris*	all areas in the Med
Black-bellied angler	*Lophius budegassa*	1.1, 1.2, 1.3, 2.2, 3.1
Anglerfish	*Lophius piscatorius*	1.1, 1.2, 1.3, 2.2, 3.1
Whiting	*Merlangius merlangus*	Black Sea GSA 29
Hake	*Merluccius merluccius*	all areas in the Med
Blue whiting	*Micromesistius poutassou*	1.1, 3.1
Grey mullets	*Mugilidae*	1.3, 2.1, 2.2, 3.1
Red mullet	*Mullus barbatus*	all areas in the Med
Red mullet	*Mullus barbatus*	Black Sea GSA 29
Striped red mullet	*Mullus surmuletus*	all areas in the Med
Common octopus	*Octopus vulgaris*	all areas in the Med
Norway lobster	*Nephrops norvegicus*	all areas in the Med
Pandora	*Pagellus erythrinus*	all areas in the Med
Deepwater rose shrimp	*Parapenaeus longirostris*	all areas in the Med
Caramote prawn	*Penaeus kerathurus*	3.1
Turbot	*Psetta maxima*	Black Sea GSA 29
Sardine	*Sardina pilchardus*	all areas in the Med
Mackerel	*Scomber* spp.	all areas in the Med
Cuttlefish	*Sepia officinalis*	all areas in the Med
Sole	*Solea vulgaris*	1.2, 2.1, 3.1
Gilthead sea bream	*Sparus aurata*	1.2, 3.1
Picarels	*Spicara smaris*	2.1, 3.1, 3.2
Sprat	*Sprattus sprattus*	Black Sea GSA 29
Mantis shrimp	*Squilla mantis*	1.3, 2.1, 2.2
Mediterranean horse mackerel	*Trachurus mediterraneus*	All areas in the Med
Mediterranean horse mackerel	*Trachurus mediterraneus*	Black Sea GSA 29
Horse mackerel	*Trachurus trachurus*	all areas in the Med

Species (common name)	Species (scientific name)	Area (ICES [2], IBSFC [3] or FAO [4] area code) where the stock is located/stock code
Horse mackerel	*Trachurus trachurus*	Black Sea GSA 29
Tub gurnard	*Trigla lucerna*	1.3, 2.2, 3.1
Clam	*Veneridae*	2.1, 2.2
Transparent gobid	*Aphia minuta*	GSA 9, 10, 16 and 19
Sand smelt	*Atherina* spp.	GSA 9, 10, 16 and 19
Poor cod	*Trisopterus minutus*	All Regions
All commercial Sharks, rays & skates [5]	*Selachii, Rajidae*	All Regions

[1] This Table replaces Table 1A of Implementing Decision (EU) 2016/1251.
[2] International Council for the Exploration of the Sea.
[3] International Baltic Sea Fisheries Commission.
[4] Food and Agricultural Organisation of the United Nations.
[5] To be reported at species level.

BIOLOGICAL DATA

Table 1B [1]

Stocks of Outermost Regions of the Union

Species (common name)	Species (scientific name)
French Guyana	
Red snapper	*Lutjanus purpureus*
Prawns	*Farfantepenaeus subtilis*
Acoupa weakfish	*Cynoscion acoupa*
Smalltooth weakfish	*Cynoscion steindachneri*
Green weakfish	*Cynoscion virescens*
Sea catfishes	*Ariidae*
Tripletail	*Lobotes surinamensis*
Torroto grunt	*Genyatremus luteus*
Snooks	*Centropomus* spp.
Groupers	*Serranidae*
Mullets	*Mugil* spp.
Guadeloupe and Martinique	
Snappers	*Lutjanidae*
Grunters	*Haemulidae*

Species (common name)	Species (scientific name)
Groupers	*Serranidae*
Lion fish	*Pterois volitans*
Tuna-like fish	*Scombridae*
Blue marlin	*Makaira nigricans*
Dolphinfish	*Coryphaena hippurus*
Reunion Island and Mayotte	
Snappers	*Lutjanidae*
Groupers	*Serranidae*
Tuna-like fish	*Scombridae*
Swordfish	*Xiphias gladius*
Other bill fishes	*Istiophoridae*
Dolphinfish	*Coryphaena hippurus*
Bigeye scad	*Selar crumenophthalmus*
Azores, Madeira and Canary Islands	
Atlantic chub mackerel	*Scomber colias*
Sardinella	*Sardinella maderensis*
Horse mackerel	*Trachurus* spp.
Sardine	*Sardina pilchardus*
Parrotfish	*Sparisoma cretense*
Limpets	*Patellidae*

(1) This Table replaces Table 1B of Implementing Decision (EU) 2016/1251.

BIOLOGICAL DATA

Table 1C (1)

Stocks in marine regions under Regional fisheries management organisations (RFMOs) and Sustainable Fishing Partnership Agreements (SFPAs)

IATTC (Inter-American Tropical Tuna Commission)

SPECIES When designing sampling plans aiming at collecting biological information as laid down in Chapter III of this Annex, stock boundaries, as fixed by the competent RFMOs or Regional fisheries organisations (RFOs), shall be taken into account and appropriate sampling effort shall be allocated to each stock.				Frequency of Collection of Biological variables
Scientific name	Common name	Geographical Area	Priority	The data collection is annual and the updating/processing of the data must be done timely to fit the schedule of the stock assessments.
Thunnus albacares	Yellowfin tuna	East Pacific Ocean	High	
Thunnus obesus	Bigeye tuna	East Pacific Ocean	High	

SPECIES When designing sampling plans aiming at collecting biological information as laid down in Chapter III of this Annex, stock boundaries, as fixed by the competent RFMOs or Regional fisheries organisations (RFOs), shall be taken into account and appropriate sampling effort shall be allocated to each stock.				Frequency of Collection of Biological variables
Katsuwonus pelamis	Skipjack tuna	East Pacific Ocean	High	
Thunnus alalunga	Albacore tuna	East Pacific Ocean	High	
Thunnus orientalis	Pacific bluefin tuna	East Pacific Ocean	High	
Xiphias gladius	Swordfish	East Pacific Ocean	High	
Makaira nigricans (or mazara)	Blue marlin	East Pacific Ocean	High	
Makaira indica	Black marlin	East Pacific Ocean	High	
Tetrapturus audax	Striped marlin	East Pacific Ocean	High	

ICCAT (The International Commission for the Conservation of Atlantic Tunas)

SPECIES When designing sampling plans aiming at collecting biological information as laid down in Chapter III of this Annex, stock boundaries, as fixed by the competent RFMOs or RFOs, shall be taken into account and appropriate sampling effort shall be allocated to each stock.				Frequency of Collection of Biological variables
Scientific name	Common name	Geographical Area	Priority	The data collection is annual and the updating/processing of the data must be done timely to fit the schedule of the stock assessments.
Thunnus albacares	Yellowfin tuna	Atlantic Oceanand adjacent seas	High	
Thunnus obesus	Bigeye tuna	Atlantic Oceanand adjacent seas	High	
Katsuwonus pelamis	Skipjack tuna	Atlantic Oceanand adjacent seas	High	
Thunnus alalunga	Albacore tuna	Atlantic Oceanand adjacent seas	High	
Thunnus thynnus	Bluefin tuna	Atlantic Oceanand adjacent seas	High	
Xiphias gladius	Swordfish	Atlantic Oceanand adjacent seas	High	
Makaira nigricans (or mazara)	Blue marlin	Atlantic Oceanand adjacent seas	High	
Istiophorus albicans	Sailfish	Atlantic Oceanand adjacent seas	High	

SPECIES When designing sampling plans aiming at collecting biological information as laid down in Chapter III of this Annex, stock boundaries, as fixed by the competent RFMOs or RFOs, shall be taken into account and appropriate sampling effort shall be allocated to each stock.				Frequency of Collection of Biological variables
Tetrapturus albidus	White marlin	Atlantic Oceanand adjacent seas	High	
Prionace glauca	Blue shark	Atlantic Oceanandadjacent seas	High	
Auxis rochei	Bullet tuna	Atlantic Oceanandadjacent seas	High	
Sarda sarda	Atlantic bonito	Atlantic Oceanandadjacent seas	High	
Euthynnus alleteratus	Atlantic back skipjack	Atlantic Oceanandadjacent seas	Medium	
Thunnus atlanticus	Blackfin tuna	Atlantic Ocean and adjacent seas	Medium	
Orcynopsis unicolor	Plain bonito	Atlantic Ocean and adjacent seas	Medium	
Scomberomorus brasiliensis	Serra Spanish mackerel	Atlantic Ocean and adjacent seas	Medium	
Scomberomorus regalis	Cero	Atlantic Ocean and adjacent seas	Medium	
Auxis thazard	Frigate tuna	Atlantic Ocean and adjacent seas	Medium	
Scomberomorus cavalla	King mackerel	Atlantic Ocean and adjacent seas	Medium	
Scomberomorus tritor	West African Spanish mackerel	Atlantic Ocean and adjacent seas	Medium	
Scomberomorus maculatus	Atlantic Spanish mackerel	Atlantic Ocean and adjacent seas	Medium	
Acanthocybium solandri	Wahoo	Atlantic Ocean and adjacent seas	Medium	
Coryphaena hippurus	Dolphinfish	Atlantic Ocean and adjacent seas	Medium	

NAFO (North Atlantic Fisheries Organisation)

SPECIES When designing sampling plans aiming at collecting biological information as laid down in Chapter III of this Annex, stock boundaries, as fixed by the competent RFMOs or RFOs, shall be taken into account and appropriate sampling effort shall be allocated to each stock.				Frequency of Collection of Biological variables
Scientific name	Common name	Stocks as defined by the RFMO	Priority	The data collection is annual and the updating/processing of the data must be done timely to fit the schedule of the stock assessments.
Gadus morhua	Cod	NAFO 2J 3KL	Low	
Gadus morhua	Cod	NAFO 3M	High	

SPECIES When designing sampling plans aiming at collecting biological information as laid down in Chapter III of this Annex, stock boundaries, as fixed by the competent RFMOs or RFOs, shall be taken into account and appropriate sampling effort shall be allocated to each stock.				Frequency of Collection of Biological variables
Gadus morhua	Cod	NAFO 3NO	High	
Gadus morhua	Cod	NAFO 3Ps	High	
Gadus morhua	Cod	NAFO SA1	High	
Glyptocephalus cynoglossus	Witch flounder	NAFO 3NO	High	
Glyptocephalus cynoglossus	Witch flounder	NAFO 2J3KL	Low	
Hippoglossoides platessoides	American plaice	NAFO 3LNO	High	
Hippoglossoides platessoides	American plaice	NAFO 3M	High	
Limanda ferruginea	Yellowtail flounder	NAFO 3LNO	Medium	
Coryphaenoides rupestris	Roundnose Grenadier	NAFO SA0 + 1	Low	
Macrourus berglax	Roughhead grenadier	NAFO SA2 + 3	High	
Pandalus borealis	Northern shrimp	NAFO 3LNO	High	
Pandalus borealis	Northern shrimp	NAFO 3M	High	
Amblyraja radiata	Thorny skate	NAFO 3LNOPs	High	
Reinhardtius hippoglossoides	Greenland halibut	NAFO 3KLMNO	High	
Reinhardtius hippoglossoides	Greenland halibut	NAFO SA1	High	
Hippoglossus hippoglossus	Atlantic halibut	NAFO SA1	Low	
Sebastes mentella	Redfish	NAFO SA1	High	
Sebastes spp.	Redfish	NAFO 3LN	High	
Sebastes spp.	Redfish	NAFO 3M	High	
Sebastes spp.	Redfish	NAFO 3O	High	
Urophycis tenuis	White hake	NAFO 3NO	High	
Mallotus villosus	Capelin	NAFO 3NO	High	
Beryx sp.	Alfonsinos	NAFO 6G	High	
Illex illecebrosus	Shortfin squid	NAFO Subareas 3 + 4	Low	
Salmo salar	Salmon	NAFO S1+ ICES Subarea XIV, NEAF, NASCO	High	

FAO marine area 34- Fisheries Committee for the Eastern Central Atlantic (CECAF)

SPECIES When designing sampling plans aiming at collecting biological information as laid down in chapter III of this Annex, stock boundaries, as fixed by the competent RFMOs or RFOs, shall be taken into account and appropriate sampling effort shall be allocated to each stock.				Frequency of Collection of Biological variables
Scientific name	Common name	Geographical Area	Priority	
Brachydeuterus spp.	Grunt	34.1.3, 34.3.1, 34.3.3-6	high	The data collection is annual and the updating/processing of the data shall be done timely to fit the schedule of the stock assessments.
Caranx spp.	Jack	34.3.1, 34.3.3-6	high	
Cynoglossus spp.	Tongue sole	34.1.1, 34.1.3, 34.3.1, 34.3.3-6	high	
Decapterus spp.	Scad	34.3.1, 34.3.3-6	high	
Dentex canariensis	Canary dentex	34.1.1, 34.1.3, 34.3.1, 34.3.3-6	medium	
Dentex congoensis	Congo dentex	34.1.1, 34.1.3, 34.3.1, 34.3.3-6.	medium	
Dentex macrophthalmus	Large-eye dentex	34.1.1, 34.1.3, 34.3.1, 34.3.3-6.	high	
Dentex maroccanus	Morocco dentex	34.1.1, 34.1.3, 34.3.1, 34.3.3-6.	medium	
Dentex spp.	Dentex	34.1.1, 34.1.3, 34.3.1, 34.3.3-6.	high	
Engraulis encrasicolus	Anchovy	34.1.1, 34.1.3, 34.3.1, 34.3.3-6.	high	
Epinephelus aeneus	White grouper	34.1.3, 34.3.1, 34.3.3-6	high	
Ethmalosa fimbriata	Bonga shad	34.3.1, 34.3.3-6	high	
Farfantepenaeus notialis	Southern pink shrimp	34.1.1, 34.1.3, 34.3.1, 34.3.3-6	high	
Galeoides decadactylus	Lesser African threadfin	34.1.3, 34.3.1, 34.3.3-6	high	The data collection is annual and the updating/processing of the data shall be done timely to fit the schedule of the stock assessments.
Loligo vulgaris	Common squid	34.1.1, 34.1.3, 34.3.1, 34.3.3-6	high	
Merluccius polli	Benguela hake	34.1.1, 34.1.3, 34.3.1, 34.3.3-6	high	
Merluccius senegalensis	Senegalese hake	34.1.1, 34.1.3, 34.3.1, 34.3.3-6	high	
Merluccius spp.	Other hake	34.1.1, 34.1.3, 34.3.1, 34.3.3-6	medium	

SPECIES When designing sampling plans aiming at collecting biological information as laid down in chapter III of this Annex, stock boundaries, as fixed by the competent RFMOs or RFOs, shall be taken into account and appropriate sampling effort shall be allocated to each stock.				Frequency of Collection of Biological variables
Octopus vulgaris	Common octopus	34.1.1, 34.1.3, 34.3.1, 34.3.3-6.	high	
Pagellus acarne	axillary sea bream	34.1.1	high	
Pagellus bellottii	Red pandora	34.1.1, 34.1.3, 34.3.1, 34.3.3-6	high	
Pagellus bogaraveo	Blackspot sea bream	34.1.1	medium	
Pagellus spp.	Pandora	34.1.1, 34.1.3, 34.3.1, 34.3.3-6	high	
Pagrus caeruleostictus	Blue spotted sea bream	34.1.1, 34.1.3, 34.3.1, 34.3.3-6	high	
Parapenaeus longirostris	Deepwater rose shrimp	34.1.1, 34.1.3, 34.3.1, 34.3.3-6	high	
Pomadasys incisus	Bastard grunt	34.1.1	medium	
Pomadasys spp.	Grunt	34.1.1, 34.1.3, 34.3.1, 34.3.3-6	high	
Pseudotolithus spp.	West African croakers	34.1.1	high	
Sardina pilchardus	Sardine	34.1.1, 34.1.3	high	
Sardinella aurita	Round sardinella	34.1.1, 34.1.3, 34.3.1, 34.3.3-6	high	
Sardinella maderensis	Short-body sardinella	34.1.1, 34.1.3, 34.3.1, 34.3.3-6	high	The data collection is annual and the updating/processing of the data shall be done timely to fit the schedule of the stock assessments.
Scomber japonicus	Chub mackerel	34.1.1, 34.1.3, 34.3.1, 34.3.3-6	high	
Scomber spp.	Other Mackerel	34.1.1, 34.1.3, 34.3.1, 34.3.3-6	high	
Sepia hierredda	Cuttlefish	34.1.1, 34.1.3, 34.3.1, 34.3.3-6	high	
Sepia officinalis	Common cuttlefish	34.1.1, 34.1.3, 34.3.1, 34.3.3-6.	high	
Sepia spp.	cuttlefishes	34.1.1, 34.1.3, 34.3.1, 34.3.3-6	medium	
Sparidae	Sea bream	34.1.1, 34.1.3, 34.3.1, 34.3.3-6	high	
Sparus spp.	Sea bream	34.1.1	high	
Trachurus trachurus	Atlantic horse mackerel	34.1.1, 34.1.3, 34.3.1, 34.3.3-6	high	
Trachurus trecae	Cunene horse mackerel	34.1.1, 34.1.3, 34.3.1, 34.3.3-6	high	
Umbrina canariensis	Canary drum	34.3.3-6	medium	

SEAFO (South East Atlantic Fisheries Organisation)

SPECIES When designing sampling plans aiming at collecting biological information as laid down in chapter III of this Annex, stock boundaries, as fixed by the competent RFMOs or RFOs, shall be taken into account and appropriate sampling effort shall be allocated to each stock.				Frequency of Collection of Biological variables
Scientific name	Common name	Geographical Area	Priority	
Dissostichus eleginoides	Patagonian toothfish	South East Atlantic	High	The data collection is annual and the updating/processing of the data shall be done timely to fit the schedule of the stock assessments.
Beryx spp.	Alfonsinos	South East Atlantic	High	
Chaceon spp.	Red/Golden crabs	South East Atlantic	High	
Pseudopentaceros richardsoni	Pelagic armourhead/Southern boarfish	South East Atlantic	High	
Helicolenus spp.	Blackbelly rosefishes	South East Atlantic	High	
Hoplostethus atlanticus	Orange roughy	South East Atlantic	High	
Trachurus spp.	Horse mackerel	South East Atlantic	High	
Scomber spp.	Mackerel	South East Atlantic	High	
Polyprion americanus	Wreckfish	South East Atlantic	Medium	
Jasus tristani	Tristan rock lobster	South East Atlantic	Medium	
Lepidotus caudatus	Silver scabbardfish	South East Atlantic	Medium	
Schedophilus ovalis	Imperial Blackfish	South East Atlantic	Low	
Schedophilus velaini	Violet warehou	South East Atlantic	Low	
Allocyttus verucossus	Oreo dories	South East Atlantic	Low	
Neocyttus romboidales		South East Atlantic		
Allocyttus guineensis		South East Atlantic		
Pseudocyttu smaculatus		South East Atlantic		

SPECIES When designing sampling plans aiming at collecting biological information as laid down in chapter III of this Annex, stock boundaries, as fixed by the competent RFMOs or RFOs, shall be taken into account and appropriate sampling effort shall be allocated to each stock.				Frequency of Collection of Biological variables
Emmelichthys nitidus	Cape Bonnetmouth	South East Atlantic	Low	
Ruvettus pretiosus	Oilfish	South East Atlantic	Low	
Promethichthys prometheus	Roudi escolar	South East Atlantic	Low	
Macrourus spp.	Grenadiers	South East Atlantic	Low	
Antimora rostrata	Blue antimora	South East Atlantic	Low	
Epigonus spp.	Cardinal fish	South East Atlantic	Low	
Merluccius spp.	Hake	South East Atlantic	Low	
Notopogon fernandezianus	Orange bellowfish	South East Atlantic	Low	
Octopodidae and Loliginidae	Octopus and squids	South East Atlantic	Low	

WCPFC (Western and Central Pacific Fisheries Commission)

SPECIES When designing sampling plans aiming at collecting biological information as laid down in Chapter III of this Annex, stock boundaries, as fixed by the competent RFMOs or RFOs, shall be taken into account and appropriate sampling effort shall be allocated to each stock.				Frequency of Collection of Biological variables
Scientific name	Common name	Geographical Area	Priority	The data collection is annual and the updating/processing of the data shall be done timely to fit the schedule of the stock assessments.
Thunnus albacares	Yellowfin tuna	West Central Pacific Ocean	High	
Thunnus obesus	Bigeye tuna	West Central Pacific Ocean	High	
Katsuwonus pelamis	Skipjack tuna	West Central Pacific Ocean	High	
Thunnus alalunga	Albacore tuna	West Central Pacific Ocean	High	
Thunnus orientalis	Pacific bluefin tuna	West Central Pacific Ocean	High	

SPECIES When designing sampling plans aiming at collecting biological information as laid down in Chapter III of this Annex, stock boundaries, as fixed by the competent RFMOs or RFOs, shall be taken into account and appropriate sampling effort shall be allocated to each stock.				Frequency of Collection of Biological variables
Xiphias gladius	Swordfish	West Central Pacific Ocean	High	
Makaira nigricans (or mazara)	Blue marlin	West Central Pacific Ocean	High	
Makaira indica	Black marlin	West Central Pacific Ocean	High	
Tetrapturus audax	Striped marlin	West Central Pacific Ocean	High	
Acanthocybium solandri	Wahoo	West Central Pacific Ocean	Medium	
Coryphaena hippurus	Dolphinfish	West Central Pacific Ocean	Medium	
Elagatis bipinnulata	Rainbow runner	West Central Pacific Ocean	Medium	
Lepidocybium flavobrunneum	Escolar	West Central Pacific Ocean	Medium	
Lampris regius	Moonfish (opah)	West Central Pacific Ocean	Medium	
Mola mola	Sunfish	West Central Pacific Ocean	Medium	
Istiophorus platypterus	Sailfish	West Central Pacific Ocean	Medium	
Tetrapturus angustirostris	Spearfish	West Central Pacific Ocean	Medium	
Ruvettus pretiosus	Oilfish	West Central Pacific Ocean	Medium	
Prionace glauca	Blue shark	West Central Pacific Ocean	High	
Carcharhinus longimanus	Oceanic whitetip shark	West Central Pacific Ocean	High	
Carcharhinus falciformis	Silky shark	West Central Pacific Ocean	High	
Alopias superciliosus	big eye thresher	West Central Pacific Ocean	High	

SPECIES When designing sampling plans aiming at collecting biological information as laid down in Chapter III of this Annex, stock boundaries, as fixed by the competent RFMOs or RFOs, shall be taken into account and appropriate sampling effort shall be allocated to each stock.				Frequency of Collection of Biological variables
Alopias vulpinus	Common thresher	West Central Pacific Ocean	High	
Alopias pelagicus	Pelagic thresher	West Central Pacific Ocean	High	

NB: for WCPF, the following reporting requirements for long liners shall be added:

(1) Number of branch lines between floats. The number of branch lines between floats shall be reported for each set.

(2) Number of fish caught per set, for the following species: albacore (Thunnus alalunga), bigeye (Thunnus obesus), skipjack (Katsuwonus pelamis), yellowfin (Thunnus albacares), striped marlin (Tetrapturus audax), blue marlin (Makaira mazara), black marlin (Makaira indica) and swordfish (Xiphias gladius), blue shark, silky shark, oceanic whitetip shark, mako sharks, thresher sharks, porbeagle shark (south of 20°S, until biological data shows this or another geographic limit to be appropriate), hammerhead sharks (winghead, scalloped, great, and smooth), whale shark, and other species as determined by the Commission.

If the total weight or average weight of fish caught per set has been recorded, then the total weight or average weight of fish caught per set, by species, shall also be reported. If the total weight or average weight of fish caught per set has not been recorded, then the total weight or average weight of fish caught per set, by species, shall be estimated and the estimates reported. The total weight or average weight shall refer to whole weights, rather than processed weights.

WECAFC (Western Central Atlantic Fishery Commission)

SPECIES When designing sampling plans aiming at collecting biological information as laid down in chapter III of this Annex, stock boundaries, as fixed by the competent RFMOs or RFOs, shall be taken into account and appropriate sampling effort shall be allocated to each stock.				Frequency of Collection of Biological variables
Scientific name	Common name	Geographical Area	Priority	The data collection is annual and the updating/processing of the data shall be done timely to fit the schedule of the stock assessments.
Panulirus argus	Caribbean Spiny Lobster	West Central Atlantic	High	
Strombus gigas	Queen Conch	West Central Atlantic	High	
Shark-like Selachii, Rajidae	Sharks, rays & skates	West Central Atlantic	High	
Coryphaena hippurus	Dolphin fish	West Central Atlantic	High	
Acanthocybium solandri	Wahoo	West Central Atlantic	High	
Epinephelus guttatus	Red Hind	West Central Atlantic	High	
Lutjanus vivanus	Silk snapper	West Central Atlantic	High	
Lutjanus buccanella	Blackfin snapper	West Central Atlantic	High	
Lutjanus campechanus	Red snapper	West Central Atlantic	High	
Penaeus subtilis	Penaeus shrimp	French Guiana EEZ	High	

IOTC (Indian Ocean Tuna Commission)

SPECIES When designing sampling plans aiming at collecting biological information as laid down in chapter III of this Annex, stock boundaries, as fixed by the competent RFMOs or RFOs, shall be taken into account and appropriate sampling effort shall be allocated to each stock.				Frequency of Collection of Biological variables
Scientific name	Common name	Geographical Area	Priority	
Thunnus albacares	Yellowfin tuna	Indian Ocean Western and Eastern	High	The data collection is annual and the updating/processing of the data shall be done timely to fit the schedule of the stock assessments.
Thunnus obesus	Bigeye tuna	Indian Ocean Western and Eastern	High	
Katsuwonus pelamis	Skipjack tuna	Indian Ocean Western and Eastern	High	
Thunnus alalunga	Albacore tuna	Indian Ocean Western and Eastern	High	
Xiphias gladius	Swordfish	Indian Ocean Western and Eastern	High	
Makaira nigricans (or mazara)	Blue marlin	Indian Ocean Western and Eastern	High	
Makaira indica	Black marlin	Indian Ocean Western and Eastern	High	
Tetrapturus audax	Striped marlin	Indian Ocean Western and Eastern	High	
Istiophorus platypterus	Indo-Pacific sailfish	Indian Ocean Western and Eastern	High	
Auxis rochei	Bullet tuna	Indian Ocean Western and Eastern	Medium	
Auxis thazard	Frigate tuna	Indian Ocean Western and Eastern	Medium	
Euthynnus affinis	Kawakawa	Indian Ocean Western and Eastern	Medium	
Thunnus tonggol	Longtail tuna	Indian Ocean Western and Eastern	Medium	
Scomberomorus guttatus	Indo-Pacific king mackerel	Indian Ocean Western and Eastern	Medium	
Scomberomorus commerson	Narrow-barred Spanish mackerel	Indian Ocean Western and Eastern	Medium	

SPECIES When designing sampling plans aiming at collecting biological information as laid down in chapter III of this Annex, stock boundaries, as fixed by the competent RFMOs or RFOs, shall be taken into account and appropriate sampling effort shall be allocated to each stock.				Frequency of Collection of Biological variables
Prionace glauca	Blue shark	Indian Ocean Western and Eastern	High	
Alopias superciliosus	Bigeye thresher shark	Indian Ocean Western and Eastern	High	
Carcharhinus falciformes	Silky shark	Indian Ocean Western and Eastern	High	
Carcharhinus longimanus	Oceanic whitetip shark	Indian Ocean Western and Eastern	High	
Alopias pelagicus	Pelagic thresher shark	Indian Ocean Western and Eastern	High	
Sphyrna lewini	Scalloped hammerhead shark	Indian Ocean Western and Eastern	High	

Other RFMOs

SPECIES When designing sampling plans aiming at collecting biological information as laid down in chapter III Annex, stock boundaries, as fixed by the competent RFMOs or RFOs, shall be taken into account and appropriate sampling effort shall be allocated to each stock.				Frequency of Collection of Biological variables
Scientific name	Common name	Geographical Area	Priority	The data collection is annual and the updating/processing of the data shall be done timely to fit the schedule of the stock assessments.
Trachurus murphyi	Jack mackerel	SPRFMO Convention Area	High	
Euphausia superba	Krill	CCAMLR Convention Area	High	
Dissostichus spp. *Dissostichus eleginoides and Dissostichus mawsoni)*	Toothfish	CCAMLR Convention Area	High	
Champsocephalus gunnari	Mackerel icefish	CCAMLR Convention Area	Low	
Resources of fish, molluscs, crustaceans and other sedentary species within the competence area, but excluding: (i) sedentary species subject to the fishery jurisdiction of coastal States pursuant to article 77(4) of the 1982 UN Convention on the Law of the Sea, and; (ii) highly migratory species listed in Annex I of the 1982 UN Convention on the Law of the Sea.		SIOFA Convention Area		

(1) This Table replaces Table 1C of Implementing Decision (EU) 2016/1251.

BIOLOGICAL DATA

Table 1D (1)

Species to be monitored under protection programmes in the Union or under international obligations

Common name	Scientific name	Region/RFMO	Legal framework
Bony fishes	Teleostei		
Sturgeons	*Acipenser* spp.	Mediterranean Sea and Black Sea; Baltic sea; OSPAR II, IV	Annex II of the Barcelona Convention (2), Annex IV of the Black Sea Biodiversity and Landscape Conservation Protocol; OSPAR (3); HELCOM (4)
Smoothheads (Slickheads)	*Alepocephalidae*	All Regions	Relevant for deep sea fisheries (5)
Baird's smoothhead	*Alepocephalus Bairdii*	All Regions	Relevant for deep sea fisheries
Risso's smoothhead	*Alepocephalus rostratus*	All Regions	Relevant for deep sea fisheries
Pontic shad	*Alosa immaculata*	Black Sea	Annex IV of the Black Sea Biodiversity and Landscape Conservation Protocol
Allis shad	*Alosa alosa*	OSPAR II, III, IV	OSPAR
Common Whitefish/houting	*Coregonus lavaretus*	OSPAR II	OSPAR
Cod	*Gadus morhua*	OSPAR II, III; Baltic Sea	OSPAR; Helcom
Long-snouted seahorse	Hippocampus guttulatus (synonym: Hippocampus ramulosus)	OSPAR II, III, IV, V	OSPAR
Short-snouted seahorse	Hippocampus hippocampus	OSPAR II, III, IV, V	OSPAR
Black Sea shad	*Alosa tanaica*	Black Sea	Annex IV of the Black Sea Biodiversity and Landscape Conservation Protocol
Blue antimora (Blue hake)	*Antimora rostrata*	All Regions	Relevant for deep sea fisheries
Black scabbardfish	*Aphanopus carbo*	All Regions	Relevant for deep sea fisheries
Scabbardfish	*Aphanopus intermedius*	All Regions	Relevant for deep sea fisheries
Crayfish	*Astacus* spp.	Black Sea	Annex IV of the Black Sea Biodiversity and Landscape Conservation Protocol
Big-scale sand smelt	*Atherina pontica*	Black Sea	Annex IV of the Black Sea Biodiversity and Landscape Conservation Protocol

Common name	Scientific name	Region/RFMO	Legal framework
Garfish	*Belone belone euxini Günther*	Black Sea	Annex IV of the Black Sea Biodiversity and Landscape Conservation Protocol
Alfonsinos	*Beryx* spp.	All Regions	Relevant for deep sea fisheries
Brotula	*Cataetyx laticeps*	All Regions	Relevant for deep sea fisheries
Vendace	*Coregonus albula*	Baltic Sea	RCG (Regional Coordination Group) Baltic recommendation
lumpfish	*Cyclopterus lumpus*	All Regions	Relevant for deep sea fisheries
Annular seabream	*Diplodus annularis*	Mediterranean Sea	Council Regulation (EC) No 1967/2006 ([6]) (min. cons. size)
Sharpsnout sea bream	*Diplodus puntazzo*	Mediterranean Sea	Regulation (EC) No 1967/2006 (min. cons. size)
White sea bream	*Diplodus sargus*	Mediterranean Sea	Regulation (EC) No 1967/2006 (min. cons. size)
Two-banded sea bream	*Diplodus vulgaris*	Mediterranean Sea	Regulation (EC) No 1967/2006 (min. cons. size)
Patagonian toothfish	*Dissostichus eleginoides*	All Regions	Relevant for deep sea fisheries
Antarctic toothfish	*Dissostichus mawsoni*	All Regions	Relevant for deep sea fisheries
Groupers	*Epinephelus* spp.	Mediterranean Sea	Regulation (EC) No 1967/2006 (min. cons. size)
Black cardinalfish	*Epigonus telescopus*	All Regions	Vulnerable species Relevant for deep sea fisheries
Gobies	*Gobiidae*	Black Sea	Annex IV of the Black Sea Biodiversity and Landscape Conservation Protocol
Bluemouth (Bluemouth redfish)	*Helicolenus dactylopterus*	All Regions	Relevant for deep sea fisheries
Atlantic halibut	*Hippoglossus hippoglossus*	All Regions	Relevant for deep sea fisheries
Orange roughy	*Hoplostethus atlanticus*	All Regions; OSPAR I, V	Vulnerable species Relevant for deep sea fisheries
Silver roughy (Pink)	*Hoplosthetus mediterraneus*	All Regions	Relevant for deep sea fisheries

Common name	Scientific name	Region/RFMO	Legal framework
Silver scabbard fish (Cutless fish)	*Lepidopus caudatus*	All Regions	Relevant for deep sea fisheries
Stripped sea bream	*Lithognathus mormyrus*	Mediterranean Sea	Regulation (EC) No 1967/2006 (min. cons. size)
Golden grey mullet	*Liza aurata*	Black Sea	Annex IV of the Black Sea Biodiversity and Landscape Conservation Protocol
Leaping mullet	*Liza saliens*	Black Sea	Annex IV of the Black Sea Biodiversity and Landscape Conservation Protocol
Greater Eelpout	*Lycodes esmarkii*	All Regions	Relevant for deep sea fisheries
Grenadiers (rattails) other than roundnose grenadier and roughhead grenadier	*Macrouridae other than Coryphaenoides rupestris and Macrourus berglax*	All Regions	Relevant for deep sea fisheries
Roughhead grenadier (Rough rattail)	*Macrourus berglax*	All Regions	Relevant for deep sea fisheries
Whiting	*Merlangius merlangus*	Baltic Sea and Black Sea	RCG Baltic recommendation; Annex IV of the Black Sea Biodiversity and Landscape Conservation Protocol
European eel	*Anguilla anguilla*	OSPAR I, II, III, IV, Baltic sea	OSPAR; HELCOM
Atlantic Salmon	*Salmo salar	OSPAR I, II, III, IV, Baltic Sea	OSPAR; HELCOM
Bluefin tuna	*Thunnus thynnus	OSPAR V	OSPAR; HELCOM
Blue ling	*Molva dypterygia*	All Regions	Relevant for deep sea fisheries
Common mora	*Mora moro*	All Regions	Relevant for deep sea fisheries
Mullet	*Mugil* spp.	Black Sea	Annex IV of the Black Sea Biodiversity and Landscape Conservation Protocol
Black gemfish	*Nesiarchus nasutus*	All Regions	Relevant for deep sea fisheries
Snubnosed spiny eel	*Notocanthus chemnitzii*	All Regions	Relevant for deep sea fisheries
Smelt	*Osmerus eperlanus*	Baltic Sea	RCG Baltic recommendation, HELCOM
Spanish sea bream	*Pagellus acarne*	Mediterranean Sea	Regulation (EC) No 1967/2006 (min. cons. size)
Blackspot seabream	*Pagellus bogaraveo*	Mediterranean Sea	Regulation (EC) No 1967/2006 (min. cons. size)
Common sea bream	*Pagrus pagrus*	Mediterranean Sea	Regulation (EC) No 1967/2006 (min. cons. size)

Common name	Scientific name	Region/RFMO	Legal framework
Wreckfish	*Polyprion americanus*	Mediterranean Sea	Regulation (EC) No 1967/2006 (min. cons. size)
Wreckfish	*Polyprion americanus*	All Regions	Relevant for deep sea fisheries
Bluefish	*Pomatomus saltatrix*	Black Sea	Annex IV of the Black Sea Biodiversity and Landscape Conservation Protocol
Small redfish (Norway redfish)	*Sebastes viviparus*	All Regions	Relevant for deep sea fisheries
Beluga	*Huso huso*	Black Sea	Annex IV of the Black Sea Biodiversity and Landscape Conservation Protocol
Spiny (deep sea) scorpionfish	*Trachyscorpia cristulata*	All Regions	Relevant for deep sea fisheries
Oceanic sea breams	*Brama* spp.	GSA 1.1, 1.2, 1.3 and Black Sea GSA 29	Annex VIII of Council Regulation (EC) No 894/97 ([7])
Atlantic chub mackerel	*Scomber colias Gmelin*	Black sea	Annex IV of the Black Sea Biodiversity and Landscape Conservation Protocol
Crystal gobid	*Crystallogobius linearis*	Black sea	National management plans
Rabbit fish	*Chimaera monstrosa*	Baltic Sea	Helcom
Allis shad	*Alosa alosa*	Baltic Sea	Helcom
Twaite shad	*Alosa fallax*	Baltic Sea	Helcom
Autumn-spawning herring	*Clupea harengus subsp.*	Baltic Sea	Helcom
Zope	*Abramis ballerus*	Baltic Sea	Helcom
Bleak	*Alburnus alburnus*	Baltic Sea	Helcom
Asp	*Aspius aspius*	Baltic Sea	Helcom
Barbel	*Barbus barbus*	Baltic Sea	Helcom
Gudgeon	*Gobio gobio*	Baltic Sea	Helcom
Ziege	*Pelecus cultratus*	Baltic Sea	Helcom
Eurasian minnow	*Phoxinus phoxinus*	Baltic Sea	Helcom
Vimba	*Vimba vimba*	Baltic Sea	Helcom

Common name	Scientific name	Region/RFMO	Legal framework
Spined loach	*Cobitis taenia*	Baltic Sea	Helcom
Trout	*Salmo trutta*	Baltic Sea	Helcom
Vendace	*Coregonus albula*	Baltic Sea	Helcom
Baltic houting	*Coregonus balticus* *Synonym: Coregonus lavaretus, migratory*	Baltic Sea	Helcom
Maraena	*Coregonus maraena* *Synonym: Coregonus lavaretus, stationary*	Baltic Sea	Helcom
Pallas's houting	*Coregonus pallasii*	Baltic Sea	Helcom
Marine smelt	*Osmerus eperlanomarinus*	Baltic Sea	Helcom
Black-bellied angler	*Lophius budegassa*	Baltic Sea	Helcom
Sea stickleback	*Spinachia spinachia*	Baltic Sea	Helcom
Snake pipefish	*Entelurus aequoreus*	Baltic Sea	Helcom
Straightnose pipefish	*Nerophis ophidion*	Baltic Sea	Helcom
Worm pipefish	*Nerophis lumbriciformis*	Baltic Sea	Helcom
Greater pipefish	*Syngnathus acus*	Baltic Sea	Helcom
Broad-nosed pipefish	*Syngnathus typhle*	Baltic Sea	Helcom
Roundnose grenadier	*Coryphaenoides rupestris*	Baltic Sea	Helcom
Haddock	*Melanogrammus aeglefinus*	Baltic Sea	Helcom
Pollack	*Pollachius pollachius*	Baltic Sea	Helcom
Ling	*Molva molva*	Baltic Sea	Helcom
Snakeblenny	*Lumpenus lampretaeformis*	Baltic Sea	Helcom
Ocean perch	*Sebastes marinus*	Baltic Sea	Helcom

Common name	Scientific name	Region/RFMO	Legal framework
Norway redfish	*Sebastes viviparus*	Baltic Sea	Helcom
Miller's thumb	*Cottus gobio*	Baltic Sea	Helcom
Alpine bullhead	*Cottus poecilopus*	Baltic Sea	Helcom
Shorthorn sculpin	*Myoxocephalus scorpius*	Baltic Sea	Helcom
Longspined bullhead	*Taurulus bubalis*	Baltic Sea	Helcom
Fourhorn sculpin	*Triglopsis quadricornis*	Baltic Sea	Helcom
Lumpsucker	*Cyclopterus* lumpus	Baltic Sea	Helcom
Striped seasnail	*Liparis liparis*	Baltic Sea	Helcom
Montagu's seasnail	*Liparis montagui*	Baltic Sea	Helcom
John Dory	*Zeus faber*	Baltic Sea	Helcom
European seabass	*Dicentrarchus labrax*	Baltic Sea	Helcom
Ballan wrasse	*Labrus bergylta*	Baltic Sea	Helcom
Cuckoo wrasse	*Labrus mixtus*	Baltic Sea	Helcom
Corkwring wrasse	*Symphodus melops*	Baltic Sea	Helcom
Greater weever	*Trachinus draco*	Baltic Sea	Helcom
Wolf-fish	*Anarhichas lupus*	Baltic Sea	Helcom
Lesser sandeel	*Ammodytes marinus*	Baltic Sea	Helcom
Small sandeel	*Ammodytes tobianus*	Baltic Sea	Helcom
Painted goby	*Pomatoschistus pictus*	Baltic Sea	Helcom
Bullet tuna	*Auxis rochei*	Baltic Sea	Helcom
Little thunny	*Euthynnus alleteratus*	Baltic Sea	Helcom
Plain bonito	*Orcynopsis unicolor*	Baltic Sea	Helcom
Atlantic mackerel	*Scomber scombrus*	Baltic Sea	Helcom

Common name	Scientific name	Region/RFMO	Legal framework
Atlantic halibut	*Hippoglossus hippoglossus*	Baltic Sea	Helcom
Swordfish	*Xiphias gladius*	Baltic Sea	Helcom
Niger Blackfish	*Centrolophus niger*	Baltic Sea	Helcom
Cartilaginous fishes	Chondrichthyes		
Narrow sawfish	*Anoxypristis cuspidata*	All oceans	RFMOs, High priority
Birdbeak dogfish	*Deania calcea*	All oceans	RFMOs, High priority
smooth lanternshark	*Etmopterus pusillus*	All oceans	RFMOs, High priority
Dwarf sawfish	*Pristis clavata*	All oceans	RFMOs, High priority
Green sawfish	*Pristis zijsron*	All oceans	RFMOs, High priority
Norwegian skate	*Raja (Dipturus) nidarosiensis*	All oceans	RFMOs, High priority
Thornback ray	*Raja clavata*	All oceans	RFMOs, High priority OSPAR; Helcom
Undulate ray	*Raja undulata*	All oceans	RFMOs, High priority
Pelagic Thresher	*Alopias pelagicus*	All oceans	RFMOs, High priority
Big Eye Thresher	*Alopias superciliosus*	All oceans	RFMOs, High priority
Common Thresher	*Alopias vulpinus*	All oceans	RFMOs, High priority; Helcom
Starry ray	*Amblyraja radiata*	All oceans	RFMOs, High priority
Iceland catshark	*Apristurus* spp.	All oceans	RFMOs, High priority, Vulnerable species Relevant for deep sea fisheries
Silky shark	*Carcharhinus falciformis*	All oceans	RFMOs, High priority
Galapagos shark	*Carcharhinus galapagensis*	All oceans	RFMOs, High priority
Oceanic whitetip shark	*Carcharhinus longimanus*	All oceans	RFMOs, High priority
Sandbar shark	*Carcharhinus plumbeus*	All oceans + Mediterranean and Black Sea	RFMOs, High priority, Barcelona Convention Annex II
Sand tiger shark	*Carcharias taurus*	All oceans + Mediterranean and Black Sea	RFMOs, High priority, Barcelona Convention Annex II

Common name	Scientific name	Region/RFMO	Legal framework
Great white shark	*Carcharodon carcharias*	All oceans	RFMOs, High priority
Gulper shark	*Centrophorus granulosus*	All oceans and seas	RFMOs, High priority, Barcelona Convention Annex III; OSPAR
Gulper shark species	*Centrophorus* spp.	All Regions	Relevant for deep sea fisheries
Leafscale gulper shark	*Centrophorus squamosus*	All oceans and seas	RFMOs, High priority; OSPAR
Black dogfish	*Centroscyllium fabricii*	All oceans	RFMOs, High priority, Relevant for deep sea fisheries
Portuguese dogfish	*Centroscymnus coelolepis*	All oceans	RFMOs, High priority, Relevant for deep sea fisheries; OSPAR
Longnose velvet dogfish	*Centroscymnus crepidater*	All oceans	RFMOs, High priority, Vulnerable species Relevant for deep sea fisheries
Basking shark	*Cetorhinus maximus*	All oceans and seas	RFMOs, High priority; OSPAR; Helcom
Rabbit fish (rattail)	*Chimaera monstrosa*	All Regions	Relevant for deep sea fisheries
Frilled shark	*Chlamydoselachus anguineus*	All oceans	RFMOs, High priority, Vulnerable species Relevant for deep sea fisheries
Kitefin shark	*Dalatias licha*	All oceans	RFMOs, High priority, Vulnerable species Relevant for deep sea fisheries
Stingray	*Dasyatis pastinaca*	Black Sea	Annex IV of the Black Sea Biodiversity and Landscape Conservation Protocol; Helcom
Birdbeak dogfish	*Deania calcea*	All oceans	RFMOs, High priority, Relevant for deep sea fisheries
Common skate	*Dipturus batis*	All oceans and seas	RFMOs, High priority, Barcelona Convention Annex II; OSPAR; Helcom
White skate	*Rostroraja alba	OSPAR II, III, IV	OSPAR
Greater lanternshark	*Etmopterus princeps*	All oceans	RFMOs, High priority, Vulnerable species Relevant for deep sea fisheries
Velvet belly	*Etmopterus spinax*	All oceans	RFMOs, High priority, Relevant for deep sea fisheries; Helcom
Winghead hammerhead	*Eusphyra blochii*	All oceans	RFMOs, High priority
school shark, tope shark	*Galeorhinus galeus*	All oceans + Mediterranean and Black Sea	RFMOs, High priority, Barcelona Convention Annex II; Helcom
Blackmouth dogfish	*Galeus melastomus*	All oceans	RFMOs, High priority, Relevant for deep sea fisheries

Common name	Scientific name	Region/RFMO	Legal framework
Mouse catshark	*Galeus murinus*	All oceans	RFMOs, High priority, Relevant for deep sea fisheries
Spiny butterfly ray	*Gymnura altavela*	All oceans + Mediterranean and Black Sea	RFMOs, High priority, Barcelona Convention Annex II
Sharpnose sevengill shark	*Heptranchias perlo*	All oceans + Mediterranean and Black Sea	RFMOs, High priority, Barcelona Convention Annex III
Bluntnose six-gilled shark	*Hexanchus griseus*	All oceans + Mediterranean and Black Sea	RFMOs, High priority, Barcelona Convention Annex II; Helcom
Large-eyed rabbitfish (Ratfish)	*Hydrolagus mirabilis*	All Regions	Relevant for deep sea fisheries
Shortfin mako	*Isurus oxyrinchus*	All oceans	RFMOs, High priority
Longfin mako	*Isurus paucus*	All oceans	RFMOs, High priority
Porbeagle	*Lamna nasus*	All oceans	RFMOs, High priority, OSPAR; Helcom
Sandy Skate	*Leucoraja circularis*	All oceans + Mediterranean and Black Sea	RFMOs, High priority, Barcelona Convention Annex II
Maltese skate	*Leucoraja melitensis*	All oceans + Mediterranean and Black Sea	RFMOs, High priority, Barcelona Convention Annex II
Reef manta ray	*Manta alfredi*	All oceans	RFMOs, High priority
Giant manta ray	*Manta birostris*	All oceans	RFMOs, High priority
Longhorned mobula	*Mobula eregoodootenkee*	All oceans	RFMOs, High priority
Lesser devil ray	*Mobula hypostoma*	All oceans	RFMOs, High priority
Spinetail mobula	*Mobula japanica*	All oceans	RFMOs, High priority
Shortfin devil ray	*Mobula kuhlii*	All oceans	RFMOs, High priority
Devil fish	*Mobula mobular*	All oceans	RFMOs, High priority

Common name	Scientific name	Region/RFMO	Legal framework
Munk's devil ray	*Mobula munkiana*	All oceans	RFMOs, High priority
Lesser Guinean devil ray	*Mobula rochebrunei*	All oceans	RFMOs, High priority
Chilean devil ray	*Mobula tarapacana*	All oceans	RFMOs, High priority
Smoothtail mobula	*Mobula thurstoni*	All oceans	RFMOs, High priority
Starry smooth-hound	*Mustelus asterias*	All oceans + Mediterranean and Black Sea	RFMOs, High priority, Barcelona Convention Annex III
Common smooth-hound	*Mustelus mustelus*	All oceans + Mediterranean and Black Sea	RFMOs, High priority, Barcelona Convention Annex III
Blackspotted smooth-hound	*Mustelus punctulatus*	All oceans + Mediterranean and Black Sea	RFMOs, High priority, Barcelona Convention Annex III
Blackmouth catshark	*Galeus melanostomus*	Baltic sea	Helcom
Small-spotted catshark	*Scyliorhinus canicula*	Baltic sea	Helcom
Thorny skate	*Amblyraja radiata*	Baltic sea	Helcom
Shagreen ray	*Leucoraja fullonica*	Baltic sea	Helcom
Spotted torpedo	*Torpedo marmorata*	Baltic sea	Helcom
Sailfin roughshark (Sharpback shark)	*Oxynotus paradoxus*	All oceans	RFMOs, High priority, Vulnerable species Relevant for deep sea fisheries
Smalltooth sawfish	*Pristis pectinata*	All oceans + Mediterranean and Black Sea	RFMOs, High priority, Barcelona Convention Annex II
Common sawfish	*Pristis pristis*	All oceans + Mediterranean and Black Sea	RFMOs, High priority, Barcelona Convention Annex II
Crocodile shark	*Pseudocarcharias kamoharai*	All oceans	RFMOs, High priority
Blue stingray	*Pteroplatytrygon violacea*	All oceans	RFMOs, High priority
Round skate	*Raja fyllae*	All Regions	Relevant for deep sea fisheries
Arctic skate	*Raja hyperborea*	All Regions	Relevant for deep sea fisheries

Common name	Scientific name	Region/RFMO	Legal framework
Norwegian skate	*Raja nidarosiensus*	All Regions	Relevant for deep sea fisheries
Spotted ray	*Raja montagui*	OSPAR I, II, III, IV	OSPAR; Helcom
Whale shark	*Rhincodon typus*	All oceans	RFMOs, High priority
Blackchin guitarfish	*Rhinobatos cemiculus*	All oceans +Mediterranean and Black Sea	RFMOs, High priority, Barcelona Convention Annex II
Common guitarfish	*Rhinobatos rhinobatos*	All oceans + Mediterranean and Black Sea	RFMOs, High priority, Barcelona Convention Annex II
Straightnose rabbitfish	*Rhinochimaera atlantica*	All Regions	Relevant for deep sea fisheries
Bottlenose skate	*Rostroraja alba*	All oceans + Mediterranean and Black Sea	RFMOs, High priority, Barcelona Convention Annex II
Knifetooth dogfish	*Scymnodon ringens*	All oceans	RFMOs, High priority, Relevant for deep sea fisheries
Other sharks	Selachimorpha (or Selachii), Batoidea (to be defined by species according to landing, survey or catch data)	All oceans	RFMOs, High priority; Helcom
Greenland shark	*Somniosus microcephalus*	All oceans	RFMOs, High priority, Relevant for deep sea fisheries; Helcom
Scalloped hammerhead	*Sphyrna lewini*	All oceans	RFMOs, High priority
Great hammerhead	*Sphyrna mokarran*	All oceans	RFMOs, High priority
Smooth hammerhead	*Sphyrna zygaena*	All oceans	RFMOs, High priority
Spurdog, spiked dogfish	*Squalus acanthias*	All oceans + Mediterranean and Black Sea	RFMOs, High priority, Barcelona Convention Annex III, OSPAR; Helcom
Sawback angelshark	*Squatina aculeata*	All oceans + Mediterranean and Black Sea	RFMOs, High priority, Barcelona Convention Annex II
Smoothback angelshark	*Squatina oculata*	All oceans + Mediterranean and Black Sea	RFMOs, High priority, Barcelona Convention Annex II
Angel shark	*Squatina squatina*	All oceans + Mediterranean and Black Sea	RFMOs, High priority, Barcelona Convention Annex II, OSPAR; Helcom

Common name	Scientific name	Region/RFMO	Legal framework
Sea lamprey	*Petromyzon marinus*	OSPAR I, II, III, IV	OSPAR; Helcom
River lamprey	*Lampetra fluviatilis*	Baltic sea	Helcom
Mammals	*Mammalia*		
Cetaceans — all species	*Cetacea — all species*	All areas	Council Directive 92/43/EEC ([8])
Minke whale	*Balaenoptera acutorostrata*	Mediterranean Sea	Rec. GFCM ([9])/36/2012/2 & Annex II of the Barcelona Convention
Bowhead whale	*Balaena mysticetus*	OSPAR I	OSPAR
Blue whale	*Balaenoptera musculus*	All OSPAR	OSPAR
Northern right whale	*Eubalaena glacialis*	All OSPAR	OSPAR
Sei whale	*Balaenoptera borealis*	Mediterranean Sea	Rec. GFCM/36/2012/2 & Annex II of the Barcelona Convention
Fin whale	*Balaenoptera physalus*	Mediterranean Sea	Rec. GFCM/36/2012/2 & Annex II of the Barcelona Convention
Short-beaked common dolphin	*Delphinus delphis*	Mediterranean Sea	Rec. GFCM/36/2012/2 & Annex II of the Barcelona Convention
North Atlantic right whale	*Eubalaena glacialis*	Mediterranean Sea	Rec. GFCM/36/2012/2 & Annex II of the Barcelona Convention
Long-finned pilot whale	*Globicephala melas*	Mediterranean Sea	Rec. GFCM/36/2012/2 & Annex II of the Barcelona Convention
Risso's dolphin	*Grampus griseus*	Mediterranean Sea	Rec. GFCM/36/2012/2 & Annex II of the Barcelona Convention
Dwarf sperm whale	*Kogia simus*	Mediterranean Sea	Rec. GFCM/36/2012/2 & Annex II of the Barcelona Convention
Humpback whale	*Megaptera novaeangliae*	Mediterranean Sea	Rec. GFCM/36/2012/2 & Annex II of the Barcelona Convention
Blainville's beaked whale	*Mesoplodon densirostris*	Mediterranean Sea	Rec. GFCM/36/2012/2 & Annex II of the Barcelona Convention
Killer whale	*Orcinus orca*	Mediterranean Sea	Rec. GFCM/36/2012/2 & Annex II of the Barcelona Convention
Harbour porpoise	*Phocoena phocoena*	Mediterranean Sea; OSPAR II, III	Rec. GFCM/36/2012/2 & Annex II of the Barcelona Convention; Directive 92/43/EEC OSPAR
Sperm whale	*Physeter macrocephalus*	Mediterranean Sea	Rec. GFCM/36/2012/2 & Annex II of the Barcelona Convention

Common name	Scientific name	Region/RFMO	Legal framework
False killer whale	*Pseudorca crassidens*	Mediterranean Sea	Rec. GFCM/36/2012/2 & Annex II of the Barcelona Convention
Striped dolphin	*Stenella coeruleoalba*	Mediterranean Sea	Rec. GFCM/36/2012/2 & Annex II of the Barcelona Convention
Rough-toothed dolphin	*Steno bredanensis*	Mediterranean Sea	Rec. GFCM/36/2012/2 & Annex II of the Barcelona Convention
Bottlenose dolphin	*Tursiops truncatus*	Mediterranean Sea	Rec. GFCM/36/2012/2 & Annex II of the Barcelona Convention
Cuvier's beaked whale	*Ziphius cavirostris*	Mediterranean Sea	Rec. GFCM/36/2012/2 & Annex II of the Barcelona Convention
Monk seal	*Monachus monachus*	All areas	Rec. GFCM/35/2011/5 & Annex II of the Barcelona Convention; Directive 92/43/EEC
Saimaa ringed seal	*Phoca hispida saimensis*	All areas	Directive 92/43/EEC
Grey seal	*Halichoerus grypus*	All areas	Directive 92/43/EEC
Harbour seal	*Phoca vitulina*	All areas	Directive 92/43/EEC
Baltic ringed seal	*Phoca hispida bottnica*	All areas	Directive 92/43/EEC
Birds	Aves		
Cory's Shearwater	*Calonectris borealis*	All areas	Directive 2009/147/EC of the European Parliament and of the Council ([10])
Great Cormorant	*Phalacrocorax carbo*	All areas	Directive 2009/147/EC
Northern Gannet	*Morus bassanus*	All areas	Directive 2009/147/EC
Atlantic Puffin	*Fratercula arctica*	All areas	Directive 2009/147/EC
Balearic Shearwater	*Puffinus mauretanicus*	All areas	Directive 2009/147/EC
Black-headed Gull	*Larus ridibundus*	All areas	Directive 2009/147/EC
Common Scoter	*Melanitta nigra*	All areas	Directive 2009/147/EC
European Shag	*Phalacrocorax aristotelis*	All areas	Directive 2009/147/EC
Great Shearwater	*Ardenna gravis*	All areas	Directive 2009/147/EC
Manx Shearwater	*Puffinus puffinus*	All areas	Directive 2009/147/EC
Northern Fulmar	*Fulmarus glacialis*	All areas	Directive 2009/147/EC
Scopoli's Shearwater	*Calonectris diomedea*	All areas	Directive 2009/147/EC

Common name	Scientific name	Region/RFMO	Legal framework
Sooty Shearwater	*Ardenna grisea*	All areas	Directive 2009/147/EC
Yelkouan Shearwater	*Puffinus yelkouan*	All areas	Directive 2009/147/EC
Audouin's Gull	*Larus audouinii*	All areas	Directive 2009/147/EC
Barrow's Goldeneye	*Bucephala islandica*	All areas	Directive 2009/147/EC
Bulwer's Petrel	*Bulweria bulwerii*	All areas	Directive 2009/147/EC
Common Goldeneye	*Bucephala clangula*	All areas	Directive 2009/147/EC
European Herring Gull	*Larus argentatus*	All areas	Directive 2009/147/EC
Glaucous Gull	*Larus hyperboreus*	All areas	Directive 2009/147/EC
Great Black-backed Gull	*Larus marinus*	All areas	Directive 2009/147/EC
Great Skua	*Catharacta skua*	All areas	Directive 2009/147/EC
Greater Scaup	*Aythya marila*	All areas	Directive 2009/147/EC; Annex IV of the Black Sea Biodiversity and Landscape Conservation Protocol
Common pochard	*Aythya ferina*	Black Sea	Annex IV of the Black Sea Biodiversity and Landscape Conservation Protocol
Lesser Black-backed Gull	*Larus fuscus*	All areas	Directive 2009/147/EC
Little Auk	*Alle alle*	All areas	Directive 2009/147/EC
Long-tailed Jaeger	*Stercorarius longicaudus*	All areas	Directive 2009/147/EC
Razorbill	*Alca torda*	All areas	Directive 2009/147/EC
Arctic Jaeger	*Stercorarius parasiticus*	All areas	Directive 2009/147/EC
Arctic Loon	*Gavia arctica*	All areas	Directive 2009/147/EC
Audubon's Shearwater	*Puffinus lherminieri*	All areas	Directive 2009/147/EC
Black Guillemot	*Cepphus grylle*	All areas	Directive 2009/147/EC
Black Scoter	*Melanitta americana*	All areas	Directive 2009/147/EC
Black-necked Grebe	*Podiceps nigricollis*	All areas	Directive 2009/147/EC
Caspian Gull	*Larus cachinnans*	All areas	Directive 2009/147/EC
Common Eider	*Somateria mollissima*	All areas	Directive 2009/147/EC

Common name	Scientific name	Region/RFMO	Legal framework
Common Guillemot	*Uria aalge*	All areas	Directive 2009/147/EC
Common Loon	*Gavia immer*	All areas	Directive 2009/147/EC
Common Merganser	*Mergus merganser*	All areas	Directive 2009/147/EC
Great Crested Grebe	*Podiceps cristatus*	All areas	Directive 2009/147/EC
Harlequin Duck	*Histrionicus histrionicus*	All areas	Directive 2009/147/EC
Horned Grebe	*Podiceps auritus*	All areas	Directive 2009/147/EC
Iceland Gull	*Larus glaucoides*	All areas	Directive 2009/147/EC
King Eider	*Somateria spectabilis*	All areas	Directive 2009/147/EC
Long-tailed Duck	*Clangula hyemalis*	All areas	Directive 2009/147/EC
Mediterranean Gull	*Larus melanocephalus*	All areas	Directive 2009/147/EC
Mew Gull	*Larus canus*	All areas	Directive 2009/147/EC
Red-breasted Merganser	*Mergus serrator*	All areas	Directive 2009/147/EC
Red-necked Grebe	*Podiceps grisegena*	All areas	Directive 2009/147/EC
Red-throated Loon	*Gavia stellata*	All areas	Directive 2009/147/EC
Slender-billed Gull	*Larus genei*	All areas	Directive 2009/147/EC
Steller's Eider	*Polysticta stelleri*	All areas	Directive 2009/147/EC
Pomarine Jaeger	*Stercorarius pomarinus*	All areas	Directive 2009/147/EC
Thick-billed Murre/Brünnig's Guillemot	Uria lomvia	All areas	Directive 2009/147/EC
Velvet Scoter	*Melanitta fusca*	All areas	Directive 2009/147/EC
Yellow-billed Loon	*Gavia adamsii*	All areas	Directive 2009/147/EC
Yellow-legged Gull	*Larus michahellis*	All areas	Directive 2009/147/EC
Zino's Petrel	*Pterodroma madeira*	All areas	Directive 2009/147/EC
Pallas's Gull	*Larus ichthyaetus*	All areas	Directive 2009/147/EC

Common name	Scientific name	Region/RFMO	Legal framework
Black-legged Kittiwake	*Rissa tridactyla*	All areas	Directive 2009/147/EC
Great White Pelican	*Pelecanus onocrotalus*	All areas	Directive 2009/147/EC
Leach's Storm-petrel	*Oceanodroma leucorhoa*	All areas	Directive 2009/147/EC
Red Phalarope	*Phalaropus fulicarius*	All areas	Directive 2009/147/EC
Red-necked Phalarope	*Phalaropus lobatus*	All areas	Directive 2009/147/EC
Wilson's Storm-petrel	*Oceanites oceanicus*	All areas	Directive 2009/147/EC
Arctic Tern	*Sterna paradisaea*	All areas	Directive 2009/147/EC
Band-rumped Storm-petrel	*Hydrobates castro*	All areas	Directive 2009/147/EC
Black Tern	*Chlidonias niger*	All areas	Directive 2009/147/EC
Caspian Tern	*Hydroprogne caspia*	All areas	Directive 2009/147/EC
Common Gull-billed Tern	*Gelochelidon nilotica*	All areas	Directive 2009/147/EC
Common Tern	*Sterna hirundo*	All areas	Directive 2009/147/EC
Desertas Petrel	*Pterodroma deserta*	All areas	Directive 2009/147/EC
Ivory Gull	*Pagophila eburnea*	All areas	Directive 2009/147/EC
Lesser Crested Tern	*Thalasseus bengalensis*	All areas	Directive 2009/147/EC
Little Gull	*Hydrocoloeus minutus*	All areas	Directive 2009/147/EC
Little Tern	*Sternula albifrons*	All areas	Directive 2009/147/EC
Monteiro's Storm-petrel	*Hydrobates monteiroi*	All areas	Directive 2009/147/EC
Roseate Tern	*Sterna dougallii*	All areas	Directive 2009/147/EC
Ross's Gull	*Rhodostethia rosea*	All areas	Directive 2009/147/EC
Sabine's Gull	*Xema sabini*	All areas	Directive 2009/147/EC
Sandwich Tern	*Thalasseus sandvicensis*	All areas	Directive 2009/147/EC
Thayer's Gull	*Larus thayeri*	All areas	Directive 2009/147/EC

Common name	Scientific name	Region/RFMO	Legal framework
White-faced Storm-petrel	*Pelagodroma marina*	All areas	Directive 2009/147/EC
European Storm-petrel	*Hydrobates pelagicus*	All areas	Directive 2009/147/EC
Lesser black-backed gull	*Larus fuscus fuscus*	OSPAR I	OSPAR list of threatened and declining species
Ivory gull	*Pagophila eburnea*	OSPAR I	OSPAR list of threatened and declining species
Steller's eider	*Polysticta stelleri*	OSPAR I	OSPAR list of threatened and declining species
Little shearwater	*Puffinus assimilis baroli (auct.incert.)*	OSPAR V	OSPAR list of threatened and declining species
Balearic shearwater	*Puffinus mauretanicus*	OSPAR II, III, IV, V	OSPAR list of threatened and declining species
Black-legged kittiwake	*Rissa tridactyla*	OSPAR I, II,	OSPAR list of threatened and declining species
Roseate tern	*Sterna dougallii*	OSPAR II, III, IV, V	OSPAR list of threatened and declining species
Iberian guillemot	*Uria aalge — Iberian population (synonyms: Uria aalge albionis, Uria aalge ibericus)*	OSPAR IV	OSPAR list of threatened and declining species
Thick-billed murre	*Uria lomvia*	OSPAR I	OSPAR list of threatened and declining species
Reptiles	Reptilia		
Kemp's ridley sea turtle	*Lepidochelys kempii*	All areas	Directive 92/43/EEC; Rec. GFCM/35/2011/4 & Annex II of the Barcelona Convention
Loggerhead turtle	*Caretta caretta*	All areas	Directive 92/43/EEC; Rec. GFCM/35/2011/4 & Annex II of the Barcelona Convention; OSPAR
Leatherback turtle	*Dermochelys coriacea*	All areas	Directive 92/43/EEC; Rec. GFCM/35/2011/4 & Annex II of the Barcelona Convention; OSPAR
Hawksbill sea turtle	*Eretmochelys imbricata*	All areas	Directive 92/43/EEC; Rec. GFCM/35/2011/4 & Annex II of the Barcelona Convention
Green turtle	*Chelonia mydas*	All areas	Directive 92/43/EEC; Rec. GFCM/35/2011/4 & Annex II of the Barcelona Convention
Nile soft-shelled turtle	*Trionyx triunguis*	Mediterranean Sea	Rec. GFCM/35/2011/4 & Annex II of the Barcelona Convention
Molluscs	Mollusca		

Common name	Scientific name	Region/RFMO	Legal framework
Striped venus	*Chamelea gallina*	Black Sea	Annex IV of the Black Sea Biodiversity and Landscape Conservation Protocol
Banded wedge shell	*Donacilla cornea*	Black Sea	Annex IV of the Black Sea Biodiversity and Landscape Conservation Protocol
Eledone especies	*Eledone* spp.	All areas	National management plans
Mediterranean mussel	*Mytilus galloprovincialis*	All areas out of Med	National management plans
Mediterranean mussel	*Mytilus galloprovincialis*	Black Sea	Annex IV of the Black Sea Biodiversity and Landscape Conservation Protocol
Patella	*Patella* spp.	Mediterranean Sea	Annex II of the Barcelona Convention
Rapa whelk	*Rapana venosa*	Black Sea	Annex IV of the Black Sea Biodiversity and Landscape Conservation Protocol
Tuberculate cockle	*Acanthocardia tuberculata*	All areas	National management plans
Murex	*Bolinus brandaris*	All areas	National management plans
Hard clam	*Callista chione*	All areas	National management plans
Wedge shell	*Donax trunculus*	All areas	National management plans
Ocean quahog	*Arctica islandica*	OSPAR II	OSPAR
Azorean barnacle	*Megabalanus azoricus*	OSPAR V All where it occurs	OSPAR
Dog whelk	*Nucella lapillus*	OSPAR II, III, IV	OSPAR
Flat oyster	*Ostrea edulis*	OSPAR II	OSPAR
Azorean limpet	*Patella ulyssiponensis aspera*	All OSPAR where it occurs	OSPAR
Crustaceans	Crustacea		
Lobster	*Homarus gammarus*	Mediterranean Sea	Regulation (EC) No 1967/2006 (min. cons. size)

Common name	Scientific name	Region/RFMO	Legal framework
Deep-water red crab	*Chaceon (Geryon) affinis*	All Regions	Relevant for deep sea fisheries
Brown shrimp	*Crangon crangon*	Black Sea	Annex IV of the Black Sea Biodiversity and Landscape Conservation Protocol
Baltic prawn	*Palaemon adspersus*	Black Sea	Annex IV of the Black Sea Biodiversity and Landscape Conservation Protocol
Rockpool prawn	*Palaemon elegans*	Black Sea	Annex IV of the Black Sea Biodiversity and Landscape Conservation Protocol
Crawfish	*Palinuridae*	Mediterranean Sea	Regulation (EC) No 1967/2006 (min. cons. size)
Cnidarians	Cnidaria		
Red coral	*Corallium rubrum*	Mediterranean Sea	Rec. GFCM/36/2012/1 & Rec. GFCM/35/2011/2

(1) This Table replaces Table 1D of Implementing Decision (EU) 2016/1251.
(2) Barcelona Convention for the Protection of the Marine Environment and the Coastal Region of the Mediterranean.
(3) OSPAR Convention for the Protection of the Marine Environment of the North-East Atlantic.
(4) HELCOM Convention on the Protection of the Marine Environment of the Baltic Sea Area.
(5) Council Regulation (EC) No 2347/2002 of 16 December 2002 establishing specific access requirements and associated conditions applicable to fishing for deep-sea stocks (OJ L 351, 28.12.2002, p. 6).
(6) Council Regulation (EC) No 1967/2006 of 21 December 2006 concerning management measures for the sustainable exploitation of fishery resources in the Mediterranean Sea, amending Regulation (EEC) No 2847/93 and repealing Regulation (EC) No 1626/94 (OJ L 409, 30.12.2006, p. 11).
(7) Council Regulation (EC) No 894/97 of 29 April 1997 laying down certain technical measures for the conservation of fishery resources (OJ L 132, 23.5.1997, p. 1).
(8) Council Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora (OJ L 206, 22.7.1992, p. 7).
(9) General Fisheries Commission for the Mediterranean.
(10) Directive 2009/147/EC of the European Parliament and of the Council of 30 November 2009 on the conservation of wild birds (OJ L 20, 26.1.2010, p. 7).

For prohibited species: only individuals captured dead shall be used. They shall be discarded after the measurements. The data collection is annual and the updating/processing of the data must be done timely to fit the schedule of the stock assessments.

BIOLOGICAL DATA

Table 1E (1)

Freshwater anadromous and catadromous species

Species (common name)	Species (Scientific name)	Non marine Areas where the Stock is located/stock code
European Eel	*Anguilla anguilla*	Eel Management Units as defined in accordance with Council Regulation (EC) No 1100/2007 (2)
Salmon	*Salmo salar*	all areas of natural distribution
Sea trout	*Salmo trutta*	All inland waters that exit in the Baltic Sea

(1) This Table replaces Table 1E of Implementing Decision (EU) 2016/1251.
(2) Council Regulation (EC) No 1100/2007 of 18 September 2007 establishing measures for the recovery of the stock of European eel (OJ L 248, 22.9.2007, p. 17).

Table 2 (1)

Fishing activity (metier) by Region

Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	LOA classes (m) (d)					
Activity	Gear classes	Gear groups	Gear type	Target assemblage (a)	Mesh size and other selective devices	< 10	10 - < 12	12 - < 18	18 - < 24	24 - < 40	40 & +
Fishing activity	Dredges	Dredges	Boat dredge [DRB]	Anadromous species (ANA) Catadromous species (CAT) Cephalopods (CEP) Crustaceans (CRU) Demersal species (DEF) Deep-Water species (DWS) Finfish (FIF) Freshwater species (no code) Miscellaneous (MIS) Mixed Cephalopod and Demersal (MCF) Mixed Crustaceans and Demersal (MCD) Mixed Deep-water species and Demersal (MDD) Mixed Pelagic and Demersal (MPD) Molluscs (MOL) Large Pelagic fish (LPF) Small Pelagic fish (SPF) Large Pelagic fish (LPF) and Small Pelagic fish (SPF)	(b)						
			Mechanised/Suction dredge [HMD]		(b)						
	Trawls	Bottom trawls	Bottom otter trawl [OTB]		(b)						
			Multi-rig otter trawl [OTT]		(b)						
			Bottom pair trawl [PTB]		(b)						
			Beam trawl [TBB]		(b)						
		Pelagic trawls	Midwater otter trawl [OTM]		(b)						
			Midwater pair trawl [PTM]		(b)						
	Hooks and Lines	Rods and Lines	Hand and Pole lines [LHP] [LHM]		(b)						
			Trolling lines [LTL]		(b)						
		Longlines	Drifting longlines [LLD]		(b)						
			Set longlines [LLS]		(b)						

Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	LOA classes (m) (d)					
Activity	Gear classes	Gear groups	Gear type	Target assemblage (a)	Mesh size and other selective devices	< 10	10 - < 12	12 - < 18	18 - < 24	24 - < 40	40 & +
	Traps	Traps	Pots and Traps [FPO]		(b)						
			Fyke nets [FYK]		(b)						
			Stationary uncovered pound nets [FPN]		(b)						
			Fixed installations for fences and weirs (code needed)		(b)						
	Nets	Nets	Trammel net [GTR]		(b)						
			Set gillnet [GNS]		(b)						
			Driftnet [GND]		(b)						
	Seines	Surrounding nets	Purse seine [PS]		(b)						
			Lampara nets [LA]		(b)						
		Seines (c)	Fly shooting seine [SSC]		(b)						
			Anchored seine [SDN]		(b)						
			Pair seine [SPR]		(b)						
			Beach and boat seine [SB] [SV]		(b)						
	Other gear	Other gear	Glass eel fishing (no code)	Glass eel	(b)						
	Misc. (Specify)	Misc. (Specify)			(b)						
Other activity than fishing				Other activity than fishing							
Inactive				Inactive							

Footnotes:
(a) according to existing coding in relevant Regulations.
(b) according to existing coding in relevant Regulations.
(c) with Fish Aggregating Devices (FADs)/in free schools.
(d) in the Mediterranean < 6 m and 6-12 m.
([1]) This Table replaces Table 2 of Implementing Decision (EU) 2016/1251.

Table 3 (1)

Species to be collected for recreational fisheries

	Area	Species
1	Baltic Sea (ICES Subdivisions 22-32)	Salmon, eels and seatrout (including in fresh water) and cod.
2	North Sea (ICES areas IIIa, IV and VIId)	Salmon and eels (including in fresh water). Seabass, cod, pollack and elasmobranchs.
3	Eastern Arctic (ICES areas I and II)	Salmon and eels (including in fresh water). Cod, pollack and elasmobranchs.
4	North Atlantic (ICES areas V-XIV and NAFO areas)	Salmon and eels (including in fresh water). Seabass, cod, pollack, elasmobranchs and highly migratory ICCAT species.
5	Mediterranean Sea	Eels (including in fresh water), elasmobranchs and highly migratory ICCAT species.
6	Black Sea	Eels (including in fresh water), elasmobranchs and highly migratory ICCAT species.

(1) This Table replaces Table 3 of Implementing Decision (EU) 2016/1251.

Table 4 (1)

Fishing activity variables

	Variables (2)	Unit
	Capacity	
	Number of vessels	Number
	GT, kW, Vessel Age	Number
	Effort	
	Days at sea	Days
	Hours fished (optional)	Hours
	Fishing days	Days
	kW * Fishing Days	Number
	GT * Fishing days	Number
	Number of trips	Number
	Number of fishing operations	Number
	Number of nets/Length (*)	Number/metres
	Number of hooks, Number of lines (*)	Number
	Numbers of pots, traps (*)	Number

	Variables (2)	Unit
	Landings	
	Value of landings total and per commercial species	Euro
	Live Weight of landings total and per species	Tonnes
	Prices by commercial species	Euro/kg

(*) Collection of these variables for vessels less than 10 metres is to be agreed at marine region level
(1) This Table replaces Table 4 of Implementing Decision (EU) 2016/1251.
(2) All variables to be reported at the aggregation level (metiers and fleet segment) specified in Table 3 and Table 5B. and by Sub-region/Fishing ground as specified in table 5C.

FLEET ECONOMIC DATA

Table 5A (1)

Economic variables for the fleet

Variable group	Variable	Unit
Income	Gross value of landings	Euro
	Income from leasing out quota or other fishing rights	Euro
	Other income	Euro
Labour costs	Personnel costs	Euro
	Value of unpaid labour	Euro
Energy costs	Energy costs	Euro
Repair and maintenance costs	Repair and maintenance costs	Euro
Other operating costs	Variable costs	Euro
	Non-variable costs	Euro
	Lease/rental payments for quota or other fishing rights	Euro
Subsidies	Operating subsidies	Euro
	Subsidies on investments	Euro
Capital costs	Consumption of fixed capital	Euro
Capital value	Value of physical capital	Euro
	Value of quota and other fishing rights	Euro
Investments	Investments in tangible assets, net	Euro
Financial position	Long/short Debt	Euro
	Total assets	Euro

Variable group	Variable	Unit
Employment	Engaged crew	Number
	Unpaid labour	Number
	Total hours worked per year	Number
Fleet	Number of vessels	Number
	Mean LOA of vessels	Metres
	Total vessel's tonnage	GT
	Total vessel's power	kW
	Mean age of vessels	Years
Effort	Days at sea	Days
	Energy consumption	Litres
Number of fishing enterprises/units	Number of fishing enterprises/units	Number
Production value per species	Value of landings per species	Euro
	Average price per species	Euro/kg

(1) This Table replaces 5A of Implementing Decision (EU) 2016/1251.

FLEET ECONOMIC DATA

Table 5B (1)

Fleet segmentation

		Length classes (LOA) (2)					
Active Vessels		0 - < 10 m 0 - < 6 m	10 - < 12 m 6 - < 12 m	12 - < 18 m	18 - < 24 m	24 - < 40 m	40 m or larger
Using 'Active' gears	Beam trawlers						
	Demersal trawlers and/or demersal seiners						
	Pelagic trawlers						
	Purse seiners						
	Dredgers						
	Vessel using other active gears						
	Vessels using Polyvalent 'active' gears only						

		Length classes (LOA) (2)					
Active Vessels		0 - < 10 m 0 - < 6 m	10 - < 12 m 6 - < 12 m	12 - < 18 m	18 - < 24 m	24 - < 40 m	40 m or larger
Using 'Passive' gears	Vessels using hooks	(3)	(3)				
	Drift and/or fixed netters						
	Vessels using Pots and/or traps						
	Vessels using other Passive gears						
	Vessels using Polyvalent 'passive' gears only						
Using Polyvalent gears	Vessels using active and passive gears						
Inactive vessels							

(1) This Table replaces Table 5B of Implementing Decision (EU) 2016/1251.
(2) For vessels less than 12 meters in the Mediterranean Sea and the Black sea, the length categories are 0 - < 6, 6 - < 12 metres. For all other regions, the length categories are defined as 0 - < 10, 10 - < 12 metres.
(3) Vessels less than 12 meters using passive gears in the Mediterranean Sea and the Black Sea may be disaggregated by gear type.The fleet segment definition shall also include an indication of the supra-region and, if available, a geographical indicator to identify vessels fishing in outermost regions and exclusively outside EU waters.

FLEET ECONOMIC DATA

Table 5C (1)

Geographical stratification by Region

Sub-region/Fishing ground	Region	Supra region
I	II	III
Cluster of spatial units on level 3 as defined in Table 3 (NAFO Division)	NAFO (FAO area 21)	Baltic Sea; North sea; Eastern Arctic; NAFO; Extended North Western waters (Ices areas V, VI and VII) and Southern Western waters
Cluster of spatial units on level 4 as defined in Table 3 (ICES subdivision)	Baltic Sea (ICES areas III b-d)	
Cluster of spatial units on level 3 as defined in Table 3 (ICES Division)	North Sea (ICES areas IIIa and IV), Eastern Arctic (ICES areas I and II)	
	North Western waters (ICES areas Vb (only Union waters), VI and VII)	
	Non Union North Western waters (ICES areas Va and Vb (only non-Union waters))	

Sub-region/Fishing ground	Region	Supra region
I	II	III
Cluster of spatial units on level 3 as defined in Table 3 (ICES/CECAF Division)	Southern Western waters (ICES zones VIII, IX and X (waters around Azores)), CECAF areas 34.1.1, 34.1.2 and 34.2.0 (waters around Madeira and the Canary Islands)	
Cluster of spatial units on level 4 as defined in Table 3 (GSA)	Mediterranean Sea (Maritime Waters of the Mediterranean to the East of line 5°36′ West), Black Sea (GFCM geographical sub-area as defined in Resolution FCM/33/2009/2)	Mediterranean Sea and Black Sea
RFMO's sampling Sub-areas (except GFCM)	Other regions where fisheries are operated by Union vessels and managed by RFMO's to which the European Union is contracting party or observer (e.g. ICCAT, IOTC, CECAF…)	Other Regions.

(1) This Table replaces Table 5C of Implementing Decision (EU) 2016/1251.

Table 6 (1)

Social variables for the fishing and aquaculture sectors

Variable	Unit
Employment by gender	Number
FTE by gender	Number
Unpaid labour by gender	Number
Employment by age	Number
Employment by education level	Number per education level
Employment by nationality	Number from EU, EEA and Non-EU/EEA
Employment by employment status	Number
FTE National	Number

(1) This Table replaces Table 6 of Implementing Decision (EU) 2016/1251.

Table 7 (1)

Economic variables for the aquaculture sector

Variable group	Variable	Unit
Income (*)	Gross sales per species	Euro
	Other income	Euro
Personnel costs	Personnel costs	Euro
	Value of unpaid labour	Euro

Variable group	Variable	Unit
Energy costs	Energy costs	Euro
Raw material costs	Livestock costs	Euro
	Feed costs	Euro
Repair and maintenance	Repair and maintenance	Euro
Other operating costs	Other operating costs	Euro
Subsidies	Operating subsidies	Euro
	Subsidies on investments	Euro
Capital costs	Consumption of fixed capital	Euro
Capital value	Total value of assets	Euro
Financial results	Financial income	Euro
	Financial expenditures	Euro
Investments	Net Investments	Euro
Debt	Debt	Euro
Raw material weight	Livestock used	kg
	Fish Feed used	kg
Weight of sales	Weight of sales per species	kg
Employment	persons employed	Number/FTE
	Unpaid labour	Number/FTE
	Number of hours worked by employees and unpaid workers	Hours
Number of enterprises	Number of enterprises (by category on the number of persons employed)	Number

(1) This Table replaces Table 7 of Implementing Decision (EU) 2016/1251.
(*) Includes direct payments, e.g. compensation for stopping trading, refunds of fuel duty or similar lump sum compensation payments; excludes social benefit payments and indirect subsidies, e.g. reduced duty on inputs such as fuel or investment subsidies.

Table 8 (1)

Environmental variables for the aquaculture sector

Variable	Specification	Unit
Medicines or treatments administered (2)	By type	Gram
Mortalities (3)		Percent

(1) This Table replaces Table 8 of Implementing Decision (EU) 2016/1251.
(2) Extrapolated from data recorded under Annex I, point 8(b), of Regulation (EC) No 852/2004 of the European Parliament and of the Council of 29 April 2004 on the hygiene of foodstuffs (OJ L 139, 30.4.2004, p. 1).
(3) Extrapolated as a percentage of national production from data recorded under Council Directive 2006/88/EC of 24 October 2006 on animal health requirements for aquaculture animals and products thereof, and on the prevention and control of certain diseases in aquatic animals (OJ L 328, 24.11.2006, p. 14), Article 8, Paragraph 1(b).

Table 9 (1)

Segmentation to be applied for the collection of aquaculture data (2)

	Fish farming techniques (3)						Polyculture	Hatcheries and nurseries (4)	Shellfish farming techniques			
	Ponds	Tanks and raceways	Enclosures and pens (5)	Recirculation systems (6)	Other methods	Cages (7)	All methods		Off-bottom		On-bottom (8)	Other
									Rafts	Long line		
Salmon												
Trout												
Sea bass & Sea bream												
Carp												
Tuna												
Eel												
Sturgeon (Eggs for human consumption)												
Other fresh water fish												
Other marine fish												
Mussel												
Oyster												
Clam												
Crustaceans												
Other molluscs												
Multispecies												
Seaweeds												

	Fish farming techniques (3)						Polyculture	Hatcheries and nurseries (4)	Shellfish farming techniques			
	Ponds	Tanks and raceways	Enclosures and pens (5)	Recirculation systems (6)	Other methods	Cages (7)	All methods		Off-bottom		On-bottom (8)	Other
									Rafts	Long line		
Other aquatic organisms												

(1) This Table replaces Table 9 of Implementing Decision (EU) 2016/1251.
(2) For definitions of farming techniques, see Regulation (EC) No 762/2008 of the European Parliament and of the Council of 9 July 2008 on the submission by Member States of statistics on aquaculture and repealing Council Regulation (EC) No 788/96 (OJ L 218, 13.8.2008, p. 1).
(3) Enterprises shall be segmented according to their main farming technique.
(4) Hatcheries and nurseries are defined as places for the artificial breeding, hatching and rearing through the early life stages of aquatic animals. For statistical purposes, hatcheries are limited to the production of fertilised eggs. Further juveniles stages of aquatic animals are considered being produced in nurseries. When hatcheries and nurseries are closely associated, statistics shall refer only to the latest juvenile stage produced (COM(2006) 864 of 19 July 2007).
(5) Enclosures and pens are defined as areas of water confined by nets, mesh and other barriers allowing uncontrolled water interchange and distinguished by the fact that enclosures occupy the full water column between substrate and surface; pens and enclosures generally enclose a relatively large volume of water. (COM(2006) 864 of 19 July 2007).
(6) Recirculation systems means systems where the water is reused after some form of treatment (e.g. filtering).
(7) Cages are defined as open or covered enclosed structures constructed with net, mesh or any porous material allowing natural water interchange. These structures may be floating, suspended or fixed to the substrate but still permitting water interchange from below (COM(2006) 864 of 19 July 2007).
(8) 'On-bottom' techniques cover shellfish farming in inter-tidal areas (directly on the ground or surelevated).

Table 10 (1)

Economic and social variables for the processing industry sector that may be collected on a voluntary basis

Variable group	Variable	Unit
ECONOMIC VARIABLES		
Income	Turnover	Euro
	Other income	Euro
Personnel Costs	Personnel costs	Euro
	Value of unpaid labour	Euro
	Payment for external agency workers (optional)	Euro
Energy costs	Energy costs	Euro
Raw material costs	Purchase of fish and other raw material for production	Euro
Other operational costs	Other operational costs	Euro
Subsidies	Operating subsidies	Euro
	Subsidies on investments	Euro
Capital costs	Consumption of fixed capital	Euro

Variable group	Variable	Unit
Capital value	Total value of assets	Euro
Financial results	Financial income	Euro
	Financial expenditures	Euro
Investments	Net Investments	Euro
Debt	Debt	Euro
Employment	Number of persons employed	Number
	FTE National	Number
	Unpaid labour	Number
	Number of hours worked by employees and unpaid workers	Number
Number of enterprises	Number of enterprises (1)	Number
weight of raw material (OPTIONAL)	weight of raw material per species and origin (OPTIONAL)	Kg

SOCIAL VARIABLES

Employment by gender	Number
Employment by age	Number
Employment by education level	Number per education level
Employment by nationality	Number per country in the world
FTE National	Number

(1) This Table replaces Table 11 of Implementing Decision (EU) 2016/1251.

COMMISSION IMPLEMENTING DECISION (EU) 2016/1251

of 12 July 2016

adopting a multiannual Union programme for the collection, management and use of data in the fisheries and aquaculture sectors for the period 2017-2019

(notified under document C(2016) 4329)

THE EUROPEAN COMMISSION,

Having regard to the Treaty on the Functioning of the European Union,

Having regard to Council Regulation (EC) No 199/2008 of 25 February 2008 concerning the establishment of a Community framework for the collection, management and use of data in the fisheries sector and support for scientific advice regarding the common fisheries policy ([1]), and in particular Article 3 thereof,

Whereas:

(1) Pursuant to Article 3 of Regulation (EC) No 199/2008, a multiannual Union programme for the collection, management and use of data in the fisheries sector is to be adopted for a period of three years for the purpose of ensuring uniform application of the obligation to collect and manage data.

(2) The current multiannual Union programme is based on the multiannual programme for the period 2011-2013, that was prolonged by Commission Implementing Decision C(2013)5243 in order to bridge the period between the adoption of Regulation (EU) No 1380/2013 of the European Parliament and of the Council ([2]) and 31 December 2016. It is therefore necessary to establish a multiannual Union programme for a three-year period starting 1 January 2017.

(3) Pursuant to Article 25 of Regulation (EU) No 1380/2013, the Member States shall collect biological, environmental, technical and socioeconomic data necessary for fisheries management. The multiannual Union programme is necessary for Member States to specify and plan their data collection activities in their national work plans. In accordance with Article 21 of Regulation (EU) No 508/2014 of the European Parliament and of the Council ([3]) these national work plans have to be submitted to the Commission by 31 October preceding the year from which the work plan is to apply.

(4) The multiannual Union programme should define data collection requirements in accordance with Article 1 of Regulation (EC) No 199/2008. It should contain the elements needed for the implementation of the common fisheries policy in as far as they are not already required under other legislative frameworks.

(5) In order to achieve the objectives of the reformed common fisheries policy set out in Article 2 of Regulation (EU) No 1380/2013, it is necessary to update the Union data requirements for sound scientific advice for the period starting from 1 January 2017.

(6) Moreover, new international obligations and commitments imposed upon Member States and the Union by multilateral and bilateral agreements with regard to fisheries require incorporation of certain requirements concerning data collection into the multiannual Union programme, in particular those stemming from Sustainable Fisheries Partnership Agreements (SFPAs).

([1]) OJ L 60, 5.3.2008, p. 1.

([2]) Regulation (EU) No 1380/2013 of the European Parliament and of the Council of 11 December 2013 on the Common Fisheries Policy, amending Council Regulations (EC) No 1954/2003 and (EC) No 1224/2009 and repealing Council Regulations (EC) No 2371/2002 and (EC) No 639/2004 and Council Decision 2004/585/EC (OJ L 354, 28.12.2013, p. 22).

([3]) Regulation (EU) No 508/2014 of the European Parliament and of the Council of 15 May 2014 on the European Maritime and Fisheries Fund and repealing Council Regulations (EC) No 2328/2003, (EC) No 861/2006, (EC) No 1198/2006 and (EC) No 791/2007 and Regulation (EU) No 1255/2011 of the European Parliament and of the Council (OJ L 149, 20.5.2014, p. 1).

(7) Evaluation of the current framework for the collection, management and use of data in the fisheries sector and subsequent stakeholder consultations have indicated that the multiannual Union programme should focus on what data are required from Member States, rather than on the methods to collect them. Methodological requirements shall be described in Member States' work plans to be approved by the Commission, following close cooperation between Member States at the level of marine regions.

(8) The Union programme for the period 2017-2019 should therefore take account of all these elements and of the objectives of Regulation (EU) No 1380/2013, in particular Articles 2 and 25 thereof, to the extent possible within the current legal framework provided by Regulation (EC) No 199/2008. Where new data requirements go beyond the current legislative framework, they should be optional. Once a new legal framework amending Regulation (EC) No 199/2008 will enter into force, the Commission may amend the multiannual Union programme, if necessary, to reflect any new data collection requirements.

(9) The Commission has taken account of the recommendations resulting from consultation with the Regional Coordination Meetings referred to in Article 5 of Regulation (EC) No 199/2008 and the Scientific, Technical and Economic Committee for Fisheries (STECF). Other appropriate consultative scientific bodies such as the International Council for the Exploration of the Seas (ICES) have also been consulted, as well as representatives of Member States gathered in dedicated expert groups.

(10) For reasons of legal certainty, Implementing Decision C(2013)5243 should be repealed.

(11) The measures provided for in this Decision are in accordance with the opinion of the Management Committee for Fisheries and Aquaculture,

HAS ADOPTED THIS DECISION:

Article 1

The multiannual Union programme for the collection, management and use of data in the fisheries sector for the period 2017-2019, as referred to in Article 3 of Regulation (EC) No 199/2008, is set out in the Annex to this Decision.

Article 2

Implementing Decision C(2013)5243 is repealed with effect from 1 January 2017.

Article 3

This Decision is addressed to the Member States.

Done at Brussels, 12 July 2016.

For the Commission

Karmenu VELLA

Member of the Commission

ANNEX

CHAPTER I

Definitions

For the purpose of this Annex, definitions in Council Regulation (EC) No 1224/2009 ([1]), Commission Implementing Regulation (EU) No 404/2011 ([2]), and Regulation (EU) No 1380/2013 of the European Parliament and of the Council ([3]) shall apply. In addition, the following definitions shall also apply:

(1) **Active vessels**: vessels that have been engaged in any fishing operation (one day or more) during a calendar year. A vessel that has not been engaged in fishing operations during a year is considered 'inactive'.

(2) **Anadromous species**: living aquatic resources with lifecycle starting by hatching in freshwater, migrating to saltwater, returning and finally spawning in freshwater.

(3) **Catadromous species**: living aquatic resources with lifecycle starting by hatching in saltwater, migrating to freshwater, returning and finally spawning in saltwater.

(4) **Catch fraction**: a part of the total catch, such as the part of the catch landed above the minimum conservation reference size, the part landed below the minimum conservation reference size, the part discarded below the minimum conservation reference size, *de minimis* discards or discards.

(5) **Days at sea**: any continuous period of 24 hours (or part thereof) during which a vessel is present within an area and absent from port.

(6) **Fishing days**: any calendar day at sea in which a fishing operation takes place, without prejudice to the international obligations of the Union and its Member States. One fishing trip can contribute to both the sum of the fishing days for passive gears and the sum of the fishing days for active gears on that trip.

(7) **Fishing ground**: (group of) geographical units where fishing takes place. These units shall be agreed at marine region level on the basis of existing areas defined by regional fisheries management organisations or scientific bodies.

(8) **Fleet segment**: group of vessels with the same length class (LOA, length overall) and predominant fishing gear during the year.

(9) **Metier**: a group of fishing operations targeting a similar (assemblage of) species, using similar gear ([4]), during the same period of the year and/or within the same area and which are characterised by a similar exploitation pattern.

(10) **Research surveys at sea**: trips carried out on a research vessel, or a vessel dedicated to scientific research for stock and ecosystem monitoring, and designated for this task by the body in charge of the implementation of the national work plan established in accordance with Article 21 of Regulation (EU) No 508/2014.

([1]) Council Regulation (EC) No 1224/2009 of 20 November 2009 establishing a Community control system for ensuring compliance with the rules of the common fisheries policy, amending Regulations (EC) No 847/96, (EC) No 2371/2002, (EC) No 811/2004, (EC) No 768/2005, (EC) No 2115/2005, (EC) No 2166/2005, (EC) No 388/2006, (EC) No 509/2007, (EC) No 676/2007, (EC) No 1098/2007, (EC) No 1300/2008, (EC) No 1342/2008 and repealing Regulations (EEC) No 2847/93, (EC) No 1627/94 and (EC) No 1966/2006 (OJ L 343, 22.12.2009, p. 1).

([2]) Commission Implementing Regulation (EU) No 404/2011 of 8 April 2011 laying down detailed rules for the implementation of Council Regulation (EC) No 1224/2009 establishing a Community control system for ensuring compliance with the rules of the Common Fisheries Policy (OJ L 112, 30.4.2011, p. 1).

([3]) Regulation (EU) No 1380/2013 of the European Parliament and of the Council of 11 December 2013 on the Common Fisheries Policy, amending Council Regulations (EC) No 1954/2003 and (EC) No 1224/2009 and repealing Council Regulations (EC) No 2371/2002 and (EC) No 639/2004 and Council Decision 2004/585/EC (OJ L 354, 28.12.2013, p. 22).

([4]) As specified in Annex XI of Regulation (EU) No 404/2011.

CHAPTER II

Data collection methods

Data collection methods and quality shall be appropriate for the intended purposes defined in Article 25 of Regulation (EU) No 1380/2013 and shall follow the best practices and relevant methodologies advised by the relevant scientific bodies. To this end, the methods and the result of the application of the methods shall be examined at regular intervals by independent scientific bodies in order to verify their appropriateness with respect to the management of the common fisheries policy.

CHAPTER III

Data requirements

1. **Data sets**

1.1. Member States shall establish, as part of the work plans drawn up in accordance with Article 21 of Regulation (EU) No 508/2014, the data to be collected amongst the following sets as specified in points 2 to 7 of this Chapter:

(a) biological data, by catch fraction, on stocks caught by Union commercial fisheries in Union and outside Union waters and by recreational fisheries in Union waters;

(b) data to assess the impact of Union fisheries on the marine ecosystem in Union waters and outside Union waters;

(c) detailed data on the activity of Union fishing vessels in Union waters and outside Union waters as reported under Regulation (EC) No 1224/2009;

(d) social and economic data on fisheries ([1]);

(e) social, economic and environmental data on aquaculture;

1.2. The data to be collected shall be established in accordance with Articles 3, 4 and 5 of Regulation (EC) No 199/2008 and taking into account the thresholds set out in Chapter V of this Annex.

1.3. Data shall be collected to enable valid estimates to be derived for the type of fisheries, temporal periods and areas based on end-user needs agreed at marine region level. The frequency of data collection is to be coordinated at marine region level, unless stated otherwise in this Annex and corresponding tables.

2. **Biological data on stocks caught by Union commercial fisheries in Union and outside Union waters and by recreational fisheries in Union waters.**

Those data shall consist of the following:

(a) Catch quantities by species and biological data from individual specimens enabling the estimation of:

(i) For commercial fisheries, volume and length frequency of all catch fractions (including discards and unwanted catches) for the stocks listed in Tables 1A, 1B and 1C, reported at the aggregation level 6 as set out in Table 2. The temporal resolution shall be coordinated at marine region level based on end-user needs;

(ii) For commercial fisheries, mean-weight and age distribution of catches of the stocks listed in Table 1A, 1B and 1C. The selection of stocks from which these variables have to be collected and the temporal resolution shall be coordinated at marine region level based on end-user needs;

([1]) Data on the processing industry may be collected on a voluntary base, in that case the segmentation and variable in Table 11 may be used.

(iii) For commercial fisheries, sex-ratio, maturity and fecundity data for stocks listed in Tables 1A, 1B and 1C of catches at frequencies needed for scientific advice. The selection of stocks from which these variables have to be collected and the temporal resolution shall be coordinated at marine region level based on end-user needs;

(iv) For recreational fisheries, annual volume (numbers and weights or length) of catches and releases for the species listed in Table 3 and/or the species identified at marine region level as needed for fisheries management purposes End-user needs for age or other biological data as specified in paragraphs (i)-(iii) shall be evaluated for recreational fisheries at marine region level.

(b) In addition to data collected under point (a), data on anadromous and catadromous species listed in Table 1E caught by commercial fisheries during the freshwater part of their lifecycle, irrespective of the way these fisheries are undertaken, as follows:

(i) stock-related variables (for individual specimens, on age, length, weight, sex, maturity and fecundity, by life stage, but further specified on a species and regional basis); and

(ii) annual catch quantities by age class or life stage.

(c) In addition:

as regards eel, information (e.g. data, estimates, relative trends, etc.) collected annually in at least one river basin per eel management unit on:

(i) the abundance of recruits;

(ii) the abundance of the standing stock (yellow eel); and

(iii) the number or weight and sex ratio of emigrating silver eels;

and as regards all wild salmon: information collected annually — unless agreed otherwise at regional level — on the abundance of smolt and parr and number of ascending individuals.

The designation of rivers to be monitored for eel and salmon shall be defined at regional level. The selection of stocks from which these variables have to be collected shall be coordinated at regional level based on end-user needs.

3. **Data to assess the impact of Union fisheries on marine ecosystems in Union waters and outside Union waters**

Those data shall consist of the following:

(a) For all types of fisheries, incidental by-catch of all birds, mammals and reptiles and fish protected under Union legislation and international agreements, including the species listed in Table 1D, including absence in the catch, during scientific observer trips on fishing ships or by the fishers themselves through logbooks.

Where data collected during observer trips are not considered to provide sufficient data on incidental by-catch for end-user needs, other methodologies, shall be implemented by Member States. The selection of these methodologies shall be coordinated at marine region level and be based on end-user needs.

(b) Data to assist in the assessment of the impact of fisheries in Union waters and outside Union waters on marine habitats.

The variables used for assessing the impact of fisheries on marine habitat shall be those recorded under Regulation (EC) No 1224/2009. Data shall be disaggregated at fishing activity level 3 ([1]), unless a lower level of aggregation is required at regional level, in particular in the case of marine protected areas.

([1]) See Table 2.

When data recorded under Regulation (EC) No 1224/2009 are not at the correct resolution or are not of sufficient quality or coverage for the intended scientific use, they shall be collected in an alternative way by using appropriate sampling methods. Data as recorded under Regulation (EC) No 1224/2009 are to be made available at the appropriate level of aggregation to the national institutions implementing the work plans.

(c) Data for estimating the level of fishing and the impact of fishing activities on marine biological resources and on marine ecosystems, such as effects on non-commercial species, predator-prey relationships and natural mortality of fish species in each marine region.

These data shall be first assessed within pilot studies. Based on the outcomes of these pilot studies, Member States shall determine future data collection specific for each marine region, coordinated at marine region level and based on end-user needs.

4. **Detailed data on the activity of Union fishing vessels** [1] **in Union waters and outside Union waters as recorded under Regulation (EC) No 1224/2009.**

Data to assess the activity of Union fishing vessels in Union waters and outside Union waters consist of the variables as indicated in Table 4. Data as recorded, reported and transmitted under Regulation (EC) No 1224/2009 are to be made available in the form of primary data to the national institutions implementing the work plans. When these data are not to be collected under Regulation (EC) No 1224/2009 or when data collected under Regulation (EC) No 1224/2009 are not at the correct resolution or are not of sufficient quality or coverage for the intended scientific use, they shall be collected in an alternative way by using appropriate sampling methods. These methods shall allow for the estimation of variables listed in Table 4 at the lowest relevant geographic level by fleet segment (Table 5a) and metier level 6 (Table 2).

5. **Social and economic data on fisheries to enable the assessment of the social and economic performance of the Union fisheries sector.**

Those data shall consist of the following:

(a) Economic variables as indicated in Table 5A according to the sector segmentation of Table 5B and according to the supraregions as defined in Table 5C.

The population shall be all active and inactive vessels registered in the Union Fishing Fleet Register as defined in Commission Regulation (EC) No 26/2004 [2] on 31 December of the reporting year and vessels that do not appear on the Register at that date but have fished at least one day during the reporting year

For inactive vessels only capital value and capital cost shall be collected.

In cases where there is a risk of natural persons and/or legal entities being identified clustering may be applied to report economic variables in order to ensure statistical confidentiality. Clustering may also be used if necessary to design a statistically sound sampling plan. Such a clustering scheme shall be consistent over time.

Economic data shall be collected on an annual basis.

(b) Social variables as indicated in Table 6.

Social data shall be collected every three years starting in 2018.

Data on employment by education level and employment by nationality may be collected on the basis of pilot studies.

[1] Including specific requirements for RFMOs such as specified in Regulation (EU) No 1343/2011 of the European Parliament and of the Council of 13 December 2011 on certain provisions for fishing in the GFCM (General Fisheries Commission for the Mediterranean) Agreement area and amending Council Regulation (EC) No 1967/2006 concerning management measures for the sustainable exploitation of fishery resources in the Mediterranean Sea (OJ L 347, 30.12.2011, p. 44).

[2] Commission Regulation (EC) No 26/2004 of 30 December 2003 on the Community fishing fleet register (OJ L 5, 9.1.2004, p. 25).

6. **Social, economic and environmental data on marine aquaculture, and optionally on freshwater aquaculture, to enable the assessment of the social, economic and environmental performance of the Union aquaculture sector.**

Those data shall consist of the following:

(a) Economic variables as indicated in Table 7 according to the sector segmentation set out in Table 9.

The population shall be all enterprises whose primary activity is defined according to the European classification of economic activities NACE ([1]) codes 03.21 and 03.22 and who operate for profit.

Economic data shall be collected on an annual basis.

(b) Social variables as indicated in Table 6.

Social data shall be collected every three years starting in 2018.

Data on employment by education level and employment by nationality may be collected on the basis of pilot studies.

(c) Environmental data on aquaculture as indicated in Table 8 to enable the assessment of aspects of its environmental performance.

Environmental data may be collected on the basis of pilot studies and extrapolated to indicate totals relevant to the total volume of fish produced in the Member State.

Environmental data shall be collected every two years.

CHAPTER IV

Research surveys at sea

1. At least all research surveys at sea listed in Table 10 shall be carried out, unless a review of surveys leads to the conclusion that a survey is no longer appropriate for informing stock assessment and fisheries management. Based on the same scientific review criteria, new surveys can be added to this table.

2. Member States shall set out, as part of the work plans defined in Article 21 of Regulation (EU) No 508/2014, the research surveys at sea to be carried out and shall be responsible for these surveys.

3. Member States' respective contribution to international research surveys shall be coordinated within the same marine region.

4. Member States shall guarantee within their national work plans continuity with previous survey designs.

CHAPTER V

Thresholds

1. This Chapter shall apply to Union fisheries.

2. No biological data need to be collected if, for a certain fish stock or species:

(a) a Member State's share of the related total allowable catch (TAC) is less than 10 % of the total of the Union; or

([1]) Regulation (EC) No 1893/2006 of the European Parliament and of the Council of 20 December 2006 establishing the statistical classification of economic activities NACE Revision 2 and amending Council Regulation (EEC) No 3037/90 as well as certain EC Regulations on specific statistical domains (OJ L 393, 30.12.2006, p. 1).

(b) in case no TAC is fixed, the total landings of a Member State of a stock or species are less than 10 % of the average total EU landings in the previous 3 years; or

(c) the total annual landings of a Member State of a species is less than 200 tonnes. For species with a specific management need, a lower threshold may be defined at marine region level.

When the sum of the relevant quotas of several Member States, whose share of a TAC is less than 10 %, is higher than 25 % of the share of the TAC for a certain stock, the 10 % threshold referred to under (a) shall not apply and Member States shall ensure task-sharing at regional level in order to ensure that the stock is covered by sampling in concordance with end-user needs.

No threshold shall apply to large pelagic species and anadromous and catadromous species.

3. Without prejudice to more specific provisions relating to international obligations under RFMOs, no biological data need to be collected if, for a certain internationally exploited fish stock other than stocks of large pelagic or highly migratory species, the Union's share is less than 10 %.

4. Member States shall provide catch estimates from existing recreational fishery surveys, including those carried out under the data collection framework or from an additional pilot study, within two years from the date on which this Decision takes effect. These surveys shall allow assessment of the share of catches from recreational fisheries in relation to commercial catches for all species in a marine region for which recreational catch estimates are required under this multiannual Union programme. The subsequent design and extent of national surveys of recreational fisheries, including any thresholds for data collection, shall be coordinated at marine region level and shall be based on end-user needs.

No threshold shall apply to recreational catches of fish stocks which are subject to recovery or multiannual management plans such as those applying to large pelagic species and highly migratory species.

5. No social and economic data on aquaculture need to be collected if the total production of the Member State is less than 1 % of the total Union production volume and value. No data need to be collected on aquaculture for species accounting for less than 10 % of the Member State's aquaculture production by volume and value. Additionally, Member States with a total production of less than 2,5 % of the total Union aquaculture production volume and value may define a simplified methodology such as pilot studies with a view to extrapolate the data required for species accounting for more than 10 % of the Member States' aquaculture production by volume and value.

The reference data shall be the Member States' latest submission under Regulation (EC) No 762/2008 of the European Parliament and of the Council ([1]) and the corresponding data published by Eurostat.

6. No environmental data on aquaculture need to be collected where the total aquaculture production of the Member State is less than 2,5 % of the total Union aquaculture production volume and value.

The reference data shall be the Member States' latest submission under Regulation (EC) No 762/2008 of the European Parliament and of the Council, and corresponding data published by Eurostat.

7. A Member State's participation (physical or financial) in research surveys at sea listed in Table 10 is not mandatory when its share of a Union TAC of the survey target species is below a threshold of 3 %. Where no TAC is set, a Member State's participation (physical or financial) in research surveys at sea is not mandatory when its share of the total Union landings of the preceding 3 years of a stock or species is below a threshold of 3 %. Thresholds for multispecies and ecosystem surveys may be defined at marine region level.

8. Notwithstanding points 2 to 7, within the same marine region, Member States may agree on alternative thresholds.

([1]) Regulation (EC) No 762/2008 of the European Parliament and of the Council of 9 July 2008 on the submission by Member States of statistics on aquaculture and repealing Council Regulation (EC) No 788/96 (OJ L 218, 13.8.2008, p. 1).

BIOLOGICAL DATA

Table 1A

Stocks in Union waters

Species (common name)	Species (scientific name)	Area (ICES [1], IBSFC [2] or FAO [3] area code) where the stock is located/stock code
East Arctic, Norwegian Sea and Barents Sea		
European eel	*Anguilla anguilla*	I, II
Tusk	*Brosme brosme*	I, II
Atlanto-Scandian herring	*Clupea harengus*	I, II,
Cod	*Gadus morhua*	I, II
Capelin	*Mallotus villosus*	I, II
Haddock	*Melanogrammus aeglefinus*	I, II
Blue whiting	*Micromesistius poutassou*	I-II
Northern shrimp	*Pandalus borealis*	I, II
Saithe	*Pollachius virens*	I, II
Greenland halibut	*Reinhardtius hippoglossoides*	I, II
Salmon	*Salmo salar*	I, II
Mackerel	*Scomber scombrus*	II,
Golden redfish	*Sebastes marinus.*	I, II
Deep sea redfish	*Sebastes mentella.*	I, II
Horse mackerel	*Trachurus trachurus*	IIa,
Skagerrak and Kattegat		
Sand eel	*Ammodytidae*	IIIa
European eel	*Anguilla anguilla*	IIIa
Herring	*Clupea harengus*	IIIa/22-24, IIIa
Roundnose grenadier	*Coryphaenoides rupestris*	IIIa
Grey gurnard	*Eutrigla gurnardus*	IIIa
Red gurnard	*Aspitrigla cuculus*	IIIa,

Species (common name)	Species (scientific name)	Area (ICES [1], IBSFC [2] or FAO [3] area code) where the stock is located/stock code
Cod	*Gadus morhua*	IIIaN
Cod	*Gadus morhua*	IIIaS
Witch flounder	*Glyptocephalus cynoglossus*	IIIa
Dab	*Limanda limanda*	IIIa
Haddock	*Melanogrammus aeglefinus*	IIIa
Whiting	*Merlangius merlangus*	IIIa
Hake	*Merluccius merluccius*	IIIa,
Blue whiting	*Micromesistius poutassou*	IIIa
Norway lobster	*Nephrops norvegicus*	Functional unit
Northern shrimp	*Pandalus borealis*	IIIa
Plaice	*Pleuronectes platessa*	IIIa
Saithe	*Pollachius virens*	IIIa
Salmon	*Salmo salar*	IIIa
Turbot	*Psetta maxima*	IIIa
Mackerel	*Scomber scombrus*	IIIa
Brill	*Scophthalmus rhombus*	IIIa
Sole	*Solea solea*	IIIa
Sprat	*Sprattus sprattus*	IIIa
Norway pout	*Trisopterus esmarki*	IIIa
All commercial sharks, rays & skates [4]	*Selachii, Rajidae*	IIIa
Baltic Sea —		
European eel	*Anguilla anguilla*	22-32
Herring	*Clupea harengus*	22-24/25-29, 32/30/31/Gulf of Riga
Common whitefish/houting	*Coregonus lavaretus*	IIId
Vendace	*Coregonus albula*	22-32
Cod	*Gadus morhua*	22-24/25-32

Species (common name)	Species (scientific name)	Area (ICES [1], IBSFC [2] or FAO [3] area code) where the stock is located/stock code
Dab	*Limanda limanda*	22-32
Perch	*Perca fluviatilis*	IIId
Flounder	*Platichthys flesus*	22-32
Plaice	*Pleuronectes platessa*	22-32
Turbot	*Psetta maxima*	22-32
Salmon	*Salmo salar*	22-31/32
Sea trout	*Salmo trutta*	22-32
Pike-perch	*Sander lucioperca*	IIId
Brill	*Scophthalmus rhombus*	22-32
Sole	*Solea solea*	22
Sprat	*Sprattus sprattus*	22-32
North Sea and Eastern Channel		
Sand eel	*Ammodytidae*	IV
Catfish	*Anarhichas* spp.	IV
European eel	*Anguilla anguilla*	IV, VIId
Argentine	*Argentina* spp.	IV
Grey gurnard	*Eutrigla gurnardus*	IV
Tusk	*Brosme brosme*	IV
Herring	*Clupea harengus*	IV, VIId
Common shrimp	*Crangon crangon*	IV, VIId
Sea bass	*Dicentrarchus labrax*	IV, VIId
Grey gurnard	*Eutrigla gurnardus*	IV
Cod	*Gadus morhua*	IV, VIId
Witch flounder	*Glyptocephalus cynoglossus*	IV
Blue-mouth rockfish	*Helicolenus dactylopterus*	IV
Four-spot megrim	*Lepidorhombus boscii*	IV, VIId

Species (common name)	Species (scientific name)	Area (ICES [1], IBSFC [2] or FAO [3] area code) where the stock is located/stock code
Megrim	*Lepidorhombus whiffiagonis*	IV, VIId
Dab	*Limanda limanda*	IV, VIId
Black-bellied angler	*Lophius budegassa*	IV, VIId
Anglerfish	*Lophius piscatorius*	IV
Roughhead grenadier	*Macrourus berglax*	IV
Haddock	*Melanogrammus aeglefinus*	IV
Whiting	*Merlangius merlangus*	IV, VIId
Hake	*Merluccius merluccius*	IV VII
Blue whiting	*Micromesistius poutassou*	IV, VIId
Lemon sole	*Microstomus kitt*	IV, VIId
Blue ling	*Molva dypterygia*	IV
Ling	*Molva molva*	IV
Red mullet	*Mullus barbatus*	IV, VIId
Striped red mullet	*Mullus surmuletus*	IV, VIId
Norway lobster	*Nephrops norvegicus*	all functional units
Northern shrimp	*Pandalus borealis*	IVa East/IVa/IV
Common scallop	*Pecten maximus*	VIId
Greater forkbeard	*Phycis blennoides*	IV
Forkbeard	*Phycis phycis*	IV
Flounder	*Platichthys flesus*	IV
Plaice	*Pleuronectes platessa*	IV
Plaice	*Pleuronectes platessa*	VIId
Saithe	*Pollachius virens*	IV
Turbot	*Psetta maxima*	IV, VIId
Greenland halibut	*Reinhardtius hippoglossoides*	IV

Species (common name)	Species (scientific name)	Area (ICES [1], IBSFC [2] or FAO [3] area code) where the stock is located/stock code
Salmon	*Salmo salar*	IV, VIId
Mackerel	*Scomber scombrus*	IV, VIId
Brill	*Scophthalmus rhombus*	IV, VIId
Redfish	*Sebastes mentella.*	IV
Sole	*Solea solea*	IV
Sole	*Solea solea*	VIId
Sprat	*Sprattus sprattus*	IV/VIId
Horse mackerel	*Trachurus trachurus*	IV, VIId
Tub gurnard	*Trigla lucerna*	IV
Norway pout	*Trisopterus esmarki*	IV
John Dory	*Zeus faber*	IV, VIId
All commercial sharks, rays & skates [4]	*Selachii, Rajidae*	IV, VIId
North-East Atlantic and Western Channel		
Smoothhead	*Alepocephalus bairdii*	VI, XII
Sand eel	*Ammodytidae*	VIa
Boarfish	*Capros aper*	V, VI,VII
Scallop	*Pecten maximus*	IV, VI, VII
Queen scallop	*Aequipecten opercularis*	VII
Spider crab	*Maja squinado*	V, VI,VII
European eel	Anguilla anguilla	all areas
Scabbardfish	*Aphanopus spp.*	all areas
Argentine	*Argentina* spp.	all areas
Meagre	*Argyrosomus regius*	all areas
Red gurnard	*Aspitrigla cuculus*	all areas
Alfonsinos	*Beryx* spp.	all areas, excluding X and IXa
Alfonsinos	*Beryx* spp.	IXa and X

Species (common name)	Species (scientific name)	Area (ICES [1], IBSFC [2] or FAO [3] area code) where the stock is located/stock code
Edible crab	*Cancer pagurus*	all areas
Herring	*Clupea harengus*	VIa/VIaN/ VIa S, VIIbc/VIIa/VIIj
Conger	*Conger conger*	all areas, excluding X
Conger	*Conger conger*	X
Roundnose grenadier	*Coryphaenoides rupestris*	all areas
Kitefin shark	*Dalatias licha*	All areas
Common stingray	*Dasyatis pastinaca*	VII, VIII
Birdbeak dogfish	*Deania calcea*	V, VI, VII, IX, X, XII
Sea bass	*Dicentrarchus labrax*	all areas, excluding IX
Sea bass	*Dicentrarchus labrax*	IX
Wedge sole	*Dicologlossa cuneata*	VIIIc, IX
Anchovy	*Engraulis encrasicolus*	IXa (only Cádiz)
Anchovy	*Engraulis encrasicolus*	VIII
Velvet belly	*Etmopterus spinax*	VI, VII, VIII
Grey gurnard	*Eutrigla gurnardus*	VIId,e
Cod	*Gadus morhua*	Va/Vb/VIa/VIb/VIIa/VIIe-k
Witch	*Glyptocephalus cynoglossus*	VI, VII
Bluemouth rockfish	*Helicolenus dactylopterus*	all areas
Lobster	*Homarus gammarus*	all areas
Orange roughy	*Hoplostethus atlanticus*	all areas
Silver scabbardfish	*Lepidopus caudatus*	IXa
Four-spot megrim	*Lepidorhombus boscii*	VIIIc, IXa
Megrim	*Lepidorhombus whiffiagonis*	VI/VII, VIIIabd/VIIIc, IXa
Dab	*Limanda limanda*	VIIe/VIIa,f-h
Common squid	*Loligo vulgaris*	all areas, excluding VIIIc, IXa
Common squid	*Loligo vulgaris*	VIIIc, IXa

Species (common name)	Species (scientific name)	Area (ICES [1], IBSFC [2] or FAO [3] area code) where the stock is located/stock code
Black-bellied angler	*Lophius budegassa*	IV, VI/VIIb-k, VIIIabd
Black-bellied angler	*Lophius budegassa*	VIIIc, IXa
Anglerfish	*Lophius piscatorious*	IV, VI/VIIb-k, VIIIabd
Anglerfish	*Lophius piscatorious*	VIIIc, IXa
Capelin	*Mallotus villosus*	XIV
Haddock	*Melanogrammus aeglefinus*	Va/Vb
Haddock	*Melanogrammus aeglefinus*	VIa/VIb/VIIa/VIIb-k
Whiting	*Merlangius merlangus*	VIII/IX, X
Whiting	*Merlangius merlangus*	Vb/VIa/VIb/VIIa/VIIe-k
Hake	*Merluccius merluccius*	IIIa, IV, VI, VII, VIIIab/VIIIc, IXa
Wedge sole	*Microchirus variegatus*	all areas
Blue whiting	*Micromesistius poutassou*	I-IX, XII, XIV
Lemon sole	*Microstomus kitt*	all areas
Blue ling	*Molva dypterygia*	all areas, excluding X
Spanish ling	*Molva macrophthalma*	X
Ling	*Molva molva*	all areas
Striped red mullet	*Mullus surmuletus*	all areas
Starry smooth-hound	*Mustelus asterias*	VI, VII, VIII, IX
Smooth-hound	*Mustelus mustelus*	VI, VII, VIII, IX
Blackspotted smooth-hound	*Mustelus punctulatus*	VI, VII, VIII, IX
Norway lobster	*Nephrops norvegicus*	VI Fuctional unit
Norway lobster	*Nephrops norvegicus*	VII Functional unit
Norway lobster	*Nephrops norvegicus*	VIII, IX Functional unit
Common octopus	*Octopus vulgaris*	all areas, excluding VIIIc, IXa
Common octopus	*Octopus vulgaris*	VIIIc, IXa

Species (common name)	Species (scientific name)	Area (ICES [1], IBSFC [2] or FAO [3] area code) where the stock is located/stock code
Blackspot sea bream	*Pagellus bogaraveo*	IXa, X
Pandalid shrimps	*Pandalus* spp.	all areas
Deepwater rose shrimp	*Parapenaeus longirostris*	IXa
Greater forkbeard	*Phycis blennoides*	all areas
Forkbeard	*Phycis phycis*	all areas
Plaice	*Pleuronectes platessa*	VIIa/VIIe/VIIfg
Plaice	*Pleuronectes platessa*	VIIbc/VIIh-k/VIII, IX, X
Pollack	*Pollachius pollachius*	all areas except IX, X
Pollack	*Pollachius pollachius*	IX, X
Saithe	*Pollachius virens*	Va/Vb/IV, IIIa, VI
Saithe	*Pollachius virens*	VII, VIII
Wreckfish	*Polyprion americanus*	X
Turbot	*Psetta maxima*	all areas
Greenland halibut	*Reinhardtius hippoglossoides*	V, XIV/VI
Atlantic halibut	*Hippoglossus hippoglossus*	V, XIV
Salmon	*Salmo salar*	all areas
Sardine	*Sardina pilchardus*	VIIIabd/VIIIc, IXa
Spanish mackerel	*Scomber colias*	VIII, IX, X
Mackerel	*Scomber scombrus*	II, IIIa, IV, V, VI, VII, VIII, IX
Brill	*Scophthalmus rhombus*	all areas
Golden redfish	*Sebastes marinus*	ICES sub-areas V, VI, XII, XIV & NAFO SA 2 + (Div. 1F + 3K).
Deep sea redfish	*Sebastes mentella*	ICES sub-areas V, VI, XII, XIV & NAFO SA 2 + (Div. 1F + 3K)
Cuttlefish	*Sepia officinalis*	all areas
Sole	*Solea solea*	VIIa/VIIfg
Sole	*Solea solea*	VIIbc/VIIhjk/IXa/VIIIc

Species (common name)	Species (scientific name)	Area (ICES [1]), IBSFC [2]) or FAO [3]) area code) where the stock is located/stock code
Sole	*Solea solea*	VIIe
Sole	*Solea solea*	VIIIab
Sea breams (in plural)	*Sparidae*	all areas
Mediterranean horse mackerel	*Trachurus mediterraneus*	VIII, IX
Blue jack mackerel	*Trachurus picturatus*	VIII, IX, X
Horse mackerel	*Trachurus trachurus*	IIa, IVa, Vb, VIa, VIIa-c, e-k, VIIIabde/X
Horse mackerel	*Trachurus trachurus*	VIIIc, IXa
Pouting	*Trisopterus* spp.	all areas
John Dory	*Zeus faber*	all areas
All commercial sharks, rays & skates [4])	*Selachii, Rajidae*	IV, VIId
Mediterranean Sea and Black Sea		
European eel	*Anguilla anguilla*	all areas in the Med
Giant red shrimp	*Aristeomorpha foliacea*	all areas in the Med
Red shrimp	*Aristeus antennatus*	all areas in the Med
Bogue	*Boops boops*	1.3, 2.1, 2.2, 3.1, 3.2
Dolphinfish	*Coryphaena equiselis*	all areas in the Med
Dolphinfish	*Coryphaena hippurus*	all areas in the Med
Sea bass	*Dicentrarchus labrax*	all areas in the Med
Horned/curled octopus	*Eledone cirrhosa*	1.1, 1.3, 2.1, 2.2, 3.1
Musky octopus	*Eledone moschata*	1.3, 2.1, 2.2, 3.1
Anchovy	*Engraulis encrasicolus*	all areas in the Med
Anchovy	*Engraulis encrasicolus*	Black Sea GSA 29
Grey gurnard	*Eutrigla gurnardus*	2.2, 3.1
Squid	*Illex* spp., *Todarodes* spp.	all areas in the Med
Billfish	*Istiophoridae*	all areas in the Med

Species (common name)	Species (scientific name)	Area (ICES [1]), IBSFC [2]) or FAO [3]) area code) where the stock is located/stock code
Common squid	*Loligo vulgaris*	all areas in the Med
Black-bellied angler	*Lophius budegassa*	1.1, 1.2, 1.3, 2.2, 3.1
Anglerfish	*Lophius piscatorius*	1.1, 1.2, 1.3, 2.2, 3.1
Whiting	*Merlangius merlangus*	Black Sea GSA 29
Hake	*Merluccius merluccius*	all areas in the Med
Blue whiting	*Micromesistius poutassou*	1.1, 3.1
Grey mullets	*Mugilidae*	1.3, 2.1, 2.2, 3.1
Red mullet	*Mullus barbatus*	all areas in the Med
Red mullet	*Mullus barbatus*	Black Sea GSA 29
Striped red mullet	*Mullus surmuletus*	all areas in the Med
Common octopus	*Octopus vulgaris*	all areas in the Med
Norway lobster	*Nephrops norvegicus*	all areas in the Med
Pandora	*Pagellus erythrinus*	all areas in the Med
Deepwater rose shrimp	*Parapenaeus longirostris*	all areas in the Med
Caramote prawn	*Penaeus kerathurus*	3.1
Turbot	*Psetta maxima*	Black Sea GSA 29
Sardine	*Sardina pilchardus*	all areas in the Med
Mackerel	*Scomber* spp.	all areas in the Med
Cuttlefish	*Sepia officinalis*	all areas in the Med
Sole	*Solea vulgaris*	1.2, 2.1, 3.1
Gilthead sea bream	*Sparus aurata*	1.2, 3.1
Picarels	*Spicara smaris*	2.1, 3.1, 3.2
Sprat	*Sprattus sprattus*	Black Sea GSA 29
Mantis shrimp	*Squilla mantis*	1.3, 2.1, 2.2
Mediterranean horse mackerel	*Trachurus mediterraneus*	All areas in the Med

Species (common name)	Species (scientific name)	Area (ICES [1], IBSFC [2] or FAO [3] area code) where the stock is located/stock code
Mediterranean horse mackerel	*Trachurus mediterraneus*	Black Sea GSA 29
Horse mackerel	*Trachurus trachurus*	all areas in the Med
Horse mackerel	*Trachurus trachurus*	Black Sea GSA 29
Tub gurnard	*Trigla lucerna*	1.3, 2.2, 3.1
Clam	*Veneridae*	2.1, 2.2
Transparent gobid	*Aphia minuta*	GSA 9,10,16 and 19
Sand smelt	*Atherina* spp.	GSA 9,10,16 and 19
Poor cod	*Trisopterus minutus*	All regions
All commercial sharks, rays & skates [4]	*Selachii, Rajidae*	All regions

[1] International Council for the Exploration of the Sea.
[2] International Baltic Sea Fisheries Commission.
[3] Food and Agricultural Organisation of the United Nations.
[4] To be reported at species level.

BIOLOGICAL DATA

Table 1B

Stocks of outermost regions of the Union

Species (common name)	Species (scientific name)
French Guyana	
Red snapper	*Lutjanus purpureus*
Prawns	*Farfantepenaeus subtilis*
Acoupa weakfish	*Cynoscion acoupa*
Smalltooth weakfish	*Cynoscion steindachneri*
Green weakfish	*Cynoscion virescens*
Sea catfishes	*Ariidae*
Tripletail	*Lobotes surinamensis*
Torroto grunt	*Genyatremus luteus*
Snooks	*Centropomus* spp.

Species (common name)	Species (scientific name)
Groupers	*Serranidae*
Mullets	*Mugil* spp.
Guadeloupe and Martinique	
Snappers	*Lutjanidae*
Grunters	*Haemulidae*
Groupers	*Serranidae*
Lion fish	*Pterois volitans*
Tuna-like fish	*Scombridae*
Blue marlin	*Makaira nigricans*
Dolphinfish	*Coryphaena hippurus*
Réunion and Mayotte	
Snappers	*Lutjanidae*
Groupers	*Serranidae*
Tuna-like fish	*Scombridae*
Swordfish	*Xiphias gladius*
Other bill fishes	*Istiophoridae*
Dolphinfish	*Coryphaena hippurus*
Bigeye scad	*Selar crumenophthalmus*
Azores, Madeira and Canary Islands	
Atlantic chub mackerel	*Scomber colias*
Sardinella	*Sardinella maderensis*
Horse mackerel	*Trachurus* spp.
Sardine	*Sardina pilchardus*
Parrotfish	*Sparisoma cretense*
Limpets	*Patellidae*

BIOLOGICAL DATA

Table 1C

Stocks in marine regions under regional fisheries management organisations (RFMOS) and Sustainable Fishing Partnership Agreements (SFPAS)

IATTC (Inter-American Tropical Tuna Commission)

SPECIES When designing sampling plans aiming at collecting biological information as laid down in Chapter III of this Annex, stock boundaries, as fixed by the competent RFMOs or regional fisheries organisations (RFOs), shall be taken into account and appropriate sampling effort shall be allocated to each stock.				Frequency of collection of biological variables
Scientific name	Common name	Geographical Area	Priority	The data collection is annual and the updating/processing of the data must be done timely to fit the schedule of the stock assessments.
Thunnus albacares	Yellowfin tuna	East Pacific Ocean	High	
Thunnus obesus	Bigeye tuna	East Pacific Ocean	High	
Katsuwonus pelamis	Skipjack tuna	East Pacific Ocean	High	
Thunnus alalunga	Albacore tuna	East Pacific Ocean	High	
Thunnus orientalis	Pacific bluefin tuna	East Pacific Ocean	High	
Xiphias gladius	Swordfish	East Pacific Ocean	High	
Makaira nigricans (or mazara)	Blue marlin	East Pacific Ocean	High	
Makaira indica	Black marlin	East Pacific Ocean	High	
Tetrapturus audax	Striped marlin	East Pacific Ocean	High	

ICCAT (The International Commission for the Conservation of Atlantic Tunas)

SPECIES When designing sampling plans aiming at collecting biological information as laid down in Chapter III of this Annex, stock boundaries, as fixed by the competent RFMOs or RFOs, shall be taken into account and appropriate sampling effort shall be allocated to each stock.				Frequency of collection of biological variables
Scientific name	Common name	Geographical Area	Priority	The data collection is annual and the updating/processing of the data must be done timely to fit the schedule of the stock assessments.
Thunnus albacares	Yellowfin tuna	Atlantic Ocean and adjacent seas	High	
Thunnus obesus	Bigeye tuna	Atlantic Ocean and adjacent seas	High	
Katsuwonus pelamis	Skipjack tuna	Atlantic Ocean and adjacent seas	High	
Thunnus alalunga	Albacore tuna	Atlantic Ocean and adjacent seas	High	

SPECIES When designing sampling plans aiming at collecting biological information as laid down in Chapter III of this Annex, stock boundaries, as fixed by the competent RFMOs or RFOs, shall be taken into account and appropriate sampling effort shall be allocated to each stock.				Frequency of collection of biological variables
Thunnus thynnus	Bluefin tuna	Atlantic Ocean and adjacent seas	High	
Xiphias gladius	Swordfish	Atlantic Ocean and adjacent seas	High	
Makaira nigricans (or mazara)	Blue marlin	Atlantic Ocean and adjacent seas	High	
Istiophorus albicans	Sailfish	Atlantic Ocean and adjacent seas	High	
Tetrapturus albidus	White marlin	Atlantic Ocean and adjacent seas	High	
Prionace glauca	Blue shark	Atlantic Ocean and adjacent seas	High	
Auxis rochei	Bullet tuna	Atlantic Ocean and adjacent seas	High	
Sarda sarda	Atlantic bonito	Atlantic Ocean and adjacent seas	High	
Euthynnus alleteratus	Atlantic back skipjack	Atlantic Ocean and adjacent seas	Medium	
Thunnus atlanticus	Blackfin tuna	Atlantic Ocean and adjacent seas	Medium	
Orcynopsis unicolor	Plain bonito	Atlantic Ocean and adjacent seas	Medium	
Scomberomorus brasiliensis	Serra Spanish mackerel	Atlantic Ocean and adjacent seas	Medium	
Scomberomorus regalis	Cero	Atlantic Ocean and adjacent seas	Medium	
Auxis thazard	Frigate tuna	Atlantic Ocean and adjacent seas	Medium	
Scomberomorus cavalla	King mackerel	Atlantic Ocean and adjacent seas	Medium	
Scomberomorus tritor	West African Spanish mackerel	Atlantic Ocean and adjacent seas	Medium	
Scomberomorus maculatus	Atlantic Spanish mackerel	Atlantic Ocean and adjacent seas	Medium	

SPECIES When designing sampling plans aiming at collecting biological information as laid down in Chapter III of this Annex, stock boundaries, as fixed by the competent RFMOs or RFOs, shall be taken into account and appropriate sampling effort shall be allocated to each stock.				Frequency of collection of biological variables
Acanthocybium solandri	Wahoo	Atlantic Ocean and adjacent seas	Medium	
Coryphaena hippurus	Dolphinfish	Atlantic Ocean and adjacent seas	Medium	

NAFO (North Atlantic Fisheries Organisation)

SPECIES When designing sampling plans aiming at collecting biological information as laid down in Chapter III of this Annex, stock boundaries, as fixed by the competent RFMOs or RFOs, shall be taken into account and appropriate sampling effort shall be allocated to each stock.				Frequency of collection of biological variables
Scientific name	Common name	Stocks as defined by the RFMO	Priority	The data collection is annual and the updating/processing of the data must be done timely to fit the schedule of the stock assessments.
Gadus morhua	Cod	NAFO 2J 3KL	Low	
Gadus morhua	Cod	NAFO 3M	High	
Gadus morhua	Cod	NAFO 3NO	High	
Gadus morhua	Cod	NAFO 3Ps	High	
Gadus morhua	Cod	NAFO SA1	High	
Glyptocephalus cynoglossus	Witch flounder	NAFO 3NO	High	
Glyptocephalus cynoglossus	Witch flounder	NAFO 2J3KL	Low	
Hippoglossoides platessoides	American plaice	NAFO 3LNO	High	
Hippoglossoides platessoides	American plaice	NAFO 3M	High	
Limanda ferruginea	Yellowtail flounder	NAFO 3LNO	Medium	
Coryphaenoides rupestris	Roundnose Grenadier	NAFO SA0 + 1	Low	
Macrourus berglax	Roughhead grenadier	NAFO SA2 + 3	High	
Pandalus borealis	Northern shrimp	NAFO 3LNO	High	
Pandalus borealis	Northern shrimp	NAFO 3M	High	
Amblyraja radiata	Thorny skate	NAFO 3LNOPs	High	
Reinhardtius hippoglossoides	Greenland halibut	NAFO 3KLMNO	High	

SPECIES When designing sampling plans aiming at collecting biological information as laid down in Chapter III of this Annex, stock boundaries, as fixed by the competent RFMOs or RFOs, shall be taken into account and appropriate sampling effort shall be allocated to each stock.				Frequency of collection of biological variables
Reinhardtius hippoglossoides	Greenland halibut	NAFO SA1	High	
Hippoglossus hippoglossus	Atlantic halibut	NAFO SA1	Low	
Sebastes mentella	Redfish	NAFO SA1	High	
Sebastes spp.	Redfish	NAFO 3LN	High	
Sebastes spp.	Redfish	NAFO 3M	High	
Sebastes spp.	Redfish	NAFO 3O	High	
Urophycis tenuis	White hake	NAFO 3NO	High	
Mallotus villosus	Capelin	NAFO 3NO	High	
Beryx sp.	Alfonsinos	NAFO 6G	High	
Illex illecebrosus	Shortfin squid	NAFO Subareas 3 + 4	Low	
Salmo salar	Salmon	NAFO S1 + ICES Sub-area XIV, NEAF, NASCO	High	

FAO marine area 34 — Fisheries Committee for the Eastern Central Atlantic (CECAF)

SPECIES When designing sampling plans aiming at collecting biological information as laid down in chapter III of this Annex, stock boundaries, as fixed by the competent RFMOs or RFOs, shall be taken into account and appropriate sampling effort shall be allocated to each stock.				Frequency of collection of biological variables
Scientific name	Common name	Geographical Area	Priority	The data collection is annual and the updating/processing of the data shall be done timely to fit the schedule of the stock assessments.
Brachydeuterus spp.	Grunt	34.1.3, 34.3.1, 34.3.3-6	high	
Caranx spp.	Jack	34.3.1, 34.3.3-6	high	
Cynoglossus spp.	Tongue sole	34.1.1, 34.1.3, 34.3.1, 34.3.3-6	high	
Decapterus spp.	Scad	34.3.1, 34.3.3-6	high	
Dentex canariensis	Canary dentex	34.1.1, 34.1.3, 34.3.1, 34.3.3-6	medium	
Dentex congoensis	Congo dentex	34.1.1, 34.1.3, 34.3.1, 34.3.3-6	medium	
Dentex macrophthalmus	Large-eye dentex	34.1.1, 34.1.3, 34.3.1, 34.3.3-6	high	

SPECIES When designing sampling plans aiming at collecting biological information as laid down in chapter III of this Annex, stock boundaries, as fixed by the competent RFMOs or RFOs, shall be taken into account and appropriate sampling effort shall be allocated to each stock.				Frequency of collection of biological variables
Dentex maroccanus	Morocco dentex	34.1.1, 34.1.3, 34.3.1, 34.3.3-6	medium	
Dentex spp.	Dentex	34.1.1, 34.1.3, 34.3.1, 34.3.3-6	high	
Engraulis encrasicolus	Anchovy	34.1.1, 34.1.3, 34.3.1, 34.3.3-6	high	
Epinephelus aeneus	White grouper	34.1.3, 34.3.1, 34.3.3-6	high	
Ethmalosa fimbriata	Bonga shad	34.3.1, 34.3.3-6	high	
Farfantepenaeus notialis	Southern pink shrimp	34.1.1, 34.1.3, 34.3.1, 34.3.3-6	high	
Galeoides decadactylus	Lesser African threadfin	34.1.3, 34.3.1, 34.3.3-6	high	The data collection is annual and the updating/processing of the data shall be done timely to fit the schedule of the stock assessments.
Loligo vulgaris	Common squid	34.1.1, 34.1.3, 34.3.1, 34.3.3-6	high	
Merluccius polli	Benguela hake	34.1.1, 34.1.3, 34.3.1, 34.3.3-6	high	
Merluccius senegalensis	Senegalese hake	34.1.1, 34.1.3, 34.3.1, 34.3.3-6	high	
Merluccius spp.	Other hake	34.1.1, 34.1.3, 34.3.1, 34.3.3-6	medium	
Octopus vulgaris	Common octopus	34.1.1, 34.1.3, 34.3.1, 34.3.3-6	high	
Pagellus acarne	axillary sea bream	34.1.1	high	
Pagellus bellottii	Red pandora	34.1.1, 34.1.3, 34.3.1, 34.3.3-6	high	
Pagellus bogaraveo	Blackspot sea bream	34.1.1	medium	
Pagellus spp.	Pandora	34.1.1, 34.1.3, 34.3.1, 34.3.3-6	high	
Pagrus caeruleostictus	Blue spotted sea bream	34.1.1, 34.1.3, 34.3.1, 34.3.3-6	high	
Parapenaeus longirostris	Deepwater rose shrimp	34.1.1, 34.1.3, 34.3.1, 34.3.3-6	high	
Pomadasys incisus	Bastard grunt	34.1.1	medium	
Pomadasys spp.	Grunt	34.1.1, 34.1.3, 34.3.1, 34.3.3-6	high	

SPECIES When designing sampling plans aiming at collecting biological information as laid down in chapter III of this Annex, stock boundaries, as fixed by the competent RFMOs or RFOs, shall be taken into account and appropriate sampling effort shall be allocated to each stock.				Frequency of collection of biological variables
Pseudotolithus spp.	West African croakers	34.1.1	high	
Sardina pilchardus	Sardine	34.1.1, 34.1.3	high	
Sardinella aurita	Round sardinella	34.1.1, 34.1.3, 34.3.1, 34.3.3-6	high	
Sardinella maderensis	Short-body sardinella	34.1.1, 34.1.3, 34.3.1, 34.3.3-6	high	The data collection is annual and the updating/processing of the data shall be done timely to fit the schedule of the stock assessments.
Scomber japonicus	Chub mackerel	34.1.1, 34.1.3, 34.3.1, 34.3.3-6	high	
Scomber spp.	Other Mackerel	34.1.1, 34.1.3, 34.3.1, 34.3.3-6	high	
Sepia hierredda	Cuttlefish	34.1.1, 34.1.3, 34.3.1, 34.3.3-6	high	
Sepia officinalis	Common cuttlefish	34.1.1, 34.1.3, 34.3.1, 34.3.3-6	high	
Sepia spp.	Cuttlefishes	34.1.1, 34.1.3, 34.3.1, 34.3.3-6	medium	
Sparidae	Sea bream	34.1.1, 34.1.3, 34.3.1, 34.3.3-6	high	
Sparus spp.	Sea bream	34.1.1	high	
Trachurus trachurus	Atlantic horse mackerel	34.1.1, 34.1.3, 34.3.1, 34.3.3-6	high	
Trachurus trecae	Cunene horse mackerel	34.1.1, 34.1.3, 34.3.1, 34.3.3-6	high	
Umbrina canariensis	Canary drum	34.3.3-6	medium	

SEAFO (South-East Atlantic Fisheries Organisation)

SPECIES When designing sampling plans aiming at collecting biological information as laid down in Chapter III of this Annex, stock boundaries, as fixed by the competent RFMOs or RFOs, shall be taken into account and appropriate sampling effort shall be allocated to each stock.				Frequency of collection of biological variables
Scientific name	Common name	Geographical Area	Priority	The data collection is annual and the updating/processing of the data shall be done timely to fit the schedule of the stock assessments.
Dissostichus eleginoides	Patagonian toothfish	South-East Atlantic	*High*	
Beryx spp.	Alfonsinos	South-East Atlantic	*High*	

SPECIES When designing sampling plans aiming at collecting biological information as laid down in Chapter III of this Annex, stock boundaries, as fixed by the competent RFMOs or RFOs, shall be taken into account and appropriate sampling effort shall be allocated to each stock.				Frequency of collection of biological variables
Chaceon spp.	Red/Golden crabs	South-East Atlantic	*High*	
Pseudopentaceros richardsoni	Pelagic armourhead/ Southern boarfish	South-East Atlantic	*High*	
Helicolenus spp.	Blackbelly rosefishes	South-East Atlantic	*High*	
Hoplostethus atlanticus	Orange roughy	South-East Atlantic	*High*	
Trachurus spp.	Horse mackerel	South-East Atlantic	*High*	
Scomber spp.	Mackerel	South-East Atlantic	*High*	
Polyprion americanus	Wreckfish	South-East Atlantic	*Medium*	
Jasus tristani	Tristan rock lobster	South-East Atlantic	*Medium*	
Lepidotus caudatus	Silver scabbardfish	South-East Atlantic	*Medium*	
Schedophilus ovalis	Imperial blackfish	South-East Atlantic	*Low*	
Schedophilus velaini	Violet warehou	South-East Atlantic	*Low*	
Allocyttus verucossus	Oreo dories	South-East Atlantic	*Low*	
Neocyttus romboidales		South-East Atlantic		
Allocyttus guineensis		South-East Atlantic		
Pseudocyttu smaculatus		South-East Atlantic		
Emmelichthys nitidus	Cape bonnetmouth	South-East Atlantic	*Low*	
Ruvettus pretiosus	Oilfish	South-East Atlantic	*Low*	
Promethichthys prometheus	Roudi escolar	South-East Atlantic	*Low*	
Macrourus spp.	Grenadiers	South-East Atlantic	*Low*	
Antimora rostrata	Blue antimora	South-East Atlantic	*Low*	
Epigonus spp.	Cardinal fish	South-East Atlantic	*Low*	
Merluccius spp.	Hake	South-East Atlantic	*Low*	

SPECIES When designing sampling plans aiming at collecting biological information as laid down in Chapter III of this Annex, stock boundaries, as fixed by the competent RFMOs or RFOs, shall be taken into account and appropriate sampling effort shall be allocated to each stock.				Frequency of collection of biological variables
Notopogon fernandezianus	Orange bellowfish	South-East Atlantic	*Low*	
Octopodidae and Loliginidae	Octopus and squids	South-East Atlantic	*Low*	

WCPFC (Western and Central Pacific Fisheries Commission)

SPECIES When designing sampling plans aiming at collecting biological information as laid down in Chapter III of this Annex, stock boundaries, as fixed by the competent RFMOs or RFOs, shall be taken into account and appropriate sampling effort shall be allocated to each stock.				Frequency of collection of biological variables
Scientific name	Common name	Geographical Area	Priority	The data collection is annual and the updating/processing of the data shall be done timely to fit the schedule of the stock assessments.
Thunnus albacares	Yellowfin tuna	West Central Pacific Ocean	High	
Thunnus obesus	Bigeye tuna	West Central Pacific Ocean	High	
Katsuwonus pelamis	Skipjack tuna	West Central Pacific Ocean	High	
Thunnus alalunga	Albacore tuna	West Central Pacific Ocean	High	
Thunnus orientalis	Pacific bluefin tuna	West Central Pacific Ocean	High	
Xiphias gladius	Swordfish	West Central Pacific Ocean	High	
Makaira nigricans (or mazara)	Blue marlin	West Central Pacific Ocean	High	
Makaira indica	Black marlin	West Central Pacific Ocean	High	
Tetrapturus audax	Striped marlin	West Central Pacific Ocean	High	
Acanthocybium solandri	Wahoo	West Central Pacific Ocean	Medium	
Coryphaena hippurus	Dolphinfish	West Central Pacific Ocean	Medium	
Elagatis bipinnulata	Rainbow runner	West Central Pacific Ocean	Medium	
Lepidocybium flavobrunneum	Escolar	West Central Pacific Ocean	Medium	
Lampris regius	Moonfish (opah)	West Central Pacific Ocean	Medium	

SPECIES When designing sampling plans aiming at collecting biological information as laid down in Chapter III of this Annex, stock boundaries, as fixed by the competent RFMOs or RFOs, shall be taken into account and appropriate sampling effort shall be allocated to each stock.				Frequency of collection of biological variables
Mola mola	Sunfish	West Central Pacific Ocean	Medium	
Istiophorus platypterus	Sailfish	West Central Pacific Ocean	Medium	
Tetrapturus angustirostris	Spearfish	West Central Pacific Ocean	Medium	
Ruvettus pretiosus	Oilfish	West Central Pacific Ocean	Medium	
Prionace glauca	Blue shark	West Central Pacific Ocean	High	
Carcharhinus longimanus	Oceanic whitetip shark	West Central Pacific Ocean	High	
Carcharhinus falciformis	Silky shark	West Central Pacific Ocean	High	
Alopias superciliosus	big eye thresher	West Central Pacific Ocean	High	
Alopias vulpinus	Common thresher	West Central Pacific Ocean	High	
Alopias pelagicus	Pelagic thresher	West Central Pacific Ocean	High	

NB: for WCPF, the following reporting requirements for long liners shall be added:

(1) Number of branch lines between floats. The number of branch lines between floats shall be reported for each set.

(2) Number of fish caught per set, for the following species: albacore (*Thunnus alalunga*), bigeye (*Thunnus obesus*), skipjack (*Katsuwonus pelamis*), yellowfin (*Thunnus albacares*), striped marlin (*Tetrapturus audax*), blue marlin (*Makaira mazara*), black marlin (*Makaira indica*) and swordfish (*Xiphias gladius*), blue shark, silky shark, oceanic whitetip shark, mako sharks, thresher sharks, porbeagle shark (south of 20° S, until biological data shows this or another geographic limit to be appropriate), hammerhead sharks (winghead, scalloped, great, and smooth), whale shark, and other species as determined by the Commission.

If the total weight or average weight of fish caught per set has been recorded, then the total weight or average weight of fish caught per set, by species, shall also be reported. If the total weight or average weight of fish caught per set has not been recorded, then the total weight or average weight of fish caught per set, by species, shall be estimated and the estimates reported. The total weight or average weight shall refer to whole weights, rather than processed weights.

WECAFC (Western Central Atlantic Fishery Commission)

SPECIES When designing sampling plans aiming at collecting biological information as laid down in chapter III of this Annex, stock boundaries, as fixed by the competent RFMOs or RFOs, shall be taken into account and appropriate sampling effort shall be allocated to each stock.				Frequency of collection of biological variables
Scientific name	Common name	Geographical Area	Priority	The data collection is annual and the updating/processing of the data shall be done timely to fit the schedule of the stock assessments.
Panulirus argus	Caribbean spiny lobster	West Central Atlantic	High	
Strombus gigas	Queen conch	West Central Atlantic	High	

SPECIES When designing sampling plans aiming at collecting biological information as laid down in chapter III of this Annex, stock boundaries, as fixed by the competent RFMOs or RFOs, shall be taken into account and appropriate sampling effort shall be allocated to each stock.				Frequency of collection of biological variables
Shark-like Selachii, Rajidae	Sharks, rays & skates	West Central Atlantic	High	
Coryphaena hippurus	Dolphin fish	West Central Atlantic	High	
Acanthocybium solandri	Wahoo	West Central Atlantic	High	
Epinephelus guttatus	Red hind	West Central Atlantic	High	
Lutjanus vivanus	Silk snapper	West Central Atlantic	High	
Lutjanus buccanella	Blackfin snapper	West Central Atlantic	High	
Lutjanus campechanus	Red snapper	West Central Atlantic	High	
Penaeus subtilis	Penaeus shrimp	French Guiana EEZ	High	

IOTC (Indian Ocean Tuna Commission)

SPECIES When designing sampling plans aiming at collecting biological information as laid down in chapter III of this Annex, stock boundaries, as fixed by the competent RFMOs or RFOs, shall be taken into account and appropriate sampling effort shall be allocated to each stock.				Frequency of collection of biological variables
Scientific name	Common name	Geographical Area	Priority	
Thunnus albacares	Yellowfin tuna	Indian Ocean Western and Eastern	High	The data collection is annual and the updating/processing of the data shall be done timely to fit the schedule of the stock assessments.
Thunnus obesus	Bigeye tuna	Indian Ocean Western and Eastern	High	
Katsuwonus pelamis	Skipjack tuna	Indian Ocean Western and Eastern	High	
Thunnus alalunga	Albacore tuna	Indian Ocean Western and Eastern	High	
Xiphias gladius	Swordfish	Indian Ocean Western and Eastern	High	
Makaira nigricans (or mazara)	Blue marlin	Indian Ocean Western and Eastern	High	
Makaira indica	Black marlin	Indian Ocean Western and Eastern	High	
Tetrapturus audax	Striped marlin	Indian Ocean Western and Eastern	High	
Istiophorus platypterus	Indo-Pacific sailfish	Indian Ocean Western and Eastern	High	

SPECIES When designing sampling plans aiming at collecting biological information as laid down in chapter III of this Annex, stock boundaries, as fixed by the competent RFMOs or RFOs, shall be taken into account and appropriate sampling effort shall be allocated to each stock.				Frequency of collection of biological variables
Auxis rochei	Bullet tuna	Indian Ocean Western and Eastern	Medium	
Auxis thazard	Frigate tuna	Indian Ocean Western and Eastern	Medium	
Euthynnus affinis	Kawakawa	Indian Ocean Western and Eastern	Medium	
Thunnus tonggol	Longtail tuna	Indian Ocean Western and Eastern	Medium	
Scomberomorus guttatus	Indo-Pacific king mackerel	Indian Ocean Western and Eastern	Medium	
Scomberomorus commerson	Narrow-barred Spanish mackerel	Indian Ocean Western and Eastern	Medium	
Prionace glauca	Blue shark	Indian Ocean Western and Eastern	High	
Alopias superciliosus	Bigeye thresher shark	Indian Ocean Western and Eastern	High	
Carcharhinus falciformes	Silky shark	Indian Ocean Western and Eastern	High	
Carcharhinus longimanus	Oceanic whitetip shark	Indian Ocean Western and Eastern	High	
Alopias pelagicus	Pelagic thresher shark	Indian Ocean Western and Eastern	High	
Sphyrna lewini	Scalloped hammerhead shark	Indian Ocean Western and Eastern	High	

Other RFMOs

SPECIES When designing sampling plans aiming at collecting biological information as laid down in chapter III Annex, stock boundaries, as fixed by the competent RFMOs or RFOs, shall be taken into account and appropriate sampling effort shall be allocated to each stock.				Frequency of collection of biological variables
Scientific name	Common name	Geographical Area	Priority	The data collection is annual and the updating/processing of the data shall be done timely to fit the schedule of the stock assessments.
Trachurus murphyi	Jack mackerel	SPRFMO Convention Area	High	
Euphausia superba	Krill	CCAMLR Convention Area	High	

SPECIES When designing sampling plans aiming at collecting biological information as laid down in chapter III Annex, stock boundaries, as fixed by the competent RFMOs or RFOs, shall be taken into account and appropriate sampling effort shall be allocated to each stock.				Frequency of collection of biological variables
Dissostichus spp. *Dissostichus eleginoides and Dissostichus mawsoni)*	Toothfish	CCAMLR Convention Area	High	
Champsocephalus gunnari	Mackerel icefish	CCAMLR Convention Area	Low	
Resources of fish, molluscs, crustaceans and other sedentary species within the competence area, but excluding: (i) sedentary species subject to the fishery jurisdiction of coastal states pursuant to Article 77(4) of the 1982 UN Convention on the Law of the Sea; and (ii) highly migratory species listed in Annex I of the 1982 UN Convention on the Law of the Sea.		SIOFA Convention Area		

BIOLOGICAL DATA

Table 1D

Species to be monitored under protection programmes in the Union or under international obligations

Common name	Scientific name	Region/RFMO	Legal framework
Bony fishes	Teleostei		
Sturgeons	*Acipenser* spp.	Mediterranean Sea and Black Sea; Baltic Sea; OSPAR II, IV	Annex II of the Barcelona Convention ([1]), Annex IV of the Black Sea Biodiversity and Landscape Conservation Protocol; OSPAR ([2]); Helcom ([3])
Smoothheads (Slickheads)	*Alepocephalidae*	All regions	Relevant for deep sea fisheries ([4])
Baird's smoothhead	*Alepocephalus Bairdii*	All regions	Relevant for deep sea fisheries
Risso's smoothhead	*Alepocephalus rostratus*	All regions	Relevant for deep sea fisheries
Pontic shad	*Alosa immaculata*	Black Sea	Annex IV of the Black Sea Biodiversity and Landscape Conservation Protocol
Allis shad	*Alosa alosa*	OSPAR II, III, IV	OSPAR
Common Whitefish/ houting	*Coregonus lavaretus*	OSPAR II	OSPAR
Cod	*Gadus morhua*	OSPAR II, III; Baltic Sea	OSPAR; Helcom

Common name	Scientific name	Region/RFMO	Legal framework
Long-snouted seahorse	*Hippocampus guttulatus* (synonym: *Hippocampus ramulosus*)	OSPAR II, III, IV, V	OSPAR
Short-snouted seahorse	*Hippocampus hippocampus*	OSPAR II, III, IV, V	OSPAR
Black Sea shad	*Alosa tanaica*	Black Sea	Annex IV of the Black Sea Biodiversity and Landscape Conservation Protocol
Blue antimora (Blue hake)	*Antimora rostrata*	All regions	Relevant for deep sea fisheries
Black scabbardfish	*Aphanopus carbo*	All regions	Relevant for deep sea fisheries
Scabbardfish	*Aphanopus intermedius*	All regions	Relevant for deep sea fisheries
Crayfish	*Astacus* spp.	Black Sea	Annex IV of the Black Sea Biodiversity and Landscape Conservation Protocol
Big-scale sand smelt	*Atherina pontica*	Black Sea	Annex IV of the Black Sea Biodiversity and Landscape Conservation Protocol
Garfish	*Belone belone euxini Günther*	Black Sea	Annex IV of the Black Sea Biodiversity and Landscape Conservation Protocol
Alfonsinos	*Beryx* spp.	All regions	Relevant for deep sea fisheries
Brotula	*Cataetyx laticeps*	All regions	Relevant for deep sea fisheries
Vendace	*Coregonus albula*	Baltic Sea	RCM Baltic recommendation
lumpfish	*Cyclopterus lumpus*	All regions	Relevant for deep sea fisheries
Annular seabream	*Diplodus annularis*	Mediterranean Sea	Council Regulation (EC) No 1967/2006 ([5]) (min. cons. size)
Sharpsnout sea bream	*Diplodus puntazzo*	Mediterranean Sea	Regulation (EC) No 1967/2006 (min. cons. size)
White sea bream	*Diplodus sargus*	Mediterranean Sea	Regulation (EC) No 1967/2006 (min. cons. size)
Two-banded sea bream	*Diplodus vulgaris*	Mediterranean Sea	Regulation (EC) No 1967/2006 (min. cons. size)
Patagonian toothfish	*Dissostichus eleginoides*	All regions	Relevant for deep sea fisheries
Antarctic toothfish	*Dissostichus mawsoni*	All regions	Relevant for deep sea fisheries

Common name	Scientific name	Region/RFMO	Legal framework
Groupers	*Epinephelus* spp.	Mediterranean Sea	Regulation (EC) No 1967/2006 (min. cons. size)
Black cardinalfish	*Epigonus telescopus*	All regions	Vulnerable species Relevant for deep sea fisheries
Gobies	*Gobiidae*	Black Sea	Annex IV of the Black Sea Biodiversity and Landscape Conservation Protocol
Bluemouth (Bluemouth redfish)	*Helicolenus dactylopterus*	All regions	Relevant for deep sea fisheries
Atlantic halibut	*Hippoglossus hippoglossus*	All regions	Relevant for deep sea fisheries
Orange roughy	*Hoplostethus atlanticus*	All regions; OSPAR I, V	Vulnerable species Relevant for deep sea fisheries
Silver roughy (Pink)	*Hoplosthetus mediterraneus*	All regions	Relevant for deep sea fisheries
Silver scabbard fish (Cutless fish)	*Lepidopus caudatus*	All regions	Relevant for deep sea fisheries
Stripped sea bream	*Lithognathus mormyrus*	Mediterranean Sea	Regulation (EC) No 1967/2006 (min. cons. size)
Golden grey mullet	*Liza aurata*	Black Sea	Annex IV of the Black Sea Biodiversity and Landscape Conservation Protocol
Leaping mullet	*Liza saliens*	Black Sea	Annex IV of the Black Sea Biodiversity and Landscape Conservation Protocol
Greater eelpout	*Lycodes esmarkii*	All regions	Relevant for deep sea fisheries
Grenadiers (rattails) other than roundnose grenadier and roughhead grenadier	*Macrouridae other than Coryphaenoides rupestris and Macrourus berglax*	All regions	Relevant for deep sea fisheries
Roughhead grenadier (Rough rattail)	*Macrourus berglax*	All regions	Relevant for deep sea fisheries
Whiting	*Merlangius merlangus*	Baltic Sea and Black Sea	RCM Baltic recommendation; Annex IV of the Black Sea Biodiversity and Landscape Conservation Protocol
European eel	*Anguilla anguilla*	OSPAR I, II, III, IV, Baltic sea	OSPAR; Helcom
Atlantic Salmon	**Salmo salar*	OSPAR I, II, III, IV, Baltic Sea	OSPAR; Helcom
Bluefin tuna	**Thunnus thynnus*	OSPAR V	OSPAR; Helcom

Common name	Scientific name	Region/RFMO	Legal framework
Blue ling	*Molva dypterygia*	All regions	Relevant for deep sea fisheries
Common mora	*Mora moro*	All regions	Relevant for deep sea fisheries
Mullet	*Mugil* spp.	Black Sea	Annex IV of the Black Sea Biodiversity and Landscape Conservation Protocol
Black gemfish	*Nesiarchus nasutus*	All regions	Relevant for deep sea fisheries
Snubnosed spiny eel	*Notocanthus chemnitzii*	All regions	Relevant for deep sea fisheries
Smelt	*Osmerus eperlanus*	Baltic Sea	RCM (Regional Coordination Meeting) Baltic recommendation, Helcom
Spanish sea bream	*Pagellus acarne*	Mediterranean Sea	Regulation (EC) No 1967/2006 (min. cons. size)
Blackspot seabream	*Pagellus bogaraveo*	Mediterranean Sea	Regulation (EC) No 1967/2006 (min. cons. size)
Common sea bream	*Pagrus pagrus*	Mediterranean Sea	Regulation (EC) No 1967/2006 (min. cons. size)
Wreckfish	*Polyprion americanus*	Mediterranean Sea	Regulation (EC) No 1967/2006 (min. cons. size)
Wreckfish	*Polyprion americanus*	All regions	Relevant for deep sea fisheries
Bluefish	*Pomatomus saltatrix*	Black Sea	Annex IV of the Black Sea Biodiversity and Landscape Conservation Protocol
Small redfish (Norway redfish)	*Sebastes viviparus*	All regions	Relevant for deep sea fisheries
Beluga	*Huso huso*	Black Sea	Annex IV of the Black Sea Biodiversity and Landscape Conservation Protocol
Spiny (deep sea) scorpionfish	*Trachyscorpia cristulata*	All regions	Relevant for deep sea fisheries
Oceanic sea breams	*Brama* spp.	GSA 1.1, 1.2, 1.3 and Black Sea GSA 29	Annex VIII of Council Regulation (EC) No 894/97 ([6])
Atlantic chub mackerel	*Scomber colias Gmelin*	Black sea	Annex IV of the Black Sea Biodiversity and Landscape Conservation Protocol
Crystal gobid	*Crystallogobius linearis*	Black sea	National management plans
Rabbit fish	*Chimaera monstrosa*	Baltic Sea	Helcom

Common name	Scientific name	Region/RFMO	Legal framework
Allis shad	*Alosa alosa*	Baltic Sea	Helcom
Twaite shad	*Alosa fallax*	Baltic Sea	Helcom
Autumn-spawning herring	*Clupea harengus* subsp.	Baltic Sea	Helcom
Zope	*Abramis ballerus*	Baltic Sea	Helcom
Bleak	*Alburnus alburnus*	Baltic Sea	Helcom
Asp	*Aspius aspius*	Baltic Sea	Helcom
Barbel	*Barbus barbus*	Baltic Sea	Helcom
Gudgeon	*Gobio gobio*	Baltic Sea	Helcom
Ziege	*Pelecus cultratus*	Baltic Sea	Helcom
Eurasian minnow	*Phoxinus phoxinus*	Baltic Sea	Helcom
Vimba	*Vimba vimba*	Baltic Sea	Helcom
Spined loach	*Cobitis taenia*	Baltic Sea	Helcom
Trout	*Salmo trutta*	Baltic Sea	Helcom
Vendace	*Coregonus albula*	Baltic Sea	Helcom
Baltic houting	*Coregonus balticus* *Synonym: Coregonus lavaretus, migratory*	Baltic Sea	Helcom
Maraena	*Coregonus maraena* *Synonym: Coregonus lavaretus, stationary*	Baltic Sea	Helcom
Pallas's houting	*Coregonus pallasii*	Baltic Sea	Helcom
Marine smelt	*Osmerus eperlanomarinus*	Baltic Sea	Helcom
Black-bellied angler	*Lophius budegassa*	Baltic Sea	Helcom
Sea stickleback	*Spinachia spinachia*	Baltic Sea	Helcom
Snake pipefish	*Entelurus aequoreus*	Baltic Sea	Helcom
Straightnose pipefish	*Nerophis ophidion*	Baltic Sea	Helcom
Worm pipefish	*Nerophis lumbriciformis*	Baltic Sea	Helcom

Common name	Scientific name	Region/RFMO	Legal framework
Greater pipefish	*Syngnathus acus*	Baltic Sea	Helcom
Broad-nosed pipefish	*Syngnathus typhle*	Baltic Sea	Helcom
Roundnose grenadier	*Coryphaenoides rupestris*	Baltic Sea	Helcom
Haddock	*Melanogrammus aeglefinus*	Baltic Sea	Helcom
Pollack	*Pollachius pollachius*	Baltic Sea	Helcom
Ling	*Molva molva*	Baltic Sea	Helcom
Snakeblenny	*Lumpenus lampretaeformis*	Baltic Sea	Helcom
Ocean perch	*Sebastes marinus*	Baltic Sea	Helcom
Norway redfish	*Sebastes viviparus*	Baltic Sea	Helcom
Miller's thumb	*Cottus gobio*	Baltic Sea	Helcom
Alpine bullhead	*Cottus poecilopus*	Baltic Sea	Helcom
Shorthorn sculpin	*Myoxocephalus scorpius*	Baltic Sea	Helcom
Longspined bullhead	*Taurulus bubalis*	Baltic Sea	Helcom
Fourhorn sculpin	*Triglopsis quadricornis*	Baltic Sea	Helcom
Lumpsucker	*Cyclopterus lumpus*	Baltic Sea	Helcom
Striped seasnail	*Liparis liparis*	Baltic Sea	Helcom
Montagu's seasnail	*Liparis montagui*	Baltic Sea	Helcom
John Dory	*Zeus faber*	Baltic Sea	Helcom
European seabass	*Dicentrarchus labrax*	Baltic Sea	Helcom
Ballan wrasse	*Labrus bergylta*	Baltic Sea	Helcom
Cuckoo wrasse	*Labrus mixtus*	Baltic Sea	Helcom
Corkwring wrasse	*Symphodus melops*	Baltic Sea	Helcom
Greater weever	*Trachinus draco*	Baltic Sea	Helcom

Common name	Scientific name	Region/RFMO	Legal framework
Wolf-fish	*Anarhichas lupus*	Baltic Sea	Helcom
Lesser sandeel	*Ammodytes marinus*	Baltic Sea	Helcom
Small sandeel	*Ammodytes tobianus*	Baltic Sea	Helcom
Painted goby	*Pomatoschistus pictus*	Baltic Sea	Helcom
Bullet tuna	*Auxis rochei*	Baltic Sea	Helcom
Little thunny	*Euthynnus alleteratus*	Baltic Sea	Helcom
Plain bonito	*Orcynopsis unicolor*	Baltic Sea	Helcom
Atlantic mackerel	*Scomber scombrus*	Baltic Sea	Helcom
Atlantic halibut	*Hippoglossus hippoglossus*	Baltic Sea	Helcom
Swordfish	*Xiphias gladius*	Baltic Sea	Helcom
Niger blackfish	*Centrolophus niger*	Baltic Sea	Helcom
Cartilaginous fishes	Chondrichthyes		
Narrow sawfish	*Anoxypristis cuspidata*	All oceans	RFMOs, High priority
Birdbeak dogfish	*Deania calcea*	All oceans	RFMOs, High priority
Smooth lanternshark	*Etmopterus pusillus*	All oceans	RFMOs, High priority
Dwarf sawfish	*Pristis clavata*	All oceans	RFMOs, High priority
Green sawfish	*Pristis zijsron*	All oceans	RFMOs, High priority
Norwegian skate	*Raja (Dipturus) nidarosiensis*	All oceans	RFMOs, High priority
Thornback ray	*Raja clavata*	All oceans	RFMOs, High priority OSPAR; Helcom
Undulate ray	*Raja undulata*	All oceans	RFMOs, High priority
Pelagic thresher	*Alopias pelagicus*	All oceans	RFMOs, High priority
Big eye thresher	*Alopias superciliosus*	All oceans	RFMOs, High priority
Common thresher	*Alopias vulpinus*	All oceans	RFMOs, High priority; Helcom
Starry ray	*Amblyraja radiata*	All oceans	RFMOs, High priority

Common name	Scientific name	Region/RFMO	Legal framework
Iceland catshark	*Apristurus* spp.	All oceans	RFMOs, High priority, Vulnerable species Relevant for deep sea fisheries
Silky shark	*Carcharhinus falciformis*	All oceans	RFMOs, High priority
Galapagos shark	*Carcharhinus galapagensis*	All oceans	RFMOs, High priority
Oceanic whitetip shark	*Carcharhinus longimanus*	All oceans	RFMOs, High priority
Sandbar shark	*Carcharhinus plumbeus*	All oceans + Mediterranean and Black Sea	RFMOs, High priority, Barcelona Convention Annex II
Sand tiger shark	*Carcharias taurus*	All oceans + Mediterranean and Black Sea	RFMOs, High priority, Barcelona Convention Annex II
Great white shark	*Carcharodon carcharias*	All oceans	RFMOs, High priority
Gulper shark	*Centrophorus granulosus*	All oceans and seas	RFMOs, High priority, Barcelona Convention Annex III; OSPAR
Gulper shark species	*Centrophorus* spp.	All regions	Relevant for deep sea fisheries
Leafscale gulper shark	*Centrophorus squamosus*	All oceans and seas	RFMOs, High priority; OSPAR
Black dogfish	*Centroscyllium fabricii*	All oceans	RFMOs, High priority, Relevant for deep sea fisheries
Portuguese dogfish	*Centroscymnus coelolepis*	All oceans	RFMOs, High priority, Relevant for deep sea fisheries; OSPAR
Longnose velvet dogfish	*Centroscymnus crepidater*	All oceans	RFMOs, High priority, Vulnerable species Relevant for deep sea fisheries
Basking shark	*Cetorhinus maximus*	All oceans and seas	RFMOs, High priority; OSPAR; Helcom
Rabbit fish (rattail)	*Chimaera monstrosa*	All regions	Relevant for deep sea fisheries
Frilled shark	*Chlamydoselachus anguineus*	All oceans	RFMOs, High priority, Vulnerable species Relevant for deep sea fisheries
Kitefin shark	*Dalatias licha*	All oceans	RFMOs, High priority, Vulnerable species Relevant for deep sea fisheries
Stingray	*Dasyatis pastinaca*	Black Sea	Annex IV of the Black Sea Biodiversity and Landscape Conservation Protocol; Helcom

Common name	Scientific name	Region/RFMO	Legal framework
Birdbeak dogfish	*Deania calcea*	All oceans	RFMOs, High priority, Relevant for deep sea fisheries
Common skate	*Dipturus batis*	All oceans and seas	RFMOs, High priority, Barcelona Convention Annex II; OSPAR; Helcom
White skate	**Rostroraja alba*	OSPAR II, III, IV	OSPAR
Greater lanternshark	*Etmopterus princeps*	All oceans	RFMOs, High priority, Vulnerable species Relevant for deep sea fisheries
Velvet belly	*Etmopterus spinax*	All oceans	RFMOs, High priority, Relevant for deep sea fisheries; Helcom
Winghead hammerhead	*Eusphyra blochii*	All oceans	RFMOs, High priority
School shark, tope shark	*Galeorhinus galeus*	All oceans + Mediterranean and Black Sea	RFMOs, High priority, Barcelona Convention Annex II; Helcom
Blackmouth dogfish	*Galeus melastomus*	All oceans	RFMOs, High priority, Relevant for deep sea fisheries
Mouse catshark	*Galeus murinus*	All oceans	RFMOs, High priority, Relevant for deep sea fisheries
Spiny butterfly ray	*Gymnura altavela*	All oceans + Mediterranean and Black Sea	RFMOs, High priority, Barcelona Convention Annex II
Sharpnose sevengill shark	*Heptranchias perlo*	All oceans + Mediterranean and Black Sea	RFMOs, High priority, Barcelona Convention Annex III
Bluntnose six-gilled shark	*Hexanchus griseus*	All oceans + Mediterranean and Black Sea	RFMOs, High priority, Barcelona Convention Annex II; Helcom
Large-eyed rabbitfish (Ratfish)	*Hydrolagus mirabilis*	All regions	Relevant for deep sea fisheries
Shortfin mako	*Isurus oxyrinchus*	All oceans	RFMOs, High priority
Longfin mako	*Isurus paucus*	All oceans	RFMOs, High priority
Porbeagle	*Lamna nasus*	All oceans	RFMOs, High priority, OSPAR; Helcom
Sandy skate	*Leucoraja circularis*	All oceans + Mediterranean and Black Sea	RFMOs, High priority, Barcelona Convention Annex II

Common name	Scientific name	Region/RFMO	Legal framework
Maltese skate	*Leucoraja melitensis*	All oceans + Mediterranean and Black Sea	RFMOs, High priority, Barcelona Convention Annex II
Reef manta ray	*Manta alfredi*	All oceans	RFMOs, High priority
Giant manta ray	*Manta birostris*	All oceans	RFMOs, High priority
Longhorned mobula	*Mobula eregoodootenkee*	All oceans	RFMOs, High priority
Lesser devil ray	*Mobula hypostoma*	All oceans	RFMOs, High priority
Spinetail mobula	*Mobula japanica*	All oceans	RFMOs, High priority
Shortfin devil ray	*Mobula kuhlii*	All oceans	RFMOs, High priority
Devil fish	*Mobula mobular*	All oceans	RFMOs, High priority
Munk's devil ray	*Mobula munkiana*	All oceans	RFMOs, High priority
Lesser Guinean devil ray	*Mobula rochebrunei*	All oceans	RFMOs, High priority
Chilean devil ray	*Mobula tarapacana*	All oceans	RFMOs, High priority
Smoothtail mobula	*Mobula thurstoni*	All oceans	RFMOs, High priority
Starry smooth-hound	*Mustelus asterias*	All oceans + Mediterranean and Black Sea	RFMOs, High priority, Barcelona Convention Annex III
Common smooth-hound	*Mustelus mustelus*	All oceans + Mediterranean and Black Sea	RFMOs, High priority, Barcelona Convention Annex III
Blackspotted smooth-hound	*Mustelus punctulatus*	All oceans + Mediterranean and Black Sea	RFMOs, High priority, Barcelona Convention Annex III
Blackmouth catshark	*Galeus melanostomus*	Baltic sea	Helcom
Small-spotted catshark	*Scyliorhinus canicula*	Baltic sea	Helcom
Thorny skate	*Amblyraja radiata*	Baltic sea	Helcom
Shagreen ray	*Leucoraja fullonica*	Baltic sea	Helcom
Spotted torpedo	*Torpedo marmorata*	Baltic sea	Helcom

Common name	Scientific name	Region/RFMO	Legal framework
Sailfin roughshark (Sharpback shark)	*Oxynotus paradoxus*	All oceans	RFMOs, High priority, Vulnerable species Relevant for deep sea fisheries
Smalltooth sawfish	*Pristis pectinata*	All oceans + Mediterranean and Black Sea	RFMOs, High priority, Barcelona Convention Annex II
Common sawfish	*Pristis pristis*	All oceans + Mediterranean and Black Sea	RFMOs, High priority, Barcelona Convention Annex II
Crocodile shark	*Pseudocarcharias kamoharai*	All oceans	RFMOs, High priority
Blue stingray	*Pteroplatytrygon violacea*	All oceans	RFMOs, High priority
Round skate	*Raja fyllae*	All regions	Relevant for deep sea fisheries
Arctic skate	*Raja hyperborea*	All regions	Relevant for deep sea fisheries
Norwegian skate	*Raja nidarosiensus*	All regions	Relevant for deep sea fisheries
Spotted ray	*Raja montagui*	OSPAR I, II, III, IV	OSPAR; Helcom
Whale shark	*Rhincodon typus*	All oceans	RFMOs, High priority
Blackchin guitarfish	*Rhinobatos cemiculus*	All oceans + Mediterranean and Black Sea	RFMOs, High priority, Barcelona Convention Annex II
Common guitarfish	*Rhinobatos rhinobatos*	All oceans + Mediterranean and Black Sea	RFMOs, High priority, Barcelona Convention Annex II
Straightnose rabbitfish	*Rhinochimaera atlantica*	All regions	Relevant for deep sea fisheries
Bottlenose skate	*Rostroraja alba*	All oceans + Mediterranean and Black Sea	RFMOs, High priority, Barcelona Convention Annex II
Knifetooth dogfish	*Scymnodon ringens*	All oceans	RFMOs, High priority, Relevant for deep sea fisheries
Other sharks	Selachimorpha (or Selachii), Batoidea (to be defined by species according to landing, survey or catch data)	All oceans	RFMOs, High priority; Helcom
Greenland shark	*Somniosus microcephalus*	All oceans	RFMOs, High priority, Relevant for deep sea fisheries; Helcom

Common name	Scientific name	Region/RFMO	Legal framework
Scalloped hammerhead	*Sphyrna lewini*	All oceans	RFMOs, High priority
Great hammerhead	*Sphyrna mokarran*	All oceans	RFMOs, High priority
Smooth hammerhead	*Sphyrna zygaena*	All oceans	RFMOs, High priority
Spurdog, spiked dogfish	*Squalus acanthias*	All oceans + Mediterranean and Black Sea	RFMOs, High priority, Barcelona Convention Annex III, OSPAR; Helcom
Sawback angelshark	*Squatina aculeata*	All oceans + Mediterranean and Black Sea	RFMOs, High priority, Barcelona Convention Annex II
Smoothback angelshark	*Squatina oculata*	All oceans + Mediterranean and Black Sea	RFMOs, High priority, Barcelona Convention Annex II
Angel shark	*Squatina squatina*	All oceans + Mediterranean and Black Sea	RFMOs, High priority, Barcelona Convention Annex II, OSPAR; Helcom
Sea lamprey	*Petromyzon marinus*	OSPAR I, II, III, IV	OSPAR; Helcom
River lamprey	*Lampetra fluviatilis*	Baltic sea	Helcom
Mammals	Mammalia		
Cetaceans — all species	*Cetacea* — all species	All areas	Council Directive 92/43/EEC (7)
Minke whale	*Balaenoptera acutorostrata*	Mediterranean Sea	Rec. GFCM (8)/36/2012/2 & Annex II of the Barcelona Convention
Bowhead whale	*Balaena mysticetus*	OSPAR I	OSPAR
Blue whale	*Balaenoptera musculus*	All OSPAR	OSPAR
Northern right whale	*Eubalaena glacialis*	All OSPAR	OSPAR
Sei whale	*Balaenoptera borealis*	Mediterranean Sea	Rec. GFCM/36/2012/2 & Annex II of the Barcelona Convention
Fin whale	*Balaenoptera physalus*	Mediterranean Sea	Rec. GFCM/36/2012/2 & Annex II of the Barcelona Convention
Short-beaked common dolphin	*Delphinus delphis*	Mediterranean Sea	Rec. GFCM/36/2012/2 & Annex II of the Barcelona Convention
North Atlantic right whale	*Eubalaena glacialis*	Mediterranean Sea	Rec. GFCM/36/2012/2 & Annex II of the Barcelona Convention

Common name	Scientific name	Region/RFMO	Legal framework
Long-finned pilot whale	*Globicephala melas*	Mediterranean Sea	Rec. GFCM/36/2012/2 & Annex II of the Barcelona Convention
Risso's dolphin	*Grampus griseus*	Mediterranean Sea	Rec. GFCM/36/2012/2 & Annex II of the Barcelona Convention
Dwarf sperm whale	*Kogia simus*	Mediterranean Sea	Rec. GFCM/36/2012/2 & Annex II of the Barcelona Convention
Humpback whale	*Megaptera novaeangliae*	Mediterranean Sea	Rec. GFCM/36/2012/2 & Annex II of the Barcelona Convention
Blainville's beaked whale	*Mesoplodon densirostris*	Mediterranean Sea	Rec. GFCM/36/2012/2 & Annex II of the Barcelona Convention
Killer whale	*Orcinus orca*	Mediterranean Sea	Rec. GFCM/36/2012/2 & Annex II of the Barcelona Convention
Harbour porpoise	*Phocoena phocoena*	Mediterranean Sea; OSPAR II, III	Rec. GFCM/36/2012/2 & Annex II of the Barcelona Convention; Directive 92/43/EEC; OSPAR
Sperm whale	*Physeter macrocephalus*	Mediterranean Sea	Rec. GFCM/36/2012/2 & Annex II of the Barcelona Convention
False killer whale	*Pseudorca crassidens*	Mediterranean Sea	Rec. GFCM/36/2012/2 & Annex II of the Barcelona Convention
Striped dolphin	*Stenella coeruleoalba*	Mediterranean Sea	Rec. GFCM/36/2012/2 & Annex II of the Barcelona Convention
Rough-toothed dolphin	*Steno bredanensis*	Mediterranean Sea	Rec. GFCM/36/2012/2 & Annex II of the Barcelona Convention
Bottlenose dolphin	*Tursiops truncatus*	Mediterranean Sea	Rec. GFCM/36/2012/2 & Annex II of the Barcelona Convention
Cuvier's beaked whale	*Ziphius cavirostris*	Mediterranean Sea	Rec. GFCM/36/2012/2 & Annex II of the Barcelona Convention
Monk seal	*Monachus monachus*	All areas	Rec. GFCM/35/2011/5 & Annex II of the Barcelona Convention; Directive 92/43/EEC
Saimaa ringed seal	*Phoca hispida saimensis*	All areas	Directive 92/43/EEC
Grey seal	*Halichoerus grypus*	All areas	Directive 92/43/EEC
Harbour seal	*Phoca vitulina*	All areas	Directive 92/43/EEC
Baltic ringed seal	*Phoca hispida bottnica*	All areas	Directive 92/43/EEC

Common name	Scientific name	Region/RFMO	Legal framework
Birds	Aves		
Cory's Shearwater	*Calonectris borealis*	All areas	Directive 2009/147/EC of the European Parliament and of the Council [9]
Great Cormorant	*Phalacrocorax carbo*	All areas	Directive 2009/147/EC
Northern Gannet	*Morus bassanus*	All areas	Directive 2009/147/EC
Atlantic Puffin	*Fratercula arctica*	All areas	Directive 2009/147/EC
Balearic Shearwater	*Puffinus mauretanicus*	All areas	Directive 2009/147/EC
Black-headed Gull	*Larus ridibundus*	All areas	Directive 2009/147/EC
Common Scoter	*Melanitta nigra*	All areas	Directive 2009/147/EC
European Shag	*Phalacrocorax aristotelis*	All areas	Directive 2009/147/EC
Great Shearwater	*Ardenna gravis*	All areas	Directive 2009/147/EC
Manx Shearwater	*Puffinus puffinus*	All areas	Directive 2009/147/EC
Northern Fulmar	*Fulmarus glacialis*	All areas	Directive 2009/147/EC
Scopoli's Shearwater	*Calonectris diomedea*	All areas	Directive 2009/147/EC
Sooty Shearwater	*Ardenna grisea*	All areas	Directive 2009/147/EC
Yelkouan Shearwater	*Puffinus yelkouan*	All areas	Directive 2009/147/EC
Audouin's Gull	*Larus audouinii*	All areas	Directive 2009/147/EC
Barrow's Goldeneye	*Bucephala islandica*	All areas	Directive 2009/147/EC
Bulwer's Petrel	*Bulweria bulwerii*	All areas	Directive 2009/147/EC
Common Goldeneye	*Bucephala clangula*	All areas	Directive 2009/147/EC
European Herring Gull	*Larus argentatus*	All areas	Directive 2009/147/EC
Glaucous Gull	*Larus hyperboreus*	All areas	Directive 2009/147/EC
Great Black-backed Gull	*Larus marinus*	All areas	Directive 2009/147/EC
Great Skua	*Catharacta skua*	All areas	Directive 2009/147/EC

Common name	Scientific name	Region/RFMO	Legal framework
Greater Scaup	*Aythya marila*	All areas	Directive 2009/147/EC; Annex IV of the Black Sea Biodiversity and Landscape Conservation Protocol
Common pochard	*Aythya ferina*	Black Sea	Annex IV of the Black Sea Biodiversity and Landscape Conservation Protocol
Lesser Black-backed Gull	*Larus fuscus*	All areas	Directive 2009/147/EC
Little Auk	*Alle alle*	All areas	Directive 2009/147/EC
Long-tailed Jaeger	*Stercorarius longicaudus*	All areas	Directive 2009/147/EC
Razorbill	*Alca torda*	All areas	Directive 2009/147/EC
Arctic Jaeger	*Stercorarius parasiticus*	All areas	Directive 2009/147/EC
Arctic Loon	*Gavia arctica*	All areas	Directive 2009/147/EC
Audubon's Shearwater	*Puffinus lherminieri*	All areas	Directive 2009/147/EC
Black Guillemot	*Cepphus grylle*	All areas	Directive 2009/147/EC
Black Scoter	*Melanitta americana*	All areas	Directive 2009/147/EC
Black-necked Grebe	*Podiceps nigricollis*	All areas	Directive 2009/147/EC
Caspian Gull	*Larus cachinnans*	All areas	Directive 2009/147/EC
Common Eider	*Somateria mollissima*	All areas	Directive 2009/147/EC
Common Guillemot	*Uria aalge*	All areas	Directive 2009/147/EC
Common Loon	*Gavia immer*	All areas	Directive 2009/147/EC
Common Merganser	*Mergus merganser*	All areas	Directive 2009/147/EC
Great Crested Grebe	*Podiceps cristatus*	All areas	Directive 2009/147/EC
Harlequin Duck	*Histrionicus histrionicus*	All areas	Directive 2009/147/EC
Horned Grebe	*Podiceps auritus*	All areas	Directive 2009/147/EC
Iceland Gull	*Larus glaucoides*	All areas	Directive 2009/147/EC
King Eider	*Somateria spectabilis*	All areas	Directive 2009/147/EC

Common name	Scientific name	Region/RFMO	Legal framework
Long-tailed Duck	*Clangula hyemalis*	All areas	Directive 2009/147/EC
Mediterranean Gull	*Larus melanocephalus*	All areas	Directive 2009/147/EC
Mew Gull	*Larus canus*	All areas	Directive 2009/147/EC
Red-breasted Merganser	*Mergus serrator*	All areas	Directive 2009/147/EC
Red-necked Grebe	*Podiceps grisegena*	All areas	Directive 2009/147/EC
Red-throated Loon	*Gavia stellata*	All areas	Directive 2009/147/EC
Slender-billed Gull	*Larus genei*	All areas	Directive 2009/147/EC
Steller's Eider	*Polysticta stelleri*	All areas	Directive 2009/147/EC
Pomarine Jaeger	*Stercorarius pomarinus*	All areas	Directive 2009/147/EC
Thick-billed Murre/ Brünnig's Guillemot	*Uria lomvia*	All areas	Directive 2009/147/EC
Velvet Scoter	*Melanitta fusca*	All areas	Directive 2009/147/EC
Yellow-billed Loon	*Gavia adamsii*	All areas	Directive 2009/147/EC
Yellow-legged Gull	*Larus michahellis*	All areas	Directive 2009/147/EC
Zino's Petrel	*Pterodroma madeira*	All areas	Directive 2009/147/EC
Pallas's Gull	*Larus ichthyaetus*	All areas	Directive 2009/147/EC
Black-legged Kittiwake	*Rissa tridactyla*	All areas	Directive 2009/147/EC
Great White Pelican	*Pelecanus onocrotalus*	All areas	Directive 2009/147/EC
Leach's Storm-petrel	*Oceanodroma leucorhoa*	All areas	Directive 2009/147/EC
Red Phalarope	*Phalaropus fulicarius*	All areas	Directive 2009/147/EC
Red-necked Phalarope	*Phalaropus lobatus*	All areas	Directive 2009/147/EC
Wilson's Storm-petrel	*Oceanites oceanicus*	All areas	Directive 2009/147/EC
Arctic Tern	*Sterna paradisaea*	All areas	Directive 2009/147/EC
Band-rumped Storm-petrel	*Hydrobates castro*	All areas	Directive 2009/147/EC
Black Tern	*Chlidonias niger*	All areas	Directive 2009/147/EC
Caspian Tern	*Hydroprogne caspia*	All areas	Directive 2009/147/EC

Common name	Scientific name	Region/RFMO	Legal framework
Common Gull-billed Tern	*Gelochelidon nilotica*	All areas	Directive 2009/147/EC
Common Tern	*Sterna hirundo*	All areas	Directive 2009/147/EC
Desertas Petrel	*Pterodroma deserta*	All areas	Directive 2009/147/EC
Ivory Gull	*Pagophila eburnea*	All areas	Directive 2009/147/EC
Lesser Crested Tern	*Thalasseus bengalensis*	All areas	Directive 2009/147/EC
Little Gull	*Hydrocoloeus minutus*	All areas	Directive 2009/147/EC
Little Tern	*Sternula albifrons*	All areas	Directive 2009/147/EC
Monteiro's Storm-petrel	*Hydrobates monteiroi*	All areas	Directive 2009/147/EC
Roseate Tern	*Sterna dougallii*	All areas	Directive 2009/147/EC
Ross's Gull	*Rhodostethia rosea*	All areas	Directive 2009/147/EC
Sabine's Gull	*Xema sabini*	All areas	Directive 2009/147/EC
Sandwich Tern	*Thalasseus sandvicensis*	All areas	Directive 2009/147/EC
Thayer's Gull	*Larus thayeri*	All areas	Directive 2009/147/EC
White-faced Storm-petrel	*Pelagodroma marina*	All areas	Directive 2009/147/EC
European Storm-petrel	*Hydrobates pelagicus*	All areas	Directive 2009/147/EC
Lesser black-backed gull	*Larus fuscus fuscus*	OSPAR I	OSPAR list of threatened and declining species
Ivory gull	*Pagophila eburnea*	OSPAR I	OSPAR list of threatened and declining species
Steller's eider	*Polysticta stelleri*	OSPAR I	OSPAR list of threatened and declining species
Little shearwater	*Puffinus assimilis baroli (auct.incert.)*	OSPAR V	OSPAR list of threatened and declining species
Balearic shearwater	*Puffinus mauretanicus*	OSPAR II, III, IV, V	OSPAR list of threatened and declining species
Black-legged kittiwake	*Rissa tridactyla*	OSPAR I, II,	OSPAR list of threatened and declining species
Roseate tern	*Sterna dougallii*	OSPAR II, III, IV, V	OSPAR list of threatened and declining species

Common name	Scientific name	Region/RFMO	Legal framework
Iberian guillemot	*Uria aalge — Iberian population (synonyms: Uria aalge albionis, Uria aalge ibericus)*	OSPAR IV	OSPAR list of threatened and declining species
Thick-billed murre	*Uria lomvia*	OSPAR I	OSPAR list of threatened and declining species
Reptiles	Reptilia		
Kemp's ridley sea turtle	*Lepidochelys kempii*	All areas	Directive 92/43/EEC; Rec. GFCM/35/2011/4 & Annex II of the Barcelona Convention
Loggerhead turtle	*Caretta caretta*	All areas	Directive 92/43/EEC; Rec. GFCM/35/2011/4 & Annex II of the Barcelona Convention; OSPAR
Leatherback turtle	*Dermochelys coriacea*	All areas	Directive 92/43/EEC; Rec. GFCM/35/2011/4 & Annex II of the Barcelona Convention; OSPAR
Hawksbill sea turtle	*Eretmochelys imbricata*	All areas	Directive 92/43/EEC; Rec. GFCM/35/2011/4 & Annex II of the Barcelona Convention
Green turtle	*Chelonia mydas*	All areas	Directive 92/43/EEC; Rec. GFCM/35/2011/4 & Annex II of the Barcelona Convention
Nile soft-shelled turtle	*Trionyx triunguis*	Mediterranean Sea	Rec. GFCM/35/2011/4 & Annex II of the Barcelona Convention
Molluscs	Mollusca		
Striped venus	*Chamelea gallina*	Black Sea	Annex IV of the Black Sea Biodiversity and Landscape Conservation Protocol
Banded wedge shell	*Donacilla cornea*	Black Sea	Annex IV of the Black Sea Biodiversity and Landscape Conservation Protocol
Eledone especies	*Eledone* spp.	All areas	National management plans
Mediterranean mussel	*Mytilus galloprovincialis*	All areas out of Med	National management plans
Mediterranean mussel	*Mytilus galloprovincialis*	Black Sea	Annex IV of the Black Sea Biodiversity and Landscape Conservation Protocol
Patella	*Patella* spp.	Mediterranean Sea	Annex II of the Barcelona Convention
Rapa whelk	*Rapana venosa*	Black Sea	Annex IV of the Black Sea Biodiversity and Landscape Conservation Protocol
Tuberculate cockle	*Acanthocardia tuberculata*	All areas	National management plans
Murex	*Bolinus brandaris*	All areas	National management plans

Common name	Scientific name	Region/RFMO	Legal framework
Hard clam	*Callista chione*	All areas	National management plans
Wedge shell	*Donax trunculus*	All areas	National management plans
Ocean quahog	*Arctica islandica*	OSPAR II	OSPAR
Azorean barnacle	*Megabalanus azoricus*	OSPAR V All where it occurs	OSPAR
Dog whelk	*Nucella lapillus*	OSPAR II, III, IV	OSPAR
Flat oyster	*Ostrea edulis*	OSPAR II	OSPAR
Azorean limpet	*Patella ulyssiponensis aspera*	All OSPAR where it occurs	OSPAR
Crustaceans	Crustacea		
Lobster	*Homarus gammarus*	Mediterranean Sea	Regulation (EC) No 1967/2006 (min. cons. size)
Deep-water red crab	*Chaceon (Geryon) affinis*	All regions	Relevant for deep sea fisheries
Brown shrimp	*Crangon crangon*	Black Sea	Annex IV of the Black Sea Biodiversity and Landscape Conservation Protocol
Baltic prawn	*Palaemon adspersus*	Black Sea	Annex IV of the Black Sea Biodiversity and Landscape Conservation Protocol
Rockpool prawn	*Palaemon elegans*	Black Sea	Annex IV of the Black Sea Biodiversity and Landscape Conservation Protocol
Crawfish	*Palinuridae*	Mediterranean Sea	Regulation (EC) No 1967/2006 (min. cons. size)
Cnidarians	Cnidaria		
Red coral	*Corallium rubrum*	Mediterranean Sea	Rec. GFCM/36/2012/1 & Rec. GFCM/35/2011/2

(1) Barcelona Convention for the Protection of the Marine Environment and the Coastal Region of the Mediterranean.
(2) OSPAR Convention for the Protection of the Marine Environment of the North-East Atlantic.
(3) Helcom Convention on the Protection of the Marine Environment of the Baltic Sea Area.
(4) Council Regulation (EC) No 2347/2002 of 16 December 2002 establishing specific access requirements and associated conditions applicable to fishing for deep-sea stocks (OJ L 351, 28.12.2002, p. 6).
(5) Council Regulation (EC) No 1967/2006 of 21 December 2006 concerning management measures for the sustainable exploitation of fishery resources in the Mediterranean Sea, amending Regulation (EEC) No 2847/93 and repealing Regulation (EC) No 1626/94 (OJ L 409, 30.12.2006, p. 11).
(6) Council Regulation (EC) No 894/97 of 29 April 1997 laying down certain technical measures for the conservation of fishery resources (OJ L 132, 23.5.1997, p. 1).
(7) Council Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora (OJ L 206, 22.7.1992, p. 7).
(8) General Fisheries Commission for the Mediterranean.
(9) Directive 2009/147/EC of the European Parliament and of the Council of 30 November 2009 on the conservation of wild birds (OJ L 20, 26.1.2010, p. 7).

For prohibited species: only individuals captured dead shall be used. They shall be discarded after the measurements, The data collection is annual and the updating/processing of the data must be done timely to fit the schedule of the stock assessments.

BIOLOGICAL DATA

Table 1E

Freshwater Anadromous and Catadromous species

Species (common name)	Species (Scientific name)	Non-marine areas where the stock is located/stock code
European eel	*Anguilla anguilla*	Eel management units as defined in accordance with Council Regulation (EC) No 1100/2007 (1)
Salmon	*Salmo salar*	All areas of natural distribution
Sea trout	*Salmo trutta*	All inland waters that exit in the Baltic Sea

(1) Council Regulation (EC) No 1100/2007 of 18 September 2007 establishing measures for the recovery of the stock of European eel (OJ L 248, 22.9.2007, p. 17).

Table 2

Fishing activity (metier) by region

Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	LOA classes (m) (d)					
Activity	Gear classes	Gear groups	Gear type	Target assemblage (a)	Mesh size and other selective devices	< 10	10- < 12	12- < 18	18- < 24	24- < 40	40 & +
Fishing activity	Dredges	Dredges	Boat dredge [DRB]	Anadromous species (ANA) Catadromous species (CAT) Cephalopods (CEP) Crustaceans (CRU) Demersal species (DEF) Deep-Water species (DWS) Finfish (FIF) Freshwater species (no code) Miscellaneous (MIS) Mixed Cephalopod and Demersal (MCF) Mixed Crustaceans and Demersal (MCD) Mixed Deep-water species and Demersal (MDD) Mixed Pelagic and Demersal (MPD) Molluscs (MOL) Large Pelagic fish (LPF) Small Pelagic fish (SPF) Large Pelagic fish (LPF) and Small Pelagic fish (SPF)	(b)						
			Mechanised/ Suction dredge [HMD]		(b)						
	Trawls	Bottom trawls	Bottom otter trawl [OTB]		(b)						
			Multi-rig otter trawl [OTT]		(b)						
			Bottom pair trawl [PTB]		(b)						
			Beam trawl [TBB]		(b)						
		Pelagic trawls	Midwater otter trawl [OTM]		(b)						
			Midwater pair trawl [PTM]		(b)						

Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	LOA classes (m) (d)					
Activity	Gear classes	Gear groups	Gear type	Target assemblage (a)	Mesh size and other selective devices	< 10	10- < 12	12- < 18	18- < 24	24- < 40	40 & +
	Hooks and Lines	Rods and Lines	Hand and Pole lines [LHP] [LHM]		(b)						
			Trolling lines [LTL]		(b)						
		Longlines	Drifting long-lines [LLD]		(b)						
			Set longlines [LLS]		(b)						
	Traps	Traps	Pots and Traps [FPO]		(b)						
			Fyke nets [FYK]		(b)						
			Stationary uncovered pound nets [FPN]		(b)						
			Fixed installa-tions for fences and weirs (code needed)		(b)						
	Nets	Nets	Trammel net [GTR]		(b)						
			Set gillnet [GNS]		(b)						
			Driftnet [GND]		(b)						
	Seines	Surround-ing nets	Purse seine [PS]		(b)						
			Lampara nets [LA]		(b)						
		Seines (c)	Fly shooting seine [SSC]		(b)						
			Anchored seine [SDN]		(b)						

Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	LOA classes (m) (d)					
Activity	Gear classes	Gear groups	Gear type	Target assemblage (a)	Mesh size and other selective devices	< 10	10- < 12	12- < 18	18- < 24	24- < 40	40 & +
			Pair seine [SPR]		(b)						
			Beach and boat seine [SB] [SV]		(b)						
	Other gear	Other gear	Glass eel fishing (no code)	Glass eel	(b)						
	Misc. (Specify)	Misc. (Specify)			(b)						
Other activity than fishing				Other activity than fishing							
Inactive				Inactive							

Footnotes:
(a) according to existing coding in relevant Regulations.
(b) according to existing coding in relevant Regulations.
(c) with Fish Aggregating Devices (FADs)/in free schools.
(d) in the Mediterranean < 6m and 6-12 m.

Table 3

Species to be collected for recreational fisheries

	Area	Species
1	Baltic Sea (ICES Subdivisions 22-32	Salmon, eels and seatrout (including in fresh water) and cod.
2	North Sea (ICES areas IIIa, IV and VIId)	Salmon and eels (including in fresh water). Seabass, cod, pollack and elasmobranchs
3	Eastern Arctic (ICES areas I and II)	Salmon and eels (including in fresh water). Cod, pollack and elasmobranchs
4	North Atlantic (ICES areas V-XIV and NAFO areas)	Salmon and eels (including in fresh water). Seabass, cod, pollack, elasmobranchs and highly migratory ICCAT species.
5	Mediterranean Sea	Eels (including in fresh water), elasmobranchs and highly migratory ICCAT species.
6	Black Sea	Eels (including in fresh water), elasmobranchs and highly migratory ICCAT species

Table 4

Fishing activity variables

	Variables [1]	Unit
	Capacity	
	Number of vessels	Number
	GT, kW, Vessel Age	Number
	Effort	
	Days at sea	Days
	Hours fished (optional)	Hours
	Fishing days	Days
	kW * Fishing Days	Number
	GT * Fishing days	Number
	Number of trips	Number
	Number of fishing operations	Number
	Number of nets/Length (*)	Number/metres
	Number of hooks, Number of lines (*)	Number
	Numbers of pots, traps (*)	Number
	Landings	
	Value of landings total and per commercial species	Euro
	Live Weight of landings total and per species	Tonnes
	Prices by commercial species	Euro/kg

[1] All variables to be reported at the aggregation level (metiers and fleet segment) specified in Table 3 and Table 5B. and by Sub-region/Fishing ground as specified in Table 5Cb.

(*) Collection of these variables for vessels less than 10 metres is to be agreed at marine region level

FLEET ECONOMIC DATA

Table 5A

Economic variables for the fleet

Variable group	Variable	Unit
Income	Gross value of landings	Euro
	Income from leasing out quota or other fishing rights	Euro
	Other income	Euro
Labour costs	Personnel costs	Euro
	Value of unpaid labour	Euro
Energy costs	Energy costs	Euro
Repair and maintenance costs	Repair and maintenance costs	Euro
Other operating costs	Variable costs	Euro
	Non-variable costs	Euro
	Lease/rental payments for quota or other fishing rights	Euro
Subsidies	Operating subsidies	Euro
	Subsidies on investments	Euro
Capital costs	Consumption of fixed capital	Euro
Capital value	Value of physical capital	Euro
	Value of quota and other fishing rights	Euro
Investments	Investments in tangible assets, net	Euro
Financial position	Long/short Debt	Euro
	Total assets	Euro
Employment	Engaged crew	Number
	Unpaid labour	Number
	Total hours worked per year	Number

Variable group	Variable	Unit
Fleet	Number of vessels	Number
	Mean LOA of vessels	Metres
	Total vessel's tonnage	GT
	Total vessel's power	kW
	Mean age of vessels	Years
Effort	Days at sea	Days
	Energy consumption	Litres
Number of fishing enterprises/units	Number of fishing enterprises/units	Number
Production value per species	Value of landings per species	Euro
	Average price per species	Euro/kg

FLEET ECONOMIC DATA

Table 5B

Fleet segmentation

		Length classes (LOA) [1]					
Active Vessels		0-< 10 m 0-< 6 m	10-< 12 m 6-< 12 m	12-< 18 m	18-< 24 m	24-< 40 m	40 m or larger
Using 'Active' gears	Beam trawlers						
	Demersal trawlers and/or demersal seiners						
	Pelagic trawlers						
	Purse seiners						
	Dredgers						
	Vessel using other active gears						
	Vessels using Polyvalent 'active' gears only						

		Length classes (LOA) (1)					
Active Vessels		0-< 10 m 0-< 6 m	10-< 12 m 6-< 12 m	12-< 18 m	18-< 24 m	24-< 40 m	40 m or larger
Using 'Passive' gears	Vessels using hooks	(2)	(2)				
	Drift and/or fixed netters						
	Vessels using Pots and/or traps						
	Vessels using other Passive gears						
	Vessels using Polyvalent 'passive' gears only						
Using Polyvalent gears	Vessels using active and passive gears						
Inactive vessels							

(1) For vessels less than 12 metres in the Mediterranean Sea and the Black sea, the length categories are 0-< 6, 6-< 12 metres. For all other regions, the length categories are defined as 0-< 10, 10-< 12 metres.
(2) Vessels less than 12 metres using passive gears in the Mediterranean Sea and the Black Sea may be disaggregated by gear type. The fleet segment definition shall also include an indication of the supraregion and, if available, a geographical indicator to identify vessels fishing in outermost regions and exclusively outside EU waters

FLEET ECONOMIC DATA

Table 5C

Geographical stratification by region

Sub-region/Fishing ground	Region	Supra region
I	II	III
Cluster of spatial units on level 3 as defined in Table 3 (NAFO Division)	NAFO (FAO area 21)	Baltic Sea; North Sea; Eastern Arctic; NAFO; Extended North-Western waters (Ices areas V, VI and VII) and Southern Western waters
Cluster of spatial units on level 4 as defined in Table 3 (ICES sub-division)	Baltic Sea (ICES areas III b-d)	
Cluster of spatial units on level 3 as defined in Table 3 (ICES Division)	North Sea (ICES areas IIIa and IV), Eastern Arctic (ICES areas I and II)	
	North-Western waters (ICES areas Vb (only Union waters), VI and VII)	
	Non-Union North-Western waters (ICES areas Va and Vb) (only non-Union waters))	

Sub-region/Fishing ground	Region	Supra region
I	II	III
Cluster of spatial units on level 3 as defined in Table 3 (ICES/CECAF Division)	Southern Western waters (ICES zones VIII, IX and X (waters around Azores), CECAF areas 34.1.1, 34.1.2 and 34.2.0 (waters around Madeira and the Canary Islands))	
Cluster of spatial units on level 4 as defined in Table 3 (GSA)	Mediterranean Sea (Maritime Waters of the Mediterranean to the east of line 5° 36′ West), Black Sea (GFCM geographical sub-area as defined in Resolution FCM/33/2009/2)	Mediterranean Sea and Black Sea
RFMO's sampling sub-areas (except GFCM)	Other regions where fisheries are operated by Union vessels and managed by RFMOs to which the European Union is contracting party or observer (e.g. ICCAT, IOTC, CECAF etc.)	Other regions.

Table 6

Social variables for the fishing and aquaculture sectors

Variable	Unit
Employment by gender	Number
FTE by gender	Number
Unpaid labour by gender	Number
Employment by age	Number
Employment by education level	Number per education level
Employment by nationality	Number from EU, EEA and Non-EU/EEA
Employment by employment status	Number
FTE National	Number

Table 7

Economic variables for the aquaculture sector

Variable group	Variable	Unit
Income (*)	Gross sales per species	Euro
	Other income	Euro

Variable group	Variable	Unit
Personnel costs	Personnel costs	Euro
	Value of unpaid labour	Euro
Energy costs	Energy costs	Euro
Raw material costs	Livestock costs	Euro
	Feed costs	Euro
Repair and maintenance	Repair and maintenance	Euro
Other operating costs	Other operating costs	Euro
Subsidies	Operating subsidies	Euro
	Subsidies on investments	Euro
Capital costs	Consumption of fixed capital	Euro
Capital value	Total value of assets	Euro
Financial results	Financial income	Euro
	Financial expenditures	Euro
Investments	Net Investments	Euro
Debt	Debt	Euro
Raw material weight	Livestock used	kg
	Fish Feed used	kg
Weight of sales	Weight of sales per species	Kg
Employment	persons employed	Number/FTE
	Unpaid labour	Number/FTE
	Number of hours worked by employees and unpaid workers	Hours
Number of enterprises	Number of enterprises (by category on the number of persons employed)	Number

(*) Includes direct payments, e.g. compensation for stopping trading, refunds of fuel duty or similar lump sum compensation payments; excludes social benefit payments and indirect subsidies, e.g. reduced duty on inputs such as fuel or investment subsidies.

Table 8

Environmental variables for the aquaculture sector

Variable	Specification	Unit
Medicines or treatments administered (1)	By type	Gram
Mortalities (2)		Per cent

(1) Extrapolated from data recorded under Annex I, point 8(b), of Regulation (EC) No 852/2004 of the European Parliament and of the Council (OJ L 139, 30.4.2004, p. 1).
(2) Extrapolated as a percentage of national production from data recorded under Council Directive 2006/88/EC (OJ L 328, 24.11.2006, p. 14), Article 8, Paragraph 1(b).

Table 9

Segmentation to be applied for the collection of aquaculture data (1)

	Fish farming techniques (2)						Poly-culture	Hatch-eries and nurser-ies (3)	Shellfish farming techniques			
	Ponds	Tanks and race-ways	Enclo-sures and pens (6)	Recir-culation sys-tems (5)	Other meth-ods	Cages (7)	All methods		Off-bottom		On-bot-tom (4)	Other
									Rafts	Long line		
Salmon												
Trout												
Sea bass & Sea bream												
Carp												
Tuna												
Eel												
Sturgeon (Eggs for human consumption)												
Other fresh water fish												
Other marine fish												
Mussel												

	Fish farming techniques (2)						Poly-culture	Hatch-eries and nurser-ies (3)	Shellfish farming techniques			
	Ponds	Tanks and race-ways	Enclo-sures and pens (6)	Recir-culation sys-tems (5)	Other meth-ods	Cages (7)	All methods		Off-bottom		On-bot-tom (4)	Other
									Rafts	Long line		
Oyster												
Clam												
Crustaceans												
Other molluscs												
Multispecies												
Seaweeds												
Other aquatic organisms												

(1) For definitions of farming techniques, see Regulation (EC) No 762/2008.
(2) Enterprises shall be segmented according to their main farming technique.
(3) Hatcheries and nurseries are defined as places for the artificial breeding, hatching and rearing through the early life stages of aquatic animals. For statistical purposes, hatcheries are limited to the production of fertilised eggs. Further juveniles stages of aquatic animals are considered being produced in nurseries. When hatcheries and nurseries are closely associated, statistics shall refer only to the latest juvenile stage produced. (COM(2006) 864 of 19 July 2007)
(4) 'On-bottom' techniques cover shellfish farming in inter-tidal areas (directly on the ground or surelevated)
(5) Recirculation systems means systems where the water is reused after some form of treatment (e.g. filtering).
(6) Enclosures and pens are defined as areas of water confined by nets, mesh and other barriers allowing uncontrolled water interchange and distinguished by the fact that enclosures occupy the full water column between substrate and surface; pens and enclosures generally enclose a relatively large volume of water. (COM(2006) 864 of 19 July 2007).
(7) Cages are defined as open or covered enclosed structures constructed with net, mesh or any porous material allowing natural water interchange. These structures may be floating, suspended or fixed to the substrate but still permitting water interchange from below. (COM(2006) 864 of 19 July 2007).

Table 10

Research surveys at sea

Name of the survey	Acronym	Area	Period	Main targeted species
Baltic Sea				
Baltic International Trawl Survey	BITS Q1 BITS Q4	IIIaS, IIIb-d	1st and 4th Quarter	Cod and other demersal species
Baltic International Acoustic Survey (Autumn)	BIAS	IIIa, IIIb-d	Sep-Oct	Herring and sprat
Gulf of Riga Acoustic Herring Survey	GRAHS	IIId	3rd Quarter	Herring

Name of the survey	Acronym	Area	Period	Main targeted species
Sprat Acoustic Survey	SPRAS	IIId	May	Sprat and herring
Rügen Herring Larvae Survey	RHLS	IIId	March-June	Herring
North Sea and Eastern Arctic (ICES areas I and II)				
International Bottom Trawl Survey	IBTS Q1 IBTS Q3	IIIa, IV	1st and 3rd Quarter	Haddock, Cod, Saithe, Herring, Sprat, Whiting, Mackerel, Norway pout.
North Sea Beam Trawl Survey	BTS	IVb,IVc,VIId	3rd Quarter	Plaice, Sole
Demersal Young Fish Survey	DYFS	Coasts of NS	3rd and 4th Quarter	Plaice, sole, brown shrimp
Sole Net Survey	SNS	IVb, IVc	3rd Quarter	Sole, Plaice
North Sea Sandeels Survey	NSSS	IVa, IVb	4th Quarter	Sandeels
International Ecosystem Survey in the Nordic Seas	ASH	IIa	May	Herring, Blue whiting
Redfish Survey in the Norwegian Sea and adjacent waters	REDNOR	II	August- September	Redfish
Mackerel egg Survey (Triennial)	NSMEGS	IV	May-July	Mackerel egg production
Herring Larvae survey	IHLS	IV,VIId	1st and 3rd Quarter	Herring, Sprat Larvae
NS Herring Acoustic Survey	NHAS	IIIa, IV,VIa	June, July	Herring, Sprat
Nephrops TVsurvey (FU 3&4)	NTV3&4	IIIA	2nd or 3rd Quarter	Nephrops
Nephrops TVsurvey (FU 6)	NTV6	IVb	September	Nephrops
Nephrops TVsurvey (FU 7)	NTV7	IVa	2nd or 3rd Quarter	Nephrops
Nephrops TVsurvey (FU 8)	NTV8	IVb	2nd or 3rd Quarter	Nephrops
Nephrops TVsurvey (FU 9)	NTV9	IVa	2nd or 3rd Quarter	Nephrops

Name of the survey	Acronym	Area	Period	Main targeted species
North Atlantic (ICES Areas V-XIV and NAFO areas)				
International Redfish Trawl and Acoustic Survey (Biennial)	REDTAS	Va, XII, XIV; NAFO SA 1-3	June/July	Redfish
Flemish Cap Groundfish survey	FCGS	3M	July	Demersal species
Greenland Groundfish survey	GGS	XIV, NAFO SA1	October/November	Cod, redfish and other demersal species
3LNO Groundfish survey	PLATUXA	NAFO 3LNO	2nd or 3rd Quarter	Demersal species
Western IBTS 4th quarter (including Porcupine survey)	IBTS Q4	VIa, VII, VIII, IXa	4th Quarter	Demersal species
Scottish Western IBTS	IBTS Q1	VIa,VIIa	March	Gadoids, herring, mackerel
ISBCBTS September	ISBCBTS	VIIa f g	September	Sole, Plaice
WCBTS	VIIe BTS	VIIe	October	Sole, Plaice, Anglerfish, Lemon sole
Blue whiting survey		VI, VII	1st and 2nd Quarter	Blue whiting
International Mackerel and Horse Mackerel Egg Survey (Triennial)	MEGS	VIa, VII,VIII, IXa	January-July	Mackerel, Horse Mackerel egg production
Sardine, Anchovy Horse Mackerel Acoustic Survey		VIII, IX	March-April-May	Sardine, Anchovy, Mackerel, Horse Mackerel abundance indices
Sardine DEPM (Triennial)		VIIIc, IXa	2nd and 4th Quarter	Sardine SSB and use of CUFES
Spawning/Pre-spawning Herring/Boarfish acoustic survey		VIa, VIIa-g	July, Sept, Nov, March, Jan	Herring, Sprat
Biomass of Anchovy	BIOMAN	VIII	May	Anchovy SSB (DEP)
Nephrops UWTV survey (offshore)	UWTV (FU 11-13)	VIa	2nd or 3rd Quarter	Nephrops

Name of the survey	Acronym	Area	Period	Main targeted species
Nephrops UWTV Irish Sea	UWTV (FU 15)	VIIa	August	Nephrops
Nephrops UWTV survey Aran Grounds	UWTV (FU 17)	VIIb	June	Nephrops
Nephrops UWTV survey Celtic Sea	UWTV (FU 20-22)	VIIg,h,j	July	Nephrops
Nephrops Survey Offshore Portugal NepS	UWTV (FU 28-29)	IXa	June	Nephrops
Mediterranean waters and Black sea				
Pan-Mediterranean Acoustic Survey ()	MEDIAS	GSA 1, 6, 7, 9, 10, 15, 16, 17, 18, 20, 22	Spring-summer (qtrs 2-3)	Small pelagic species
Bottom trawl survey in Black Sea,	BTSBS	GSA 29	Spring-autumn (qtrs 2, 3, 4)	Turbot
Pelagic trawl survey in Black Sea,	PTSBS	GSA 29	Spring-autumn (qtrs 2, 3, 4)	Sprat and whiting
International bottom trawl survey in the Mediterranean (),	MEDITS	GSA 1, 2, 3, 5, 6, 7, 8, 9, 10, 11, 15, 16, 17, 18, 19, 20, 22, 23, 25	Spring-summer (qtrs 2-3)	Demersal species

Table 11

Economic and social variables for the processing industry sector that may be collected on a voluntary basis

Variable group	Variable	Unit
ECONOMIC VARIABLES		
Income	Turnover	Euro
	Other income	Euro
Personnel costs	Personnel costs	Euro
	Value of unpaid labour	Euro
	Payment for external agency workers (optional)	Euro
Energy costs	Energy costs	Euro
Raw material costs	Purchase of fish and other raw material for production	Euro

Variable group	Variable	Unit
Other operational costs	Other operational costs	Euro
Subsidies	Operating subsidies	Euro
	Subsidies on investments	Euro
Capital costs	Consumption of fixed capital	Euro
Capital value	Total value of assets	Euro
Financial results	Financial income	Euro
	Financial expenditures	Euro
Investments	Net investments	Euro
Debt	Debt	Euro
Employment	Number of persons employed	Number
	FTE National	Number
	Unpaid labour	Number
	Number of hours worked by employees and unpaid workers	Number
Number of enterprises	Number of enterprises	Number
Weight of raw material (optional)	Weight of raw material per species and origin (optional)	Kg

SOCIAL VARIABLES

Employment by gender	Number
Employment by age	Number
Employment by education level	Number per education level
Employment by nationality	Number per country in the world
FTE National	Number

REC.DIR-GFCM/40/2016/2

on the progressive implementation of data submission in line with the GFCM Data Collection Reference Framework (DCRF)

The General Fisheries Commission for the Mediterranean (GFCM),

CONSIDERING that rational management for sustainable fisheries is dependent on the scientific utilization of relevant data on fishing fleet capacity, on the fishing activities carried out, on the status of exploited biological resources and on the social and economic situation of fisheries;

RECALLING the subregional approach to fisheries management as enshrined in the Agreement for the establishment of the General Fisheries Commission for the Mediterranean (GFCM Agreement), with a view to better addressing the specificities of the Mediterranean and the Black Sea region;

NOTING the importance of multidisciplinary data and information to monitor and assess fisheries and fisheries resources and to ensure their sustainable exploitation;

RECOGNIZING the need to develop a GFCM database, on the basis of the information received from Contracting Parties and Cooperating non-Contracting Parties (CPCs) according to a standardized format;

FURTHER RECOGNIZING the Data Collection Reference Framework (DCRF) as an instrument supporting the identification of fisheries-related data necessary to formulate sound scientific advice;

CONSIDERING that a timely submission of complete data and the analysis of the status of fisheries and exploited resources are of paramount importance for the effectiveness and credibility of GFCM management measures;

TAKING INTO ACCOUNT the importance of the classification of groups of priority species as identified by the Scientific Advisory Committee on Fisheries (SAC), of the use of the GFCM fleet segmentation for the sake of collection of the economic and biological data, as well as of the use of standard nominal fishing effort measurement;

NOTING that relevant data on fishing fleet, red coral and common dolphinfish as identified by the SAC in the DCRF are already requested under existing GFCM Recommendations GFCM/30/2006/2, GFCM/33/2009/5, GFCM/33/2009/6 and GFCM/36/2012/1;

ADOPTS, in conformity with the provisions of Articles 5 b), 8 b) and 13 of the GFCM Agreement, that:

1. CPCs shall submit to the GFCM Secretariat national data on catch, incidental catch of vulnerable species, fishing effort, socio-economics and biological information (as specified in Annex 1) for the first time in 2017, and subsequently on each calendar year. Such submission shall be done in accordance with appropriate data submission standards, procedures and protocols to be made available online by the GFCM Secretariat. Data shall be compiled following the specifications on the GFCM fleet segmentation (Annex 2) and on fishing effort measurement (Annex 3).

2. In addition to the data mentioned above, CPCs shall submit to the GFCM Secretariat for the first time in 2017, and subsequently on each calendar year, information needed to assess the status of those stocks considered priority by the Commission. Such submission shall be done using the stock assessment form (SAF) made available online by the GFCM Secretariat and following the data structure specified in Annex 5.

3. CPCs shall submit the data referred to in paragraphs 1 and 2 according to submission specifications (reporting schedule, reference year and frequency) as defined in Annex 4. With a view to ensuring consistency of the time series in the GFCM database, populated with data submitted in line

with Recommendation GFCM/33/2009/3 up to the 2014 reference year, the first data submission in 2017 shall also cover the preceding two-year timeframe, i.e. 2015 and 2016.

4. The quality of data submitted pursuant to this recommendation shall be regularly assessed with a view to ensuring the formulation of scientific advice for the Commission.

5. Relevant GFCM subsidiary bodies may draw the attention of the Commission to the possible need for any revision of Annexes 1–5 to this recommendation in order to ensure the effectiveness of data collection and analysis.

Annex 1

Data fields (DCRF tasks)

The data variables listed below are those that should be submitted to the GFCM Secretariat following the guidance provided by the relevant GFCM subsidiary bodies through the DCRF manual, including field definitions, list of species (groups 1, 2 and 3 by GFCM subregion), fishing gear, vulnerable species, shared stocks. In line with the GFCM data confidentiality policy and procedures, the "data confidentiality status" identifies the access level criteria for the sake of data dissemination: public (P), semi-private (S) or private (R).

DATA FIELDS (DCRF tasks and subtasks)			**MANDATORY (X)**	**DATA CONFIDENTIALITY STATUS**
Global figures of national fisheries		Number of vessels	X	P
		Total landings	X	P
		Total capacity (GT)	X	P
		Total engine power (kW)	X	P
Catch	**Total landing** *(by GSA and fleet segment)*	Number of vessels	X	P
		Total landings	X	P
	Catch per species *(by GSA and fleet segment)*	Species	X	P
		Total landings per species	X	P
		Total discards per species (if any)	X	S
		Total catch per species	X	P
Incidental catch of vulnerable species *(by GSA and fleet segment)*[1]		Date	X	P
		Source of data	X	S
		Fishing gear (if available)	X	P
		Group of vulnerable species[1]	X	P
		Family (if available)	X	P
		Species (if available)	X	P
		Total number of individuals caught	X	P
		Total weight of individuals caught (if available)	X	P
		Number of individuals released alive (if available)	X	S
		Number of dead individuals (if available)	X	S
		Number of individuals released in unknown status (if available)	X	S
Effort	**Fleet segment** *(by GSA and fleet segment)*	Fishing days	X	S
		Capacity	X	P
		Nominal effort	X	S
		Number of vessels	X	P
	Fishing gear *(by GSA)*	Fishing gear	X	S
		Fishing days (by fishing gear)	X	S
	CPUE *(by GSA)*[2]	Fishing gear	X	P
		Species[2]	X	P
		Nominal effort	X	S
		CPUE	X	S

[1] Mandatory for the GFCM vulnerable species
[2] Mandatory for the species of group 1 and group 2

DATA FIELDS (DCRF tasks and subtasks)			**MANDATORY (X)**	**DATA CONFIDENTIALITY STATUS**
Socio-economics	**Economic and social data** *(by GSA and fleet segment)*	Capacity (gross tonnage)	X	P
		Capacity (engine power)	X	P
		Number of vessels	X	P
		Total landing value	X	S
		Total days at sea	X	S
	Operating costs *(by GSA and fleet segment)*	Number of vessels	X	P
		Personnel costs	X	R
		Fuel consumption (if available)	X	R
		Fuel price (if available)	X	R
		Total fuel cost (if available)	X	R
		Repair and maintenance costs	X	R
		Commercial costs	X	R
		Other variable costs	X	R
		Capital costs	X	R
		Value of physical capital	X	R
		Fixed costs	X	R
		Employment	X	R
		Currency	X	S
	Species value *(by GSA and fleet segment)*[3]	Number of vessels	X	P
		Species[3]	X	P
		Total landing volume	X	P
		Total landing value	X	S
		Prices by commercial species	X	S
		Currency	X	S
	Other economic aspects *(by GSA and fleet segment)*	Operating subsidies		R
		Investments in physical capital		R
		Other income		R
		Full-time equivalent (FTE)		S
		Number of persons in the crew < 25 years-old		S
		Number of persons in the crew 25–40 years-old		S
		Number of persons in the crew > 40 years-old		S
		Currency		S
Biological information	**Length data** *(by GSA)*[4]	Source of data	X	S
		Name of the scientific survey (if any)	X	S
		Fleet segment (only if from fishery-dependent data)	X	S
		Species[4]	X	S
		Length	X	S
		Number of individuals sampled (per length classes)	X	S
		Weight of individuals sampled (per length classes)	X	S
		Number of individuals expanded (per length classes)	X	S

[3] Mandatory for the species of group 1 and 2
[4] Mandatory for the species of group 1, 2 and 3

DATA FIELDS (DCRF tasks and subtasks)			**MANDATORY (X)**	**DATA CONFIDENTIALITY STATUS**
Biological information	**Size at first maturity** *(by GSA)*[5]	Species[5]	X	P
		Sex	X	S
		L_{50}	X	S
		Reference (if any)	X	S
	Maturity data *(by GSA)*[5]	Source of data	X	S
		Name of the scientific survey (if any)	X	P
		Fleet segment (only if from fishery-dependent data)	X	P
		Species[5]	X	P
		Length	X	S
		Sex	X	S
		Maturity[6]	X	S
		Number of individuals sampled (per length class, sex and maturity stage)	X	S
		Weight of individuals sampled (per length class, sex and maturity stage)	X	S
		Number of individuals expanded (per length class, sex and maturity stage)	X	S
	European eel	Habitat	X	P
		Site	X	P
		Gear types	X	P
		Mesh size (if any)	X	S
		Number of fishermen	X	S
		Fishing days	X	S
		Average number of “gear units” per day per fisherman (if any)	X	S
		Total catch of silver eel (if any)	X	P
		Total catch of yellow eel (if any)	X	P
		Total catch of glass eel (if any)	X	P

[5] Mandatory for the species of group 1.
[6] Following the scale of maturity stages (DCRF manual).

Annex 2

GFCM fleet segmentation
(Combination of vessel groups and length classes)

<table>
<tr><th colspan="3" rowspan="2">VESSEL GROUPS</th><th colspan="4">LENGTH CLASSES (LOA)</th></tr>
<tr><th>< 6 m</th><th>6–12 m</th><th>12-24 m</th><th>> 24 m</th></tr>
<tr><td rowspan="3">Polyvalent</td><td rowspan="3">P</td><td rowspan="2">Small-scale vessels without engine using passive gears</td><td>P-01</td><td>P-02</td><td rowspan="2">P-03</td><td rowspan="2">P-04</td></tr>
<tr><td colspan="2">P-13</td></tr>
<tr><td>Small-scale vessels with engine using passive gears</td><td>P-05</td><td>P-06</td><td>P-07</td><td>P-08</td></tr>
<tr><td></td><td></td><td>Polyvalent vessels</td><td>P-09</td><td>P-10</td><td>P-11</td><td>P-12</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td colspan="2">P-14</td></tr>
<tr><td rowspan="4">Seiners</td><td rowspan="4">S</td><td rowspan="2">Purse seiners</td><td rowspan="2">S-01</td><td rowspan="2">S-02</td><td>S-03</td><td>S-04</td></tr>
<tr><td colspan="2">S-09</td></tr>
<tr><td rowspan="2">Tuna seiners</td><td rowspan="2">S-05</td><td rowspan="2">S-06</td><td>S-07</td><td>S-08</td></tr>
<tr><td colspan="2">S-10</td></tr>
<tr><td>Dredgers</td><td>D</td><td>Dredgers</td><td>D-01</td><td>D-02</td><td>D-03</td><td rowspan="2">D-04</td></tr>
<tr><td></td><td></td><td></td><td></td><td colspan="2">D-05</td></tr>
<tr><td rowspan="3">Trawlers</td><td rowspan="3">T</td><td>Beam trawlers</td><td>T-01</td><td>T-02</td><td>T-03</td><td>T-04</td></tr>
<tr><td rowspan="2">Pelagic trawlers</td><td rowspan="2">T-05</td><td>T-06</td><td>T-07</td><td>T-08</td></tr>
<tr><td colspan="3">T-13</td></tr>
<tr><td></td><td></td><td>Trawlers</td><td>T-09</td><td>T-10</td><td>T-11</td><td>T-12</td></tr>
<tr><td rowspan="2">Longliners</td><td rowspan="2">L</td><td rowspan="2">Longliners</td><td rowspan="2">L-01</td><td>L-02</td><td>L-03</td><td>L-04</td></tr>
<tr><td colspan="3">L-05</td></tr>
</table>

Note

- 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 the vessels using more than one gear, with a combination of passive and active gear, none of which exceeding 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.
- The yellow cells contain the codes of reported fleet segments which should be included in the GFCM data submission. If necessary, fleet segments as identified in the orange cells can be used: P-13 (P-01 + P-02), P-14 (P-11 + P-12), S-09 (S-03 + S-04), S-10 (S-07 + S-08), D-05 (D-02 + D-03), T-13 (T-06 + T-07 + T-08) and L-05 (L-02 + L-03 + L-04). Any proposal for a different aggregation of fleet segments should be brought to the attention of the relevant GFCM subsidiary bodies, mentioning the rationale and corresponding references (e.g. existing scientific studies), which in turn should confirm the similarity/homogeneity of the combined cells.

Annex 3

Table on fishing effort measurement

Effort measurement by fleet segment

FLEET SEGMENTS			EFFORT MEASUREMENTS		
Vessel groups		**Length classes (LOA)**	**Unit of capacity**	**Unit of activity**	**Nominal effort**
P	Small-scale vessels without engine using passive gear Small-scale vessels with engine using passive gear Polyvalent vessels	All	Net length[1]	Fishing days	Net length* Fishing days
			Number of traps/pots[1]	Fishing days	Number of traps/pots* Fishing days
			Number of lines[1]	Fishing days	Number of lines* Fishing days
S	Purse seiners Tuna seiners	All	GT	Number of fishing sets[2]	GT* Number of fishing sets
D	Dredgers	All	GT	Fishing days	GT* Fishing days
T	Beam trawlers Pelagic trawlers Trawlers	All	GT	Fishing days	GT* Fishing days
L	Longliners	All	Number of hooks	Fishing days	Number of hooks* Fishing days

[1] Should this information not be available, "GT" may be used as capacity unit upon approval by relevant GFCM subsidiary bodies on a case by case basis.

[2] Should this information not be available, "fishing days" may be used as activity unit upon approval by relevant GFCM subsidiary bodies on a case by case basis.

Effort measurement by fishing gear

Fishing gear		Gear code	Unit of capacity	Unit of activity	Nominal effort
Surrounding nets	With purse lines (purse seines)	PS	GT	Number of fishing sets[1]	GT* Number of fishing sets
	One boat operated purse seines	PS1			
	Two boats operated purse seines	PS2			
	Without purse lines (lampara)	LA			
Seine nets	Beach seines	SB	Net length[2]	Fishing days	Net length* Fishing days
	Boat or vessel seines	SV			
	Danish seines	SDN			
	Scottish seines	SSC			
	Pair seines	SPR			
	Seine nets (not specified)	SX			
Trawls	Bottom trawls	TB	GT	Fishing days	GT* Fishing days
	Bottom beam trawls	TBB			
	Bottom otter trawls	OTB			
	Bottom pair trawls	PTB			
	Bottom nephrops trawls	TBN			
	Bottom shrimp trawls	TBS			
	Midwater trawls	TM			
	Midwater otter trawls	OTM			
	Midwater pair trawls	PTM			
	Midwater shrimp trawls	TMS			
	Otter twin trawls	OTT			
	Otter trawls (not specified)	OT			
	Pair trawls (not specified)	PT			
	Other trawls (not specified)	TX			

[1] Should this information not be available, “fishing days” may be used as activity unit upon approval by relevant GFCM subsidiary bodies on a case by case basis.

[2] Should this information not be available, “GT” may be used as capacity unit upon approval by relevant GFCM subsidiary bodies on a case by case basis.

Fishing gear		Gear code	Unit of capacity	Unit of activity	Nominal effort
Dredges	Boat dredges	DRB	GT	Fishing days	GT * Fishing days
	Mechanised dredges	HMD			
	Hand dredges	DRH			
Gillnets and Entangling nets	Set gillnets (anchored)	GNS	Net length[2]	Fishing days	Net length * Fishing days
	Driftnets	GND			
	Encircling gillnets	GNC			
	Fixed gillnets (on stakes)	GNF			
	Trammel nets	GTR			
	Combined gillnets-trammel nets	GTN			
	Gillnets and entangling nets (not specified)	GEN			
	Gillnets (not specified)	GN			
Traps	Stationary uncovered pound nets	FPN	Number of traps/pots[2]	Fishing days	Number of traps/pots * Fishing days
	Pots	FPO			
	Fyke nets	FYK			
	Stow nets	FSN			
	Barrier, fences, weirs, etc.	FWR			
	Aerial traps	FAR			
	Traps (not specified)	FIX			
Hooks and lines	Handlines and pole-lines (hand operated)	LHP	Number of lines[2]	Fishing days	Number of lines * Fishing days
	Handlines and pole-lines (mechanised)	LHM			
	Trolling lines	LTL			
	Set longlines	LLS	Number of hooks	Fishing days	Number of hooks * Fishing days
	Drifting longlines	LLD			
	Longlines (not specified)	LL			
	Hooks and lines (not specified)	LX			

Annex 4

Data submission calendar

Each calendar year (n), the requested data, as specified in Annex 2 and pertaining to the year before submission (n-1), shall be submitted to the GFCM Secretariat on the basis of the following schedule:

- May
  - Global figures of national fisheries
  - Socio-economics – Species value[11]
  - Socio-economics – Other economic aspects[1]
  - Socio-economics – Operating costs[1]

- June
  - Catch – Landing data
  - Catch – Catch data per species
  - Effort – Fleet segment
  - Effort – Fishing gear
  - Effort – CPUE

- July
  - Incidental catch of vulnerable species
  - Biological information – Length data
  - Biological information – Size at first maturity
  - Biological information – Maturity data

- September
  - Biological information – Stock assessment form[12]
  - Biological information – European eel

- November
  - Socio-economics – Economic and social data

[11] Data should refer to the reference year n-2 and their submission should take place on biennial basis only for those countries that do not have annual economic surveys in place. Countries collecting these data on a yearly basis are requested to submit them annually (keeping reference year n-2).

[12] The date of data submission is linked to the scheduling of the GFCM stock assessment working groups and therefore may differ from one year to another.

Annex 5

Stock assessment forms

The stock assessment forms (SAFs) to be used to submit the information required to assess the status of those stocks considered as priority stocks by the Commission shall be provided by relevant GFCM subsidiary bodies according to the following structure:

- Basic identification data;
- Stock identification and biological information (stock unit, growth and maturity);
- Fisheries information (description of the fleet, historical trends, management measures, reference points);
- Fisheries independent information (name, brief description of the chosen method and assumptions used, spatial distribution of the resources, historical trends);
- Ecological information (protected species potentially affected by the fisheries, environmental indexes);
- Stock assessment (name of the model, model assumptions, scripts, input data and parameters, tuning data, results, robustness analysis, retrospective analysis, comparison between model runs, sensitivity analysis, assessment quality);
- Stock predictions (short, medium, and long term); and
- Draft scientific advice.

The SAFs shall be revised by relevant GFCM subsidiary bodies on a regular basis and their most up-to-date version shall be disseminated online by the GFCM Secretariat.

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София

AGENȚIA NAȚIONALĂ PENTRU PESCUIT ȘI ACVACULTURĂ anpa

№. 2449/25.03.2015

AGREEMENT

Between

NATIONAL AGENCY FOR FISHERIES AND AQUACULTURE OF BULGARIA
and
NATIONAL AGENCY FOR FISHERIES AND AQUACULTURE OF ROMANIA

Today ..25..MARCH..... 2015, in..SOFIA.., between:

The NATIONAL AGENCY FOR FISHERIES AND AQUACULTURES OF BULGARIA, Sofia, Hristo Botev bul. 17, BULSTAT 000649519, tel.: 02/805 16 66, fax: 02/805 16 86, represented by Yancho Yanev - Executive director, on one side

and

The NATIONAL AGENCY FOR FISHERIES AND AQUACULTURES OF ROMANIA, Str Transilvaniei, nr. 2, sectorul 1, Bucuresti, represented by Cristinel George Gherghisan – President, on the other side,

The two parties having regarded to:

- Regulation (EC) No 199/2008 which establishes the Community framework for the collection, management and use of data for the purpose of providing a solid basis for scientific analyses for the field of fisheries and of providing for the formulation of sound scientific advice for the implementation of the common fisheries policy (CFP).
- Commission Decision of 18 December 2009, 2010/93/EU adopting multiannual Community programmes for the collection, management and use of data in the fisheries sector for the period 2011-2013.
- Commission Implementing Decision C(2013) 5568 final /30.08.2013 extending the national programmes for the collection of primary biological, technical, environmental and socio-economic data for fisheries for the period 20 I 1 -201 3 to the period 20 1 4-20 16.
- Report of the 10th Regional Coordination Meeting for the Mediterranean and Black Sea.
- Bulgarian national legislation on fisheries: Fishery and Aquaculture Act (FAA)/2013.
- Romanian national legislation on fisheries: G.E.O. No. 23/2008 on Fisheries and Aquaculture.

HAVE AGREED ON THE FOLLOWING:

Art. 1. Scope of the collaboration

Cooperation in implementing the National Programmes for collection, management and use of data for marine fisheries in Bulgaria and Romania, in accordance with the objectives of the Common Fisheries Policy (CFP) in the Black Sea.

Art. 2 (1). Objectives of the collaboration

The present Cooperation Agreement covers activities included in the following modules of the Multi-annual community programme for data collection (Commission Decision 2010/93/EU):

a. Module of evaluation of the fishing sector
   - Section for the collection of biological variables
   - Section for research surveys at sea

b. Module of evaluation of the effects of the fishing sector on the marine ecosystems

c. Module for management and use of the data covered by the data collection framework

(2) The main objectives of this Collaboration Agreement are:

- Cooperation on conducting research surveys-at-sea;
- Adoption of common methodology when conducting research surveys-at-sea;
- Adoption of a coordination and sharing best practices between the national systems;
- Increasing the efficiency of scientific work of the institutes and the accuracy of collected data and analyses;

(3) Specific objectives of the collaboration:

- Harmonization of the sampling methods and data analyses (characteristics of the nets used, biological parameters to be sampled, statistical analyses);
- Harmonization of methods for stock assessment of commercially important fish species in the Romanian and Bulgarian marine zones (growth parameters, mortality rates);
- Collected data to be used for the development of indicators to assess the effects of fisheries on marine ecosystems;
- To protect and conserve living aquatic resources and their sustainable exploitation through a common approach on the implementation of management measures.

Art. 3. Participating institutions

Both Agencies for Fisheries and Aquaculture from Bulgaria and Romania are the national institutions responsible for implementation of the Fisheries Data Collection Program in each country.

For the implementation of scientific objectives, the participating institutes are:

• *In Bulgaria:*
   - Institute of Fishing Resources, Varna (IFR)
   - Institute of Oceanology of the Bulgarian Academy of Science, Varna (IOBAS)
   - Institute for fisheries and aquaculture, Plovdiv

• *In Romania:*
   - National Institute for Marine Research and Development *Grigore Antipa* (NIMRD), Constanta

Art. 4. Planned activities for 2014-2020:

1. Research surveys at sea:

During the period of agreement (2015 - 2020), each country will undertake annually research surveys in their territorial waters and EEZ under their jurisdiction - demersal trawl surveys and acoustic surveys, following common methodology that is going to be adopted by the countries and that will follow the methodology already adopted by other EU countries (MEDIAS and MEDITS). The survey number and the target species can be amended following Regional Coordination Meetings recommendations subject to EC-DG MARE approval. National scientific teams are responsible for collection and analysis of data, stock assessments, providing information on biological variables and reporting only for their national waters (territorial waters and EEZ).

2. Harmonization of biological data sampling and analysis:

- Sampling of the catch and landings: age, size, spawning intensity, growth parameters, mortality rates;

3. Harmonization of stock assessment methods:

- Methodology for demersal Trawl Surveys;
- Methodology for hydroacoustic surveys;
- Methodology for collection and analysis of biological variables;

Art. 5. Responsibilities of the partners:

1. The partners must harmonize the methodologies used for biological sampling/data processing and stock assessment according to the best available methodologies following suggestions from GFCM/STECF and, as necessary, to cooperate with the third countries in the Black Sea region in order to improve the quality of the data and the stock assessments interferences.
2. The partners shall take the necessary steps to coordinate the sampling methodology in similar segments/métiers. These methodologies are to be specified at the Regional coordination meeting between representatives of NAFA and scientists from the two countries.
3. The National Agencies for Fisheries and Aquaculture of Bulgaria and Romania are obliged to contract the respective national research institutes, responsible for the surveys, ensuring the Programme and Agreement implementation for each year.
4. The contracted research institutes shall organize meeting annually before starting the surveys for planning of the surveys-at-sea (starting dates, simultaneously in both areas) and harmonize the methodology that shall be used.
5. The two parties shall carry out the pelagic and bottom trawl surveys in the territorial waters of their respective countries, and, in order to facilitate the harmonization of the methodologies used, are committed to ensure the presence of scientists of the country's research institutes on board of the research vessels of the other contracting party, depending of the case.
6. The undersigned parties engage to collaborate when working on the next National Programmes for Fisheries Data Collection (NPFDC), submitted for approval to be co-financed by EC and national NAFA (for 2014-2020).
7. The procedures and methodologies to be used in collecting and analyzing data and in estimating their accuracy and precision shall be included in the national programmes.
8. In accordance with the acting legislation in Bulgaria and Romania, respectively, the partners commit to provide the financial means for the scientific surveys and working meetings (the cost will be covered by national NAFA with contribution of European

Maritime and Fisheries Fund (EMFF). Each party will cover the costs of the surveys (according to Appendix IX – List of research survey at sea, of Decision (EC)93/2010) for own research vessel in its national waters and the costs of participation of its scientific team on board the other research vessel during the surveys execution.

9. The data obtained is to be stored in national computer databases so that they are accessible to the Partners and Commission, and could also be transmitted to end-users.
10. The Partners and the Commission should coordinate and cooperate in the relevant international scientific bodies. Priority should also be given to ensure the attendance of scientific personnel in the expert groups conducting the scientific evaluation needed to achieve the goals of the CFP.
11. Recommendations made at the Regional Coordination Meetings shall be taken into account when drafting and amending the National Programmes during the programming period.
12. All the expenses for specialists (surveys, data analyses, data managements, working meetings, etc.) will be supported by the NP under EC Regulations.
13. Each year, both parties shall have a meeting aiming exchanging of data, best practices and knowledge, and discussing the results of the Agreement implementation for the previous year. The meeting shall take place at a date prior Annual Report Data Collection submission to CE/DG MARE, under the commitments to the EU legislation on DCF.

FOR NAFA BULGARIA

Yancho Yanev
Executive director NAFA - Bulgaria

FOR NAFA ROMANIA

Cristinel George Gherghisan
President NAFA - Romania

EAFA
EXECUTIVE AGENCY FOR FISHERIES AND AQUACULTURE

ИЗПЪЛНИТЕЛНА АГЕНЦИЯ ПО РИБАРСТВО И АКВАКУЛТУРИ
Вх. № 12-00-582
11.10.2021 год.
Бургас

AGENȚIA NAȚIONALĂ PENTRU PESCUIT ȘI ACVACULTURĂ
anpa

MINISTERUL AGRICULTURII ȘI DEZVOLTĂRII RURALE
AGENȚIA NAȚIONALĂ PENTRU PESCUIT ȘI ACVACULTURĂ
Secretariat
INTRARE / IEȘIRE Nr. 10.014
Ziua 11 Luna 10 Anul 2021

AGREEMENT

between

NATIONAL AGENCY FOR FISHERIES AND AQUACULTURE OF ROMANIA

and

EXECUTIVE AGENCY FOR FISHERIES AND AQUACULTURE OF BULGARIA

The NATIONAL AGENCY FOR FISHERIES AND AQUACULTURE OF ROMANIA, (NAFA RO), 29, Sf. Vineri Str, Floor 3, București, represented by Eng. Ioan DOBROTCHI - President, on one side, and

The EXECUTIVE AGENCY FOR FISHERIES AND AQUACULTURE OF BULGARIA (EAFA BG), 1 Aleksandar Batenberg str., Burgas 8000, Bulgaria, Phone: (+35956) 87 60 60, Fax: (+35956) 87 60 90, e-mail: office@iara.government.bg, represented by Assoc. Prof. Galin Nikolov, PhD executive director, on the other side,

The two parties having regarded to:

- Regulation (EU) 2017/1004 of the European Parliament and of the Council of 17 May 2017 on the establishment of a Union framework for the collection, management and use of data in the fisheries sector and support for scientific advice regarding the common fisheries policy and repealing Council Regulation (EC) No 199/2008 (recast) which establishes the Community framework for the collection, management and use of data for the purpose of providing a solid basis for scientific analyses for the field of fisheries and of providing for the formulation of sound scientific advice for the implementation of the common fisheries policy (CFP);

- COMMISSION DELEGATED DECISION (EU) 2021/1167 of 27 April 2021 establishing the multiannual Union programme for the collection and management of biological, environmental, technical and socioeconomic data in the fisheries and aquaculture sectors from 2022;

- COMMISSION IMPLEMENTING DECISION (EU) 2021/1168 of 27 April 2021 establishing the list of mandatory research surveys at sea and thresholds as part of the multiannual Union programme for the collection and management of data in the fisheries and aquaculture sectors from 2022;
- Commission Decision of 18 December 2009, 2010/93/EU adopting multiannual Community programs for the collection, management and use of data in the fisheries sector for the period 2011-2013;
- Report of the 10th Regional Coordination Meeting for the Mediterranean and Black Sea;
- Commission Delegated Decision (EU) 2019/910 of 13 March 2019 establishing the multiannual Union programme for the collection and management of biological environmental, technical and socioeconomic data in the fisheries and aquaculture sectors;
- Commission Implementing Decision (EU) 2019/909 of 18 February 2019 establishing the list of mandatory surveys and thresholds for the purposes of the multiannual Union programme for the collection and management of data in the fisheries and aquaculture sectors:
- Commission Implementing Decision (EU) 2016/1701 of 19 August 2016 laying down rules on the format for the submission of work plans for data collection in the fisheries and aquaculture sectors – (notified under document C(2016) 5304);
- Commission Implementing Decision (EU) 2018/1283 of 24 August 2018 laying down rules on the

format and timetables for the submission of annual data collection reports in the fisheries and aquaculture sectors (notified under document C(2018) 5270);

- Commission Decision of 30.5.2016, Brussels, 30.5.2016 C(2016) 3301 final, establishing horizontal rules on the creation and operation of Commission expert groups;
- The new expected Framework on Data collection legislation would be adopted by E.C. applicable for the next EMFAF 2021-2027 programming period including data collection, that will be applied for actual Agreement;
- Bulgarian national legislation on fisheries: Fishery and Aquaculture Act (FAA)/2020;
- Romanian national legislation on fisheries: G.E.O. No. 23/2008 on Fisheries and Aquaculture,

HAVE AGREED ON THE FOLLOWING:

Art. 1. Scope of the collaboration

Cooperation in the implementation of the multiannual Union programme for collection, management and use of data in the fisheries sector and support for scientific advice regarding the common fisheries policy at national level in Bulgaria and Romania, in accordance with the objectives of the Common Fisheries Policy (CFP) in the Black Sea.

Art. 2. Objectives of the collaboration

The present Cooperation Agreement covers activities included in the following modules activities of the Multi-annual community program for data collection, format proposal under legislative procedure for adoption, referring to:

- Evaluation of the fishing sector – general, results, including pilot studies, regular sampling;
- Data collection activities;
- Planning of sampling for biological variables;
- Recreational fisheries;
- Sampling plan description for biological data;
- Research surveys at sea;
- Fishing activity variables data collection strategy;
- Incidental by-catch of vulnerable species;
- Economic and social variables for fisheries data collection;
- Economic and social variables for aquaculture data collection;
- Economic and social variables for fish processing data collection;
- Quality report for biological data sampling scheme;
- Quality report for socioeconomic data sampling scheme.

1. The main objectives of this Collaboration Agreement are:

Cooperation on conducting research surveys-at-sea;

Adoption of common methodology when conducting research surveys-at-sea; Adoption of a coordination and sharing best practices between the national systems; Increasing the efficiency of scientific work of the institutes and the accuracy of collected data and analyses;

2. Specific objectives of the collaboration:

Harmonization of the sampling methods and data analyses (characteristics of the nets used, biological parameters to be sampled, statistical analyses);

Harmonization of methods for stock assessment of commercially important fish species in the Romanian and Bulgarian marine zones (growth parameters, mortality rates);

Collected data to be used for the development of indicators to assess the effects of fisheries on marine ecosystems;

To protect and conserve living aquatic resources and their sustainable exploitation through a common approach on the implementation of management measures.

Art. 3. Participating institutions

Both agencies for fisheries and aquaculture from Bulgaria and Romania are the national authorities responsible for implementation of the multiannual Union programme at national level.

For the implementation of scientific objectives, the participating institutes that could be accompanied by other scientific bodies authorized in each country are:

* *In Bulgaria:*

Institute of Fish Resources, Varna, Agricultural Academy (IFR);
Institute of Oceanology, Varna, Bulgarian Academy of Science, (IO-BAS);
Institute of Fisheries and Aquaculture, Plovdiv, Agricultural Academy (IFA).

* *In Romania:*

National Institute for Marine Research and Development *Grigore Antipa* (NIMRD), Constanta,

Institute for Research-Development for Aquatic Ecology, Fisheries and Aquaculture (IRDFAEFA), Galati,

Research and Development Station for Fisheries (RDSF), Nucet.

Art. 4. Planned activities for 2021-2027:

1. Research surveys at sea:

During the period of agreement (2021 - 2027), each country will undertake annually research surveys in their territorial waters and EEZ under their jurisdiction - bottom trawl surveys and pelagic trawl surveys, following common methodology that is going to be agreed by the parties and that will follow the methodology already adopted at EU level – regional, i.e.: GFCM methodologies, MEDIAS and MEDITS.

The number of surveys and the target species could be amended according to the changes in the European legislation or in accordance to the Regional Coordination Group for the Mediterranean and Black Sea and GFCM recommendations.

National scientific teams are responsible for collection and analysis of data, stock assessments, providing information on biological variables and reporting only for their national waters (territorial waters and EEZ).

2. Harmonization of biological data sampling and analysis:

Sampling of the catch and landings: length, age, weight, sex ratio, maturity, fecundity, spawning intensity, growth parameters, mortality rates, and stomach content.

3. Harmonization of stock assessment methods:

Methodology for Bottom Trawl Surveys;

Methodology for Pelagic Trawl surveys;

Methodology for collection and analysis of biological variables from biological sampling from landings and by observers on board.

Art. 5. Responsibilities of the parties:

1. The parties shall use harmonized methodologies for biological sampling/data processing and stock assessment according to the best available methodologies following suggestions from GFCM/STECF, GFCM - WGBS and, as necessary, to cooperate with the third countries in the Black Sea region in order to improve the quality of the data and the stock assessments interferences.

2. The parties shall take the necessary steps to coordinate the sampling methodology in similar segments /métiers.

3. The methodologies should be specified at the Regional coordination meeting between representatives of NAFA, Romania, EAFA, Bulgaria and responsible scientists from the two countries.

4. The National Agencies for Fisheries and Aquaculture of Bulgaria and Romania should contract the respective national research institutes with the responsibilities for the surveys, in order to ensure the implementation of the Programme for each year.

5. The research institutes could organize annual meetings before starting the surveys for planning of the surveys-at-sea (starting dates, simultaneously in both areas, etc.) and harmonize/update the methodology

that shall be used.

6. The parties shall carry out the pelagic and bottom trawl surveys in the territorial waters of their respective countries, and, in order to facilitate the harmonization of the methodologies used, are committed to ensure the presence of scientists of the country's research institutes on board of the research vessels of the other contracting party, depending of the case.

7. The undersigned parties engage to collaborate when working on the next National Work Plans for Fisheries Data Collection (NWPs), submitted for approval and under co-financed by EC and national management authorities (for 2021-2027).

8. The procedures and methodologies to be used in collecting and analysing data and in estimating their accuracy and precision shall be included in the national Work Plans.

9. In accordance with the acting legislation in Bulgaria and Romania, respectively, the parties commit to provide the financial costs for the scientific surveys established in their countries. Each party shall cover the costs for their own surveys (in regards to the List of research surveys at sea listed in Commission Implementing Decision (EU) 2019/909 of 18 February 2019), for the research vessel for their own surveys and the costs for the participation of its scientific team on board the research vessel during the surveys execution of the other country.

10. The data obtained during the surveys shall be stored in national electronic databases in order to be provided to the Commission, to the parties in this agreement, when is needed, and could also be used under data transmission procedures/commitments to the end-users.

11. The parties should coordinate and cooperate in the relevant international scientific bodies. Also, priority should be given to ensure the attendance of experts in the expert groups conducting the scientific evaluation needed to achieve the objectives of the CFP.

12. Recommendations made at the Regional Coordination Group shall be applied when drafting and amending the National Work Plans during the programming period.

13. All the expenses for specialists (surveys, data analyses, data managements, working meetings, etc.) shall be supported through NWPs under EU Funds.

14. Each year, both countries shall have at least one meeting aiming to exchange data, best practices and knowledge and analyzing data and results of the implementation of the agreement for the previous year. On the meeting/s could be coordinated also the activities for the submission of the national work plans and annual reports.

Art. 6. Period of the agreement

This agreement is applicable for the period 2021-2027.

SIGNATORY PARTIES,

NATIONAL AGENCY FOR FISHERIES AND AQUACULTURE OF ROMANIA
PRESIDENT,

Eng. Ioan DOBROTCHI

EXECUTIVE AGENCY FOR FISHERIES AND AQUACULTURE OF BULGARIA
EXECUTIVE DIRECTOR,

Assoc. Prof. Galin NIKOLOV, PhD

Galin Yankov Nikolov

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NATIONAL CORRESPONDENTS FOR DATA COLLECTION

Constantin STROIE

Simona NICHEVA

Simona Vasileva Nicheva

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Recommendation GFCM/41/2017/6

on the submission of data on fishing activities in the GFCM area of application

The General Fisheries Commission for the Mediterranean (GFCM),

CONSIDERING that rational management for sustainable fisheries is dependent on the scientific utilization of relevant data on fishing fleet capacity, on the fishing activities carried out, on the status of exploited biological resources and on the social and economic situation of fisheries;

RECALLING the subregional approach to fisheries management as enshrined in the Agreement for the establishment of the General Fisheries Commission for the Mediterranean (GFCM Agreement), with a view to better addressing the specificities of the Mediterranean and the Black Sea region;

NOTING the importance of multidisciplinary data and information to monitor and assess fisheries and fisheries resources and to ensure their sustainable exploitation;

RECOGNIZING the need to develop a GFCM database, on the basis of the information received from contracting parties and cooperating non-contracting parties (CPCs) according to a standardized format;

FURTHER RECOGNIZING the Data Collection Reference Framework (DCRF) as an instrument supporting the implementation of the mid-term strategy (2017–2020) towards the sustainability of Mediterranean and Black Sea fisheries (mid-term strategy) through the identification and collection of fisheries-related data necessary to improve the formulatation of sound scientific advice by relevant GFCM subsidiary bodies;

CONSIDERING that a timely submission of complete data and the analysis of the status of fisheries and exploited resources are of paramount importance for the effectiveness and credibility of GFCM management measures;

TAKING INTO ACCOUNT the importance of the classification priority species groups as identified by the Scientific Advisory Committee on Fisheries (SAC), of the use of the GFCM fleet segmentation for the collection of economic and biological data, as well as of the use of standard nominal fishing effort measurement;

NOTING that relevant data on fishing fleets, red coral and common dolphinfish as identified by the SAC in the DCRF are already requested under existing recommendations GFCM/30/2006/2 on the establishment of a closed season for common dolphinfish fisheries using fish aggregating devices, GFCM/33/2009/5 on the establishment of the GFCM regional fleet register, GFCM/33/2009/6 concerning the establishment of a GFCM record of vessels over 15 metres authorized to operate in the GFCM area of application, amending Recommendation GFCM/29/2005/2, and GFCM/36/2012/1 on further measures for the exploitation of red coral in the GFCM area of application;

RECALLING the decision taken by the Commission at its fortieth session to adopt, for a one-year period, Recommendation GFCM/40/2016/2 on the progressive implementation of data submission in line with the GFCM Data Collection Reference Framework, and to reconsider its contents at its forty-first session;

ADOPTS, in conformity with Articles 5 b), 8 b) and 13 of the GFCM Agreement, the following recommendation:

1. CPCs shall submit to the GFCM Secretariat national data on catch, incidental catch of vulnerable species, fishing effort, socio-economic and biological information (as specified in Annex 1) for the first time in 2018, and subsequently each calendar year. Such submission shall be done in accordance with appropriate data submission standards, procedures and protocols to be made available online by the GFCM Secretariat. Data shall be compiled following the

specifications on the GFCM fleet segmentation (Annex 2) and on fishing effort measurement (Annex 3).

2. In addition to the data mentioned above, CPCs shall submit to the GFCM Secretariat for the first time in 2018, and subsequently each calendar year, information needed to assess the status of those stocks considered priority by the Commission. Such submission shall be done using the stock assessment form (SAF) made available online by the GFCM Secretariat and following the data structure specified in Annex 5.

3. CPCs shall submit the data referred to in paragraphs 1 and 2 according to submission specifications (reporting schedule, reference year and frequency) as defined in Annex 4. With a view to ensuring consistency of the time series in the GFCM database, populated with data submitted in line with Recommendation GFCM/33/2009/3 on the implementation of the GFCM Task 1 statistical matrix and repealing Resolution GFCM/31/2007/1 up to the 2015 reference year, the first data submission in 2018 shall also cover the preceding two-year timeframe, i.e. 2016 and 2017.

4. The quality of data submitted pursuant to this recommendation shall be regularly assessed with a view to ensuring the formulation of scientific advice for the Commission.

5. Relevant GFCM subsidiary bodies may draw the attention of the Commission to the possible need for any revision of Annexes 1–5 to this recommendation in order to ensure the effectiveness of data collection and analysis.

6. Recommendation GFCM/33/2009/3 is hereby repealed.

7. All references to the Task 1 statistical matrix and Recommendation GFCM/33/2009/3 found in previous GFCM recommendations and resolutions will be automatically replaced by references to the DCRF upon the entry into force of this recommendation.

Annex 1

GFCM DATA FIELDS (DCRF TASKS)

The data variables listed below are those that should be submitted to the GFCM Secretariat following the guidance provided by the relevant GFCM subsidiary bodies through the DCRF manual, including field definitions, list of species (groups 1, 2 and 3 by GFCM subregion), fishing gear, vulnerable species, shared stocks. In line with the GFCM data confidentiality policy and procedures, the "data confidentiality status" identifies the access-level criteria for the sake of data dissemination: Public (P), Semi-private (S), Private (R).

DATA FIELDS (DCRF tasks and subtasks)			**MANDATORY (X)**	**DATA CONFIDENTIALITY STATUS**
Global figures of national fisheries		Number of vessels	X	P
		Total landings	X	P
		Total capacity (GT)	X	P
		Total engine power (kW)	X	P
Catch	**Total landing** *(by GSA and fleet segment)*	Number of vessels	X	P
		Total landings	X	P
	Catch per species *(by GSA and fleet segment)*	Species	X	P
		Total landings per species	X	P
		Total discards per species (if any)	X	S
		Total catch per species	X	P
Incidental catch of vulnerable species *(by GSA and fleet segment)*[1]		Date	X	P
		Source of data	X	S
		Fishing gear (if available)	X	P
		Group of vulnerable species[1]	X	P
		Family (if available)	X	P
		Species (if available)	X	P
		Total number of individuals caught	X	P
		Total weight of individuals caught (if available)	X	P
		Number of individuals released alive (if available)	X	S
		Number of dead individuals (if available)	X	S
		Number of individuals released in unknown status (if available)	X	S
Effort	**Fleet segment** *(by GSA and fleet segment)*	Fishing days	X	S
		Capacity	X	P
		Activity	X	S
		Nominal effort	X	S
		Number of vessels	X	P
	Fishing gear *(by GSA)*	Fishing gear	X	S
		Fishing days (by fishing gear)	X	S
	CPUE *(by GSA)*[2]	Fishing gear	X	P
		Species[2]	X	P
		Nominal effort	X	S
		CPUE	X	S

[1] Mandatory for the GFCM vulnerable species

[2] Mandatory for the species of group 1 and group 2

DATA FIELDS (DCRF tasks and subtasks)			MANDATORY (X)	DATA CONFIDENTIALITY STATUS
Socio-economics	**Economic and social data** *(by GSA and fleet segment)*	Capacity (gross tonnage)	X	P
		Capacity (engine power)	X	P
		Number of vessels	X	P
		Total landing value	X	S
		Total days at sea	X	S
	Operating costs *(by GSA and fleet segment)*	Number of vessels	X	P
		Personnel costs	X	R
		Fuel consumption (if available)	X	R
		Fuel price (if available)	X	R
		Total fuel cost (if available)	X	R
		Repair and maintenance costs	X	R
		Commercial costs	X	R
		Other variable costs	X	R
		Capital costs	X	R
		Value of physical capital	X	R
		Fixed costs	X	R
		Employment	X	R
		Currency	X	S
	Species value *(by GSA and fleet segment)*[3]	Number of vessels	X	P
		Species[3]	X	P
		Total landing volume	X	P
		Total landing value	X	S
		Prices by commercial species	X	S
		Currency	X	S
	Other economic aspects *(by GSA and fleet segment)*	Operating subsidies		R
		Investments in physical capital		R
		Other income		R
		Full-time equivalent (FTE)		S
		Number of persons in the crew < 25 years-old		S
		Number of persons in the crew 25-40 years-old		S
		Number of persons in the crew > 40 years-old		S
		Currency		S

Biological information	**Length data** *(by GSA)*[4]	Source of data	X	S
		Name of the scientific survey (if any)	X	S
		Fleet segment (only if from fishery-dependent data)	X	S
		Species[4]	X	S
		Length	X	S
		Number of individuals sampled (per length classes)	X	S
		Weight of individuals sampled (per length classes)	X	S
		Number of individuals expanded (per length classes)	X	S

[3] Mandatory for the species of group 1 and 2

[4] Mandatory for the species of group 1, 2 and 3

DATA FIELDS (DCRF tasks and subtasks)			MANDATORY (X)	DATA CONFIDENTIALITY STATUS
Biological information	**Size at first maturity** *(by GSA)*[5]	Species[5]	X	P
		Sex	X	S
		L_{50}	X	S
		Reference (if any)	X	S
	Maturity data *(by GSA)*[5]	Source of data	X	S
		Name of the scientific survey (if any)	X	P
		Fleet segment (only if from fishery-dependent data)	X	P
		Species[5]	X	P
		Length	X	S
		Sex	X	S
		Maturity[6]	X	S
		Number of individuals sampled (per length class, sex and maturity stage)	X	S
		Weight of individuals sampled (per length class, sex and maturity stage)	X	S
		Number of individuals expanded (per length class, sex and maturity stage)	X	S
	European eel	Habitat	X	P
		Site	X	P
		Gear type	X	P
		Mesh size		S
		Number of fishermen	X	S
		Fishing days	X	S
		Average number of “gear units” per day per fisherman	X	S
		Total catch of silver eel	X	P
		Total catch of yellow eel	X	P
		Total catch of silver and yellow eel	X	P
		Total catch of glass eel	X	P
		Stocking lifestage	X	P
		Stocking (kg/year)	X	P

[5] Mandatory for the species of group 1.

[6] Following the scale of maturity stages (DCRF manual).

Annex 2

GFCM fleet segmentation
(Combination of vessel groups and length classes)

<table>
<tr><th colspan="3" rowspan="2">VESSEL GROUPS</th><th colspan="4">LENGTH CLASSES (LOA)</th></tr>
<tr><th>< 6 m</th><th>6 - 12 m</th><th>12-24 m</th><th>> 24 m</th></tr>
<tr><td rowspan="3">Polyvalent</td><td rowspan="3">P</td><td rowspan="2">Small-scale vessels without engine using passive gear</td><td>P-01</td><td>P-02</td><td rowspan="2">P-03</td><td rowspan="2">P-04</td></tr>
<tr><td colspan="2">P-13</td></tr>
<tr><td>Small-scale vessels with engine using passive gear</td><td>P-05</td><td>P-06</td><td>P-07</td><td>P-08</td></tr>
<tr><td></td><td></td><td>Polyvalent vessels</td><td>P-09</td><td>P-10</td><td>P-11</td><td>P-12</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td colspan="2">P-14</td></tr>
<tr><td rowspan="4">Seiners</td><td rowspan="4">S</td><td rowspan="2">Purse seiners</td><td rowspan="2">S-01</td><td rowspan="2">S-02</td><td>S-03</td><td>S-04</td></tr>
<tr><td colspan="2">S-09</td></tr>
<tr><td rowspan="2">Tuna seiners</td><td rowspan="2">S-05</td><td rowspan="2">S-06</td><td>S-07</td><td>S-08</td></tr>
<tr><td colspan="2">S-10</td></tr>
<tr><td rowspan="2">Dredgers</td><td rowspan="2">D</td><td rowspan="2">Dredgers</td><td rowspan="2">D-01</td><td>D-02</td><td>D-03</td><td rowspan="2">D-04</td></tr>
<tr><td colspan="2">D-05</td></tr>
<tr><td rowspan="4">Trawlers</td><td rowspan="4">T</td><td>Beam trawlers</td><td>T-01</td><td>T-02</td><td>T-03</td><td>T-04</td></tr>
<tr><td rowspan="2">Pelagic trawlers</td><td rowspan="2">T-05</td><td>T-06</td><td>T-07</td><td>T-08</td></tr>
<tr><td colspan="3">T-13</td></tr>
<tr><td>Trawlers</td><td>T-09</td><td>T-10</td><td>T-11</td><td>T-12</td></tr>
<tr><td rowspan="2">Longliners</td><td rowspan="2">L</td><td rowspan="2">Longliners</td><td rowspan="2">L-01</td><td>L-02</td><td>L-03</td><td>L-04</td></tr>
<tr><td colspan="3">L-05</td></tr>
</table>

<u>Note</u>

- 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 the vessels using more than one gear, with a combination of passive and active gear, none of which exceeding 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.
- The yellow cells contain the codes of reported fleet segments which should be included in the GFCM data submission. If necessary, fleet segments as identified in the orange cells can be used: P-13 (P-01 + P-02), P-14 (P-11 + P-12), S-09 (S-03 + S-04), S-10 (S-07 + S-08), D-05 (D-02 + D-03), T-13 (T-06 + T-07 + T-08) and L-05 (L-02 + L-03 + L-04). Any proposal for a different aggregation of fleet segments should be brought to the attention of the relevant GFCM subsidiary bodies, mentionning the rationale and corresponding references (e.g. existing scientific studies), which in turn should confirm the similarity/homogeneity of the combined cells.

Annex 3

Table on fishing effort measurement

Effort measurement by fleet segment

FLEET SEGMENTS			EFFORT MEASUREMENTS		
Vessel groups		**Length classes (LOA)**	**Unit of capacity**	**Unit of activity**	**Nominal effort**
P	Small-scale vessels without engine using passive gear Small-scale vessels with engine using passive gear Polyvalent vessels	All	Net length[1]	Fishing days	Net length x Fishing days
			Number of traps/pots[1]	Fishing days	Number of traps/pots x Fishing days
			Number of lines[1]	Fishing days	Number of lines x Fishing days
S	Purse seiners Tuna seiners	All	GT	Number of fishing sets[2]	GT x Number of fishing sets
D	Dredgers	All	GT	Fishing days	GT x Fishing days
T	Beam trawlers Pelagic trawlers Trawlers	All	GT	Fishing days	GT x Fishing days
L	Longliners	All	Number of hooks[1]	Fishing days	Number of hooks x Fishing days

[1] Should this information not be available, "GT" may be used as capacity unit upon approval by relevant GFCM subsidiary bodies on a case by case basis.

[2] Should this information not be available, "fishing days" may be used as activity unit upon approval by relevant GFCM subsidiary bodies on a case by case basis.

Effort measurement by fishing gear

Fishing gear		Gear code	Unit of capacity	Unit of activity	Nominal effort
Surrounding nets	With purse lines (purse seines)	PS	GT	Number of fishing sets[1]	GT x Number of fishing sets
	One boat operated purse seines	PS1			
	Two boats operated purse seines	PS2			
	Without purse lines (lampara)	LA			
Seine nets	Beach seines	SB	Net length[2]	Fishing days	Net length x Fishing days
	Boat or vessel seines	SV			
	Danish seines	SDN			
	Scottish seines	SSC			
	Pair seines	SPR			
	Seine nets (not specified)	SX			
Trawls	Bottom trawls	TB	GT	Fishing days	GT x Fishing days
	Bottom beam trawls	TBB			
	Bottom otter trawls	OTB			
	Bottom pair trawls	PTB			
	Bottom nephrops trawls	TBN			
	Bottom shrimp trawls	TBS			
	Midwater trawls	TM			
	Midwater otter trawls	OTM			
	Midwater pair trawls	PTM			
	Midwater shrimp trawls	TMS			
	Otter twin trawls	OTT			
	Otter trawls (not specified)	OT			
	Pair trawls (not specified)	PT			
	Other trawls (not specified)	TX			
Dredges	Boat dredges	DRB	GT	Fishing days	GT x Fishing days
	Mechanised dredges	HMD			
	Hand dredges	DRH			
Gillnets and entangling nets	Set gillnets (anchored)	GNS	Net length[2]	Fishing days	Net length x Fishing days
	Driftnets	GND			
	Encircling gillnets	GNC			
	Fixed gillnets (on stakes)	GNF			
	Trammel nets	GTR			
	Combined gillnets-trammel nets	GTN			
	Gillnets and entantling nets (not specified)	GEN			
	Gillnets (not specified)	GN			
Traps	Stationary uncovered pound nets	FPN	Number of traps/pots [2]	Fishing days	Number of traps/pots x Fishing days
	Pots	FPO			
	Fyke nets	FYK			
	Stow nets	FSN			
	Barrier, fences, weirs, etc	FWR			
	Aerial traps	FAR			
	Traps (not specified)	FIX			

[1] Should this information not be available, "fishing days" may be used as activity unit upon approval by relevant GFCM subsidiary bodies on a case by case basis.

[2] Should this information not be available, "GT" may be used as capacity unit upon approval by relevant GFCM subsidiary bodies on a case by case basis.

Fishing gear		Gear code	Unit of capacity	Unit of activity	Nominal effort
Hooks and lines	Handlines and pole-lines (hand operated)	LHP	Number of lines[2]	Fishing days	Number of lines x Fishing days
	Handlines and pole-lines (mechanised)	LHM			
	Trolling lines	LTL			
	Set longlines	LLS	Number of hooks[2]	Fishing days	Number of hooks x Fishing days
	Drifting longlines	LLD			
	Longlines (not specified)	LL			
	Hooks and lines (not specified)	LX			

Annex 4

Data submission calendar

Each calendar year (n), the requested data, as specified in Annex 2 and pertaining to the year before submission (n-1), shall be submitted to the GFCM Secretariat on the basis of the following schedule:

- May
  - Global figures of national fisheries
  - Socio-economics – Species value[11]
  - Socio-economics – Other economic aspects[1]
  - Socio-economics – Operating costs[1]
- June
  - Catch – Landing data
  - Catch – Catch data per species
  - Effort – Fleet segment
  - Effort – Fishing gear
  - Effort – CPUE
- July
  - Incidental catch of vulnerable species
  - Biological information – Length data
  - Biological information – Size at first maturity
  - Biological information – Maturity data
- September
  - Biological information – Stock assessment form[12]
  - Biological information – European eel
- November
  - Socio-economics – Economic and social data

[11] Data should refer to the reference year n-2 and their submission should take place on a biennial basis only for those countries that do not have annual economic surveys in place. Countries collecting these data on a yearly basis are requested to submit them annually (keeping reference year n-2).

[12] The date of data submission is linked to the scheduling of the GFCM stock assessment working groups and therefore may differ from one year to another.

Annex 5

Stock assessment forms

The stock assessment forms (SAFs) to be used to submit the information required to assess the status of those stocks considered as priority stocks by the Commission shall be provided by relevant GFCM subsidiary bodies according to the following structure:

- basic identification data;
- stock identification and biological information (stock unit, growth and maturity);
- fisheries information (description of the fleet, historical trends, management measures, reference points);
- fisheries independent information (name, brief description of the chosen method and assumptions used, spatial distribution of the resources, historical trends);
- ecological information (protected species potentially affected by the fisheries, environmental indexes);
- stock assessment (name of the model, model assumptions, scripts, input data and parameters, tuning data, results, robustness analysis, retrospective analysis, comparison between model runs, sensitivity analysis, assessment quality);
- stock predictions (short, medium, and long term); and
- draft scientific advice.

SAFs shall be revised by relevant GFCM subsidiary bodies on a regular basis and their most updated version will be disseminated online by the GFCM Secretariat.

Recommendation GFCM/42/2018/2

on fisheries management measures for the conservation of sharks and rays in the GFCM area of application, amending Recommendation GFCM/36/2012/3

The General Fisheries Commission for the Mediterranean (GFCM),

RECALLING that the objective of the Agreement for the establishment of the General Fisheries Commission for the Mediterranean (GFCM Agreement) is to ensure the conservation and sustainable use, at the biological, social, economic and environmental level, of marine living resources in the GFCM area of application;

RECALLING the 2002 Johannesburg Declaration on Sustainable Development and in particular its Plan of Implementation;

RECALLING the 2003 Declaration of the Ministerial Conference for the Sustainable Development of Fisheries in the Mediterranean (2003 Venice Declaration);

REAFFIRMING the principles of the Code of Conduct for Responsible Fisheries of the Food and Agriculture Organization of the United Nations (FAO) and recalling the precautionary and ecosystem approach to fishery management;

RECALLING the FAO International Plan of Action for the Conservation and the Management of Sharks (IPOA-SHARKS);

RECALLING the Convention for the Protection of the Marine Environment and the Coastal Region of the Mediterranean (Barcelona Convention) and the listing of some shark species in either Annex II or Annex III of its Protocol concerning Specially Protected Areas and Biological Diversity in the Mediterranean (SPA/BD Protocol);

NOTING the importance of harmonizing conservation and management measures with other international conventions for the protection of these species;

TAKING INTO ACCOUNT the advice of the Scientific Advisory Committee on Fisheries (SAC) and, in particular, the need to identify species and ensure a better conservation status of sharks, including by protecting coastal areas from the most active fishing gear;

ADOPTS, in conformity with Articles 5 b), 8 b) and 13 of the GFCM Agreement, the following recommendation:

PART I
Scope

1. Contracting parties and cooperating non-contracting parties (CPCs) shall ensure that sharks are kept on board, transhipped, landed and marketed at first sale in a way that species are recognizable and identifiable, and that the catch, incidental catch and, whenever appropriate, release of these species can be monitored and recorded.

2. CPCs shall adopt fisheries management measures to ensure adequate conservation status of sharks.

PART II
Definitions

3. For the purpose of this recommendation, the following definitions shall apply:

- "Shark" means any species of the taxon Elasmobranchii;
- "Shark fins" means any fin of sharks, including caudal fins but excluding the pectoral fins of rays, which are a constituent part of ray wings;
- "trawl nets" means nets which are actively towed by the main boat engine and consisting of a cone- or pyramid-shaped body (as trawl body) closed at the back by a codend and which can extend at the opening by the wings or can be mounted on a rigid frame. Horizontal opening is either obtained by otter boards or provided by a beam or frame of variable shape and size. Such nets can be towed either on the bottom (bottom trawl net) or in midwater (pelagic trawl net).

PART III
Fisheries management measures

4. CPCs shall ensure that:

a) it is prohibited to remove shark fins onboard vessels and to retain, transship or land shark fins;

b) in order to facilitate onboard storage, shark fins may be partially sliced through and folded against the carcass, but they shall not be removed from the carcass before landing;

c) beheading and skinning of specimens onboard and before landing are prohibited, and beheaded and skinned sharks shall not be marketed at first sale after landing; and

d) it is prohibited to purchase, offer for sale or sell shark fins which have been removed, retained onboard, transhipped or landed in contravention of this recommendation.

5. In relation to the reduction of trawl fishing in coastal areas to enhance the protection of coastal sharks:

a) CPCs shall ensure that fishing activities carried out with trawl nets are prohibited within 3 nautical miles off the coast, provided that the 50 metre isobath is not reached, or within the 50 metre isobath where that depth is reached at a shorter distance from the coast.

b) Specific and spatially limited derogations may be granted by CPCs on condition that such derogations only affect a limited number of vessels and provided that they:

i) are justified by particular geographical constraints, such as the limited size of the continental shelf along the entire coastline of a CPC or the limited extent of trawlable fishing grounds due to different factors;

and/or

ii) concern small trawling vessels of less than or equal to 12 metres length overall and engine power of less than or equal to 85 kW traditionally operating in coastal areas;

or

iii) concern a limited number of vessels during a seasonal fishing campaign;

and

iv) have no significant impact on the marine environment.

c) CPCs shall inform the GFCM Secretariat on the modalities of applying the derogations under subparagraph b) above no later than 31 March. Such notification shall include:

i) a list of authorized trawling vessels with their characteristics;

ii) relevant zones identified by geographic coordinates, both on land and at sea, and by GFCM statistical rectangles as defined in Recommendation GFCM/35/2011/1 concerning the establishment of a GFCM logbook, amending Recommendation GFCM/34/2010/1; and

iii) measures taken to monitor and mitigate impacts on the marine environment.

d) CPCs shall establish a specific monitoring plan for the trawl fisheries operating under derogation, as stipulated by subparagraph b).

e) These provisions are without prejudice to more detailed or stricter rules implemented by CPCs.

Elasmobranchs species under Annex II (list of endangered or threatened species) and Annex III (list of species whose exploitation is regulated) of the SPA/BD Protocol to the Barcelona Convention

6. CPCs shall ensure a high protection from fishing activities for elasmobranch species listed in Annex II of the SPA/BD Protocol of the Barcelona Convention, which must be released unharmed and alive, to the extent possible.

7. Specimens of shark species listed in Annex II of the SPA/BD Protocol shall not be retained on board, transhipped, landed, transferred, stored, sold or displayed or offered for sale.

8. CPCs shall ensure that tope shark (*Galeorhinus galeus*) specimens caught with bottom-set gillnets, longlines and tuna traps be promptly released unharmed and alive, to the extent possible.

PART IV
Monitoring, data collection and research

9. CPCs shall ensure that:

a) information on fishing activities, catch data, incidental catches, release and/or discarding of sharks species listed either in Annex II or Annex III of the SPA/BD Protocol, is recorded by the ship owner in the logbook or in an equivalent document, in line with the requirements of Recommendation GFCM/35/2011/1;

b) such information is reported to the national authorities for notification to the GFCM Secretariat within their annual national reporting to the SAC and in accordance with the data reporting requirements of relevant GFCM recommendations, in line with the GFCM Data Collection Reference Framework (DCRF); and

c) any other additional measure is taken to improve data collection in view of the scientific monitoring of species.

10. As appropriate, the GFCM and its CPCs shall, individually and collectively, engage in capacity-building efforts and other research cooperative activities to improve knowledge on sharks and shark fisheries and to support the effective implementation of this recommendation, including entering into cooperative arrangements with other relevant international bodies.

11. The provisions referred to in paragraphs 4, 5, 6, 7, 8 and 9 are without prejudice to stricter rules implemented by CPCs.

Recommendation GFCM/42/2018/9

on a regional research programme for rapa whelk fisheries in the Black Sea (geographical subarea 29)

The General Fisheries Commission for the Mediterranean (GFCM),

CONSIDERING that the objective of the Agreement for the establishment of the General Fisheries Commission for the Mediterranean (GFCM Agreement) is to ensure the conservation and sustainable use, at the biological, social, economic and environmental level, of marine living resources in the GFCM area of application;

RECALLING that, in giving effect to the objective of the GFCM Agreement, the GFCM shall adopt recommendations on conservation and management measures aimed at ensuring the long-term sustainability of fishing activities, in order to preserve the marine living resources and the economic and social viability of fisheries and that, in adopting such recommendations, the GFCM shall give particular attention to measures to prevent overfishing and minimize discards as well as to the potential impacts on small-scale fisheries and local communities;

RECALLING that in giving effect to the objective of the GFCM Agreement, the GFCM shall foster, as appropriate, a subregional approach to fisheries management and aquaculture development in order to better address the specificities of the Mediterranean and the Black Sea;

CONSIDERING that the GFCM shall adopt management measures based on an ecosystem approach to fisheries to guarantee the maintenance of stocks at levels which can produce maximum sustainable yield (MSY);

RECALLING that the 2016 Bucharest Declaration towards enhanced cooperation on Black Sea fisheries and aquaculture, in particular the technical outputs of the expert meetings (Panel 1) in its Annex, recommends cooperation with the GFCM towards the promotion of an ecosystem approach to fisheries management, which includes the collection of information on fisheries-related issues, such as relevant socio-economic data, discards, incidental catches of vulnerable species, invasive species and other aspects of marine ecosystems;

RECALLING that the 2018 Sofia Ministerial Declaration on Black Sea fisheries and aquaculture calls upon Black Sea riparian countries to enhance multilateral cooperation and implement actions to improve the sustainability of resources, particularly with regard to data collection, scientific evaluation and implementation of an ecosystem-based fisheries management framework in the Black Sea;

CONSIDERING that the GFCM shall apply the precautionary approach in accordance with the Agreement for the Implementation of the Provisions of the United Nations Convention on the Law of the Sea of 10 December 1982 relating to the Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks of 4 August 1995 and the Code of Conduct for Responsible Fisheries of the Food and Agriculture Organization of the United Nations (FAO);

CONSIDERING that the FAO Code of Conduct for Responsible Fisheries provides that states "should apply the precautionary approach widely to conservation, management and exploitation of living aquatic resources in order to protect them and preserve the aquatic environment, taking account of the best scientific evidence available. The absence of adequate scientific information should not be used as a reason for postponing or failing to take measures to conserve target species, associated or dependent species and non-target species and their environment";

CONSIDERING that the measures formulated by the GFCM shall be based on the best scientific advice available and on the work of the BlackSea4Fish project in supporting the advice delivered by the Working Group on the Black Sea (WGBS), taking into account relevant environmental, economic and social factors;

NOTING that the conclusions of the fifth meeting of the Subregional Group on Stock Assessment in the Black Sea (Georgia, December 2017) suggest that rapa whelk fisheries are already reaching MSY levels and that care should be taken in further expanding this fishery;

CONSIDERING that fishing mortality should be kept below safe thresholds to ensure long-term high yields while limiting the risk of stocks collapse and guaranteeing stable and more viable fisheries;

CONSIDERING the socio-economic importance of rapa whelk fisheries in the Black Sea and the need to ensure their long-term economic sustainability;

CONSIDERING that certain fisheries management measures need to be revised and adapted to the evolution of both the status of exploited stock and scientific knowledge and that an appropriate method shall be established to this end;

ADOPTS, in conformity with Articles 5 b), 8 b), and 13 of the GFCM Agreement the following recommendation:

PART I
Objectives, scope and definitions

Objectives of the research programme

1. This recommendation shall establish a regional research programme towards the sustainable exploitation of rapa whelk in the Black Sea (geographical subarea [GSA] 29) (hereafter "regional research programme").

2. This recommendation shall apply to all commercial fishing activities exploiting rapa whelk in the Black Sea (GSA 29).

3. The regional research programme established by this recommendation shall support the WGBS and be scientifically assessed and coordinated within the BlackSea4Fish project.

4. Contracting parties and cooperating non-contracting parties (CPCs) whose vessels are actively fishing in GSA 29 agree to implement the regional research programme in accordance with the objectives of this recommendation.

Geographical scope

5. The regional research programme and the transitional measures established by this recommendation shall apply to GSA 29.

Definitions

6. For the purpose of this recommendation:

a) "Black Sea" means GSA 29 as defined in Resolution GFCM/33/2009/2 on the establishment of geographical subareas in the GFCM area of application, amending Resolution GFCM/31/2007/2;

b) “Rapa whelk” means gastropods pertaining to the species *Rapana venosa*;

c) “Vessel actively fishing for rapa whelk” means any vessel equipped with fishing gear to fish for rapa whelk or used for scuba diving to fish for rapa whelk, and holding a valid fishing authorization for rapa whelk.

PART II
Operational and specific objectives

7. The operational objective of this recommendation shall be to improve scientific, technical and socio-economic knowledge of the fisheries exploiting rapa whelk by establishing a regional research programme on rapa whelk.

8. The specific objective of this recommendation shall be to collect data on fishing activities in order to improve research and scientific knowledge for the sustainable exploitation of the stock, aiming at maintaining the stock at MSY levels as well as the socio-economic viability of rapa whelk fisheries.

9. The WGBS, at its annual meeting in 2021, shall assess the outcome of the regional research programme established by this recommendation, taking into consideration the national efforts made by CPCs to manage rapa whelk fisheries. The WGBS shall report to the GFCM, at its forty-fifth session in 2021, and, if deemed necessary, present proposals for the adaptation of the measures set by this recommendation and for complementary management and control measures.

PART III
Regional research programme and scientific monitoring

10. CPCs with fishing fleets targeting rapa whelk shall ensure that a mechanism for adequate scientific monitoring of rapa whelk catches in the Black Sea is duly in place, with a view to facilitating the implementation of the regional research programme and to allowing the WGBS to provide descriptive information and advice on at least the following:

a) deployed fishing effort (e.g. number of fishing days/week) and overall catch levels at the national or supranational levels, indicating the fishing gear used;

b) data on overall bycatch quantities by fishing gear and species, excluding scuba diving;

c) biological and socio-economic effects of alternative management scenarios, including input/output and/or technical measures, such as fishing gear/environmental impacts, as proposed by the CPCs; and

d) possible spatio-temporal closures in order to preserve fisheries sustainability.

11. The BlackSea4Fish project shall facilitate and coordinate the assessment of relevant data at the regional level under the regional research programme.

12. The GFCM Secretariat, with the support of the WGBS, shall provide terms of reference, including costs, services and other requirements to support the implementation of a research programme on rapa whelk in the Black Sea, as described in Annex 1 of this recommendation. The regional research programme shall be launched in 2019.

PART IV
Final provisions

13. In light of the results of the regional research programme referred to in Part III of this recommendation, the GFCM may propose and adopt new appropriate management and control measures, including monitoring of fishing activities and catches.

Annex 1

Key elements of the regional research programme on rapa whelk in the Black Sea

Introduction

There is high need for scientific and research projects in the Black Sea aimed to fill gaps of knowledge on rapa whelk, a high commercial value species in the Black Sea. There has been an increase in the coverage and in the quality of data on the abundance of rapa whelk, with some data on length and age composition. Based on such data, the first rapa whelk scientific assessment was carried out in 2017 by the Subregional Group on Stock Assessment in the Black Sea. However, the overall lack of fisheries-independent surveys in the Black Sea covering the regional distribution of the main commercial species in a comprehensive manner persists.

Main features of the regional research programme on rapa whelk in the Black Sea

- Clear objectives defined in advance (e.g. biomass in tonnes, abundance in number of km^2, spatio-temporal distribution patterns);
- Priority given to the collection of useful data for the provision of scientific advice in support of management (length, age, life cycle);
- Combination of fishery-dependent and fishery-independent sources of information to ensure a regular monitoring;
- All Black Sea CPCs should be involved;
- The regional research programme should also provide guidelines and facilitate harmonization, standardization of protocols, coordination and comparison of the results obtained by past, ongoing and future national, regional and international research programmes addressing rapa whelk, such as the BlackSea4Fish project.

Work packages

Work packages are designed to address the main aspects mentioned above as well as the need to evaluate the social and economic aspects of the rapa whelk fisheries in the context of the sustainable management and exploitation of the stock.

Work Package 1 – Biology and ecology

Work Package 2 – Fishery-independent data collection – Surveys-at-sea

Work Package 3 – Fishery-dependent data collection

Work Package 4 – Stock assessment

Work Package 5 – Socio-economic elements

Work Package 6 – Management proposals

Main objectives of each work package

WP 1 – Biology and ecology of rapa whelk, including demography. Biology: studies on size, density, abundance, biomass, recruitment, growth, reproduction, physiology, environmental parameters, habitat,

feeding and bycatch surveys). Ecology: genetics, interactions with other species, impacts of fishing gear on the marine environment).

WP 2 – Fishery-independent data collection through multiannual demersal beam trawl/dredge surveys-at-sea, e.g. biomass and abundance indices, size/age distribution, bycatch.

WP 3 – Fishery-dependent data collection through port sampling (e.g. landings, length/distribution, fishing techniques used and vessels engaged in the fishing activity, value) and through observers on board (e.g. bycatch, days at sea).

WP 4 – Stock assessment: investigation on methodologies for assessing the status of rapa whelk, including by compiling historical data.

WP 5 – Socio-economic elements: socio-economic survey on the sector, trade, markets and development of economic indicators, external aspects affecting the fishery, economic sustainability of related fishing gear.

WP 6 – Management proposals: identification of possible additional measures through management strategy evaluation (MSE) for the sustainability of rapa whelk fisheries.

Implementation of the regional research programme

The GFCM shall:

- Assess progress in the different work packages,
- Define standardized methods (e.g. in ageing) as well as research protocols, and
- Organize capacity-building activities.

RES-GFCM40/2016/3

on sustainable small-scale fisheries in the GFCM area of application

RECALLING the 1982 United Nations Convention on the Law of the Sea (UNCLOS) which calls upon States to cooperate in the conservation and management of living resources, including through subregional or regional fisheries organizations;

TAKING NOTE of the 1995 Code of Conduct for Responsible Fisheries of the Food and Agriculture Organization of the United Nations (FAO) which recognizes the important contributions of small-scale fisheries to employment, income and food security;

ACKNOWLEDGING the 2014 FAO Voluntary Guidelines for Securing Sustainable Small-Scale Fisheries in the Context of Food Security and Poverty Eradication (SSF Guidelines) which aim at enhancing the contribution of small-scale fisheries to global food security and nutrition and at supporting the progressive realization of the right to adequate food;

TAKING INTO ACCOUNT the Agreement establishing the General Fisheries Commission for the Mediterranean (GFCM Agreement) whereby the Commission shall pay particular attention to the potential impacts on small-scale fisheries and local communities in adopting conservation and management measures aimed at ensuring the long-term sustainability of fishing activities;

CONSIDERING the role of the GFCM as the FAO regional fishery body competent over the Mediterranean and the Black Sea to contribute to the sustainable development of small-scale fisheries and to improve the socio-economic situation of fishers and fish workers within the context of sustainable fisheries management;

WELCOMING the conclusions of the 2013 First Regional Symposium on Sustainable Small-Scale Fisheries in the Mediterranean and the Black Sea organized by the GFCM in partnership with the FAO, the Centre International de hautes études agronomiques méditerranéennes (CIHEAM-Bari), the Network of Marine Protected Area Managers in the Mediterranean (MedPAN), the World Wide Fund for Nature (WWF) and in collaboration with the Government of Malta;

FURTHER WELCOMING the conclusions of the 2016 Regional Conference on Building a future for sustainable small-scale fisheries in the Mediterranean and the Black Sea organized by the GFCM in partnership with the FAO, CIHEAM-Bari, MedPAN, WWF and in collaboration with the Algerian Ministry for Agriculture, Rural Development and Fisheries;

ADOPTS, in conformity with the provisions of Articles 5 and 8 of the GFCM Agreement, the following resolution:

1. The GFCM should provide support to Contracting Parties and Cooperating non-Contracting Parties (CPCs) to accelerate the implementation of the SSF Guidelines by adapting them to the Mediterranean and the Black Sea context.

2. The CPCs acknowledge the importance of the work by the Regional Conference on Building a future for sustainable small-scale fisheries in the Mediterranean and the Black Sea, and underline the significance of the conclusions adopted by this conference, which are attached in Annex 1 to this resolution, in the context of the sustainable development of small-scale fisheries at the regional level.

3. The GFCM should facilitate the elaboration of national strategies for the sustainable development of the small-scale fisheries sector, in line with the SSF Guidelines and with the conclusions of the Regional Conference.

4. CPCs should continue to build political will to invest in participative management approaches – such as co-management schemes – in order to sustainably develop fisheries in the Mediterranean and the Black Sea. Particular attention should be accorded to improving livelihoods and socio-economic opportunities – including access to markets – for small-scale fishers, in line with Target 14 of the United Nations Sustainable Development Goals (SDG). To this effect, marine spatial planning, including *inter alia* preserved fisheries areas and the installation of artificial reefs, presents an effective tool for engaging stakeholders in the sustainable management of fisheries.

5. Specific actions should be foreseen to elaborate coordinated policies in support of the small-scale fishing sector, including a common regional strategy, in coordination with the existing regional small-scale fisher networks and platforms throughout the Mediterranean and the Black Sea, and a high-level event on sustainable small-scale fisheries.

Annex 1

Conclusions of the Regional Conference "Building a future for sustainable small-scale fisheries in the Mediterranean and the Black Sea"
(Algiers, Algeria, 7–9 March 2016)

PREAMBLE

The Regional Conference on "Building a future for sustainable small-scale fisheries in the Mediterranean and the Black Sea" (7-9 March 2016, Algiers, Algeria) enjoyed the robust attendance of over 200 participants, which included policy-makers, scientists, practitioners, fishers representatives, fish workers, civil society organizations, NGOs, research institutions, international organizations and more. The conference was organized by the General Fisheries Commission for the Mediterranean (GFCM) and the Fisheries and Aquaculture Department of the Food and Agriculture Organization of the United Nations (FAO), including its Mediterranean regional projects, in collaboration with the Algerian Ministry for Agriculture, Rural Development and Fisheries and in partnership with CIHEAM-Bari, MedPAN, and WWF.

In 2013, on the occasion of the First Regional Symposium on Sustainable Small-Scale Fisheries in the Mediterranean and the Black Sea (27-30 November 2013, Malta), the main challenges and opportunities for the sustainable development of the small-scale fishery sector in this region were brought to the forefront. Since then, such issues have continued to gain prominence in discussions on small-scale fishery management in the context of the Blue Growth Initiative in the Mediterranean and the Black Sea.

This Regional Conference was conceived as a practical response to the outcomes of the Symposium in Malta, seeking to capitalize on the momentum already generated in order to offer a tangible strategy for the future sustainable development of this sector. Concrete case studies were carried out, which further explored key themes identified through the Symposium, and their results were presented in a format which deliberately sought to promote discussions, express opinions and share experiences in order to better grasp priorities and opportunities for this sector.

There is no doubt that small-scale fisheries in the Mediterranean and the Black Sea play a significant social and economic role. These fisheries constitute over 80 percent of the fishing fleet, employ at least 60 percent of total on-vessel fishing labour and account for approximately 25 percent of the total landing value from capture fisheries in the region. At their best, small-scale fisheries exemplify sustainable resource use: exploiting living marine resources in a way that minimizes environmental degradation while maximizing economic and social benefits. Yet concerted effort is needed to ensure that best practices become standard practice.

In recognition of this need for a concerted action for the sustainable development of the small-scale fishery sector, the Algerian Ministry for Agriculture, Rural Development and Fisheries graciously offered to host the Regional Conference with a view to mobilizing such an effort. This event perfectly aligned with the "Aquapêche 2020" strategy, recently launched by Algeria as a result of a nation-wide consultation process with all stakeholders and with the support of the United Nations Development Programme (UNDP) and the FAO. Consistent with Blue Growth principles, this strategy is also expected to provide a decisive contribution towards the promotion of sustainable small-scale fisheries, both at the national and regional level.

The following conclusions have been developed based on the outcomes of the Regional Conference. The conclusions are put forth to urge actions in support of sustainable small-scale fisheries in the Mediterranean and the Black Sea and they are grouped, first, under a cluster of general and transversal proposals and, next, under five clusters relating to the specific thematic sessions of the conference.

GENERAL CONCLUSIONS

In light of the UN Sustainable Development Goals which, among other issues, stress the importance of providing access for small-scale artisanal fisheries to marine resources and markets, the importance of the Regional Conference on "Building a future for sustainable small-scale fisheries in the Mediterranean and the Black Sea" was acknowledged. Widespread support was expressed by conference participants for the conference objectives to raise awareness, share knowledge, and devise future strategy to promote this crucial fishing sector.

In particular, the following general proposals were made:

- Tailor implementation of the Voluntary Guidelines for Securing Sustainable Small-Scale Fisheries in the Context of Food Security and Poverty Eradication (SSF Guidelines) to the Mediterranean and Black Sea context and provide support to GFCM contracting parties in the implementation of these guidelines.
- Launch a comprehensive and region-wide survey to develop accurate, timely and complete baseline data on the value and economic impact of small-scale fisheries, with a view to ultimately informing policy interventions.
- Launch wide-ranging consultations, including a mechanism for the sustainable development of the small-scale fishing sector and specific actions to develop coordinated policy to support this sector. To this end, implement a joint regional strategy which builds on existing regional networks and platforms and promotes a level playing field throughout the Mediterranean and the Black Sea.
- Develop a regional programme aiming to provide support and technical assistance, in particular to developing countries, in order to build capacity in the field of small-scale fisheries. Carry out at the national level, where necessary, an analysis of legislation and institutional mechanisms which ensure the full participation of small-scale fishers in all activities regarding the sustainable development of the sector (development of alternative activities, co-management, financial support, labelling, traceability, right to decent work, social protection, etc.)
- Build the political will to invest in small-scale fisheries as a crucial tool to transform fisheries management, particularly within the context of the Blue Growth initiative and the implementation of the reformed EU Common Fisheries Policy. It was suggested that the GFCM member countries, the European Commission and FAO provide joint leadership in this regard (i.e. through the organization of a high-level event).
- Disseminate the conclusions of the Regional Conference on "Building a future for sustainable small-scale fisheries in the Mediterranean and the Black Sea" to relevant international meetings, such as GFCM regular sessions, the FAO Committee on Fisheries (COFI) and relevant European Union (EU) meetings.

SPECIFIC CONCLUSIONS RELATING TO THE PANELS

PANEL I – Supporting the sustainable development of small-scale fisheries in the Mediterranean and the Black Sea under the Blue Growth perspective

Blue Growth is a recent concept that seeks to create sustainable economic, environmental and social development in the aquatic environment. As Mediterranean and Black Sea fisheries are dominated by small-scale fishing activities, if the exploitation of fish resources in these seas is to contribute to Blue Growth, then small-scale fishing will necessarily play an integral role in Blue Growth strategies.

In light of the discussions held during the panel, it is proposed to:

- Develop indicators to measure the economic and social impact of small-scale fishing, both in quantitative and qualitative terms. In particular, efforts should be made to estimate not only the value of the output produced by such fishing and its economic impact on coastal communities in the Mediterranean and Black Sea, but efforts should also be made to measure small-scale fishing's impact on related sectors such as fish processing and tourism. Furthermore, an analysis of the interaction of small-scale fishing with other sectors, particularly those also engaged in Blue Growth strategies (i.e. marine transportation, oil and gas, tourism, etc.), is needed for a better understanding of both the wider economic and social impacts of small-scale fishing, as well as, the risks these other sectors may pose to small-scale fishing communities.
- Examine the economic impact of small-scale fishing under different exploitation arrangements, with a view to identifying circumstances under which this activity might generate an investable surplus and undertake studies to estimate the potential size of this surplus. Similarly, efforts should be made to identify points of entry for technological, management, marketing and policy interventions that would facilitate the above-mentioned favourable circumstances.
- Identify relevant parameters – having acknowledged the need to develop a common definition of small-scale fisheries - for the classification of "small-scale fishing" in the Mediterranean and Black Sea, based on relevant regional characteristics (e.g. dimension of the vessel, gear used, activities of non-vessel based fisheries, etc.) and in relation to the harvested resources.
- Disseminate information on the effectiveness of the GFCM Data Collection Reference Framework (DCRF) and promote its use as a data collection tool for small-scale fishing. Provide technical assistance in the practical application of the DCRF in the collection of standardized data on small-scale fishing in the Mediterranean and the Black Sea.
- Produce a desk study on the social protection systems and national legislations in place and available to small-scale fishers in the Mediterranean and Black Sea riparian States, with a view to identifying and promoting the most successful options.
- Identify policy interventions which facilitate income and livelihood diversification for small-scale fishers. In particular, efforts should be made to identify opportunities for cross-over between the small-scale fishing and small-scale aquaculture sectors.
- Develop, in collaboration with GFCM members, a pilot programme that would test ways to both better integrate small-scale fisheries into a Blue Growth approach, as well as better integrate small-scale fisheries in the decision-making processes of other sectors whose Blue Growth activity may have an impact on small-scale fisheries.

PANEL II – Strengthening the role of stakeholders in the context of management and co-management schemes

Acknowledging concrete evidence on how co-management can be an effective approach for both resolving conflicts and developing innovative solutions for the management of small-scale fisheries, key actions were identified that would create enabling conditions for the institutionalization of stakeholder engagement through co-management schemes. Such key actions include the need for stronger investment in capacity building, both for institutions and for fisher organizations, and the need for a better understanding of legal and institutional frameworks that allow for the participation of fishers in fisheries management. The panel stressed that while Blue Growth presents important opportunities for small-scale fisheries, the effects of Blue Growth in other sectors may also present a risk to these fisheries. Stronger organization and co-management initiatives are needed in order to guard against such risks.

In light of the discussions held during the panel, the following actions are proposed:

- Conduct an analysis to assess national and international legal frameworks with a view to identifying institutional contexts that allow for the establishment of small-scale fisheries co-management schemes and with a view to defining general rules for the engagement and compliance of small-scale fishers with these schemes.
- Prepare best practice guidelines for the enforcement of small-scale fisheries co-management schemes in the Mediterranean and the Black Sea. Such guidelines should be linked directly to the SSF Guidelines and, in addition to providing advice on the institutional and legislative context, should provide direction for the elaboration and implementation of participatory processes, co-management settings and tools, approaches for monitoring, control and surveillance schemes and indicators to monitor the effectiveness of management measures.
- Provide support to currently ongoing co-management processes in the Mediterranean and build commitment for their multiplication across the region. A regional programme, based on a solid institutional framework and building on existing experiences and partnerships, should be established to offer a longer-term vision on how co-management can benefit small-scale fisheries at the regional scale.
- Map fishing activities in order to provide relevant information to be integrated into marine spatial planning processes. Such processes are crucial to securing tenure rights and access to the resources for small-scale fishers, and thus ensuring livelihoods and the sustainable development of communities reliant on small-scale fisheries. The GFCM, on behalf of its member countries, should advocate for this issue at a high-level with the European Commission, prior to the commencement of the marine spatial planning processes.
- Establish a capacity building programme devoted to supporting stakeholder roles in small-scale fisheries co-management and tailored to different targets (institutional, marine protected areas administration, local administrations, natural and social scientists, civil society, small-scale fishers and other resource users).

PANEL III – Improving the efficiency of marine protected areas (MPAs) as fisheries management tools and benefits from involving the small-scale fisheries sector

Recognising the priority socio-economic and environmental challenges for the management of marine ecosystems, marine protected areas (MPAs) offer a potential solution to concurrently address a multiplicity of issues. Indeed, an important strategy for reconciling conservation and sustainability objectives is the integration of the small-scale fisheries sector into management decisions in and around MPAs. Action must be taken at the local and national levels in view of reaching international and regional agreements. Such action can be effected by decision makers, MPA managers, fishers, scientists and the private sector.

In light of the discussions held during the panel, it is proposed to:

- Adapt and draw lessons from the experience of MPAs with no take zones and regulated buffer zones that have been successful in involving fishers in management decisions and in processes that both safeguard wild resources, while also preserving the livelihoods upon which small-scale fishers depend. Given the socio-economic benefits obtained by small-scale fishers in these exemplary MPAs, learning from such cases would provide guidance on how to sustain economic, social and cultural aspects of the profession. To support replication of these successful MPAs, adequate legal frameworks, political will and financial and human capital would be required.
- Replicate examples of collaboration at the inter- and intra-ministerial level that demonstrate the successful management of small-scale fisheries in and around MPAs when working "hand in hand". Such integrative models could encourage top-down and bottom-up processes in many riparian countries for securing the future sustainability of the profession, while also providing international technical guidance.
- Improve the management of MPAs, including multiple use MPAs, by relying on the scientific and traditional knowledge of fishers, by involving concerned users/stakeholders and by using adaptive approaches. To this end:
    - Tailor management in light of the outcomes of long term comparative monitoring of biological features, ecological effects of small-scale fisheries and socio-economic benefits in and outside MPAs
    - Develop adaptive participatory approaches for management plans for small-scale fisheries in and around MPAs, based on biological and socio-economic data, which could be jointly formulated, implemented and revised by MPA practitioners and fishers.
    - Adopt regulations to overcome conflicting uses of MPAs which could have a negative impact on the livelihood of small-scale fisheries, having regard to relevant conservation objectives
    - Consider participative management, in cases of use conflicts, specifically those between small-scale fisheries and recreational fisheries, to create a balance between the sustainable development of small-scale fisheries and, where applicable, the sustainable development of responsible tourism, so as to achieve conservation objectives.
- Consider conservation efforts, and MPAs in particular, as an investment in natural capital rather than as a public expenditure. As such, efforts should be made to protect this investment from risks, such as conflicting marine-based activities and land-based pollution.
- Safeguard the small-scale fisheries sector in and around MPAs, including by setting up cooperatives, through strategies that are integrated in development plans devised by local authorities and that provide a market edge in favour of responsible and sustainable fisheries practices.

PANEL IV – Enhancing small-scale fisheries value chains

The value chain of small-scale fisheries is enhanced by a favourable environment where fishers are strongly connected with other local actors, including public and private institutions and even consumers. This permits the creation of competitive economic clusters, which can foster the development of coastal communities. Clustering must be encouraged, eliminating all possible bottlenecks. In the case of SSF in the Mediterranean and Black Sea, four relevant areas of intervention have been identified: sustainability aspects (including governance and MPAs), marketing strategies (quality aspects), inter-sectoral integration and provision of infrastructures and services (in particular, access to markets and credit).

In light of the discussions held during the panel, it is proposed to:

- Identify best practices for value creation, especially in the fields of labelling, direct sale, processing, diversification, inter-sectoral integration and vertical coordination. Additional case studies should be carried out to further examine such best practice interventions and to promote their replication in various Mediterranean and Black Sea contexts.
- Model successful value chains, particularly in cases where clustering of various coastal economic activities occurs, to identify entry points for innovation and to better understand the scope for fisher cooperation in resource management and in product marketing.
- Establish a capacity building programme to support stakeholder roles in the creation of cooperatives, formulation of agreements with public and private institutions, development of partnerships and projects for coastal development.
- Better study and analyse issues related both to credit and financial institution support. Public institutions should provide basic infrastructures and services to foster value chains and to prevent market failure. Access to formal finance is a crucial concern. This includes access to both formal credit for capital expenses and financing for fishing operations. Facilities and financial products can be developed in partnership with banks for medium to long-term investment. Formal financing schemes (production contracts, storage receipts) can be applied with the participation of fishers, traders and public authorities.

PANEL V – Putting the principles of the SSF Guidelines into practice: the case of the Mediterranean and Black Sea

The SSF Guidelines constitute an important tool for supporting actions to securing sustainable small-scale fisheries in the Mediterranean and the Black Sea. These guidelines take a holistic perspective on the needs of small-scale fisheries and recognize that the implementation of these guidelines will necessarily be cross-sectoral. With a view to adapting these guidelines to the regional context, key elements to operationalize the principles of the SSF guidelines were explored: (i) Policy and legal frameworks; (ii) Main stakeholders; (iii) Institutional structures; (iv) Key entry points; and (v) Collaboration with other initiatives. The panel noted the importance of action at the local level and the need for effective participation of fishing communities. There are already positive developments taking place in the region in support of the SSF Guidelines implementation, e.g. the existence of regional organizations and platforms such as the Maghreb Platform for sustainable small-scale fisheries, the Mediterranean Platform of Artisanal Fishers (MedArtNet), Low Impact Fishers of Europe (LIFE) and the Mediterranean Advisory Council (MEDAC), and the development of national policies and initiatives (e.g., Aquapêche 2020 in Algeria, SSF national action plan proposals in EU countries).

In light of the discussions held during the panel, it is proposed to:

- Establish a GFCM working group on small-scale fisheries to facilitate the implementation of the SSF Guidelines in the GFCM region by developing national action plans and taking into account recommendations from relevant events and existing experience within the region and beyond.
- Strengthen the GFCM engagement with small-scale fishing communities by establishing a mechanism for supporting organisational development and agreeing on a modus operandi for meaningful collaboration. In particular, FAO's work on small-scale fisheries should be taken into account and special efforts should be made to collaborate with existing small-scale fisheries organizations and platforms, as well as to include women and marginalized groups in such collaboration.
- Promote, without compromising environmental sustainability, the improvement of socio-economic conditions within small-scale fisheries, particularly through the promotion of livelihood diversification as appropriate, and the endorsement of the principle of decent work, as defined by the Work in Fishing Convention (C188) of the International Labour Organization (ILO). Furthermore, ratification of this convention by GFCM member countries should be encouraged.
- Promote and facilitate the development of a forum for small-scale fisheries associations of northern and southern Mediterranean riparian countries, particularly through specific projects financed by member countries or by other international, governmental or non-governmental entities.

ACKNOWLEDGEMENTS

Satisfaction and gratitude were expressed by all participants in the Regional Conference to the Government of Algeria for kindly hosting the event and to the co-organizers for the thorough preparation of the event.

Resolution GFCM/40/2016/2
for a mid-term strategy (2017–2020) towards the sustainability of Mediterranean and Black Sea fisheries

The General Fisheries Commission for the Mediterranean (GFCM),

RECALLING that the objective of the Agreement establishing the General Fisheries Commission for the Mediterranean (GFCM Agreement) is to ensure the conservation and sustainable use, at the biological, social, economic and environmental level, of living marine resources in the area of application;

RECALLING the Agreement for the Implementation of the Provisions of the United Nation Convention on the Law of the Sea of 10 December 1982 relating to the Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks of 4 August 1995, the Agreement to promote Compliance with International Conservation and Management Measures by Fishing Vessels on the High Seas of 24 November 1993, as well as other relevant international instruments concerning the conservation and management of living marine resources;

RECALLING the Declaration of the Ministerial Conference for Sustainable Development of the Fisheries in the Mediterranean held in Venice on 2003;

RECALLING that, according to the Code of Conduct for Responsible Fisheries of the Food and Agriculture Organization of the United Nations (FAO), States should widely apply the precautionary approach to the conservation, management and exploitation of living aquatic resources in order to protect them and preserve the aquatic environment, and highlighting besides that the lack of adequate scientific information should not be used as a reason for postponing or failing to take conservation and management measures;

RECALLING the Guidelines on precautionary conservation measures pending the development and adoption by the GFCM of multiannual management plans for relevant fisheries at the subregional level in the GFCM area of application, as agreed during its thirty-seventh session;

RECALLING that the FAO Council adopted on 23 June 2001 an International Plan of Action to Prevent, Deter and Eliminate Illegal, Unreported and Unregulated Fishing (IPOA-IUU);

RECALLING the 2030 Agenda for Sustainable Development adopted in the context of the United Nations Sustainable Development Summit (New York, September 2015) and the United Nations Sustainable Development Goal (SDG) 14 “Conserve and sustainably use the oceans, seas and marine resources”;

TAKING INTO ACCOUNT the FAO Agreement on Port State Measures to Prevent, Deter, and Eliminate Illegal, Unreported and Unregulated Fishing, signed in Rome on 22 November 2009;

RECALLING the subregional approach to fisheries management as enshrined in the GFCM Agreement, with a view to better addressing the specificities of the Mediterranean and the Black Sea region;

CONSIDERING that rational management for sustainable fisheries is dependent on the scientific utilization of relevant data on fishing fleet capacity, on the fishing activities carried out, on the status of exploited biological resources and on the social and economic situation of fisheries;

CONSIDERING that the GFCM Scientific Advisory Committee on Fisheries (SAC) considers that several stocks are overexploited, some with a high risk of collapse, and that sustainable management requires that measures aimed at limiting the capture of juveniles are implemented;

NOTING the importance of multidisciplinary data and information to monitor and assess fisheries and fisheries resources and to ensure their sustainable exploitation;

FURTHER RECOGNIZING the GFCM Data Collection Reference Framework (DCRF) as an instrument supporting the identification of fisheries-related data necessary to formulate sound scientific advice;

TAKING into account the importance of the classification of groups of priority species as identified by the SAC, of the use of the GFCM fleet segmentation for the sake of collection of the economic and biological data, as well as of the use of standard nominal fishing effort measurement;

RECONIZING to have a mutual interest in the development and the proper utilization of the living marine resources in the Mediterranean and the Black Sea;

RECOGNIZING the need for assistance to developing countries to adopt and implemented port State measures;

ADOPTS, in conformity with Articles 5 and 8 of the GFCM Agreement, the following resolution:

1. The GFCM shall establish a mid-term strategy (2017–2020) towards the sustainability of Mediterranean and Black Sea fisheries (the strategy) aimed at supporting the GFCM in better fulfilling its mandate, as presented in Annex 1.
2. The implementation of the strategy is expected to ensure that by 2020 the alarming trend in the status of commercially exploited stocks is reversed.
3. The strategy is divided into the following five targets, with selected outputs and proposed actions:

a) Reverse the declining trend of fish stocks through strengthened scientific advice in support of management;

b) Support livelihoods for coastal communities through sustainable small-scale fisheries;

c) Curb illegal unreported and unregulated (IUU) fishing, through a regional plan of action;

d) Minimize and mitigate unwanted interactions between fisheries and marine ecosystems and environment; and

e) Enhance capacity-building and cooperation.

4. The GFCM shall review the contents of the mid-term strategy in due course.

5. The Commission agreed on the importance to convene an intersessional meeting to be held in 2016. The terms of reference of this meeting, as reproduced in Annex 2 of this resolution, will include in particular issues relating to governance and integration of national strategies into the mid-term strategy.

Annex 1

Mid-term strategy (2017–2020) towards the sustainability of Mediterranean and Black Sea fisheries (Mid-term strategy)

1. INTRODUCTION

The need for a strategy

1. Fishing has a tremendous cultural, social and economic importance in the Mediterranean and the Black Sea, providing an important source of food and livelihood for riparian countries and sustaining the traditions and the way of life of many coastal communities. However, Mediterranean and Black Sea fisheries are currently facing serious challenges, with roughly 90 percent of the scientifically assessed stocks considered to be fished outside safe biological limits, decreasing catches and shrinking fleets at the regional scale.
2. As some of these challenges are also experienced globally and in other regions of the world, a pledge to act to avoid the serious risk of irreversible environmental and socio-economic damage was renewed at the level of the United Nations (UN) and at the regional scale. Against the backdrop of international commitments towards the sustainability of fisheries as a means to support the livelihood of coastal communities in a Blue Growth perspective, existing challenges in the Mediterranean and the Black Sea bring about the need to develop tailor-made actions, taking into account the specificities of the region and the capacities of all actors involved.
3. The mid-term strategy is in line with the mandate of the General Fisheries Commission for the Mediterranean (GFCM) as a regional fisheries management organization (RFMO) having competence over the Mediterranean and the Black Sea. It is indeed fully consistent with the Agreement establishing the General Fisheries Commission for the Mediterranean (GFCM Agreement) as amended in 2014. The mid-term strategy is based on key actions identified by the GFCM subsidiary bodies and intends to capitalize on accomplishments in the region over recent years in the field of stock assessment and fisheries management, marine environment and control, as well as to consolidate efforts pursued within the context of the GFCM Framework Programme (FWP), born in 2013 as a platform to promote sustainable development and cooperation in the Mediterranean and the Black Sea through multiannual and multidonor arrangements.
4. In addition, the mid-term strategy has been discussed with relevant organizations having interest in different aspects of fisheries and marine ecosystems, including observers to the GFCM and organizations that have a memorandum of understanding (MoU) with the GFCM (currently adding up to 14 international organizations). Therefore, the implementation of the mid-term strategy is based on a unique interdisciplinary partnership that provides for a perfect opportunity to enhance cooperation in the region and maximize the probability of success.

Historical background

5. The issue of sustainable fisheries has evolved over the years at the regional and subregional levels, before and after the Venice Ministerial Declaration for the Sustainable Development of Fisheries in the Mediterranean[1]. Created in 1949 as a Council under Article XIV of the FAO Constitution, by means of an international agreement, the GFCM was entrusted with the primary responsibility of supporting Mediterranean and Black Sea riparian countries in elaborating common rules on exploited fisheries. The GFCM Agreement had been amended three times prior to the Venice Declaration, including in 1997 when new obligations were

[1] In 2003, the Ministers of Mediterranean riparian countries met in Venice (Italy) with a view to renewing their commitment to work together towards developing sustainable and responsible fisheries. This commitment was embodied in the Venice Declaration which focused, in particular, on the future work of the GFCM and its role in this endeavour.

agreed upon by Contracting Parties, consequently morphing the Council into a Commission endowed with administrative and financial autonomy.

6. With the entry into force of the third amendment to its constitutive Agreement, in 2004, the GFCM was provided with the operational means to step up its work in its area of application. Progress should in fact be measured from 2004 onward, following the Venice Declaration, when the role of its Scientific Advisory Committee on Fisheries (SAC) was reinforced and new subsidiary bodies – such as the Compliance Committee (CoC) and, later, the Working Group on the Black Sea (WGBS), developed as an ad hoc mechanism for scientific work and decision-making for Black Sea riparian States – were created. This allowed to better address the challenges identified. Such challenges include the need to provide timely data and information, to encourage the active participation of scientists in technical work, to revert the overexploitation of main fish stocks, to improve the evaluation and management of fishery resources, to protect marine biodiversity and marine ecosystems from harmful bycatch and discarding practices and to reduce the incidence of illegal, unreported and unregulated (IUU) fishing. Since 2004, some 50 decisions have been taken including binding recommendations underpinning a regional management system consisting of data collection and reporting schemes, assessments and evaluations of commercially exploited stocks, elaboration of management measures, area-based management tools, monitoring, control and surveillance (MCS) instruments and periodical discussions on the implementation of decisions in place.

7. Consistent with the calls by the UN General Assembly and the Committee on Fisheries of the FAO, a performance review was carried out in 2009–2011 to assess the effectiveness of the GFCM, under the stewardship of an ad hoc Task Force that eventually recommended a set of amendments to the GFCM Agreement with the objective of further modernizing the Commission. From an institutional point of view, the legacy of the Venice Declaration is enshrined in the GFCM Agreement, as amended in 2014. The renewed institutional framework of the GFCM is a response to a new generation of challenges currently affecting sustainable fisheries in the region. Its premise is a subregional approach to fisheries management, reinforced by a strong network of partner organizations that collaborate based on several MoU and with the support of the GFCM FWP to carry out the increasing technical activities.

8. The positive impacts of the resolute actions stemming from the GFCM reform will likely play out in the near future. Although the challenges ahead are important, the GFCM nowadays is a modern RFMO with the capability and expertise to take appropriate decisions based on the best available scientific advice and ensure their implementation. In parallel, a number of organizations have made substantial progress in working on several aspects connected to fisheries in the Mediterranean and the Black Sea, placing them among their priorities and thus paving the paving the way for enhanced collaboration and synergies

International context

9. At the UN Sustainable Development Summit 2015 (New York, 25–27 September), world leaders adopted the 2030 Agenda for Sustainable Development, which includes a set of 17 Sustainable Development Goals (SDGs) to end poverty, fight inequality and injustice, and tackle climate change by 2030. The SDG 14 – entitled "Conserve and sustainably use the oceans, seas and marine resources for sustainable development" – builds upon the provisions of numerous legal instruments that have been adopted to ensure the conservation and sustainable use of the marine environment and its resources – e.g. the United Nations Convention on the Law of the Sea (UNCLOS), the FAO Code of Conduct for Responsible Fisheries and the United Nations Fish Stocks Agreement – and advocates for healthy and resilient marine ecosystems based on multiple elements. Similar relevance in the context of sustainable fisheries can be attributed to the Aichi Biodiversity Targets (ABT), in particular Target 6 which concerns fisheries. The SDG 14 and ABT 6 can therefore be regarded as embodying comprehensive strategies calling for phased action at all levels of governance, including at the regional level. The SDG 14 in particular offers substantial guidance as to how challenges to the sustainability of fisheries should be tackled, including the following, which

are particularly relevant to the sustainability of Mediterranean and Black Sea fisheries:

SDG 14	
Target 14.2	**by 2020**, sustainably manage and protect marine and coastal ecosystems to avoid significant adverse impacts, including by strengthening their resilience, and take action for their restoration in order to achieve healthy and productive oceans
Target14.4	**by 2020**, effectively regulate harvesting and end overfishing, illegal, unreported and unregulated fishing and destructive fishing practices and implement science-based management plans, in order to restore fish stocks in the shortest time feasible, at least to levels that can produce maximum sustainable yield as determined by their biological characteristics
Target 14.5	**by 2020**, conserve at least 10 percent of coastal and marine areas, consistent with national and international law and based on the best available scientific information
Target 14.7	**by 2030**, increase the economic benefits to Small Island developing States and least developed countries from the sustainable use of marine resources, including through sustainable management of fisheries, aquaculture and tourism
Target 14.7.a	increase scientific knowledge, develop research capacity and transfer marine technology, taking into account the Intergovernmental Oceanographic Commission Criteria and Guidelines on the Transfer of Marine Technology, in order to improve ocean health and to enhance the contribution of marine biodiversity to the development of developing countries, in particular small island developing States and least developed countries
Target 14.7.b	provide access for small-scale artisanal fishers to marine resources and markets
Target 14.7.c	enhance the conservation and sustainable use of oceans and their resources by implementing international law as reflected in UNCLOS, which provides the legal framework for the conservation and sustainable use of oceans and their resources

10. As a UN specialized agency, the FAO already contributes to the global implementation of the SDGs through a strategic framework, of which Strategic Objective 2 specifically aims to increase and improve the provision of goods and services from fisheries in a sustainable manner, addressing in particular multi-sectoral approaches for ecosystem management, capacity building, governance frameworks and the like.

11. In order to support the achievement of UN targets, as well as the international obligations stemming therefrom, including the FAO Strategic Objectives, the mid-term strategy towards the sustainability of Mediterranean and Black Sea fisheries has been elaborated.

12. The mid-term strategy will have an external dimension in that progress in implementing SDG 14 and ABT 6 through the regional targets, outputs and actions foreseen therein will be reported to international fora where the achievement of globally agreed goals is being monitored. As a regional body having a competence relevant to the implementation of SDG 14 and ABT 6, the GFCM is expected to provide information on the Mediterranean and Black Sea through, *inter alia*, the submission of reports and participation in meetings.

Regional context

13. The geopolitical situation in the Mediterranean and the Black Sea is currently complex. As of late, the Mediterranean has been experiencing significant instability due to ongoing conflicts and political turmoil in the region which, in turn, has exacerbated the problem of migration across the sea. At the same time, the existing gap in the level of development between the different subregions of the Mediterranean remains a top priority on the regional agenda. Similar considerations apply to the case of the Black Sea although different issues are at stake, including weaker fisheries governance resulting *inter alia* from the fact that not all six riparian countries are members of a same institutional arrangement such as the GFCM. In light of the special characteristics of the Mediterranean and Black Sea, it is all the more imperative to ensure a sound strategy is in place to promote the region's sustainable development. The fisheries sector, in particular, has an important role to play in such a strategy, as it is crucial to livelihood protection, food security and sustainable long-term development in the Mediterranean and Black Sea.

14. The GFCM's recently released assessment *The state of Mediterranean and the Black Sea fisheries* (SoMFi 2016) highlights the impact of fisheries, and in particular the small-scale

fisheries sector, within the region. Indeed, 80 percent of the region's fisheries are small-scale fisheries, underlining the role of fisheries in sustaining the region's coastal communities. Although the value generated from the first sale of fish products from Mediterranean and Black Sea fisheries may seem relatively small compared with other sectors (representing less than 1 percent of regional GDP), the sector's ability to target some of the region's most economically vulnerable coastal communities makes it a key player in any sustainable development strategy. In fact, the value at first sale as a percentage of GDP is six times greater in the developing countries of the southern Mediterranean than in the wealthier northern Mediterranean countries. Furthermore, exports of fish products from this region represent over 10 percent of total global exports, indicating significant secondary impacts of this sector on the wider economy.

15. Likewise, around a quarter of a million people are directly employed onboard fishing vessels in this region; yet the number of people dependent on the fishing sector for their livelihoods increases exponentially when considering the families supported by the region's fishers and those employed in related sectors, such as fish processing, vessel maintenance and tourism. Furthermore, around 60 percent of fishing employment is found in the developing countries of the southern and eastern Mediterranean, meaning that the majority of the jobs provided by this sector are located precisely where jobs are needed.

16. Taken together, these factors endorse the potential of the fishing sector to play an instrumental role in the sustainable development of the Mediterranean and Black Sea region and, in particular, its most vulnerable coastal communities. To this end, reliable data on the status and trends on stocks and fisheries is needed, so that management plans embracing the ecological, economic and social aspects are adopted to ensure the sustainability of fisheries. Building on the success of the SDGs in drawing the attention of the international community to the role of fisheries in sustainable development, a regional strategy which adapts such principles to the Mediterranean and Black Sea context is of paramount importance to address current challenges in this area.

2. NATURE AND SCOPE

17. The proposed mid-term strategy is linked to SDG 14 and the FAO Strategic Objective 2. As this strategy stems from existing international and regional legal instruments, it does not create any new obligations on GFCM Contracting Parties and Cooperating non-Contracting Parties (CPCs). On the other hand, it purports to define a course of instrumental action to further progress in the development of sustainable fisheries at the regional level. It is programmatic and multiannual in nature and provides guidance for the strategic priorities in the 2017–2020 period, identifying key actions that complement, when needed, the regular work carried out by the different organizations in relation to fisheries. The mid-term strategy addresses three main pillars of the work of the GFCM, as the RFMO in the area,: i) the scientific and technical work of the SAC and its subregional committees in the Mediterranean Sea and of the WGBS in the Black Sea, each of them carrying out core functions towards the provision of scientific advice for the Commission in light of relevant biological, social and economic parameters; ii) the decisions taken by the Commission in relation to capture fisheries, including all industrial, small-scale and recreational fisheries, and iii) the thorough assessment of the implementation of adopted management measures by CPCs, including efforts to fight against IUU fishing through the enhancement of MCS, as overseen by the CoC.

18. The mid-term strategy does not apply to aquaculture as this increasingly important sector has distinctive requirements that need to be addressed specifically. A dedicated Task Force within the framework of the GFCM is currently developing a strategy for the sustainable development of Mediterranean and Black Sea aquaculture.

3. GUIDING PRINCIPLES

19. The implementation of the proposed mid-term strategy towards the sustainability of Mediterranean and Black Sea fisheries will be guided by the following select principles which are in place at the FAO level:

Best available knowledge: The provision of advice, including on the status and trends of stocks and fisheries, should be based on the best available knowledge, including scientific advice and relevant information emanating from a variety of sources and stakeholders. Efforts to collect all information available shall be ensured, and standards for assuring the quality of information should be applied wherever and whenever practicable and appropriate within SAC and WGBS;

Objectivity and transparency: The collection, analysis and dissemination of information on the status and trends of fisheries, ecosystems and marine environment should contribute to the transparent provision of the best scientific evidence available, while respecting any confidentiality requirements. Uncertainty associated with information on status and trends should be expressed, without detracting from the application of the precautionary approach, when data and information are incomplete. Information on activities towards the fight against IUU fishing should be made available, respecting confidentiality requirements;

Timeliness: The collection, analysis and dissemination of information on the status and trends of fisheries, ecosystems and marine environment, as well as information on IUU fishing, should be provided in as timely a manner as possible;

Participation and cooperation: The collection, analysis and dissemination of information on the status and trends of fisheries, ecosystems and marine environment, as well as information on IUU fishing, should account for all relevant participants in the preparation, analysis and presentation of scientific advice and conclusions. Relevant participants may include, *inter alia*, representatives of CPCs and other riparian states, relevant international, non-governmental and civil society organizations. The existing cooperative network established through the adoption of MoU would be relied upon, having regard to the cross-sectoral nature of the strategy;

Adaptability: The collection, analysis and dissemination of information on the status and trends of fisheries, ecosystems and marine environment, as well as information on IUU fishing, should be adaptive enough to permit adjustments, as necessary, to ensure their effective support of fisheries management based on the most recent scientific advice available.

4. OBJECTIVE AND TARGETS

20. The overall objective of the mid-term strategy is to improve, by 2020, the sustainability of Mediterranean and Black Sea fisheries, by achieving five targets and related outputs and actions.

TARGET 1: REVERSE THE DECLINING TREND OF FISH STOCKS THROUGH STRENGTHENED SCIENTIFIC ADVICE IN SUPPORT OF MANAGEMENT

It is recognized that, with only 40 percent of the landings in the GFCM area of application coming from stocks for which scientific advice is provided to the Commission, and with an even smaller percentage of the landings coming from fisheries that are subject to comprehensive management plans, there is a need to improve the coverage of advice on the status of stocks and to increase the percentage of landings coming from fisheries regulated by specific multiannual management plans.

It is also recognized that, whenever possible, the advice provided to the GFCM as the international body in charge of adopting binding recommendations for the region should address all relevant aspects needed for decision making, including past and current socio-economic characteristics of the fisheries, as well as the potential socio-economic impacts of alternative management measures. Furthermore,

when this information is lacking or scarce, precautionary measures should be advised so that, based on the precautionary approach, the Commission can still efficiently take decisions to regulate fisheries.

It is agreed that, consistently with SDG Targets 14.2, 14.4 and 14.7, commitment is needed to implement, by 2020, actions to increase the existing scientific and socio-economic knowledge in support of fisheries management, and to adopt necessary decisions to reverse the current overexploitation rates, reducing the percentage of stocks outside biologically safe limits, through the achievement of the following:

Output 1.1: Enhanced knowledge and expertise on Mediterranean and Black Sea fisheries

Mediterranean and Black Sea riparian states have systems in place for the collection of fisheries data and information and its subsequent submission in line with specific binding recommendations. The GFCM in particular receives such information through dedicated data calls, national reports to its technical subsidiary bodies and through ad hoc questionnaires. The GFCM Data Collection Reference Framework (DCRF) organizes the different data calls and provides indications and tools on how to collect and submit data to the GFCM, with a view to creating a more rational and efficient database in support of decision making. Furthermore, regional workshops and working groups on a variety of topics, including stock assessment, and dedicated conferences such as the Regional Conference "Building a future for sustainable small-scale fisheries in the Mediterranean and the Black Sea" (SSF Conference) have provided experts with fora in which information could be exchanged and incorporated into the advice from the subsidiary bodies to the Commission. However, this information is still fragmented and unbalanced between different subregions and aspects such as socio-economic characteristics of fisheries are still not well understood and incorporated in the advice.

This output will require the compilation of data and information on different fisheries-related issues, including through the implementation of the DCRF, as well as the execution of a number of actions as listed below:

a. The creation of a **GFCM Forum on Fisheries Science (GFCM FishForum)**, expected to act as a hub for collecting in a more comprehensive manner experiences and scientific information/data on aspects related to fisheries, from stock assessment to socio-economic issues and anthropogenic effects on fisheries and ecosystems. Among other results, the GFCM FishForum should support stock assessment-related work, the compilation of existing knowledge on the status of stocks and discussion on harmonized ways to provide advice on stocks and fisheries, the creation of a database with comprehensive and reliable fisheries data and the establishment of a network of experts and research institutions covering different domains of fisheries science. The Forum will be organized around the following thematic clusters: stock assessment, socio-economic aspects, small-scale and recreational fisheries, bycatch and discards, IUU fishing, fishing technology, interactions between fisheries and marine ecosystems, stakeholders and regional/subregional platforms.

b. The realization of **regional surveys at sea**, including acoustic surveys for pelagic species as well as trawl surveys for demersal fisheries. These joint surveys, carried out in the context of FAO, are expected to provide information on a large number of species over large areas and to serve as tuning indices for assessment purposes, as well as provide validation on the advice on the status of the main commercial stocks.

c. The compilation of **catalogues of fishing activities** by geographical subarea, also for small-scale and recreational fisheries, and including information on fishing gear and fishing operations, description of fishing areas as well as target and bycatch species. This catalogue is expected to provide a comprehensive summary of fishing activities in the Mediterranean and the Black Sea, as well as updated estimates of fishing capacity by fleet segment and subregion.

All information gathered through this output is expected to feed into the process of the provision of advice (see Outputs 1.2 and 1.3) and will also be summarized among others in the next issues of the report on *The State of Mediterranean and Black Sea Fisheries* (SoMFi), expected to be delivered biennially under the framework of this strategy (in 2018 and 2020).

Output 1.2: Socio-economic information and analysis incorporated into scientific and management advice

In recent years, GFCM subsidiary bodies have made efforts to integrate available socio-economic analysis into the advice provided to the Commission through dedicated workshops on bioeconomic assessment of management measures. Despite data limitations, attempts have been made to review existing methodologies to perform management strategy evaluation (MSE) simulations and to assess the economic, social and biological implications of alternative management scenarios for certain stocks. However, the quality and quantity of available socio-economic data are still limited and work is needed to harmonize methodologies for socio-economic analysis, including on the definition of adequate indicators that could be used across the region, so as to further integrate socio-economic data into management advice. Furthermore, information on socioeconomic characteristics should facilitate an analysis of profitability and therefore the integration of dedicated measures for the valorization of fish products into management measures (see Output 1.3). In order to achieve this output, the following actions should be executed within the mid-term strategy:

a. The definition of socio-economic indicators and the completion of **a comprehensive regional survey on the socio-economic characteristics of fisheries** in the Mediterranean and the Black Sea. This survey is expected to help overcome a main barrier to the integration of socio-economic data in management advice by providing accurate, timely and complete socio-economic baseline data on the region's fisheries.

b. The **incorporation of socio-economic information** into the assessment of the state of main commercial fisheries and the provision of advice on the comparative impacts of alternative management scenarios.

Output 1.3: Enhanced science-based GFCM regulations on fisheries management

In recent years, relevant GFCM subsidiary bodies have improved their advice, both in terms of scope (e.g. covering aspects ranging from red coral to artificial reefs to the status of stocks and fisheries) and coverage (e.g. improving subregional coverage and increasing the percentage of the landings for which advice on stock status is given) and cooperation has been enhanced with relevant partner organizations towards an increased scientific base. At the same time, and following the adoption of the GFCM Guidelines on precautionary conservation measures pending the development and adoption of GFCM multiannual management plans for relevant fisheries at the subregional level in the GFCM area[1], the GFCM has advanced towards the regulation of fisheries in its area of application, with the adoption of a comprehensive management plan for small pelagic fisheries in the Adriatic Sea and demersal trawlers in the Strait of Sicily, and with an incipient management plan for turbot gillnet fisheries in the Black Sea.

However, advice in support of management measures still focuses on a limited number of topics and still addresses a small percentage of exploited stocks, marine populations, ecosystems and areas. In some cases, existing advice at the national level (e.g. assessment of national stocks) is not presented to the GFCM subsidiary bodies and therefore is not taken into account in the provision of advice. In other cases, information is scarce or lacking, and no scientific advice is provided. Furthermore, scientific advice is not always immediately incorporated into recommendations and, as a result, only a very small percentage of the landings come from fisheries regulated by comprehensive management plans.

Technical work for the improvement of the advice on cases with limited information (data-limited stock assessment methods) as well as technical work in support of the establishment of new management plans (e.g. for small pelagic fisheries in the western Mediterranean, deep-water shrimp in the central-eastern Mediterranean, anchovy in the Black Sea or European eel in the Mediterranean Sea) is already underway within the GFCM. Output 1.2, coupled with the work towards the estimation of IUU activity (see Output 3.3), will also support better decision making through the incorporation of socio-economic

[1] OTH-GFCM/37/2013/1

information, including aspects of valorization of fish products, as well as information on the impact of IUU.

In order to achieve this output, the following actions should be carried out within the mid-term strategy:

a. The implementation of a dedicated **approach for the provision of advice to the GFCM by its subsidiary bodies**. Such an approach envisions action for stocks/fisheries where information on stocks/fisheries is either fragmented or not made available, and stocks/fisheries for which a validated scientific advice exists. In the former situation, immediate actions to collect the required information and make it available should be launched, while at the same time precautionary advice should be issued. On the other hand, when a validated scientific advice exists, the advice should include indications on the effect of alternative management measures on both the stocks and the fisheries, including on socio-economic aspects. Within this approach, and without prejudice to addressing additional species, the GFCM agreed on a list of priority commercial species by subregion for which an advice should be produced:

	Western Mediterranean	**Central Mediterranean**	**Adriatic Sea**	**Eastern Mediterranean**	**Black Sea**	
Pelagic species	*Engraulis encrasicolus*	*Engraulis encrasicolus*	*Engraulis encrasicolus*	*Engraulis encrasicolus*	*Engraulis encrasicolus*	*Trachurus mediterraneus*
	Sardina pilchardus	*Sardina pilchardus*	*Sardina pilchardus*	*Sardinella aurita*	*Sprattus sprattus*	*Sarda sarda*
Demersal species	*Parapenaeus longirostris*	*Parapenaeus longirostris*	*Mullus barbatus*	*Mullus barbatus*	*Merlangius merlangus*	*Psetta maxima*
	Merluccius merluccius	*Merluccius merluccius*	*Merluccius merluccius*	*Saurida lessepsianus*		*Mullus barbatus*
	Pagellus bogaraveo					
Species of conservation concern	*Anguilla anguilla*				*Squalus acanthias*	
	Corallium rubrum					
Invasive species	*Pterois miles*				*Rapana venosa*	
	Lagocephalus sceleratus					

b. [The **operationalization of the Review Panel**, as established by GFCM (Rule XVI of the GFCM Rules of Procedure) to review the scientific advice formulated by its subsidiary bodies and provide conclusions to support the decision-making process.]

c. The **revision of existing management plans / development of new management plans**, based on the technical advice provided by the subsidiary bodies, with the objective of addressing the main commercial fisheries as well as those fisheries that rely on or show a strong interaction with resources in need of urgent action.

TARGET 2: SUPPORT LIVELIHOODS FOR COASTAL COMMUNITIES THROUGH SUSTAINABLE SMALL-SCALE FISHERIES

It is recognized that small-scale fisheries play an important role in providing income and ensuring food security, particularly within economically vulnerable coastal communities. Therefore concerted action should be taken to support this sector.

It is recognized that the data available to measure the extent and impact of small-scale fishing activity are limited and can vary widely from country to country. Due to these data limitations, small-scale fisheries tend to be undervalued, potentially leading to their marginalisation in the decision-making process.

It is also recognized that States should be responsible for collecting complete, timely and accurate socio-economic data on the impact of small-scale fishing and for developing coherent policies to ensure resource and market access for small-scale fishers. Support will be provided within the mid-term strategy to enhance the coordination of efforts and to harmonize existing measures to support the small-scale fishing sector.

It is agreed that commitment is needed, by 2020, to support livelihoods within sustainable small-scale fisheries, consistent with SDG Target 14.b and 14.7, through the realisation of the following:

Output 2.1: Robust and timely information on the impacts of small-scale fisheries and recreational fisheries on living marine resources and on their interactions with other human activities in coastal communities

In recent years, work has been carried out to better understand the importance of small-scale fisheries in the Mediterranean and the Black Sea. Preliminary analyses have shown that these fisheries are the predominant sector in the region (accounting for 80 percent of the region's fishing fleet, 60 percent of all on-vessel fishing labour and approximately 25 percent of the total landing value from the region's capture fisheries), highlighting the crucial role that these fisheries must play in any strategy to sustainably manage the region's living marine resources. As discussed in depth at the First Regional Symposium on sustainable small-scale fisheries (27–30 November 2013, Malta) and the subsequent SSF Conference (7–9 March 2016, Algeria), due to the delicate socio-economic role these fisheries play in providing livelihoods for hundreds of thousands of people in the region's coastal communities, concerted efforts are needed to support this sector. The importance of producing an accurate, timely and comprehensive socio-economic description of small-scale fisheries, and their interactions with other sectors such as recreational fisheries, have been identified as a crucial first step towards mitigating detrimental socio-economic impacts of efforts to manage the region's marine resources. However, despite similarities between small-scale fisheries and recreational fisheries, the latter deserve a specific action. Socio-economic indicators are needed to inform policy interventions that will help to maximize economic and social benefit, while minimizing environmental and ecological impacts. This output will require the execution of a number of actions as listed below:

a. The implementation of a **regional survey on small-scale fisheries**. This survey is expected to provide a snapshot of the ecological, social and economic impacts of small-scale fisheries in the Mediterranean and Black Sea and at the same time improve the capacity to collect relevant data on small-scale fisheries as requested through the DCRF. Information on the different gear used in SSF will be collected as part of the catalogue of fishing activities (Target 1) with a view to better linking SSF to the different fishing activities in coastal areas.

b. The establishment of a **permanent Working Group on Small-Scale and Recreational Fisheries**. This working group is expected to foster knowledge-sharing platforms among the region's small-scale and recreational fishers for the dissemination of best practices and the sharing of information, to oversee the completion of the regional survey on small-scale fisheries and to coordinate efforts among CPCs and relevant organizations.

c. The assessment of the impacts of **recreational fisheries** and the consideration of best management measures to regulate these activities.

The information gathered through these actions should result in an **estimate of the economic impact of small-scale fisheries** on coastal communities and their interactions with related sectors, as well as inform the development of **indicators to monitor the socio-economic status of small-scale fisheries** and the management of recreational fisheries.

Output 2.2: FAO Small-Scale Fisheries Guidelines tailored to the specificities of the Mediterranean and the Black Sea

The FAO *Voluntary Guidelines for Securing Sustainable Small-Scale Fisheries in the Context of Food Security and Poverty Eradication* (SSF Guidelines) constitute an important tool for supporting actions to secure sustainable small-scale fisheries and support livelihoods in coastal communities. These

guidelines take a holistic approach, among others, promoting the importance of tenure rights, livelihood diversification, market access, decent working conditions and the engagement of women and marginalized groups, as crucial elements towards improving socio-economic conditions and strengthening small-scale coastal fishing communities. This output will require a holistic approach to supporting the region's small-scale fisheries, including by carrying out the following actions:

a. The development of **national plans of action for the implementation of the SSF Guidelines** is expected to provide roadmaps for bolstering valorization, commercialization and livelihoods in small-scale fisheries and coastal communities in a way that adapts to the specific needs at the regional, subregional and national levels.

b. The establishment of **a regional platform to engage and promote dialogue among small-scale fishing associations** in the Mediterranean and the Black Sea. This platform is expected to build on and reinforce existing subregional and national platforms in order to provide a participatory mechanism for knowledge-sharing, collaboration, stakeholder involvement, and the dissemination of best practices.

c. The **endorsement of the principle of decent work**, as defined by the Work in Fishing Convention (C188) of the International Labour Organization (ILO), so as to promote, without compromising environmental sustainability, the improvement of socio-economic conditions within small-scale fisheries and the promotion of livelihood diversification.

d. The organization of **a high-level meeting** in collaboration with strategic partners, including the Mediterranean Initiative of the World Wildlife Fund (WWF), to generate political will in small-scale fisheries within a Blue Growth context.

TARGET 3: CURB ILLEGAL UNREPORTED AND UNREGULATED (IUU) FISHING, THROUGH A REGIONAL PLAN OF ACTION

It is recognized that better management of fisheries in the Mediterranean and the Black Sea is undermined by IUU fishing activities and the disregard of common rules. Although the impacts of IUU fishing are currently not assessed and therefore under-represented in the current status of fisheries and trends information, they must be adequately considered in the development of scientific advice for management.

It is stressed that CPCs, in their capacity as flag states, coastal states, port states and market states, have the primary responsibility to ensure respect of common rules by fishing vessels. Support will be provided within the mid-term strategy to enhance coordination of efforts and harmonize existing measures aimed at improving monitoring, control and surveillance.

It is acknowledged that, while the implementation of the two roadmaps to fight IUU fishing in the Mediterranean and the Black Sea adopted by the GFCM has been positive thus far, there is an important need to set political and operational objectives to counter illegal activities, building upon the elements of these roadmaps and reflecting relevant elements in the FAO International Plan of Action against IUU, which is already voluntarily applied in the region. It is also acknowledged that support will be provided for **the organization and celebration of an international day for the fight against IUU fishing**, to be imminently declared by the FAO upon the request of the GFCM.

It is agreed that there is a need to commit to **effectively reducing IUU fishing in the Mediterranean and the Black Sea** by 2020, consistent with SDG Target 14.4, by developing a holistic **regional plan of action to fight IUU fishing**, to eventually be transposed at the national level and that would among others achieve the following:

Output 3.1: Regular quantification of IUU fishing in the Mediterranean and the Black Sea and harmonization of existing measures to fight against IUU fishing

IUU fishing remains one of the greatest threats to the conservation and sustainable use of fisheries, undermining national and regional management efforts. In 2003, it was calculated that the lower and

upper estimates of the total value of IUU fishing worldwide were between US$10 billion and US$23 billion annually, representing between 11.06 and 25.91 million tonnes of fish, and there is today a general recognition that the incidence of IUU fishing has not decreased since. Another topical issue relating to IUU fishing is the need to harmonize at the regional level existing measures used to counter illegal activities. In this regard, guidance is not only sought from the Regional Plan of Action to fight IUU fishing but also from an evaluation of relevant national legislations in place which are collected in the GFCM database of national legislations. In order to meet the target of considerably reducing IUU fishing, it will be instrumental to carry out the following actions:

a. The realization of an **assessment of the quantity, magnitude and characteristics of IUU fishing** in the Mediterranean and the Black Sea. Whereas work is ongoing within the FAO to bring about a common methodology to assess IUU fishing, a tailored approach for the Mediterranean and the Black Sea is needed with a view to supporting the scientific work of the SAC and WGBS.
b. The evaluation of the adequateness of national legislations relating to IUU fishing adopted by CPCs as contained in the GFCM database of national legislations. As appropriate, this evaluation should lead to the revision of national legislations in view of the harmonization of measures to fight IUU fishing which will be facilitated by the Regional Plan of Action to fight IUU fishing.

Output 3.2: Reinforced inspection procedures in the framework of port State control

The regional system of port state measures in the Mediterranean and the Black Sea should be aligned with the provisions in the FAO Port State Measures Agreement (PSMA). Most importantly, the 5 June 2016 entry into force of the FAO PSMA brings about actions and initiatives to promote port controls worldwide. The GFCM should be involved in the correct implementation of the FAO PSMA, through the adoption of robust port state measures. Efforts will be needed, on the one hand, to support the ratification of the FAO PSMA by states and, on the other hand, to make sure that appropriate conditions are in place to strengthen port State measures (both political, legal and technical). This will entail carrying out several actions within the remit of the GFCM:

a. The promotion of **training of national inspectors** and, as appropriate, relevant officers, including jointly with other partners and by developing specific online instruments, with a view to launch national actions to better take stock of the needs of each recipient country relating to efficient port controls.

b. The establishment of a **mutual assistance system** will facilitate exchange of information between flag states and port states via the GFCM Secretariat and that of a **regional information system to exchange port State measures related data** will operationalize port state measures in the GFCM area of application, consistent with the provisions of the FAO PSMA, complementing the ongoing establishment of a regional monitoring and control system.

Output 3.3: Enhanced modular monitoring, control and surveillance (MCS) at the regional level

Since the adoption of the GFCM recommendation on the establishment of a vessel monitoring system (VMS), the Commission has been advancing on the phased development of a regional control system, with a view to enhancing monitoring, control and surveillance capabilities in the Mediterranean and the Black Sea. This system is needed in order to have the same control standards in place across the Mediterranean and the Black Sea and therefore ensure all CPCs are on par, regardless of whether or not they have a fishing monitoring centre. In this regard, priority will be given to the development of national VMS to verify whether these are consistent with minima requirements in place at the GFCM level. Furthermore, because of the high number of small-scale vessels operating in the Mediterranean and the Black Sea, the system will underpin a modular approach which is responsive to the needs of those CPCs which rely primarily on small-scale vessels. This output will complement control related activities already agreed upon by the GFCM, such as the working group on integrated MCS measures for demersal fisheries in the Strait of Sicily, and will be achieved by carrying out the following action:

a. The continuation of the operationalization of a **regional VMS and control system**, in order to help monitor adherence to fisheries restricted areas and to underpin GFCM data collection systems by progressively incorporating electronic tools, such as the e-logbook, which could be developed at the regional level. Effort and catches information deriving from this system would support the enhanced assessment of fisheries stocks, identification of fishing grounds and fishing activities, contributing to the achievement of Target 1.

TARGET 4: MINIMIZE AND MITIGATE UNWANTED INTERACTIONS BETWEEN FISHERIES AND MARINE ECOSYSTEMS AND ENVIRONMENT

It is underlined that healthy and productive marine ecosystems are an important means to supporting maximum sustainable yield and facilitating blue growth.

It is recognized that fisheries, as well as other anthropogenic-driven phenomena, such as climate change or the introduction of non-indigenous species, can have potentially negative effects on the marine environment and marine ecosystems.

It is agreed that, by 2020, consistent with SDG Targets 14.1, 14.2 and 14.5, necessary measures will be taken to minimize and mitigate negative impacts of fisheries on marine biodiversity and ecosystems, especially in relation to vulnerable species and ecosystems, as well as to mitigate negative anthropogenic effects on fisheries, in close coordination with partner organizations. These measures should be implemented by achieving the following outputs:

Output 4.1: Reduced bycatch rates in Mediterranean and Black Sea fisheries

Bycatch is considered as one of the most important threats to the profitability and sustainability of fisheries and, as such, it is considered to be one of the major concerns for most RFMOs and other fisheries management bodies. In the Mediterranean and the Black Sea, based on the analysis presented in SoMFi 2016, discard rates vary between areas and fishing gear, but can reach up to 20 percent of the total catch. In order to address this threat and to take into account previous concerns raised, this output will require the execution of the actions as listed below:

a. The implementation of a **bycatch monitoring programme,** including through the use of observers onboard commercial fishing vessels. This programme is expected to obtain representative data on the discard component of total bycatch in Mediterranean and Black Sea fisheries, as well as information on the incidental catch of vulnerable species that could occur during sampled fishing operations, with a view to facilitating the adoption of required management measures towards the reduction of bycatch rates.

b. The development and launch of a fully encompassing **communication mechanism** to educate fishers on the negative impacts of bycatch on fisheries productivity and on marine ecosystems. This activity entails, among others, the publication of infographics, cards and posters. Ecolabelling and certificates for fishers who ensure their commitment in fishing according to sustainable practices in the Mediterranean and the Black Sea should also be envisaged.

c. The implementation of **effective management measures to improve the selectivity of fisheries**, including the possibility to use artificial reefs to protect fish essential habitats (e.g. nursery areas) as well as the implementation of more selective fishing gear.

d. The proposition of measures to reduce catches of vulnerable species when appropriate, by entrusting the SAC with this task.

e. The identification and implementation of **mitigation measures to address the interaction between cetaceans and fishing gear**.

Output 4.2: Healthier marine ecosystems and more productive fisheries

The GFCM was a pioneer in adopting, in 2005, a binding recommendation on the protection of seabeds below 1 000 meters depth from trawling, as a measure to minimize the impact of these fisheries on

deep-sea ecosystems. Moreover, in 2006, the GFCM adopted a specific area-based management tool, the fisheries restricted areas (FRAs), to protect vulnerable marine ecosystems (VMEs) in the region. Furthermore, the Joint Cooperation Strategy on Spatial-based Protection and Management Measures for Marine Biodiversity has been elaborated among the Secretariats of the Agreement on the Conservation of Cetaceans of the Black Sea, Mediterranean Sea and Contiguous Atlantic Area (ACCOBAMS), the GFCM, the Mediterranean Programme of the International Union for Conservation of Nature (IUCN-Med), the UNEP/MAP through its Regional Activity Centre for Specially Protected Areas (RAC/SPA) and in collaboration with the Network of Managers of Marine Protected Areas in the Mediterranean (MedPAN) , which will focus on the identification of priority spatial areas at regional scale for the implementation of protection measures, in order to maximize the potential benefits of such measures.

Specific actions towards the protection of Mediterranean populations of red coral (*Corallium rubrum*) have also been developed, and, within the context of the MoU between the GFCM and the United Nations Environment Programme – Mediterranean Action Plan (UNEP-MAP), a number of indicators for good environmental status (GES) of exploited marine populations have been established. In addition, within the same MoU, work towards the implementation of the Mediterranean Regional Plan on Marine Litter has been initiated. Finally, SAC subsidiary bodies have highlighted the potential combined effects of climate change and other direct and indirect anthropogenic impacts such as the introduction of non-indigenous species (often referred to as “alien species”) in the Mediterranean and the Black Sea, stressing the need to launch dedicated actions to better understand such phenomena so as to better mitigate their effects.

To achieve Output 4.2, coordination will be guaranteed between relevant regional organizations so to ensure:

a. The promotion of the **identification and establishment of new FRAs** to protect priority areas within ecologically or biologically significant marine areas (EBSAs), VMEs, etc. from harmful fishing activities, and the implementation of monitoring and control systems to ensure the efficiency of these spatial measures, also in relation to Target 3. This action should aim to achieve at least the protection of 10% of the coastal and marine areas, as expressed in Aichi Target 11. The CPCs should be closely involved in the definition of new FRAs.

b. The adoption of a comprehensive **regional management plan for red coral**, based on previous technical work carried out in the context of the GFCM subsidiary bodies, including relevant GFCM guidelines, and updated advice as provided within Output 1.3.

c. The creation of an **adaptation strategy to cope with potential effects of invasive species and climate change on fisheries**. Such a strategy should be based on the results of an evaluation of the potential ecological and socio-economic effects of climate change and of the introduction of non-indigenous species on Mediterranean and Black Sea fisheries.

d. The creation of an **adaptation strategy to cope with potential effect of marine litter on fisheries**, as well as the implementation of fisheries management measures aimed to minimize the production of litter from fishing activities (e.g. abandoned fish gear), in line with existing Mediterranean regional management plan on marine litter.

TARGET 5: ENHANCE CAPACITY BUILDING AND COOPERATION

It is urged that CPCs, relevant intergovernmental and non-governmental organizations and concerned stakeholders enhance cooperation to promote sustainable development and blue growth in the Mediterranean and the Black Sea.

It is acknowledged that fulfilling the objective of the mid-term strategy through the proposed actions both requires and promotes increased scientific and technical cooperation a throughout the region. Particular efforts will be needed for the Black Sea, given that not all riparian countries are currently contracting parties to the GFCM.

It is agreed that commitment is needed, by 2020, in line with SDG 14.7, to help level the playing field for developing countries and to ensure the accrual of socio-economic benefits from the sustainable management of fisheries, by achieving the following:

Output 5.1: Improved national capacity for the management of fisheries resources

In recent years, the CoC has acknowledged that there is strong political willingness to support the work of the GFCM and to routinely carry out the assessment of adopted GFCM decisions. Some CPCs are, however, experiencing some difficulties in meeting their obligations stemming from GFCM decisions and, therefore, capacity-building efforts must be enhanced. In this regard, the GFCM Agreement recognizes, in particular, the needs of developing CPCs. This output will be achieved through the completion of the following actions:

a. The provision of **capacity building for CPCs**, as obliged by the Commission, when necessary, to assist CPCs in meeting their obligations stemming from relevant GFCM decisions. The provision of technical assistance by the GFCM has been sparse up to now as no clear mechanism existed to govern the provision of technical assistance, including from the identification of needs to the actual support on the ground.

b. The implementation of a **technical assistance mechanism** to support CPCs in bridging existing gaps. Such a mechanism should be based on recent work carried out by the CoC to thoroughly address the link between national gaps/shortcomings and the implementation of GFCM recommendations. Based on requests for technical assistance received by the GFCM thus far, the main following areas would be, among others, covered by the technical assistance mechanism: i) stock assessment and management plans; ii) data collection, analysis and transmission; iii) elaboration and amendment of national legislations; iv) assessment and development of national VMS and control systems in accordance with GFCM standards; v) the strengthening of port controls and vi) the elaboration and development of case studies on small-scale fisheries.

c. The launch of a **regional programme for education and training** to lay down the foundation for a new generation of fisheries experts through mid- and long-term specialization curricula, in collaboration with regional and national research/training institutions, which would essentially cover domains such as population dynamics, including stock assessment, fishing technology, socio-economic analysis and fisheries legislation.

Output 5.2: Strengthened fisheries governance in the Black Sea

On the occasion of the 2014 amendment to the GFCM Agreement, the specificities of the Black Sea were recognized when it was decided to establish a specific mechanism to promote cooperation among riparian countries. Over the past decades, many efforts have been made to bring about a concerted approach to the issues and challenges that are faced in the Black Sea. The trend has shifted towards a regional decision-making process which has been promoted through the WGBS since 2011 (the year it was established). The contribution of the WGBS to fisheries governance has been decisive, to the extent that three binding recommendations have been adopted by the GFCM in the years that followed the establishment of the WGBS. Furthermore, a non-binding roadmap to fight IUU fishing in the Black Sea was also adopted. The most crucial element for fisheries governance in the Black Sea remains cooperation among the riparian countries. Enhanced cooperation has been staunchly pursued by the GFCM, leading to the granting of cooperating non-contracting party status to Georgia and Ukraine in 2015. There is momentum, at present, to build upon ongoing cooperation and further strengthen fisheries governance in the Black Sea. To this end, this output will be achieved through the completion of the following actions:

a. The organization of a **high-level conference on fisheries governance** in order to examine existing institutional hurdles and provide a forum for riparian countries to provide inputs to the ongoing process of cooperation in the Black Sea. Discussions are needed in particular to ensure full membership of the six riparian countries to the GFCM, in due course.

b. The launch of the start-up phase of a **regional, scientific and technical cooperation project for the Black Sea**, the BlackSea4Fish project, carried out in the remit of the WGBS. It is expected that this project would operate under the umbrella of the GFCM, with the aim to support the activities of the WGBS, and would contribute to further bridging gaps at the regional level, endowing the WGBS with the necessary support to make sure that its work programme is efficiently implemented.

Output 5.3: Increased cooperation with relevant actors

As part of the same organization, tight collaboration with the FAO Fisheries and Aquaculture Department on issues such as the development and implementation of the SSF Guidelines, the management of marine areas beyond national jurisdiction (ABNJ), the implementation of the FAO PSMA or the Global Record, has been instrumental to align regional actions with global practices and to showcase regional initiatives in reply to international guidelines. The establishment of the FAO regional projects for the Mediterranean, starting with the launch of Copemed in 1996 and followed by MedSudMed, AdriaMed and EastMed, has substantially supported the SAC in the provision of scientific advice, thanks to the technical support and capacity-building activities directly provided to countries over the years.

In addition to the GFCM's ongoing collaboration with relevant FAO departments and projects, at the time of writing, the GFCM has concluded 14 MoU. These instruments have been central to fostering synergies and avoiding duplications. Moreover, several initiatives are being undertaken in the framework of these instruments which are extremely important due to the transversal nature of the areas of cooperation addressed therein. In addition to the governmental cooperation promoted by the GFCM, intra-governmental cooperation with other institutions is also important. This output will be achieved through the following actions:

a. The **operationalization of existing MoU**, including the launching of joint activities, with a view to avoiding duplications. Where new possibilities arise for new MoU, these should be submitted to the Commission for its consideration and adoption.

b. In line with the FAO Strategic Objective 2, the **strengthened coordination with the FAO Fisheries and Aquaculture Department and FAO regional projects**, taking into account current challenges and recent changes within the GFCM, including the focus on a subregional approach and the launch of this strategy.

5. IMPLEMENTATION MECHANISMS

21. Consistent with Article 17 of the GFCM Agreement, the capacity of developing CPCs will be duly taken into account in implementing the strategy in order to level the playing field and bridge existing gaps. Technical assistance will be provided where there is a need to build national capacities so that existing commitments can be fulfilled equally. In this respect, the promotion of the "concerted actions" initiative or the signature of bilateral letters of agreement, as already implemented by the GFCM in the past with selected CPCs, should be encouraged.

22. The effective implementation of existing and future fisheries management-related decisions by CPCs is instrumental in reaching the objectives of the mid-term strategy.

23. The GFCM, through its relevant subsidiary bodies, should regularly assess the attainment of the targets during the period of implementation of the strategy, by reviewing the outcomes of specific activities, revising and updating, as appropriate, the expected outputs and providing guidance to reach more effectively agreed objectives.

This strategy is dedicated to the late Mohamed HadjAli Salem, an important member of the GFCM family having twice served as GFCM Chairperson and also as the long-standing coordinator of the SIPAM network. His experience and commitment intelligently led the Commission through delicate times of change.

Annex 2

Terms of reference for the intersessional meeting of the Commission on the mid-term strategy towards the sustainability of Mediterranean and Black Sea fisheries

The intersessional meeting of the Commission on the mid-term strategy towards the sustainability of Mediterranean and Black Sea fisheries will:

- Be open to CPCs and all relevant partner organizations, including the FAO and FAO regional projects;
- Set specific agreed targets, based on national strategies, under the five objectives in the mid-term strategy, as endorsed by the Commission at its fortieth session;
- Match agreed objectives in GFCM recommendation against the targets in the mid-term strategy with a view to promote complementarities further;
- Integrate relevant outcomes of previous work by the GFCM (e.g. SSF, IUU, etc.) in the strategy;
- Consider the possibility to clarify the scope of activities foreseen in the mid-term strategy, as appropriate;
- Review the progress of the two year feasibility study on the implementation of the subregional approach and make recommendations on the course of action to be followed;
- Discuss the *modus operandi* and practical arrangements for the implementation of the mid-term strategy;
- Identify the necessary resources, including means to pool resources in the context of concerted actions;
- Define the composition and methods of work of the review panel.

Resolution GFCM/41/2017/4
on a permanent working group on vulnerable marine ecosystems

ACKNOWLEDGING the United Nations General Assembly (UNGA) Resolutions 59/25, 61/105 and 64/72 on sustainable fisheries, in particular regarding the obligation to prevent significant adverse impacts on vulnerable marine ecosystems (VMEs);

TAKING INTO ACCOUNT the 2009 FAO International Guidelines for the Management of Deep-sea Fisheries in the High Seas, which provide states and regional fisheries management organizations or arrangements (RFMO/As) with guidance in formulating and implementing appropriate measures for the management of deep-sea fisheries in the high seas through a range of management tools and measures necessary to ensure the conservation of target and non-target species as well as affected habitats;

TAKING NOTE of the mid-term strategy (2017–2020) towards the sustainability of Mediterranean and Black Sea fisheries, Target 4: "Minimize and mitigate unwanted interactions between fisheries and marine ecosystems and environment";

CONSIDERING the advice of the Scientific Advisory Committee on Fisheries (SAC) regarding the protection of VMEs, based on the outcomes of the first meeting of the Working Group on Vulnerable Marine Ecosystems (WGVME) (Spain, April 2017);

CONSIDERING the necessity to give a more permanent status to the activities of the WGVME;

ADOPTS, in conformity with Articles 5 and 8 of the Agreement for the establishment of the General Fisheries Commission for the Mediterranean (GFCM Agreement), the following resolution:

1. The WGVME and its activities should be included, on a permanent basis, in the GFCM annual work programme;

2. The mandate and terms of reference of the WGVME, as provided in the Annex, should be reviewed and complemented so as to ensure the implementation of the above-mentioned UNGA resolutions.

3. The WGVME should continue to review and examine, in 2018, the technical elements[1] for the protection of VMEs in the GFCM area of application, as provided by the SAC at its nineteenth session (Slovenia, May 2017), in order to formulate advice towards the adoption by the Commission of dedicated protocols for the protection of VMEs, in line with similar protocols established by other regional fisheries management organizations (RFMOs).

4. The WGVME should also contribute to identify the technical elements concerning management measures to be applied for:

- fishing vessels above 15 m length overall (LOA) operating with bottom contact fishing gear targeting the species *Aristaeomorpha foliacea*, *Aristeus antennatus*, or *Plesionika martia*; and
- fishing vessels above 15 m LOA operating with bottom contact gear (bottom trawls, bottom set gillnets, bottom longlines and pots and traps) at depths deeper than 300 m.

[1] Notably on the basis of the work of the WGVME.

Annex

Terms of reference for a permanent working group on vulnerable marine ecosystems

As agreed by the fortieth session of the GFCM, the Working Group on VMEs (WGVME) was established to develop initial measures related to the protection of VMEs in the GFCM area of application, in accordance with the FAO mandate. Once such initial measures are defined, the WGVME should also provide advice for the SAC.

In particular the WGVME should carry out the following tasks:

- collect information and map the distribution of VMEs (annual update);
- advise on new proposals for closures and on the enforcement of existing measures (efficiency of existing FRAs addressing VME protection);
- assess technical information provided by fishers and other institutions;
- advise the SAC on any VME-related matter and coordinate the elaboration of management tools.

The WGVME will also contribute to:

- the design and management of the Mediterranean VME geodatabase;
- the establishment of a close collaboration and proper communication channels with scientific bodies from other RFMOs (e.g. ICES working group on deep-water ecology), scientific national institutions and the FAO.