Module 2

DISCARDED SPECIES IN FISHERY AND SUGGESTED METHODS TO REDUCE

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Summary

Discarding, that portion of the catch that is not retained on board and may include target species or other commercial and noncommercial species that are discarded dead or alive into the sea, is a worldwide problem. The extent of discarding varies by region, species, and fishery due to legal obligations or economic incentives, damage to fish, or prohibitions on catching these species. The multispecies/multi-gear fisheries in the Mediterranean Sea result in wide variation in catch, target species, sorting methods, and discard composition, both geographically and among different gears. Discard rates vary widely by fishing method and geographic area. Trawlers have by far the highest discard rates, while all other gears have much lower rates. Discarded fish depend on the fishing fleet and fishing methods, but even within the same fishing fleet there are large differences in discarded fish by target species or season. Good fisheries management focusing on reducing discards requires understanding how fisheries work and being aware of opportunities for fishermen to reduce discards through improved gear selectivity. There are some legal restrictions on fishing, the main direct restrictions are: Gear restrictions, temporary gear closures, landing bans for undersized fish, discard bans - landing obligations. Given the lack of information on discards, it is important to establish and implement a comprehensive monitoring and control system to ensure compliance and collect adequate data for scientific and management information.

1. INTRODUCTION

Discards, the part of the catch that is not retained on board, which may include target species or any other commercial and noncommercial species that are returned to the sea dead or alive, is a global issue. Globally, it is estimated that between 7 and 10 million tonnes of commercial fisheries catch are discarded annually. The extent of discards varies by region, species, and fishery. There are several reasons why fisherman discard their catches: legal obligations (e.g. minimum landing sizes, species quota exhausted) or economic incentives (e.g.: low or no market value), fish is damaged or it is prohibited to catch those species (European Commission, 2023). Bycatch, which includes discards and incidental catch of vulnerable species, constitute a waste of natural resources; from an ecological perspective, it negatively impacts the marine ecosystem and causes changes in the overall structure of trophic webs and habitats, threatening the sustainability of current fisheries (FAO, 2019).

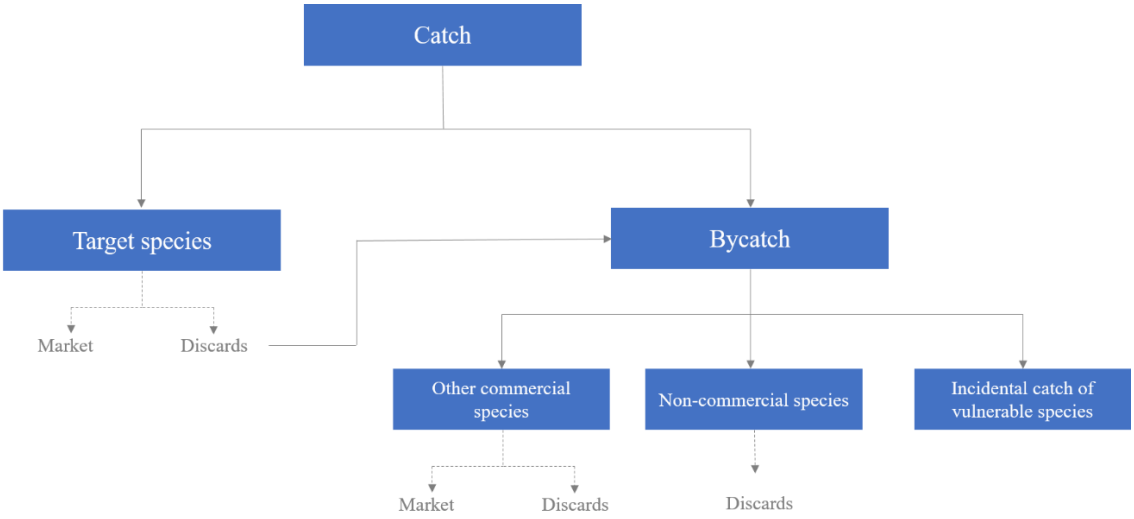


Figure 1. Different components of the catch as defined by the GFCM Data Collection Reference Framework (DCRF) (FAO, 2019)

From a managers' perspective, the problem is to meet simultaneously both socioeconomic and biological objectives and develop appropriate performance indicators to measure progress towards those objectives; from the fishermen's perspective, this involves additional work and expense (Damalas, 2015).

Studies on discards were scarce before the 2000s but much progress has been made in recent years after

- the establishment of the ecosystem approach to fisheries (EAF) as an integrated management approach that considers the entire ecosystem

- the implementation of the EU Data Collection Regulation and other, rather sporadic and fragmented national projects for non-EU countries (Tsagarakis et al., 2014).

European Union (EU) fisheries are responsible for fairly high levels of discards due to unselective fishing techniques, excessive fishing effort, and patchy species distribution (Damalas, 2015).

Why is discarding a problem?

Discarding of commercial and non-commercial species is a complex and multifaceted issue. Discards usually result in a reduction of harvesting opportunities and can have negative consequences on the stocks, ecosystems and the marine environment. They increase changes in food chain ecology by generating increased levels of food through dead fish or fish that may not survive after release, altering the relative prey-predator abundance and causing additional interactions between species (e.g. scavenging organisms on the sea floor and feeding populations of seabirds, marine mammals, sharks). Especially in deep-sea environments where food is scarce, the input of organic matter from discards increases the diversity of benthic communities in localized areas. In contrast, species with low discard mortality in areas with extensive fisheries may increase in abundance and alter ecosystem relationships (FAO, 2019).

2. MEDITERRANEAN FISHERY

Semi enclosed basins host a multitude of commercially important species, often landed together by multispecies fisheries that exploit a variety of benthic and pelagic fish, molluscs and crustacean stocks. The stocks are shared by neighbouring industrial, semi-industrial, and small-scale fisheries, and by different countries, setting the context for necessary cooperation on scientific-based management of common resources (FAO, 2022).

There are nearly 800 different species of fish in the Mediterranean (www.fishbase.com). About 74,200 fishing vessels operate in the Mediterranean. Of the total fleet, 82 % are small vessels, 8% bottom trawler, purse seiners and pelagic trawlers are represented both with 5%. Turkey, followed by Tunisia, Greece and Italy account for 59% of the total fishing fleet in terms of

number of vessels. In terms of production shares by fleet segment, purse seiners and pelagic trawlers landed 54% of the total regional catch, followed by trawlers (21%) and small vessels (15%) (FAO, 2022).

In general, the multispecies/multi-gear nature of the Mediterranean fisheries results in fisheries which are highly diversified both geographically and among the different fishing gears in terms of catches, target species, sorting practices, and discard composition. Diversity of marine environments, multi-gear specificity, multispecies fisheries and wide range of cultural characteristics can influence and distinguish discard patterns in the basins (Tsagarakis et al., 2014).

Discard ratios vary widely depending on the fishing method and geographical area (Figure 2). Trawlers show by far the highest discard ratios, ranging from 34 to 44 percent across the region. All other types of gear show much lower ratios, from small pelagic purse seines (< 6 percent) to demersal longlines (6–7 percent) and pelagic longlines (< 1 percent). Discard ratios in small-scale fisheries range from 3 to15 percent (FAO, 2022).

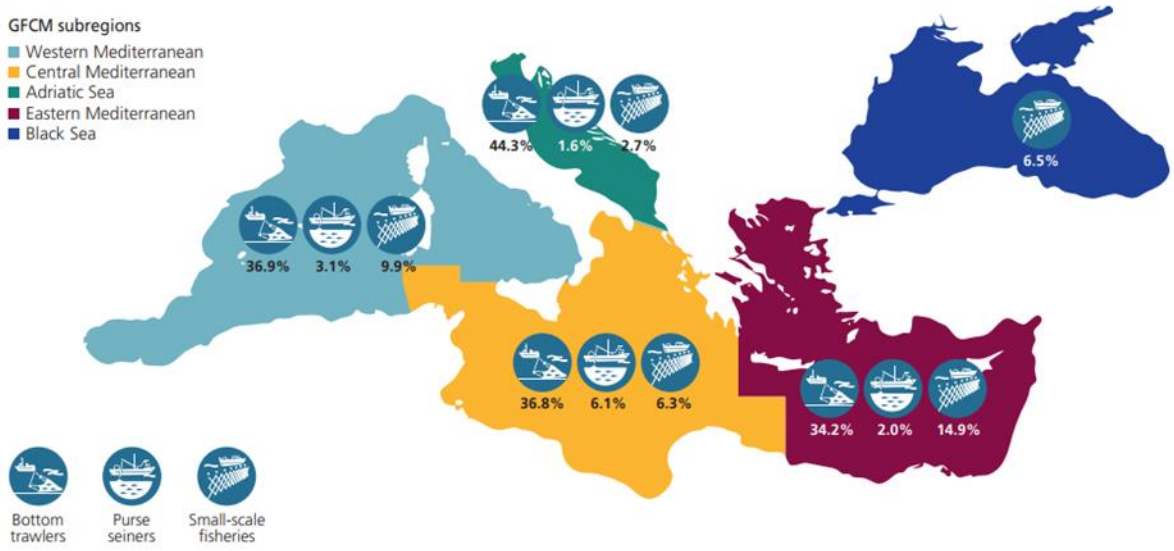


Figure 2. Discard ratios of bottom trawlers, purse seiners and small-scale fisheries by GFCM subregion (FAO, 2022)

The main reasons for discarding in the Mediterranean are economic and regulatory:

- absence of commercial value for some species (economic)
- low value of legally sized species which are discard to save space and ice for other more valuable species(economic)
- specimens not reaching minimum landing size (regulatory).

The European Commission (EC) has identified the 'discard problem' as a driver of poor economic performance and a significant component of marine ecosystem functioning (Commission's green paper on the reform of the CFP—COM 2009/163 final). Towards eradicating this problem, the reformed Common Fisheries Policy (CFP—EU regulation1380/2013) introduced the obligation to land all catches. This represents a fundamental shift in the management approach to EU fisheries, switching from landings monitoring to catches monitoring (Damalas, 2015).

3. DISCARD SPECIES IN MEDITERRANEAN FISHERIES

The landing obligation (LO), reform introduced by Common Fisheries Policy, objectives are to reduce the wasteful practice of discarding by inciting fishers to fish more selectively and avoid unwanted catches and, ultimately, avoiding resource waste. Thus, it requires a behavioural change from the industry towards more selective practices in order to be successful in reducing discards and unwanted catches. The landing obligation was introduced for all catches of species subject to catch limits and, in the Mediterranean, for catches of species subject to Minimum Conservation Reference Sizes (MCRS) (only bluefin tuna and swordfish are under Total Allowable Catches - TAC in this sea basin and are managed by the International Commission for the Conservation of Atlantic Tunas - ICCAT). It applies to all EU vessels fishing in Union waters and high seas. The LO came into force gradually, starting in 2015, with full implementation since January 2019.

Figure 3 shows the chronological sequence of the individual steps in the implementation of the LO and consequently in the delivery of Joint Recommendations and Discard Plans in the Mediterranean Sea (Spedicato et al., 2022).

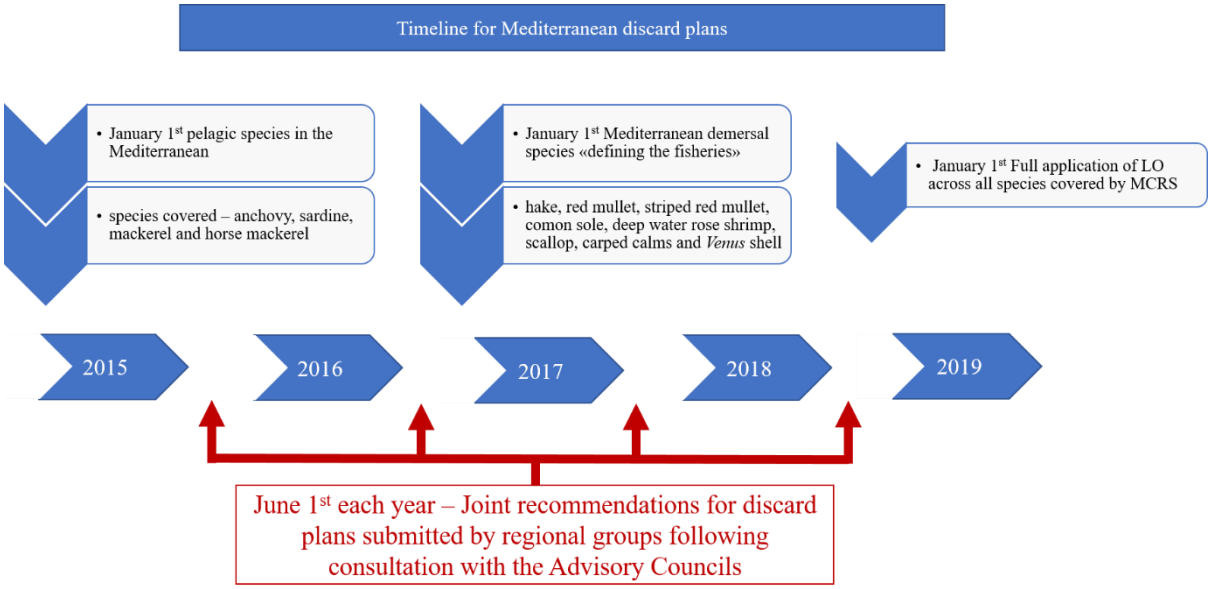


Figure 3. Timeline of the Landing Obligation implementation and Joint Recommendations for discard plans (Mediterranean) (Spedicato et al., 2022)

For stocks regulated through the control of fisheries output, i.e. total allowable catches (TAC), the discards sum to the marketable landings in the TAC. These conditions apply to many stocks in the northern EU seas where the LO results in a strong incentive to adopt technical solutions as well as to choose fishing grounds and seasons that allow reducing the catches of undersized specimens and other unwanted species. The rationale for introducing LO is less clear for areas where the management is mainly based on the fishing effort control rather than TAC, such as the EU Mediterranean Sea (Celić et al., 2018).

The case of the Mediterranean Sea is different because discards of regulated species are relatively low and the destination of catches of fish under the minimum conservation reference size (MCRS) is limited and exclude sale for human consumption. These differences explain that the implementation of LO in the Mediterranean has been done mainly using some flexibility instruments like the de minimis and high survival exemptions (Spedicato et al., 2022).

The LO for species with MCRS might have very critical effects such as:

- the impoverishment of the marine ecosystem due to further energy removal

- an impairment of food web dynamics induced by effects on scavengers' populations

- a further workload and infrastructure costs to fishermen

- an increase in the illegal market of undersized individuals (Sardà et al., 2015).

3.1. Bottom trawlers

As mentioned before trawlers show by far the highest discard ratios in the Mediterranean region. Trawl fishing in the Mediterranean is multi-species without clearly defined target species. Over 100 species are totally or partially discard and landings of some species (e.g., hake, *Merluccius merluccius* (Linnaeus, 1758)) often include undersized catch (i.e., smaller than the Minimum Conservation Reference Size) due to poor selectivity in the Mediterranean trawl fisheries and the existence of market demands for this part of the catch (Tsagarakis et al., 2018). The main commercial species targeted by bottom trawlers in the Mediterranean and Black Seas are listed in the Table 1 together with the data available on the discard rates for the main commercial species targeted by bottom trawlers in the Mediterranean (FAO, 2022).

Table 1. Discard ratios for main commercial species targeted by bottom trawlers by GFCM subregion (FAO, 2022)

Species	i (%)	ii (%)	iii (%)	iv (%)
Giant red shrimp (*Aristaeomorpha foliacea*)	0.03	0.20	-	-
Blue and red shrimp (*Aristeus antennatus*)	0.48	0.10	-	-
Aristeidae	-	-	-	0.80
Bogue (*Boops boops*)	83.27	36.45	86.77	47.35
European hake (*Merluccius merluccius*)	9.80	7.80	6.09	9.20
Red mullet (*Mullus barbatus*)	4.26	1.02	14.20	0.46
Surmullet (*Mullus surmuletus*)	6.81	0.83	13.67	0.21
Norway lobster (*Nephrops norvegicus*)	1.48	2.88	2.23	3.21
Common pandora (*Pagellus erythrinus*)	28.55	63.23	55.15	11.55
Deep-water rose shrimp (*Parapenaeus longilostris*)	4.79	9.50	8.61	7.38
Mediterranean horse mackerel (*Trachurus mediterraneus*)	54.65	93.90	67.23	-
Atlantic horse mackerel (*Trachurus trachurus*)	76.92	68.34	56.32	-
Jack and horse mackerels nei (*Trachurus* spp)	-	-	-	9.11

(i)Western Mediterranean; (ii) Central Mediterranean; (iii) Adriatic Sea; (iv) Eastern Mediterranean

For *Merluccius merliuccius*, *Nephrops norvegicus*, and *Parapenaeus longirostris*, discard ratio is less than 10%. For *Mullus barbatus* and *Mullus surmuletus*, the proportion of discards ranges from 4 to 14% in the western Mediterranean and Adriatic Sea, respectively. For *Pagellus erythrinus*, the proportion of discards varies widely, from 11.55% in the eastern Mediterranean to 63.23% in the central Mediterranean. Ancillary species such as *Boops boops*, *Trachurus* sp. and the small pelagic species *Engraulius encrasicolus* and *Sardina pilchardus* have very high discard rates, exceeding 40% in most records and reaching up to 94%. The three most common elasmobranchs in trawl fisheries, *Galeus melastomus*, *Scyliorhinus canicula*, and *Etmopterus spinax*, are discard over 70% (FAO, 2022).

3.2. Purse seine fisheries

In the purse seine fishery, *Engraulius encrasicolus*, *Sardina pilchardus*, and *Sardinella aurita* are the target species, and discards are very low at less than 6%, but also very high due to the large amount of pelagic fish caught by purse seiners. These are non-target species such as *Scomber* spp., *Trachurus* spp. and *Boops boops* that are undersized or have no economic value in a given time period (FAO, 2022)

3.3. Artisanal fisheries

In artisanal fisheries, discard rates are low, ranging from 2.7 to 14.9% of the total catch. It depends on many factors, such as the gear used and the market. Discard rates for pelagic trawlers range from 6 to 19%, for pelagic longliners from 0 to 1%, and for bottom longliners from 6 to 7% (FAO, 2022).

3.4. Characteristics of the main commercial fish species targeted by bottom trawlers by GFCM subregion

It was found that most discards occur in trawl catches and, at the same time, the species that are commercially exploited account for the largest proportion of total discards recorded. According to Table 1, these species are as follows:

Boops boops has a common length of about 20 cm and is found on the continental shelf with different types of bottoms or in the coastal pelagic (www.fishbase.org). It is an economically important fish that is intensively fished in the Mediterranean Sea (Katsanevakis et al., 2010;

Monteiro et al., 2006), and is often caught together with other pelagic species (Dahel et al., 2019). It is the most abundant species year-round in some local markets (El-Okda, 2008), but also has limited commercial value in some areas (Massaro, 2012).

Merluccius merliuccius is demersal fish with common length of 45 cm. Adults live near the bottom during the day, but move off the bottom at night. It is a highly commercialised species that is very vulnerable (www.fishbase.org).

Mullus barbatus occurs on the continental shelf on muddy, sandy, or gravelly soils, and its usual size is about 20 cm. It is of little to moderate fishery concern and has a medium price range (www.fishbase.org).

Mullus surmuletus occurs in the adult stage on rough grounds but also on soft bottoms. It's common lenght is 25 cm. This species has a very high price and is moderately fishery endangered (www.fishbase.org).

Pagellus erythrinus common lenght is about 25 cm, it is found in inshore waters, on a variety of bottoms and moves to deeper waters in winter. It is moderately vulnerable to fishing and has a medium price (www.fishbase.org).

Trachurus mediterraneus common lenght is about 30 cm, adults usually stay near the bottom, sometimes in surface waters, they are pelagic and migrate in large schools. They are moderately vulnerable to fishing and have a low price (www.fishbase.org).

Adult *Trachurus trachurus* forms large shoals in coastal areas with sandy substrate. Its usual length is about 22 cm. It has a medium price on the market and is highly vulnerable to fishing (www.fishbase.org).

There is only a few works with discard species lists, because there is no systematic monitoring, especially for species not covered by the Landing Obligations Directive, i.e., species not covered by the Minimum Conservation Reference Size. Table 2 shows the Minimum conservation reference size in the EU (MCRS, Annex IX, Part A to Regulation EC No. 2019/1241) and from the Turkish Fish Regulation (Anonymous, 2020).

Table 2. Minimum conservation reference sizes for EU (Anex IX Mediterranean Sea PART A) and from Turkish Fish Regulation (Anonymous, 2020)

MINIMUM CONSERVATION REFERENCE SIZES	
Species	Whole Area
Bass (*Dicentrarchus labrax*)	25 cm
Annular sea bream (*Diplodus annularis*)	12 cm
Sharpsnout sea-bream (*Diplodus puntazzo*)	18 cm
White sea-bream (*Diplodus sargus*)	23 cm
Two-banded sea-bream (*Diplodus vulgaris*)	18 cm
European anchovy (*Engraulis encrasicolus*)	9 cm (1)
Groupers (*Epinephelus* spp.)	45 cm
White grouper (*Epinephelus aeneus*)	50 cm*
Stripped sea-bream (*Lithognathus mormyrus*)	20 cm
Hake (*Merluccius merluccius*)	20 cm
Red mullets (*Mullus barbatus*)	11 cm; 13 cm*
Surmullet (*Mullus surmuletus*)	11 cm*
Spanish sea-bream (*Pagellus acarne*)	17 cm
Red sea-bream (*Pagellus bogaraveo*)	33 cm
Common Pandora (*Pagellus erythrinus*)	15 cm
Common sea bream (*Pagrus pagrus*)	18 cm
Wreckfish (*Polyprion americanus*)	45 cm
European sardine (*Sardina pilchardus*)	11 cm (2), (4)
Mackerel (*Scomber* spp.)	18 cm
Atlantic mackerel (*Scomber scombrus*)	20 cm*
Common sole (*Solea vulgaris*)	20 cm
Gilt-head sea-bream (*Sparus aurata*)	20 cm
Horse mackerel (*Trachurus mediterraneus*) (*Trachurus trachurus*)	15 cm; 13 cm*
Norway lobster (*Nephrops norvegicus*)	20 mm CL (3) 70 mm TL (3)
Lobster (*Homarus gammarus*)	105 mm CL (3) 300 mm TL (3)
Crawfish (Palinuridae)	90 mm CL (3)
Deep water rose shrimp (*Parapenaeus longirostris*)	20 mm CL (3)
Scallop (*Pecten jacobeus*)	10 cm
Carpet Clams (*Venerupis* spp.)	25 mm
Venus shells (*Venus* spp.)	25 mm; 30 mm*

(*) MCRS from the Turkish Fish Regulation
(1) Member States may convert the minimum conservation reference size into 110 specimens per kg.
(2) Member States may convert the minimum conservation reference size into 55 specimens per kg.
(3) CL — carapace length; TL — total length.
(4) This minimum conservation reference size shall not apply to fries of sardine landed for human consumption if caught by boat seines or shore seines and authorised in accordance with national provisions established in a management plan as referred to in Article 19 of Regulation (EC) No 1967/2006, provided that the stock of sardine concerned is within safe biological limits

Discard fish depend on the fishing fleet and fishing methods, but even within the same fishing fleet there are large differences in discard fish depending on the target species or season (Oro & Ruiz, 1997).

In trawl fisheries in Turkish waters, there are examples that the highest discard biomass consists of chondrichthyes species that feed on carcasses as a result of intensive fishing activity, such as *Glaucostegus cemiculus, Mustelus mustelus, Dasyatis pastinaca, Gymnura altavela*. A high percentage of the landed discard biomass is also accounted for by Red Sea immigrants such as *Saurida lessepsianus* and *Nemipterus randalli*. *Equulites klunzingeri* and *Champsodon nudivittis* were also detected in large numbers (Daylan, 2020). According to fishermen, the most frequently discard fish species in the cuttlefish trammel net fishery conducted in Mallorca from January to July were *Torpedo marmorata, Scorpaena porcus, Dasyatis pastinaca* and *Dactylopterus volitans* (Gil et. al., 2018). Discard from deep-water bottom trawling in the eastern-central Mediterranean Sea was mainly represented by *Coelorinchus caelorhincus, Hymenocephalus italicus, Nezumia sclerorhynchus, Hoplostethus mediterraneus, Chlorophthalmus agassizi* and *Galeus melastomus* (D'Onghia et al., 2003).

As an example of the large differences in discard fish species, two different surveys are compared, one from Iskenderun Bay, Turkey, conducted with a trawler, and the other from Mallorca, Spain, conducted with a trammel net (Table 3). There is wide variation in the species of fish discard, and in addition, many of the species are not covered by the Landing Obligations Directive, so the actual situation regarding discards is poorly known.

Table 3. Comparison of the discard fish species from two Mediterranean area (Gi let al., 2018; Dalyan, 2020)

Species	İskenderun Bay (Northeastern Levantine Sea) (Dalyan, 2020)	Mediterranean Sea (Spain) (Gil et al., 2018)
Apterichtus caecus	+	
Arnoglossus grohmanni	+	
Arnoglossus thori	+	
Auxis rochei		+
Blennius ocellaris	+	
Bregmaceros nectabanus	+	
Cepola macrophthalma	+	
Champsodon nudivittis	+	
Citharus linguatula	+	
Cynoglossus sinusarabici	+	
Dactylopterus volitans		+
Dasyatis marmorata	+	
Dasyatis pastinaca	+	+
Deltentosteus collonianus	+	
Deltentosteus quadrimaculatus	+	

Echelus myrus	+	
Echeneis naucrates	+	
Engraulis encrasicolus	+	
Equulites klunzingeri	+	
Glaucostegus cemiculus	+	
Gobius niger	+	
Gobius paganellus	+	
Jaydia queketti	+	
Jaydia smithi	+	
Labrus viridis		+
Lagocephalus guentheri	+	
Lagocephalus suezensis	+	
Lepidotrigla cavillone	+	
Lepidotrigla dieuzeidei	+	
Leucoraja naevus		+
Mustelus mustelus	+	
Ostorhinchus fasciatus	+	
Oxyurichthys petersii	+	
Raja clavata		+
Raja miraletus	+	
Scorpaena porcus		+
Scyliorhinus canicula		+
Serranus hepatus	+	
Solea sp		+
Spicara smaris	+	
Synodus saurus		+
Torpedo marmorata		+
Torquigener flavimaculosus	+	
Trachinus draco	+	
Zeus faber	+	

4. METHODS TO REDUCE DISCARDS

Good fisheries management focusing on reducing discards requires an understanding of how fisheries work, and the awareness of fisherman's ability to reduce discards through improved gear selectivity. In addition, fishermen's tactical decisions about "where, when and how to fish" can play a key role in reducing discards.

The most important direct restrictions are:

1. Fishing gear restrictions

- Minimum (and sometimes maximum) mesh sizes
- Bans on the use of certain types of fishing gear, sometimes only in certain areas and at certain times
- The requirement to equip fishing gear in certain fisheries (shrimp) with fish selectors

2. Time-area-gear closures

- Sometimes they only apply to certain fishing gears
- Long term area closures (lasting years)
- Short term area closures (e.g. seasonal)
- Temporary area closures (These are imposed immediately based on observed small fish catches. They are valid for only one week at a time and usually cover small areas, often only a few km^2)

3. Bans on landing undersized fish

- Minimum landing sizes have been established for many species. This is to reduce the catch of small fish, but of course leads to more discards.

4. Discard bans ⇨ Landing Obligations

- Discard bans for certain species have been in place for some time

*Arnaso, 2014

1. *Fishing gear restrictions*

Fishing gear is not perfectly selective; it generally catches a wider range of species and sizes than intended. There are many factors that affect the efficiency of gillnets and trammel nets. These include the hanging ratio, the type and thickness of twine, mesh size, time of day, and lunar effect. Selective gear fishing has long been used as a management measure to promote the sustainable exploitation of commercial fisheries. In the European Union and many other jurisdictions, there are measures based on the technical specifications of the fishing gear used. For example, minimum mesh size, maximum twine thickness, and the use of devices such as square mesh panels and sorting grids in demersal trawl fisheries; beam size and number of dredges in beam trawl and dredge fisheries; net height, length, and hanging ratio in gillnet

fisheries; hook size, shape and type of bait in longline fisheries; and escape gap size and number of traps in creel and pot fisheries are prescribed (Ulhman et al., 2019).

These technical conservation measures with fishing gear were usually concerned with selectivity or catching a single species or a small number of species. This was usually the main target species, but in some cases, it was a protected species or a marine bird or mammal. With the introduction of the EU Landing Obligation (LO), the selectivity of a fishing gear must be considered in relation to all species in the catch to which the LO applies. Developing a suite of fishing gears to meet the unique challenges of the LO will require input from fishermen, net and gear manufacturers, gear technologists, and fish behaviourists.

As an example, we can take the selectivity of bottom trawling, which is often accused of having low selectivity and being primarily the main source of discards. Discards in the Mediterranean trawl fishery are the result of the low selectivity of the gear, fishing practices, but also the interest of the market in the bycatch. Depending on the season or the fishing area, a sudden contribution to the catch of excessive quantities of low-value species can lead to large quantities of discards. Because of the great diversity of species in coastal waters and on the continental shelf, discards may be of particular importance to coastal trawl fisheries. The development of deep-sea fisheries for deep-sea shellfish (red shrimp, Norway lobster) has also resulted in high levels of discard, affecting both non-commercial species and juveniles of commercial species. The survival of discard species may also be in question, and although a large proportion of discard crustaceans may survive.

Technical solutions (Sacchi, 2008):

(i) • Increase mesh size in the codend

(ii) • Square mesh codend

(iii) • Bycatch Reduction Devices (BRDs)

(iiii) • Separator panel

(i) Increase mesh size in the codend

This is the simplest way to improve trawl selectivity. For example, to better protect the hake stock, the mesh size should be above 40 mm and be about 60 mm to reach the 25 cm of the first maturity length of this species. The adoption of larger mesh sizes by fishermen is difficult to achieve when trawlers use the same gear to fish both for deepwater shrimp beyond 400 m depth and for hake on the edge of the continental shelf and sometimes for red mullet in very shallow waters.

In the context of multispecies fisheries, where several species are caught at the same time, it is difficult to rely on mesh size alone because nets pick up large and small species without distinction. On the other hand, the traditional hanging of the panels of a trawl net results in the meshes having a diamond shape, which tends to close when trawling. This reduction in codend mesh size, which may increase with trawling speed and catch weight, consequently limits the escape of fish that may suffer major injuries leading to death.

However, in the context of multispecies fisheries, where several species are caught at the same time, it is difficult to rely on mesh size alone because large and small species are not equally captured in the nets. Thus, a trade-off must be made between gear type, selectivity gain, and catch loss (Fiorentino and Ragonese, 2000).

(ii) Square mesh codend

This selectivity system consists of hanging a net panel along its mesh line in order to transform the diamond shape of the net into a square shape and keep it constantly open. Considering the results of the various studies carried out in the Mediterranean Sea, the use of a codend with square meshes of 40 mm provides undeniable advantages for most Mediterranean species and the ecosystem, since it does not retain smaller fish than an ordinary codend with diamond meshes of the same size.

These studies also indicate that immediately after implementation, the yield- per recruit (Y/R) of hake, one of the main species affected, would decrease by up to 20%, but that within five years, Y/R of this species would increase by more than 50%. Considering the overall positive aspects of the square mesh codend, the European Council, in its Regulation concerning

measures for the sustainable management of fishery resources in the Mediterranean Sea, decided to adopt it as the main technical solution to improve the selectivity of bottom trawls.

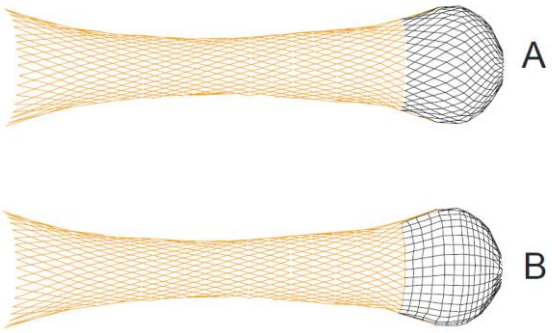


Figure 3. Traditional diamond mesh codend (A) and square mesh codend (B) (from Sacchi, 2008)

(iii) Bycatch Reduction Devices (BRDs)

BRDs are another interesting way to release live bycatch as well as small fish and large protected specimens. They restrict the passage of unwanted bycatch and direct it out through some type of escape hole or exit. They are typically placed behind the codend and consist of a sorting grid that physically diverts bycatch to an escape trap attached to either the top or bottom of the trawl, depending on the behaviour of the species being released and the fishing conditions.

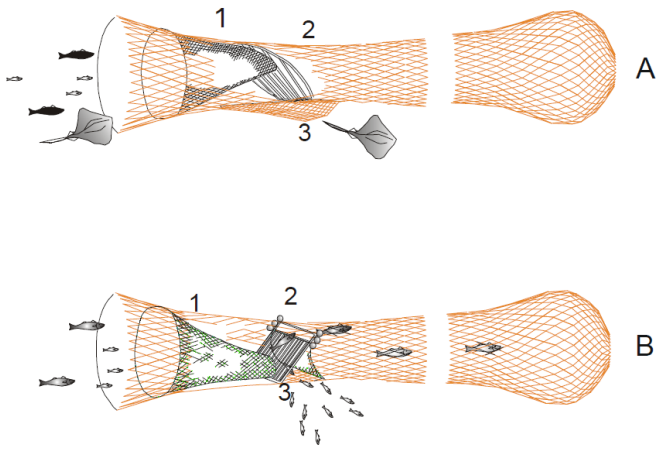


Figure 4. BRDs “Super shooter” for the escape of large specimens such as ray and turtles (A) and “Dejupa” for the escape of juveniles (B); funnel (1), sortin grid (2), escape panel (3) (from Sacchi, 2008)

(iv) Separator panel

This is another selectivity system based on behavioural differences between species. The typical design is found in many shrimp fisheries and consists of a single panel deployed horizontally by dividing all or part of the trawl into two levels. The selectivity process is completed by the use of meshes in the upper part of the net, large enough to allow the escape of juvenile fish. However, the placement and position of this net is critical to the efficiency of this system.

Although these selectivity devices clearly provide long-term economic value to fisheries, fishermen may be reluctant to adopt such devices, claiming that such devices result in a loss of commercial species and income, particularly in shallow waters and some areas of the continental shelf.

2. *Time-area-gear closures*

These are management solutions aimed at protecting juveniles, breeders of commercial or protected species when they are particularly numerous and endangered. The goal is to ban the most aggressive fishing gear from sensitive areas for a limited period of time. The advantage of these attractive management measures is that they are very flexible and do not prevent fishing activity, but they also have some disadvantages, such as the increase in fishing effort in neighbouring areas and the difficulty of implementing effective control (Sacchi, 2008).

Spatial closures are a proven fisheries management tool worldwide. In the past, areas have been permanently closed to fishing, for example, through the establishment of marine protected areas. Such closures are often criticised by fishermen as inappropriate, disproportionate, and

unproven. Seasonal closures are also established by fisheries managers to protect temporary features such as spawning aggregations from targeted exploitation. Spatial closures are applied in coastal regions of the Mediterranean Sea under local marine protected area (MPA) management plans for coastal (artisanal) fisheries. Certain habitats are also protected from trawl gear (Fishing Marine Reserves) to protect both sensitive and essential fish habitats, with particular attention to juveniles of important commercial demersal species. Fishing with trawls, dredges, purse seines, boat seines, beach seines, or similar nets over seagrass beds, especially *Posidonia oceanica* or other marine phanerogams, and over coral-like habitats and shellfish beds is prohibited. However, for this measure to be adequately enacted, these habitats must be mapped in the shelf and slope zones (through seabed habitat mapping projects). For deep-sea species, fishing regulations prohibit fishing at depths less than 1,000 metres. In addition, trawling may not occur within 3 miles of shore or in areas where the seabed is less than 50 m deep (Sacchi, 2008; Bailey et al., 2010).

Temporary closures have typically been implemented in several countries during a specific period of the year (e.g., during the recruitment or spawning season in spring or fall) as part of local management plans. In practise, a reduction in the number of hours per day was also introduced, requiring vessels to return to port earlier to rest in port during the night (Bailey et al., 2010). Temporary closures of fishing areas require the complete cessation of trawling for a variable period of time and can result in up to a 20% reduction in annual fishing effort (Demestre et al., 2008).

Seasonal closures are generally imposed with the goal of protecting groundfish stocks during the most vulnerable phase of their life cycle, recruitment. The duration and seasonality of these closures varies from country to country and port to port, ranging from 30 days to 5 months. Research suggests that closing areas to trawling could have negative impacts on benthic communities if it promotes a shift in trawling effort to other, previously less exploited areas. In theory, the closure of trawl fishing areas in the Mediterranean consists of the complete cessation of fleet activity without a shift of fishing effort to other areas (Demestre et al., 2008).

3. *Bans on landing undersized fish*

This was the first management measure to reduce the selectivity problem, mainly related to the marketing of juvenile fish. Measures should be adapted to new situations in the fishery and to the status of fish populations in order to protect species that are in poor condition or endangered. *For example*, since the first age of maturity for hake is 25 cm, the European Council Regulation proposes a gradual increase in the minimum landing size for hake, from 15 cm to 20 cm. On the other hand, the minimum landing size for black sea bream has been increased from 25 to 33 cm due to its hermaphroditism, in order to ensure a balance between the two sexes. “Total discards" refers to total volume discard, considering both commercial and noncommercial species as well as undersized discards. Total discards in the Mediterranean are at 18.6% of the total catch. Undersized discards depend on the strength of recruitment and area. Very low discard rates are noted in some zones, while the opposite is true in other areas and are generally associated with high densities of juveniles (Bellido Millán et al., 2014).

4. *Discard bans ⇨ Landing Obligations*

The landings obligation (or 'discard ban') included in the new EU Common Fisheries Policy prohibits the discarding of species subject to catch limits and those subject to minimum size limits in the Mediterranean Sea. The landing obligation was introduced in 2015 and has been fully in force since January 2019. Its goal is to eliminate discards by encouraging fishers to fish more selectively and to avoid unwanted catches. The discard ban and landing obligation should be accompanied by other measures to ensure their successful implementation. Some of these measures include better control of fishing effort, better selectivity of fishing, spatio-temporal catch limits for sensitive sizes and/or areas, effective enforcement, and finally an agreement by the fishing industry to comply with the rules and regulations (Bellido Millán et al., 2014).

Rules related to the landing obligation stipulate that:

- all catches of species regulated through catch limits (such as mackerel) or minimum size (such as anchovy in the Mediterranean) should be landed and counted against the fishers’ quotas

- undersized fish caught and landed should not be used (sold) for direct human consumption, but for products such as pet food, fish meal, pharmaceuticals, and food supplements

- producer organisations have a duty to help their members find adequate outlets for undersized catches, without promoting the creation of a market for them

- EU countries also have the obligation to assist fishers by facilitating the storage of undersize fish and finding possible outlets.

Intense collaboration and exchanges between EU countries, fishers, NGOs, scientists, the European Parliament, the European Fisheries Control Agency (EFCA) and the Commission, have helped to reach a better understanding and, in some cases, a common understanding of the challenges and solutions related to the landing obligation (European Commission).

4.1. Discard management plans for Mediterranean fisheries

Discards in the region are estimated at around 230,000 t or 18.6% (13.3–26.8%) of the catch (Tsagarakis et al., 2014). However, studies on discards cover only a small proportion of the total fishing activity in the Mediterranean Sea, indicating a shortage of information. Significant part of the catch (small/immature/juvenile individuals) that should have been discard may reach the market if there is sufficient economic incentive for a 'bonus' source of income; a black market has been in place for long. At some point, both managers and scientists will have to admit that the true level of catches (landings and discards) for EU Mediterranean fisheries is currently unknown. Regulation (EC) No. 1224/2009 requires that "Masters of Community fishing vessels shall also record in their fishing logbook all estimated discards above 50 kg of live-weight equivalent in volume for any species". A typical Mediterranean vessel (>80% less than 12 m of length—classified under small scale coastal fisheries) will rarely make a daily catch of 50 kg per species (Dalamas, 2015).

STECF (2013) identified that EU logbook records reported a minor 0.06% of the actual amount estimated from scientific observer trips. Furthermore, the General Fisheries Commission for the Mediterranean reviewing the status of logbook data collection in Mediterranean EU countries (GFCM, 2009) concluded that information in the logbooks suffers from falsification, misreporting, incompleteness and ineligibility.

For the above reasons, it is essential to establish and implement a comprehensive monitoring and control system to ensure compliance and the collection of adequate data for scientific and management information needs. The first ever agreed common recommendations for discard

management plans were submitted by EU Member States for revision in early 2014 (STECF, 2014).

- Regional discard management plan should be structured in a way to address the following topics:

Define fisheries, management units and timelines for implementation

Justify exemptions on the basis of high survivability

- species demonstrating high survival rates

Include provisions for the de minimis exemptions

Selectivity very difficult to achieve

- interpreted as a technical restriction where gears cannot be improved to become more selective

Disproportionate costs of handling unwanted catches

- increased crew costs due to sorting

Include provisions on documentation of catches

Fix minimum conservation reference sizes

- introduction of other more appropriate measures than the commonly applied Minimum Landing Size, e.g. size at maturity

*Arnaso, 2014

- Volume of illegal discarding out of a given volume of catch can be reduced by:

Increasing the landed price of fish that would otherwise be discarded

Reducing landing costs of fish that would otherwise be discarded

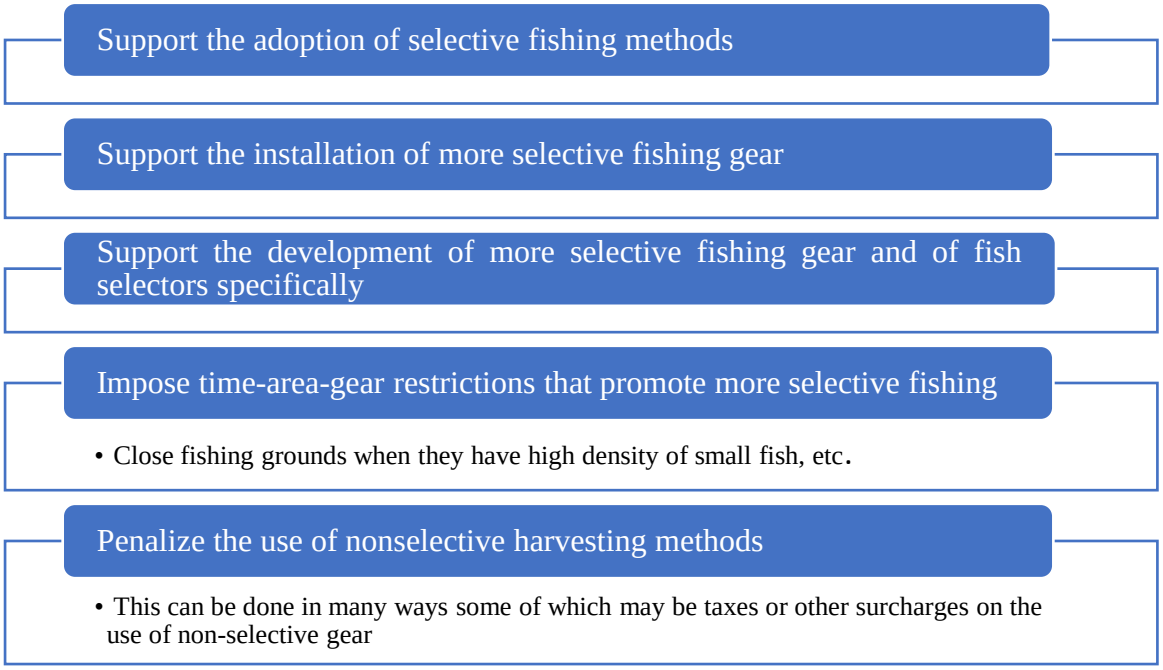
Reducing on-board processing and handling costs

Increasing the costs of discarding, e.g. by increasing the expected penalty of discarding

- Increased enforcement effort (monitoring etc)
- Increased penalties for discarding violations
- Less legal requirements for establishing that discarding violations occurred.
- Increasing the social stigma for discarding

*Arnaso, 2014

- Encouraging harvesting selectivity:



*Arnaso, 2014

4.2. Example of good practises

In many countries, policies regarding reduction of unwanted catch and discards are crafted in response to concerns regarding accountability, conservation, and waste as well as scientific needs to fully account for all sources of fishing mortality.

Many people think of the production of pet food, cosmetics, food supplements and even medicines when it comes to possible products from unwanted catches. And indeed, there are possibilities for such products, but they depend on the landed catch being of the highest quality and the fish being processed on land. The raw materials used for such products are generally certain parts of the fish and not the whole fish. For such products, it is therefore only necessary to ensure on board that the entire catch is properly handled, i.e. bled, cleaned, cooled, sorted and stored. This is already the case in countries that have long had discard bans, such as Iceland and Norway (Uhlmann et al., 2019).

Iceland

In 1977, a ban on discarding six commercial species was introduced in Icelandic fisheries (European Commission 2007). The requirements evolved as management strategies moved from effort to quota restrictions. The ban was gradually extended to all species, including those with no market value. Catches that slightly exceed quotas can be landed legally, as the law allows 5% of the quota to be carried over from one year to the next. Fishermen are also allowed to land up to 5% of the catch without this being deducted from the quota, but then have to forfeit most of the value of the excess catch. Fishermen are also allowed to land catches below the minimum size, with only 50% of the weight of this part of the catch deducted from their quotas (Table 4). This creates an incentive to land undersized catches. Larger overruns and non-target catches can be covered by purchasing or leasing additional quota. If excess catches are not covered by permitted overages or purchased quotas, this can lead to fines and/or withdrawal of licences (Uhlmann et al., 2019).

Table 4. Minimum conservation reference sizes for Iceland (www.reglugerd.is)

Species	**Benchmark**
cod (*Gadus morhua*)	50% under 55 cm
haddock (*Melanogrammus aeglefinus*)	50% under 45 cm
coalfish (*Pollachius virens*)	50% under 55 cm
Greenland halibut (*Reinhardtius hippoglossoides*)	25% under 50 cm
redfish (*Sebastes norvegicus*)	20% under 33 cm
cusk (*Brosme brosme*)	25% under 55 cm
plaice (*Pleuronectes platessa*)	20% under 30 cm
common dab (*Limanda limanda*)	20% under 25 cm
herring (*Clupea harengus*)	25% under 27 cm
capelin (*Mallotus villosus*)	20% under 14 cm
blue whiting (*Micromesistius poutassou*)	50% under 23 cm
deep water prawn (*Pandalus borealis*)	30% under 13 mm carapace width (in fjords and around Eldey island) 30% under 15 mm carapace width (the far ocean)
European lobster (*Nephrops norvegicus*)	30% under 35 mm carapace width
Atlantic mackrele (*Scomber scombrus*)	25% under 24 cm

The capture of juvenile fish is prevented by real-time closed areas, regulations, and spawning closures in fishing areas, and there are also rules for gear equipment (www.reglugerd.is).

Improved selectivity is important to reduce discards in Iceland. Improved selectivity is primarily due to advances in gear technology, regulations on selectivity devices and the widespread use of voluntary fish entrainment solutions based on real-time information shared by fishermen.

Key features to the success of the discard ban include:

(i) • Improved selectivity

(ii) • Real-time closures

(iii) • Monitoring, Control and Surveillance (MCS) mechanisms that include discard monitoring (although of limited in scope))

(iv) • Regulatory incentives to land undersized catch with partial or zero deduction from quota

(v) • Voluntary move-on measures are used to collect and share information on where and when to avoid unwanted catch

Fish are monitored throughout the whole supply chain. Data from electronic logbooks, official weighings on port scales, purchase receipts/receipts from fish auctions, re-weighing by processors, processing agreements/production reports and sales/export reports are passed on to the Directorate of Fisheries, which can then monitor the consistency of the mass balance. Similar arrangements exist in Norway, where electronic data exchange and transparency are already well advanced. This type of monitoring is efficient in combination with other MCS tools and gives the authorities an indication of where they need to focus their attention in particular (Uhlmann et al., 2019).

Norway

Norwegian fisheries are managed through a complex system of regulations that aim to control both inputs (i.e. fishing licences) and outputs (i.e. quotas) as well as exploitation patterns through a multi-layered collection of regulations and technical measures known as the "Discard Ban Package'. This is an integrated package of regulatory and technical measures to minimise unwanted catches, including: the legal discard ban, technical selectivity measures for fishing gear, closed areas, and monitoring and control measures.

Key features of the discard ban package include:

(i) • Improved selectivity

(ii) • Real-time closures

(iii) • Monitoring

(iv) • Decriminalisation

(v) • Pragmatic application of regulations

(vi) • Improved dialogue – between management, fishers and scientists.

About 90 % of Norwegian small-scale fisheries are regulated by quotas, the rest by other regulations such as minimum/maximum legal landing size (Table 5), open/closed areas or seasons, by-catch and discard bans, etc. by Norwegian authorities (Nedreaas et al., 2022).

Table 5. Minimum landing sizes for Norway (https://lovdata.no/dokument/SFO/forskrift/1989-10-10-1095)

Species	**MLS (cm)**
Atlantic halibut (*Hippoglossus hippoglossus*)	60
Atlantic cod (*Gadus morhua*)*	47/30
Haddock (*Melanogrammus aeglefinus*)*	44/27
European hake (*Merluccius merluccius*)	30
European plaice (*Pleuronectes platessa*)*	29/27
Witch flounder (*Glyptoceophalus cynoglossus*)	28
Common dab (*Limanda limanda*)	23
Lemon sole (*Microstomus kitt*)	25
Common sole (*Solea solea*)	24
Turbot (*Scophthalmus maximus*)	30
Brill (*Scophthalmus rhombus)*	30
Megrim (*Lepidorhombus whiffiagonis)*	25
Whiting (*Merlangius merlangus)*	23
European flounder (*Platichthys flesus)*	20
European eel (*Anguilla anguilla*)*	40/37
Saithe (*Pollachius virens*)*	42/40/35
Picked dogfish (*Squalus acanthias)*	70
Atlantic mackerel (*Scomber scombrus*)	30

Atlantic herring (*Clupea harengus*)*	18/20/25/23
Capelin (*Mallotus villosus*)*	11/12
Greenland halibut (*Reinhardtius hippoglossoides*)	45
European angler/monkfish (*Lophius piscatorius*)	60
Atlantic redfish (*Sebastes marinus*)	32

*different MLS depending on the area of fishery

In Norway, it is legal to release viable UWC from purse seiners, but vessels have individual transferable quotas (ITQs) to reduce regulatory pressure for discards. In addition, all sales of pelagic fish are controlled by a single authority ("Norges Sildesalgslag"), so landings (including bycatch) by individual vessels are closely monitored and controlled (Uhlmann et al., 2019).

LITERATURE

Anonymous, 2020. Notification 5/1 the commercial fish catching regulations in 2020–2024 fishing period

Arnaso, R. 2014. Best Practice in the Use of Right-based Management to Reduce Discards in Mixed Fisheries. European Parliament, Brussels. 42 pp. URL: https://www.europarl.europa.eu

Bailey, N., Campbell, N., Holmes, S., Needle, C., Wright, P. 2010. Real time closures of fisheries. European Parliament, Brussels. 50 pp. URL: https://www.europarl.europa.eu

Bellido Millán, J. M., Carbonell Quetglas, A., Garcia Rodriguez, M., Garcia Jimenez, T., González Aguilar, M. 2014. The obligation to land all catches – consequences for the Mediterranean. European Parliament, Brussels. 52 pp. URL: https://www.europarl.europa.eu

Celić, I., Libralato, S., Scarcella, G., Raicevich, S., Marčeta, B., Solidoro, C. 2018. Ecological and economic effects of the landing obligation evaluated using a quantitative ecosystem approach: a Mediterranean case study. ICES Journal of Marine Science, 75(6): 1992–2003. doi:10.1093/icesjms/fsy069

Dahel, A., Rachedi, M., Tahri, M., Benchikh, N., Djebar, A. B. 2019. Fisheries status of the bogue *Boops boops* (Linnaeus, 1758) in Algerian East Coast (Western Mediterranean Sea). Egypt. J. Aquat. Biol. Fish. 23: 577-589.

Dalyan, C. 2020. The Commercial and Discard Catch Rates of the Trawl Fishery in the İskenderun Bay (Northeastern Levantine Sea). Trakya. Univ. J. Nat. Sci. 21(2): 123-129.

Damalas, D. 2015. Mission impossible: Discard management plans for the EU Mediterranean fisheries under the reformed Common Fisheries Policy. Fisheries Research 165: 96-99.

Demestre, M., de Juan, S., Sartor, P., Ligas, A. 2008. Seasonal closures as a measure of trawling effort control in two Mediterranean trawling grounds: Effects on epibenthic communities. Marine Pollution Bulletin, 56: 1765-1773

D'Onghia, G., Carlucci, R., Maiorano, P., and Panza, M. 2003. Discards from deep-water bottom trawling in the eastern-central Mediterranean Sea and effects of mesh size changes. Journal of Northwest Atlantic Fishery Science, 31: 245–261.

El-Okda, 2008. Age and growth of *Boops boops* (L.) from Egyptian Mediterranean waters of Alexandria. Egypt. J. Aquat. Biol. & Fish. Vol. 12 (1): 13-23.

European Commission. Sustainable fisheries. Discarding in fisheries. https://oceans-and-fisheries.ec.europa.eu/fisheries/rules/discarding-fisheries_en - access 2023

FAO. 2019. Monitoring discards in Mediterranean and Black Sea fisheries. Methodology for data collection. FAO Fisheries and Aquaculture Technical Paper No. 639. Rome.

FAO. 2022. The State of Mediterranean and Black Sea Fisheries 2022. General Fisheries Commission for the Mediterranean. Rome. https://doi.org/10.4060/cc3370en

Fiorentino, F., Ragonese, S. 2000. Trawl selectivity in main target species of Mediterranean on the basis experiences reported in literature. SAC-GFCM sub-committee on stock assessment, Madrid (Spain), 26-28 April 2000.

GFCM, 2009. Report of Workshop on the GFCM Regional Logbook for the Mediterranean and Black Sea GFCM, Rome, Italy (2009)

Gil, M.M., Catanese, G., Palmer, M., Hinz, H., Pastor, E., Mira, A., Grau, A., Koleva, E., Grau, A.M., Morales-Nin, B. 2018. Commercial catches and discards of a Mediterranean small-scale cuttlefish fishery: implications of the new EU discard policy. Sci. Mar. 82S1: 155-164.

Katsanevakis, S., Maravelias, C., Vassilopoulou, V., 2010. Otter trawls in Greece: Landing profiles and potential metiers in Greek set longliners. ICES Journal of Marine Science, 67: 646-656.

Massaro, A. 2012. Reproductive Biology of *Boops Boops* (Linnaeus, 1758) off Gran Canaria (Canary Islands): A Preliminary Study", Ph.D. in Sustainable Management of Fisheries Resources.

Monteiro, P., Bentes, L., Coelho, R., Correia, C., Goncalves, J.M.S., Lino, P.G., Ribeiro, J., Erzini, K. 2006. Age and growth, mortality, reproduction and relative yield per recruit of the bogue, *Boops boops* Linne, 1758 (Sparidae), from the Algarve (south of Portugal) longline fishery. Journal of Applied Ichthyology, 22 (5): 345-352.

Nedreaas, K., Kuhnle, G.A., Iversen, S.A., Kjellevold, M. 2022. The Norwegian small scale fishery and data provided for the IHH FAO-Duke-WorldFish project. Rapport fra havforskningen 2022-18 ISSN: 1893-4536

Oro, D., Ruiz, X. 1997. Exploitation of trawler discards by breeding seabirds in the north-western Mediterranean: differences between the Ebro Delta and the Balearic Islands areas. ICES Journal of Marine Science, 54: 695–707.

Sacchi J. 2008. The use of trawling nets in the Mediterranean. Problems and selectivity options. In: Basurco B. (ed.). The Mediterranean fisheries sector. A reference publication for the VII meeting of Ministers of agriculture and fisheries of CIHEAM member countries (Zaragoza, Spain, 4 February 2008). Zaragoza: CIHEAM / FAO / GFCM, 2008. p. 87-96. Options Méditerranéennes: Série B. Etudes et Recherches; n. 62

Sardà, F., Coll, M., Heymans, J. J., and Stergiou, K. I. 2015. Overlooked impacts and challenges of the new European discard ban. Fish and Fisheries, 16: 175–180.

Spedicato, M.T., Lizaso, J.L.S., Tsagarakis, K. et al., 2022. Synthesis of the Landing Obligation Measures and Discard Rates for the Mediterranean and the Black Sea. Final Report. European Climate, Infrastructure and Environment Executive Agency. 73 pp. ISBN 978-92-95225-55-8 | Doi: 10.2926/237700 | HZ-07-22-550-EN-N

STECF, 2013. Scientific, Technical and Economic Committee for Fisheries (STECF) Landing Obligation in EU Fisheries (STECF-13-23) Publications Office of the European Union, Luxembourg (2013) (EUR 26330 EN, JRC 86112, 115pp.)

STECF, 2014c. Scientific, Technical and Economic Committee for Fisheries (STECF) 46th Plenary Meeting Report (PLEN-14-02). 2014 EUR—Scientific and Technical Research Series—1831-9424 (online), Publications Office of the European Union, Luxembourg (2014) (1018-5593 (print), 115pp.)

Tsagarakis, K., Nikolioudakis, N., Papandroulakis, N., Vassilopoulou, V., Machias, A. 2018. Preliminary assessment of discards survival in a multi-species Mediterranean bottom trawl fishery. Journal of Applied Ichthyology, 34: 791-1096. DOI: 10.1111/jai.13691

Tsagarakis, K., Palialexis A., Vassilopoulou V. 2014. Mediterranean fishery discards: review of the existing knowledge. Journal of Marine Science, 71(5): 1219–1234. doi:10.1093/icesjms/fst074

Uhlmann, S.S., Ulrich, C., Kennelly, S.J. 2019. The European Landing Obligation: Reducing Discards in Complex, Multi-Species and Multi-Jurisdictional Fisheries. Springer Open pp. 431