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Mediterranean Fisheries. Stocks, Assessments and Exploitation Status

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The state of Mediterranean fisheries follows the same trends and faces similar problems as most of the world's fisheries, i.e., a generalised overexploitation and broad habitat degradation (Clover 2005, Roberts 2007, Cury 2008). Moreover, Mediterranean fisheries are particularly complex due to the high diversity of cases and the many countries of very different cultures involved. Oliver (2002) estimated the number of boats at around 100,000 and fishermen at around 300,000; Farrugio (2013) gives the figure of 250,000 fishermen, including the Black Sea, for 2008. Fisheries are also diverse, constituted by multispecies resources caught using different fishing gears. Furthermore, their long history makes it very difficult to envisage what the state of the ecosystem would have been without them.

Much work has been done in recent years to assess Mediterranean fishery stocks, led by the Regional Fishery Bodies. Fifteen years ago, few international, standardised and peer-reviewed assessments could be found (Oliver 2002, Leonart & Maynou 2003). In the last five years 300 assessments have been carried out on 130 stocks involving 27 species, although this only covers 26% of landings. However, the assessments by area are unbalanced, since the central and western basins are much better covered than the eastern one. The results show that most of the stocks analysed are overexploited and resolute actions to redress this trend are needed to make fisheries sustainable, nature-respecting and economically and socially efficient.

Mediterranean Areas

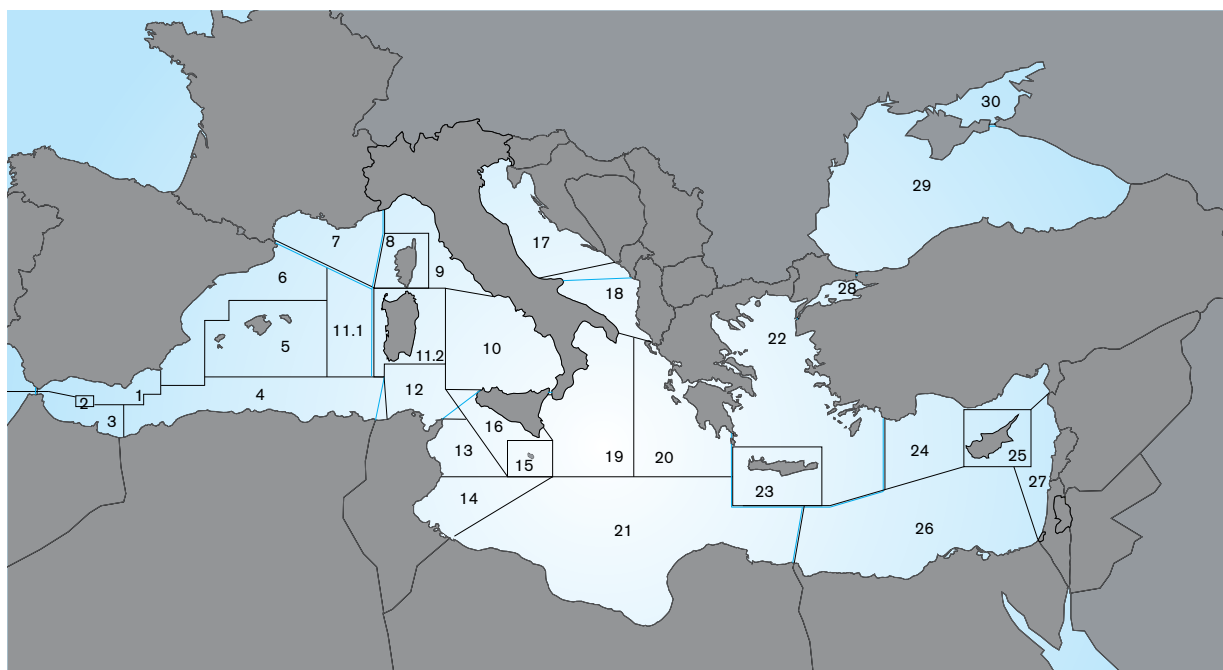
The Mediterranean Sea constitutes a Large Marine Ecosystem (LME), number 26 as defined by UNEP (United Nations Environmental Programme), limited by the straits of Gibraltar and Bosphorus, and including the Marmara Sea, although it is considered separate to the Black Sea (LME number 62).

The FAO defined Major Fishing Areas for statistical and fishery management purposes. The Mediterranean and Black Sea is number 37. This area has four subareas split into ten statistical divisions. On the other hand, the GFCM (General Fisheries Commission for the Mediterranean) (2009) defined 30 Geographical Subareas (GSA) for assessment and management purposes (Map 2). The large pelagic migratory species are allocated to the whole Mediterranean.

In this paper, it is considered the Mediterranean LME (including the Marmara Sea) with 28 GSAs, but not the Black Sea.

Fishery Resources and Global Catch

Mediterranean fisheries have been described in several instances from different viewpoints (i.e. Farrugio *et al.* 1992, Oliver 2002, Bas 2005, Caddy 2009, Leonart 2011, Barros 2011). The Mediterranean landings, disaggregated by taxon, country and statistical division, from 1970 to 2011, were reported by FAO-GFCM (2014). The data base includes 285 taxa (species or groups of species) for the triennium 2009-2011, which is the period analysed in this paper. Of these taxa eight are small pelagics, 54 medium and large pelagics, 200 demersals, 15 bivalves and eight groups of species (such as 'osteichthyes' or 'mollusca').



FAO subarea	FAO statistical division	GFCM Geographical Sub Area (GSA)	
Western	1.1 Balearic	01 - Northern Alboran Sea	
		02 - Alboran Island	
		03 - Southern Alboran Sea	
		04 - Algeria	
		05 - Balearic Island	
		06 - Northern Spain	
		11.1 - Sardinia (west)	
		1.2 Gulf of Lions	07 - Gulf of Lions
		1.3 Sardinia	08 - Corsica Island
			09 - Ligurian and North Tyrrhenian Sea
			10 - South and Central Tyrrhenian Sea
			11.2 - Sardinia (east)
12 - Northern Tunisia			
Central	2.1 Adriatic	17 - Northern Adriatic	
		18 - Southern Adriatic Sea	
	2.2 Ionian	13 - Gulf of Hammamet	
		14 - Gulf of Gabes	
		15 - Malta Island	
		16 - South of Sicily	
		19 - Western Ionian Sea	
		20 - Eastern Ionian Sea	
Eastern	3.1 Aegean	21 - Southern Ionian Sea	
		22 - Aegean Sea	
	3.2 Levant	23 - Crete Island	
		24 - North Levant	
		25 - Cyprus Island	
		26 - South Levant	
		27 - Levant	
Black Sea	4.1 Marmara	28 - Marmara Sea	
	4.2 Black Sea	29 - Black Sea	
	4.3 Azov Sea	30 - Azov Sea	

Source: GFCM.

During the period 1981-2009 the historical reported landings exceeded one million tonnes, reaching a maximum of 1.2 million in 1994. The average of the three years 2009-2011 is 0.918 million tons. According to these data 54% of landings are pelagic fish, 37% benthic and demersal and 9% of the groups are not identified at species level.

17 taxa, out of the 285, account for more than 1% of total catch, and only two represent more than 10%: sardines and anchovies (see table 8). The third most landed taxon is a set of undetermined species under the general name of 'bony fish,' incidentally stressing the importance of effective species identification for reporting catches. Pauly *et al.* (2014) consider these landings to be underestimated.

Assessments

There are three international organisations with the mandate of assessing Mediterranean stocks: GFCM, the STECF (Mediterranean EWG) and ICCAT. The former, the General Fisheries Commission for the Mediterranean" (www.gfcm.org) comprises 23 Member States and includes the Black Sea.

The Expert Working Group on Assessment of Mediterranean Sea stocks (MedEWG), is a group created by the STECF (Scientific, Technical and Economic Committee for Fisheries) of the European Commission (<http://stecf.jrc.ec.europa.eu/>). Its mandate includes the stocks exploited by the EU Member Countries in the Mediterranean Sea.

Both GFCM and STECF-Med EWG assess stocks. A stock is usually defined as one species in one GSA. The ICCAT (International Commission for the Conservation of Atlantic Tunas) (www.iccat.int) is an organisation responsible for the conservation of tunas and tuna-like species in the Atlantic Ocean and adjacent seas. There are 50 contracting parties, nine of them riparian areas of the Mediterranean. The European Union acts as a single member but includes all European countries. The stocks of large pelagics assessed by ICCAT embraces the whole Mediterranean.

Other assessments, usually restricted to national frameworks, can be found in grey literature or scientific journals, but since they have not been peer-reviewed or presented in formats standard to international assessment fora, they are not considered here.

During the last five years around 300 assessments involving 130 stocks (species by GSA) and 27 species have been conducted. Reports are available on the organisations' websites. In some cases the same stock has been assessed several times in the last five years.

Of the 27 species assessed, nine belong to the group with more than 1% of Mediterranean landings. The other 18 have particular economic importance or local interest or both. These 27 species include 20 bony fish (13 demersal, three small pelagics, one medium pelagic, three large pelagics), one elasmobranch, five crustaceans and one mollusc (see Table 8).

The 130 stocks assessed are not evenly distributed. The western and central basins are far more studied than the eastern (see table 9). Around 75% of assessments have been carried out in European waters. Although major efforts are currently being made to assess stocks, only 26% of catches have a known status. This knowledge is higher in the central region (37%), followed by the western (26%) and the eastern (11%). The assessed large pelagics represent around 40% of their total catch. Not a single stock has been assessed in six GSAs (two European, four non-European).

Red mullet, hake, deep-water rose shrimp and sardine are the species that have been analysed most frequently, with more than 10 stocks assessed several times.

Assessment Procedures

A fish stock assessment is a complex operation involving several steps: 1) collecting data and estimating parameters; 2) choosing an assessment method, usually based on mathematical models; 3) determining the reference points, i.e. MSY (Maximum Sustainable Yield), and associated biomass and fishing mortality; 4) estimating indicators, i.e. current catch, catch per unit effort, biomass and fishing mortality; 5) diagnosing the status of the stock in terms of indicators, trends and their distances to the reference points; and 6) providing management advice to the decision makers.

The results of an assessment can be expressed in a bivariate context (biomass vs. fishing mortality), or more simply associating the stock status to a single

TABLE 8 Taxa (scientific and common name) with Landings Exceeding 1% of the Total Mediterranean Landings*, or Assessed in the Last Five Years**

Species		Total landings	% in the landings	Percentage of assessed landings by basin and total				Taxonomic group	Ecological habitat
				Western	Central	Eastern	Total		
<i>Sardina pilchardus</i>	European pilchard (= Sardine)	178,860	19.47%	60.19%	77.23%	26.31%	58.70%	bony fish	small pelagic
<i>Engraulis encrasicolus</i>	European anchovy	124,293	13.53%	34.50%	76.54%	26.80%	51.95%	bony fish	small pelagic
Osteichthyes	bony fish	60,902	6.63%	NA	NA	NA	NA	bony fish	
<i>Sardinella aurita</i>	Round sardinella	52,756	5.74%	NA	NA	25.00%	4.95%	bony fish	small pelagic
<i>Trachurus</i> spp	Jack and horse mackerels	42,348	4.61%	NA	NA	NA	NA	bony fish	medium pelagic
<i>Boops boops</i>	Bogue	28,800	3.14%	16.36%	NA	22.99%	14.70%	bony fish	demersal
<i>Mullus barbatus</i> + <i>Mullus</i> spp	Red mullet	26,213	2.85%	65.22%	55.64%	34.45%	51.25%	bony fish	demersal
<i>Merluccius merluccius</i>	European hake	26,105	2.84%	92.88%	78.74%	0.34%	73.32%	bony fish	demersal
<i>Chamelea gallina</i>	Striped venus	19,426	2.12%	NA	NA	NA	NA	mollusc	demersal
<i>Parapenaeus longirostris</i>	Deep-water rose shrimp	15,227	1.66%	75.36%	70.95%	NA	64.29%	crustacean	demersal
Natantia	shrimps and prawns	15,126	1.65%	NA	NA	NA	NA	crustacean	
Mugilidae	grey mullets	13,347	1.45%	NA	NA	NA	NA	bony fish	demersal
<i>Pagellus erythrinus</i>	Common pandora	11,777	1.28%	2.38%	28.16%	25.00%	22.82%	bony fish	demersal
Sepiidae, Sepiolidae	Cuttlefish, bobtail squids	11,728	1.28%	NA	NA	NA	NA	mollusc	demersal
<i>Scomber colias</i>	Chub mackerel	11,323	1.23%	NA	NA	NA	NA	bony fish	medium pelagic
<i>Octopus vulgaris</i>	Common octopus	10,468	1.14%	0.01%	NA	NA	0.004%	mollusc	demersal
<i>Sepia officinalis</i>	Common cuttlefish	10,439	1.14%	NA	NA	NA	NA	mollusc	demersal
<i>Squilla mantis</i>	Spottail mantis squillid	7,195	0.78%	8.67%	82.55%	NRL	64.74%	crustacean	demersal
<i>Mullus surmuletus</i>	Surmullet	7,017	0.76%	18.03%	28.26%	3.79%	17.91%	bony fish	demersal
<i>Solea solea</i>	Common sole	6,198	0.67%	NA	35.49%	15.18%	21.47%	bony fish	demersal
<i>Spicara</i> spp (<i>Spicara smaris</i>)	Picarel	6,117	0.67%	NA	NA	7.36%	3.81%	bony fish	demersal
<i>Lophius</i> spp (<i>L. budegassa</i>)	Blackbellied angler	5,929	0.65%	43.60%	19.48%	NA	27.68%	bony fish	demersal
<i>Micromesistius poutassou</i>	Blue whiing (= Poutassou)	5,422	0.59%	31.41%	NA	NA	16.64%	bony fish	demersal
<i>Nephrops norvegicus</i>	Norway lobster	4,884	0.53%	40.21%	61.91%	NA	50.96%	crustacean	demersal
<i>Aristaeomorpha foliacea</i> + <i>Aristeidae</i>	Giant red shrimp	3,114	0.34%	77.50%	57.01%	NRL	61.50%	crustacean	demersal
<i>Sphyræna sphyræna</i>	European barracuda	2,682	0.29%	7.60%	14.25%	NA	5.29%	bony fish	medium pelagic
<i>Aristeus antennatus</i>	Blue and red shrimp	2,154	0.23%	48.45%	28.57%	NRL	48.30%	crustacean	demersal
<i>Trisopterus minutus</i>	Poor cod	1,736	0.19%	1.67%	NA	NRL	1.36%	bony fish	demersal
<i>Phycis blennoides</i>	Greater forkbeard	687	0.07%	1.77%	NA	NA	1.73%	bony fish	demersal
<i>Xiphias gladius</i>	Swordfish	356	0.04%					bony fish	large pelagic
<i>Thunnus thynnus</i>	Atlantic bluefin tuna	327	0.04%					bony fish	large pelagic
<i>Saurida undosquamis</i>	Brushtooth lizardfish	122	0.01%	NRL	NRL	25.00%	25.00%	bony fish	demersal
<i>Galeus melastomus</i>	Blackmouth catshark	107	0.01%	A-NRL	NRL	NRL	A-NRL	bony fish	demersal
<i>Pagellus bogaraveo</i>	Blackspot (= red) seabream	65	0.01%	A-NRL	NA	NRL	A-NRL	bony fish	demersal
<i>Thunnus alalunga</i>	Albacore	7	0.001%					bony fish	large pelagic

* Average 2009-2010-2011; (FAO-GFCM 2014). ** Total landings expressed in weight (tonnes) and percentage, and fraction of assessed landings by basin and total (NA: not assessed, NRL: no reported landings, A-NRL: assessed but no reported landings). The taxonomic group as well as the habitat of the taxa are indicated.

TABLE 9 Global Numbers of Stock Assessments by Basin				
	Western	Central	Eastern	TOTAL
Landings (tonnes)	322,501	344,761	251,165	918,427
% landings	35.11%	37.54%	27.35%	100%
No. assessments	183	104	22	309
No. GSAs	12	9	7	28
No. stocks assessed	68	45	14	127
No. species assessed	20	14	11	24
landings assessed (tonnes)	83,733	125,910	27,963	237,605
% landings assessed	25.96%	36.52%	11.13%	25.87%

descriptor such as: 'underexploited,' 'fully exploited,' 'overexploited,' 'depleted,' 'recovering,' etc. The term 'overexploitation', or its synonym 'overfishing', can also be detailed as growth overfishing (the fish caught are too small, so the yield is under the potential productivity) or recruitment overfishing (the spawning stock biomass is too little, thereby threatening the future recruitment). Sometimes other descriptors are used like 'uncertain,' 'sustainable,' 'unbalanced' or 'risk of overexploitation.'

Assessments Results

We know about the status of 26% of Mediterranean landings, but what is the status of these stocks?

For most of the stocks assessed, 80%, appear to be overexploited. All assessed species present overexploited stocks.

In a few cases (6%) the stocks appear to be underexploited. This happens particularly with sardine and anchovy, but also occasionally in some stocks of demersals, like picarel, Norway lobster, common pandora and deep-water rose shrimp. The 'fully exploited' cases represent 11% of assessed stocks including the same species as before plus red mullets. The status of the remaining 3% is unknown.

Anchovy in the Gulf of Lion was diagnosed as depleted: in 2007, landings of 13,340 tonnes were reported, and five years later, in 2012, only 5%, 635 tonnes, were landed.

Bluefin tuna seems to be on its way to recovery after suffering from overfishing in the recent past.

Conclusions

The knowledge of the status of Mediterranean fish stocks is quite limited since assessments cover only

26% of catches and 80% of the assessed stocks are overexploited. The impact on fisheries in certain sensitive habitats, especially benthonic ones in shallow waters, although difficult to quantify, has been fully demonstrated.

Great efforts have been made to assess Mediterranean stocks; 300 assessments and 130 stocks assessed in the last few years is no small task. But despite such efforts, the status of only a quarter of the landed fish is known. This is due to the diversity of commercial species and stocks in the Mediterranean. Its fishery is a complex multispecies and multi-gear system and our knowledge of the interactions, both technical and biological, is poor. Many elements must be added to understand the exploited system, such as: (a) the high levels of discards would probably provide a worse picture of the status of the exploited ecosystem, (b) the invasion of new species through the Suez canal or the Strait of Gibraltar, or by means of other sources like ballast water or recreational activities, strengthened by climate change are modifying the marine ecosystem with unknown consequences for fishing, (c) technological advances which make fishing effort (i.e. time at sea) more efficient.

Is there any chance of correcting the trend of overfishing and redressing the fishery to make it more sustainable and productive? Probably, but strong and resolute management measures must be agreed and implemented. Here are some suggestions: (i) the creation of no-take zones to protect productive ecosystems (not necessarily coastal) which host essential fish habitats, i.e. both spawning and nursery grounds. These protected fishing areas must be of a good size (currently they are confined to a few micro coastal areas) and must be subject to an efficient monitoring, control and surveillance system; (ii) trawling has a major impact on the overexploitation due to its poor selectivity and, although it is not the only gear

responsible for overexploitation, there is no doubt that it plays a fundamental role, so its activity should be placed under very strict and restrictive management; (iii) the Mediterranean fisheries are multispecies and multi-gear, so the traditional assessment methods based on one stock (one species) and one fleet do not always explain the current situation and trends, thus there is a need for moving beyond traditional age-structured population dynamics assessment models towards approaches that encompass the multi-species and data-poor nature of Mediterranean fisheries. A global approach is needed.

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