Regional Implementation Plan for Demersal Fisheries from the Balearic Islands
(Western Mediterranean)

myfish
Maximising yield of fisheries while balancing ecosystem, economic and social concerns

Regional Implementation Plan for Demersal Fisheries from the Balearic Islands
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Contents

Foreword

This Regional Implementation Plan (RIP) was elaborated in the framework of the MYFISH* project (http://www.myfishproject.eu/) funded by the Seventh Framework Programme under the THEME KBBE.2011.1.2-09: Beyond Maximum Sustainable Yield (MSY): defining management targets and their consequences. This RIP does not necessarily reflect the views of the European Commission.

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1 The study area: the Balearic Islands

The Balearic Islands (western Mediterranean, **Fig. 1**) are constituted by four main islands (Mallorca, Menorca, Ibiza and Formentera) covering about 5000 Km^2. The Archipelago constitutes the geographical sub-area number 05 from the General Fisheries Commission for the Mediterranean (see 2.1). Compared to the nearest mainland, the Balearic Archipelago is one of the most distant insular areas in the Mediterranean. They are separated from the Iberian Peninsula by depths of 2000 m, except in the Ibiza Channel (the nearest point between the Peninsula and the Archipelago) where the maximum depths are 800 m.

Several decades ago the Balearic Islands were defined as an individualized fishing area in the western Mediterranean (Massutí, 1991). More recently, a comprehensive comparison including different aspects such as geomorphology, habitats, fisheries and exploitation state of resources and ecosystems between the Balearic Islands and the adjacent coast of the Iberian Peninsula, concluded that the Archipelago should be maintained as an independent unit for assessment and management purposes in the western Mediterranean (Quetglas et al., 2012).

The present Regional Implementation Plan is focused on the main demersal fisheries (bottom trawl and small-scale fleets, see 3.1 and 3.2) from the Balearic Islands. Most

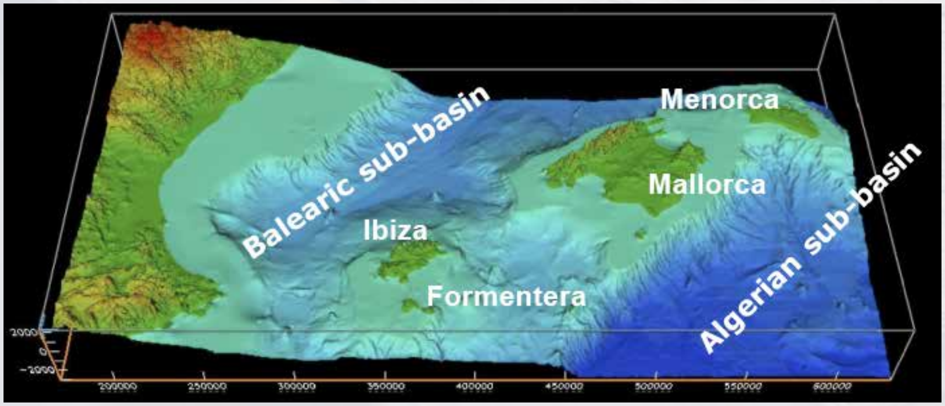


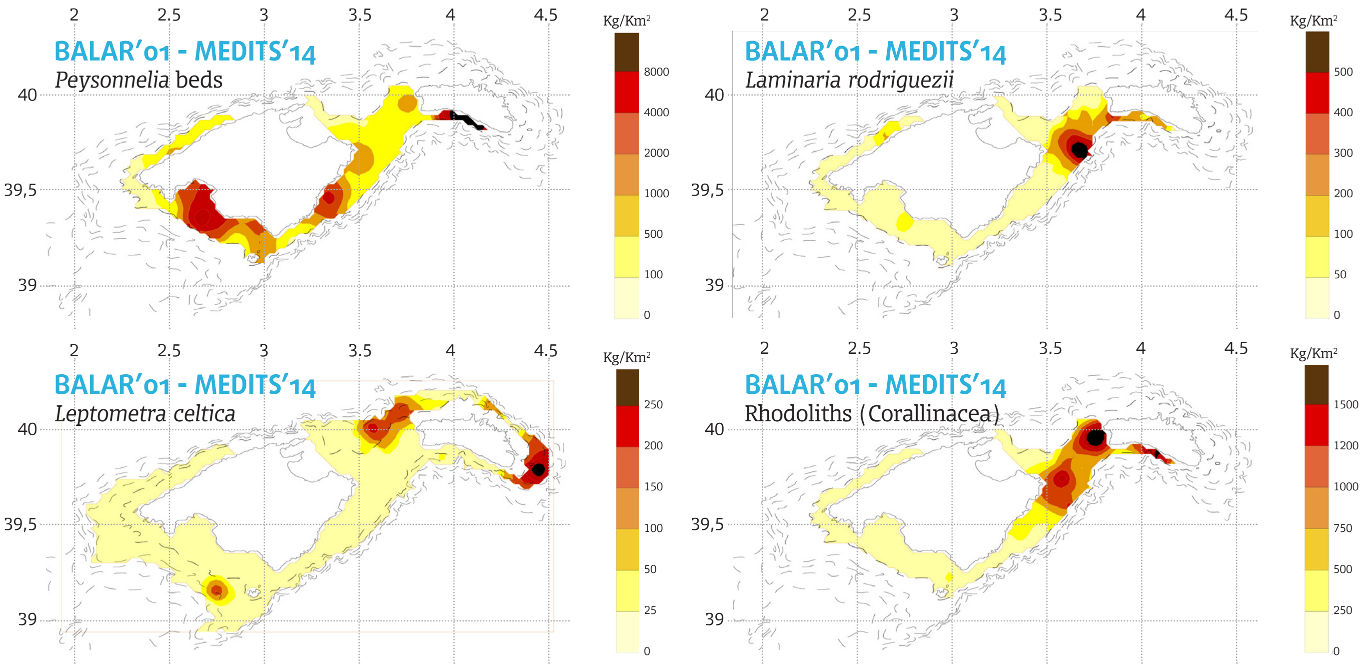
Fig. 1.
Map of the Balearic Sea showing its two main sub-basins (Balearic and Algerian) and the four main islands of the Balearic Archipelago. From Acosta et al. (2002).

of the studies presented here were done using exclusively data from Mallorca because: 1) the reliability and availability of their fishery statistics is much better than those from the remaining islands; and 2) its landings represent about 75% of the total Balearic Islands landings.

1.1. Demersal fishing grounds

The fishing grounds exploited by the demersal fisheries from the Balearic Islands are characterized by the presence of sensitive and essential fish habitats, especially on the coastal continental shelf (**Box 1**). The waters around the Balearic Archipelago are comparatively more oligotrophic than adjacent waters off the Iberian coast and the Gulf of Lions (Estrada, 1996; Bosc et al., 2004). Such oligotrophy and the lack of river inputs due to a dry climate, the reduced watershed areas, and the karstic nature of most of the islands that favours rapid infiltration of rainfall, explain the high transparency of the waters in the area and favour the production of benthic biogenic sediments (Canals and Ballesteros, 1997). This allows the development of red algae beds in the coastal shelf of the Balearic Islands, where they are frequent down to 90 m depth (Ballesteros, 1992, 1994; Barberá et al., 2012a).

Fig. 1.1.
Contour maps of the standardized biomass of species/taxons characterizing the main macro-epibenthic communities detected on the continental shelf bottom trawl fishing grounds from the Balearic Islands. Data from scientific surveys Balar and Medits (2001-2014).



The fishing grounds traditionally exploited by the demersal fisheries overlap with these beds (**Fig. 1.1**), which basically include maërl and *Peyssonnelia* beds (Ordines and Massutí, 2009). It has been demonstrated that both habitats are essential for the fishing resources (Ordines et al., 2009, 2015; Ordines, 2015), being catalogued with the term *Essential Fish Habitats* (EFH), whereas the maërl beds are sensitive habitats protected under the European fishing regulation EC Nº 1967/2006 of 21 December 2006 concerning management measures for the sustainable exploitation of fishery resources in the Mediterranean Sea. The crinoid beds, also considered an EFH (Colloca et al. 2004; Ardizzone, 2006; Ordines and Massutí, 2009; Ordines, 2015), dominate certain areas of the deep shelf, primarily between 120 and 200 m depth.

Studies carried out in the Balearic Islands confirm the importance of these habitats in structuring demersal resources assemblages to which the main resources are associated (Ordines and Massutí, 2009; Ordines et al., 2009). On the shallow shelf, maërl and *Peyssonnelia* beds appeared to influence the distribution of most demersal resources, as 12 out of the 16 species studied showed their highest average abundances on these bottoms. On the deep shelf, 12 out of the 23 demersal species analyzed showed the highest average abundances over crinoid beds. These studies have shown that benthic biogenic habitats such as maërl and *Peyssonnelia* beds not only affect the distribution of demersal resources, but also enhance their individual physiological condition, allowing them to afford critical life stages such as reproduction with more lipid reserves than individuals living in bare sandy bottoms (Ordines et al., 2011, 2015). These habitats have a high productivity and enhance the three-dimensional complexity of benthic communities, providing refuge for small demersal species and juveniles of some of the main fishing resources (Ordines et al., 2009). Whereas the maërl and crinoid beds are particularly vulnerable to towed gears (Barberá et al., 2003; Colloca et al., 2004), the *Peyssonnelia* beds, widespread and characteristic of the shallow shelf although little known in the Mediterranean, would be less suscepti-ble to bottom trawl effects. In fact, compared to the maërld beds, they showed similar values of species richness, the highest biomass indexes (mostly attributable to algae and invertebrates) and higher abundance of demersal resources. In this sense, they are considered as a critical habitat on the shallow shelf off the Balearic Islands and ecological indicators of highly productive areas playing a major role in the production of the main demersal resources.

Although the bottom trawl has traditionally been considered as one of the main threats for the maërl and coralligenous beds (Barberá et al., 2003), the impact of the small-scale fishery targeting the spiny lobster with trammel nets cannot be ignored (Díaz, 2009). However, recent scientific studies suggest that some environmental variables, such as current intensity and depth, seem to be more important than trawling when explaining the distribution and characteristics of maërl beds in the Balearic Islands (Barberá et al., 2012b; Moranta et al., 2014.). The fact that the fishing pressure in the Archipelago is an order of magnitude lower than adjacent areas of the Iberian Peninsula (Massutí and Guijarro, 2004), along with the greater transparency of its waters, would explain the persistence of maërl beds in the fishing grounds traditionally exploited by the commercial fisheries.

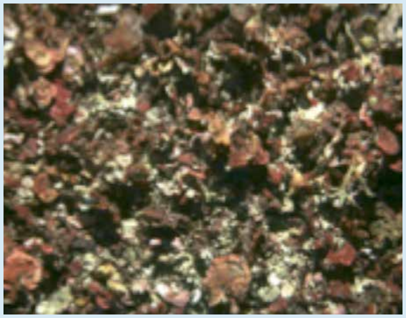
The presence of these benthic habitats highlights the need to go towards multispecies and ecosystem-based assessment and management of demersal fisheries in the Balearic Islands. Thus, fishery management on the Balearic shelf requires the development of technical measures to protect its benthic communities which should allow combining the habitat conservation and the sustainability of fisheries.

BOX 1

Benthic habitats and fishing grounds on the shallow shelf of the Balearic Islands

The macro-epibenthic assemblages on the continental shelf sedimentary grounds exploited by the demersal fisheries from the Balearic Islands are characterized by the abundance of macroalgae and echinoderms (Ordines and Massutí, 2009). The following assemblages are found:

1. Maërl beds: On the shallow shelf, down to 80 m depth. Mainly structured by the hard, long-living red algae Corallinaceae in the basal layer and the brown algae *Laminaria rodriguezii* in the erect stratum. Maërl beds are characterized by accumulations of living and dead rhodoliths, often being found in twilight conditions, so their bathymetric limit depends primarily on the degree of light penetration (Barberá et al., 2003).



2. *Peyssonnelia* beds: On the shallow shelf, down to almost 90 m depth (Ballesteros, 1994). They are mainly structured by free-living red algae of the Peyssonneliaceae family in the basal layer (there is also Corallinaceae, but with lower biomass indexes) and the soft red algae *Phyllophora nervosa* in the erect stratum. The irregular sea urchin *Spatangus purpureus* is also very abundant in this community. These soft red algae bottoms have a great amount of biomass, with average values much higher than those of maërl beds.

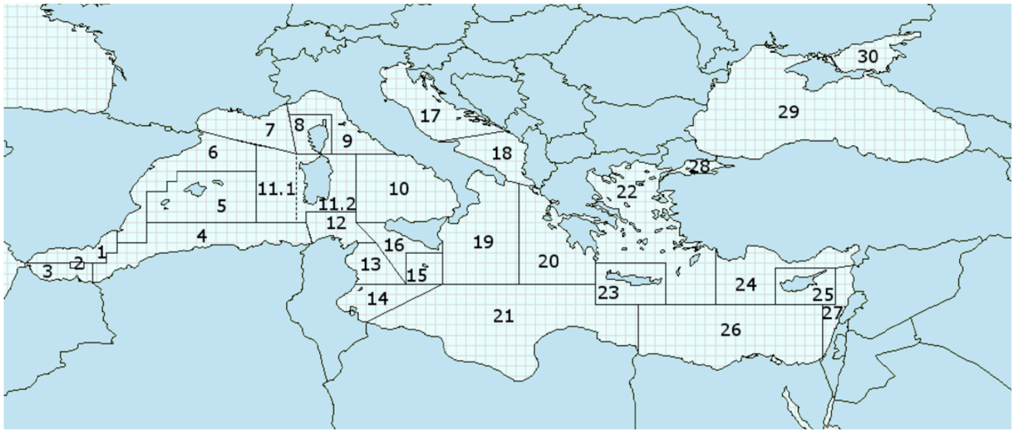
3. Crinoid beds: On the deep shelf detritic sandy-mud bottoms, mainly from 120 to 200 m depth. These beds are characterized by the presence of the crinoid *Leptometra celtica*, which has been associated with detritic bottoms with regular currents in the Mediterranean (Colloca et al., 2003).

2 Fishery management

2.1. Management organizations

The main fishery management organization in the Mediterranean is the General Fisheries Commission for the Mediterranean (GFCM; www.gfcm.org). Consisting of 23 member countries along with the European Union, the GFCM's objectives are to promote the development, conservation, rational management and best utilization of living marine resources, as well as the sustainable development of aquaculture in the Mediterranean, Black Sea and connecting waters. The GFCM has the authority to adopt binding recommendations for fisheries conservation and management in its Convention Area and plays a critical role in fisheries governance in the Region. The GFCM has established 30 management areas in the Mediterranean (**Fig. 2.1**) based on political and statistical considerations rather than biological or economic factors (Lleonart and Maynou, 2003).

Apart from the GFCM, the European Union, through its Scientific, Technical and Economic Committee for Fisheries (STECF; https://stecf.jrc.ec.europa.eu), established in 2008 a working group specifically focused to the assessment of Mediterranean and Black Sea stocks (known as SG-MED up to 2011). The SG-MED was born as a request to the STECF to set up an operation work-programme to: i) update the status of the main demersal stocks; ii) evaluate the exploitation levels with respect to their biological and economic production potentials; and iii) evaluate the sustainability of the stocks by using both trawl surveys and commercial catch/landing data, as collected through the Community Data Collection regulation N° 1543/2000 as well as other scientific information collected at national level.



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 Islands	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. 2.1.
Map of the Mediterranean Sea showing the thirty geographical subareas (GSAs) established by the General Fisheries Commission for the Mediterranean (GFCM).

2.2. Fishing regulations

Fisheries management in the Balearic Islands involves regulations at European, national and local levels (**Box 2**). The main European regulations are: I) Council Regulation (EU) Nº 1967/2006 of 21 December 2006 concerning management measures for the sustainable exploitation of fishery resources in the Mediterranean Sea (amended on certain provisions by Regulation (EU) 2015/2102 of 28 October 2015); and II) Regulation (EU) Nº 1380/2013 of the European Parliament and of the Council of 11 December 2013. Both legislations amend previous regulations for the conservation and sustainable exploitation of fisheries resources under the Common Fisheries Policy concerning management measures for the sustainable exploitation of fishery resources in the Mediterranean Sea.

At national level, the Order AAA/2808/2012 of 21 December established an Integral Management Plan for the conservation of Mediterranean fisheries resources caught by purse seine, bottom trawl and small-scale fleets for the period 2013-2017. At local scale, there exist regulations focused to local fisheries taking place, fully or partially, within external waters.

Fishing regulations in the Balearic Islands

	European	National	Local
General	• Council Regulation (EU) Nº 1967/2006 of 21 December 2006 (R1967) • Regulation (EU) Nº 1343/2011 of the European Parliament and of the Council of 13 December 2011 (R1343) • Regulation (EU) Nº 1380/2013 of the European Parliament and of the Council of 11 December 2013 (R1380) • Regulation (EU) 2015/2102 of the European Parliament and of the Council of 28 October 2015 (R2102)	• Order AAA/2808/2012 of 21 December (AAA2808) • Order AAA/1504/2014 of 30 July (AAA1504)	• Law 7/2013 of 26 November (L7-2013)
Bottom trawl fleet		• Royal Decree 1440/1999 of 10 September (RD1440)	
Small-scale fleet	• Commission Implementing Regulation (EU) Nº 1233/2013 of 29 November 2013 (R1233)	• Royal Decree 395/2006 of 31 March (RD395) • Order of 30 May 2001 (O300501) • Order AAA/2794/2012 of 21 December (AAA2794) • Order AAA/1688/2013 of 10 September (AAA1688)	• Decree 17/2003 of 21 February (D17) • Order of 23/03/2001 (O230301) • Order of 14/03/2002 (O140302) • Decree 44/2013 of 4 October (D44)

BOX 2

Regarding the landing obligation, all catches of species subjected to catch limits (only bluefin tuna and swordfish in the Mediterranean) and catches of species subjected to minimum landing sizes shall be brought and retained on board the fishing vessels, recorded and landed in accordance with the following time frames: I) from 1 January 2015 at the latest for small and large pelagic fisheries; II) from 1 January 2017 at the latest for the species defining the fisheries; and III) from 1 January 2019 for all other species.

2.2.1. Bottom trawl fishery

At national level, bottom trawl fishery (BTF) activities carried out in national waters are regulated by the Royal Decree 1440/1999 of 10 September and several protected areas for trawlers, dredges, seiners and similar nets, over certain seamounts in the Mallorca Channel and in the eastern of the Maritime-Terrestrial National Park of Cabrera Archipelago are regulated by the Order AAA/1504/2014 of 30 July. The BTF is partially regulated at local level by the *Llei 6/2013, de 7 de novembre, de pesca marítima, marisqueig i aqüicultura a les Illes Balears*, although all internal waters, if not covered by regional legislations, are regulated by national laws.

An important aspect of the regulations governing the BTF is the freezing of their fishing capacity, which affects both the total number of vessels of this fleet in the Balearic Sea (new additions are not allowed, only replacement of scrapped units under some circumstances) as tonnage (GT) and gear power (HP) of individual vessels.

Apart from this fleet freezing capacity, and as a summary of the regulations in force, the following main technical measures are currently applied to the BTF from the Balearic Islands: I) vessel size must range between 14 and 24 m; II) the maximum allowed gear power is 500 HP; III) fishing time at sea is restricted to 12 h per day and 5 days per week; IV) minimum mesh size allowed in the codend is 40 mm (squared) or 50 mm (diamond); V) there are minimum landing sizes for different fish species; and VI) trawling is only permitted at depths higher than 50 m. The local regulation also includes the prohibition of fishing at different marine protected areas from the Balearic Archipelago.

2.2.2. Small-scale fishery

At European level, the Commission Implementing Regulation (EU) Nº 1233/2013 established a derogation to the small-scale fishery (SSF) in certain territorial waters of the Balearic Islands related to the minimum distance from the coast and the minimum sea depth for boat seines fishing for transparent and Ferrer's gobies (*Aphia minuta* and *Pseudaphia ferreri*, respectively) and lowbody picarel (*Spicara smaris*). Currently, these species are included in a management plan approved in 2013 by the Balearic Government, with the approval of the European Commission.

At national level, the SSF is regulated by the Royal Decree 395/2006 of 31 March and Order AAA/2794/2012 of 21 December. There are specific laws related to the fishery of spiny lobster *Palinurus* spp. (Order 30 May 2001, BOE 141, 13/06/2001) and dolphinfish *Coryphaena hippurus* (Order AAA/1688/2013, BOE 226, 20/09/2013). For spiny lobster, the law establishes fishing periods and authorized depths, a minimum landing size, the ban of catching ovate females and measures related to the technical characteristics of the gear, type of net and its maximum effort. For dolphinfish, the law regulates the technical characteristics of the gear, effort (number of FADs, fish aggregating devices) and minimum depth.

At regional level the SSF is regulated by the Decree 17/2003 of 21 February (BOIB, 01/03/2003) and the list of the SSF vessels from the Balearic Islands is published in the BOIB 70, 09/05/2015. Spiny lobster and dolphinfish fisheries in internal waters are also regulated by two regional orders (from 14/03/2002 and 23/03/2001, respectively).

3 Fisheries

A total of 16 different fishing ports exist in the Balearic Islands (**Fig. 3.1**), where the main commercial fisheries include bottom trawl, small-scale, purse seine and pelagic longline (**Fig. 3.2**); the recreational fishery is also very important (see 3.3). Currently (2014), the commercial fleet from the Balearic Islands is constituted by 44 trawlers, 267 small-scale vessels, 7 purse-seiners and 2 long-liners. These fisheries involve a total of 598 fishermen, the majority of them working on the small-scale (344) and bottom trawl (210) fisheries (**Table 3.1**). The purse seiners and long-liners are only found in Mallorca, which fishing fleet also includes 28 trawlers and 147 small-scale vessels and involves a total of 385 fishermen.

In spite of the marked decrease in the number of vessels observed with time (see 3.1 and 3.2), total landings from the Balearic Islands have not shown any clear trend during the last 75 years, ranging between 3000 and 4000 tons per year (**Fig. 3.3**).

Fig. 3.1. Location of the sixteen different fishing ports from the Balearic Islands: Mallorca (10), Menorca (3), Ibiza (2) and Formentera (1).

	Trawl		Small-scale		Purse seine		Longline		Total	
	V	C	V	C	V	C	V	C	V	C
Mallorca	28	139	147	202	7	33	2	11	184	385
Menorca	7	37	54	74	0	0	0	0	61	111
Ibiza	6	23	49	49	0	0	0	0	55	72
Formentera	3	11	17	19	0	0	0	0	20	30
Balearic Islands	**44**	**210**	**267**	**344**	**7**	**33**	**2**	**11**	**320**	**598**

Table 3.1.
Number of vessels (V) and crew (C) by fishing gear for the different islands of the Balearic Archipelago in 2014.

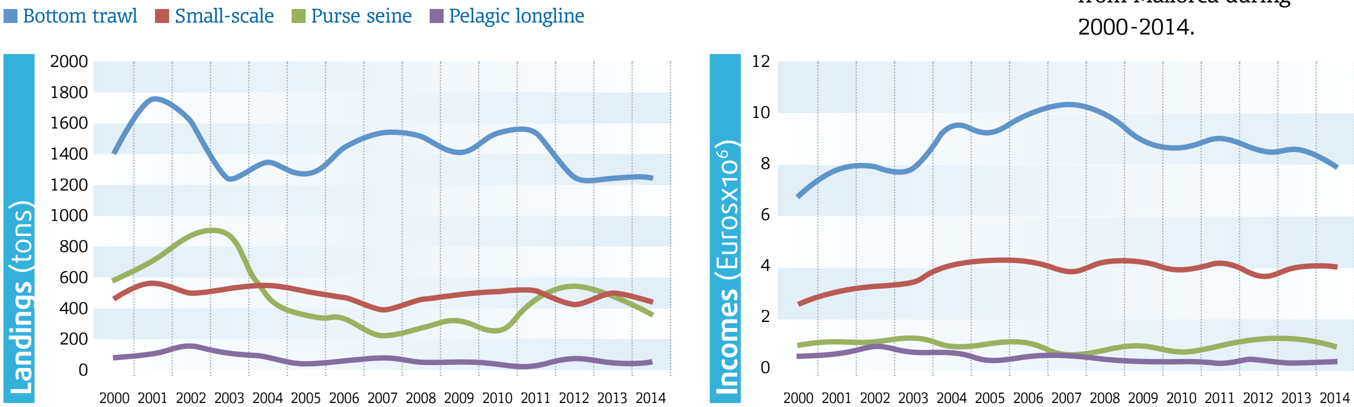


Fig. 3.2.
Landings and incomes of the main fishing fleets from Mallorca during 2000-2014.

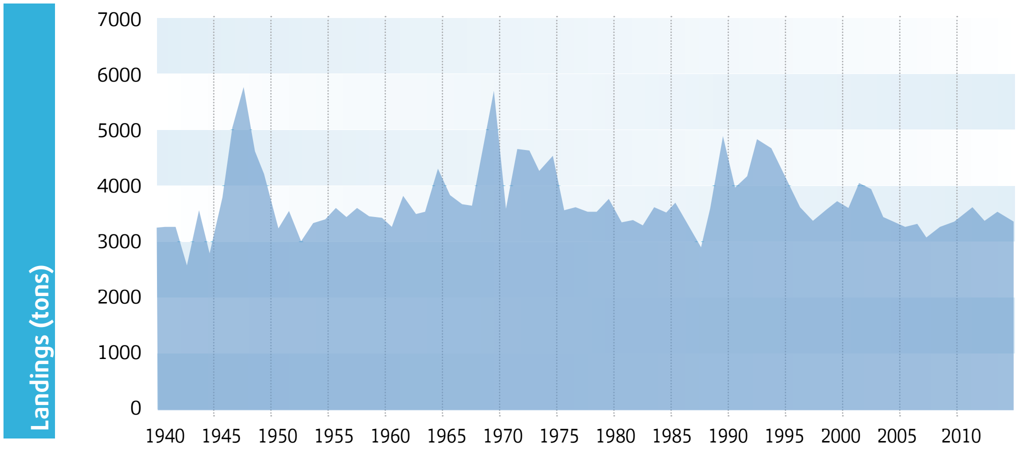


Fig. 3.3.
Total fisheries landings from the Balearic Islands during 1940-2014.

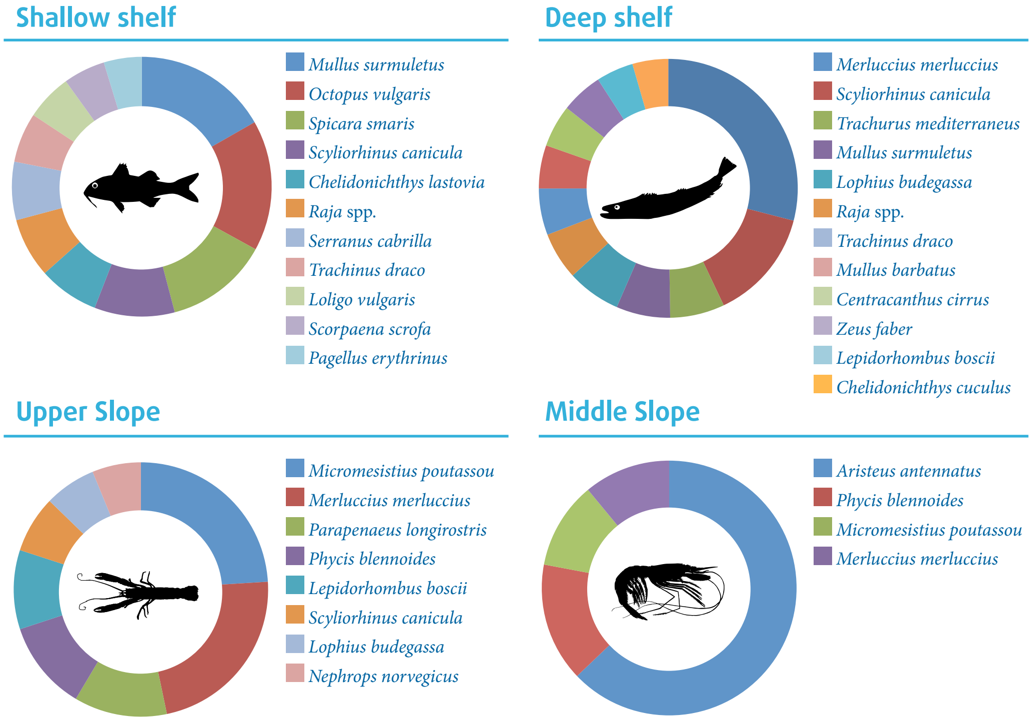
As aforementioned, the following sections are focused on the main demersal fisheries (bottom trawl and small-scale, see 3.1 and 3.2) from the Balearic Islands. As in the rest of the Mediterranean (Lleonart and Maynou, 2003), the demersal fisheries from the Archipelago are characterized by being highly multispecific, with more than 100 species in their landings.

3.1. Bottom trawl fishery

Landings of the bottom trawl fleet (BTF) have accounted for between 46 and 70% (mean 59%) in terms of biomass and between 60 and 69% (mean 64%) in terms of incomes of the total Mallorca landings during 2000-2014. During this period, the BTF landings ranged between 1234 and 1752 tons (mean 1417 tons; **Fig. 3.2**).

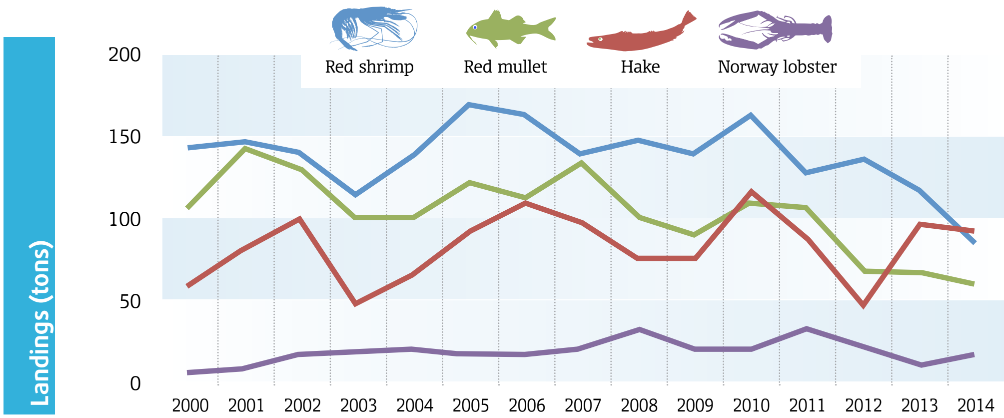
In the Balearic Islands, commercial trawlers use up to four different fishing tactics (Palmer et al., 2009), which are associated with the shallow and deep continental shelf, and the upper and middle continental slope (Ordines et al., 2006; Guijarro and Massutí, 2006). Vessels mainly target striped red mullet (*Mullus surmuletus*) and European hake (*Merluccius merluccius*) on the shallow and deep shelf respectively. However, these two target species are caught along with a large variety of fish and cephalopod species (**Fig. 3.1.1** and **Table A1**). The Norway lobster (*Nephrops norvegicus*) and the red shrimp (*Aristeus antennatus*) are the main target species on the upper and middle slope respectively. The Norway lobster is caught at the same time as a large number of other fish and crustacean species, but the red shrimp fishery is the only Mediterranean trawl fishery that could be considered monospecific.

Fig. 3.1.1.
Species composition of the four different fishing tactics (FTs) used by the bottom trawl fishery from Mallorca. Pictures represent the main target species in each FT: shallow shelf (striped red mullet), deep shelf (hake), upper slope (Norway lobster) and middle slope (red shrimp). Groups were defined according to the similarity percentage analyses shown in **Table A1**.



Time series of landings of these four target species during 2000-2014 are in **Figure 3.1.2.** The red shrimp is the most important species, with mean landings of 139 tons, followed by striped red mullet (mean 104 tons) and hake (mean 83.5 tons); landings of Norway lobster are comparatively lower (mean 18 t).

Fig. 3.1.2.
Total landings of the four main target species of the bottom trawl fishery from Mallorca during 2000-2014.



From 1965, the BTF off Mallorca has showed large variations in the number of vessels, mean engine power and the fishing time at sea (**Fig. 3.1.3**). The number of trawlers doubled during the first twelve years and reached its maximum of 70 units in 1977, but this number has decreased progressively since then and is currently (2014) lower than the initial number of vessels in 1965 (28 vs 35). Through different time steps, the number of fishing hours has also decreased from 126 $h \cdot w^{-1}$ in 1965 to 60 $h \cdot w^{-1}$ in 2000-2014. Mean engine power, however, has increased considerably with time, and currently vessels have about seven times the power they had in 1965 (650.2 vs 94.9 HP). The total fishing effort also increased with time, but at different growth rates throughout the series. This general increasing trend, however, was punctuated by episodes of rapid decreases in the fishing effort related to the decrease in time at sea due to different fishing regulations coming into force. Three main periods can be distinguished in the evolution of the fishing effort over time: I) from 1965 to the mid 1970s, it increased by a factor of 2.5; II) from the mid 1970s to 1994, it kept on growing but at a slower rate; and III) from 1994 on the fishing effort has progressively decreased, though this decrease has been specially noticeable during the last 5 years. These increases of fishing effort observed throughout the last 50 years, especially during the mid 1970s, had important effects on the demersal resources from the Balearic Islands (**Box 3**).

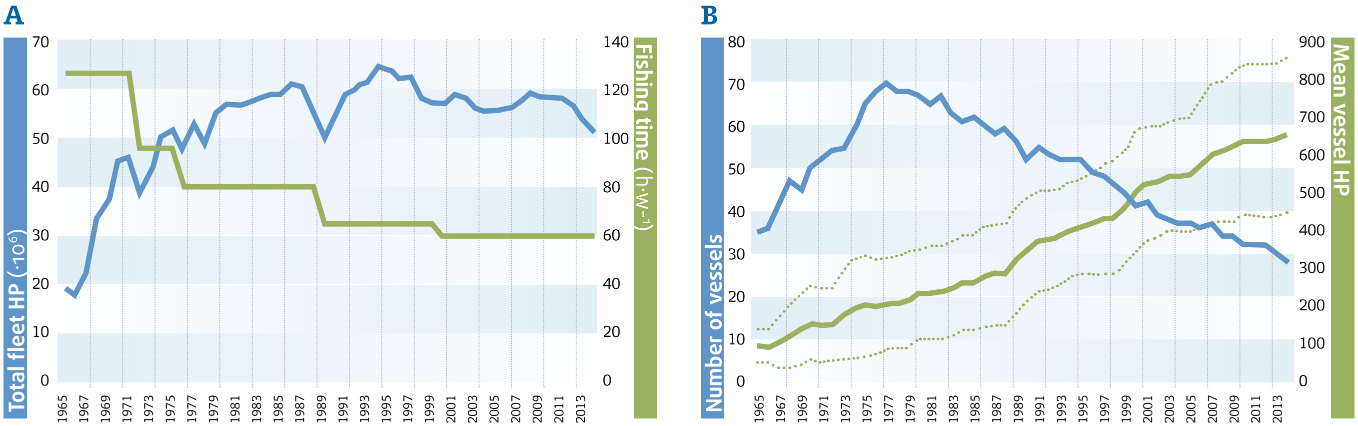


Fig. 3.1.3.
Annual horse power (HP) of the entire bottom trawl fleet of Mallorca and fishing time at sea (in hours per week, $h \cdot w^{-1}$) permitted by different regulations throughout the time series 1965 to 2014 (A). Total number of vessels along with mean and standard deviation of vessel HP during the same time series (B).

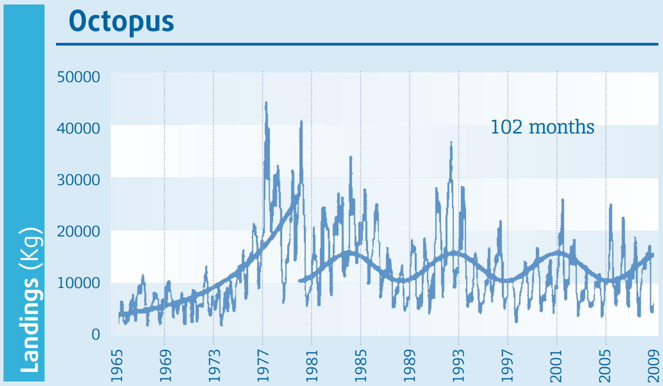
Effects of fishing and climate on marine ecosystems

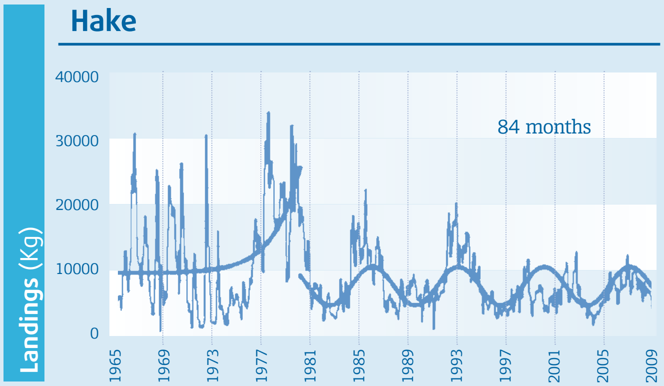
Accumulating evidence shows that fishing exploitation and environmental variables can synergistically affect the population dynamics of exploited populations (e.g. Hsieh et al., 2006; Anderson et al., 2008; Planque et al., 2010; Perry et al., 2010). Empirical evidence also exists from the Balearic Islands, where the interaction between fishing impact and climate variability triggered a synchronic response in the population fluctuations of different exploited stocks during 1965-2008 (Quetglas et al., 2013).

Through this period, the fishing activity experienced a sharp increase of fishing effort (**Fig. 3.1.3**), which caused that some stocks shifted from an early period of underexploitation to a later period of overexploitation (**Box 5**). This change altered the population resilience of the stocks and brought about an increase in the sensitivity of its dynamics to the climate variability. Landings increased exponentially when underexploited but displayed an oscillatory behaviour once overexploited.

Climatic indices related to the Mediterranean mesoscale hydrography and large-scale north Atlantic climatic variability seemed to affect the species with broader age structure and longer life span (e.g. hake, elasmobranchs), while the global-scale El Niño Southern Oscillation index (ENSO) positively influenced the population abundances of species with a narrow age structure and short life span such as cephalopods.

This study revealed that the marine ecosystems and fishing resources from the Balearic Islands are sensitive to the hydroclimatic variability linked to global climate, which should be taken into account when designing future scenarios of fisheries management.





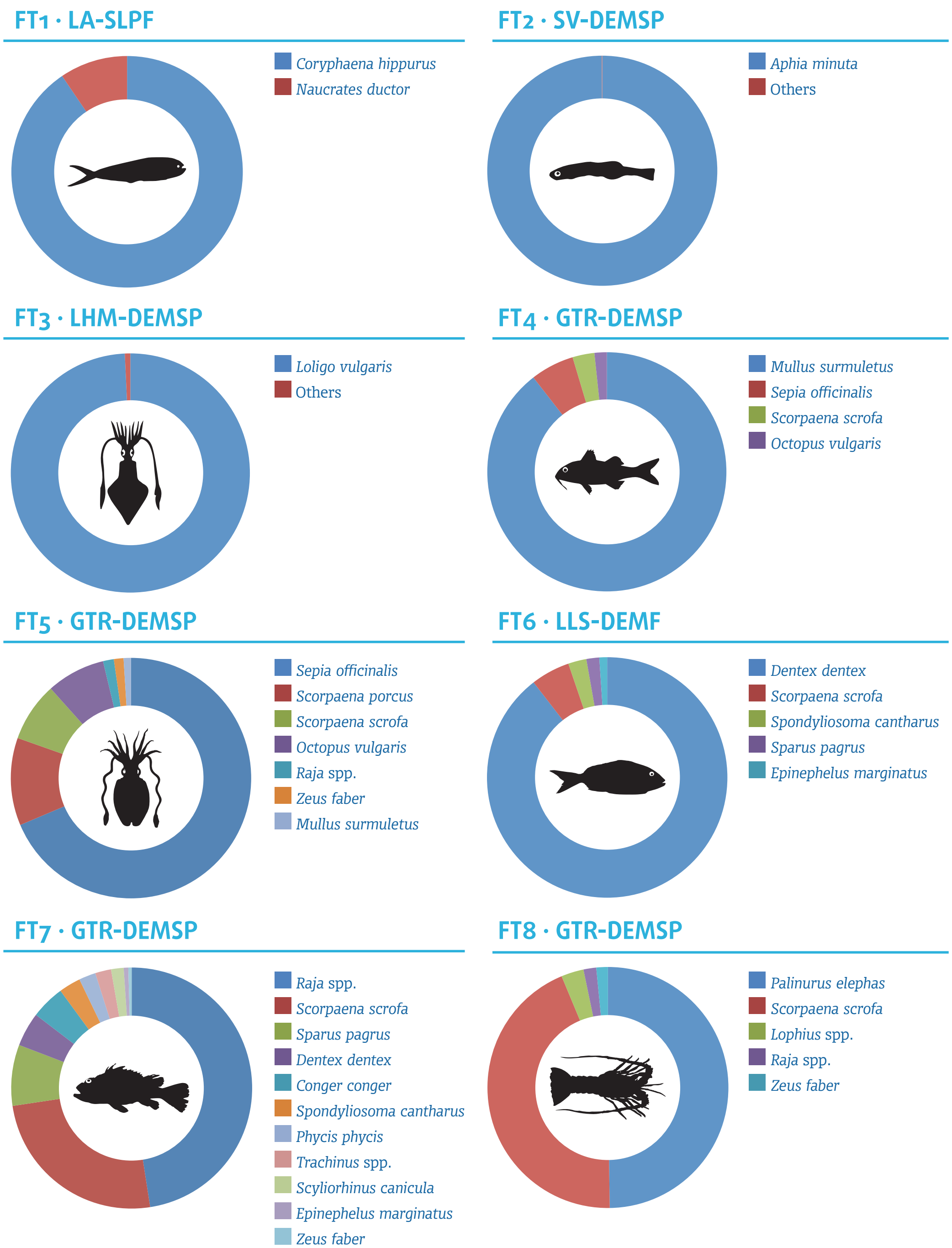
BOX 3

3.2. Small-scale fishery

Landings of the small-scale fishery (SSF) have accounted for between 16 and 24% (mean 20%) in terms of biomass and between 24 and 31% (mean 27%) in terms of incomes of the total Mallorca landings during 2000-2014. During this period, SSF landings ranged between 392 and 560 tons (mean 480 tons; **Fig. 3.2**).

The SSF from Mallorca targets the following eight fishing tactics and corresponding target species: I) purse seine: dolphinfish (*Coryphaena hippurus*); II) purse seine: transparent goby (*Aphia minuta*); III) handline: squid (*Loligo vulgaris*); IV) trammel net: striped red mullet (*Mullus surmuletus*); V) trammel net: cuttlefish (*Sepia officinalis*); VI) longline: dentex (*Dentex dentex*); VII) longline: red scorpionfish (*Scorpaena scrofa*); and VIII) trammel net: spiny lobster (*Palinurus elephas*). The fishing tactics targeting dolphinfish, transparent goby and squid are practically monospecific, having very low by-catches (**Fig 3.2.1** and **Table A2**). The remaining fishing tactics, by contrast, yield landings with comparatively important quantities of by-catch species. Altogether, those eight target species have accounted for 52% (45-58%) in terms of landings and 71% (65-76%) in terms of incomes of the Mallorca SSF during 2000-2014. The individual contribution of each species to the SSF (landings and incomes) is in **Fig. 3.2.2**; in terms of landings and economic value, the most important species are dolphinfish (11.4%) and spiny lobster (10.5%), respectively.

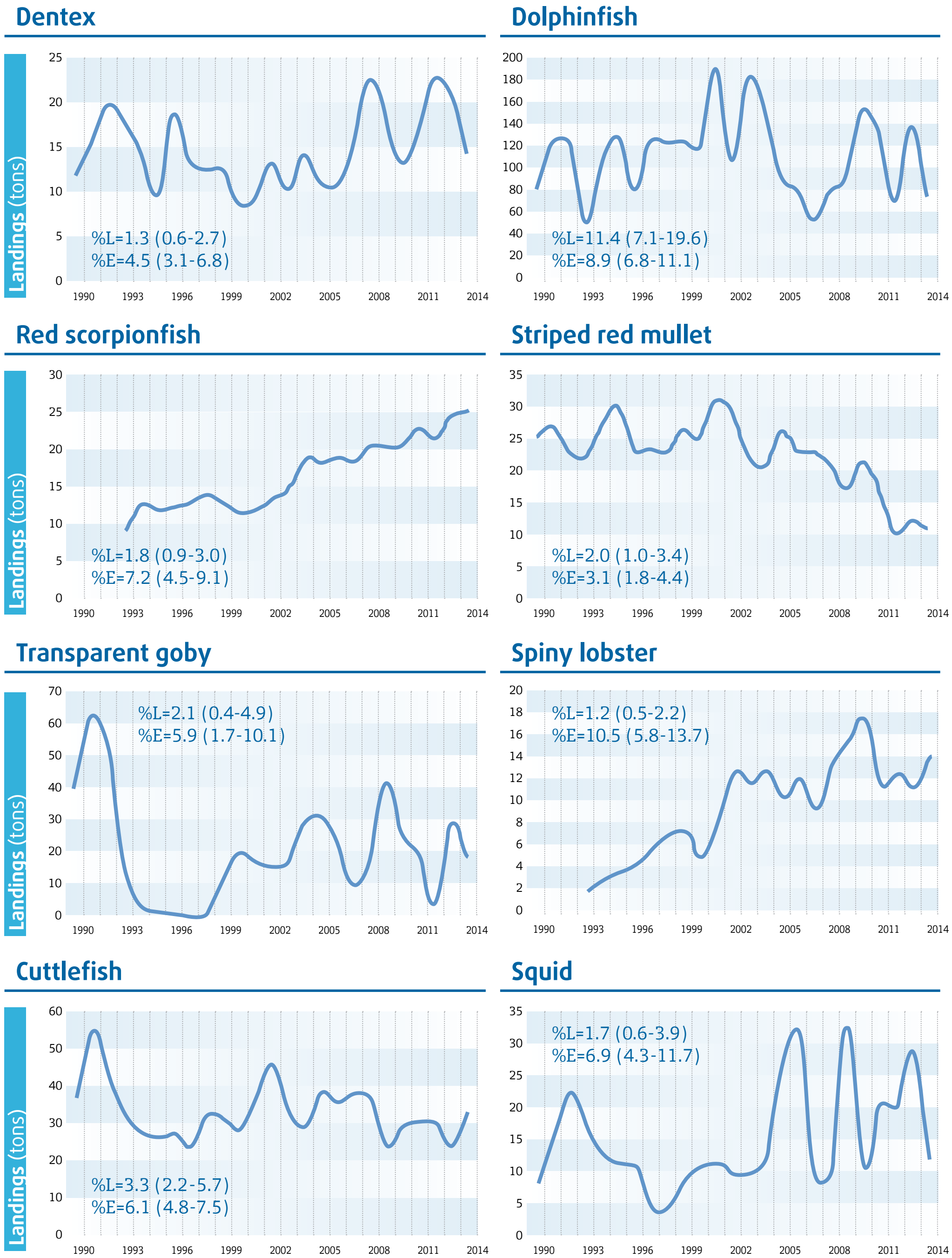
Fig 3.2.1. Species composition of the eight different fishing tactics (FTs; groups 1 to 8) used by the small-scale fishery from Mallorca. Pictures represent the main target species characterizing the FTs. The EU codes for the gears (LA: lámpara nets; SV: boat seine; LHM: hand lines; GTR: trammel net; LLS: set longlines) and métiers (SLPF: small and large pelagic fish; DEMSP: demersal species; DEMF: demersal fish) corresponding to each FT are also shown (DCF-Annex 1). FTs were defined according to cluster analysis and were characterized using the similarity percentage analysis shown in **Table A2**.



In most cases, the landings of these eight species showed important fluctuations without any clear trend during the last 25 years (**Fig. 3.2.2**). Red scorpionfish represents an exception, as their landings showed a marked increasing trend with low interannual fluctuations. Landings of striped red mullet have decreased noticeably from the early 2000s whereas those of spiny lobster showed a significant increase also in early 2000s. The stock of transparent goby was close to depletion at mid-1990s but it recovered during the early 2000s. With the exception of dentex, which showed two peaks (May, October), all other fisheries were clearly seasonal (**Fig. 3.2.3**), with landing peaks in winter (transparent goby), spring (cuttlefish), summer (lobster, scorpionfish, striped red mullet, squid) and autumn (dolphinfish).

The number of boats has decreased noticeably during the last 25 years in the whole Archipelago, from about 600 units in 1990 down to 254 units in 2013 (**Fig. 3.2.4**). The SSF is composed of (numbers between parenthesis are means and ranges) old (37.0 yr; 3-101), small (8.0 m; 4.8-14.1) vessels with low engine power (49.5 HP; 4.0-192.0), low gross tonnage (3.2 GT; 0.5-75.0) and low gross registered tonnes (4.3 GRT; 0.7-20.0) and very small crews (1.3 fishermen; 1-3). Currently (2014), the official census of the SSF in the Archipelago includes a total of 340 fishermen and 265 boats. In Mallorca, there are a total of 147 vessels and 202 fishermen. With the exception of a large number of vessels with sporadic fishing activity, most boats carried out four or five months of effective fishing in 2014 (**Fig. 3.2.4**).

Fig. 3.2.2.
Landings (in tons) for the eight main target species of the small-scale fishery (SSF) from Mallorca during 1990-2014. The contribution of each species (in percentage) to the total SSF landings (L%) and economic value (E%) are also shown (mean and ranges).



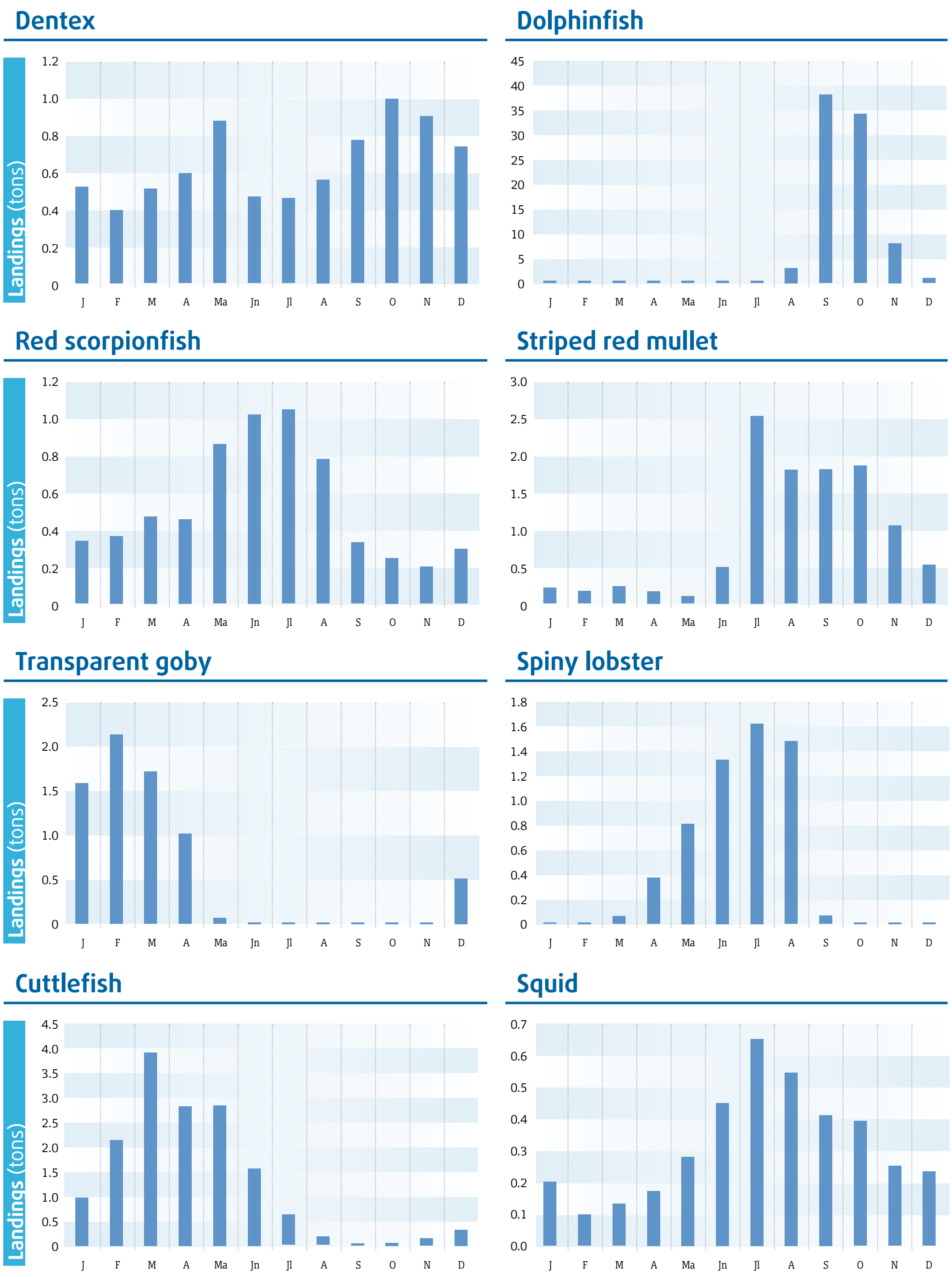


Fig. 3.2.3.
Monthly mean landings (in tons) for the eight main target species of the small-scale fishery from Mallorca during 1990-2014.

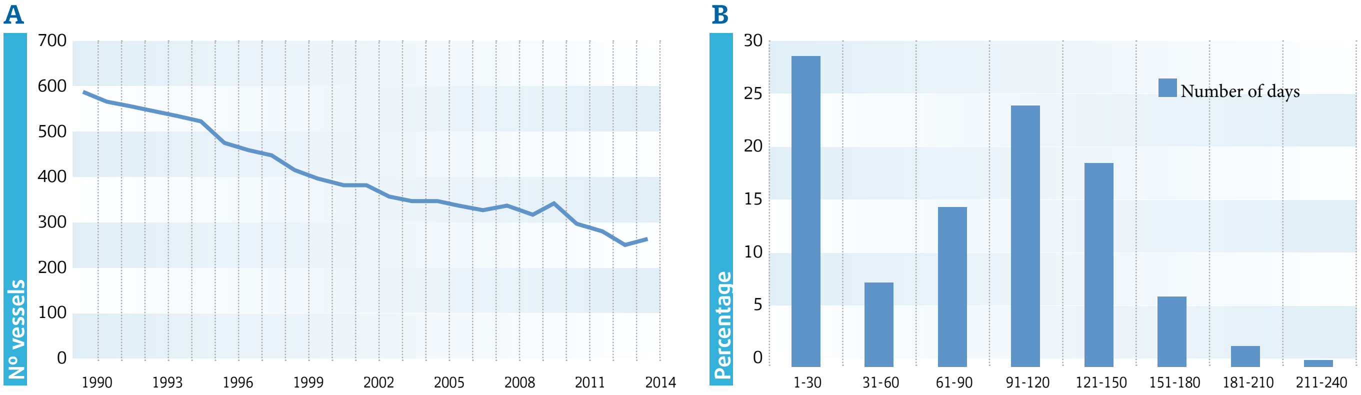


Fig. 3.2.4.
Number of boats during 1990-2014 (A) and percentage of boats in intervals of effective fishing days in 2014 (B) of the small-scale fishery from the Balearic Islands.

3.3. Recreational fishery

Recreational fisheries have been largely overlooked for fisheries management, probably in the belief that they are less valuable than commercial fisheries (Cooke and Cowx, 2006). However, total expenditure of this fishing practice across Europe is believed to exceed 25 billion Euros per year, a quantity very similar to the 26 billion Euros of trade in commercial fisheries (Pawson et al., 2008). Recreational fishing has important economic, social and cultural roles in the Mediterranean, representing more than 10% of total fisheries production (European Commission, 2004).

The recreational fishery from the Balearic Islands has been studied from the mid-2000s (Morales-Nin et al., 2005, 2008). It was estimated that between 5 and 10% of the Archipelago population were recreational fishers. A total of 73000 people practiced this leisure activity in Mallorca, using a high diversity of fishing gears (e.g. hand lines, anglers, pelagic or bottom trolling lines, pots and traps, jigging) depending on the fishing methods (shore fishing, boat fishing and spear diving fishing), season, target species and fishermen. Recreational catches included 60 species of fishes and cephalopods belonging to 28 different families, although few species comprised the bulk of catches (e.g. *Serranus cabrilla*, *S scriba*, *Coris julis*, *Symphodus tinca*, *Diplodus annularis*, *Diplodus vulgaris*, *Diplodus sargus*, *Octopus vulgaris*, *Xyrichthys novacula* and *Seriola dumerili*). Total annual catches of the recreational fishery from Mallorca ranged between 1200 and 2700 t, accounting for 30-65% of the official commercial landings (4000 t per year).

Although recreational fishery has important socioeconomic benefits for coastal communities, it can also have negative demographic and ecological effects on exploited populations, similar to commercial fishing (Coleman et al., 2004). Its potential impact on the marine ecosystems and living resources of the Balearic Islands is not negligible. Recreational and competitive spear fishing have a sizeable impact on the depletion of large rocky bottom littoral fish (e.g. grouper, *Epinephelus* spp.) and contributes to the non-profitability of some gears used by the small-scale fleet (Coll et al., 2004). Captures of the recreational fishery for squid (*Loligo vulgaris*) represent 34% of the total commercial landings, playing a relevant role in the population dynamics of this species (Cabanellas-Reboredo, 2014).

Due to the high number of practitioners of recreational fishing in the Balearic Islands, its impact on marine ecosystems and biological resources of the Archipelago cannot be ignored. The number of recreational fishing licenses increased dramatically during the first decade of the 2000s to reach the 51000 licenses in 2011, but has dropped to the 42000 over the last four years (**Fig. 3.3.1**). Given that there are still fishermen who operate without a license, this means that currently exist about 70 recreational fishermen for every professional fisherman. Based on these figures and the fact that recreational fishing shares with the small-scale fishery some of its main target species, it is essential to incorporate information on catches of this fleet when assessing and managing fishery resources from the Balearic Islands (see 5). This has not been possible so far owing to the lack of catch records from the recreational fishery, whereby it is absolutely necessary to establish a control and monitoring system of catches generated by this fleet (see 9.2).

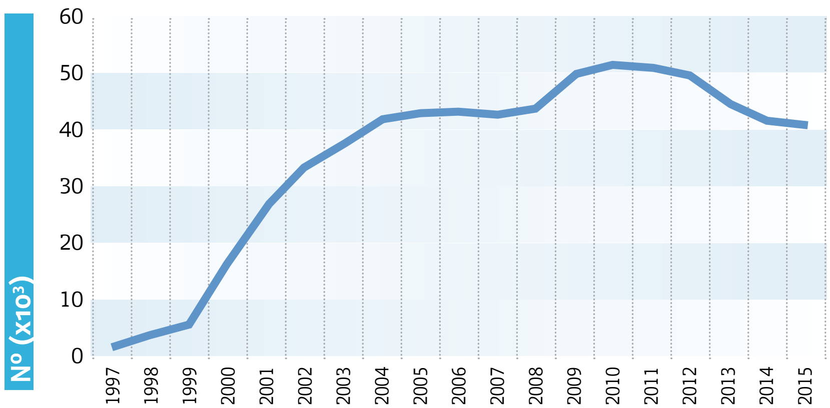


Fig. 3.3.1.
Number of licenses of the recreational fishery from the Balearic Islands during the period 1997-2015.

4 Stakeholders

From the beginning of the MYFISH project, two different stakeholders directly involved in the fishing industry have collaborated with scientists to elaborate this Regional Implementation Plan (RIP):

i) The Fishery Association of the Balearic Islands; and

ii) The General Directorate of Fisheries of the Autonomous Government of the Balearic Islands.

There have been continuous contacts and meetings with representatives of both stakeholders to outline a framework for the attainment of maximum sustainable yield (MSY; **Box 4**) variants and the design of the Decision Support Tables (see 7).

The non-governmental organization OCEANA (oceana.org) published a report entitled *Proposal for a responsible fishing in the Balearic Islands* (Carreras and Cornax, 2011) in the form of five different leaflets including:

i) a global view of the local fisheries;

ii) recreational fisheries;

iii) small-scale fisheries;

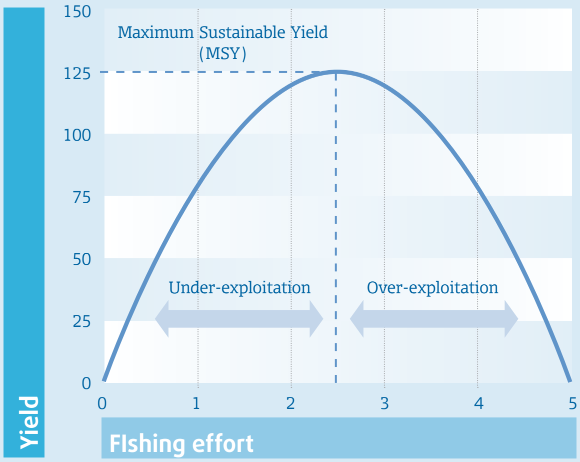
iv) marine protected areas; and

v) bottom trawl fisheries.

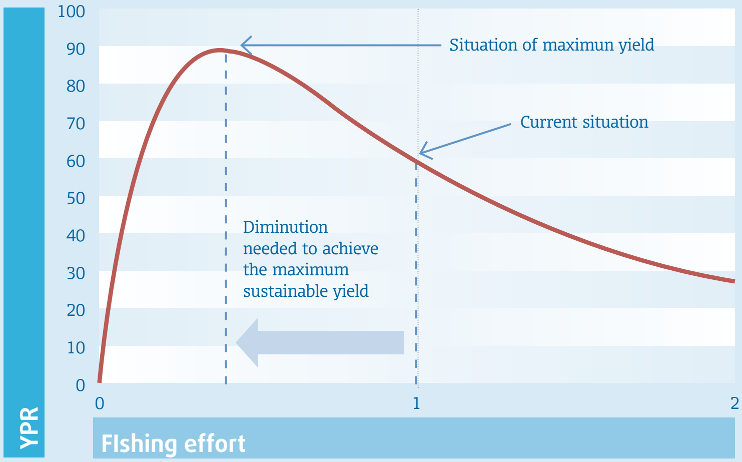
This material has been analysed and some proposals included in this RIP (see 9.1and 9.2).

What's the maximum sustainable yield (MSY)?

In fisheries science this is the greatest yield that can be taken from a fish stock over time while maintaining the stock's productive capacity under prevailing ecological conditions. The MSY refers to a hypothetical equilibrium state between the exploited population and the fishing activity. It is the maximum use that a renewable resource can sustain without impairing its renewability through natural growth and reproduction.



Theoretical evolution of the yield (vertical axis) obtained with increasing fishing effort (horizontal axis). The curve is parabola-shaped, with the highest point (vertex) representing the maximum sustainable yield (MSY). If the current effort is lower than the effort needed to get the MSY (on the left in the figure), the resource is underexploited, so that increases in effort will translate into yield increases. By contrast, if the current effort is higher than the effort needed to get the MSY, the resource is overexploited (right in the figure) and the effort should be reduced to obtain a higher yield.



Yield-per-recruit (YPR) graph of the hake population exploited by the bottom trawl fishery from Mallorca. The curve shows the theoretical evolution of the stock yield as a function of the fishing effort exerted. As shown, the yield obtained with the current effort is much lower than the maximum yield that could be obtained (MSY). This indicates that the hake stock is highly overexploited (see **Table 5.1.1**).

BOX 4

5

Exploitation status of the main stocks

5.1. Bottom trawl fishery

Table 5.1.1 compiles the total number of stocks from the Balearic Islands assessed up to now, highlighting the four main target species of the bottom trawl fishery (BTF). Regarding these four target species, hake shows the worst stock status (**Box 5**), with current fishing mortality being more than seven times the biological reference point ($F_{0.1}$). The striped red mullet is at an intermediate stock status, with $F_c=3 \cdot F_{0.1}$, whereas the red shrimp and the Norway lobster are comparatively in better status, with $F_c=1.7 \cdot F_{0.1}$.

The last assessments currently available of these four target stocks used different time series owing to differences in data availability (**Fig. 5.1.1**): hake (1980-2013), striped red mullet (2000-2013), Norway lobster (2002-2013) and red shrimp (1994-2013). The time series of recruitment and spawning stock biomass of hake showed large interannual fluctuations without a clear temporal trend. The red shrimp and Norway lobster neither showed any temporal trend and their time series did not fluctuate as much as that of hake. However, the striped red mullet did show a marked negative temporal trend in recruitment and spawning stock biomass, especially in recruits.

Table 5.1.1. Stock status indicators of species taken by the bottom trawl fishery (BTF) from the Balearic Islands showing the current fishing mortality (F_c), the reference biological point ($F_{0.1}$), the ratio between them ($F_c/F_{0.1}$) and the information source. The four main target species of the BTF are highlighted in bold.

Stock	F_c	$F_{0.1}$	$Fc/F_{0.1}$	Source
Black-bellied angler (*L. budegassa*)	0.84	0.08	10.5	STECF (2014)
European hake (*M. merluccius*)	1.15	0.15	7.7	GFCM (2014)
Red mullet (*M. barbatus*)	0.93	0.15	6.2	GFCM (2014)
Striped red mullet (*M. surmuletus*)	0.17	0.51	3.0	GFCM (2014)
Red shrimp (*A. antennatus*)	0.42	0.24	1.7	GFCM (2014)
Norway lobster (*N. norvegicus*)	0.29	0.17	1.7	STECF (2014)
Common octopus (*O. vulgaris*)	0.47	0.32	1.5	STECF (2012)
Deep-water pink shrimp (*P. longirostris*)	0.77	0.62	1.2	STECF (2013a)
Cuttlefish (*S. officinalis*)	0.44	0.41	1.1	Quetglas et al. (2015)

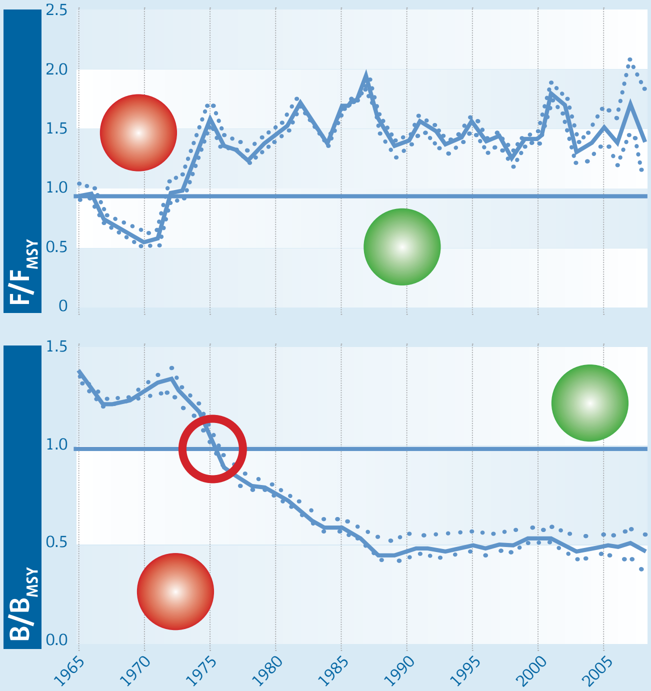
BOX 5

How to measure the exploitation state of a stock?

In fisheries science, the exploitation state of a stock is expressed by the use of reference points such as the well known F_{MSY} or $F_{0.1}$. A reference point is a conventional value, derived from technical analysis, which represents the state of the stock, and whose characteristics are believed to be useful for the management of this stock (Caddy and Mahon, 1995). The F_{MSY}, for instance, stands for the fishing effort consistent with achieving the maximum sustainable yield (see **Box 4**); the $F_{0.1}$ would be a proxy for F_{MSY}. **Table 5.1.1** shows both the $F_{0.1}$ and the current fishing effort (F_C) exerted by the bottom trawl fishery, together with the ratio between them ($F_C/F_{0.1}$). According to these ratios, the current fishing effort for hake is 7.7 times the fishing that should be applied to obtain a sustainable exploitation; hake is thus highly overexploited. The ratio for cuttlefish, by contrast, indicates this stock is close to its MSY ($F_C/F_{0.1}$=1.2).

In some cases, apart from the relative fishing mortality (F/F_{MSY}), the relative biomass (B/B_{MSY}) is also provided, which is simply the ratio between the current biomass of the stock and the biomass that enables it to deliver the MSY.

Striped red mullet



The evolution of the exploitation state of a stock with time can be represented in terms of these ratios, as shown in this figure. As a general consensus, whenever $B/B_{MSY}<1$ and $F/F_{MSY}>1$ indicate overexploitation (red light), while $B/B_{MSY}>1$ and $F/F_{MSY}<1$ indicate underexploitation (green light). The figure shows how the striped red mullet from Mallorca changed to the overexploitation state during the mid-seventies (red circle).

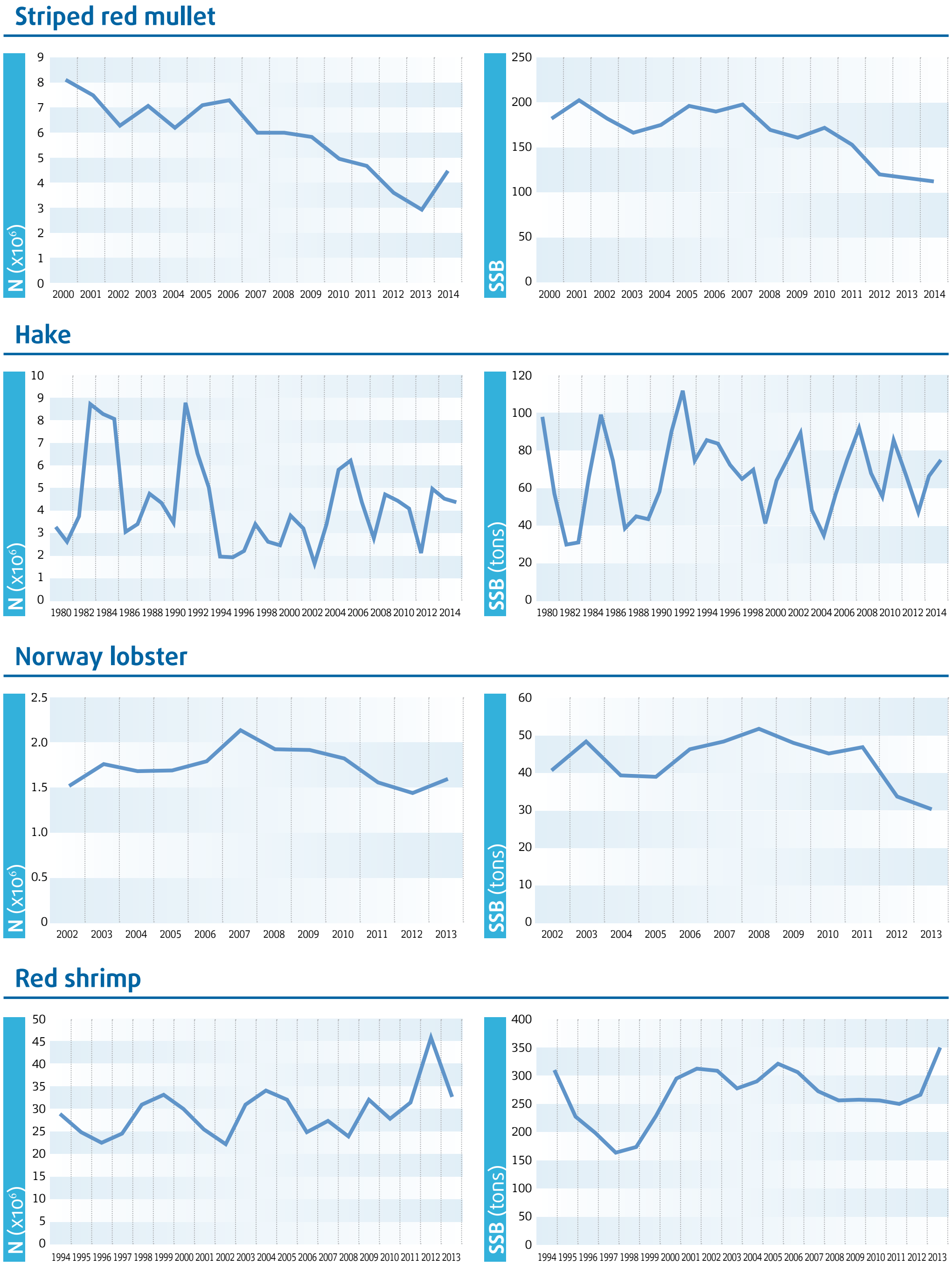


Fig. 5.1.1. Time series of recruitment and spawning stock biomass of the four main target stocks of the bottom trawl fishery from the Balearic Islands resulting from the stock assessments shown in **Table 5.1.1.**

The fishing effort that would lead the fishery towards two biological management reference points can be estimated with Figure 5.1.2, which shows total and individual (stock) catch and biomass, yield per recruit curves and fishing mortality for a range of fishing effort relative to the average from 2000 to 2011. According to these results, the maximum sustainable yield (MSY) for striped red mullet, hake, Norway lobster and red shrimp stocks would be achieved with effort reductions of 23%, 71%, 26% and 40% of current effort, respectively.

The levels of biomass, fishing mortality and yield per recruit corresponding to single species MSY are indicated with asterisks. At current effort levels, the four target species are exploited above their MSY values ($F>F_{MSY}$ and $B<B_{MSY}$). If all four species have to be exploited below their MSY, current fishing effort of Mallorca trawlers would have to be reduced by 71% (i.e. to 29% of current effort). If the multispecies maximum sustainable yield (MMSY), i.e. the aggregated catch from the four species, was to be maximized, the activity of trawlers would have to be reduced to 43% of current. At this point, hake would still be overexploited ($F>F_{MSY}$ and $B<B_{MSY}$) but the remaining three target species would be underexploited ($F<F_{MSY}$ and $B>B_{MSY}$), with red shrimp being nearby full exploitation (**Fig. 5.1.2**).

Although most available stock assessments from the BTF refer to the four main target species, efforts should be done to expand the list to other by-catch species given the multispecificity of this fishery which takes more than a hundred commercial species (**Box 6**).

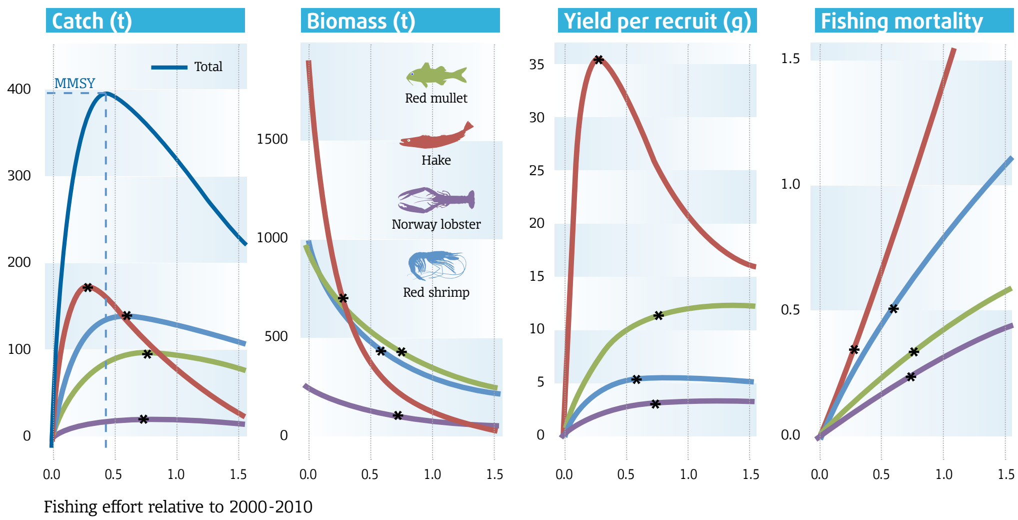
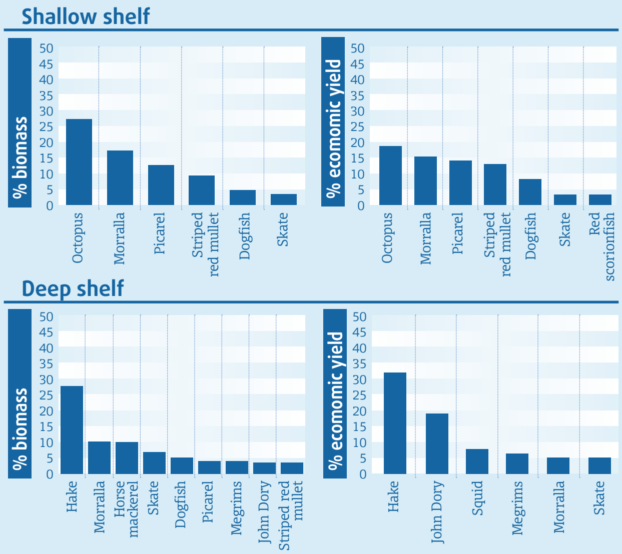
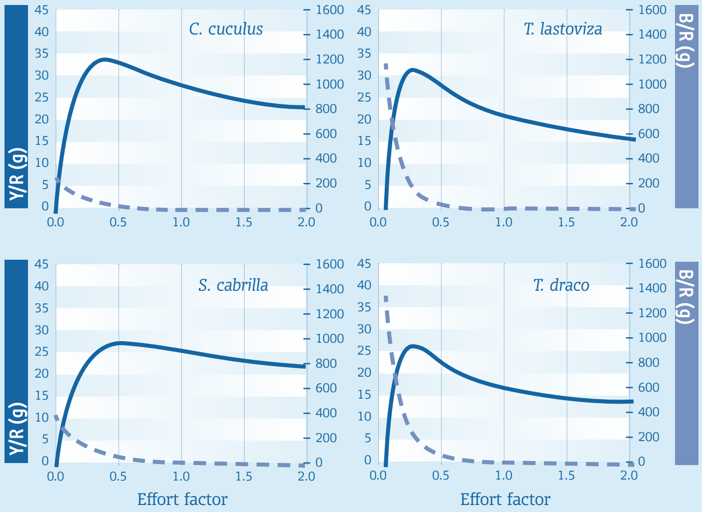


Fig. 5.1.2.
Catch, biomass, yield per recruit and mean fishing mortality at equilibrium for the four target species of the bottom trawl fishery from Mallorca as a function of fishing effort relative to the observed from 2000 to 2010. Asterisks indicate each species coordinates at maximum sustainable yield (MSY). The multispecies MSY (MMSY) of all four species combined is shown on the catch graph.

Assessing other than the target species

Demersal Mediterranean fisheries are highly multispecific, with more than 100 commercial species. This represents a challenge for the Common Fisheries Policy goal of bringing all European fish stocks to MSY levels by 2020 at the latest, as each species has specific MSYs and it is extremely difficult to regulate the fishing mortality for each species independently. Traditionally, Mediterranean stock assessments have focused on the main target species such as red mullet, hake and red shrimp. In the framework of the Ecosystem Approach to Fisheries, however, the exploitation status of a range of species other than the target stocks should also be analysed.





Apart of the target stocks (see 3.1), trawlers working on the continental shelf of the Balearic Islands take about 70 by-catch species (Ordines et al., 2006). Many of these species are sold together in a mixed fish category known as “morralla”. This is a common practice in some Mediterranean areas, allowing the commercialization of species that separately would have marketing difficulties. In the Balearic Islands, this category is among the most important in terms of both landed biomass and economic yield.

The red gurnard (*Chelidonichthys cuculus*), streaked gurnard (*Trigloporus lastoviza*), comber (*Serranus cabrilla*) and weever (*Trachinus draco*) are among the most important fish species within the “morralla”, accounting for the 55% in biomass (Ordines et al., 2014). All four species showed a general pattern of overexploitation, with yields per recruit below the MSY. Achieving the MSY in these species would require reductions of fishing effort even higher than those of some target species such as red mullet. This highlights the need of including species other than the main target stocks in management scenarios from the Balearic Islands.

BOX 6

5.2. Small-scale fishery

Annual catch per unit effort (CPUE) of the small-scale fishery (SSF) from Mallorca between 1990 and 2014 were estimated using fishery statistics (landings in kg; fishing effort in working days) provided by the local Fish Auction Wharf (OP-Mallorcamar). These data are the official statistics from the study area and thus constitute the most reliable available information.

Surplus production models were used to assess the eight target species of the SSF (**Fig. 3.2.1**) with the exception of the dolphinfish. The highly migratory behaviour of this species prevents the use of stock assessment methods at local scales such as in our case (STECF, 2013b), whereby its exploitation status was not assessed. According to the surplus production modelling, the remaining seven target species have been overexploited during the major part of the last 25 years (**Fig. 5.2.1**). In most cases, relative fishing mortality (F/F_{MSY}) has shown high fluctuations with some years being below one. Except for transparent goby during the early 1990s, F/F_{MSY} values have ranged between 0.6 and 2.5. Relative biomass (B/B_{MSY}) has remained rather constant for transparent goby and cuttlefish, whereas it has shown gradual ups and downs according to varying fishing mortality in all other species. Status indicators and management benchmarks of these seven species are in **Table 5.2.1.** Currently (2014), relative fishing mortality (F/F_{MSY}) is close to two for spiny lobster (2.13), scorpionfish (2.04) and dentex (2.02), and higher than one for transparent goby (1.53) and cuttlefish (1.27); current F equals F_{MSY} (0.98) in squid, but it is well below that reference point in the striped red mullet (0.71).

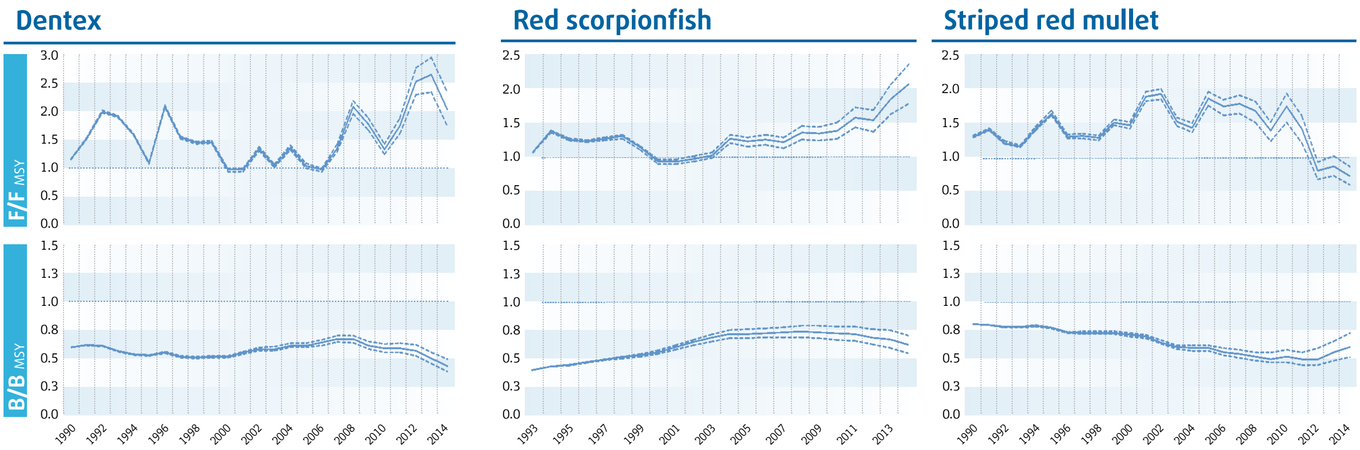
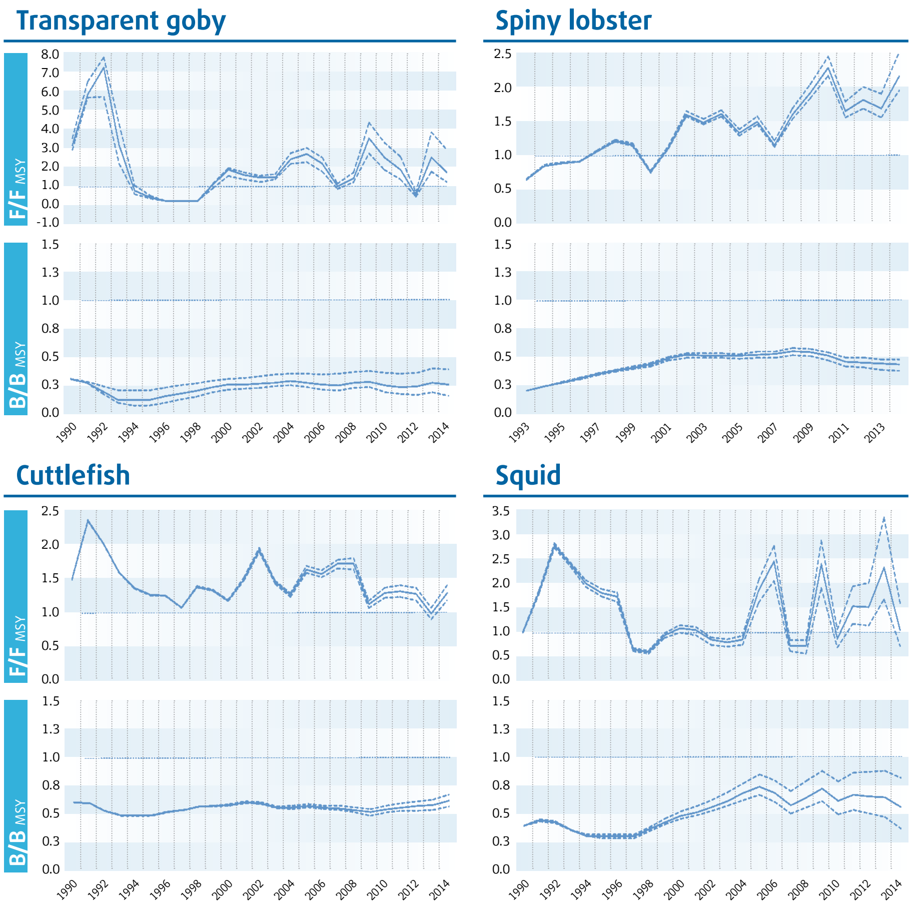


Fig. 5.2.1.
Time trajectories of the mean (continuous line) relative fishing mortality rate (F/F_{MSY}) and relative population biomass (B/B_{MSY}) estimated using non-equilibrium surplus production models for the seven (dolphinfish was not included) main target species of the small-scale fishery of Mallorca during 1990-2014. Dotted lines are 80% bias-corrected confidence intervals from bootstrapping.



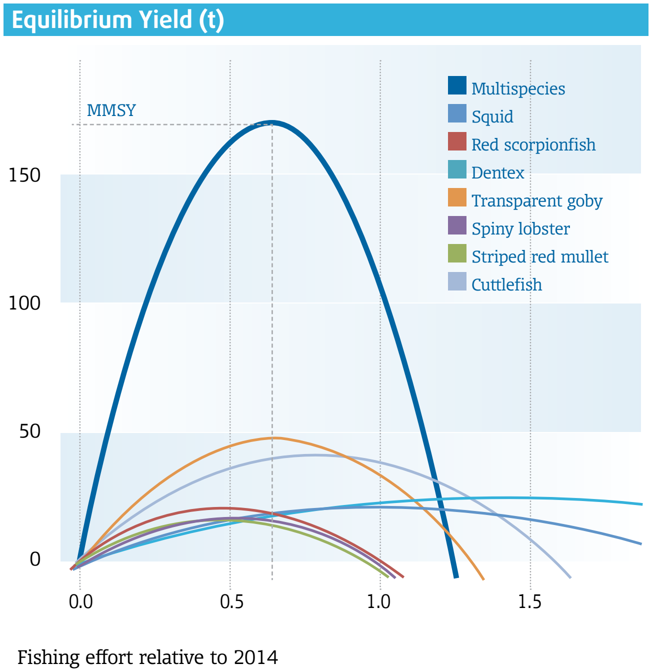
Parameter	Dentex	Red scorpionfish	Striped red mullet	Transparent goby	Spiny lobster	Cuttlefish	Squid
B1/K	0.30	0.20	0.40	0.15	0.10	0.30	0.20
K	265.5 (255.3-282.1)	266.1 (253.9-290.3)	344.8 (323.8-377.4)	1150.0 (892.1-1965.0)	217.7 (207.2-235.0)	596.7 (577.3-620.1)	260.7 (226.1-301.8)
MSY	16.8 (16.7-16.9)	20.63 (20.55-20.85)	24.57 (24.23-24.82)	46.97 (41.24-51.76)	15.82 (15.61-15.17)	41.64 (41.41-41.84)	20.87 (20.68-21.06)
$B2015/B_{MSY}$	0.411 (0.356-0.482)	0.562 (0.485-0.660)	0.657 (0.552-0.792)	0.258 (0.145-0.405)	0.398 (0.332-0.452)	0.624 (0.566-0.687)	0.601 (0.377-0.880)
$F2014/F_{MSY}$	2.023 (1.739-2.321)	2.044 (1.760-2.333)	0.708 (0.582-0.847)	1.534 (0.996-2.697)	2.135 (1.918-2.486)	1.273 (1.154-1.400)	0.982 (0.668-1.532)
Ye2015	10.97 (9.76-12.36)	16.67 (15.18-18.28)	21.67 (19.41-23.76)	21.14 (12.14-30.39)	10.09 (8.92-11.01)	35.74 (33.66-37.75)	17.55 (12.68-20.49)
Ye2014/MSY	0.653 (0.585-0.731)	0.808 (0.735-0.884)	0.882 (0.799-0.957)	0.450 (0.268-0.646)	0.638 (0.553-0.700)	0.858 (0.812-0.902)	0.841 (0.617-0.976)

Table 5.2.1.
Status indicators and management benchmarks of the logistic surplus-production models applied to seven target species of the small-scale fishery from Mallorca during 1990–2014. Point estimates and bias-corrected 80% confidence intervals (between parentheses) are shown. Where: B_1/K= ratio of the biomass at the beginning of the first year to K; K = carrying capacity; MSY = maximum sustainable yield; B_{2015}/B_{MSY} = biomass at beginning of 2015 (year following the analysis) relative to biomass at MSY; F_{2014}/F_{MSY} = fishing mortality rate in 2014 as compared with F at MSY; Ye_{2015}= equilibrium yield available in 2015; and Ye_{2015}/MSY= yield in 2015 as compared with MSY. Values of B, K, MSY and Ye are in tons.

The fishing effort that would lead the SSF toward the MSY can be inferred from **Figure 5.2.2** which shows multispecies maximum sustainable yield (MMSY) and per stock yield for a range of fishing effort relative to 2014. According to these results, red mullet and squid are not overexploited in the current year (2014) and there would be room for an important increase of current effort in the former (41%) but a slight increase (2%) in the second. In the remaining assessed stocks, the MSY would be achieved with the following effort reductions: spiny lobster (53%), red scorpionfish (51%), dentex (50%), transparent goby (35%) and cuttlefish (21%).

We would like to stress the fact that, although the overexploitation of most stocks seems to reflect the current situation of the resources, the actual values of relative fishing mortality and biomass reported here should be interpreted with much care. The assessments were performed using official fishing statistics, which are known to be underestimated in Mediterranean SSF owing to unreported catches (Coll et al., 2014; Pauly et al., 2014). Sales of fish outside the official market are especially important in species with high commercial value such as dentex, red scorpionfish and spiny lobster, which are precisely the stocks showing the worst exploitation status. Unreported catches may result in underestimation of fishing mortality, leading to biased stock assessments that hamper achieving a sustainable exploitation (Punt et al., 2006; Bellido et al., 2011). This reinforces the need to sensitize fishermen about the importance of providing the best data possible to scientists in order to help improving the stock assessment and management. Although the currently available information prevented estimating the underreported catches, our ongoing works will allow future

Fig. 5.2.2.
Yield (tons) at equilibrium for the seven small-scale fishery target species from Mallorca assessed in this study and their corresponding multispecies maximum sustainable yield (MMSY) as a function of fishing effort relative to the current effort (2014).



studies incorporating reliable estimates. The problem of the underreported catches is compounded by the recreational fisheries, which share some of the main SSF target species (see 3.3). In the highly touristic Balearic Islands, where recreational catches represent 43% of the commercial ones (Morales-Nin et al., 2015), this activity might affect seriously the exploitation state of some target stocks. Moreover, some of the recreational catches are illegally commercialized, affecting the fish demand of the SSF as well (Merino et al., 2008).

6 Bioeconomic analysis

The average price of fish from the Mallorca fish auction (OP-Mallorcamar) is 6.6 €/kg with emblematic species such as red shrimp and Norway lobster reaching 30-40 €/kg or even up to 60 €/kg in the case of spiny lobster. However, the average price of fish in the Mallorca auction has reduced progressively during the last years since it peaked in 2003. Together with the increase on fuel price, Mallorca's fishermen, as elsewhere in the Mediterranean, have had to cope with a constant decrease of the fish-price/fuel-price ratio, i.e. more fishing costs and lower value for their products (**Fig. 6.1**).

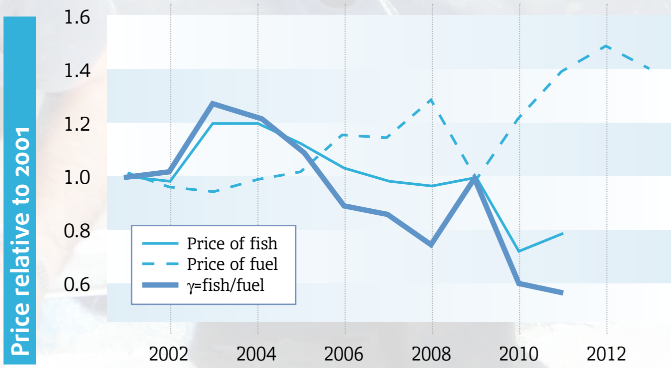


Fig. 6.1. Recent trends of the real average price of fish from Mallorca's auction wharf, price of fuel (European Commission, 2013) and fish/fuel price ratio since 2001.

In this section, alternative management actions directed towards achieving societal objectives, including rebuilding fish stocks and increasing catch and profits, were evaluated. In order to achieve conservation and economic objectives, deciding the correct dimension of fisheries and their activity is paramount. For our case study, the impact on fisheries performance indicators of the following four management scenarios were tested for the BTF and SSF: I) a projection of current conditions (Control, C); II) the main target species will be located in the green quadrant of a Kobe plot ($F<F_{MSY}$ and $B>B_{MSY}$) (All Green, AG); III) the maximum aggregated catch (Multispecies Maximum Sustainable Yield, MMSY) of the target species will be sought; and IV) the maximum economic profits (Maximum Economic Yield, MEY) of the fishery will be achieved.

The bioeconomic analyses were carried out using the MEFISTO 3.0 bio-economic simulation model (Mediterranean Fisheries Simulation Tools, www.mefisto.info), which was specifically designed to address management issues under the Mediterranean regulation system (Lleonart et al., 2003; Maynou et al., 2006). MEFISTO is composed by two main submodels (biological and economic). The first simulates the population dynamics of the main target species of a fishery using an age structured model for each species, including stock recruitment relationships, individual growth, length–weight relationships, age specific natural and fishing mortalities, and maturity. This model can also be substituted by a surplus production model (Schaefer, 1954) when data for running age structured models are not available. The fishing mortality is composed by a "static" species and age-specific component or catchability coefficient and a "dynamic" component or fishing effort, equal for all species and ages, measured as the number of boats multiplied by their activity in days and hours at sea. MEFISTO is a numeric bioeconomic model running at an annual scale; hence total fleet effort was not allocated seasonally among species in our simulations. Total fleet effort is translated into species-specific fishing mortality by appropriate catchability coefficients for each fish stock. The economic component accounts for the catch of target and secondary species, their value, the costs incurred by fishing vessels, and the resulting net profits.

6.1. Bottom trawl fishery

The following bioeconomic analysis of the bottom trawl fishery (BTF) from Mallorca has been published by Merino et al. (2015). The global outputs of this bioeconomic model are shown in **Figure 6.1.1**, where the following parameters are displayed as a function of the fishing effort relative to the observed during 2001-2011: I) total, together with target and secondary species, revenues; II) fishing costs under different fish/fuel price increases (10, 20 and 30%); and III) the fishery net profits. Target species refer to the already described (see 3.1) four stocks (striped red mullet, hake, Norway lobster and red shrimp), whereas secondary species refer to all remaining by-catch species.

Under current economic conditions and current fishing effort, the Mallorca's BTF generates $1.29 \cdot 10^6$ € of net profits. In order to achieve the maximum economic yield (MEY), which the model situates at $1.90 \cdot 10^6$ € (**Fig. 6.1.1b**), the fishing effort has to be reduced to 52% of current (approximately 115.44 fishing days per year). Lower, moderate reductions of fishing effort would also bring notable profit increases. For instance, reducing from 5 to 4 working days per week, i.e. reducing the fishing effort below 80% of what it is now, the expected profits would be above $1.60 \cdot 10^6$ €. If the price of fish to cost ratio was to increase 10, 20 and 30%, the MEY would reach 1.99, 2.11 and $2.22 \cdot 10^6$ €, respectively. Therefore, a sound fishing effort strategy would push the profitability up 146% while increasing subsidies or other interventions to increase the price/costs relationship would increase profits 116% if the fishery was at MEY. Another salient aspect is that increasing the ratio between price of fish and price of fuel with subsidies (**Box 7**) that reduce costs or other interventions to increase the price of fish would displace the economic optimum toward higher fishing effort levels than the MEY for current economic conditions.

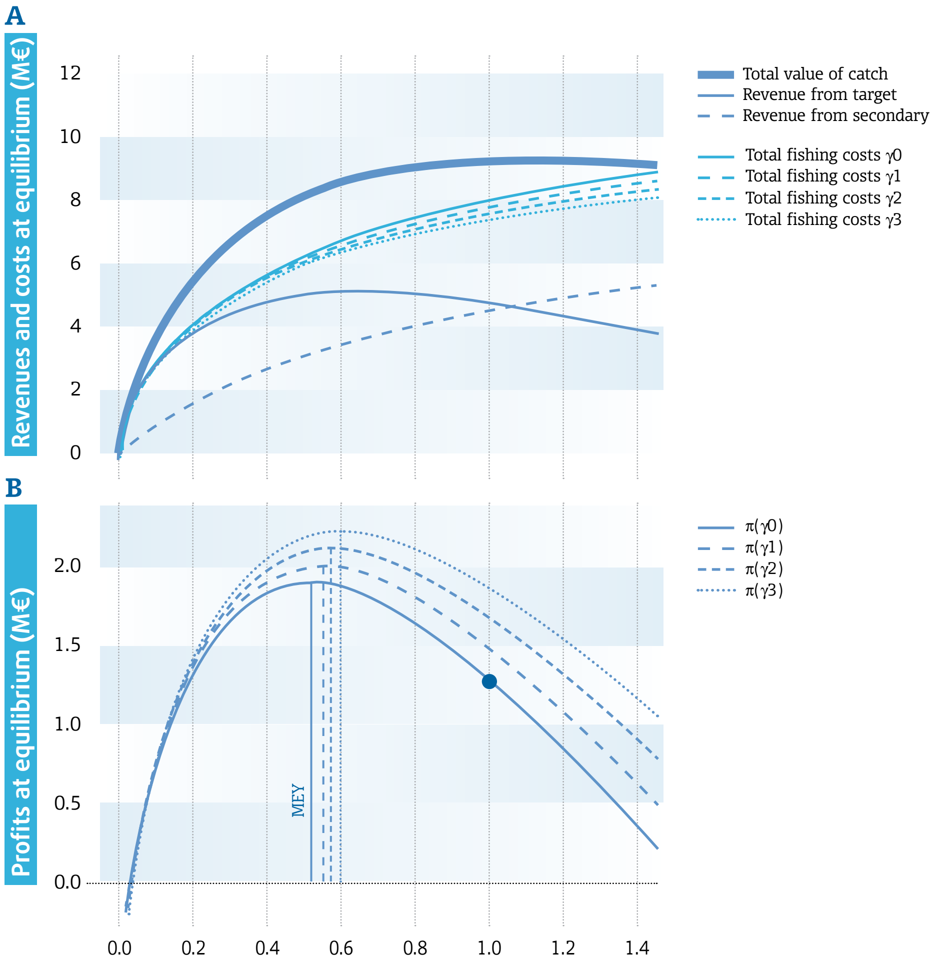


Fig. 6.1.1. (A) Equilibrium revenues (total, target and secondary species) and fishing costs of the bottom trawl fleet from Mallorca as a function of fishing effort relative to the observed from 2001 to 2011. Alternative total fishing costs trajectories represent different levels of ratios between fish and fuel price obtained by subsidizing fuel price (γ0=current situation, γ1=+10%, γ2=+20%, γ3=+30%); (B) equilibrium profits for the fishery as a function of fishing effort relative to the observed from 2001 to 2011 and for four alternative levels of ratios between fish and fuel price (γ0, γ1, γ2, γ3). The point indicates the equilibrium profits for the average effort of 2001–2011.

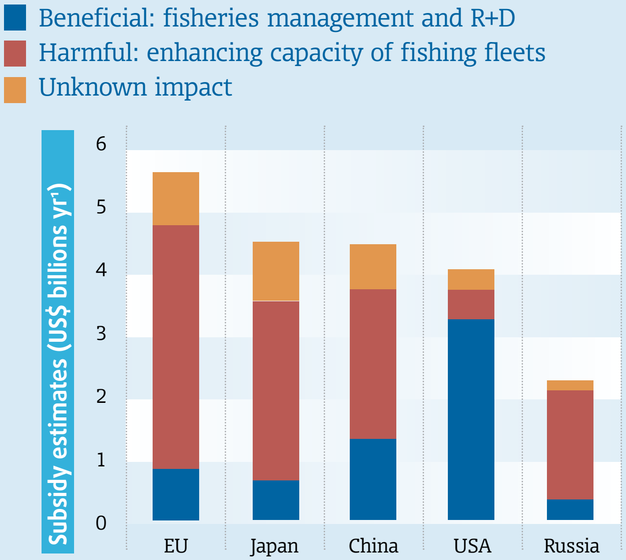
Fisheries subsidies

Subsidies intended to reduce the cost of fisheries operations and to enhance revenues make fishing enterprises more profitable, but also contribute to the overexploitation of living resources owing to excessive fishing capacity. A recent report on fishing subsidies (Sumaila et al., 2013) revealed that global fisheries subsidies were estimated at about USD 35 billion in 2009 dollars, being Asia by far the greatest subsidizing region (43% of total), followed by Europe (25% of total) and North America (16% of total).

After years of worries about overfishing and damage to the marine environment, critics advocate for more spending on sustainability and conservation rather than on capacity building (Cressey, 2013). This is the model used in the USA, which spends the vast majority of fishing subsidies to "beneficial" activities such as conservation (see Figure). By contrast, all other main regions (EU, Japan, China and Russia) dedicate the bulk of subsidies to "harmful" activities such as increases in fishing capacity.

NET SPEND

Researchers say that fisheries subsidizers allocate more to potentially harmful subsidies such as fuel than to "beneficial" activities such as conservation.



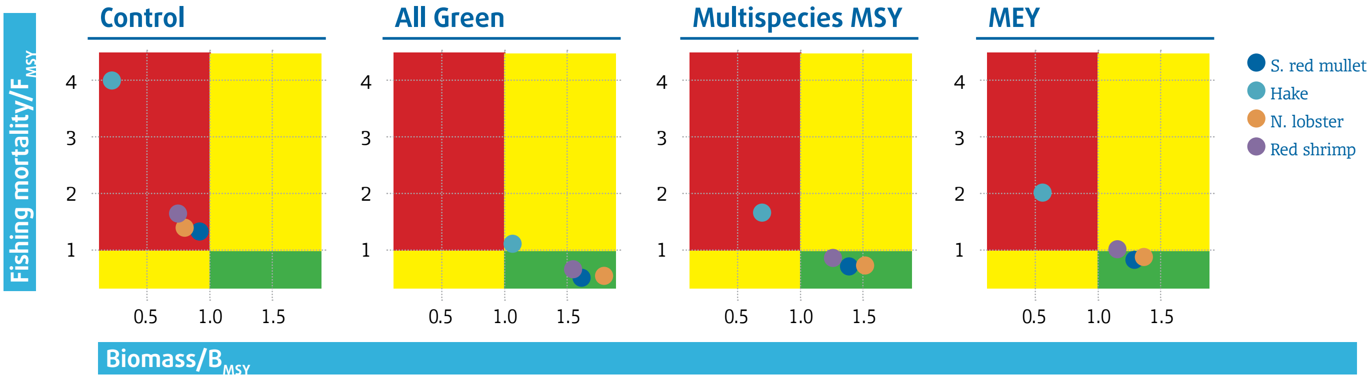
Although some nations (notably New Zealand) are phasing out damaging subsidies, a similar global agreement seems difficult because many countries, such as France and Spain, still believe they are crucial for the fishing sector.

However, there is a general agreement among scientists that "harmful" subsidies should be cut in order to have sustainable fisheries. According to Ray Hilborn, a fisheries researcher at the University of Washington in Seattle, a properly managed fishery should not need subsidies: "If fisheries are well managed, they are very profitable and they should have to fend for themselves" (Cressey, 2013).

BOX 7

The fishing effort reductions required to achieve the simulation management scenarios aforementioned are shown by means of Kobe plots (**Fig. 6.1.2**). Currently (Control) the four target stocks are overfished ($B<B_{MSY}$) and under overfishing ($F>F_{MSY}$). The "All Green" scenario would lead all stocks to the bottom-right area and therefore, none would be overfished or under overfishing. With this scenario, hake would be at B_{MSY} and the biomass of red shrimp, striped red mullet and Norway lobster would be above 1.5 times the B_{MSY}. With the effort reduction required to achieve the MMSY scenario, i.e., to maximize the total catch of all four species combined, hake would continue to be overexploited and under overexploitation but at more secure levels than in the Control scenario. The effort reduction required to achieve the MEY is not as drastic as for the MMSY scenario. However, hake would continue to be overexploited and under overexploitation while the other three would remain at secure levels, with red shrimp very close to full exploitation.

Fig. 6.1.2.
Equilibrium state of alternative management strategies for the four target species of the bottom trawl fishery from Mallorca represented in a Kobe plot.



Stochastic simulations were run for the aforementioned management scenarios. **Figure 6.1.3** shows the expected catch of the four target species and the impact of the estimated uncertainty of stocks recruitment on simulated catch. Effort reductions cause immediate reduction of catches in all four target species. However, after a transition of <10 years they reach a new equilibrium. The catch differences among scenarios are particularly notable in the case of hake, the most overexploited species. Furthermore, hake's recruitment variability is expected to produce significant uncertainty on its catch. Hake in the AG scenario would remain at MSY levels where the variability of catch is expected to be larger than for the other scenarios because fishing at MSY increases variability (Anderson et al., 2008) and because its stock recruitment model does not estimate recruitment accurately. **Figure 6.1.3** confirms the results showed in

Figure 5.1.2: effort reductions will not bring significant gains in catch for striped red mullet, red shrimp and Norway lobster but will considerably improve hake's state of exploitation. Effort reductions do bring significant economic benefit (**Fig. 6.1.4**). Although effort reductions are not expected to produce major catch increases for the most valuable species, the drastic reduction in fishing costs is expected to produce a notable increase in profits for the fleet. The equilibrium profits estimated using stochastic stock–recruitment relationships are slightly different from the ones estimated with the deterministic simulation (**Fig. 6.1.1)**. The estimated average profit at equilibrium for the current effort strategy is $1.35 \cdot 10^6$ € with a coefficient of variation of 16.8%. In contrast, the cost reduction consequent to the tested management scenarios increases profits notably: I) AG: $1.56 \cdot 10^6$ € (CV = 18.26%); II) MMSY: $1.81 \cdot 10^6$ € (CV = 14.05%); and III) MEY and three subsidized levels: 1.91, 1.96, 2.08 and $2.23 \cdot 10^6$ € with CV's between 12 and 14%. In addition to the potential benefit of effort reductions, **Figure 6.1.4** reveals the significant variability in total profits that is expected due to recruitment variability in target species.

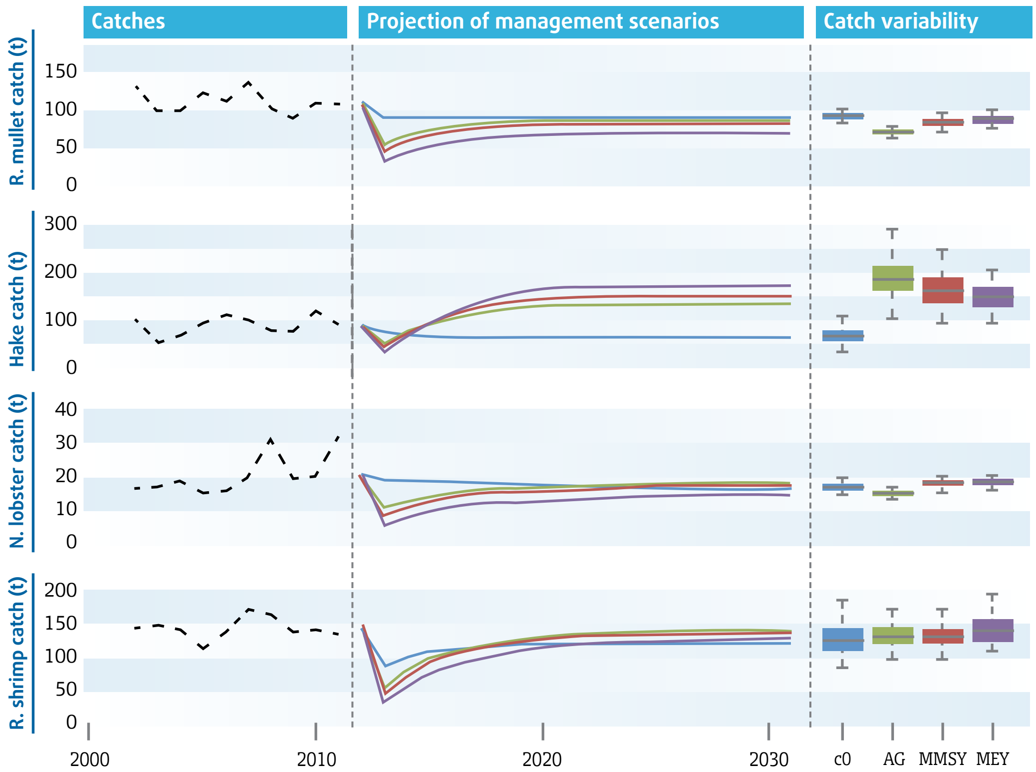
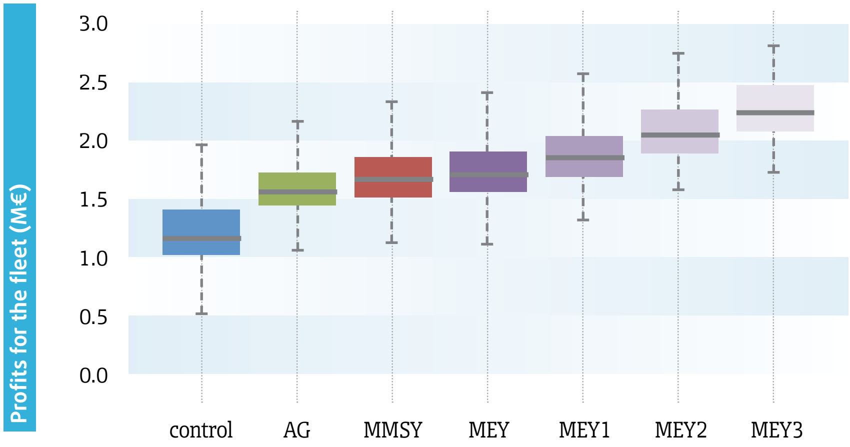


Fig. 6.1.3.
Observed fish catch from 2001 to 2011 (left), deterministic projection of four management scenarios from 2012 to 2032 (centre) and boxplot of the expected catch at equilibrium (right) considering recruitment variability for the four target species of the bottom trawl fleet from Mallorca. The scenarios are: control (c0), all green (AG), multiple maximum sustainable yield (MMSY) and maximum economic yield (MEY).

Fig. 6.1.4.
Boxplot of the expected profits (Million €) under 7 management scenarios considering recruitment variability. Average profits and 75% and 95% confidence intervals are drawn in the boxes. The scenarios are: control (c0), all green (AG), multispecies maximum sustainable yield (MMSY) and maximum economic yield (MEY). The latter with increasing ratios of price of fish/price of fuel: MEY1 = +10%, MEY2 = +20% and MEY3 = +30%.



6.2. Small-scale fishery

Given that the small-scale fishery (SSF) uses different FTs along the year, all target species have to be integrated when evaluating the economic performance of this fishery as a whole. Individual analyses for each stock will only give fragmentary information on that specific stock.

The effort reductions required to achieve sustainable exploitation of the SSF are much lower than those foreseen for the BTF. According to the bioeconomic model results, if all seven target species of the SSF were exploited below their MSY (All Green scenario), current fishing effort would have to be reduced by 53%. If the aggregated catch from all species was to be maximized (MMSY), the activity of the SSF would have to be reduced by 38%. In case the maximum economic yield (MEY) would have to be attained, reductions required in fishing effort would be markedly lower (28%).

Under current economic conditions and current fishing effort, the SSF generates $2.86 \cdot 10^6$ € of net profits. With the parameters used in this work, total profits would slightly decrease down to $2.82 \cdot 10^6$ € in the All Green scenario and would reach as much as about $3.3 \cdot 10^6$ € under the MMSY ($3.29 \cdot 10^6$ €) and MEY ($3.34 \cdot 10^6$ €) scenarios (**Fig. 6.2.1**). The equilibrium point of all these scenarios is shown in Kobe plots (**Fig. 6.2.2**), which revealed that, with the exception of the striped red mullet, all other target species are currently overfished (Control scenario). The All Green scenario would lead all stocks to the bottom-right area, where dentex, scorpionfish and spiny lobster would be at B_{MSY} while the biomass of the remaining stocks would range between 1.3 and 1.7 times the B_{MSY}. Under the MMSY and MEY scenarios, three stocks (dentex, scorpionfish and spiny lobster) would continue to be overexploited but at more secure levels than in the control scenario.

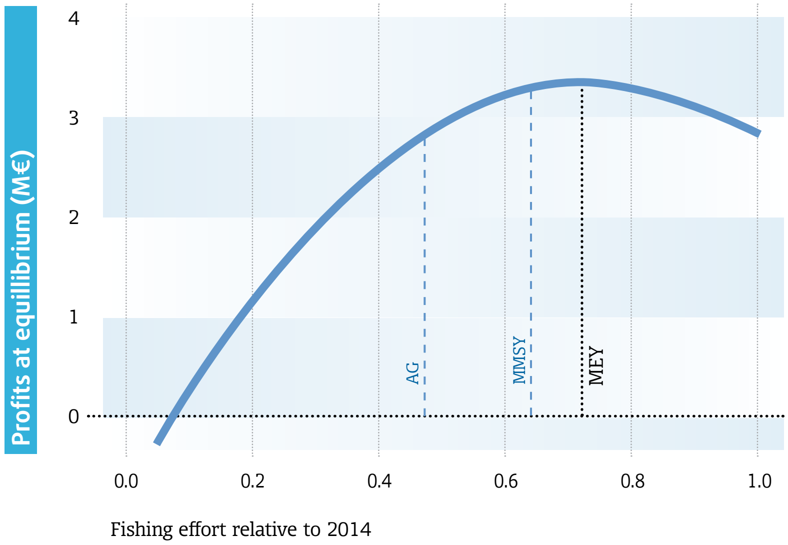
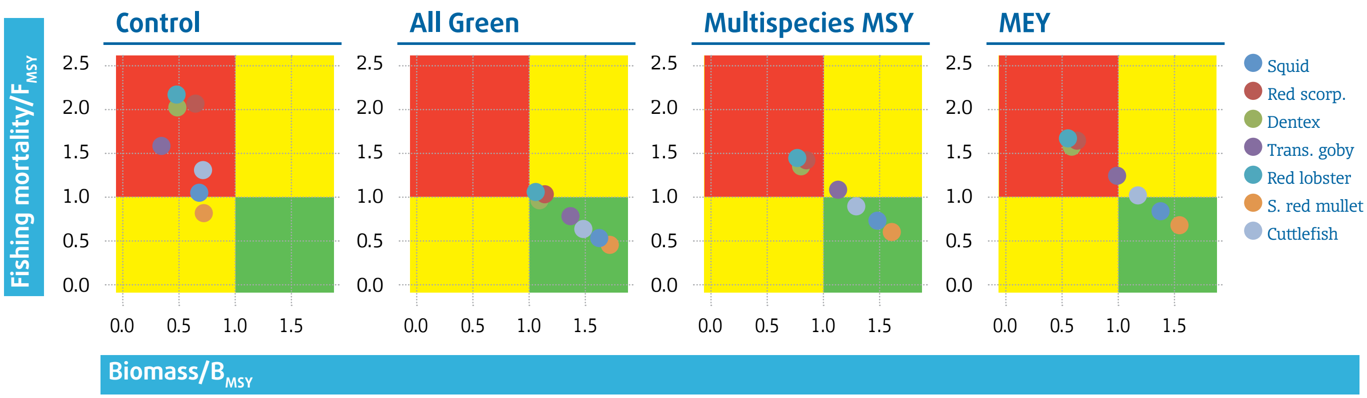


Fig. 6.2.1.
Equilibrium profits (Million €) of the small-scale fishery from Mallorca under the three different scenarios modelled in this study as a function of fishing effort relative to the current effort (2014): AG: All Green; MMSY: multispecies maximum sustainable yield; and MEY: maximum economic yield.

Fig. 6.2.2.
Kobe plot graphs showing the equilibrium state of current conditions (control) and three different alternative management scenarios for the seven SSF target species of the small-scale fishery from Mallorca.



7 Decision Support Tables

The main results of the previous studies are the basis of Decision Support Tables (DSTs), graphical tables that reflect the effects and trade-offs of implementing different MSY options on ecosystem, economic and social constraints and with particular focus on the risk of exceeding acceptable levels for these constraints. The DSTs have been designed to convey complex, alternative management scenarios in a simple and understandable way to support fisheries managers in their decision making. The DSTs allow investigation of management measures and show the potential consequences of their implementation on economic, ecological and social aspects in the region of interest. They are intended to inform a framework for implementation of MSY variants and support the development of Long Term Management Plans.

Two different DSTs were elaborated for the two main demersal fisheries from the Balearic Islands analysed in this report, the bottom trawl (**Fig. 7.1**) and the small-scale (**Fig. 7.2**) fishery. Both DSTs include three different management scenarios: i) the current situation, which is considered unsustainable given that all (BTF) or most (SSF) stocks are over-exploited; ii) the MEY predicted by the bio-economic model, which is considered unfeasible by the fishermen owing to the very high reductions in fishing effort required; and iii) an intermediate scenario in between these two previous, extreme situations in which the figures (effort, catch, economic value) are the average between the current and the predicted MEY scenarios.

In the Predicted outcomes section, the DST is split into two different parts: i) Target stocks; and ii) Fishery. The first section displays the status indicators (relative F) together with catch and economic value for each main target stock separately. The second section includes information regarding the fishery as a whole, such as total gross revenues, together with revenues, costs and profits per vessel.

The Expert opinion block takes into account qualitative aspects that are not integrated by the bioeconomic model but considered very important for the stakeholders: i) Marketing investments, necessary to increase the fish-price/fuel-price ratio;

II) Employment, or number of jobs in the fishing sector; III) The viability of the fishing sector itself; IV) The dependence on subsidies, to cope with the diminution of benefits owing to the fishing effort reductions required; and V) The ecosystem impacts on the sea bottoms exploited by the fishery.

As aforementioned, the fishing effort reductions predicted by the bioeconomic model to reach the MEY were 48% for the BTF and 28% for the SSF. As also mentioned, the large effort reductions required by the BTF are considered unfeasible by fishermen, which make necessary using the intermediate management scenario. However, the moderate reductions to be applied in the case of the SSF would make feasible considering the MEY scenario instead of the intermediate one.

In addition to the DSTs we have just described, a shorter, more visual format has also been prepared to be used in presentations and dissemination activities (**Figs. 7.3, 7.4**).

Fig. 7.1.
Decision Support Table (DST) from the Mallorca bottom trawl fishery.

Western Mediterranean DST (Mallorca, bottom trawl fishery)					
Management issue		**Subject of decision:** Balearic Sea, bottom trawl fleet, four "target" stocks (striped red mullet, hake, Norway lobster, red shrimp).			
		Management decision background: Management is carried out through effort control (allowed time at sea: 12 h/day, 5 days/week) and technical measures (species landing sizes, gear mesh sizes). Highly multispecific fishery working at four different depth strata (shallow and deep shelf, upper and middle slope) targetting different assemblages (red mullet, hake, Norway lobster, red shrimp). According to stakeholders, the viability of the fishery depends on marketing aspects (increasing fish/fuel price ratio) rather than on the exploitation status of the main stocks; for fishers, the fuel price is the main constraint.			
		Nature of decision: Reductions of fishing effort in order to improve both the exploitation status of the target stocks and the viability of the fishery by means of reducing fishing costs (mainly fuel consumption). Differential effort reductions according to the exploitation status of each single stock (diversification of the fishing exploitation). Improvements in the marketing should also be put in force.			
Options		**Name**	Current	Intermediate	MEY[3]
		Stock conservation status	unsafe	high	optimun
		Short/Medium term profit levels	medium	medium	low
Predicted outcomes	Modelled by MEFISTO[1]	**A) Target stocks**			
		A.1) Relative F (F/F_{MSY})			
		Striped red mullet	3.00	1.84	0.68
		Hake[2]	7.71	5.86	4.01
		Norway lobster	1.70	1.25	0.79
		Red shrimp	1.67	1.27	0.87
		A.2) Catch (t)			
		Striped red mullet	92.7	93.7	94.6
		Hake	84.5	128.1	171.7
		Norway lobster	32.3	25.7	19.1
		Red shrimp	111.2	125.0	138.8
		A.3) Economic value (M€)			
		Striped red mullet	0.380	0.405	0.430
		Hake	0.379	0.270	0.160
		Norway lobster	0.671	0.581	0.490
		Red shrimp	3.095	3.418	3.740
		B) Fishery (in M€)			
		Fishery gross revenues	9.400	8.700	8.000
		Mean gross revenues/vessel	0.294	0.272	0.250
		Costs/vessel	0.250	0.219	0.188
		Net profits/vessel	0.044	0.053	0.063
	Expert opinion	Marketing investments	low	high	very high
		Employment (# of jobs)	low	medium	very low
		Fishing sector viability	low	high	very low
		Dependence on subsidies	medium	medium	very high
		Ecosystem impacts	high	medium	low
Comments		(1) Bio-economic model specifically designed for Mediterranean fisheries (Lleonart et al. 2003). (2) Since hake is the most over-exploited species, effort reductions should be higher on its fishing grounds (deep shelf). Even a recovery plan should be considered. (3) The MEY is achieved reducing the current fishing effort by 48% for all four target species.			

Fig. 7.2.
Decision Support Table (DST) from the Mallorca small-scale fishery.

Western Mediterranean DST (Mallorca, small-scale fishery)					
Management issue		**Subject of decision:** Balearic Sea, small-scale fleet, seven "target" stocks (dentex, red scorpionfish, striped red mullet, transparent goby, spiny lobster, cuttlefish, squid). Although dolphinfish is the most important target species in terms of landings, it is not included here because it was not assessed (the highly migratory behaviour of this species prevents the use of stock assessment methods at local scales such as in our case).			
		Management decision background: Management is carried out through effort control (allowed time at sea: 12 h/day, 6 days/week) and technical measures (species landing sizes, gear mesh sizes). Highly seasonal fishery using different gears along the year depending on the target species. According to stakeholders, the main problems are the exploitation status of some target stocks (spiny lobster, dentex, red scorpionfish) and the competition with other fisheries, especially recreational fisheries.			
		Nature of decision: Reductions of fishing effort in order to improve the exploitation status of some target stocks (spiny lobster, dentex, red scorpionfish). Differential effort reductions according to the exploitation status of each single stock (diversification of the fishing exploitation). Improvements in the marketing should also be put in force.			
Options		**Name**	Current	Intermediate	MEY[2]
		Stock conservation status	unsafe	high	optimun
		Short/Medium term profit levels	medium	medium	low
Predicted outcomes	Modelled by MEFISTO[1]	**A) Target stocks**			
		A.1) Relative F (F/F_{MSY})			
		Dentex	2.023	1.740	1.457
		Red scorpionfish	2.044	1.758	1.472
		Striped red mullet	0.708	0.609	0.510
		Transparent goby	1.534	1.319	1.104
		Spiny lobster	2.135	1.836	1.538
		Cuttlefish	1.273	1.095	0.917
		Squid	0.982	0.844	0.707
		A.2) Catch (in t)			
		Dentex	14.359	14.515	14.671
		Red scorpionfish	24.877	21.342	17.808
		Striped red mullet	10.905	14.343	17.780
		Transparent goby	18.459	32.699	46.938
		Spiny lobster	14.002	13.444	12.885
		Cuttlefish	32.812	36.776	40.740
		Squid	11.905	15.163	18.422
		A.3) Economic value (in M€)			
		Dentex	0.204	0.232	0.261
		Red scorpionfish	0.448	0.390	0.331
		Striped red mullet	0.115	0.154	0.192
		Transparent goby	0.364	0.668	0.972
		Spiny lobster	0.512	0.497	0.483
		Cuttlefish	0.321	0.354	0.387
		Squid	0.254	0.339	0.425
		B) Fishery (in M€)			
		Fishery gross revenues	2.860	3.680	4.499
		Mean gross revenues/vessel	0.064	0.077	0.090
		Costs/vessel	0.047	0.053	0.060
		Net profits/vessel	0.017	0.024	0.030
	Expert opinion	Marketing investments	low	high	high
		Employment (# of jobs)	low	medium	medium
		Fishing sector viability	low	medium	high
		Dependence on subsidies	medium	medium	low
		Ecosystem impacts	high	medium	low
Comments		(1) Bio-economic model specifically designed for Mediterranean fisheries (Lleonart et al. 2003). (2) The MEY is achieved reducing the current fishing effort by 28% for all target species.			

Fig. 7.3.
Visualized form of the Decision Support Table (DST) from the Mallorca bottom trawl fishery.

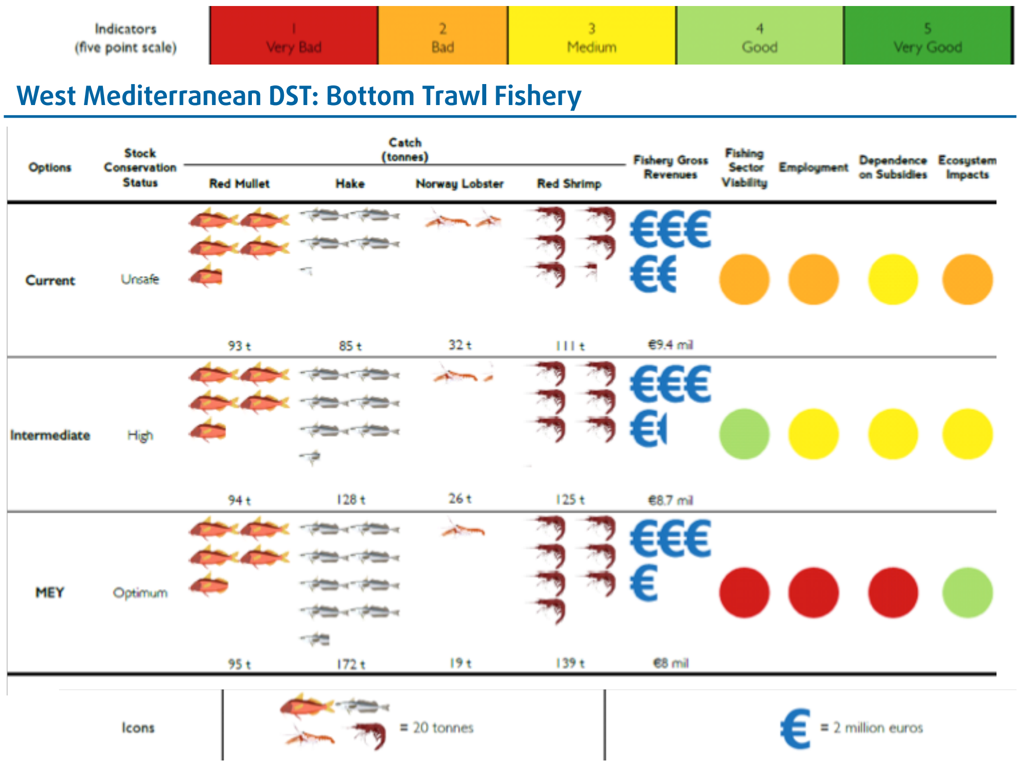
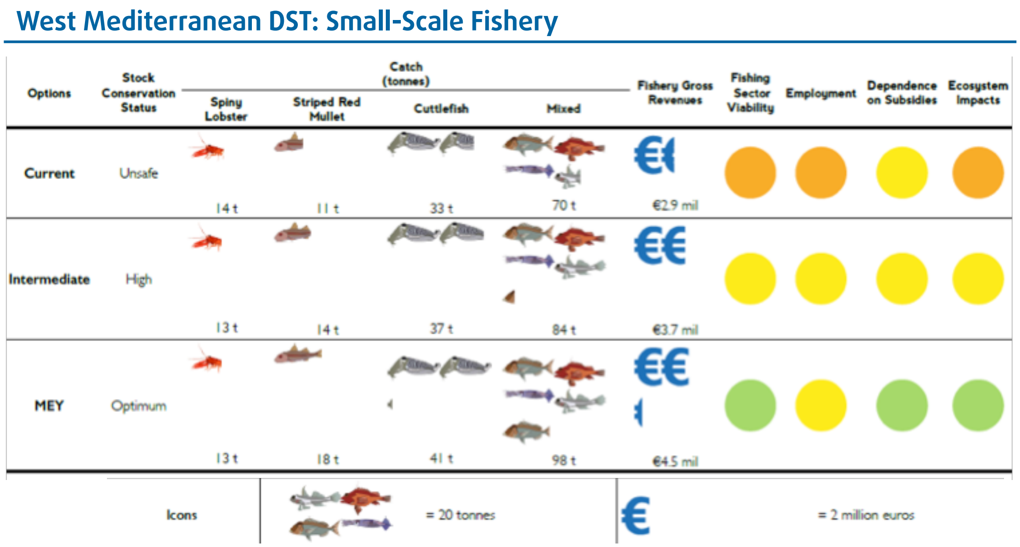


Fig. 7.4.
Visualized form of the Decision Support Table (DST) from the Mallorca small-scale fishery.



8 Fish price analysis

As it was shown in section 5, all (bottom trawl fishery; BTF) or most (small-scale fishery; SSF) stocks are currently overexploited. In addition to the ecological consequences of the overcapacity of fishing fleets, there are important economic consequences in terms of lost rent. The overcapacity and low levels of fish abundance have increased the fishing costs in recent decades, while fish prices have not undergone parallel increases, mostly due to commercialization and market problems (Delgado et al., 2003; Merino et al., 2008).

In such a context, reductions of fishing effort to achieve the MSY target may hamper the economic viability of Mediterranean fishing fleets in case those reductions are not accompanied by an increase of the fish/fuel price ratio. Aligning fishers' objectives with those of management constituted a significant factor of stock recovery in many fisheries. In fact, according to the main stakeholders, the viability of the Balearic Islands fishery depends on economic aspects (improving fish/fuel price ratio) rather than on the exploitation status of the main stocks. In this sense, price data is useful to determine how markets and consumers perceive the different fish products and which factors affect fish prices and, consequently, fisheries profitability. Moreover, fish price dynamics may drive fishing effort allocation among species in mixed fisheries.

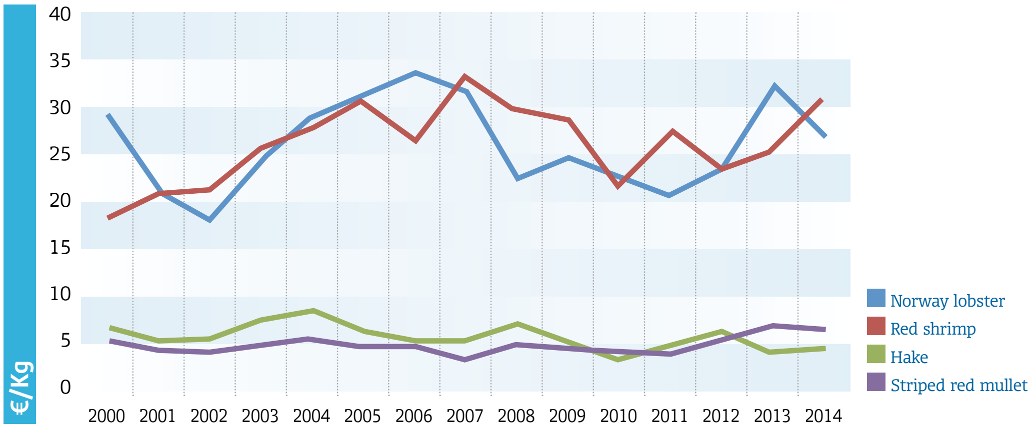
Price formation in the BTF and SSF from Mallorca were analysed using a 15 years' database (2000-2014) of daily sale bills providing catches and prices per day and vessel (and commercial category for some species). In total, more than $1.4 \cdot 10^6$ of daily transactions were analysed for the 11 main target species exploited by the BTF and SSF. The evolution of annual ex-vessel prices for these species is in **Figure 8.1**.

The average price of fish landed by the BTF at the Mallorca auction (2000-2014) was 6.1€/kg, with a peak of 7.3€/kg in 2005 followed by a gradual decrease since then down to the current 6.4€/kg (a 12% drop measured in nominal prices and 26% if constant 2014 prices[1] are considered). On the other hand, the fuel price increased a

1. Prices updated according to the inflation variation index (IPC base: 2011).

45% along the same period[2], causing a constant decrease of the fish/fuel price ratio. Compared to the BTF, fish prices from the SSF are in general higher (7.1€/kg average fish price, 2000-2014) and do not suffer important reductions; the average fish price peaked at 9.5€/kg in 2007 and has slightly decreased since then down to the current 9.1€/kg (only a 4% drop measured in nominal prices).

A



B

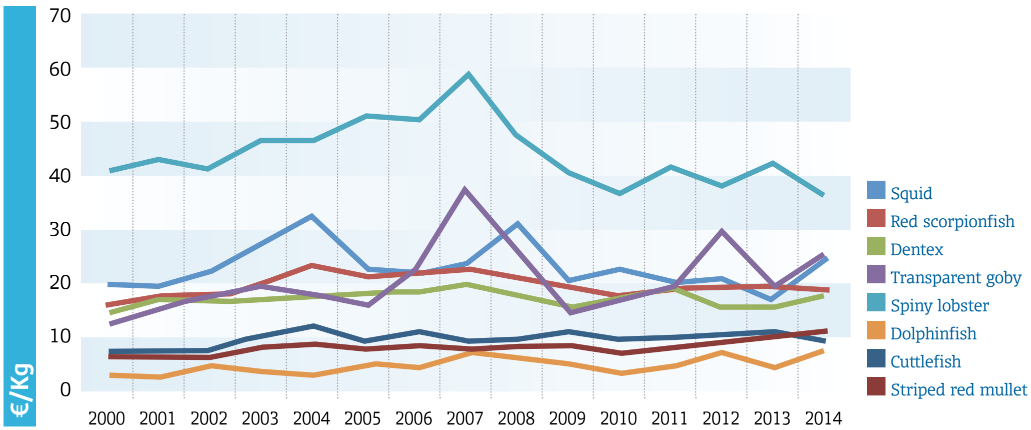


Fig. 8.1.
Price (€/kg) evolution of the main target species of the bottom trawl (A) and small-scale (B) fishery from Mallorca during 2000-2014.

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2 Ministerio de Industria, Energía y Turismo. Informe anual del precio de los carburantes (http://www.minetur.gob.es/energia/petroleo/Precios/Informes/InformesAnuales/Paginas/InformesAnuales.aspx)

Factors influencing the price formation can be estimated using hedonic analysis, which specifies a product price as a function of different attributes. The model uses a constant term, which indicates the average price of the base category from each species: fish of the highest commercial category within each species commercialized on Tuesday of January with minor gears[3]. The parameters are interpreted as the deviations, in Euros, from this base category. The combined effects of several attributes can be obtained by summing over the different parameters.

Results show that catch (supply) influences prices (higher price for lower supply). Most seafood prices decrease when their quantity landed increase, although the price-quantity elasticity varies considerably (**Table 8.1**).

	Norway lobster	Red shrimp	Hake	Striped red mullet	Spiny lobster	Dolphinfish	Red scorpionfish	Cuttlefish	Dentex	Squid	Transp. Goby
R^2	0.639	0.730	0.440	0.495	0.237	0.055	0.486	0.146	0.358	0.150	0.097
N	111.819	478.551	246.405	161.243	54.310	119.467	106.108	84.660	49.100	33.886	30.635
p-value	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Intercept	43.23	45.21	10.25	9.81	38.83	6.68	17.51	10.57	15.00	16.71	23.01
PQE	-0.67	-0.03	-0.05	-0.07	0.37	-0.01	0.08	-0.11	-0.35	-0.47	-0.31

Table 8.1. Goodness-of-fit (R^2), sample size (N), statistical significance (p-value), together with the intercept and price-quantity elasticity (PQE) of the hedonic models for the 11 main target species from Mallorca.

Size (commercial category) is the most important factor affecting seafood prices at the Mallorca fish auction (**Table 8.2**). Prices of the main species exploited by the BTF are more influenced by the commercial category of the product. Prices of small-sized individuals of red shrimp and Norway lobster are 71% and 66% lower than the prices fetched by the largest commercial category if the rest of the factors remain stable. In a lesser extent, hake and red mullet are also affected by size.

Therefore, management actions directed towards increasing the size of commercial individuals, such as improving gear selectivity, would be efficient in terms of enhancing fleet's revenues and profitability. According to Colloca et al. (2013), a radical shift of the fishing selectivity of Mediterranean fisheries would produce 2 or 3 times higher economic yields. However, the effects of such measures have to be analysed species by species at a fishery level.

In contrast, a high percentage of the main species exploited by the SSF are not commercialized under different size categories. Moreover, the majority of the species

3. For some species, the base category may change according to data availability. Nonetheless, base category for each species and variable is indicated in Table 8.2.

commercialized under different size categories present an inverse relationship: the small/medium size category fetches the highest prices. This is probably related to the fact that these captures are typically headed for restaurants (Asche and Guillen, 2012), where fresh whole fish portions fetch higher prices. As a consequence, selectivity measures would not have such a direct effect on the SSF, at least from a merely economic point of view.

Table 8.2.
Effect of different parameters (commercial category, fishing gear, day of the week and month) on fish price for the 11 main target species of the bottom trawl and small-scale fishery from Mallorca.

	Norway lobster	Red shrimp	Hake	Striped red mullet	Spiny lobster	Dolphinfish	Red scorpionfish	Cuttlefish	Dentex	Squid	Transp. Goby
CATEGORY											
Large	1	1	1	1	na	na	1	1	1	1	na
Medium	-17.44	-14.16	-3.57		na	na	2.31	na	na	na	na
Small	-28.42	-31.92	-4.98	-3.06	na	na	-5.54	0.70	3.46	5.14	na
GEAR											
Small-scale	1	na	na	na	1	1	1	1	1	1	1
Trawl	-1.57	1	1	1	na	na	-2.02	-0.36	2.07	na	na
Longline	na	na	na	na	3.63	-0.23	0.22	na	0.32	-0.32**	-0.53
Purse-seine	na	na	na	na	na	na	na	na	na	-1.53	na
DAY											
Tuesday	1	1	1	1	1	1	1	1	1	1	1
Wednesday	-0.43	-0.34	-0.60	-0.85	0.26	0.23	-0.28	-0.12	-0.09**	-0.51	-1.74
Thursday	-0.55	-0.50	-0.59	-0.62	1.12	-0.52	-0.10*	-0.02**	-0.11**	-0.66	-2.27
Friday	-0.54	-0.55	0.31	1.08	1.77	-0.43	0.32	0.54	0.27	1.13	-1.95
Saturday	-0.66	-0.63	2.06	2.67	3.14	-0.34	0.54	1.10	0.13	2.15	-1.30
MONTH											
January	1	1	1	1	na	na	1	1	1	1	1
February	0.41	-0.06	0.38	-0.02**	na	na	0.91	-1.09	1.28	2.61	-0.96
March	0.53	-0.02**	0.66	0.65	na	na	0.12**	-1.61	0.99	3.04	-1.49
April	0.24	-0.43	0.33*	1.70	1.00	na	-0.92	-1.57	0.97	1.93	-4.80
May	0.06*	-0.55	-0.96	0.23	-2.94	na	-1.66	-1.60	-0.15**	1.57	na
June	0.64	-0.42	0.27	1.66	-3.18	na	-1.13	0.04**	2.49	1.77	na
July	0.75	-0.21	2.69	-0.52	0.53	na	1.87	4.01	7.16	1.85	na
August	2.05	-0.33	8.16	4.72	8.20	1.00	5.16	7.20	8.99	4.81	na
September	0.10	-0.98	7.07	4.45	na	-2.05	3.77	5.55	3.26	-0.55	na
October	-0.14	-0.85	5.78	6.19	na	-2.05	3.18	3.94	0.02**	-2.55	na
November	-0.20	-0.44	4.93	7.37	na	-1.41	2.78	1.59	-1.11	-0.49	na
December	-0.10	0.33	11.27	13.94	na	-1.38	3.95	2.70	4.48	3.62	3.94

** Identifies coefficients that are not significant (not statistically different from the base category). All other coefficients are significant at the 1% level.

According to our results, fishing gear is also important. In general, species captured by longline or minor gear fleets fetch higher prices than those captured by trawling vessels. However, three out of the four main species of the trawl fleet are captured exclusively by this fleet and, hence, do not face competence from other fleets.

The daily price analysis has allowed the identification of two contrasting consumption strategies: fish species relatively cheap (i.e. hake, red mullet or dolphinfish) fetch higher prices on Tuesdays (beginning of the week) and reduce progressively along the week (**Table 8.2**). In contrast, prices of more expensive products (i.e. lobsters, shrimps, scorpionfish) are higher on Fridays and Saturdays showing the existence of an important consumption during the weekends. Consequently, the reduction of fishing days per week as a management measure (see 9.1) could target those days with lower prices in order to minimise the foreseen short-term negative economic effects of this measure.

Seasonality results from the hedonic price analysis (**Table 8.2**) show a differentiated behaviour depending on the type of product. In general, most expensive products/species have fewer substitutes and show a larger volatility and seasonality (Guillen and Maynou, 2015). In contrast, cheaper fish products usually have a larger degree of market integration, a wider range of substitutes and potential supply sources, and thus their price volatility is lower. For example, hake (a relatively cheap fish product and subject to a high level of imports) presents the lower level of monthly seasonality and prices remain more or less stable along the whole year due to the constant offer of hake products from different parts of the world. On the contrary, luxury products such as red shrimp or Norway lobster present a high seasonality peak at the end of the year (Christmas period) and another one in summer (August).

Along with the characterization of the main attributes influencing seafood price formation, research over the last years has also addressed the issue of market-based incentives (commercialization and marketing actions) and its potential to contribute to achieve fisheries management objectives. Owing to its high commercial interest, red shrimp is the best option to implement new commercialization strategies for the BTF (see **Box 13**). Sales of red shrimp represent 40% of the total income from the BTF and 70% of the income coming from the four main target species. Moreover, there are already successful experiences of implementing certified quality-guarantee labels for this species in other nearby areas, such as Palamós[4]. Red shrimp commercialized under this label directly at a retail level fetches prices up to a 120% higher than

4. http://www.gambadepalamos.com/

average prices at Mallorca's auction. Moreover, improved handling, packaging and transportation processes have been already tested for this and other products such as Norway lobster[5]. In the Balearic Islands, initiatives have also been undertaken in this regard[6]. Until now, different meetings for the transfer of scientific and technological knowledge have been organized, which allowed establishing synergies between the fishing industry, technology companies and research institutions. As a result of these meetings, a conceptual model was designed including a project to create a quality label for the red shrimp.

In terms of SSF, a study of consumer preferences in Mallorca (Morales-Nin et al., 2013) showed that, despite fish price was an important factor, consumers were willing to pay more for local products of good quality. This would be a market advantage for Mallorca SSF to promote their products. The development of marketing strategies, together with clear traceability and product identification measures, would enhance better selling prices (see 9.1.2).

All these analyses allow pointing out some conclusions relevant for the commercial strategies of the BTF and SSF:

- Most of the analysed species show inverse price-quantity elasticity: higher prices for lower supply. However, such elasticity does not compensate the dissipation of rents derived from the effort reductions needed to achieve the MSY.
- Size or commercial category is the most important attribute influencing prices. In the BTF case, and particularly for the red shrimp and Norway lobster, gear selectivity measures to increase the size of commercial individuals would be efficient in terms of enhancing fleet's revenues and profitability.
- Reductions of fishing days per week (input control measures) should target the days with the lowest prices in order to minimise adverse short-term economic effects.
- The implementation of market-based incentives (commercialization and marketing strategies and actions) is considered paramount to ensure the long-term economic viability of the Mallorca BTF and SSF.

5. http://www.gambadepalamos.com/; http://www.delbarcoalamesa.com/; http://www.pescarousa.com/; etc.

6. Acción Especial "Marca de calidad: gamba roja de Menorca", coordinated by the Instituto Español de Oceanografía in 2015 and financed by the Conselleria d'Innovació Recerca i Turisme del Govern de les Illes Balears (AAEE36/2014).

9

Management proposals

Based on the decision support tables (DSTs), which summarize the main results presented in this report, the management scenario agreed with stakeholders includes the reductions of fishing effort shown in the intermediate scenario. The benefits of such fishing effort reductions would be twofold. Firstly, an improvement in the exploitation status of the different target stocks and hence on the demersal ecosystems exploited by the BTF and SSF. Secondly, an improvement in the viability of the fishing industry, primarily by means of reducing fishing costs in terms of substantial reductions in fuel consumption. For fishers, especially the bottom trawl ones, the fuel price is the main constraint. According to stakeholders, the viability of the fishery depends on marketing aspects (increasing fish prices) rather than on the exploitation status of the main stocks. Consequently, marketing improvements in the fishing industry should be done in order to increase the economic value of the main species.

In this report, management proposals for both the commercial and recreational fisheries are included (**Box 8**). The management actions proposed in this report to improve the status of the exploited stocks and the commercialization of fish have been split into the two following sections: i) exploitation model; and ii) business model.

9.1. Commercial fisheries

9.1.1. Exploitation model

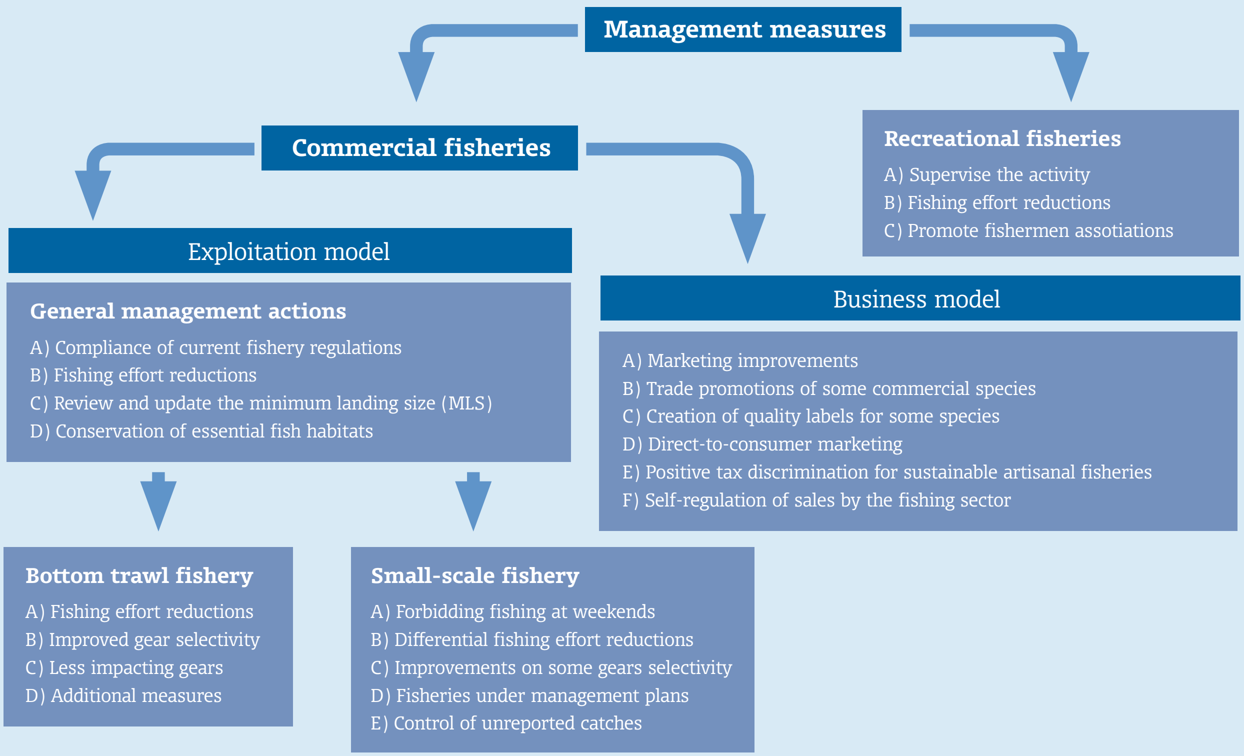
The main objective in this point is to optimize the fishing effort by means of reducing the fishing activity and using more selective gears.

9.1.1.1. General management actions

Measures under this section apply indistinctly to both the bottom trawl and small-scale fisheries.

Box 8

Proposed management measures in the Balearic Islands



A) Compliance of current fishery regulations

The bottom trawl and small-scale fisheries (BTF and SSF, respectively) are subjected to different technical measures (see 2.2) such as a maximum gear power (500 HP), minimum distance to the coast (1.5 nm) and time at sea (12 hours per day, 5 days per week) in the case of the BTF and a maximum of total length of trammel nets in the SSF. Although time at sea is well controlled (fishermen are punished when the allowed time is exceeded), other aspects are not. In many cases, these non-controlled aspects have important impacts on the actual fishing effort exerted, such as the use of gears over 500 HP by trawlers or the deployment by the SSF of total net lengths well above the legally permitted.

An effective management should begin with a full compliance of fishery regulations. Consequently, efforts should be put to ensure this compliance from the scratch and a continuous surveillance established to ensure its fulfilment with time (e.g. vessel monitoring system, VMS). Not doing it might prevent the success of further management measures.

B) Fishing effort reductions

Owing to the sharp decrease in the number of fishing units in both fisheries, further reductions are not contemplated in order to ensure the viability of the fishing industry. As aforementioned, the number of small-scale vessels in the Balearic Islands has decreased more than 50% during the last 25 years (**Fig. 3.2.4**). The number of bottom trawlers has also suffered important reductions and, if the decreasing rate observed in Mallorca during the last 25 years is maintained, the fleet would disappear in less than 25 years (**Fig. 9.1.1.1**). As explained below, the actions intended to reduce the fishing effort will include, for instance, reducing the number of hours per day or days per week, but in no case removing vessels.

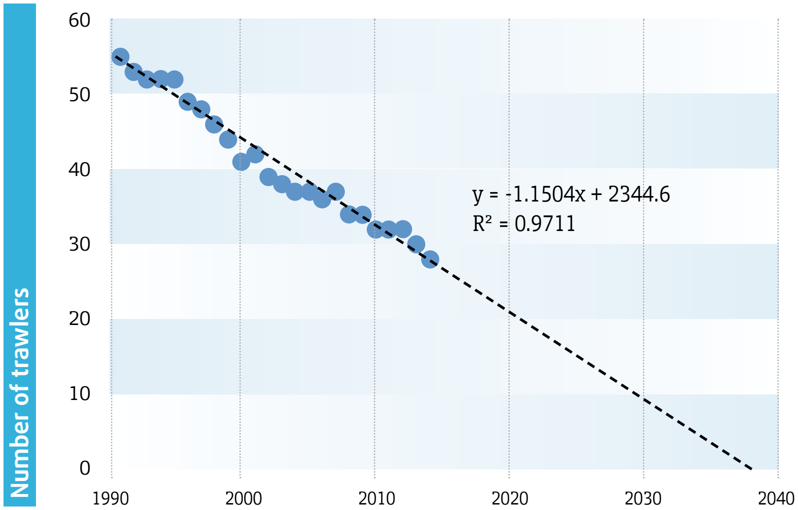


Fig. 9.1.1.1. Number of bottom trawlers in Mallorca during the last 25 years with the corresponding linear regression fit and its extrapolation until the fleet disappearance (2038).

C) Review and update the minimum landing size (MLS) for some species

To ensure the sustainability of the fishing exploitation, the MLS should be equal to the size at first maturity (L_{50}). As L_{50} is the size at which the 50% of the population has reached the sexual maturity, this measure will allow that about half of the population of commercial species can reach reproduction at least once. Paradoxically, this is not the case in many stocks in the Mediterranean Sea (**Box 9**).

The paradigm of gear selectivity

In the Mediterranean, where fisheries are regulated by technical measures instead of quotas, the gear selectivity is paramount for sustainable fisheries exploitation. To improve the selectivity of the bottom trawl fishery, the geometry of the 40 mm mesh codend was changed from diamond to square (Council Regulation Nº 1967/2006). This change, however, is still far from guarantying the individuals of most species the opportunity to reproduce at least once before being caught. Paradigmatically, the size at first capture (L_{50}) using the square mesh is still smaller than the minimum landing size (MLS) in some species.

This inconsistency is especially important in the continental shelf fishery (see Table). From the nineteen commercial species for which the selectivity was improved with the square mesh, only in six of them the L_{50} is similar, or larger than, the size at first maturity; in two of these species, the L_{50} is still below the MLS. Moreover, there are species, such as *Raja* spp. or *Lophius* spp., for which the selectivity using the square mesh did not improve compared to the diamond mesh.

Minimum landing size (MLS), length at first capture (L_{50}) using the 40 mm square mesh codend, and length at first maturity of the most important species in the Balearic Islands continental shelf bottom trawl fishery.

Species	MLS	L_{50}	Length at first maturity		
			Females	Males	Total
Chelidonichthys cuculus		12.1			16.8
Trigloporus lastoviza		7.3			15.3
Citharus linguatula		11.5	15.1	12.5	
Helicolenus dactylopterus		10.9	17.3	15.5	
Lepidotrigla cavillone		**9.6**			**9.3**
Merluccius merluccius		15.2			32.7
Mullus surmuletus	11	12.2	16.8	15	
Pagellus acarne	12	9.4		15.8	
Pagellus erythrinus	12	10.4	17.4		
Scorpaena notata		**9.7**			**9.2**
Scorpaena scrofa		8.3	15.4	17.7	
Scyliorhinus canicula		28.7	41	40	
Serranus cabrilla		**14.1**			**14.8**
Spicara smaris	**11**	**17.1**	**15.3**		
Trachinus draco		**18.1**			**14.4**
Trachurus mediterraneus	**12**	**15.2**			**15**
Eledone cirhosa		6	9.5	7.5	
Loligo vulgaris		5.8	17.8	9.3	
Octopus vulgaris		6	8.7	6.5	

Sizes at first maturity are from Bradai and Bouain (1991), Oliver (1993), Vassilopoulou and Papaconstantinou (1994), Reñones et al. (1995), Colloca et al. (1997), Pajuelo and Lorenzo (1998, 2000), Muñoz et al. (2002), Dulcic et al. (2003), Ivory et al. (2004), González et al. (2011), Uranga (2012), Giannoulaki et al. (2013), Ordines et al. (2009, 2014), Quetglas et al. (unpublished).

Further improvements in selectivity should be implemented in order to generalize to as much species as possible a true opportunity to spawn before getting caught. This *Let them spawn!* management strategy would increase the resilience of stocks to overfishing (Myers and Mertz, 1998; Froese, 2004). Although this is challenging for multispecific Mediterranean fisheries taking a great variety of species with different shapes and sizes at first maturity, efforts should be made to move fisheries management towards that strategy.

BOX 9

D) Conservation of essential fish habitats

As aforementioned (see 1.1), fishery management on the Balearic shelf requires technical measures to protect benthic communities. These measures could be based on spatial (and/or temporal) closures: I) some areas already closed to trawling (e.g. submarine cable zones, marine protected areas including traditional trawl fishing grounds, agreement by fishermen to not operate with trawl on the shelf during summer) should be reinforced and/or extended; and II) other areas to be closed (at least temporally) should be considered. Also, to avoid the degradation of the ecosystems in areas that remain open to trawl fishing, these measures should be taken along with the development of ad hoc fishing regulations for each particular habitat, in order to prevent levels of exploitation higher than the limits of resilience of the benthic communities involved.

The first step should be the implementation of Regulation (EC) No. 1967/2006, which Article 4 lists the maërl and coralligenous beds as protected habitats and prohibits fishing with trawls and dredges, among other gears, on these grounds. In order to effectively implement this regulation and make it compatible with the sustainability of the BTF, the coastal continental shelf of the Balearic Islands should be mapped. This will allow defining the areas to be opened and closed to the BTF and assess the socio-economic effects produced by the reallocation of fishing effort resulting from the application of this management measure. The scientific studies performed in the Menorca Channel (Barberá et al., 2012a; Moranta et al., 2014) and in the south of Mallorca (Domínguez et al., 2013) are good examples of how this regulation could be implemented. In fact, the first of these two studies allowed developing a management plan for the BTF in the area. Areas and periods of especial interest for hatching and recruitment of the main commercial species should be avoided by fishermen, prefer-entially by those using less selective gears such as the bottom trawl. Such avoidance should be based on scientific studies, complemented with fishermen knowledge, to map the spatiotemporal distribution of fish and hatching and nursery areas. For in-stance, the red algae *Peyssonnelia* beds (**Box 1**), which are widely distributed along the continental shelf of the Balearic Islands, constitute essential fish habitats for demer-sal resources (Ordines and Massutí, 2009; Ordines et al., 2009). Together with the already existing net of marine protected areas in the Balearic Islands (**Box 10**), the conservation of essential fish habitats (EFH) and sensitive habitats (SH) would allow improving the status of the main target stocks and its long term sustainability.

BOX 10

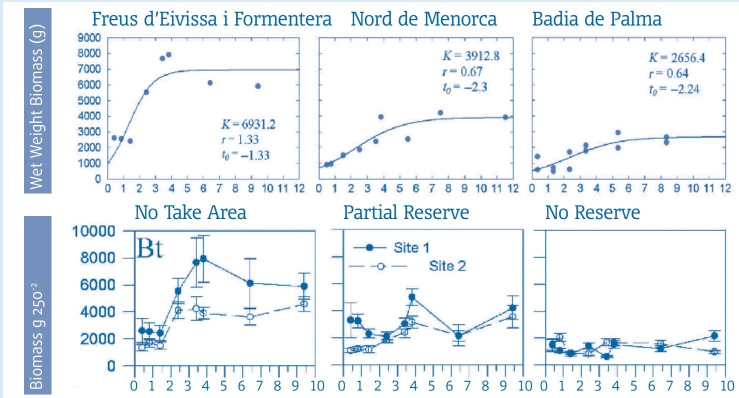
The marine protected areas from the Balearic Islands

Marine protected areas (MPAs) are environmental protection platforms where the use and exploitation of the sea is regulated in order to preserve the most relevant ecosystems and their living resources. Most human activities are limited within MPAs, which also contain areas of especial protection where fishing is entirely forbidden. These last areas are important hatching points where commercial species proliferate. Therefore, MPAs are not only environmental protection platforms but also fishing management tools allowing the sustainable exploitation of marine resources.

In the Balearic Islands, there are currently the seven following MPAs (year founded into brackets): I) Badia de Palma (1982); II) Nord de Menorca (1999); III) Freus d'Eivissa i Formentera (1999); IV) Migjorn de Mallorca (2002); V) Illa del Toro (2004); VI) Illes Malgrats (2004); and VII) Llevant de Mallorca (2007). Altogether, these seven areas encompass about 60000 ha of marine environment.

The MPAs are managed by the Directorate of Fisheries (DG-Pesca) with the assessment of the monitoring bodies, which include representatives of different sectors such as the administration, both commercial and recreational fishermen associations and environmental NGOs.

The management measures put into practice include beaconing the areas of special protection, surveillance of human activities and both fishing and scientific monitoring to follow the "reserve effect" by which the abundance and individual size of commercial species increase within the MPAs. Significant scientific results have been found after some years of protection (Coll et al., 2012, 2013). The attached figures show the evolution of total biomass with time (years) in three different MPAs (upper panel) and in areas of full and partial protection compared to no protected areas in the Freus d'Eivissa i Formentera MPA (lower panel).



9.1.1.2. Bottom trawl fishery

A) Fishing effort reductions

Once discarded vessel removals as explained above, fishing effort reductions should be based on reducing the time at sea, either in terms of hours per day or days per week. Moving from the current 5 days per week to 4 would imply not only reducing the fishing effort by 20% but also reducing the exploitation costs, primarily due to fuel saving. Preliminary experiences of this measure have been applied in the Balearic Islands, but exclusively during winter months (February to April) instead of the whole year. As a consequence of this fishing closure, and compared to the same period of the previous year, catches decreased by 14% but incomes increased by 3% owing to the increase of mean average fish price. Similarly, in experiences undertaken in Alicante, results showed that the losses from banning on Wednesday might be compensated by price increases and reductions of exploitation costs (Samy-Kamal et al., 2015).

As aforementioned (**Fig. 3.1.3**), the number of fishing hours per week has decreased with time down to the current 60 $h \cdot w^{-1}$. In spite of such a significant reduction, the current 12 h at sea plus about 2 h of additional work at port results in an unreasonable daily work schedule for current times. In case the reductions of fishing effort were not applied in terms of days per week, an alternative option could be decreasing the total number of working hours per day (**Box 11**). If this measure is economically unfeasible for the red shrimp fishery, a new daily working time will be used but always under the allowed weekly activity limits.

Given that bottom trawlers operate on different bathymetric strata depending on the target species, differential effort reductions should be put in practice according to the exploitation status of each single stock (**Table 5.1.1**). As hake is the most over-exploited species, reductions should be higher on its fishing grounds (deep shelf) and even a recovery plan should be considered for this species. This would not imply stopping the fishing activity, but a sort of diversification of the fishing exploitation to focus on healthier stocks until the recovery of the most impacted ones. A regular assessment of the main target stocks would allow deciding how to adjust such a diversification of fishing strategies among species.

B) Improved gear selectivity

According to recent studies (Colloca et al., 2013; Vasilakopoulos et al., 2014), improvements in the fisheries selectivity would be more effective than reducing the fishing effort

BOX 11

Reducing trawl fleet working-time

In general, the Spanish bottom trawl fleet is allowed to work 12 hours per day during 5 days per week. The economic consequences of reducing the fleet working-time were experimentally analyzed in the Gulf of Lions (north-western Mediterranean) using two different bottom trawl vessels (Guijarro et al., in preparation). Instead of the current, discontinuous weekly timetable (60 h), trawlers were allowed to work continuously during 46 h. Results showed that the economic value of total catches did not differ significantly between these two fishing strategies. However, and more importantly, the exploitation costs did show significant reductions in the two study vessels. Both exploitation cost and fuel consumption in relation to the first sale value decreased by 40% (see table).

The results of these experiences have important consequences for Mediterranean fisheries management. Reductions of the trawl fleet working-time such as those investigated, would be beneficial at three different levels. Firstly, it would imply an increase in the fleet economic efficiency by reducing the exploitation costs while obtaining similar profits from catches. Secondly, it would also increase the fleet ecological efficiency by reducing CO_2 emissions as a result of significant reductions in weekly fuel consumption. Last, but not least, reducing the weekly activity would improve the crew' quality of life, an important aspect within the future Common Fisheries Policy, taking into account the difficulties of the fishing sector to offer attractive jobs to young people.

Uninterrupted fishing activity during two entire days, however, might have negative effects for marine ecosystems. Longer timetables would allow exploiting fishing grounds currently inaccessible to the fleet owing to the vessels commitment of returning to home ports daily. To avoid the overexploitation of these now slightly exploited grounds would require effective management measures backed with a continuous surveillance and monitoring of the fishing activity (e.g. VMS).

	Vessel	2006	2007	test
Cost/sales (%€)	Trawler #1	61.6±16.1	35.5±20.3	p<0.05
	Trawler #2	43.1±13.2	26.8±9.8	p<0.05
Fuel/value (l/€)	Trawler #1	1.21±0.32	0.70±0.40	p<0.05
	Trawler #2	0.85±0.26	0.53±0.19	p<0.05

in order to manage Mediterranean bottom trawl fisheries. To improve the selectivity of the BTF, the geometry of the 40 mm mesh codend was changed from diamond to square (Council Regulation Nº 1967/2006). This change has been implemented in the BTF of the Balearic Islands (**Box 9**), increasing the length at first capture of many species, both target and by-catch species (Ordines et al., 2006; Guijarro and Massutí, 2006). However, as the measure is not effective for important resources such as *Lophius* spp., *Zeus faber* and rays, additional technical improvements to increase gear selectivity are still needed. Good examples are the sorting grids, which improved the bottom trawl selectivity in the western Mediterranean (Sarda et al., 2006; Massutí et al., 2009), and square mesh panels, which reduced the discards of non-commercial mesopelagic species in recent experiences carried out in the Balearic Islands (Massutí et al., 2015).

C) Less impacting gears

Recent scientific experiences have been done in the Mediterranean to develop technical modifications on trawl gears to reduce its physical impact on the seabed (**Box 12**). The use of mid-water doors, shorter sweeps and lighter nets (thinner netting and wider mesh openings) has proved successful, since these modifications allowed obtaining similar catches than those obtained with traditional gears but with a significant reduction of fuel consumption (Guijarro et al., in preparation). Such modifications allowed obtaining catches similar to those taken with the traditional gears but, together with reducing the physical impact on the sea bottom, they also reduced significantly the fuel consumption. Consequently, these modifications contribute to improve not only the ecological fingerprint through lower physical impact and lower CO_2 emissions, but also the economic efficiency of the BTF. In fact, the commercial vessels involved in these experiences are currently using the modified gears. However, potential negative consequences should be investigated, such as the increase of the doors distance and horizontal net opening, which might broaden the swept area and hence increase the effective fishing effort.

D) Additional measures

According to Oceana (Carreras and Cornax, 2011), the bottom trawl fishing should be forbidden on continental shelf grounds from the Balearic Islands. This measure would somewhat be justified under the precautionary principle as long as an effective protection of the aforementioned benthic habitats (9.1.1.1-D) are not put into force. However, this measure would have important negative effects for the fishing industry of the Balearic Islands.

Less impacting gears

One of the most controversial aspects of the bottom trawl fishery lies on the ecological impact exerted by the doors on the sea floor (but see 1.1). Alternatives to avoid or minimize such impact include the use of mid-water doors which do not contact the seabed. Experiences comparing the performance of traditional and mid-water doors were carried out using a commercial bottom trawler from Menorca (Guijarro et al., in preparation). Except the doors, all other gear components remained the same. The experiment covered both deep shelf and middle slope grounds, where the target species are hake and red shrimp respectively.

Although catches (biomass, kg/h) did not differ significantly between the two doors (see table), fuel consumption (l/h) showed a significant decrease of 12% and 5% in the deep shelf and middle slope, respectively. Consequently, the use of mid-water doors reduces the ecological impact of the bottom trawl fishery, as the lack of contact with the seabed avoids direct physical damages and reduces CO_2 emissions by means of lower fuel consumption.

It is worth noting that the vessel involved in this experiment is now using the mid-water doors, showing that this is a technical measure to take into account in order to improve the sustainability of the bottom trawl fishery. Although the skipper needed almost five months to handle the gear properly, the average fuel savings are currently of 160 l/day (ca. 25%).

Stratum	Catch	Biomass (kg/h)		t-test
		Traditional	Mid-water	
Deep shelf	Commercial	50.9±3.2	41.9±4.8	ns
	Discards	39.3±3.5	46.4±8.4	ns
	Total	88.3±12.2	90.2±5.6	ns
Middle slope	Commercial	21.9±1.7	22.1±0.8	ns
	Discards	8.6±1.2	7.3±1.0	ns
	Total	30.5±2.6	29.7±1.3	ns

BOX 12

Firstly, it would reduce the fishing activity to slope grounds where the main target species are Norway lobster and red shrimp, which populations would not be able to withstand exploitation levels higher than the current ones. Furthermore, it should be taken into account the reduced area of the continental slope compared to the shelf due to the Balearic Islands topography. This would reduce the availability of fishing grounds and would hinder the reallocation of the existing fishing effort.

Secondly, removing the fishing resources of the continental shelf from the market chain would probably prevent maintaining the marketing of local, fresh seafood products from the Balearic Islands. In this sense, the bottom trawl landings from the continental shelf stand for up to 30% of total commercial landings and about 25% in economic terms (Ordines, 2015). Shelf landings are constituted by a large variety of fish and cephalopods which catch rates could not be maintained with the current small-scale fleet.

9.1.1.3. Small-scale fishery

A) Forbidding fishing at weekends

Under current regulations, small-scale fishers are allowed to fish from Monday to Saturday. Catches taken on Saturday, however, cannot be commercialized until next Tuesday at the Mallorca central fish auction wharf; alternatively, they are directly sold to consumers. When these catches go through the wharf, they negatively affect the commercialization of the fresh fish taken during the Monday. To avoid this commercialization problem, together with reducing the fishing exploitation of the SSF, fishing might be forbidden during the weekends, reducing the weekly fishing activity from Monday to Friday. According to the Fishery Association of the Balearic Islands, preliminary experiences with different fisheries (e.g. dolphinfish, picarel and transparent goby) have proved to be positive, both for the resource and its commercialization.

B) Differential fishing effort reductions

As in the case of the BTF, differential fishing effort reductions might be implemented for the SSF since this fleet operates on different target species with contrasting exploitation states (**Table 5.2.1**). As above, this would not imply stopping the fishing activity, but a sort of diversification of the fishing exploitation to focus on healthier stocks until the recovery of the most impacted ones.

C) Improvements on some gears selectivity

Recent studies carried out in the Balearic Islands (Goñi et al., 2013) demonstrate that the SSF selectivity can also be improved. These studies focused on the trammel net fishery targeting the spiny lobster and showed that using experimental nets of polyethylene multi-monofilament, instead of the traditional ones of polyamide multifilament, reduced both the number of lobsters below the minimum landing size and the discards of rhodoliths. Some vessels from Mallorca and Menorca are currently using these new gears but its use should be generalized to the whole fleet targeting the spiny lobster in order to minimize the SSF impact on maërl grounds. Further improvements such as replacing the trammel net by gillnet, increasing the mesh size or reducing the soaking time should also be investigated.

D) Tagging catches

Recent studies in the Archipelago have also demonstrated the feasibility of using V-notch marks on the tail flipper of breeding female spiny lobsters (Goñi et al., 2013).

These marks are successfully used in other decapod crustacean fisheries from the North Atlantic to identify individuals under the legal size and breeding females that fishermen return to sea. The results obtained so far with lobsters suggest that V-notch marks would be an effective measure to protect breeding females returned at sea, thus increasing the reproductive potential of the population.

E) Fisheries under management plans

Some SSF, such as the transparent goby, are already integrated under management plans of the Balearic Islands Government. According to the Fisheries Association, integrating all SSF under management plans will be highly beneficial to improve not only the exploitation state of the main target species but also its marketing and commercialization. For this purpose, management plans have to be associated with quality labels (ecolabels) for the main target stocks, which should be a guaranty of seafood obtained through sustainable exploitation. Several years ago, the Government of the Balearic Islands began a process of sustainability certification for the dolphinfish fishery (Marine Stewardship Council-MSC), which successfully passed an initial assessment. It would be nice to take up this initiative and extend it to other species and fisheries.

F) Control of unreported catches

Sale of fish outside the official market is an important issue in SSF, especially in species with high commercial value such as dentex, red scorpionfish and spiny lobster. Together with its effects on commercialization, unreported catches are highly detrimental for the assessment and management of SSF. This reinforces the need to sensitize the fishing sector about the importance of providing scientists the best data possible in order to help improving the stock assessment and management.

9.1.2. Business model

The main objectives here are achieving reductions of exploitation costs, primarily fuel consumption, together with increases in revenues by means of marketing actions. It should be noted that the measures listed in the previous section will help addressing those objectives, since most of them entail fuel savings due to reductions of fishing activity and fish price increases as a result of lower supply. Although this issue demands specialized socio-economic studies, some general actions are listed below.

A) Marketing improvements

In order to increase the prices of some species, especially those with the highest commercial value, marketing campaigns should be launched. As discussed in section 8, red shrimp is the best option to implement new commercialization strategies for the BTF (**Box 13**). However, there are many other examples from the SSF since it catches different species of fish (e.g. grouper, John Dory) and crustaceans (e.g. spiny lobster) of high commercial value.

B) Trade promotions of some commercial species

The globalization of trade markets has changed consumer habits and affected seriously the commercialization of fresh Mediterranean seafood. This calls for trade promotions to potentiate local products, either by recovering the now abandoned traditional consumption of some species such as the picarel (*Spicara smaris*) or promoting other by-catch species both at home and at restaurants.

C) Creation of quality labels for some species

Today, there is an increasing number of markets demanding quality labels or ecolabelled products (e.g. Marine Stewardship Council-MSC). For many consumers, the quality and freshness of seafood, and even the environmental credibility, plays an increasing role in purchasing decisions. In a highly touristic place such as the Balearic Islands, this formula should be enhanced, especially for high-valued species such as spiny lobster, John Dory or red scorpionfish.

D) Direct-to-consumer marketing

Direct marketing may have several advantages: I) higher incomes to fishermen by avoiding unnecessary retailers; II) lower transportation costs since the fish will not be sent to the central auction wharf in Palma; III) fresher fish, which might imply higher

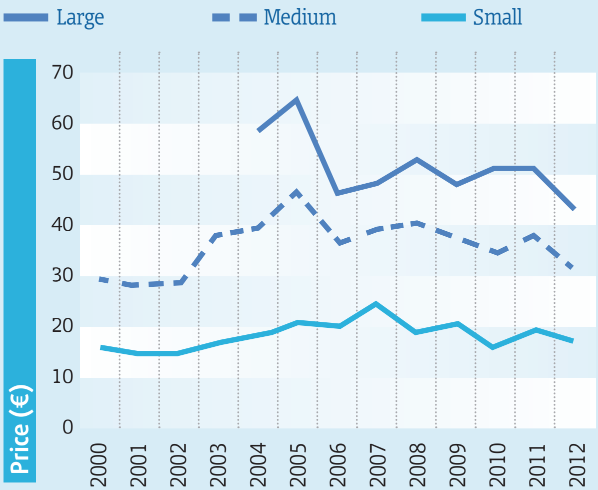
Marketing actions to improve fisheries profitability

Currently, the total fisheries production from the Balearic Islands accounts for about 15% of local fish consumption. This implies that the vast majority of fish consumption comes from imported chilled and frozen products that, in general, have lower prize and lower quality than the local fresh fish. Within such a variety of imported fish, local fishermen suffer commercialization problems to sell their catches.

During the last years, the economic scenario of increasing fishing exploitation costs and decreasing fish prices is jeopardizing further the viability of Mediterranean fisheries. Actions to improve the fisheries profitability should be put into practice, either by reducing exploitation costs (mainly fuel consumption) or increasing fish prices by means of marketing strategies. These marketing actions should be focused on the species with the highest commercial value such as the red shrimp and the spiny lobster in the bottom trawl and small-scale fisheries, respectively.

There already exist some good examples of marketing strategies directed to the red shrimp from nearby areas such as Denia (red shrimp-Denia) and Palamós (red shrimp-Palamós). Depending on the shrimp size, the species is sold in three different commercial categories (Large, Medium and Small). For comparison purposes, the figure below shows the mean prizes of these three categories in Mallorca from 2000-2012 (graph) compared with those of Palamós and Denia. For all categories, the marketing campaigns increase two or threefold the mean prices from Mallorca.

Similar marketing strategies, accompanied with trade promotions and the creation of quality labels, could be used to improve the sustainability of the commercial fisheries from the Balearic Islands.



BOX 13

prices, as a result of reducing the market chain. Direct marketing, however, should be accompanied with a reliable control system in order to avoid black market and unreported catches.

E) Positive tax discrimination for sustainable artisanal fisheries[7]

This measure would be directed to favour artisanal fisheries, primarily those using more selective gears such as traps, in front of more impacting fisheries such as bottom trawl. The use of traps in some specific fisheries, such as the spiny lobster fishery, was a common practice in the Balearic Islands some time ago but it was completely abandoned during the early 2000s for more impacting, profitable gears such as trammel nets.

F) Self-regulation of sales by the fishing sector

At the fishing industry own initiative, this measure is already in place for some SSF, such as dolphinfish in the whole Mallorca and spiny lobster in some specific ports. Setting daily quotas for dolphinfish (200 $kg \cdot day^{-1}$ per vessel) and both seasonal quotas and a constant mean price in the case of spiny lobster (e.g. in Fornells and Portocolom) is intended to render higher economic yields to fishermen. This measure could then be extended to other target species, either belonging to the BTF or the SSF.

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7. This measure was taken from Oceana (Carreras and Cornax, 2011).

9.2. Recreational fishery

A) Supervise the activity

As discussed above (see 3.3), currently there is not an official record of catches from the recreational fishing. Owing to the importance of this fishing practice in the Balearic Islands, it is essential to incorporate these catches when assessing and managing the fishery resources of the Archipelago. Aside from the monitoring of catches, it is also necessary to improve the supervision of the activity at sea in order to ensure the compliance of current regulations, especially the maximum catch allowed, the minimum legal sizes and spatio-temporal closures. It is also crucial to control the final destination of these catches because they cannot be commercialized in any case.

The impact of using new fishing gears in the recreational fishing should also be assessed. This would be particularly important in the case of highly selective gears used by the recreational fishery that are main targets of the commercial fisheries, such as the inchiku focused to the scorpionfish. The use of these fishing gears should be conditioned by the exploitation state of the target species (see 5).

B) Fishing effort reductions

The effort reductions necessary to ensure a sustainable management of marine resources cannot fall exclusively on the professional sector, but should also apply to the recreational fishing. Fishing effort limitations in the recreational fishing could be carried out through reductions in the number of allowed fishing days and the maximum authorized catches, in order to adapt them to the increasing number of practitioners of this fishing practice in recent decades (**Fig. 3.3.1**). Currently there is no limitation of activity, except for temporary closures for some species (raor *Xyrichthys novacula* and verderol *Seriola dumerili*). The fishing effort could also be reduced by activity limitations in certain areas, such as the marine reserves where, furthermore, the spearfishing should be completely banned. In the case of spearfishing, the prohibition of using artificial light would increase the chances of survival of fish seeking refuge as a defense strategy.

C) Promote fishermen associations[7]

Recreational fishermen associations would facilitate the collaboration and involvement of the sector in the management of this fishing activity, especially in providing information about their catches.

10 Monitoring

Once the management measures are put into force, a monitoring plan should be established in order to assess the effects of those measures and the actions to be undertaken if the expected results (improved exploitation status of target stocks) are not achieved.

As aforementioned (see 9.1.1.1), an effective management should begin with a full compliance of fishery regulations. Consequently, an effective and reliable control system should be set up to ensure fishermen compliance with both the fishery regulations and the management actions contemplated within this Regional Implementation Plan (RIP).

A scientific surveillance system to monitor the effects of the management measures is also needed. Such a scientific monitoring would use different sampling and data sources to assess the RIP progresses, primarily the exploitation state of the main target species. Currently, this monitoring in European waters is implemented through the Data Collection Framework (DCF, https://datacollection.jrc.ec.europa.eu/), whereby the member states collect, manage and make available a wide range of fisheries data needed for scientific advice. This data collection encompasses:

I) Fishery-dependent data: it includes time series of landings and fishing effort obtained from fishery statistics, along with scientific sampling at fish markets or on board commercial vessels to analyse the catch species composition and the size structure of the main target stocks. The availability of these data sources fully depends on the collaboration of the fishing sector (Guijarro et al., 2012a), in our case the fish auction wharf (OP-Mallorcamar) and the Fisheries Association of the Balearic Islands.

II) Fishery-independent data: it refers to scientific sampling on board research vessels. From 1994 on, the European Commission and the participating member states are co-financing the MEDITS (MEDIterranean Trawl Surveys) programme. This programme aims to conduct coordinated scientific bottom trawl surveys in the Mediterranean European waters, covering trawlable grounds over the shelf and slope from

10 to 800 m depth (Bertrand et al., 2002a). Scientific surveys following the MEDITS protocol started in the Balearic Islands in 2001, being included in the MEDITS programme in 2007. Since then the fishing grounds (50-800 m) around Mallorca and Menorca are surveyed annually during late spring or early summer (**Box 14**). The data collected in these surveys allow assessing the health of the ecosystems and living resources from the Balearic Islands using information independent from the fishing activity.

Using all these information sources, the surveillance system will assess the exploitation state of the main target stocks (e.g. striped red mullet, hake, Norway lobster and red shrimp) and present the results to the suitable international forums (see 2.1), the General Fisheries Commission for the Mediterranean (GFCM) and the Scientific, Technical and Economic Committee for Fisheries (STECF).

Conservation reference points consistent with the objective of achieving the MSY target by 2020 (EU Regulation 1380/2013) will be set out for all assessed stocks. Fishing mortality (F) and biomass (B) relative to those foreseen under the MSY will be used: F/F_{MSY} and B/B_{MSY} respectively. As a general consensus, stocks with $B/B_{MSY}<1$ and $F/F_{MSY}>1$ are indicative of an overexploitation state, while $B/B_{MSY}>1$ and $F/F_{MSY}<1$ are indicative of an underexploitation state. Given that the main objective is to exploit the target stocks at MSY ($F/F_{MSY}\leq1$ and $B/B_{MSY}\geq1$), corrective measures will be applied in case the assessments reveal overexploited stocks.

In order to assess not only the main target stocks but also other species or taxonomic groups, together with different ecosystem compartments, additional conservation indicators will be used. This assessment will allow revealing population trends in both commercial (by-catches) and non-commercial (discards) species and also taxonomic groups with special sensitivity to fishing exploitation such as elasmobranchs (Quetglas et al., 2016a). To this end, conservation indicators agreed within the Marine Strategy Framework Directive (MSFD), which aims to achieve Good Environmental Status (GES) of the EU's marine waters by 2020 and to protect the resource base upon which marine-related economic and social activities depend, will be monitored. The preliminary assessment of the Balearic Islands area under the MSFD is currently available (MSFD-Levantino Balear) and will be monitored in the future according to the MSFD road map.

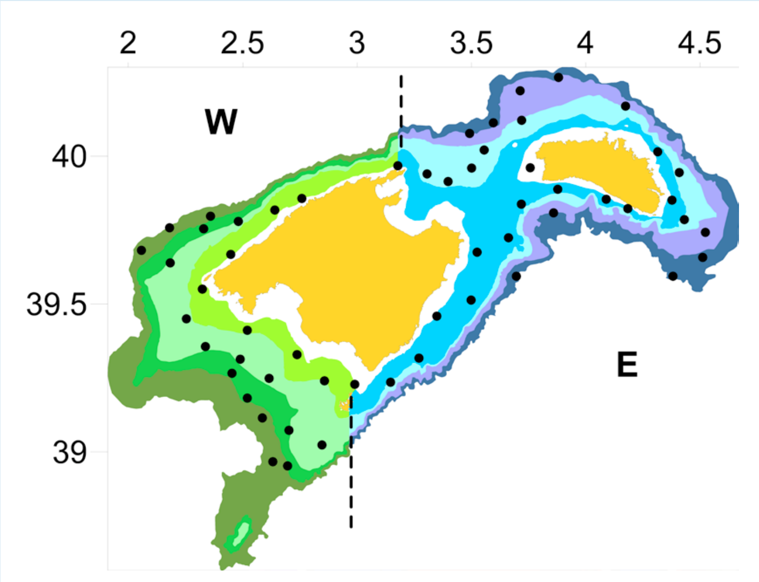
Assessing the complexity of exploited ecosystems using a variety of indicators demands the use of summarizing approaches such as the traffic lights methodology, which has already been used in the Balearic Islands (Guijarro et al., 2011, 2012b). This approach was firstly proposed as a type of precautionary management framework suitable for use in fishery assessment in data-poor situations (Caddy, 2002), but it can also be used to assess the status of all stocks whether rich or poor in data (Halliday et al., 2001). It has been applied for single- and multi-species assessments both in the Atlantic and the Mediterranean (e.g. Caddy et al., 2005; Ceriola et al., 2007) and appears to be more precautionary than traditional stock assessment methods (Koeller et al., 2000). As above, if this approach reveals negative trends in population or ecosystem indicators, corrective measures will be designed.

Scientific surveys in the Mediterranean

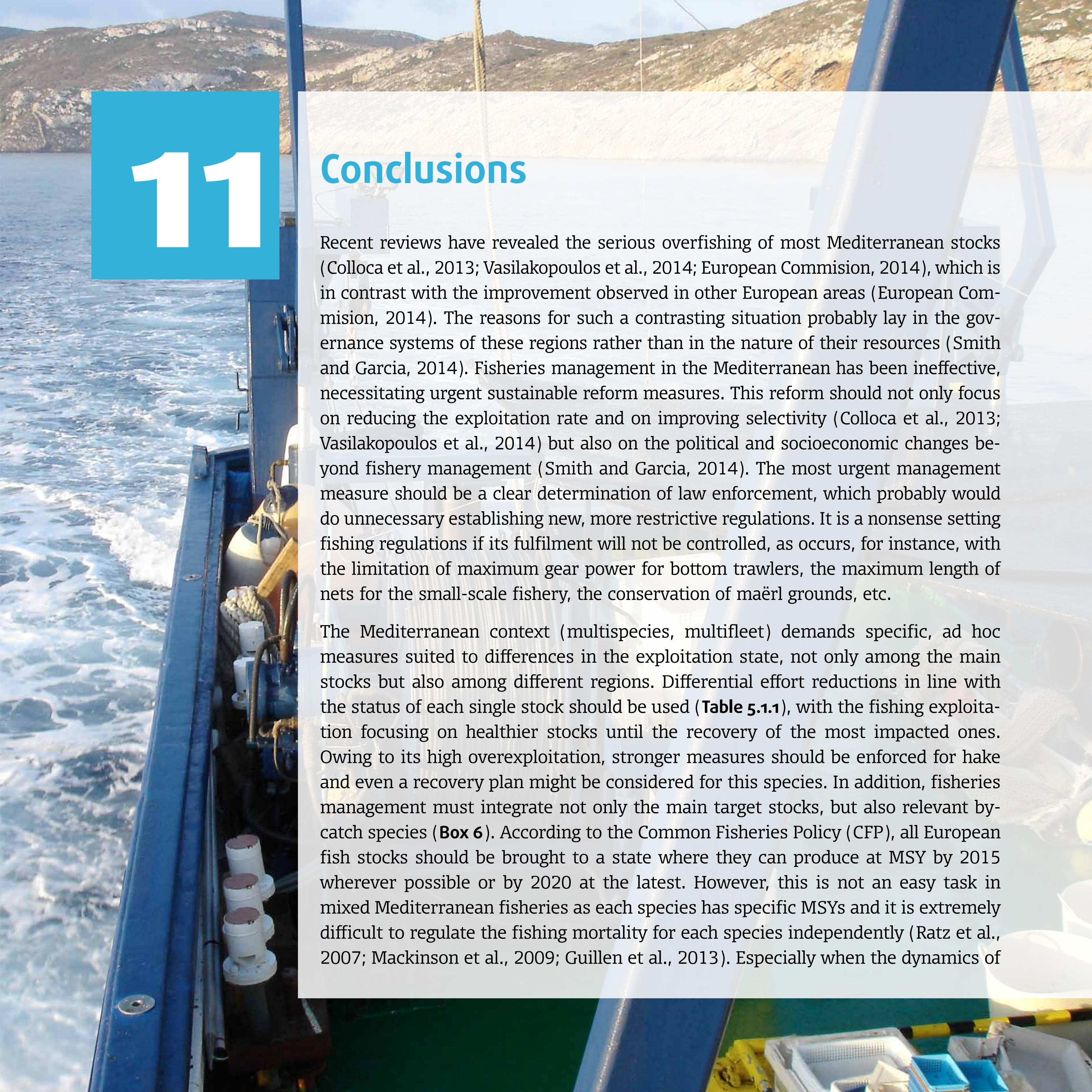
The European Commission and riparian member states co-finance scientific surveys across the Mediterranean Sea through the international programme MEDITS (MEDIterranean Trawl Surveys). This programme started with four countries (France, Greece, Italy and Spain) in 1994 but new countries and areas have been incorporated since then. The main objectives of MEDITS are obtaining information on demersal species independently of the data provided by commercial fisheries, and assessing the environmental impacts of the fishing activity. The survey follows a standardized common protocol which includes the survey design (Bertrand et al., 2002b), sampling gear, information collected, as well as data management and analysis. All surveys are performed annually during spring or early summer.

The Balearic Islands were included in the MEDITS programme in 2007. The survey covers the fishing grounds exploited by the bottom trawl fleet around Mallorca and Menorca between 50 and 800 m depth. A total of 50-60 stations (see map) are sampled each year during daytime using a bottom trawl gear specifically designed for scientific purposes (GOC 73; Bertrand et al., 2002b).

Due to its regular realization, large-scale spatio-temporal coverage and standardized methodology, the MEDITS programme constitutes the most valuable data source to investigate inter-annual changes of demersal species, communities and ecosystems in the Mediterranean.



BOX 14



11 Conclusions

Recent reviews have revealed the serious overfishing of most Mediterranean stocks (Colloca et al., 2013; Vasilakopoulos et al., 2014; European Commision, 2014), which is in contrast with the improvement observed in other European areas (European Commision, 2014). The reasons for such a contrasting situation probably lay in the governance systems of these regions rather than in the nature of their resources (Smith and Garcia, 2014). Fisheries management in the Mediterranean has been ineffective, necessitating urgent sustainable reform measures. This reform should not only focus on reducing the exploitation rate and on improving selectivity (Colloca et al., 2013; Vasilakopoulos et al., 2014) but also on the political and socioeconomic changes beyond fishery management (Smith and Garcia, 2014). The most urgent management measure should be a clear determination of law enforcement, which probably would do unnecessary establishing new, more restrictive regulations. It is a nonsense setting fishing regulations if its fulfilment will not be controlled, as occurs, for instance, with the limitation of maximum gear power for bottom trawlers, the maximum length of nets for the small-scale fishery, the conservation of maërl grounds, etc.

The Mediterranean context (multispecies, multifleet) demands specific, ad hoc measures suited to differences in the exploitation state, not only among the main stocks but also among different regions. Differential effort reductions in line with the status of each single stock should be used (**Table 5.1.1**), with the fishing exploitation focusing on healthier stocks until the recovery of the most impacted ones. Owing to its high overexploitation, stronger measures should be enforced for hake and even a recovery plan might be considered for this species. In addition, fisheries management must integrate not only the main target stocks, but also relevant bycatch species (**Box 6**). According to the Common Fisheries Policy (CFP), all European fish stocks should be brought to a state where they can produce at MSY by 2015 wherever possible or by 2020 at the latest. However, this is not an easy task in mixed Mediterranean fisheries as each species has specific MSYs and it is extremely difficult to regulate the fishing mortality for each species independently (Ratz et al., 2007; Mackinson et al., 2009; Guillen et al., 2013). Especially when the dynamics of these species, in turn, may be influenced by the ecological (i.e. climate) and fishing impacts (Mueter and Megrey, 2006).

In the Balearic Islands (GFCM-GSA05, see **Fig. 2.1**), the fishing effort has remained relatively low as compared to that in the nearby areas (Quetglas et al., 2012). The all-time maximum number of bottom trawlers in Mallorca, for instance, has been 70 units in 1977 and presently (2014) there are only 28 trawlers and some vessels leave the fishery every year. These values are clearly very far from the total number of vessels in GSA06, the adjacent area of the Iberian Peninsula where even some individual ports have more trawlers than all the ports of Mallorca combined. Trawl fishing exploitation in GSA05 is much lower than in GSA06, with the density of trawlers around the Balearic Islands being one order of magnitude lower than in adjacent waters (Massutí and Guijarro, 2004). As a result, the demersal resources and ecosystems in GSA05 are in a healthier state than in GSA06, which is reflected in: I) the population structure of the main commercial species; II) the higher abundance and diversity of sensitive species such as elasmobranchs; and III) the presence of some sensitive benthic habitats, some of them acting as essential fish habitats, which overlap with traditional fishing grounds (Quetglas et al., 2012; Ordines, 2015). These differences among areas should be taken into account for fisheries management both at national and European level, avoiding the use of general measures for all areas.

Despite the fishing effort has remained relatively low in the Balearic Islands compared to nearby areas, the fishing exploitation has produced noticeable effects on the main demersal resources. As a result of fishing, some target stocks shifted from an early period of under-exploitation to over-exploitation during the late 1970s or early 1980s (**Box 5**). This change altered the population resilience of those stocks and brought about an increase in the sensitivity of its dynamics to the climate variability (**Box 3**). These results reveal that the marine ecosystems from the Balearic Islands are also sensitive to changing environmental conditions, an issue of paramount importance in the framework of the current climate change. Consequently, the putative effects of global change should also be considered for fisheries management which, in turn, will demand an adaptive approach to face those changing conditions.

The main aim of fisheries management is the sustainable exploitation of living resources, which also requires the conservation of marine ecosystems. This is a very important issue in the Balearic Islands where, as already mentioned (see 1.1 and **Box 1**), the red algae beds (maërl) overlap with traditional fishing grounds of both the bottom trawl and small-scale fleets. Consequently, fisheries management in the area should make compatible the conservation of these habitats and the sustainability of fisheries.

This is a great challenge owing to the strong decrease in the number of fishing vessels observed in the Balearic Islands during the last decades. In case such a decrease is maintained, it might lead the fishing sector to its final disappearance, which seems not too far away in the case of bottom trawlers (**Fig. 9.1.1.1**). Another option would be to stabilize the fleet in such a low number of trawlers that it will ensure the sustainable exploitation of the resources. Fisheries management, however, should also ensure that such a low number of vessels will also allow the viability and maintenance of the fish market chain, from fishers to consumers. Needless to mention the maintenance of local traditions, culture and gastronomy within the current framework of a globalized world, especially in an area so highly dependent on tourism as the Balearic Islands. Therefore, urgent measures must be taken to improve both the profitability of commercial fishing and its attractiveness to young people, so as to guaranty the maintenance of sustainable fisheries and the protection of the marine environment.

A1

Appendix 1

Table A1.
Results of Similarity Percentage analysis (SIMPER) for the four fishing tactics developed by the bottom trawl fishery from Mallorca: shallow shelf (SS), deep shelf (DS), upper slope (US) and middle slope (MS). Species are ordered according to their importance in the average similarity contribution to the within group average similarity, and only those reaching 75% are shown. The main target species characterizing the métiers to which each group was assigned is highlighted in bold. From Palmer et al. (2009).

Group	Average similarity	Species	Mean abundance	Av. Sim.	Sim/SD	Contrib.%	Cum.%
SS	48.56	***Mullus surmuletus***	9.74	6.34	1.74	13.06	13.06
		Octopus vulgaris	7.94	6.16	1.52	12.69	25.75
		Spicara smaris	13.5	4.89	1.08	10.07	35.81
		Scyliorhinus canicula	3.59	3.79	1.14	7.8	43.61
		Chelidonichthys lastoviza	2.15	2.84	1.21	5.86	49.47
		Raja spp.	3.04	2.81	0.92	5.8	55.26
		Serranus cabrilla	2.28	2.75	1.24	5.66	60.93
		Trachinus draco	1.49	2.35	1.33	4.84	65.77
		Loligo vulgaris	2.51	2.19	0.88	4.5	70.27
		Scorpaena scrofa	1.11	1.98	1.2	4.07	74.34
		Pagellus erythrinus	2.39	1.79	0.96	3.68	78.03
DS	50.76	***Merluccius merluccius***	10.44	11.4	2.74	22.46	22.46
		Scyliorhinus canicula	2.79	5.47	2.2	10.78	33.25
		Trachurus mediterraneus	4.19	2.67	0.69	5.27	38.52
		Mullus surmuletus	2.57	2.65	1.14	5.22	43.73
		Lophius budegassa	1.11	2.64	1.31	5.2	48.93
		Raja spp.	2.68	2.33	0.79	4.59	53.52
		Trachinus draco	1.08	2.29	1.32	4.5	58.03
		Mullus barbatus	1.08	2.12	1.07	4.18	62.21
		Centracanthus cirrus	3.94	2.07	0.54	4.08	66.29
		Zeus faber	1.43	2.05	0.85	4.04	70.33
		Lepidorhombus boscii	0.91	1.83	0.86	3.6	73.93
		Chelidonichthys cuculus	1.34	1.76	0.77	3.46	77.39

Group	Average similarity	Species	Mean abundance	Av. Sim.	Sim/SD	Contrib.%	Cum.%
US	50.91	***Micromesistius poutassou***	9.13	9.38	1.27	18.43	18.43
		Merluccius merluccius	4.84	8.86	2.95	17.41	35.84
		Parapenaeus longirostris	2.8	4.62	1.25	9.07	44.9
		Phycis blennoides	1.83	4.46	1.66	8.75	53.66
		Lepidorhombus boscii	1.24	3.93	1.81	7.72	61.37
		Scyliorhinus canicula	1.98	2.82	0.83	5.55	66.92
		Lophius budegassa	1.07	2.56	1.11	5.03	71.96
		Nephrops norvegicus	1.4	2.42	0.73	4.75	76.71
MS	55.38	***Aristeus antennatus***	7.81	27.4	2.65	49.47	49.47
		Phycis blennoides	1.17	6.58	1.46	11.88	61.34
		Micromesistius poutassou	1.12	4.82	0.97	8.7	70.04
		Merluccius merluccius	0.63	4.79	1.26	8.65	78.69

A2

Appendix 2

Table A2.
Results of the Similarity Percentage analysis (SIMPER) performed on the eight fishing tactics developed by the small-scale fishery from Mallorca. The main target species characterizing the métiers to which each group was assigned is highlighted in bold. The EU codes for the gears (LA: lámpara nets; SV: boat seine; LHM: hand lines; GTR: trammel net; LLS: set longlines) and métiers (SLPF: small and large pelagic fish; DEMSP: demersal species; DEMF: demersal fish) corresponding to each group are also shown (DCF-Annex 1).

Group and EU code	Average similarity	Species	Mean abundance	Av. Sim.	Sim/SD	Con-trib.%	Cum.%
1 LA-SLPF	56.87	***Coryphaena hippurus***	65.75	51.48	1.77	90.51	90.51
		Naucrates ductor	14.28	5.39	0.39	9.49	100.00
2 SV-DEMSP	77.38	***Aphia minuta***	22.62	77.33	4.90	99.93	99.93
3 LHM-DEMSP	67.96	***Loligo vulgaris***	6.50	67.46	3.14	99.26	99.26
4 GTR-DEMSP	51.20	***Mullus surmuletus***	9.53	45.44	2.27	88.75	88.75
		Sepia officinalis	1.03	3.00	0.36	5.86	94.61
		Scorpaena scrofa	0.68	1.50	0.26	2.94	97.55
		Octopus vulgaris	0.64	0.84	0.18	1.65	99.20
5 GTR-DEMSP	39.86	***Sepia officinalis***	10.15	27.14	1.31	68.08	68.08
		Scorpaena porcus	2.22	4.66	0.41	11.69	79.77
		Scorpaena scrofa	1.55	3.14	0.40	7.89	87.66
		Octopus vulgaris	2.27	3.12	0.39	7.83	95.49
		Raja spp.	1.28	0.58	0.17	1.44	96.93
		Zeus faber	0.43	0.51	0.20	1.29	98.22
		Mullus surmuletus	0.51	0.39	0.15	0.98	99.20
6 LLS-DEMF	49.38	***Dentex dentex***	9.76	43.82	2.34	88.73	88.73
		Scorpaena scrofa	1.15	2.57	0.31	5.21	93.94
		Spondyliosoma cantharus	1.07	1.20	0.23	2.43	96.37
		Sparus pagrus	0.95	0.85	0.20	1.72	98.08
		Epinephelus marginatus	0.71	0.51	0.14	1.04	99.12

Group and EU code	Average similarity	Species	Mean abundance	Av. Sim.	Sim/SD	Con-trib.%	Cum.%
7 GTR-DEMSP	34.17	*Raja* spp.	13.27	16.10	1.01	47.10	47.10
		Scorpaena scrofa	5.83	8.49	0.91	24.85	71.95
		Sparus pagrus	4.97	2.77	0.45	8.11	80.06
		Dentex dentex	2.85	1.55	0.31	4.53	84.59
		Conger conger	3.15	1.54	0.28	4.51	89.10
		Spondyliosoma cantharus	2.08	0.99	0.28	2.90	92.00
		Phycis phycis	1.39	0.76	0.26	2.23	94.22
		Trachinus spp.	1.16	0.72	0.26	2.12	96.34
		Scyliorhinus canicula	1.97	0.57	0.19	1.67	98.02
		Epinephelus marginatus	1.24	0.21	0.12	0.61	98.62
		Zeus faber	0.28	0.15	0.11	0.44	99.06
8 GTR-DEMSP	39.51	***Palinurus elephas***	5.88	19.54	0.78	49.44	49.44
		Scorpaena scrofa	3.29	17.26	0.82	43.68	93.12
		Lophius spp.	0.96	1.19	0.22	3.00	96.12
		Raja spp.	1.44	0.67	0.16	1.70	97.82
		Zeus faber	0.57	0.61	0.17	1.54	99.37

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References

Acosta, J., Canals, M., López-Martínez, J., Muñoz, A., Herranz, P., Urgeles, R., Palomo, C., and Casamor, J.L., 2002. The Balearic Promontory geomorphology (western Mediterranean): morphostructure and active processes. Geomorphology, 49: 177-204.

Anderson, C. N. K., Hsieh, C.H., Sandin, S.A., Hewitt, R., Hollowed, A., Beddington, J., May, R.M., and Sugihara, G., 2008. Why fishing magnifies fluctuations in fish abundance. Nature, 452: 835-839.

Ardizzone, G.D., 2006. An introduction to Sensitive and Essential Fish Habitats identification and protection in the Mediterranean Sea. Working Document to the STECF/SGMED-06-01 subgroup meeting on Sensitive and Essential Fish Habitats in the Mediterranean, Rome, March 2006.

Asche, F. and Guillen, J., 2012. The importance of fishing method, gear and origin: The Spanish hake market. Marine Policy, 36: 365-369.

Ballesteros, E., 1992. Els fons rocosos profunds amb *Osmundaria volubilis* (Linné) R.E. Norris a les Balears. Bolletí de la Societat d´Història Natural de les Balears, 35: 33-50.

Ballesteros, E., 1994. The deep-water *Peyssonnelia* beds from the Balearic Islands (Western Mediterranean). Marine Ecology-Pubblicazioni Della Stazione Zoologica di Napoli I, 15: 233-253.

Barberá, C., Bordehore, C., Borg, J.A., Glemarec, M., Grall, J., Hall-Spencer, J.M., De la Huz, C., Lanfranco, E., Lastra, M., Moore, P.G., Mora, J., Pita, M.E., Ramos-Espla, A.A., Rizzo, M., Sanchez-Mata, A., Seva, A., Schembri, P.J., and Valle, C., 2003. Conservation and management of northeast Atlantic and Mediterranean maerl beds. Aquatic Conservation-Marine and Freshwater Ecosystems, 13: S65-S76.

Barberá, C., Moranta, J., Ordines, F., Ramon, M., de Mesa, A., Diaz-Valdes, M., Grau, A., and Massutí, E., 2012a. Biodiversity and habitat mapping of Menorca Channel (western Mediterranean): implications for conservation. Biodiversity and Conservation, 21: 701-728.

Barberá C., Comalada, N., Joher, S., Valls, M., Díaz-Valdés, M. and Moranta, J., 2012b. Analysis of morphological characteristics of rhodoliths as indicator of habitat complexity and fishing effects. Revista de Investigación Marina, 19(6): 346.

Bellido, J. M., Begona Santos, M., Grazia Pennino, M., Valeiras, X., and Pierce, G.J., 2011. Fishery discards and bycatch: solutions for an ecosystem approach to fisheries management? Hydrobiologia, 670: 317-333.

Bertrand, J. A., de Sola, L.G., Papaconstantinou, C., Relini, G., and Souplet, A., 2002a. The general specifications of the MEDITS surveys. Scientia Marina, 66: 9-17.

Bertrand, J. A., Leonori, I., Dremiere, P.Y., and Cosimi, G., 2002b. Depth trajectory and performance of a trawl used for an international bottom trawl survey in the Mediterranean. Scientia Marina, 66: 169-182.

Bosc, E., Bricaud, A., and Antoine, D., 2004. Seasonal and interannual variability in algal biomass and primary production in the Mediterranean Sea, as derived from 4 years of SeaWiFS observations. Global Biogeochemical Cycles, 18.

Bradai, M.N., Bouain, A., 1991. Reproduction de *Scorpaena porcus* (Linné, 1758) et de *S. scrofa* (Linné 1758) (Pisces, Scorpaenidae) du Golfe de Gabes. Oebalia, 12: 167-180.

Cabanellas-Reboredo, M., 2014. Socio-ecological approach of the recreational squid fishery. Ph.D. Thesis University of the Balearic Islands, 180 pp.

Caddy, J. F., 2002. Limit reference points, traffic lights, and holistic approaches to fisheries management with minimal stock assessment input. Fisheries Research, 56: 133-137.

Caddy, J. F. and Mahon, R., 1995. Reference points for fisheries management. FAO Fisheries Technical Paper, 347: 1-83.

Caddy, J. F., Wade, E., Surette, T., Hebert, M., and Moriyasu, M., 2005. Using an empirical traffic light procedure for monitoring and forecasting in the Gulf of St. Lawrence fishery for the snow crab, *Chionoecetes opilio*. Fisheries Research, 76: 123-145.

Canals, M. and Ballesteros, E., 1997. Production of carbonate particles by phytobenthic communities on the Mallorca-Menorca shelf, northwestern Mediterranean Sea. Deep Sea Research Part II: Topical Studies in Oceanography, 44: 611-629.

Carreras, M. and Cornax, M., 2011. Propuesta de OCEANA para una pesca responsable en las Illes Balears. OCEANA, http://oceana.org/node/20497.

Ceriola, L., Ungaro, N., and Toteda, F., 2007. A “Traffic” Light approach for the assessment of the Broadtail shortfin squid *Illex coindetii* Verany, 1839 in the Southern Adriatic Sea (Central Mediterranean). Reviews in Fish Biology and Fisheries, 17: 145-157.

Coleman, F. C., Figueira, W.F., Ueland, J.S., and Crowder, L.B., 2004. The impact of United States recreational fisheries on marine fish populations. Science, 305: 1958-1960.

Coll, J., Linde, M., Garcia-Rubies, A., Riera, F., and Grau, A.M., 2004. Spear fishing in the Balearic Islands (west central Mediterranean): species affected and catch evolution during the period 1975-2001. Fisheries Research, 70: 97-111.

Coll, J., Garcia-Rubies, A., Morey, G., and Grau, A.M., 2012. The carrying capacity and the effects of protection level in three marine protected areas in the Balearic Islands (NW Mediterranean). Scientia Marina, 76: 809-826.

Coll, J., Garcia-Rubies, A., Morey, G., Renones, O., Alvarez-Berastegui, D., Navarro, O., and Grau, A.M., 2013. Using no-take marine reserves as a tool for evaluating rocky-reef fish resources in the western Mediterranean. ICES Journal of Marine Science, 70: 578-590.

Coll, M., Carreras, M., Cornax, M., Massutí, E., Morote, E., Pastor, X., Quetglas, A., Saez, R., Silva, L., Sobrino, I., Torres, M., Tudela, S., Harper, S., Zeller, D., and Pauly, D., 2014. Closer to reality: Reconstructing total removals in mixed fisheries from Southern Europe. Fisheries Research, 154: 179-194.

Colloca, F., Cardinale, M., Ardizzone, G.D., 1997. Biology, spatial distribution and population dynamics of *Lepidotrigla cavillone* (Pisces: Triglidae) in the central Tyrrhenian Sea. Fisheries Research, 32: 21-32.

Colloca, F., Cardinale, M., Belluscio, A., and Ardizzone, G., 2003. Pattern of distribution and diversity of demersal assemblages in the central Mediterranean sea. Estuarine Coastal and Shelf Science, 56: 469-480.

Colloca, F., Cardinale, M., Maynou, F., Giannoulaki, M., Scarcella, G., Jenko, K., Bellido, J.M., and Fiorentino, F., 2013. Rebuilding Mediterranean fisheries: a new paradigm for ecological sustainability. Fish and Fisheries, 14: 89-109.

Colloca, F., Carpentieri, P., Balestri, E., and Ardizzone, G.D., 2004. A critical habitat for Mediterranean fish resources: shelf-break areas with *Leptometra phalangium* (Echinodermata: Crinoidea). Marine Biology, 145: 1129-1142.

Cooke, S. J. and Cowx, I.G., 2006. Contrasting recreational and commercial fishing: Searching for common issues to promote unified conservation of fisheries resources and aquatic environments. Biological Conservation, 128: 93-108.

Cressey, D., 2013. Europe debates fisheries funding. Nature, 502: 420.

Delgado, C.L., Wada, N., Rosegrant, M.W., Meijer, S., and Ahmed.M., 2003. Fish to 2020: Supply and demand in changing global markets. International Food Policy Research Institute, Washington DC, World Fish Center Technical Report 62, 232 pp.

Díaz D., 2009. Ecología de la fase juvenil de la langosta roja *Palinurus elephas* en el Mediterráneo noroccidental. Tesis Doctoral, Universitat de Barcelona, 453 pp.

Domínguez, M., Fontán, A., Rivera, J., and Ramón, M., 2013. Caracterización del ecosistema bentónico de la plataforma costera del área comprendida entre Sa Dragonera, Cabrera y el Cap de Ses Salines (Mallorca). Informe proyecto DRAGONSAL, Instituto Español de Oceanografía, 198 pp. + 2 Anexos + 6 Mapas.

Dulčić, J., Pallaoro, A., Cetinić, P., Kraljević, M., Soldo, A., Jardas, I., 2003. Age, growth and mortality of picarel, *Spicara smaris* L. (Pisces: Centracanthidae), from the eastern Adriatic (Croatian coast). Journal of Applied Ichthyology, 19: 10-14.

Estrada, M., 1996. Primary production in the northwestern Mediterranean. Scientia Marina, 60: 55-64.

European Commission, 2004. Mediterranean: guaranteeing sustainable fisheries. Fishing in Europe, 21: 1-12.

European Commission, 2013. Oil Bulletin. E. European Commission, Market Observatory and Statistics, https://ec.europa.eu/energy/en/data-analysis/weekly-oil-bulletin.

European Commission, 2014. Concerning a consultation on Fishing Opportunities for 2015 under the Common Fisheries Policy. COM (2014).Brussels, 26.6.2014.

Froese, R., 2004. Keep it simple: three indicators to deal with overfishing. Fish and Fisheries, 5: 86-91.

Giannoulaki, M., Iglesias, M., Leonori, I., Patti, B., Pirounaki, M.M., Tugores, P., Campanella, F., Siapatis, A., Basilone, G., D'Elia, M., Machias, A., De Felice, A., Somarakis, S., Valavanis, V., Papadopoulou, N., Nikolopoulou, M., Bonanno, A., Vasapollo, C., Tsagarakis, K., 2013. Mapping of nursery and spawning grounds of small pelagic fish. Mediterranean Sensitive Habitats (MEDISEH) Final Report, DG MARE Specific Contract SI2.600741, Heraklion.

Gonzalez, M., Barcala, E., Perez-Gil, J.L., Carrasco, M.N., García-Martínez, M.C., 2011. Fisheries and reproductive biology of *Octopus vulgaris* (Mollusca: Cephalopoda) in the Gulf of Alicante (Northwestern Mediterranean). Mediterranean Marine Science, 12: 369-389.

Goñi, R., Mallol, S., Díaz, D., Mora, J., Mateo, A., and Muñoz, A., 2013. Estudio integral de la langosta roja (*Palinurus elephas*) en las Islas Baleares para el diseño de un sistema de gestión pesquera sostenible. Informe final 2013 proyecto LANBAL. Proyecto LANBAL (2010-2013),IEO-COB/LANBAL/13-1, 90 pp.

Guijarro, B. and Massutí, E., 2006. Selectivity of diamond- and square-mesh codends in the deepwater crustacean trawl fishery off the Balearic Islands (western Mediterranean). ICES Journal of Marine Science, 63: 52-67.

Guijarro, B., Quetglas, A., and Morillas, A., 2012a. La importància del sector pesquer en la investigació oceanogràfica. Centre Oceanogràfic de les Balears & Direcció General d' Universitats, Recerca i Transferència del Coneixement, Palma de Mallorca, 52 pp.

Guijarro, B., Quetglas, A., Moranta, J., Ordines, F., Valls, M., Gonzalez, N., and Massutí, E., 2012b. Inter- and intra-annual trends and status indicators of nektobenthic elasmobranchs off the Balearic Islands (northwestern Mediterranean). Scientia Marina, 76: 87-96.

Guijarro, B., Tserpes, G., Moranta, J., and Massutí, E., 2011. Assessment of the deep water trawl fishery off the Balearic Islands (western Mediterranean): from single to multi-species approach. Hydrobiologia, 670: 67-85.

Guijarro, B., Ordines, F. and Massutí, E., (in preparation). Improving the ecological efficiency of the bottom trawl fishery in the western Mediterranean: it's about time!

Guillen, J., Macher, C., Merzereaud, M., Bertignac, M., Fifas, S., and Guyader, O., 2013. Estimating MSY and MEY in multi-species and multi-fleet fisheries, consequences and limits: an application to the Bay of Biscay mixed fishery. Marine Policy, 40: 64-74.

Guillen, J. and Maynou, F., 2015. Characterisation of fish species based on ex-vessel prices and its management implications: An application to the Spanish Mediterranean. Fisheries Research, 167: 22-29.

Halliday, R.G., Fanning, L.P., and Mohn, R.K., 2001. Use of the Traffic Light method in fishery management planning. Canadian Science Advisory Secretariat Research Document 2001/108.

Hsieh, C. H., Reiss, C.S., Hunter, J.R., Beddington, J.R., May, R.M., and Sugihara, G., 2006. Fishing elevates variability in the abundance of exploited species. Nature, 443: 859-862.

Ivory, P., Jeal, F., Nolan, C.P., 2004. Age Determination, Growth and Reproduction in the Lesser-spotted Dogfish, *Scyliorhinus canicula* (L.). Journal of Northwest Atlantic Fisheries Science, 35: 89–106.

Koeller, P., Savard, L., Parsons, D.G., and Fu, C., 2000. A precautionary approach to assessment and management of red shrimp stocks in the Nortwest Atlantic. Journal of Northwest Atlantic Fishery Science, 27: 235-246.

Lleonart, J. and Maynou, F., 2003. Fish stock assessments in the Mediterranean: state of the art. Scientia Marina, 67: 37-49.

Lleonart, J., Maynou, F., Recasens, L., and Franquesa, R., 2003. A bioeconomic model for Mediterranean fisheries, the hake off Catalonia (western Mediterranean) as a case study. Scientia Marina, 67: 337-351.

Mackinson, S., Deas, B., Beveridge, D., and Casey, J., 2009. Mixed-fishery or ecosystem conundrum? Multispecies considerations inform thinking on long-term management of North Sea demersal stocks. Canadian Journal of Fisheries and Aquatic Sciences, 66: 1107-1129.

Massutí, M., 1991. Les Illes Balears: una área de pesca individualitzada a la Mediterrània occidental. Govern de les Illes Balears. Quaderns de Pesca, 2: 62 pp.

Massutí E., Zapata, M.A., Guijarro, B., Vidal, E.M., Sintes, J., Picó, G., Uranga, I. and Ordines, F., 2015. New selectivity data for Spanish bottom trawl nets (GSA05) with square mesh panels of thinner, lighter and wider netting without knots in the upper plan. Deliverable 3.7 DISCATCH project (DG MARE European Commission, Contract Nº MARE/2012/24 Lot 2), 40 pp.

Massutí, E. and Guijarro, B., 2004. Recursos demersales en los fondos de arrastre de la plataforma y el talud de Mallorca y Menorca (Illes Balears). Resultados de las campañas BALAR0401 y BALAR0901. Informes Técnicos del Instituto Español de Oceanografía, 182: 1-132.

Massutí, E., Ordines, F., and Guijarro, B., 2009. Efficiency of flexible sorting grids to improve size selectivity of the bottom trawl in the Balearic Islands (western Mediterranean), with comparison to a change in mesh cod-end geometry. Journal of Applied Ichthyology, 25: 153-161.

Maynou, F., Sarda, F., Tudela, S., and Demestre, M., 2006. Management strategies for red shrimp (*Aristeus antennatus*) fisheries in the Catalan sea (NW Mediterranean) based on bioeconomic simulation analysis. Aquatic Living Resources, 19: 161-171.

Merino, G., Morales-Nin, B., Maynou, F., and Grau, A.M., 2008. Assessment and bioeconomic analysis of the Majorca (NW Mediterranean) trammel net fishery. Aquatic Living Resources, 21: 99-107.

Merino, G., Quetglas, A., Maynou, F., Garau, A., Arrizabalaga, H., Murua, H., Santiago, J., Barange, M., Prellezo, R., García, D., Lleonart, J., Tserpes, G., Maravelias, C., Carvalho, N., Austen, M., Fernandes, J.A., Oliver, P., and Grau, A.M., 2015. Improving the performance of a Mediterranean demersal fishery toward economic objectives beyond MSY. Fisheries Research, 161: 131-144.

Morales-Nin, B., Moranta, J., Garcia, C., Tugores, M.P., Grau, A.M., Riera, F., and Cerda, M., 2005. The recreational fishery off Majorca Island (western Mediterranean): some implications for coastal resource management. ICES Journal of Marine Science, 62: 727-739.

Morales-Nin, B., Cardona-Pons, F., García, E., Alvarez, I., and Pérez-Mayol, S., 2013. Does angling activity influence consumer choices of fresh fish? British Food Journal, 115: 1054-1066.

Morales-Nin, B., Cardona-Pons, F., Maynou, F., and Maria Grau, A., 2015. How relevant are recreational fisheries? Motivation and activity of resident and tourist anglers in Majorca. Fisheries Research, 164: 45-49.

Morales-Nin, B., Moranta, J., Garcia, C., Tugores, P., and Grau, A.M., 2008. Evaluation of the importance of recreational fisheries on a Mediterranean island. In Reconciling fisheries with conservation: Proceedings of the Fourth World Fisheries Congress, pp. 445-450. Ed. by J. Nielsen et al.. American Fisheries Society Symposium 49, 1946 pp.

Moranta, J., Barbera, C., Druet, M., and Zaragoza, N., 2014. Caracterización ecológica de la plataforma continental (50-100 m) del Canal de Menorca. Informe final área LIFE+ INDEMARES (LIFE07/NAT/E/000732). Instituto Español de Oceanografía-Centro Oceanográfico de Baleares. Coordinación: Fundación Biodiversidad, 504 pp.

Mueter, F. J. and Megrey, B.A., 2006. Using multi-species surplus production models to estimate ecosystem-level maximum sustainable yields. Fisheries Research, 81: 189-201.

Muñoz, M., Casadeval, M., 2002. Reproductive indices and fecundity of *Helicolenus dactylopterus dactylopterus* (Teleostei: Scorpaenidae) in the Catalan Sea (western Mediterranean). Journal of the Marine Biological Association of the United Kingdom, 82: 995-1000.

Myers, R. A. and Mertz, G., 1998. The limits of exploitation: A precautionary approach. Ecological Applications, 8: S165-S169.

Oliver P., 1993. Analysis of fluctuations observed in the trawl fleet landings of the Balearic Islands. Scientia Marina, 57: 219-227.

Ordines, F., 2015. Habitats and nekto-benthic communities of the bottom-trawl fishery developed on the continental shelf of the Balearic Islands. PhD Universitat de les Illes Balears, Palma de Mallorca, Spain, 228 pp.

Ordines, F., Farriols, M., Lleonart, J., Guijarro, B., Quetglas, A., and Massutí, E., 2014. Biology and population dynamics of by-catch fish species of the bottom trawl fishery in the western Mediterranean. Mediterranean Marine Science, 15: 613-625.

Ordines, F. and Massutí, E., 2009. Relationships between macro-epibenthic communities and fish on the shelf grounds of the western Mediterranean. Aquatic Conservation-Marine and Freshwater Ecosystems, 19: 370-383.

Ordines, F., Quetglas, A., Massutí, E., and Moranta, J., 2009. Habitat preferences and life history of the red scorpion fish, *Scorpaena notata*, in the Mediterranean. Estuarine Coastal and Shelf Science, 85: 537-546.

Ordines, F., Bauza, M., Sbert, M., Roca, P., Gianotti, M., and Massutí, E., 2015. Red algal beds increase the condition of nekto-benthic fish. Journal of Sea Research, 95: 115-123.

Ordines, F., Jorda, G., Quetglas, A., Flexas, M., Moranta, J., and Massutí, E., 2011. Connections between hydrodynamics, benthic landscape and associated fauna in the Balearic Islands, western Mediterranean. Continental Shelf Research, 31: 1835-1844.

Ordines, F., Massutí, E., Guijarro, B., and Mas, R., 2006. Diamond vs. square mesh codend in a multi-species trawl fishery of the western Mediterranean: effects on catch composition, yield, size selectivity and discards. Aquatic

Living Resources, 19: 329-338.

Pajuelo, J.G., Lorenzo, J.M., 1998. Population biology of the common pandora *Pagellus erythrinus* (Pisces: Sparidae) off the Canary Islands. Fisheries Research, 36: 75-86.

Pajuelo, J.G., Lorenzo, J.M., 2000. Reproduction, age, growth and mortality of axillary seabream, *Pagellus acarne* (Sparidae), from the Canarian archipelago. Journal of Applied Ichthyology, 16: 41-47.

Palmer, M., Quetglas, A., Guijarro, B., Moranta, J., Ordines, F., and Massutí, E., 2009. Performance of artificial neural networks and discriminant analysis in predicting fishing tactics from multispecific fisheries. Canadian Journal of Fisheries and Aquatic Sciences, 66: 224-237.

Pauly, D., Ulman, A., Piroddi, C., Bultel, E., and Coll, M., 2014. 'Reported' versus 'likely' fisheries catches of four Mediterranean countries. Scientia Marina, 78: 11-17.

Pawson, M., Glenn, H., and Padda, G., 2008. The definition of marine recreational fishing in Europe. Marine Policy, 32: 339-350.

Perry, R. I., Cury, P., Brander, K., Jennings, S., Moellmann, C., and Planque, B., 2010. Sensitivity of marine systems to climate and fishing: Concepts, issues and management responses. Journal of Marine Systems, 79: 427-435.

Planque, B., Fromentin, J.M., Cury, P., Drinkwater, K.F., Jennings, S., Perry, R.I., and Kifani, S., 2010. How does fishing alter marine populations and ecosystems sensitivity to climate? Journal of Marine Systems, 79: 403-417.

Punt, A. E., Smith, D.C., Tuck, G.N., and Methot, R.D., 2006. Including discard data in fisheries stock assessments: Two case studies from south-eastern Australia. Fisheries Research, 79: 239-250.

Quetglas, A., Guijarro, B., Ordines, F., and Massutí, E., 2012. Stock boundaries for fisheries assessment and management in the Mediterranean: the Balearic Islands as a case study. Scientia Marina, 76: 17-28.

Quetglas, A., Keller, S., and Massutí, E., 2015. Can Mediterranean cephalopod stocks be managed at MSY by 2020? The Balearic Islands as a case study. Fisheries Management and Ecology, 22: 349-358.

Quetglas, A., Ordines, F., Hidalgo, M., Monserrat, S., Ruiz, S., Amores, A., Moranta, J., and Massutí, E., 2013. Synchronous combined effects of fishing and climate within a demersal community. ICES Journal of Marine Science, 70: 319-328.

Quetglas, A., Rueda, L., Alvarez-Berastegui, D., Guijarro, B., and Massutí, E., 2016a. Contrasting Responses to Harvesting and Environmental Drivers of Fast and Slow Life History Species. Plos One, 11: e0148770.

Quetglas, A., Merino, G., Ordines, F., Guijarro, B., Garau, A., Grau, A.M., Oliver, P., and Massutí, E., 2016b. Assessment and management of western Mediterranean small-scale fisheries. Ocean and Coastal Management, 133: 95-104.

Ratz, H. J., Bethke, E., Dorner, H., Beare, D., and Groger, J., 2007. Sustainable management of mixed demersal fisheries in the North Sea through fleet-based management: a proposal from a biological perspective. ICES Journal of Marine Science, 64: 652-660.

Reñones, O., Massutí E., Morales-Nin B., 1995. Life history of red mullet (*Mullus surmuletus*) from the bottom trawl fishery off Mallorca Island (NW Mediterranean). Marine Biology, 123: 411-419.

Samy-Kamal, M., Forcada, A., and Sanchez Lizaso, J.L., 2015. Daily variation of fishing effort and ex-vessel prices in a western Mediterranean multi-species fishery: Implications for sustainable management. Marine Policy, 61: 187-195.

Sarda, F., Bahamon, N., Moli, B., and Sarda-Palomera, F., 2006. The use of a square mesh codend and sorting grids to reduce catches of young fish and improve sustainability in a multispecies bottom trawl fishery in the Mediterranean. Scientia Marina, 70: 347-353.

Schaefer, M. B., 1954. Some aspects of the dynamics of populations, important for the management of the commercial fisheries. Bulletin of the Inter-American Tropical Tuna Commission, 1: 1-56.

Smith, A. D. M. and Garcia, S.A.M., 2014. Fishery Management: Contrasts in the Mediterranean and the Atlantic. Current Biology, 24: R810-R812.

STECF, 2012. Assessment of Mediterranean Sea stocks, part 1 (STECF 12-19). https://stecf.jrc.ec.europa.eu/reports/medbs.

STECF, 2013a. Assessment of Mediterranean Sea stocks, part 1 (STECF 13-22). https://stecf.jrc.ec.europa.eu/reports/medbs.

STECF, 2013b. Assessment of Mediterranean Sea stocks part 2 (STECF 14-08). https://stecf.jrc.ec.europa.eu/reports/medbs.

STECF, 2014. Assessment of Mediterranean Sea stocks, part 2 (STECF-15-06). https://stecf.jrc.ec.europa.eu/reports/medbs.

Sumaila, R.U., Lam, V., Le Manach, F., Swartz, W., and Pauly, D., 2013. Global fisheries subsidies. Directorate-General for Internal Policies, Fisheries, IP/B/PECH/IC/2013-146, 45 pp.

Uranga I., 2012. Ciclo vital, ecología y pesquería de dos especies simpátricas de calamar en el Mediterráneo Occidental. MSc. Thesis, Universitat de les Illes Balears. 53 pp.

Vasilakopoulos, P., Maravelias, C.D., and Tserpes, G., 2014. The Alarming Decline of Mediterranean Fish Stocks. Current Biology, 24: 1643-1648.

Vassilopoulou, V., Papaconstantinou, C., 1994. Age, growth and mortality of the spotted flounder (*Citharus linguatula Linnaeus*, 1758) in the Aegean Sea. Scientia Marina, 58: 261-267.

According to the Common Fisheries Policy (CFP), all European fish stocks should be brought to a state where they can produce at Maximum Sustainable Yield (MSY) by 2020 at the latest. The EU Seventh Framework Programme Myfish project aimed at constructing an operational framework for the implementation of the MSY target as a tool for the future management of European fish stocks. This report presents the Regional Implementation Plan for demersal fisheries from the Balearic Islands (western Mediterranean) developed under Myfish in close collaboration with the main local stakeholders. The study is intended to be used as a first step towards the definition of management plans in European fisheries in the study area and a working example of the CFP implementation in the Mediterranean.

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