Are the Balearic Islands (GFCM-GSA05) an individualized area for assessment and management purposes in the western Mediterranean?

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1. Introduction

According to Resolution GFCM/31/2007/2, the General Fisheries Commission for the Mediterranean (GFCM) establishes 30 geographical subareas along the Mediterranean and Black Seas. These geographical subareas were established "*recalling the efforts made by Scientific Advisory Committee (SAC) and its Sub-Committees to identify appropriate boundaries for sub-areas in the GFCM area (FAO area 37)*" and "*recognizing the need to compile data, monitor fisheries and assess fisheries resources in a geo-referenced manner*". As a result of these efforts, the waters around the Balearic Islands were recognized as an independent sub-area (GSA 5), different from the adjacent waters of the Spanish Mediterranean coast (Northern Spain, GSA 6) (Fig. 1).

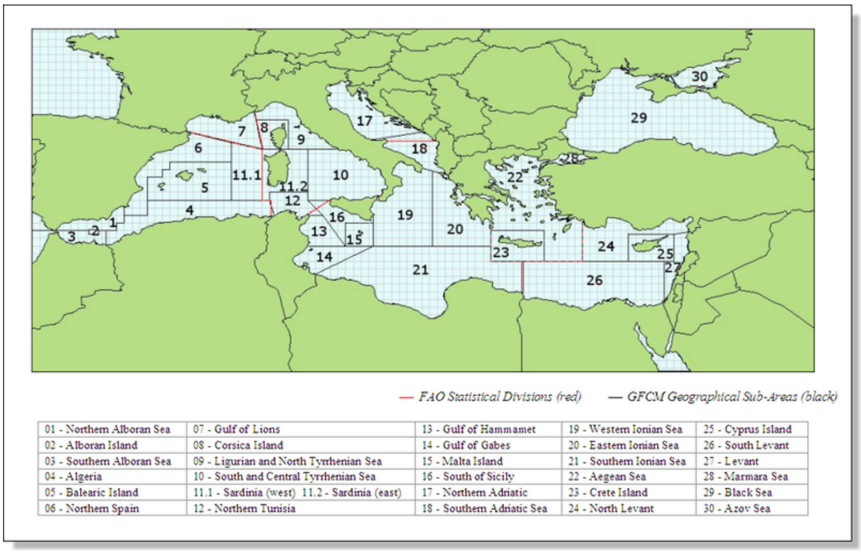

Fig. 1. GFCM Geographical Sub-Areas (GSAs) map.

In spite of this, the Report of the 12th Session of the Scientific Advisory Committee (SAC) held in Budva (Montenegro), during 25-29 January 2010 (GFCM, 2010a), contains a comment for management advice of demersal species concerning hake in GSA05. This comment points to the need of improving knowledge of stock boundary in this area and explore the possibility to join data of GSAs 5 and 6. However, no reasons were given to support such comment. The Working Group on stock assessment of demersal species (Istanbul, Turkey, 18-23 October 2010; GFCM, 2010b), identified some situations, e.g. hake stocks, where the definition of the stock units may be not well defined and having impact on the stock assessment results. To our knowledge, these are the only concerns on the issue of stocks boundary during recent GFCM meetings. Although we are not closed to a re-evaluation of stock boundaries of GFCM subareas, we think this should be done considering the entire set of current subareas, but not exclusively on individual ones. In case this debate is newly open within the framework of the GFCM, we briefly argue in this document why we consider GSA 5 should be considered an individualized geographical subarea in the western Mediterranean for stock assessment and management purposes.

2. Geomorphology

The Balearic Archipelago constitutes (Fig. 2) what is geomorphologically known as the Balearic Promontory, one of the main morphostructural features of the western Mediterranean Basin (Acosta et al., 2002). The Promontory, which is a structural elevation including four major islands (Ibiza, Formentera, Mallorca and Menorca), is 348 km in length, 105 km wide and from 1000 to 2000 m high, with respect to the surrounding basins. The Balearic shelf can be divided in two, the larger Mallorca–Menorca shelf to the east and the smaller Ibiza–Formentera shelf to the west. Mallorca and Menorca islands have a common shelf, including the smaller Cabrera Island, which total surface is 6418 km^2. The shelf is narrow and steep on the northern side, and wider and gentler in the south. The width of the shelf varies from 3 km off north Mallorca to 35 km SW of Cabrera Island. Slopes range from 3.43º to 0.23º, and the shelf-break is located on average at a depth of 139 m. Ibiza and Formentera islands have a common shelf, with a total surface area of 2709 km^2. The width of this shelf varies from 2 km east of Formentera, to more than 25 km west of this island. The slope gradient is variable from 0.37º west Formentera to 4.11º in the east side.

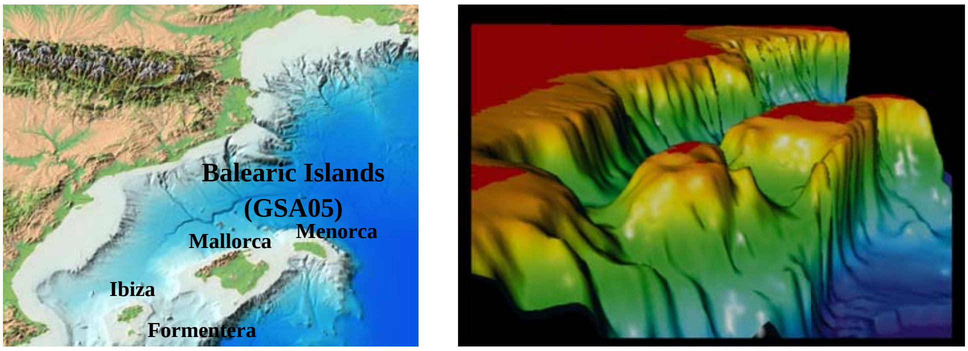

Fig. 2. Location of the GFCM GSA 5 (Balearic Islands), and image of the Balearic Promontory.

The Balearic Archipelago is separated from the mainland by a distance of between 90 and 220 km and depths between 800 and 2000 m. This distance to the nearest mainland can be comparable to other Mediterranean islands, which also are recognized as independent GSAs (e.g. Corsica: 85-160 km; Table 1). However, many of these other islands are sited closer to other islands or the mainland (e.g. Corsica-Sardinia: 11 km; Sicily-Italy: 3-20 km). In this sense, the Balearic Archipelago can be considered at least as independent as the rest of Mediterranean islands.

Table 1. Distance between GSAs and adjacent areas for the main islands in the Mediterranean Sea.

Island	GSAs	Distances between GSAs and adjacent areas
Balearic Islands	5	Spanish mainland (GSA 6): 90-220 km / 800-2000 m depth
Corsica	8	Italy (GSA 9): 85 km France (GSA 7): 160 km
Sardinia	11	Italy (GSAs 9 and 10): 400 km Corsica (GSA 11): 11 km
Sicily	10, 16, 19	Italy: 3-20 km Tunisia (GSA 13): 130 km
Malta	15	Sicily (GSA 16): 95 km (min) Tunisia (GSA 13): 290 km
Crete	23	Santorini (GSA 22): 150 km Greek mainland (GSA 22): 100 km
Cyprus	25	Turkey (GSA 24): 113 km Siria: 120 km

3. Type of habitats

The Balearic Platform represents a sort of carbonate counterpart to the terrigenous-dominated margins of the Mediterranean Iberian Peninsula. Contrary to the mainland, where there are great amounts of terrigenous incomes from rivers, the Balearic Islands has no rivers and consequently the sediments of its shelf are mainly biogenic sands and gravels, with a high percentage of carbonates. Furthermore, submarine canyons are scarce in the Balearic margin, and only the shelf-break south of Menorca is cut by a canyon head (Canals and Ballesteros, 1997). The oligotrophy of the waters around the Archipelago is even more pronounced than that of adjacent waters off the Iberian coast and the Gulf of Lions (Estrada, 1996). This fact, along with the lack of fluvial input due to a dry climate, the reduced watershed areas, and the karstic nature of most of the islands favouring rapid infiltration of rainfall, explains the high transparency of the waters in the area, thereby favouring the production of benthic biogenic sediments.

Owing to these physical characteristics, the light intensity can reach 0.05% of surface values as deep as 110 m, allowing the growth of seaweeds in most of the Balearic Islands' continental shelf. In this scenario, the red algae beds dominate the coastal continental shelf landscape off the Archipelago down to depths of 85 m (Ballesteros, 1994; Ordines and Massuti, 2009), a deeper bathymetric range than that off the Peninsula and the Gulf of Lions, were these type of bottoms seems to be restricted to depths above 60 m (Ballesteros, 1988; Bordehore et al., 2003). In the Archipelago the two main communities of red algae are the mäerl and *Peyssonnelia* beds, considered as sensitive and essential fish habitats, respectively (BIOMAERL team, 2003; Ordines and Massutí, 2009; Ordines et al., 2009). However, due to their deep distribution, these communities are subjected to the trawling fishing activity. The trawl landings from the continental shelf represent about half of the total of this fleet. However, the development of this fishery on the red algae beds dramatically influences the amount and composition of the discards in the Archipelago when compared to those in the Peninsula. The discards in the Archipelago represent up to 55-70% of the catch, mainly red algae and echinoderms, whereas in the Peninsula they represent 23-48% of the catch, mainly fish (Carbonell, 1998; Sánchez et al., 2004; Ordines et al., 2006). Hence, the particular "physical" characteristics of the Balearic Islands allow the development of red algae beds below the upper limit for legal trawling activities (50 m), which make this fishery particularly different of those found in the mainland from both discards and landings (see below).

Related to the differences in the structure and composition of the fishing grounds between GSA 5 and GSA 6, there are marked differences in the relative abundance of some commercially important resources. This is the case, for instance, of the two congeneric, sympatric species of red mullet, *Mullus barbatus* and *M. surmuletus*. In the western Mediterranean these species display spatial segregation in relation to habitat, with the red mullet *M. barbatus* and the striped red mullet *M. surmuletus* showing a clear preference for soft and rocky bottoms, respectively (Lombarte et al., 2000). Accordingly, *M. barbatus* is a main target species for fishermen working in the soft, muddy grounds of GSA 6, but a minor by-catch species for those working in GSA 5, where rocky bottoms are predominant. If we consider information obtained from the bottom trawl surveys developed in both areas (Massutí et al., 2008), the relative importance of *M. surmuletus* is 60% and 70% in terms of abundance and biomass, respectively, in the GSA 5, and 10% and 20% in terms of abundance and biomass in GSA 6 (Fig. 3).

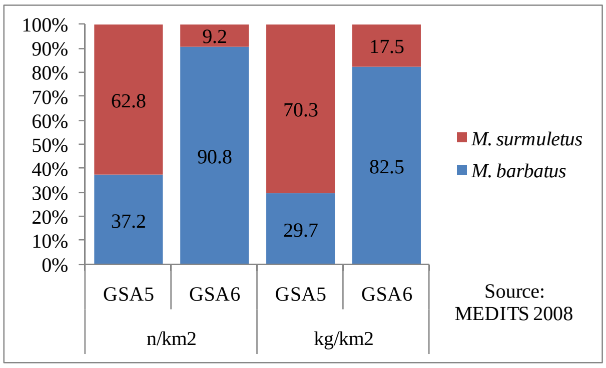

Fig 3. Relative importance of *Mullus barbatus* and *Mullus surmuletus* in GSA 5 (Balearic Islands) and GSA 6 (Northern Spain) in terms of abundance (n/km^2) and biomass (kg/km^2). Source: Massutí et al. (2008).

4. Fishing exploitation

Historically, the number of fishing boats in the Balearic Islands has remained very low compared to other areas of the Mediterranean coast off Iberian Peninsula, such as the GSA 6. Also, the importance of each fishing gear differs between both areas (Fig. 4). Although the artisanal fleet is the most numerous in both areas, their percentage is much higher in the Balearic Islands (~80% in number of commercial fishing fleet) than in the nearby Iberian coast (~60%). Bottom trawlers represent around 15% of the commercial fishing boats in the Balearic Islands and near 30% in the Iberian coast. Purse seiners are scarce in the Islands (less than 5%), but they represent around 10% in the Iberian coast. Finally, whereas there are no long-liners in the Balearic Islands, they are present, though in very small number, in the Iberian coast.

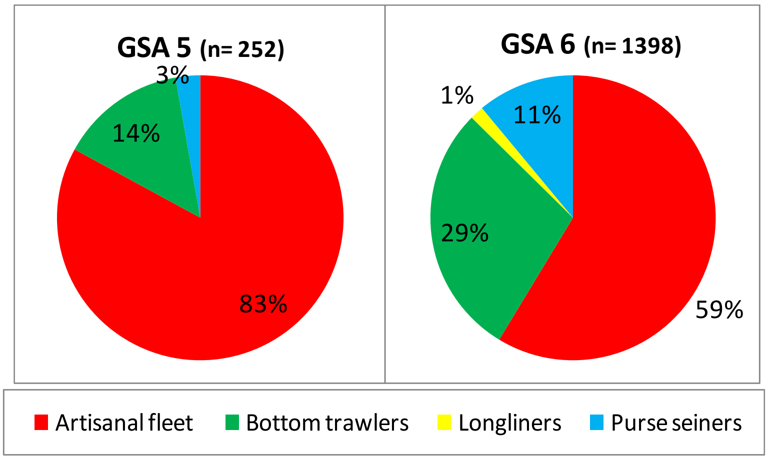

Fig. 4. Percentage of number of boats by fishing gear in the GFCM geographical subareas Balearic Islands (GSA 5) and Northern Spain (GSA 6).

These differences are more important if we consider the total landings by each fleet in both areas (Fig. 5). In the Balearic Islands, the most important fleet in terms of landings is the bottom trawl, which represents more than 70%, while in the Iberian coast this fleet represents less than 50%. The most important fleet in the Iberian coast is the purse seiners, whose landings are approximately 50% of total landings, while in the Balearic Islands this fleet represents around 10%. The importance of the landings from the artisanal fishery is four times higher in the Balearic Islands (16%) than in the Iberian coast (4%).

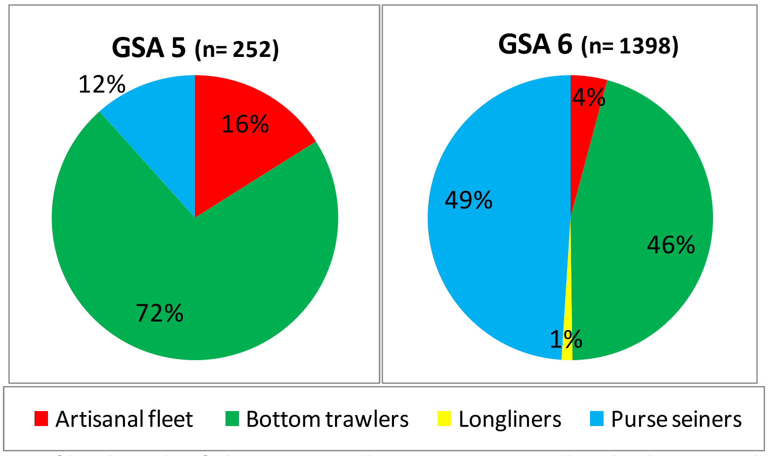

Fig. 5. Percentage of landings by fishing gear in the GFCM geographical subareas Balearic Islands (GSA 5) and Northern Spain (GSA 6).

In the case of trawlers, their number doubled in Mallorca from 35 to 70 units between 1965 and 1977, but it has decreased progressively since then, to the 32 vessels currently present. In the rest of islands, the current number of trawlers is even much more reduced: 7 in Menorca, 8 in Eivissa and 2 in Formentera. These values are clearly very far from the total number of vessels in GSA 6, where the fleet has decreased from 810 trawlers in 1998 to the current 567 trawlers. There are even individual ports of GSA 6 having more trawlers than all the ports of Mallorca combined, such as Sant Carles de la Ràpita (57), Tarragona (50), Palamós (40) or Castellón (36).

As a simple indicator of the fishing effort exerted in different areas of the Spanish Mediterranean coast, Massutí and Guijarro (2004) calculated both the number of trawlers and the gross tonnage (GT) per km^2 in each geographic sector considered in the MEDITS project (Table 2). Considering the number of vessels, the effort in the Balearic Islands was one order of magnitude lower than in the other areas.

Table 2. Number of trawlers and gross tonnage (GT) per km^2 in the GFCM GSAs 1, 5 and in the two geographic sectors of GSA 6 (Levante and Tramontana) considered in the MEDITS project. Source: Massutí and Guijarro (2004).

GSA	MEDITS Sectors	Trawlers/km^2	GT/km^2
1	Alboran	0.015	0.57
5	Mallorca and Menorca	0.004	0.17
6	Levante	0.016	0.77
6	Tramontana	0.032	1.40

With the only exception of a few number of vessels of GSA 6 working in waters off the Ibiza Channel, there are not interactions between the fleets of GSA 5 and GSA 6. These vessels, almost exclusively from the ports of Alicante, Santa Pola and Villajoyosa, carry out trips up to 4 or 5 days of duration to exploit the Norway lobster (*Nephrops norvegicus*) and the red shrimp (*Aristeus antennatus*) on the upper and middle slope bottoms (Fig. 6). This fleet is regulated by a specific management plan.

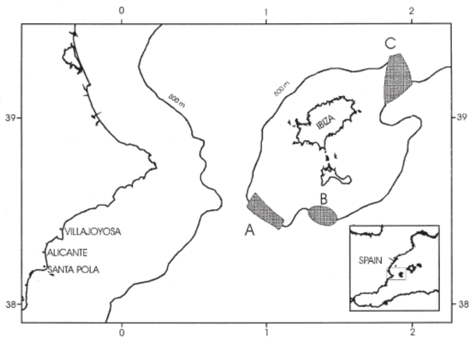

Fig. 6. Map of the Ibiza Channel, showing the principal fishing grounds in the area (A, B and C). Source: García-Rodríguez and Esteban (1999).

5. Marine living resources

The main demersal resources exploited by bottom trawlers throughout GSAs 5 and 6 shows important spatial differences, probably related to differences in the fishing grounds. Such differences are reflected in the fishing tactics (FT) developed by trawlers in each area. Trawlers use four different FTs in GSA 5 (Palmer et al., 2009), corresponding to the main depth strata (shallow shelf: SS; deep shelf: DS; upper slope: US; and middle slope: MS). However, fishermen frequently apply different FTs during the same fishing trip, which gives rise to 6 additional mixtures (SS+DS, SS+US, SS+MS, DS+US, DS+MS, and US+MS) that can be identified in the landings. Although there are no differences among different ports of GSA 5, since the entire fleet uses exclusively these FTs, this is not the case for GSA 6. where the FTs vary depending on the port. To exemplify this, we will show data from three of the most important ports of GSA 6 (Fig 7). The clusters obtained analysing daily landing data for each port, together with the species composition in the different FTs, are shown in Annex I. In Palamós, trawlers only use the same four individual FTs as in GSA 5, although they do not use mixtures and the species composition of these FTs are different. Santa Pola and Sant Carles de la Ràpita only use three different FTs and they are, however, different: SS+DS, US, and MS in the first case, and SS, DS and DS+PEL in the second one.

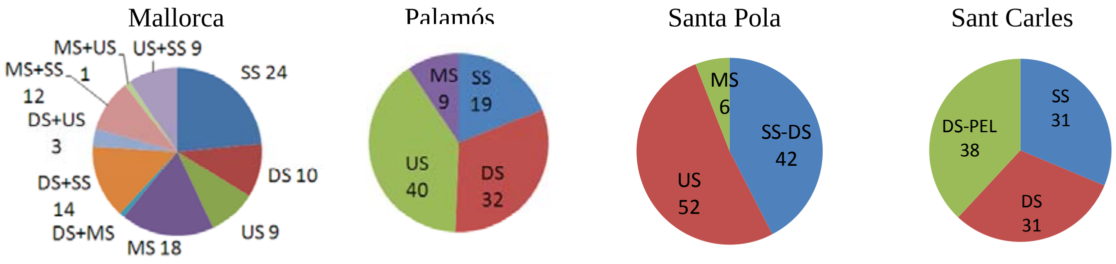

Fig. 7. Percentage in biomass for the different fishing tactics obtained analysing daily landing data in GSA05 (Mallorca) and three important ports of GSA06 (Palamós, Santa Pola and Sant Carles de la Rápita). SS: shallow shelf; DS: deep shelf; DS-PEL: pelagic deep shelf; US: upper slope; MS: middle slope.

The results of the Cluster Analysis applied to the landings of the most important species (in terms of mean kg per day and boat) by port and FT., showed important differences between ports of GSA 5 and 6 (Fig 8). Most FTs from the Balearic Islands in which the shelf had been targeted were clearly separated (at a 25% level of similarity) from those from the Iberian Coast. Similarly, the rest of FTs carried out off the Balearic Islands, with the exception of the FT exclusively targeted to US, formed a subgroup within the MS cluster which was separated from the rest of ports with FTs targeting the MS at around 50% of similarity.

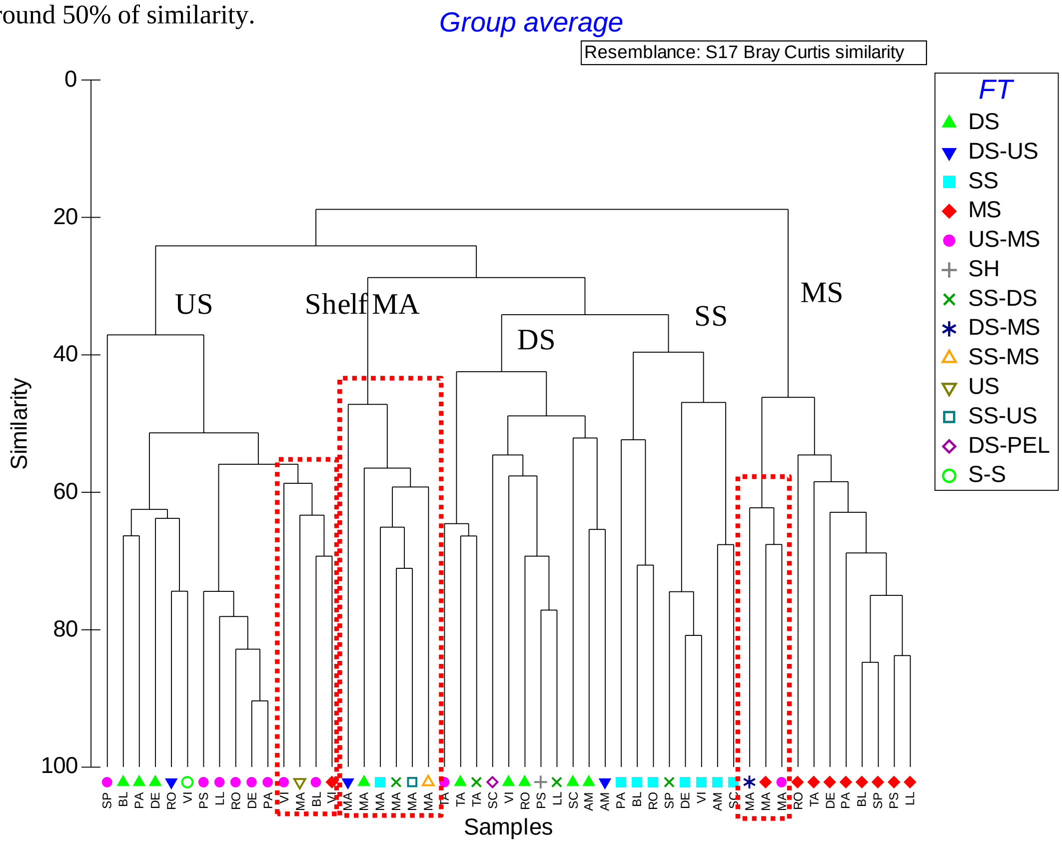

Fig. 8. Dendogram of the FT for ports corresponding to GSA05 (MA: Mallorca) and GSA06 (AM: Ametlla de Mar; BL: Blanes; DE: Dènia; PS: Port de la Selva; LL: Llançà; PA: Palamós; RO: Roses; SC: Sant Carles de la Ràpita; SP: Santa Pola; TA: Tarragona; VI: La Vila Joiosa). SS: shallow shelf; DS: deep shelf; DS-PEL: pelagic deep shelf; US: upper slope; MS: middle slope; S-S: shelf-slope.

6. State of fishery resources

According to previous works on ecological indicators performed in the Balearic Islands (Massutí & Moranta 2003; Guijarro et al. 2011a, 2011b), as well as the stock assessments presented to the GFCM both from GSA 5 and 6 (GFCM, 2010b), the resources in GSA 5 are in a healthier state than in GSA 6, which surely reflects the striking differences in fishing effort between these areas.

From an ecosystem approach, Traffic Lights (TL, Caddy, 1999, 2002) computed for the upper slope in the Balearic Islands (Fig. 9) showed a predominance of green and yellow values in the last three years, which means that the state of this assemblage have improved (Guijarro et al., 2011b). In the case of the middle slope (Fig. 10) the situation seems to be more stable, without showing any clear trend. Although the need of change from the traditional mono-specific to the ecosystemic approach to fishery assessment and management, that takes into account the complexity of the ecosystems and their natural and anthropogenic variations (Browman and Stergiou, 2004), the high complexity of this new approach demands the use of practical procedures such as the analysis of smaller system components susceptible to track environmental impacts (Rogers et al., 1999). In this sense, elasmobranchs are considered indicators of fishing pressure owing to the high vulnerability and low recovering capacity of their populations (Stevens et al., 2000). Temporal trends of community parameters and abundance series analysed by TL showed a marked inter-annual decreasing trend in the abundance indices of elasmobranches, when considering a long data series (1965-2009, Fig 11; Guijarro et al., 2011a). However, more recent data from 2000 revealed differences between the shelf and slope, with an significant increase in the state of the population in the shelf and certain stability in the slope.

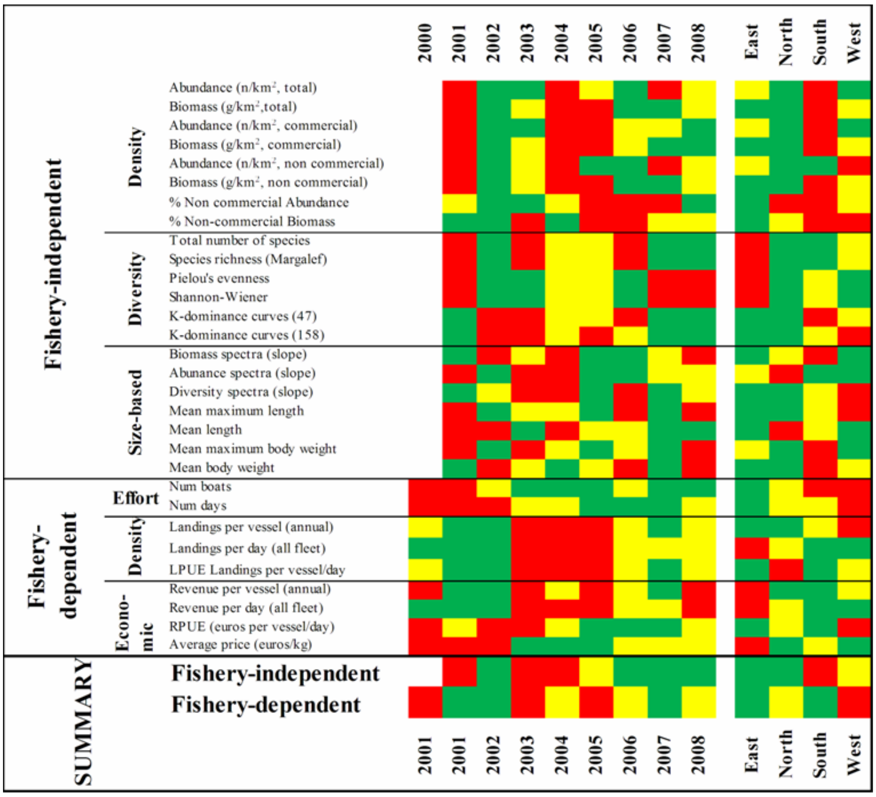

Fig. 9. Traffic Lights displaying biological and economic indicators response for the upper slope assemblage in the Balearic Islands. Red: < 33rd percentile; yellow: 33rd-66th percentiles; green: >66th percentile, except for percentage of non-commercial species and effort variables in which opposite. Source: Guijarro et al. (2011b).

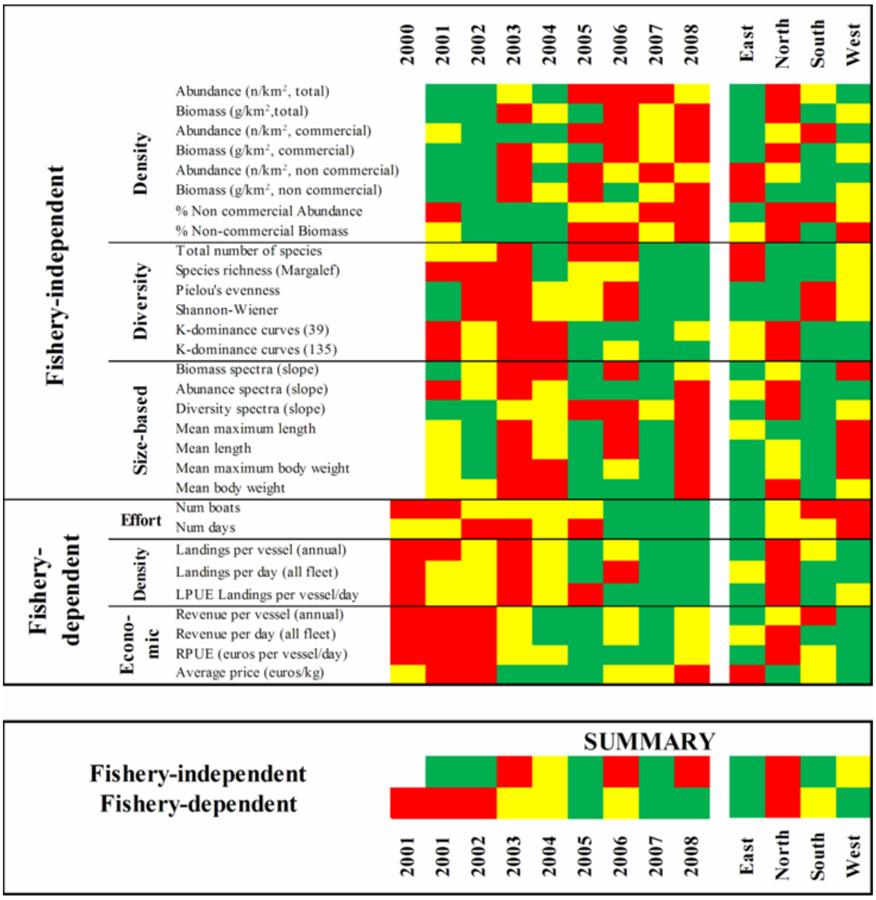

Fig. 10. Traffic Lights displaying biological and economic indicators response for the middle slope assemblage in the Balearic Islands. Red: < 33rd percentile; yellow: 33rd-66th percentiles; green: >66th percentile, except for percentage of non-commercial species and effort variables in which opposite. Source: Guijarro et al. (2011b).

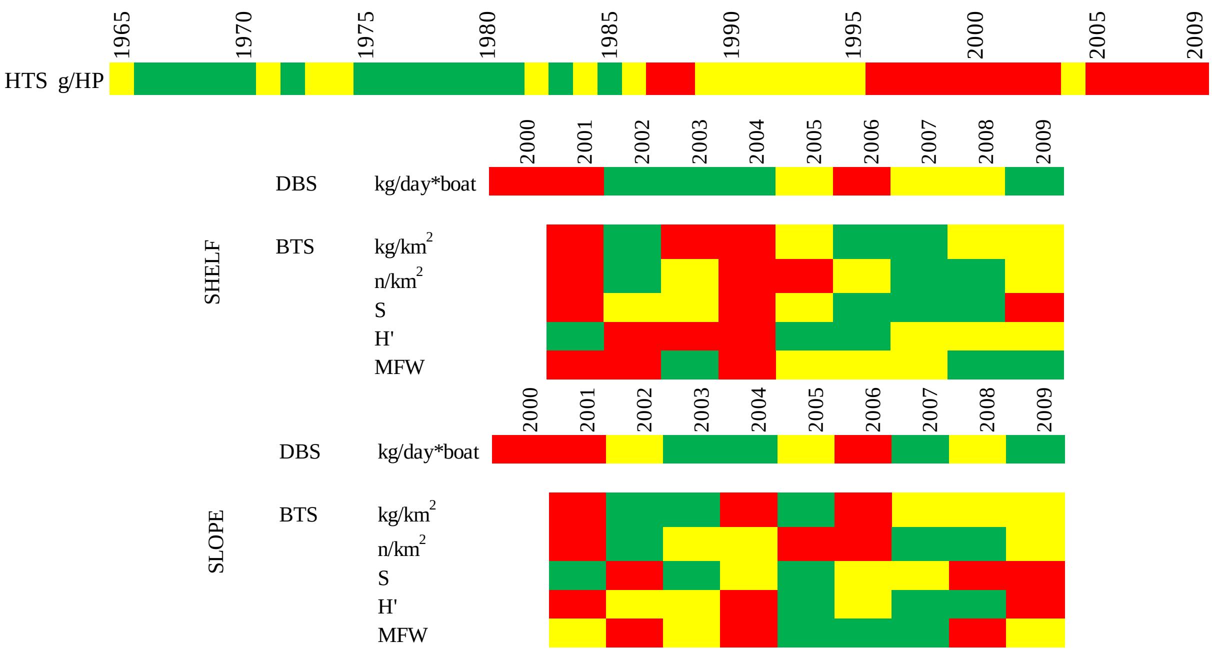

Fig. 11. Traffic Lights displaying elasmobranch indicators response for different sources of data (HTS: long term historical time series; DSB: daily sale bills from the bottom trawl fleet; BTS: annual bottom trawl surveys). S: species richness; H': diversity index; MFW: mean fish weight; comm.: commercial; disc.: discards. Source: Guijarro et al. (2011a).

Diversity of demersal elasmobranchs in the Balearic Islands is higher than in adjacent waters off the Iberian Peninsula (Massutí and Moranta, 2003; Table 3). Although biogeographic factors could form the basis of these differences, these results could also suggest the existence of some differences in fishing exploitation between areas, with lower intensity on the insular continental shelf and upper slope than along the mainland bottoms. Differences in abundance indices for some of the most important species could be related to fishing pressure. In general, abundance off the Balearic Islands is higher than that reported from the Iberian Peninsula. In addition, the regular presence of *R. oxyrhinchus* on the slope bottoms of the Balearic Islands must also be pointed out. According to Bertrand et al. (2000), this species, which shows high vulnerability to fishing pressure, only occurs around Corsica and Sardinia, where trawling activity may be lower than in other Mediterranean adjacent areas (Massutí and Moranta, 2003).

Table 3. Total number of elasmobranch species and abundance of the most frequent species caught in a sample of hauls carried out during MEDITS in waters around the Balearic Islands (GSA05) and along the Mediterranean coast of the Iberian Peninsula (GSA06). Source: Massutí and Moranta (2003).

	Analysed hauls	Species number	Abundance: number of specimens per km^2				
			R. clavata	*R. miraletus*	*S. canicula*	*G. melastomus*	*E. spinax*
Central Iberian Peninsula (*Levante*)	150	13	3.0	3.2	96.4	176.8	46.2
Northern Iberian Peninsula (*Tramontana*)	215	10	2	0	231.4	107.4	8.4
Balearic Islands	85	22	54	88	804	1131	27

Results from traditional mono-specific assessment to will be shown for hake (*Merluccius merluccius*) and red mullet (*Mullus barbatus*), given that these two species are periodically assessed using the same methodology in both areas (GFCM, 2010b), and the results are hence fully comparable. The higher value of $F_{curr}/F_{0.1}$ in both stocks in the Iberian coast indicates a higher level of overexploitation when compared to the Balearic Islands (Table 4).

Table 4. Values of Fcurrent, $F_{0.1}$ (designated as Reference Point in the WG Demersals, 2010), and $F_{current}/F_{0.1}$ ratio for red mullet and hake in GFCM GSAs 5 and 6. Source: GFCM (2010b).

	GFCM-GSA	$F_{current}$	$F_{0.1}$	$F_{current}/F_{0.1}$
Red mullet	05	0.82	0.33	0.40
	06	0.76	0.39	0.51
Hake	05	0.85	0.20	0.24
	06	1.70	0.60	0.35

The population structure of hake landings in GSA 5 and 06 are clearly different. This species has a well-defined modal size in both cases, situated in 20 and 10 cm respectively (Fig. 12). Such differences are precisely due to the healthier state of resources in the Balearic Islands compared to the mainland. Thus, the trawl fleet of the Balearic Islands targets larger individuals than in the Iberian Coast, where the low abundance of large individuals makes that this fishery is based on small-sized individuals. Although it could be argued that these size differences reflect different fractions from a unique population, with recruits inhabiting GSA 6 and juveniles GSA 5, the size distributions obtained from scientific surveys demonstrate that recruits are also present in GSA 5 (Fig. 13). However, fishing exploitation in GSA 6 has decimated the population to the point that practically all individuals are under the legal size of 20 cm.

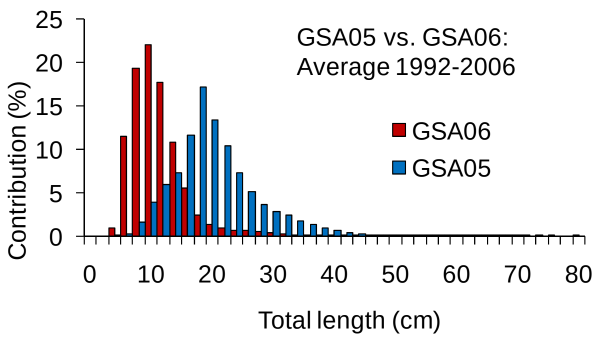

Fig. 12. Size frequency distributions of hake in the bottom trawl catches of GFCM GSAs 5 and 6.

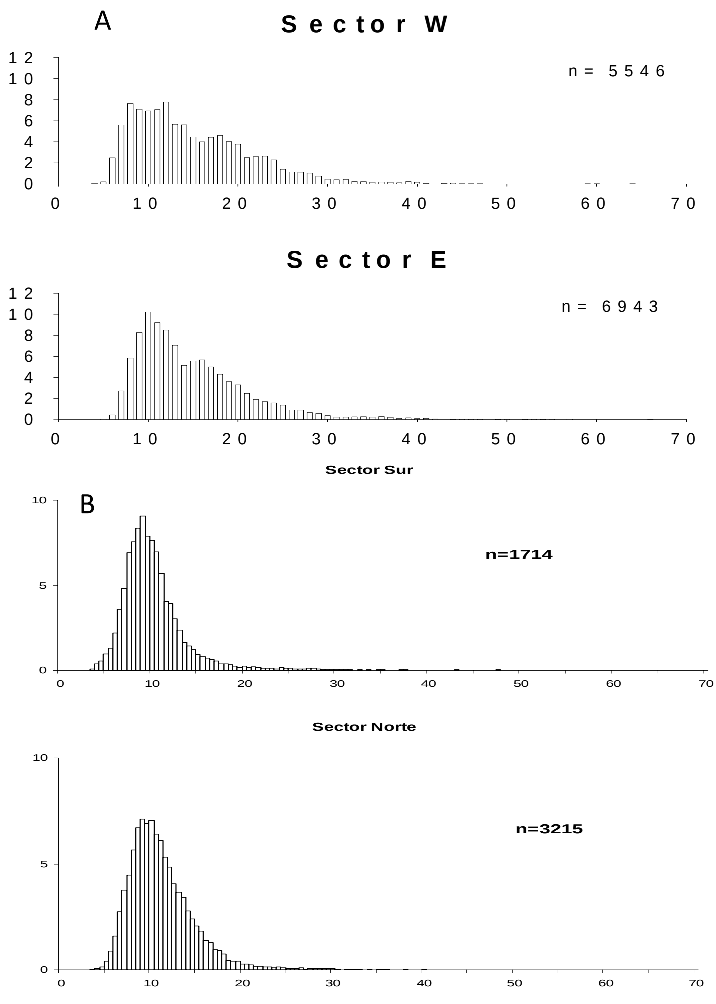

Fig. 13. Size frequency distributions (contribution in percentage) of hake caught during MEDITS in two different sectors of GFCM GSA 5 (A; sectors W and E) and 6 (B; sectors “Sur” or “Levante” and “Norte” or “Tramontana”). Total length in cm. Source: Massutí et al. (2008).

The population structure of red mullet (*M. barbatus*) in GSAs 5 and 6 are also very different. Whereas in GSA 5 has a clear mode in 15 cm and the bulk of the population ranges between 14 and 17 cm (well above the length at first maturity; L_{50}=12.2 cm), the population from GSA 6 do not has a clear mode and the population contains a lot of individuals smaller than the L_{50} (Fig.14A). Accordingly, the stock assessments of red mullet in GSA 5 and GSA 6 show a resource state of fully exploitation and overexploitation, respectively (see yield per recruit analysis Y/R of both species in Fig. 14B). It could be argued that such differences in the state of these resources are due to the fact that whereas *M. barbatus* is a target species in GSA 6, it is only a minor by-catch species in GSA 5. However, the striped red mullet (*M. surmuletus*), which is the target species in GSA 5, shows similar results in this area (Fig. 15): the population is constituted by individuals well above the L_{50} (14.2 cm) and the available stock assessments indicate that the resource is fully exploited, with the current Y/R being very close to the maximum Y/R and the population representing about 36% of the virgin stock.

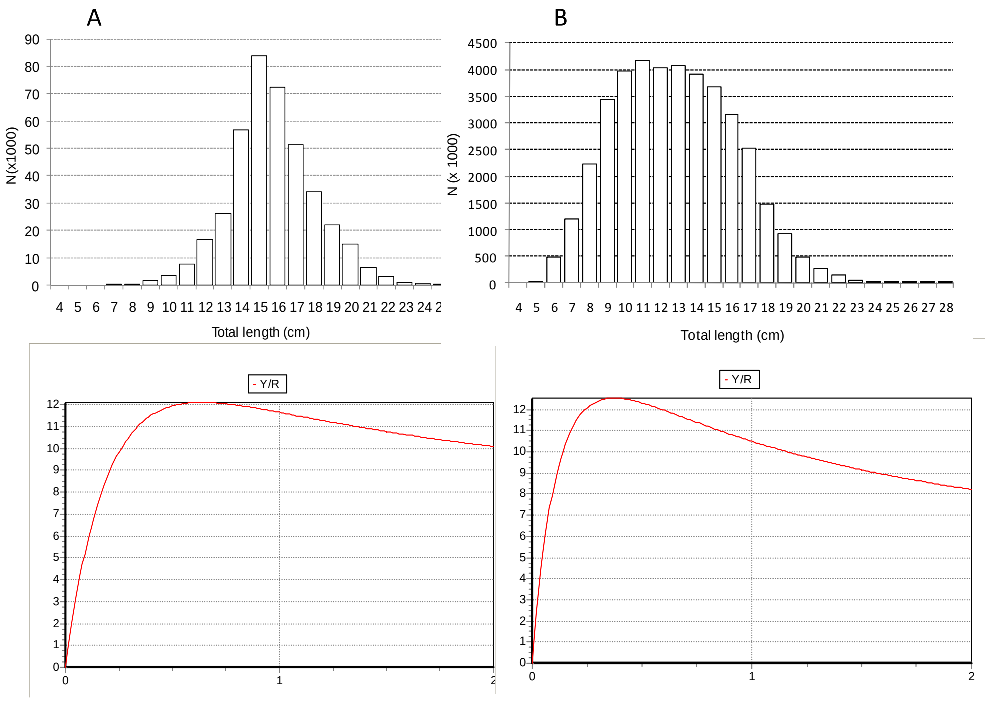

Fig. 14. Size frequency distributions and yield per recruit (Y/R) in red mullet assessments of GSAs 5 (A) and 6 (B). Source: GFCM (2010b).

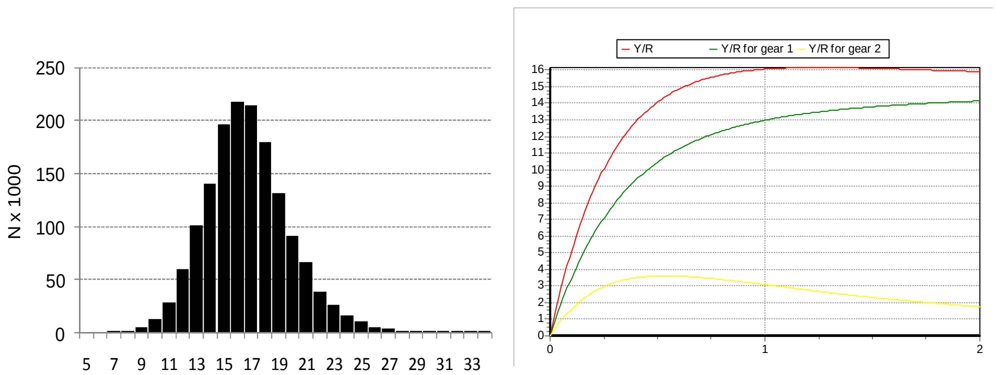

Fig. 15. Size frequency distributions and yield per recruit (Y/R) in striped red mullet assessment of GSA 5. Gear 1: bottom trawl fishery; gear 2: small-scale fishery. Source: GFCM (2010b).

7. Conclusions

Even nowadays, an accurate stock definition constitutes a major challenge for fishery scientists, largely because it is still difficult to map directly how far and in what directions larvae disperse (Thresher, 1999). In its present form, the stock concept essentially describes characteristics of a population unit assumed homogeneous for particular management purposes (Begg and Waldman, 1999). Consequently, the stock concept in its current working form defines semi-discrete groups of fish with some definable attributes of interest to managers (Begg et al., 1999). We think this definition focused on practical management purposes will be used even if genetic studies demonstrate that populations from subareas now considered independent constitute genetically homogeneous populations. If a species is found to be genetically homogeneous throughout the Mediterranean, are we going to assess this population as a whole? We do not think so, because such approach will not be useful for practical purposes in the Mediterranean context. We rather think that the specificities of each area (e.g. geography, marine habitats, fishing practices, economy) need to be considered to properly assess and manage the Mediterranean stocks, particularly if a shift from mono-specific to an ecosystem approach is to be adopted. In this document, we have reported the main specificities of GSA 5 which, to our view, are enough consistent to maintain it as a separate subarea from GSA 6 for assessment and management purposes in the western Mediterranean. Schematically, the main specificities include:

1. Geomorphologically, the Balearic Islands (GSA 5) are clearly separated from the Iberian Peninsula (GSA 6) by depths between 1000 and 2000 m and minimum and maximum distances of 40 and 180 nm.
2. Physical geographically-related characteristics give rise to differences in the structure and composition of the trawling grounds which are reflected in the relative abundance of some resources.
3. The assemblages exploited by fisheries differ between GSAs 5 and 6, giving rise to important differences in the main commercial species landed.
4. Fishing exploitation in GSA 5 is much lower than in GSA 6; the density of trawlers around the Balearic Islands is one order of magnitude lower than in adjacent waters.
5. Related to this lower fishing exploitation, the resources in GSA 5 are in a healthier state than in GSA 6.

References

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

Ballesteros E. 1988. Composición y estructura de los fondos de maërl de Tossa de Mar (Girona, España). Collectanea Botanica (Barcelona) 17, 161-182.

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.

Begg, G.A., Friedland, K.D., Pearce, J.B., 1999. Stock identification and its role in stock assessment and fisheries management: an overview. Fisheries Research 43, 1-8.

Begg, G.A., Waldman, J.R., 1999. An holistic approach to fish stock identification. Fisheries Research 43, 35-44.

Bertrand, J.A., Gil de Sola, L., Papaconstantinou, C., Relini, G., Souplet, A., 2000. Contribution on the distribution of elasmobranchs in the Mediterranean (from the MEDITS surveys). Biologia Marina Mediterranea 7, 1-15.

BIOMAERL Team. 2003. Conservation and management of NE Atlantic and Mediterranean maerl beds. Aquatic Conservation: Marine and Freshwater Ecosystems 13, S65–S76

Bordehore C., Ramos-Esplá A.A., Riosmena-Rodríguez R., 2003. Comparative study of two maerl beds with different otter trawling history, southeast Iberian Peninsula. Aquatic Conservation: Marine Freshwater Ecosystems 13, 43-54.

Browman, H. I., Stergiou, K. I., 2004. Perspectives on ecosystem-based approaches to the management of marine resources. Marine Ecology-Progress Series 274, 269-270.

Caddy, J. F., 1999. Deciding on precautionary management measures for a stock based on a suite of Limit Reference Points (LRPs) as a basis for a multi-LRP harvest law. NAFO Scientific Council Studies 32, 55-68.

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.

Canals, M., 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.

Carbonell, A., Martín, P., De Ranieri, S., WEDIS team, 1998. Discards of the western Mediterranean trawl fleets. Rapport de la Commision Internationale pour l'Exploration Scientifique de la Mer Mé diterranée 35, 392–393.

Estrada, M., 1996. Primary production in the northwestern Mediterranean. Scientia Marina 60(2), 55-64.

García-Rodríguez, M., Esteban, A., 1999. On the biology and fishery of *Aristeus antennatus* (Risso, 1816), (Decapoda, Dendrobranchiata) in the Ibiza Channel (Balearic Islands, Spain). Scientia Marina 63, 27-37.

GFCM, 2010a. Report of the 12th session of the scientific advisory committee (SAC). Budva, Montenegro, 25-29 January 2010. GFCM: XXXIV/2010/Inf.9. 212 pp.

GFCM, 2010b. Report of the SCSA practical session on stock assessment of demersal species. Istanbul, Turkey, 18-23 October 2010. GFCM: SAC13/2011. 91 pp.

Guijarro, B., Massutí, E., Quetglas, A., Moranta, J., Ordines, F., Valls, M. and González, N., 2011a. Inter- and intra-annual trends and status indicators of nektobenthic elasmobranch populations off the Balearic Islands (north-western Mediterranean). Scientia Marina, in press.

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

Lombarte, A., Recasens, L., Gonzalez, M., de Sola, L.G., 2000. Spatial segregation of two species of Mullidae (Mullus surmuletus and M. barbatus) in relation to habitat. Marine Ecology Progress Series 206, 239-249.

Massutí, E., García-Rodríguez, M., Gil de Sola, L., Guijarro, B., Ordines, F., García, C., Ponce, R., 2008. Informe campaña MEDITS_ES_2008. Instituto Español de Oceanografía, 219 pp.

Massutí, E., 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 Instituto Español de Oceanografía 182. 132 pp. ISSN: 0212-1565.

Massutí, E., Moranta, J., 2003. Demersal assemblages and depth distribution of elasmobranchs from the continental shelf and slope off the Balearic Islands (western Mediterranean). ICES Journal of Marine Science 60(4), 753-766.

Ordines, F., Massuti, 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., Massutí, E., Guijarro, B., 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.

Ordines, F., Quetglas, A., Massutí, E., Moranta, J. Habitat preferences and life history of the red scorpion fish, Scorpaena notata, in the Mediterranean. Estuarine, Coastal and Shelf Science 85(4), 537-546.

Palmer, M., Quetglas, A., Guijarro, B., Moranta, J., Ordines, F., Massuti, 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.

Rogers, S.I., D. Maxwell, A.D. Rijnsdorp, U. Damm and W. Vanhee. - 1999. Fishing effects in northeast Atlantic shelf seas: patterns in fishing effort, diversity and community structure. IV. Can comparisons of species diversity be used to assess human impacts on demersal fish faunas? Fisheries Research, 40(2), 135-152.

Sánchez, P., Demestre, M., Martín, P., 2004. Characterisation of the discards generated by bottom trawling in the northwestern Mediterranean. Fisheries Research 67, 71–80.

Stevens, J.D., R. Bonfil, N.K. Dulvy and P.A. Walker. - 2000. The effects of fishing on sharks, rays, and chimaeras (chondrichthyans), and the implications for marine ecosystems. ICES Journal of Marine Science 57(3), 476-494.

Thresher, R.E., 1999. Elemental composition of otoliths as a stock delineator in fishes. Fisheries Research 43, 165-204.

ANNEX I. Lists of the most abundant species (in kg/day*boat) for the ports of Mallorca (GSA05) and Palamós, Santa Pola and Sant Carles de la Ràpita (GS06). SS: shallow shelf; DS: deep shelf; US: upper slope; MS: middle slope; DS-PEL: pelagic deep shelf.

Mallorca (GSA05)

kg/day							
SS		**DS**		**US**		**MS**	
O. vulgaris	102.0	*M. merluccius*	92.8	*M. poutassou*	99.2	*A. antennatus*	47.8
Mixed fishes	63.1	Mixed fishes	30.8	*M. merluccius*	14.4	*M. poutassou*	6.9
S. smaris	59.5	*Trachurus* spp	18.5	*P. blennoides*	13.7	Pandalidae	6.4
M. surmuletus	35.1	*Raja* spp	16.6	*N. norvegicus*	13.1	*P. blennoides*	5.4
S. canicula	16.5	*S. smaris*	15.2	*Lophius* spp.	9.5	*G. melastomus*	3.1
Raja spp	12.6	*S. canicula*	14.0	Argentinidae	8.1	*M. merluccius*	3.1
Loligo spp	10.7	*M. surmuletus*	12.2	*Todarodes/Illex*	7.5	*G. longipes*	3.1
Lophius spp	6.6	*Z. faber*	11.7	*A. antennatus*	7.0	*Lophius* spp.	2.7
Trachurus spp	6.1	*Lepidorhombus* spp	10.8	Pandalidae	6.2	*Todarodes/Illex*	1.8
Sepia spp	4.5	*Lophius* spp	8.9	*Lepidorhombus* spp	4.4	Chondrichthyes	1.4
Eledone spp	4.3	*O. vulgaris*	7.1	Actinopterigios	3.7	*C. niger*	1.1

Palamós (GSA06)

kg/day							
SS		**DS**		**US**		**MS**	
Trachurus spp	54.4	*M. poutassou*	59.8	*M. poutassou*	302.7	*A. antennatus*	35.4
M. merluccius	38.0	*E. cirrhosa*	37.7	*M. merluccius*	25.5	*P. blennoides*	6.3
E. cirrhosa	27.6	*M. merluccius*	22.3	*N. norvegicus*	23.7	*M. poutassou*	5.5
Mullus spp	17.0	*Lophius* spp	18.8	*P. blennoides*	12.7	*P. longirostris*	4.7
P. acarne	12.8	*T. minutus*	18.3	*Lophius* spp	10.5	*M. merluccius*	4.3
P. erythrinus	11.5	*Scomber* spp	16.0	*E. cirrhosa*	7.6	*Lophius* spp	1.8
L. vulgaris	10.9	*C. cuculus*	10.3	*B. brama*	3.2	Actinopterigios	0.5
T. minutus	9.6	*Trachurus* spp	7.7	*A. antennatus*	2.3	*C. conger*	0.4
M. poutassou	8.8	*A. sphyraena*	5.0	Pleuronectidae	2.0	*N. norvegicus*	0.3
C. cuculus	8.3	*Z. faber*	3.8	*Scomber* spp	1.8	*P. acarne*	0.3

Santa Pola (GSA06)

kg/day					
SS-DS		**US**		**MS**	
Actinopterigios	42.9	*M. poutassou*	690.7	*A. antennatus*	38.3
O. vulgaris	40.5	*M. merluccius*	31.8	*M. poutassou*	16.9
M. merluccius	40.5	*P. blennoides*	19.0	*M. merluccius*	10.7
T. trachurus	31.7	Actinopterigios	15.8	*P. blennoides*	9.4
M. barbatus	18.8	*Lophius* spp	8.2	*Plesionika* spp	7.8
Perciformes	11.7	*E. cirrhosa*	7.5	Actinopterigios	6.0
L. vulgaris	11.7	*L. caudatus*	7.4	*G. longipes*	4.7
S. officinalis	10.7	*Plesionika* spp	6.8	*T. sagittatus*	4.2
E. cirrhosa	9.3	*T. sagittatus*	6.2	*P. narval*	1.7
T. minutus	8.4	*A. boyeri*	5.6	Crustacea	1.4

Sant Carles de la Ràpita (GSA06)

kg/day					
SS		**DS**		**DS-PEL**	
S. mantis	43.0	*L. depurator*	25.4	*E. encrasicolus*	79.7
M. barbatus	38.5	*E. cirrhosa*	22.6	*M. merluccius*	55.1
S. aurata	27.2	*S. mantis*	19.8	*Trachurus* spp	44.9
O. vulgaris	12.2	*M. merluccius*	19.0	*S. scombrus*	44.4
Trachurus spp	10.6	*T. minutus*	17.8	*T. minutus*	42.8
S. officinalis	7.4	*Trachurus* spp	15.8	*E. cirrhosa*	37.7
P. erythrinus	6.5	*C. linguatula*	13.1	*L. piscatorius*	34.2
M. merluccius	6.3	Actinopterigios	12.7	*M. barbatus*	26.8
C. conger	6.3	*L. piscatorius*	12.7	Actinopterigios	18.0
M. kerathurus	6.1	*C. macrophthalma*	9.5	*C. macrophthalma*	14.0