NORTH-WESTERN MEDITERRANEAN WATERS

Spatial distributions of the main stocks

In the areas of study, GSA 6 and GSA 7, there are several commercially important populations of demersal species of fishes, crustaceans and molluscs. A number of these species are clearly coastal, i.e. grey mullets (*Mugilidae*), sea breams (*Sparus aurata*), sea bass (*Dicentrarchus labrax*), some shrimps and many molluscs. The upper zones of the continental shelf are inhabited by species like red mullets (*Mullus barbatus, Mullus surmuletus*), sole (*Solea solea*), gurnards (*Trigla sp.*), poor cod (*Trisopterus minutus capelanus*), Black Sea whiting (*Merlangius melrangus*), and some shrimps. On the continental slope there are many fish species of great economic interest. Thus in the upper part of the slope (200 and 400m) there are hake (*Merluccius merlucci*us), Norway lobsters (*Nephrops norvegicus*) and various shrimps (e.g. *Peneus longirostris*). In deeper waters, from 400 to 600m, the dominant species are the greater forkbread (*Phycis blennoides*), the blue whiting (*Micromesistius poutassou*) and the red shrimps (*Aristeus antennatus, Aristaemorpha foliacea*).

A Project that considers the spatial coverage of fisheries and stocks in the Mediterranean (STOCKMED) was carried out recently. As results of the application of the STOCKMED methodological framework, the most plausible Hypotheses of stock structure of 19 fish and shellfish species of fishery interest in the Mediterranean have been identified. The hypotheses were evaluated in terms of 7 independent criteria (Genetics, Parasites, EFH and connectivity, Growth, L50, Density trends, Biomass trends).

Table 1.6. The most significant correlations in density between contiguous GSAs, number of observation (pairs of years), the coefficient of correlation for each species and the number of the species in which each correlation has been found. Only statistically significant correlation coefficients (p-value < 0.05) are shown.

Correlated GSAs		pairs of years	*A. foliacea*	*A. antennatus*	*E. cirrhosa*	*E. moschata*	*E. encrasicolus*	*G. melastomus*	*I. coindetti*	*L. budegassa*	*M. merluccius*	*M. barbatus*	*M. surmuletus*	*N. norvegicus*	*O. vulgaris*	*P. erythrinus*	*P. longirostris*	*S. vulgaris*	*T. mediterraneus*	*T. trachurus*	number of species showing significant correlation
1	2	5											0.87		0.9						2
1	5	5											0.9								1
1	6	10			0.72									0.85							2
5	6	5	0.87	0.9													0.83				3
5	11	5																			0
6	7	10							0.6							0.77				0.6	3
6	8	9							0.73												1
6	11	10									0.58					0.81					2
7	8	9							0.71	0.6	0.58	0.6				0.91	0.75		0.8		7
7	9	10						0.67			0.76						0.64		0.62		4
8	9	9															0.89				1
9	10	10											0.6		0.58	0.68					3
9	11	10			0.61									0.7							2
10	11	10				0.56															1
10	16	10						0.76	0.56		0.9		0.68								4
15	16	10						0.83	0.59	0.56				0.61							4
15	19	10					0.62													0.58	2
16	19	10								0.6											1
17	18	10					0.65			0.7											2
18	19	10																		0.82	1
18	20	5														0.77			0.9	0.83	3
19	20	5		0.82													1				2
20	22	5																			0
Number of pairs of GSAs with significant correlation			1	2	2	1	2	3	5	4	4	1	4	3	2	0	5	5	0	3	

Referring to the biomass index, the pair of contiguous GSAs with highest amount of time series of species correlated was the Gulf of Lions (GSA 7) and Corsica (GSA 8) with 7species significantly correlated, while two additional pairs showed 5 species with significantly correlated time series, i.e. Northern Alboran Sea (GSA 1) and Northern Spain (GSA 6), Northern Spain (GSA 6) and Gulf of Lions (GSA 7). Nevertheless, some of the results show that the biomass values relationships between areas (GSA 6-GSA 7, in ae.) were not significant for the main species considered in the trawl fishery.

However, low proportion of species showing synchronisms is found in adjacent GSAs: highest amount of species with positive and significant correlation was 7 species out of the 19 STOCKMED target species (37% of the STOCKMED target species). Thus, from a biological point of view merging several GSAs in

order to establish management boundaries seems not advisable. It might be useful to elaborate similar correlation matrices for the rest of the biological parameters in order to confirm this conclusions.

The report of the STOCKMED project was revised by the STECF in its Plenary meeting of November 2014.

STECF was not able to compare the validity and robustness of the stock units proposed under the STOCKMED project with the existing GFCM-GSAs limitations. However, STECF considered, the new stock unit's configuration should be checked against the major requirements for stock assessment, i.e. productivity and population isolation (i.e. self-sustained sub-populations with no major migration and immigration among neighbouring units and with separate spawning areas). While the latter cannot be checked due to lack of data, the second can be roughly done through the analysis of differences between the old and new stock configuration in productivity as for example k, density, Lmax, natural mortality rates and other features.

STECF also considered that the consequences of the new stock configuration need to be evaluated in terms of data collection and processing, stock assessment and management advice. STECF consider that these aspects need further consideration before final conclusions about a new stock configuration can be made and that this would be best advanced through a dedicated expert group.

(http://stecf.jrc.ec.europa.eu/documents/43805/896390/2014-11_STECF+PLEN-14-03_JRC93037.pdf).

Hake (*Merluccius merluccius*)

In the Mediterranean its bathymetric distribution is wide, between 30 and 1000 m depth, although the highest abundances are registered between 70 and 370 m depth, been very scarce at depths below 500 m. (Oliver & Massutí, 1995; Orsi Relini *et al*., 2002). The analysis of data from MEDITS surveys suggests that the main concentrations of recruits (age 0 individuals) and juveniles are located between 100-150 m depth, while older individuals are most abundant on the slope (Orsi Relini *et al*., 2002).

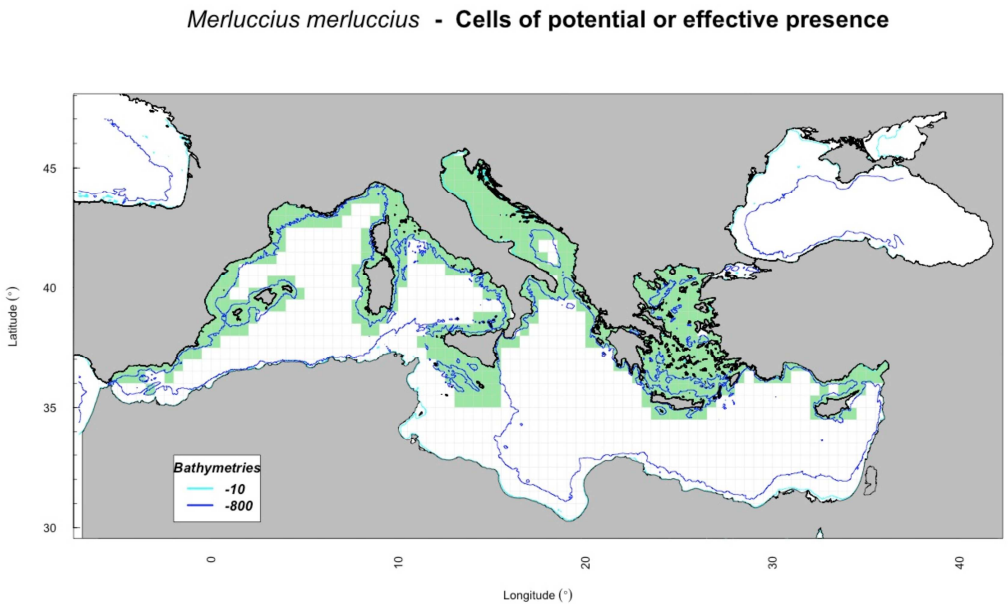


Figure 1.22 Spatial distribution of effective presence of *Merluccius merluccius* in the Mediterranean.

As a STOKMED result, the distribution of the mean Cohen's Kappa indicates the "6 stock units" as the configuration with the best agreement followed by the configurations with 5, 7 and 4 units. The acceptability analysis reinforces these results. Indeed the hypotheses with 6 units (HAI= 0.95), 7 units (HAI=0.90) and 5 units (HAI=0.85) present high acceptability indices for the best ranks and are taken as candidates for the best hypothesis of stock structure. In particular, the "6 stock units" is considered the most plausible stock structure hypothesis based on currently available knowledge.

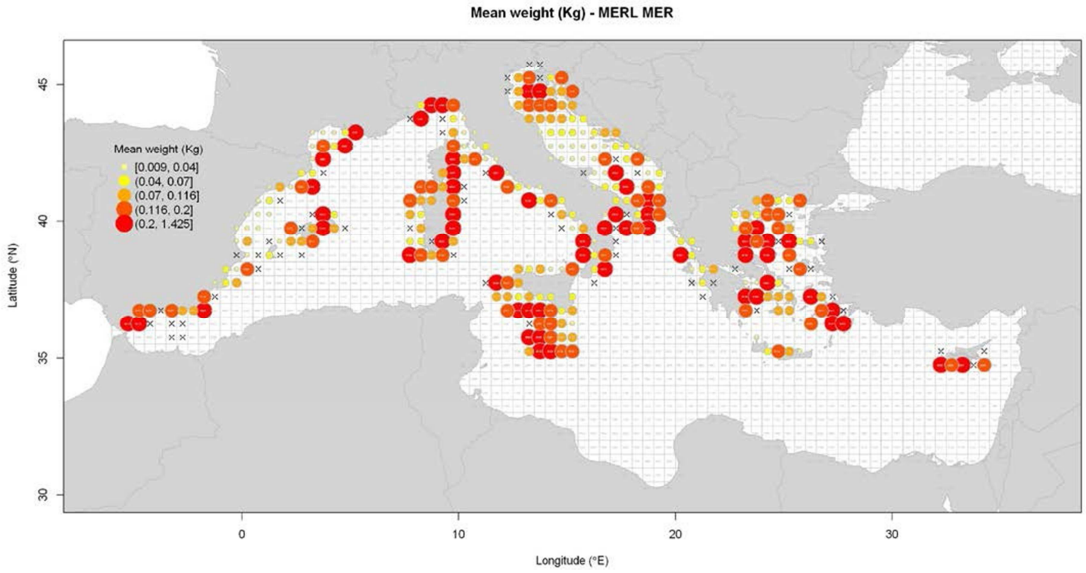


Figure 1.23. Biological indicators (Biomass) from 10 years of MEDITS surveys (2002-2011) for *.Merluccius merluccius.*

In this configuration few zones, i.e. the Gulf of Lions and the coast offshore northern Spain, the Gulf of Lakonikos along the Peloponnesus, and the area western to Adalia (Turkey) presented a slight mixture of elements belonging to two different contiguous clusters from neighbour GSAs, possibly as a result of the influence of some thematic descriptors (in these cases probably genetics, EFH and connectivity and growth. the joining of the intermixed elements to the main neighbour areas is suggested, according to the following table 3.1, in which the two units of the North Adriatic are joined, while the Gulf of Lion and the northernmost side of north Spain (GSA 6) were associated to the same cluster as GSAs 1 and 5. It should be also taken into account that in GSAs 6 and 7, as well as in GSA17 hake is also considered a shared stock by GFCM. Finally the trade-off for the most suitable configuration is based on 5 stock units

This means that *M. merluccius* populations from GSA's 1, 5, 6 and 7 are considered as a single stock.

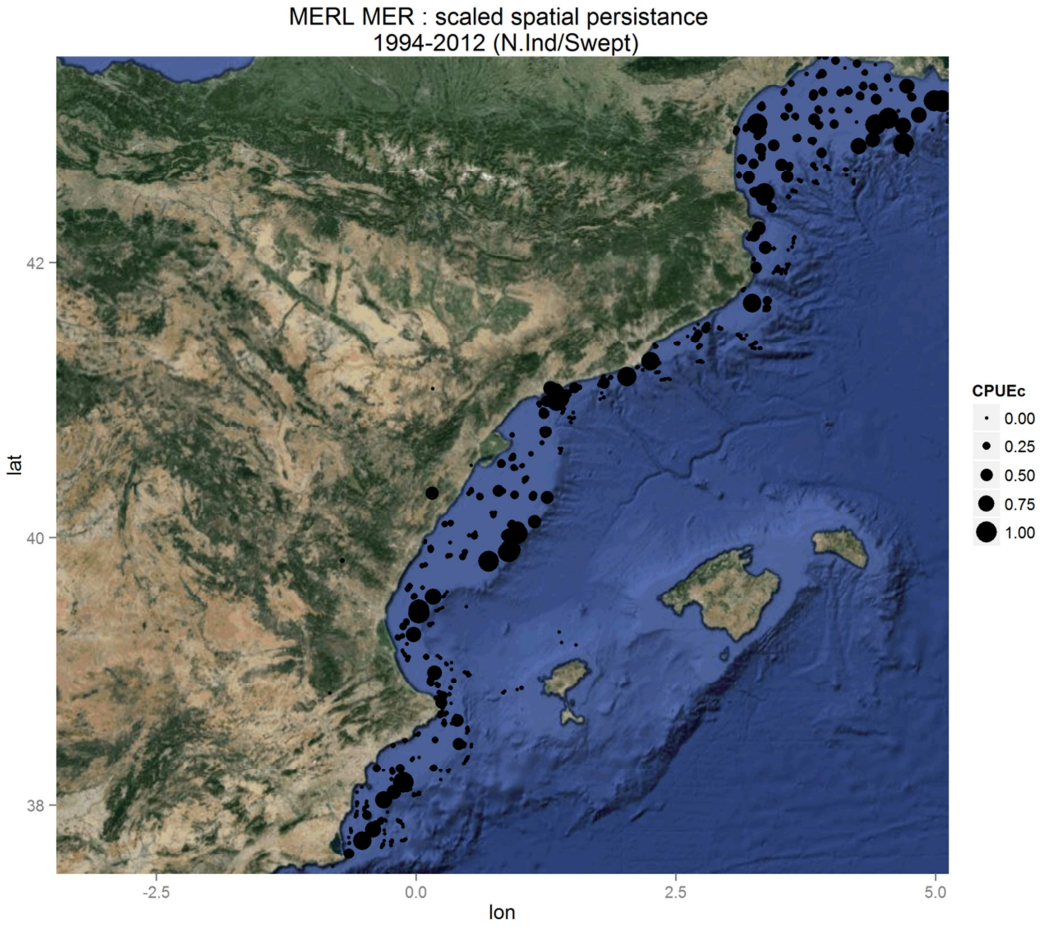


Figure 1.24. Geographical distribution of abundances (nº / km2) and distribution of *Merluccius merluccius* in GSA 6 and GSA 7 during MEDITS_ES surveys.

M. merluccius is widely distributed in the studied areas. Its abundance are greater in the shelf-slope break than in the shelf, both in the GSA 6 as in GSA 7.

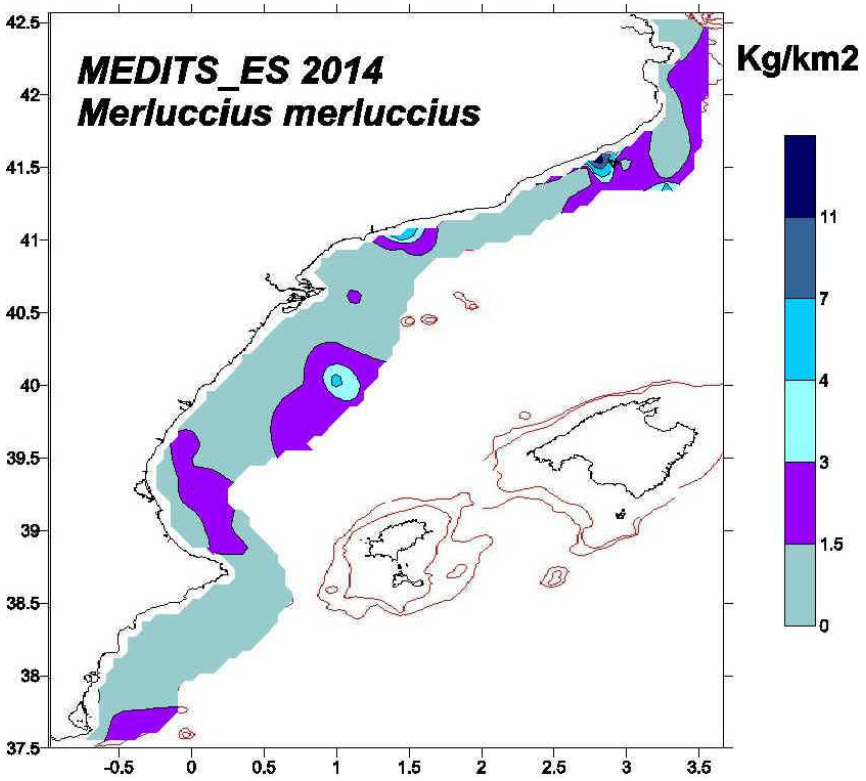


Figure 1.25. Geographical distribution of yields (kg / km2) and distribution of *Merluccius merluccius* in GSA 6 during MEDITS_ES 2014 survey.

In the GSA 6, hake it is distributed along the entire coast, shelf and slope. The areas showing higher values of biomass, according to the yields obtained, are located in Cabo de Palos, Gulf of Valencia, Columbretes Islands, Badalona, Blanes and Cap de Creus.

In the Gulf of Lions (GSA 7) hake is also one of the most important demersal target species for the commercial fisheries. In this area, hake is exploited by French and Spanish trawlers, French gillnetters and Spanish long-liners. Around 240 boats are involved in this fishery; according to official statistics the total annual landings for the period 1998-2012 have oscillated around an average value of 2030 tons (1123 tons in 2012). The French trawler fleet is the largest in number of boats and catch (42 boats and 72% of the total catch). The length of hake in the trawler catches ranges between 3 and 92 cm TL, with an average size of 21 cm TL. The French gillnetters is the second largest fleet (~41 boats and 14% of the total catch), the size of fish range between 13 and 86 cm TL and an average size of 39 cm TL. Spanish trawlers account to 11 boats and 8% of the total catch, the size of fish in catch range between 5 and 88 cm TL, and the average size is 24 cm TL. Finally, the Spanish long-liner fleet is composed by ~6 boats and account for 6% of the catch, size composition of catches range between 22 and 96 cm TL, with an average size of 52 cm TL.

The catch is dominated by the french trawlers fleet. Since 1978, the catch has been slowly decreasing. In 2013, the total catch reached 1735 tons. The hake trawlers exploits a highly diversified species assemblage: Striped mullet (*Mullus surmuletus*), Red mullet (*Mullus barbatus*), Anglerfish (*Lophius piscatorius*), Black-bellied anglerfish (*Lophius budegassa*), European conger (*Conger conger*), Poor-cod (*Trisopterus minutus capelanus*), Fourspotted megrim (*Lepidorhombus boscii*), Soles (*Solea* spp.), horned octopus (*Eledone cirrhosa*), squids (*Illex coindetii*), Gilthead seabream (*Sparus aurata*), European seabass (*Dicentrarchus labrax*), Seabreams (*Pagellus* spp.), Blue whiting (*Micromesistius poutassou*) and Tub gurnard (*Chelidonichtys lucerna*).

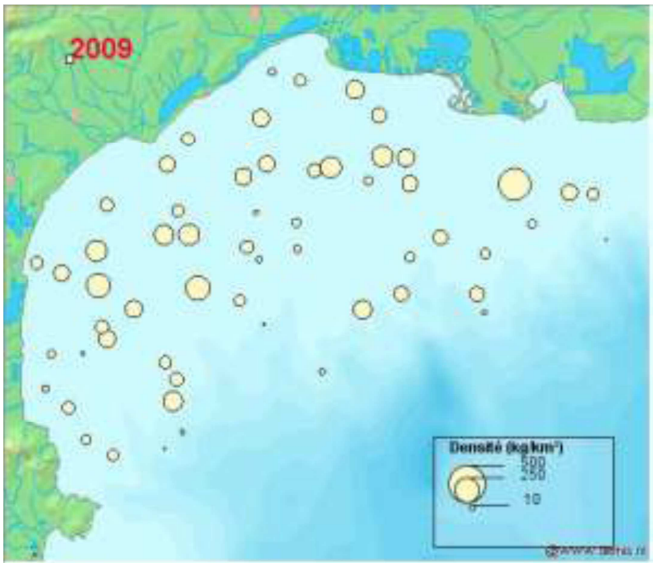


Figure 1.26. Geographical distribution of yields (kg / km2) and distribution of *Merluccius merluccius* in GSA 7 during 2009.

The hake (*Merluccius merluccius* L., 1758) is a demersal species very widely distributed in the Gulf of Lions since the very coastal sector, near 30m depth, until 800 m. The species is mainly present between 80 and 150 m. Eggs and larvae are present preferentially on the continental shelf with a peak of abundance between 100 and 200 m. The O group is very abundant from June till November between 100-150m. The higher densities are located on the upper border of the slope at depths lower than 200 m *(100).* The age group 1 (15-18cm) is dominant in these same places but can also be met in the coastal zone while the group 2+ occupies the whole shelf with variable but particularly important spatiotemporal concentrations on the border of the continental slope and on the upper part of the canyons.

Red mullet *(Mullus barbatus*)

Two species of the genus *Mullus* (*M. barbatus* and *M. surmuletus*) are present in the Western Mediterranean. Both of them have a high commercial value and are the main target species of many demersal fisheries. They are sympatric species with a similar geographical distribution that includes the continental shelf and coastal areas, although some differences in the geographical and bathymetrical distribution are observed in the Iberian Peninsula (Lombarte et al., 2000; Demestre et al., 1997).

M. barbatus occurs on sandy and muddy bottoms between 50 and 200m depth in areas with wider continental shelf, whereas *M. surmuletus* has a wider bathymetric range (occurring to a depth of 400 m) but its maximum abundance is concentrated near the coast, on gravel and rocky bottoms between 10 and 100m depth, especially in areas where the shelf is steepest and with a higher influence of seagrass beds, especially *Posidonia oceanica* (Demestre et al., 1997). The mean size of the individuals of both species, especially M. surmuletus, increases with depth due to the reproductive movement of adults individuals towards the deep shelf and upper slope bottoms in spring (Lombarte et al., 2000).

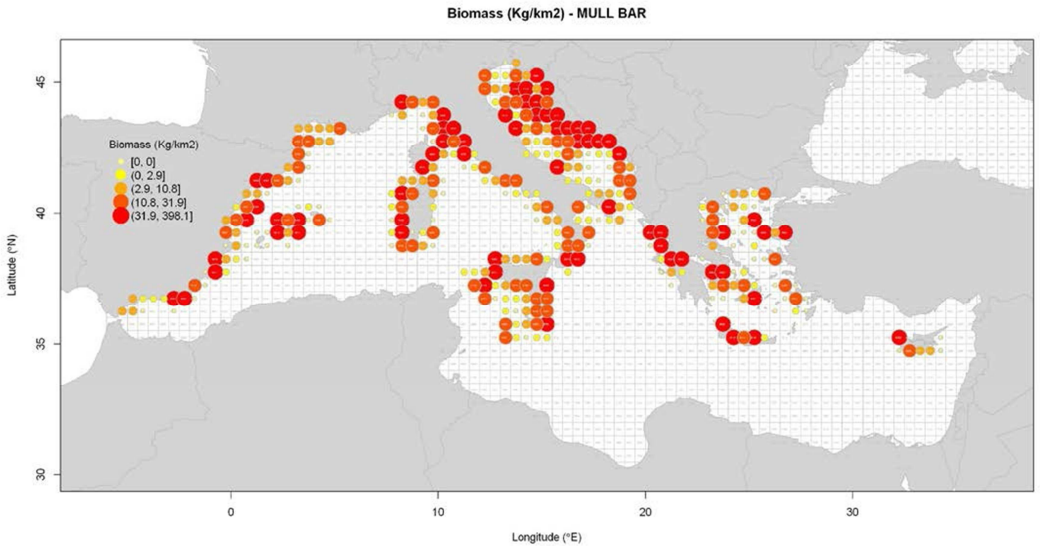


Figure 1.27. Biological indicators (Biomass) from 10 years of MEDITS surveys (2002-2011) for .*M. barbatus.*

The mean Cohen's Kappa, based on four layers of information (Genetics, Growth, Biomass trends and Oceanographic systems–surface), shows a peak at 3 clusters. The other configurations located above the upper quintile of the distribution are those with 2, 4, and 5 clusters. According to the acceptability analysis, all these candidate hypotheses receive some degree of acceptability for the highest ranks. In particular, considering the first rank acceptability index, the 3 clusters configuration appears more plausible than the 4 clusters configuration even if its HAI is lower (0.60 against 0.81). Taking into account the high number of descriptors used in the holistic approach, 6 biological indicators and 4 thematic layers of information, the results for red mullet are considered plausible.

Two hypotheses among those considered more likely in WP4 have been selected: the 3 units (Holistic Acceptability Index= 0.6) and the 4 units (HAI=0.81) hypothesis. Both were robust because based upon 6 biological indicators and 4 thematic layers. However the first one was also characterized by a higher Cohen's Kappa coefficient (0.6) and higher ranked in the quintile distribution. Thus the 3-units hypothesis is selected.

This means that *M. barbatus* populations from GSA's 1,5, 6 and 7 are considered as a single stock, being extended the limits to the Western Ionian Sea.

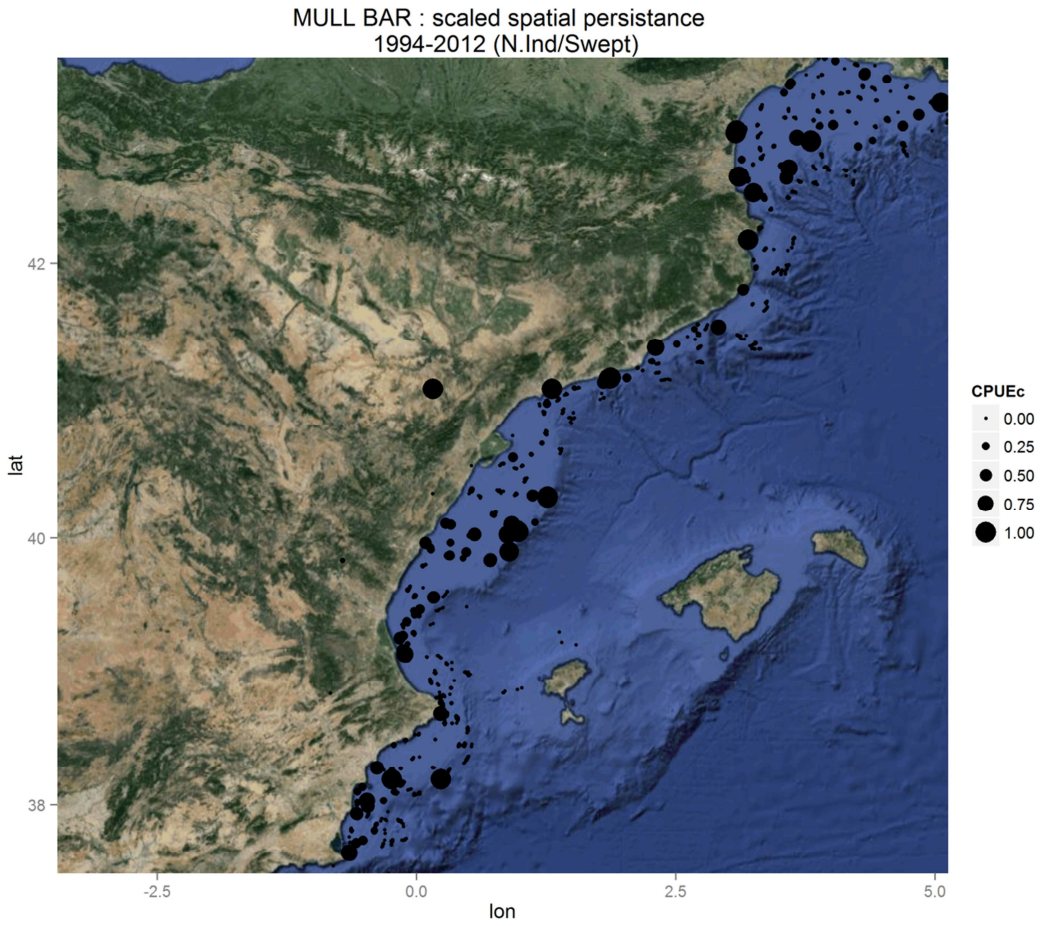


Figure 1.28. Geographical distribution of abundance (nº / km2) and distribution of *Mullus barbatus* in GSA 6 and GSA 7 during MEDITS_ES surveys.

M. barbatus is widely distributed in the studied areas. Its abundance is greater in the shelf-slope break than in the shelf, both in the GSA 6 as in GSA 7.

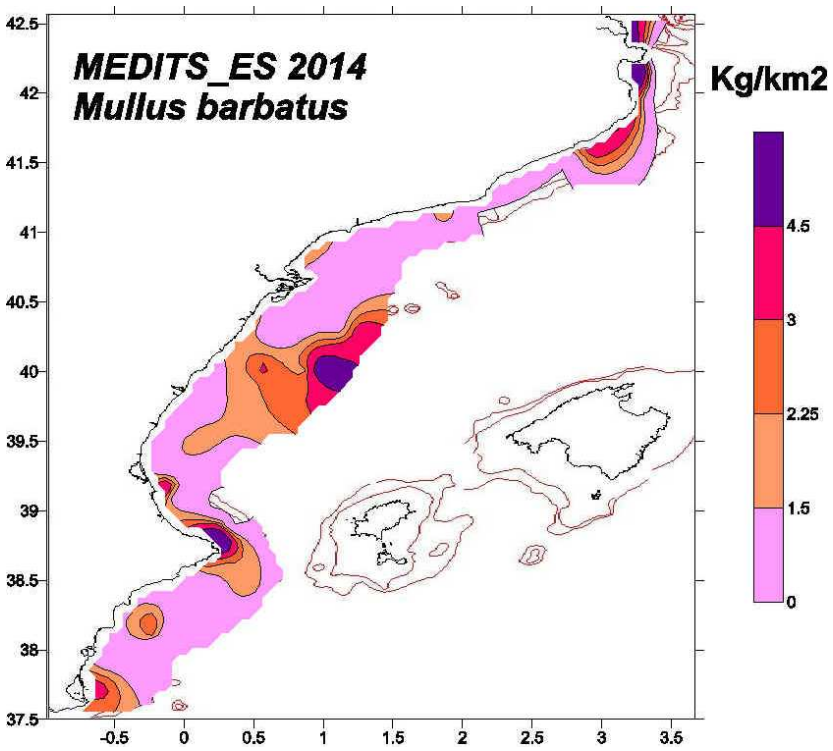


Figure 1.29 Geographical distribution of yields (kg / km2) and distribution of *Mullus barbatus* in GSA 6 during MEDITS_ES 2014 survey.

In the GSA 6, mullet (*M. barbatus*) it is distributed along the entire coast, shelf and slope. The areas showing higher values of biomass, according to the yields obtained, are located in Cape de Palos, South of the Gulf of Valencia, Columbretes Islands and Blanes-Cap de Creus.

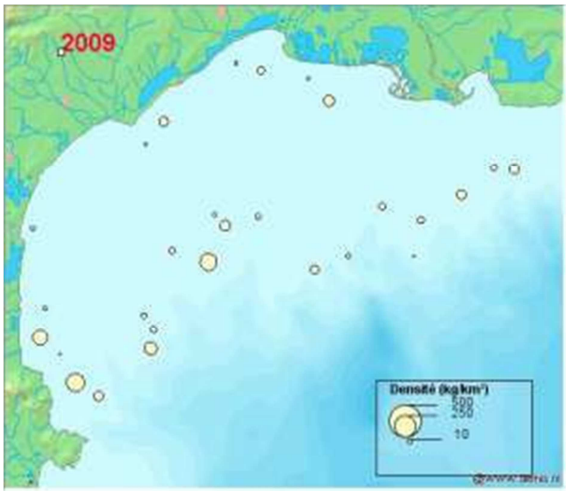


Figure 1.30. Geographical distribution of yields (kg / km2) and distribution of *Mullus barbatus* in GSA 7 during 2009.

Stripped red mullet (*M. surmuletus*) is caught in GSA 6 mainly by bottom trawlers fishing on the continental shelf, between 50 and 200 m depth. It is also caught by trammel nets, but in a lower proportion, representing in general less than 10% of total catches. OTB landings of red mullet in GSA 6 oscillated between a minimum value in 2002 (300 t) and a maximum (1700 t) in 2004, with an increasing trend during the last years (from 2010). GTR landings were always lower than 150 t.

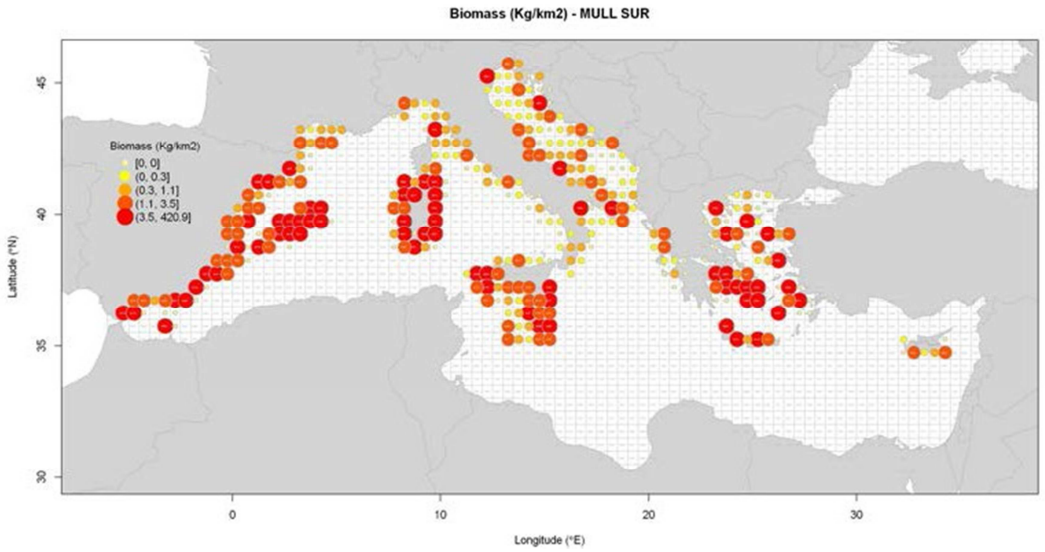


Figure 1.31. Biological indicators (Biomass) from 10 years of MEDITS surveys (2002-2011) for *.M. surmuletus.*

In the case of *M.surmuletus*, the CC was performed on only three biological indicators (Biomass index, CV % of density, mean fish weight). The graph of the mean Cohen's Kappa, evaluated on five layers of information (Genetics, L50, Biomass trends, Density trends and Oceanographic systems–surface), shows a plateau between the configurations with 5 and 8 clusters, being the last the highest value. Considering the hypotheses falling above the upper quintile (5, 6, 7, and 8 units), the acceptability analysis suggests that the two best ranked hypotheses are the "6 stock units" (HAI=0.80) and the "8 stock units" (HAI=0.79). However the "6 stock units" also presents the highest first rank acceptability index. Based on currently available knowledge, the results for *M.surmuletus* are considered plausible.

Two hypotheses among those considered more likely in WP4 have been selected: the 6 units (Holistic Acceptability Index= 0.8) and the 8 units (HAI=0.79) hypothesis. Both were based upon 3 biological indicators from the survey (the inverse of CV of density index, the biomass index and the mean weight) and 5 thematic descriptors (Genetics, L50, Biomass trends, Density trends and Oceanographic systems– surface) with scattered information among the GFCM GSAs. The 8 units hypothesis had the higher Cohen's Kappa coefficient, though the 6 units hypothesis was rather equivalent in terms of ranks in the quintile distribution and had the first rank acceptability index. In addition, it appeared less affected by possible spurious signs in the constrained clustering process. Thus the 6-units hypothesis is selected.

This means that *M. surmuletus* populations from GSA's 1, 5, and 6 are considered as a single stock, being extended the limits to the Gulf of Lions (GSA 7).

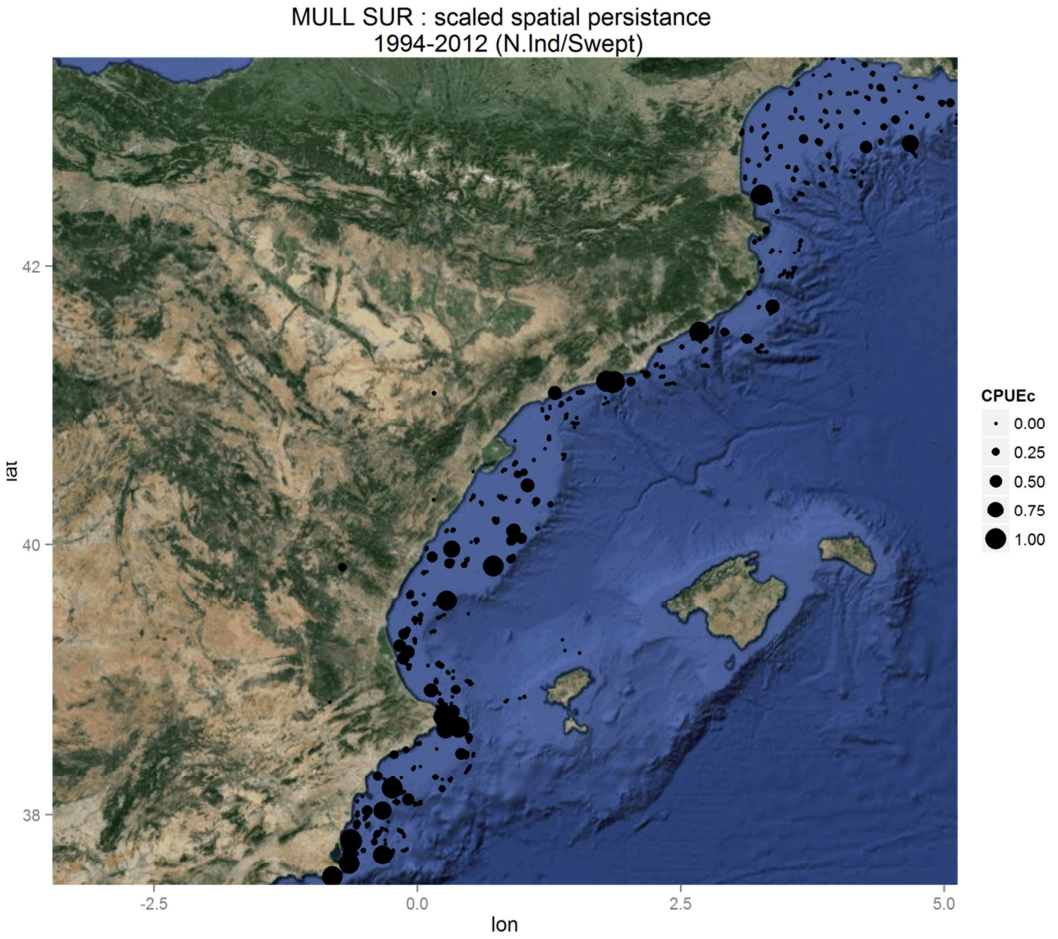


Figure 1.32. Geographical distribution of abundance (nº / km2) and distribution of *Mullus surmuletus* in GSA 6 and GSA 7 during MEDITS_ES surveys.

M. surmuletus appears to be widely distributed in the studied areas. Its abundance is greater in the shelf than in the shelf-slope break, both in the GSA 6 as in GSA 7.

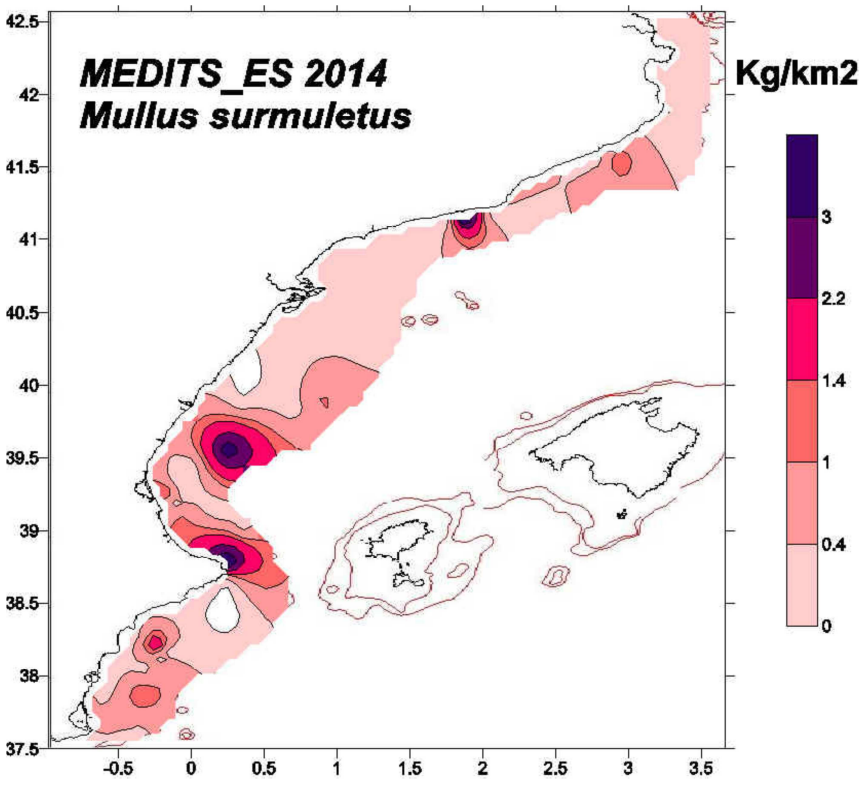


Figure 1.33. Geographical distribution of yields (kg / km2) and distribution of *Mullus surmuletus* in GSA 6 during MEDITS_ES 2014 survey.

In the GSA 6, red mullet (*M. surmuletus)* it is distributed along the entire coast, shelf and slope. The areas showing higher values of biomass, according to the yields obtained, are located in Santa Pola-Alicante, South of the Gulf of Valencia, in front of Valencia-Sagunto, Columbretes Islands, Barcelona and Blanes.

In the Gulf of Lions (GSA 7), red mullet is exploited by both French and Spanish trawlers. Information on French gillnetters is only available for 2011 and 2013, but although it is suspected that they have been fishing red mullet in the past, no data is available to quantify their catches. Between 2004 and 2013, around 100 boats have been involved in the fishery. According to official statistics, during this period the total annual landings have oscillated around an average value of 200 tons and the French trawlers have been dominating the fishery, as they represent 73% of the catches (165 tons) on the period. After 2009, because of the large decline of small pelagic fish species in the area, the trawlers fishing small pelagic have diverted their effort on demersal species, this can explain the high catches of 2010. Between 1998 and 2013, the number of French trawlers operating in the GSA 07 has decreased by 39%, while it decreased by more than 30% between 2010 and 2013. From a maximum number of 123 trawlers in 2004, the French fleet catching red mullet is nowadays composed by 61 units. This follows management measures to reduce the number of boats.

Pink shrimp (*Parapenaeus longirostris*)

The trawl feet operating in GSA06 in 2012 consisted of 540 trawlers, according to the statistics of the Autonomous Governments of Valence (269 vessels in southern GSA06) and Catalonia (271 in northern GSA06). Some units (smaller vessels) operate almost exclusively on the continental shelf (targeting red mullet, octopus, hake and sea breams). Larger vessels operate almost exclusively on the upper and middle slope (targeting decapod crustaceans). The rest can operate indistinctly on the continental shelf or slope fishing grounds, depending on the season, the weather conditions and also economic factors (e.g. landings price). The percentages of these trawl fleet segments have been estimated at around 30, 40 and 30% of the boats, respectively (Alemany and Álvarez, 2003). Note that the trawl fleet in GSA 06 has been decreasing by approximately 10% units annually over the last 2 years due to the Integral Management Plan for Mediterranean fisheries for the years 2011-2012. It is estimated that half of the trawl fleet operates on deepwater pink shrimp fishing grounds (270 units) and other deep-water fishing grounds, targeting other valuable crustaceans (Norway lobster; red shrimp).

Deepwater pink shrimp is distributed from 150 to 400 m depth in GSA 06, with higher densities on soft muddy bottoms in the southern part of GSA and, in years of high abundance of the population also in the north of GSA 06.

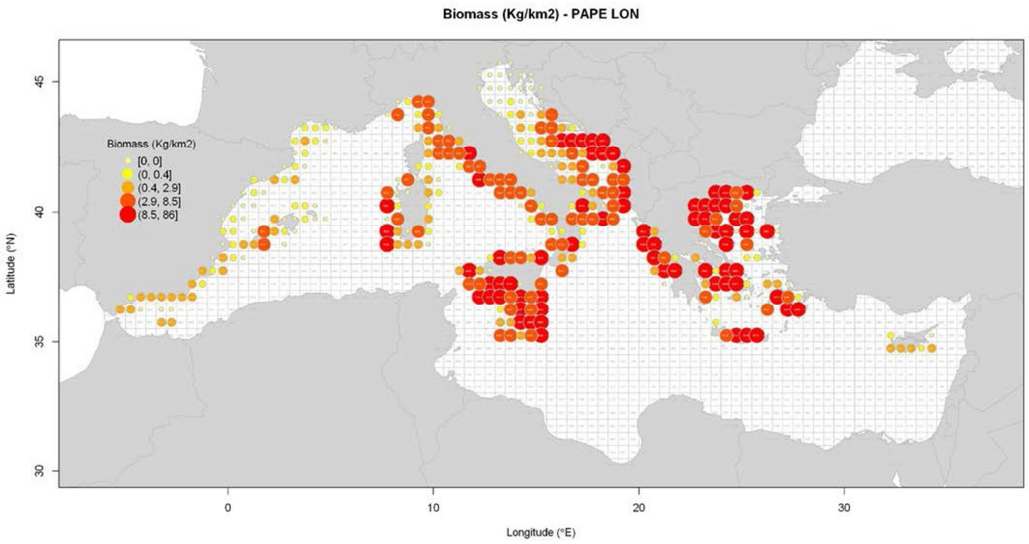


Figure 1.34. Biological indicators (Biomass) from 10 years of MEDITS surveys (2002-2011) for *P. longirostris*.

The full set of MEDITS biological parameters (Biomass index, CV % of density, mean fish weight, sex ratio, % of spawning females, median length of spawning females) was used in the CC to generate stock structure hypotheses of Deep-water pink shrimp. The mean Cohen's Kappa, evaluated on five layers of information criteria (Genetics, EFH and connectivity, Spawning season, Density trends, Biomass trends), results rather flat in the region from 3 to 9 clusters. The configurations with 5, 6, 7, and 8 units are within the upper quintile of the distribution with the "5 stock units" configuration exhibiting the highest mean Cohen's Kappa.

According to results of acceptability analysis, the four candidate configurations are comparable in terms of HAI (5 clusters, HAI= 0.83; 6 clusters, HAI=0.81; 7 clusters, HAI=0.84; 8 clusters, HAI=0.84). Based on the overall results, the "5 stock units" is considered the best hypothesis of stock structure of Deep-water pink shrimp.

For the deep water rose shrimp, the configuration with 5 clusters was considered the best candidate. This configuration was characterized by both the highest Cohen's Kappa and a higher level of acceptability (HAI=0.83). The

results, based on 6 biological indicators and 5 thematic layers of information, are considered reliable.

This means that *P. longirostris* populations from GSA's 1, 5, 6 and 7 are considered as a single stock, being extended the limits to the East of Sardinia.

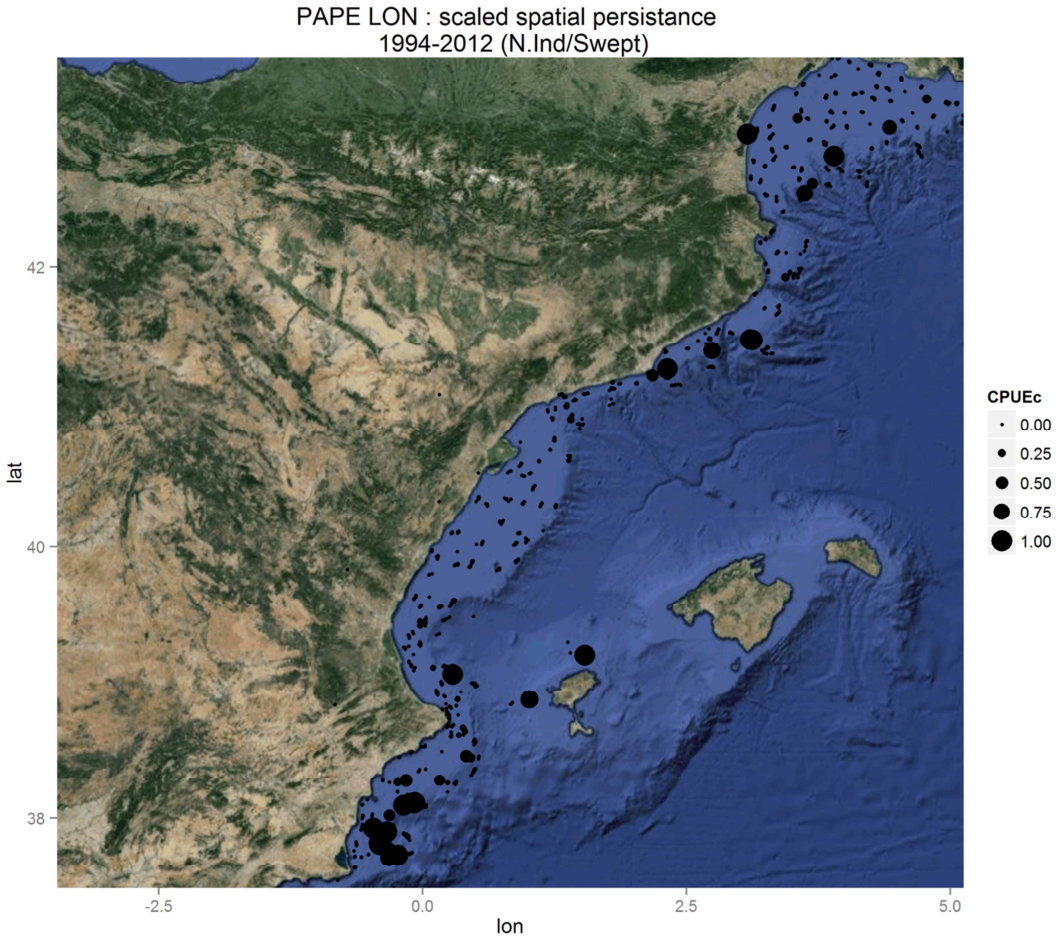


Figure 1.35. Geographical distribution of abundance (nº / km2) and distribution of *Parapenaeus longirostris* in GSA 6 and GSA 7 during MEDITS_ES surveys.

P. longirostris appears to be patchily distributed in the studied areas. Its abundance is noticeable in some areas of the shelf as well as in the shelf-slope break, both in the GSA 6 as in GSA 7.

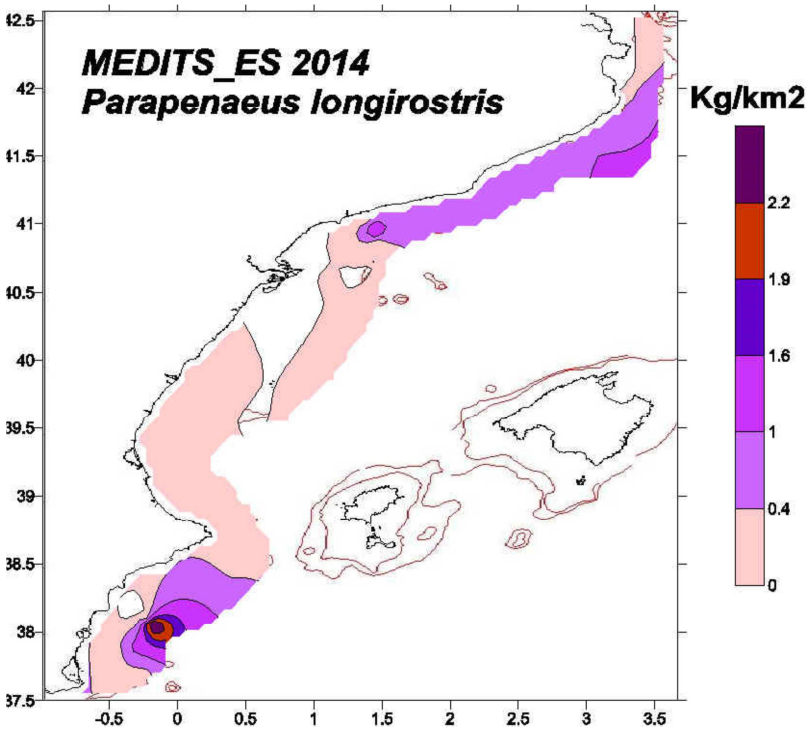


Figure 1.36. Geographical distribution of yields (kg / km2) and distribution of *Parapenaeus longirostris* in GSA 6 during MEDITS_ES 2014 survey.

In the GSA 6, pink shrimp (*P. longirostris)* it is distributed along the entire coast, shelf and slope. The areas showing higher values of biomass, according to the yields obtained, are some patches located in Santa Pola-Alicante and from Tarragona to the North (Cap de Creus).

Norway Lobster (*Nephrops norvegicus*)

The Norway lobster (*Nephrops norvegicus*) is a demersal species found on muddy bottoms in the North-Eastern Atlantic and the Mediterranean, being common in the coasts of the Iberian Peninsula. It is a sedentary lobster that inhabits borrows built in the mud and is found at depths ranging from 20 to 800 m. This is a target species in fisheries operating at depths of around 400 m. being among the most valuable resources for the trawl fleets in the area (GSA06), with landings reaching an average of 470 t per year (2007-2012) and showing some stability along time. Patchiness of the species populations seems to be related to both heterogeneity in the characteristics of the sediments and variations in fishing effort. There is a relationship between sediment type and depth in the studied area, with the grain size of the sediments decreasing as the distance from the coast increases, so that the finest mud is found in deeper areas.).

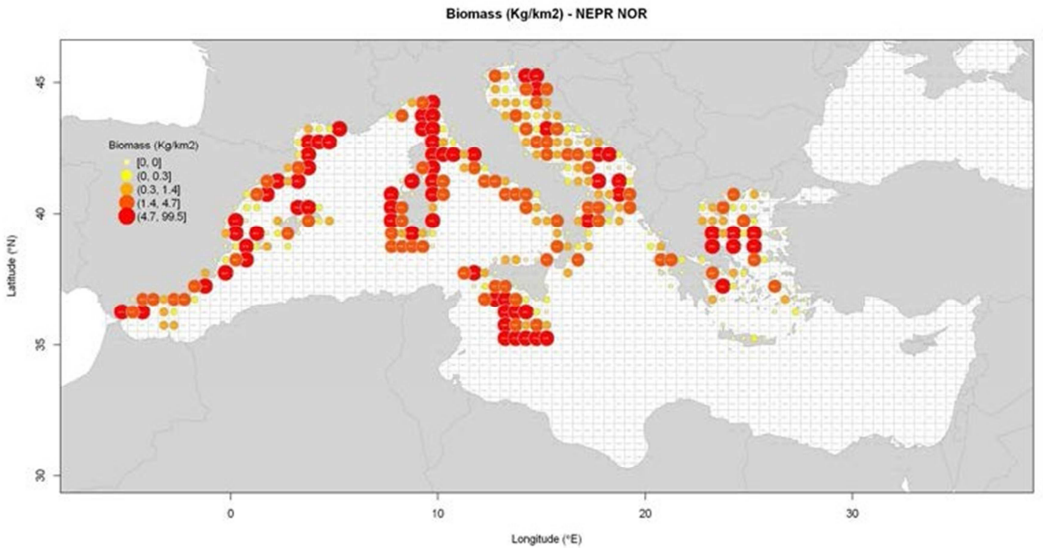


Figure 1.37. Biological indicators (Biomass) from 10 years of MEDITS surveys (2002-2011) for *Nephrops norvegicus.*

Concerning *N.norvegicus*, the CC was performed on six biological indicators (Biomass index, CV % of density, mean fish weight, sex ratio, % of spawning females, median length of spawning females) and the Cohen's Kappa coefficients averaged across four layers of information (Genetics, EFH and connectivity, Density trends, Biomass trends). The mean Cohen's Kappa

suggests that the “7 stock units” configuration has the best agreement with the three criteria. The other configurations within the upper quintile are those with 5, 6 and 8 units. According to the acceptability analysis there is weak discrimination between the candidate hypotheses in terms of acceptability for the first rank. However the “8 stock units” presents the highest Holistic Acceptability Index (HAI=0.79) whereas the “7 stock units” has the lower HAI (HAI= 0.66). Based on current information, the “7 stock units” is taken as best ranked hypothesis even if the other configurations deserve high consideration as well. The results are considered plausible, based on currently available information.

This species is one of main fishing resources of the deep-water bottom trawl fleet from the GSA06 area, representing up to 40% in biomass and 30% in economic value (2009-2013 period) from the most important deep-water crustaceans landed (*A. antennatus* and *P. longirostris*). Norway lobster is caught in GSA 6 exclusively by bottom trawlers fishing on the upper slope, between 350-600 m depth. Discards represent lower than 3.5% of the OTB catches in weight. Discards were assumed to be negligible in the present stock assessment.

As regards *N. norvegicus*, two hypotheses were selected from the results of WP4 and further analysed for a last choice. The 7 stock units and the 8 stock units. The former had the higher Cohen’s Kappa coefficient, while the latter had the highest HAI (0.79). Both are quite informative, thus given the better accordance between Cohen’s Kappa and Calinski-Harabasz indices for the 7 units option, this has been selected. Results are considered reliable because based on 6 biological indicators and 4 thematic layers.

This means that *N. norvegicus* populations from GSA’s 1 and 5 on one hand, and 6 and 7 on the other, are considered as two different stocks.

Surveys indices and commercial catches from Medits series indicate a relatively constant exploitation status of Norway lobster. Considering the analitycal approach, the data series is still too short to identify any clear trend in the population parameters.

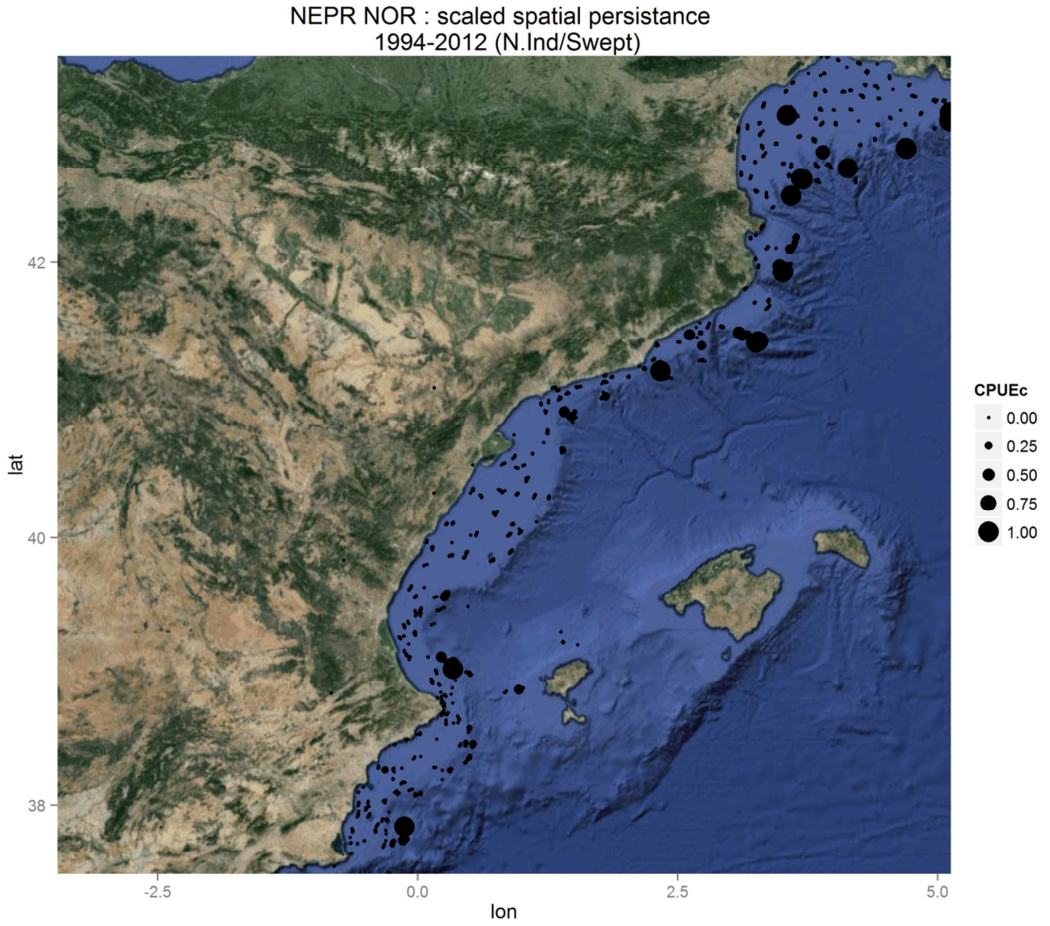


Figure 1.38. Geographical distribution of abundance (nº / km2) and distribution of *Nephrops norvegicus* in GSA 6 and GSA 7 during MEDITS_ES surveys.

N. norvegicus appears to be patchily distributed in the studied areas. Its abundance is noticeable in some areas of the shelf-slope break, both in the GSA 6 as in GSA 7.

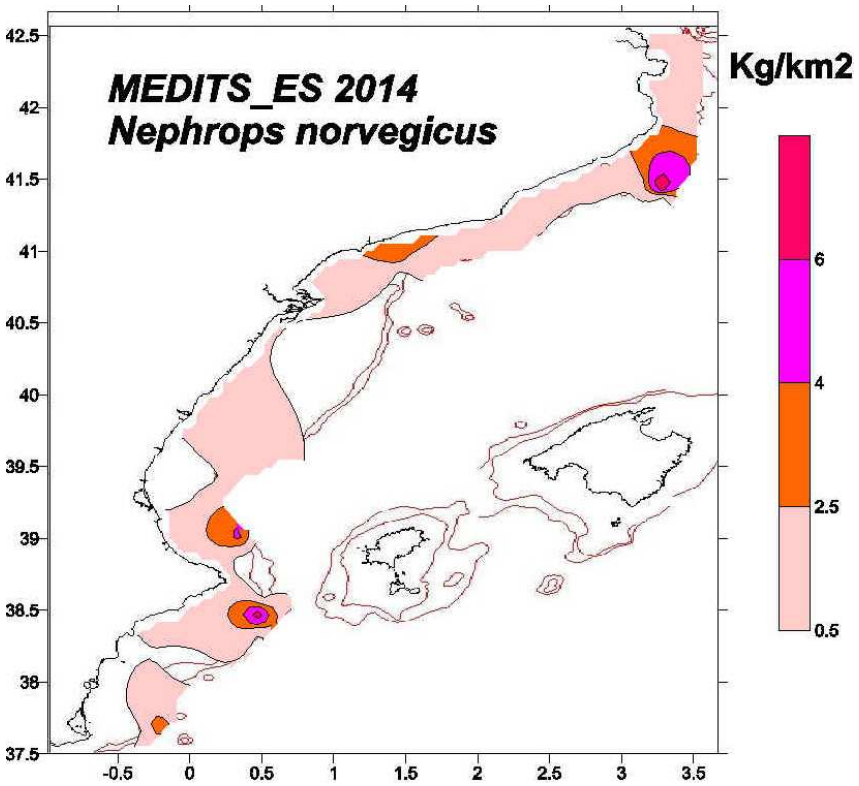


Figure 1.39. Geographical distribution of yields (kg / km2) and distribution of *Nephrops norvegicus* in GSA 6 during MEDITS_ES 2014 survey.

In the GSA 6, Norway lobster (*N. norvegicus)* it is distributed along the entire coast, shelf and mainly in the slope. The areas showing higher values of biomass, according to the yields obtained, are located in front of Mar Menor, North and South of Cape San Antonio and Cap de Creus.

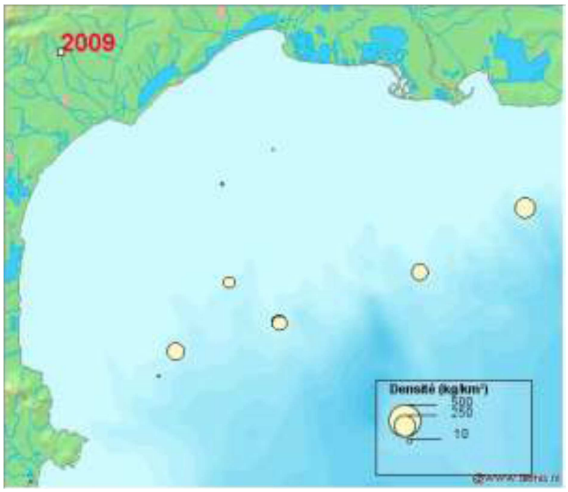
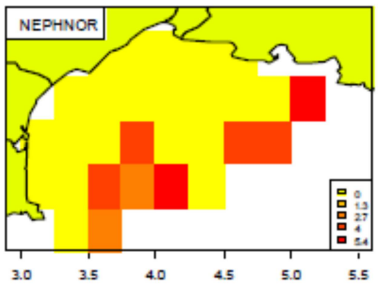


Figure 1.40. Geographical distribution of yields (kg / km2) and distribution of *Nephrops norvegicus* in GSA 7 during 2009.



Red shrimp (*Aristeus antennatus*)

The Red shrimp (*Aristeus antennatus*) is a demersal species that is found on the muddy bottoms of the slope of the continental shelf, more specifically in zones close to the submarine canyons. Its distribution area is very wide, since it is found in the Mediterranean and Atlantic south of the Iberian peninsula, reaching as far as the Portuguese coasts (Arrobas and Ribeiro-Cascalho, 1987).

In the Western Mediterranean (GSA 6 and 7), its bathymetric distribution is wide, between depths of 350 and 800 m. It carries out important migrations of both a diurnal and seasonal character. It not only moves from depths of 200 m during the night to 800 m during the day, but is also able to change its location during the year (Cartes, 1991).

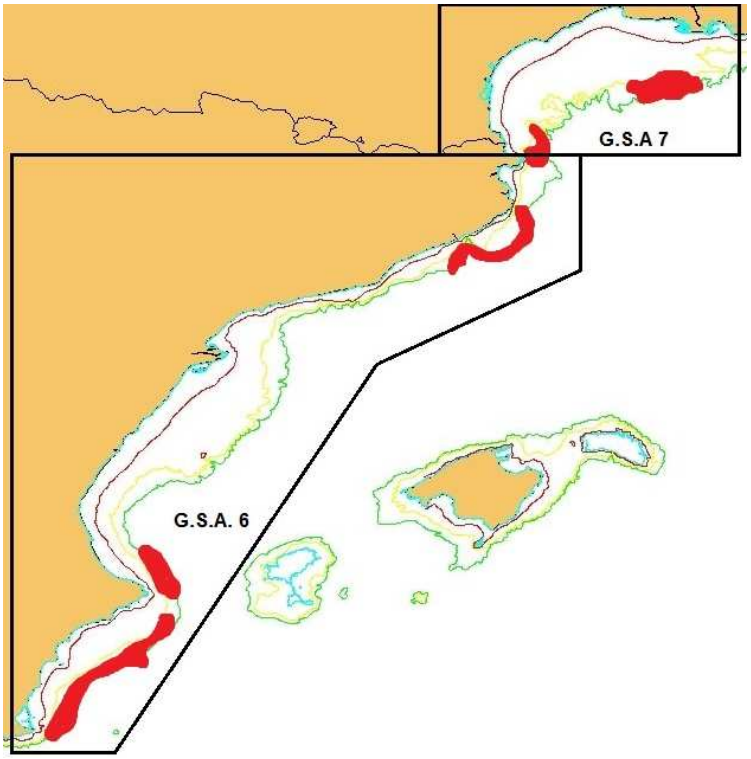


Figure 1.41. Location of the main fishing grounds of *Aristeus antennatus* in both GSAs (6 and 7).

Trawl fleets fishing effort in the ports were quite stable for the period studied with small variations of the number of vessels in the recent years. Vessels length was between 12-24 m. The gears used corresponded to a trawl net 60 and 100 longest rope. The vertical opening was between 1-3 m. The cod end mesh size used was a squared 40 mm of mesh opening. The net was rigged

two doors between 500-800 kgs. Trawl fleet in the four ports do daily trips with an unique haul directed to the red shrimp, with a duration between 5-7 hours.

The number of harbours with red shrimp fleets is 22 for the whole area, and the number of boats in this area is 241.

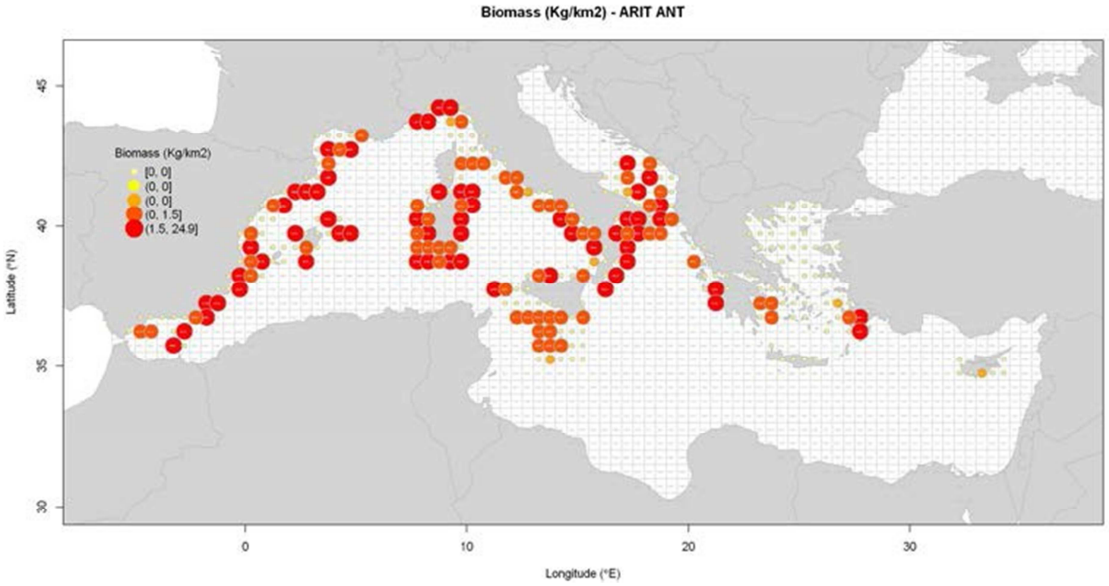


Figure 1.42. Biological indicators (Biomass) from 10 years of MEDITS surveys (2002-2011) for *Aristeus antennatus.*

The stock structure hypotheses for *A.antennatus* were generated through CC performed on six indicators (Biomass index, CV % of density, mean fish weight, sex ratio, % of spawning females, median length of spawning females). The Calinski-Harabasz index shows a decreasing trend with a peak at 4 clusters and other minor peaks at 6 and 8 clusters. The mean Cohen's Kappa, evaluated on five layers of information (Genetics, EFH and connectivity, L50, Growth, Density trends), identifies the "4 stock units" configuration as the hypothesis with the best level of agreement. The upper quintile includes also the configurations with 5, 6 and 8 units. The results of acceptability analysis provide support for these candidate hypotheses as they are the only hypotheses which obtain an acceptability for the first rank (besides the 7 clusters configuration). However, they are comparable in terms of HAI (4 clusters, HAI= 0.87; 5 clusters, HAI= 0.88; 6 clusters, HAI=0.85; 8 clusters, HAI=0.82). According to the currently

available information the configuration with 4, 5 and 6 are taken as candidates for the best hypothesis of stock structure. Taking into account the high number of descriptors used in the holistic approach, 6 biological indicators and 5 thematic layers of information, the results are considered plausible.

Regarding blue and red shrimp configurations with 4, 5 and 6 and 8 units had comparable holistic acceptability indices (4 clusters, HAI= 0.87; 5 clusters, HAI= 0.88; 6 clusters, HAI=0.85; 8 clusters, HAI=0.82) though the hypothesis of 4 units had also the higher value of mean Cohen's Kappa, coefficient. Results are considered reliable as based on 6 biological indicators and 5 thematic layers.

In order to compare this configuration with the current GSAs, few rectangles in the GSA7 belonging to the cluster of GSA6 should be instead attributed to the cluster of GSA8 (and other GSAs).

This means that *A. antennatus* populations from GSA's 1, 5, and 6 are considered as a single stock, being extended the limits to the Gulf of Lions (GSA 7).

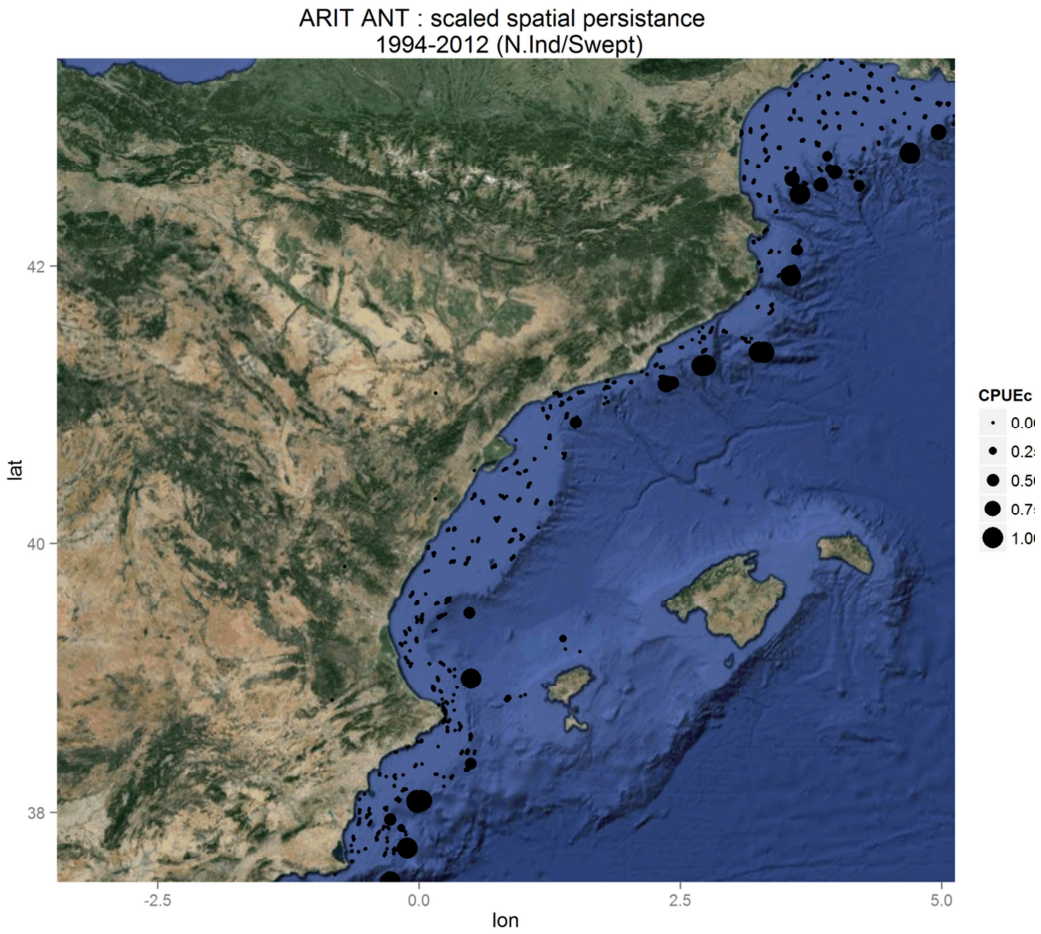


Figure 1.43. Geographical distribution of abundances (nº / km2) and distribution of *Aristeus antennatus* in GSA 6 and GSA 7 during MEDITS_ES surveys.

A. antennatus appears to be patchily distributed in the studied areas. Its abundance is noticeable in some areas of the slope, in areas close to submarine canyons, both in the GSA 6 as in GSA 7.

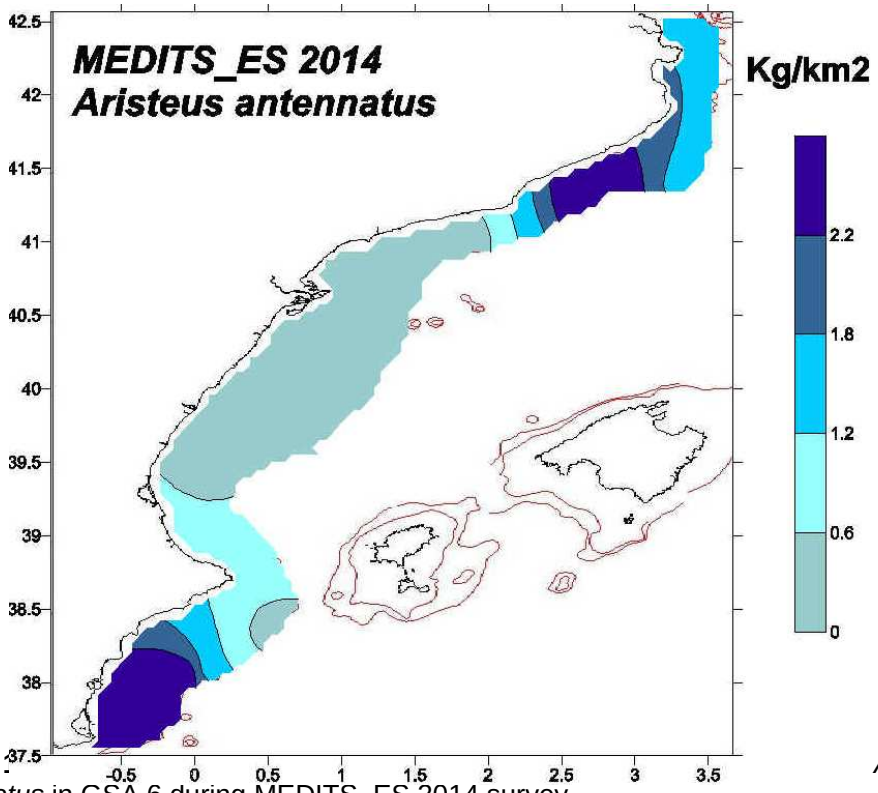


Figure . *Aristeus antennatus* in GSA 6 during MEDITS_ES 2014 survey.

In the GSA 6, red shrimp (*A. antennatus)* it is distributed along the entire coast slope, appearing in areas associated to the presence of submarine canyons. The areas showing higher values of biomass, according to the yields obtained, are located in Mar Menor- Torrevieja, Barcelona-Blanes and Cap de Creus.

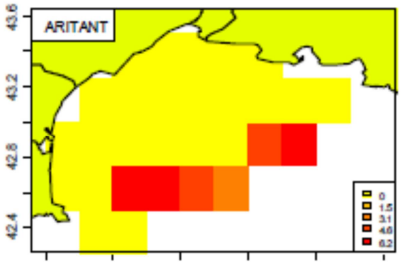


Figure 1.45. Geographical distribution of yields (kg / km2) and distribution of *Aristeus antennatus* in GSA 7 during 2009.

Monkfish (*Lophius budegassa*)

The Genus Lophius LINNEO,1758, has its two species distributed throughout the Mediterranean. The white monk fish *Lophius piscatorius* L. and the black monk fish or sapo, *Lophius budegassa* Spi. are distinguished, among other characteristics, by the different colour of the peritoneum which is white in *L. piscatorius* and black in *L. budegassa*, with both species being considered as purely benthic, since they are distributed from shallow waters down to depths of more than 500 m (Gil de Sola, 1993).

In the Spanish Mediterranean the capture of both monk fish species, by the trawl fleets that operate in the different zones, is frequent and, although they are not considered as a target species of the fisheries, their capture is interesting due to the appreciation that both enjoy in the fish markets.

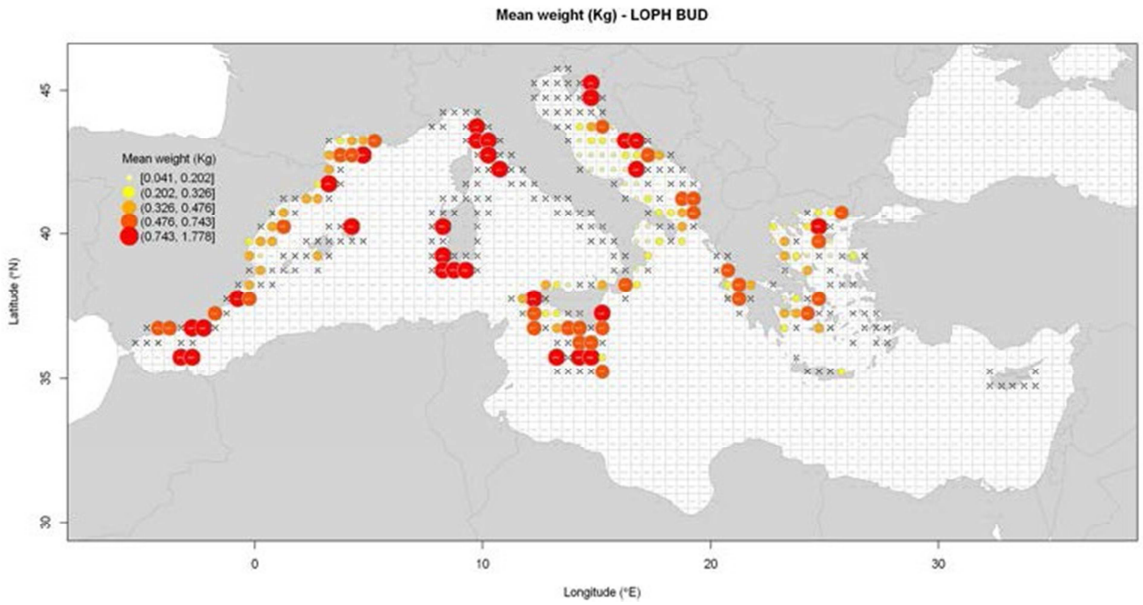


Figure 1.46. Biological indicators (Biomass) from 10 years of MEDITS surveys (2002-2011) for *Lophius budegassa.*

Overall, the stock structure identification of *L.budegassa* was based on three biological indicators (Biomass index, CV % of density, mean fish weight) and two layers of information (Biomass trends and Density trends). The Calinski-Harabasz index has a relative maximum at 6 clusters, whereas the mean

Cohen's Kappa shows the highest values at 4 and 5 clusters. One other hypothesis included in the upper quintile is the 10 clusters configuration. According to the acceptability analysis, the only hypothesis that attains an acceptability for the first rank is the "4 stock units" configuration (HAI=1).

The configurations with 5 and 10 clusters respectively, attain acceptability for the second rank but the 10 clusters configuration has the highest HAI (0.92 against 0.83). According to these results the "4 stock units" configuration represents the best hypothesis of stock structure. However, considering that the analysis was based on few strata of information (3 biological indicators and 2 thematic layers of information), the proposed stock structure should be considered as provisional.

According with the results reported in D15 the two configurations with higher probability were the 4 stock units configuration which gained a HAI=1 and the 10 clusters configuration with a HAI=0.92. However the Cohen's Kappa coefficient of the 4 stock units configuration was the higher and this configuration was also in the first rank of acceptability. However, considering that the analysis was based on few strata of information (3 biological indicators, i.e. inverse of density CV, biomass index and mean weight which were considered less powerful by the expert panel) and 2 thematic layers, the proposed stock structure should be considered as provisional. Thus the communication table is not provided.

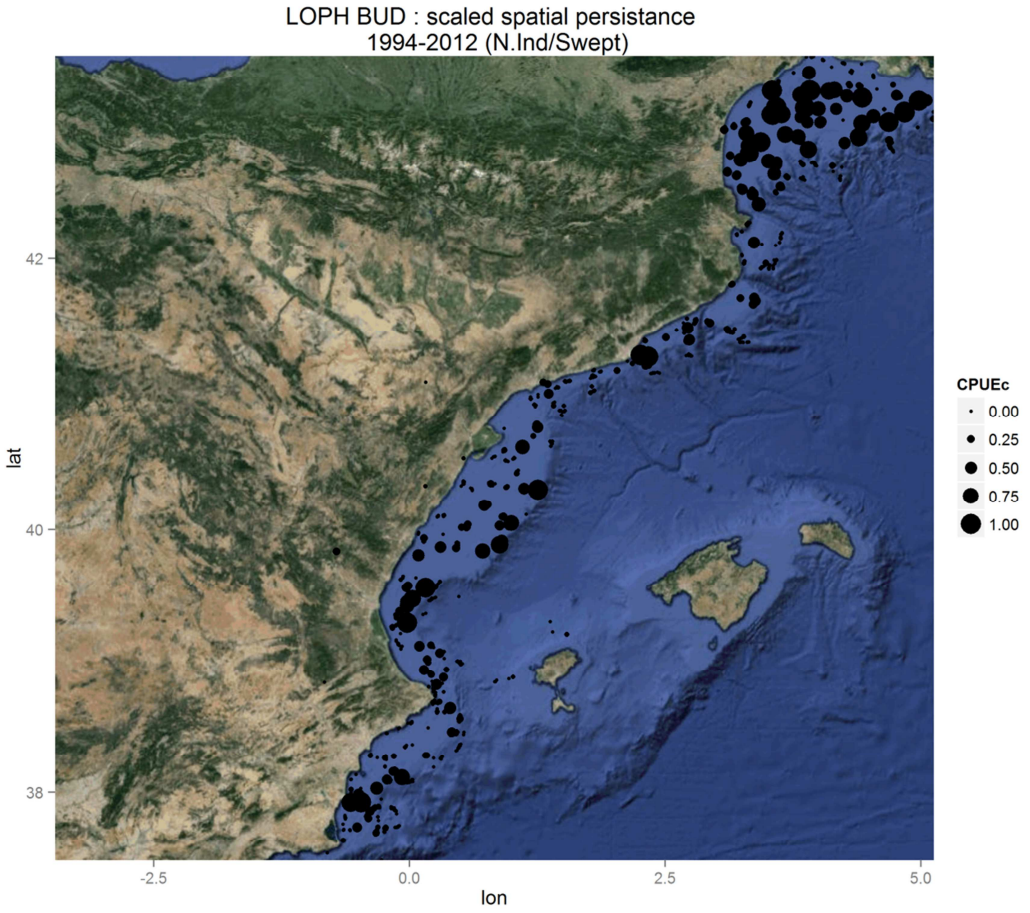


Figure 1.47. Geographical distribution of abundances (nº / km2) and distribution of *Lophius budegassa* in GSA 6 and GSA 7 during MEDITS_ES surveys.

L. budegassa appears to be widely distributed in the studied areas. Its abundance is noticeable in some areas of the shelf as well as in the shelf-slope break, both in the GSA 6 as in GSA 7.

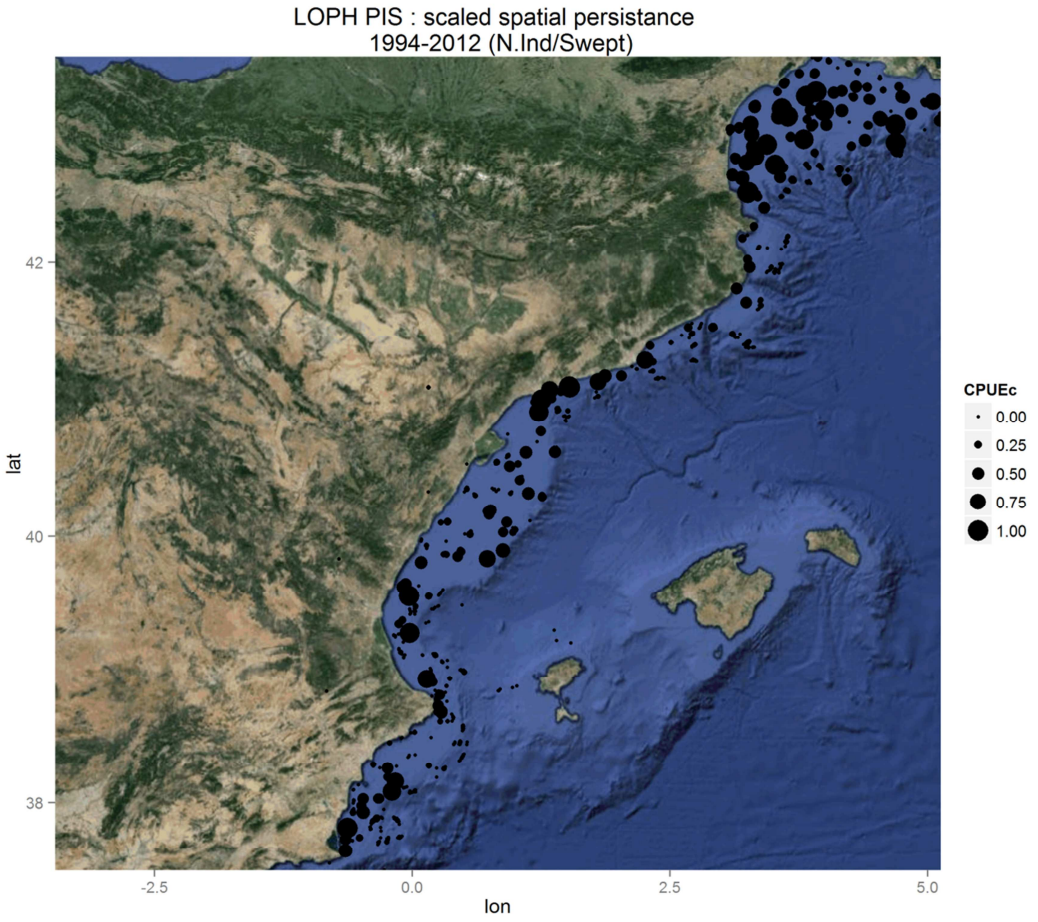


Figure 1.48. Geographical distribution of abundances (nº / km2) and distribution of *Lophius piscatorius* in GSA 6 and GSA 7 during MEDITS_ES surveys.

L. piscatorius appears to be widely distributed in the studied areas. Its abundance is noticeable in some areas of the shelf as well as in the shelf-slope break, both in the GSA 6 as in GSA 7, were is specially abundant.

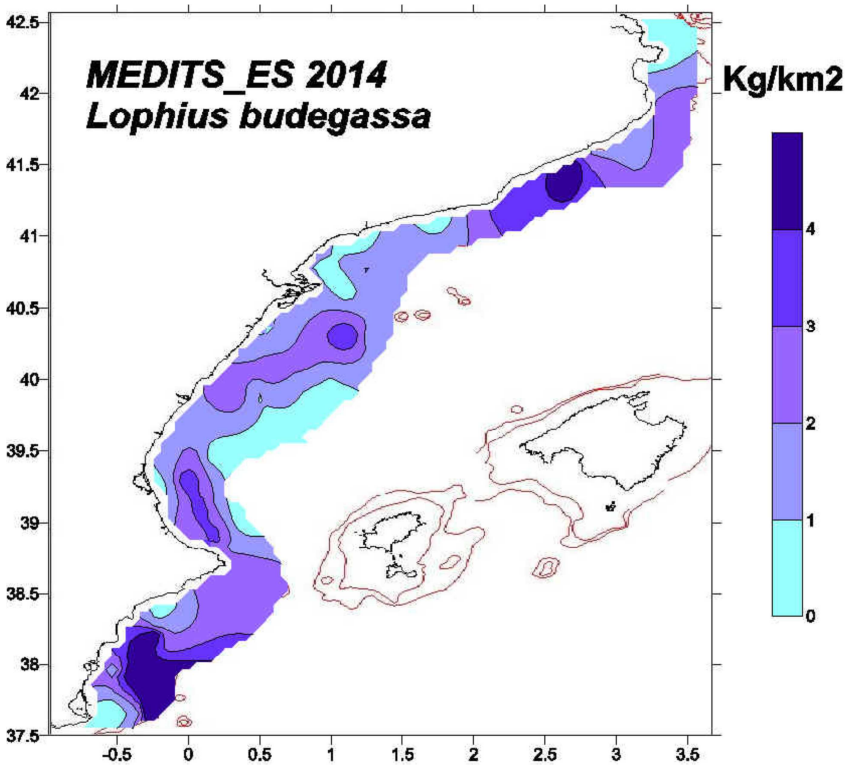


Figure 1.49. Geographical distribution of yields (kg / km2) and distribution of *Lophius budegassa* in GSA 6 during MEDITS_ES 2014 survey.

In the GSA 6, monkfish (*L. budegassa)* it is distributed along the entire coast, shelf and slope. The areas showing higher values of biomass, according to the yields obtained, are located in Santa Pola-Alicante, South of the Gulf of Valencia, South of Ebro River, Blanes and Cap de Creus.

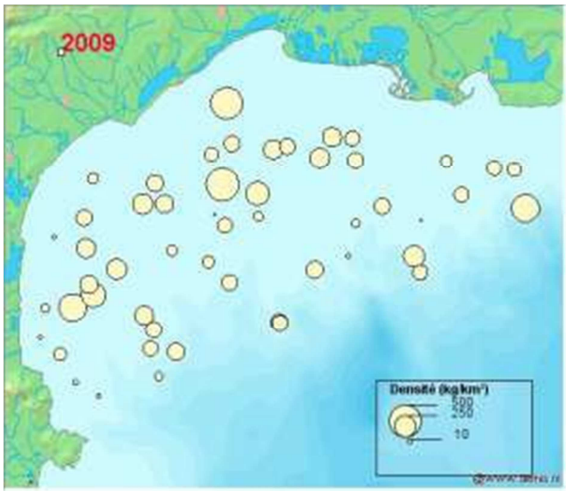


Figure 1.50. Geographical distribution of yields (kg / km2) and distribution of *Lophius budegassa* in GSA 7 during 2009.

Others stocks

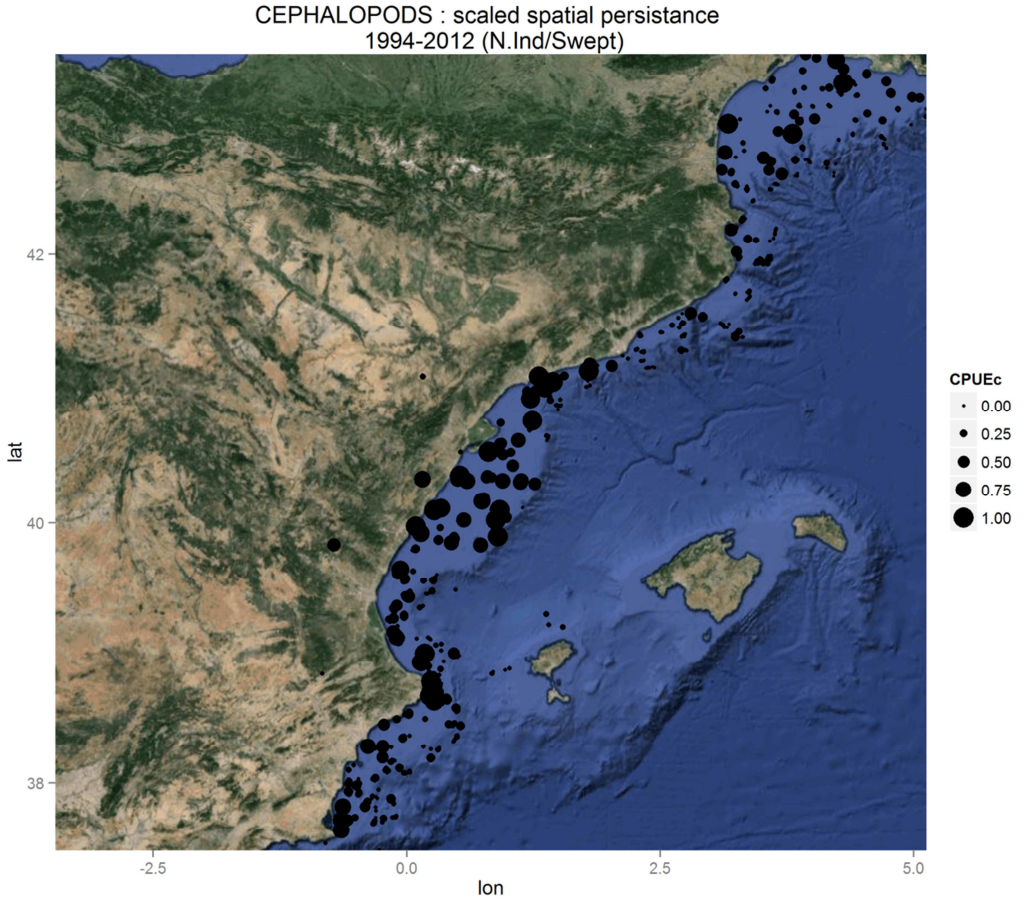


Figure 1.51. Geographical distribution of abundances (nº / km2) and distribution of *cephalopods* in GSA 6 and GSA 7 during MEDITS_ES surveys.

Cephalopods appear to be widely and uniformly distributed in the studied areas. Its abundance is noticeable along the shelf, both in the GSA 6 as in GSA 7.

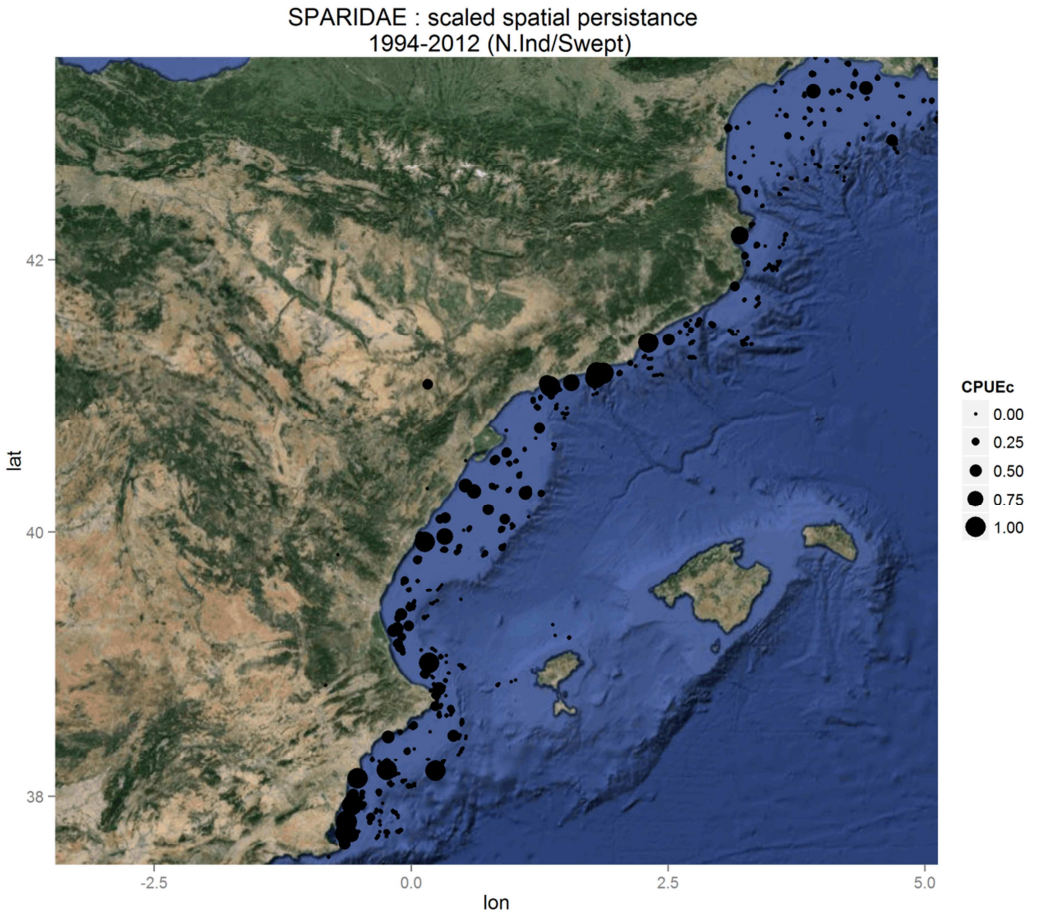


Figure 1.52. Geographical distribution of abundances (nº / km2) and distribution of *Sparidae* in GSA 6 and GSA 7 during MEDITS_ES surveys.

Sparidae appear to be widely distributed in the studied areas. Its abundance is noticeable along the coast and the shelf, both in the GSA 6 as in GSA 7, being more abundant in the GSA 6.

SPATIAL COVERAGE: CONCLUSIONS

Benthic and demersal species are exploited by the semi-industrial trawler fleets as well as artisanal vessels. Artisanal fisheries are characterized by high diversity of species caught and by the absence of large monospecific stocks. Although the number of artisanal vessels is important in some areas with high social impact, catches account for only a very small part of the total. Most of the landings of demersal species come from the bottom trawl fleets. The multispecies nature of the bottom trawl fishery is evident if we consider that catches can eventually identify more than 600 species from different taxonomic groups. Consequently, the proportion of discards is very high, up to 77% of species and 30-40% of the total weight caught. The exploitation extends to both the platform and the continental slope; the predominant species at landings vary with depth.

The Gulf of Lions supports fisheries that include bottom and pelagic trawls, purse seines, gill nets and longlines, and is furthermore an important spawning area for many pelagic and demersal species. The demersal fisheries are multi-species and multi-gears fisheries. The marine living resources of the Gulf of Lions are a “shared stock” which is essentially exploited by French and Spanish fishing boats. The main part of the fishing grounds exploited by these boats cover the entire continental shelf from the coastline to the 200 metres isobath, with an area of some 14 000 square kilometres covered by sandy deposits.

Species are widely distributed along the Mediterranean coasts, covering all GSAs. Referring to the biomass index, the pair of contiguous GSAs with highest amount of time series of species correlated was the Gulf of Lions (GSA 7) and Corsica (GSA 8) with 7species significantly correlated, while two additional pairs showed 5 species with significantly correlated time series, i.e. Northern Alboran Sea (GSA 1) and Northern Spain (GSA 6), Northern Spain (GSA 6) and Gulf of Lions (GSA 7).

M. merluccius populations from GSA’s 1, 5, 6 and 7 are considered as a single stock. In the GSA 6 is distributed along the entire coast, shelf and slope. The areas showing higher values of biomass, according to the yields obtained, are located in Cabo de Palos, Gulf of Valencia, Columbretes Islands, Badalona, Blanes and Cap de Creus. In GSA 7, The hake is a species very widely

distributed in the Gulf of Lions since the very coastal sector, near 30m depth, until 800 m. The species is mainly present between 80 and 150 m.

M. barbatus occurs on sandy and muddy bottoms between 50 and 200m depth in areas with wider continental shelf, whereas *M. surmuletus* has a wider bathymetric range (occurring to a depth of 400 m) but its maximum abundance is concentrated near the coast, on gravel and rocky bottoms between 10 and 100m depth, especially in areas where the shelf is steepest and with a higher influence of seagrass beds, especially *Posidonia oceanica*. *M. barbatus* populations from GSA's 1,5, 6 and 7 are considered as a single stock, being extended the limits to the Western Ionian Sea. In the GSA 6, mullet (*M. barbatus*) it is distributed along the entire coast, shelf and slope. The areas showing higher values of biomass, according to the yields obtained, are located in Cape de Palos, South of the Gulf of Valencia, Columbretes Islands and Blanes-Cap de Creus.

M. surmuletus populations from GSA's 1, 5, and 6 are considered as a single stock, being extended the limits to the Gulf of Lions (GSA 7). In the GSA 6, red mullet (*M. surmuletus)* it is distributed along the entire coast, shelf and slope. The areas showing higher values of biomass, according to the yields obtained, are located in Santa Pola-Alicante, South of the Gulf of Valencia, in front of Valencia-Sagunto, Columbretes Islands, Barcelona and Blanes.

P. longirostris populations from GSA's 1, 5, 6 and 7 are considered as a single stock, being extended the limits to the East of Sardinia. Deepwater pink shrimp is distributed from 150 to 400 m depth in GSA 06, with higher densities on soft muddy bottoms in the southern part of GSA and, in years of high abundance of the population also in the north of GSA 06. The areas showing higher values of biomass, according to the yields obtained, are located in Santa Pola-Alicante and from Tarragona to the North (Cap de Creus).

The Norway lobster (*Nephrops norvegicus*) is a demersal species found on muddy bottoms along the coasts of the Iberian Peninsula. It is a sedentary lobster that inhabits borrows built in the mud and is found at depths ranging from 20 to 800 m. *N. norvegicus* populations from GSA's 1 and 5 on one hand, and 6 and 7 on the other, are considered as two different stocks. In the GSA 6,

In GSA 6, Norway lobster it is distributed along the entire coast, shelf and mainly in the slope. The areas showing higher values of biomass, according to the yields obtained, are located in front of Mar Menor, North and South of Cape San Antonio and Cap de Creus.

The Red shrimp (*Aristeus antennatus*) is a demersal species that is found on the muddy bottoms of the slope of the continental shelf, more specifically in zones close to the submarine canyons. Its distribution area is very wide, since it is found in the Mediterranean and Atlantic south of the Iberian peninsula. In the Western Mediterranean (GSA 6 and 7), its bathymetric distribution is wide, being found between depths of 350 and 800 m. *A. antennatus* populations from GSA's 1, 5, and 6 are considered as a single stock, being extended the limits to the Gulf of Lions (GSA 7). In the GSA 6, red shrimp it is distributed along the entire coast slope, appearing in areas associated to the presence of submarine canyons. The areas showing higher values of biomass, according to the yields obtained, are located in Mar Menor- Torrevieja, Barcelona-Blanes and Cap de Creus.

The Genus Lophius LINNEO,1758, has its two species distributed throughout the Mediterranean. The white monk fish *Lophius piscatorius* L. and the black monk fish, *Lophius budegassa* Spi. with both species being considered as purely benthic, since they are distributed from shallow waters down to depths of more than 500 m. In the GSA 6, monkfish (*L. budegassa)* it is distributed along the entire coast, shelf and slope. The areas showing higher values of biomass, according to the yields obtained, are located in Santa Pola-Alicante, South of the Gulf of Valencia, South of Ebro River, Blanes and Cap de Creus.

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