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MEDITERRANEAN MARINE DEMERSAL RESOURCES: THE MEDITS INTERNATIONAL TRAWL SURVEY (1994-1999).
P. ABELLÓ, J.A. BERTRAND, L. GIL DE SOLA, C. PAPACONSTANTINOU, G. RELINI and A. SOUPLET (eds.)

Biogeography of epibenthic crustaceans on the shelf and upper slope off the Iberian Peninsula Mediterranean coasts: implications for the establishment of natural management areas*

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SUMMARY: The patterns of occurrence and bathymetric distribution of epibenthic crustaceans on the continental shelf and upper slope down to a depth of 800 m are analysed based on data gathered during six demersal trawl surveys performed annually in spring along the Mediterranean coasts of the Iberian Peninsula (from the Straits of Gibraltar to Cape Creus) between 1994 and 1999. A total of 598 valid hauls has been studied providing a total of 108 species of decapods, two stomatopods, one euphausiid, one mysid and one isopod. The study area has been subdivided into seven sectors according to their geomorphological characteristics, and the patterns of occurrence and abundance by depth have been analysed separately for each of the sectors. Detailed data on bathymetric distribution are presented for each species. Two main biogeographical areas can be discerned along the study area, which can approximately be separated at Palos Cape: the Alborán Sea to the southwest, and the northwestern Mediterranean (Levantine and Catalan Seas) northwest of Palos Cape. The continental shelf in the Alborán Sea (the most western area of the Mediterranean) is extremely narrow whereas it is much wider in the northwestern Mediterranean. The influence of Atlantic waters entering the Mediterranean is particularly strong in the Alborán Sea which shows a particularly high species richness of Atlantic affinity. Within the context of the western Mediterranean Sea, the Alborán Sea region shows important faunistic characteristics such that it might be considered as a possible separate natural management area for demersal fisheries.

Key words: biogeography, decapod crustaceans, stomatopods, western Mediterranean, natural management areas

INTRODUCTION

Epibenthic crustaceans are one of the most valuable resources of the Mediterranean demersal fishery. Some of them are widely known and heavily exploited throughout most of their distribution range, such as the Norway lobster (*Nephrops norvegicus*), the shrimps *Aristeus antennatus*, *Aristaeomorpha foliacea* and *Parapenaeus longirostris* or the stomatopod *Squilla mantis* (e.g. Ardizzone *et al.*, 1990; Abelló and Martín, 1993; Demestre and Lleonart, 1993; Sardà, 1998; Carbonell *et al.*, 1999). The species richness of epibenthic crustaceans in the Mediterranean is high, especially that of decapod crustaceans (Sardà and Palomera, 1981; Tunesi, 1986; Abelló *et al.*, 1988; Relini *et al.*, 1986; Mura and Cau, 1994; Falciai, 1997). They constitute an important part of the total biomass throughout the continental shelf and

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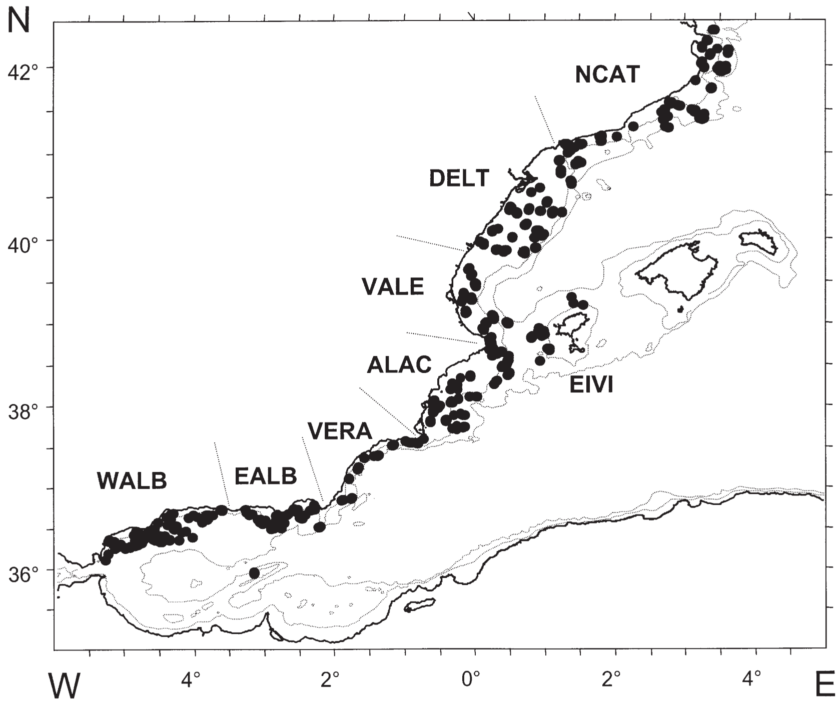

FIG. 1. – Geographical distribution of the samples taken and an indication of the geographical sectors used in the present study. WALB: Western Alborán Sea; EALB: Eastern Alborán Sea; VERA: Vera Gulf; ALAC: Alacant; EIVI: Eivissa Island; VALE: Valencia; DELT: Ebro delta region; NCAT: Northern Catalonia. 200 m and 1000 m isobaths are shown.

slope, especially in the middle and lower slope (Cartes, 1993; Cartes and Sardà, 1992, 1993; Cartes *et al.*, 1993, 1994). Well over a hundred decapod crustacean species have been reported on the trawlable bottoms of the Mediterranean (Relini *et al.*, 1986; Tunesi, 1986; Abelló *et al.*, 1988; Mura and Cau, 1994; etc.). Faunistic studies constitute essential tools to understand the dynamics of exploited communities and accordingly, food webs can be much better understood, as well as other interspecific relationships, competence mechanisms, changes in relative abundance of the species, interannual changes in community structure and dynamics, etc.

The samplings performed within the framework of the MEDITS international trawl survey (Bertrand *et al.*, 2000) have provided an unique opportunity to study and delimit, with a high degree of accuracy, the geographical and bathymetric distribution of many species, as well as their interrelationships, given the large geographical area surveyed, the bathymetrical intensity of sampling, which encompassed the trawlable bottoms between 25 and 800 m depth, and the time duration of the surveys over several (1994-1999) years.

The identification of major geographical areas with communities sharing similar specific composition may provide an insight into their characterization as ecological assemblages sharing similar problems. Thus, from the management point of view, their identification should be taken into account when designing specific policies for the sustainable management of regional fisheries. The marked geomorphological differences between different Mediterranean basins and regions, may provide or facilitate the differentitaion of a reasonably large number of relatively isolated subpopulations within species, especially so in those with a short planktonic larval life. Boundaries such as sills, capes and associated stable or semi-permanent hydrographical circulation features (frontal zones, anticyclonic and cyclonic gyres, eddies, etc.) may constitute effective semi-permeable boundaries able to differentiate communities and population units.

The main objectives of the present work were to provide detailed information on the patterns of geographical and bathymetric distribution of decapod crustaceans on the trawlable bottoms of the continental shelf, upper and middle slope off the Mediterranean coasts of the Iberian Peninsula, and to geographically analyse and delimit the main biogeographical faunistic assemblages, especially aimed at the identification of natural management areas, recognized as one of the present time key issues in Mediterranean management (Caddy, 1998).

MATERIAL AND METHODS

The study area comprised the entire Mediterranean continental shelf, upper and middle slope off the Iberian Peninsula from Gibraltar Straits to Cape Creus, excluding most of the Balearic islands (Fig. 1). An overall area of 45331 km^2 was surveyed. The Alborán Sea and the Vera Gulf are characterised by a narrow continental shelf, as well as by the direct influence of surface Atlantic waters, which lead to local areas of high productivity. The continental shelf broadens in the Alacant-Eivissa area, where surface inflowing (modified) Atlantic and outflowing Mediterranean waters meet around the Eivissa sill. Around the Ebro delta and the Columbretes islands the continental shelf is widest (up to 70 km), and the area is highly productive due to the combined effect of the Liguro-Provençal-Catalan front at the continental slope and the runoff of the Ebro river. In the central-north Catalonia area the continental shelf becomes narrow again, and is indented by submarine canyons, with the Liguro-Provençal-Catalan front flowing southwestwards along the continental slope.

The information presented herein was obtained from a total of six trawl surveys performed annually in spring (May-June) from 1994 to 1999 using the research vessel "Cornide de Saavedra". A depth stratified random sampling procedure, taking into account the surface area of five depth intervals (0-50 m, 50-100 m, 100-200 m, 200-500 m and 500-800 m) and three broad geographical sectors, (Alborán Sea, Alacant region, and Catalan Sea) was used (MEDITS protocol) (Bertrand *et al.*, 2000, 2002). The samples were obtained with a bottom trawl (model GOC-73) with a 4-m vertical opening and 20-mm codend mesh size, trawled at a speed of 3 knots. Hauls performed at depths of less than 200 m had a duration of 30 minutes; those performed deeper had a duration of 60 minutes. A total of 598 valid samples was obtained (Table 1). The depths sampled ranged between 25 and 798 m.

TABLE 1. – Dates and number of samples taken in the six studied trawl surveys.

Cruise name	Year	Dates	Number of samples
MEDITS_ES94	1994	28 May - 19 June	77
MEDITS_ES95	1995	22 April - 21 May	106
MEDITS_ES96	1996	2-26 May	105
MEDITS_ES97	1997	10 May - 3 June	101
MEDITS_ES98	1998	3-30 May	92
MEDITS_ES99	1999	4 May - 3 June	117

All crustaceans in the samples were identified, counted and weighed. It is however worth remarking here that for crustacean phyla typically with small-sized species, such as Euphausiacea, Isopoda and Mysidacea, the sampling was not adequate, given the net selectivity characteristics. Species belonging to these phyla were included in the present analysis given the focus centered on presence and absence distribution characteristics. Sampling can be considered adequate for Decapoda and Stomatopoda. Except for portunid crabs and some other exceptions, nomenclature of the decapod crustacean species has mainly followed d'Udekem d'Acoz (1999).

The patterns of distribution are analysed as a function of depth stratum and geographical sector. Intervals of 50 m depth down to 200 m and of 100 m on the slope were used to analyse the distribution patterns of occurrence (Table 2). The narrower depth strata of the shelf zone were selected to account for the greater steepness of the environmental gradients associated with depth variations within this zone. The study area was additionally divided into eight geographical sectors, according to their different

TABLE 2. – Distribution of the number of samples taken as a function of the geographical sector and depth stratum (MEDITS_ES94-99).

	Geographical sector								
Depth stratum (m)	WALB	EALB	VERA	ALAC	EIVI	VALE	DELT	NCAT	Total
0-50	6	5	2	12	-	4	19	8	56
50-100	19	12	5	30	-	27	66	28	187
100-150	8	5	2	11	2	13	16	26	83
150-200	3	2	4	11	-	1	2	4	27
200-300	7	4	6	8	5	-	1	4	35
300-400	13	4	4	7	1	4	1	10	44
400-500	5	9	3	11	5	-	2	9	44
500-600	10	11	4	14	7	-	3	14	63
600-700	17	8	1	-	4	-	1	7	38
700-800	8	1	3	-	2	6	-	1	21
Total	96	61	34	104	26	55	111	111	598

TABLE 3. – Crustacean species captured on the shelf, upper and middle slope along the Spanish Mediterranean during the MEDITS_ES cruises (1994-1999).

Subclass CIRRIPEDIA

O. **THORACICA**
Fam. SCALPELLIDAE
Scalpellum scalpellum Linnaeus, 1767

Subclass MALACOSTRACA

O. **STOMATOPODA**
Fam. SQUILLIDAE
Rissoides pallidus (Giesbrecht, 1910)
Squilla mantis (Linnaeus, 1758)

O. **EUPHAUSIACEA**
Fam. EUPHAUSIIDAE
Meganyctiphanes norvegica (M. Sars, 1857)

O. **MYSIDACEA**
Fam. LOPHOGASTRIDAE
Lophogaster typicus M. Sars, 1857

O. **ISOPODA**
Fam. CIROLANIDAE
Natatolana borealis (Lilljeborg, 1851)

O. **DECAPODA**
SO. **Dendrobranchiata**
Fam. ARISTEIDAE
Aristeomorpha foliacea (Risso, 1827)
Aristeus antennatus (Risso, 1816)
Gennadas elegans (S.I. Smith, 1882)
Fam. PENAEIDAE
Funchalia woodwardi Johnson, 1867
Parapenaeus longirostris (Lucas, 1846)
Penaeopsis serrata (Bate, 1881)
Melicertus kerathurus (Forskal, 1775)
Fam. SOLENOCERIDAE
Hymenopenaeus debilis S.I. Smith, 1882
Solenocera membranacea (Risso, 1816)
Fam. SERGESTIDAE
Sergestes arcticus Kröyer, 1855
Sergestes arachnipodus (Cocco, 1832)
Sergia robusta (S.I. Smith, 1882)

SO. **Caridea**
Fam. PASIPHAEIDAE
Pasiphaea multidentata Esmark, 1866
Pasiphaea sivado (Risso, 1816)
Fam. OPLOPHORIDAE
Acanthephyra eximia S.I. Smith, 1884
Acanthephyra pelagica (Risso, 1816)
Fam. PALAEMONIDAE
Periclimenes granulatus Holthuis, 1950
Fam. ALPHEIDAE
Alpheus glaber (Olivi, 1792)
Alpheus macrocheles (Hailstone, 1835)
Alpheus platydactylus Coutière, 1897
Fam. HIPPOLYTIDAE
Caridion steveni Lebour, 1930
Ligur ensiferus (Risso, 1816)
Fam. PROCESSIDAE
Processa canaliculata Leach, 1815
Processa nouveli Al-Adhub and Williamson, 1975
Fam. PANDALIDAE
Chlorotocus crassicornis (A. Costa, 1871)
Pandalina profunda Holthuis, 1946
Plesionika acanthonotus (S.I. Smith, 1882)
Plesionika antigai Zariquiey Álvarez, 1955
Plesionika edwardsii (Brandt, 1851)
Plesionika gigliolii (Senna, 1902)
Plesionika heterocarpus (A. Costa, 1871)
Plesionika martia A. Milne-Edwards, 1883
Plesionika narval (J.C. Fabricius, 1787)
Fam. CRANGONIDAE
Aegaeon cataphractus (Olivi, 1792)
Aegaeon lacazei (Gourret, 1887)
Philocheras echinulatus (M. Sars, 1862)
Pontophilus norvegicus (M. Sars, 1861)
Pontophilus spinosus (Leach, 1815)
SO. **Stenopodidea**
Fam. STENOPODIDAE
Richardina fredericii Lo Bianco, 1903
IO. **Eryonidea**
Fam. POLYCHELIDAE
Polycheles typhlops Heller, 1862
IO. **Palinuridea**
Fam. PALINURIDAE
Palinurus elephas (J.C. Fabricius, 1787)
Palinurus mauritanicus Gruvel, 1911
Fam. SCYLLARIDAE
Scyllarides latus (Latreille, 1803)
Scyllarus arctus (Linnaeus, 1758)
IO. **Nephropidea**
Fam. NEPHROPIDAE
Homarus gammarus (Linnaeus, 1758)
Nephrops norvegicus (Linnaeus, 1758)
IO. **Thalassinidea**
Fam. CALOCARIDIDAE
Calocaris macandreae Bell, 1846
Fam. AXIIDAE
Calocarides coronatus Trybom, 1904
IO. **Anomura**
Fam. GALATHEIDAE
Galathea dispersa Bate, 1859
Galathea intermedia parroceli Gourret, 1887
Galathea nexa Embleton, 1834
Munida intermedia A. Milne-Edwards and Bouvier, 1899
Munida rutllanti Zariquiey-Alvarez, 1952
Munida tenuimana G.O. Sars, 1872
Fam. PORCELLANIDAE
Pisidia longicornis (Linnaeus, 1767)
Fam. DIOGENIDAE
Calcinus tubularis (Linnaeus, 1767)
Dardanus arrosor (Herbst, 1796)
Dardanus calidus (Risso, 1827)
Paguristes eremita (Linnaeus, 1767)
Fam. PAGURIDAE
Anapagurus bicorniger A. Milne-Edwards and Bouvier, 1892
Anapagurus laevis (Bell, 1845)
Pagurus alatus (J.C. Fabricius, 1775)
Pagurus anachoretus Risso, 1827
Pagurus cuanensis Bell, 1845
Pagurus excavatus (Herbst, 1791)
Pagurus forbesii Bell, 1845
Pagurus prideaux Leach, 1815
IO. **Brachyura**
Fam. DROMIIDAE
Dromia personata (Linnaeus, 1758)
Fam. HOMOLIDAE
Homola barbata (J.C. Fabricius, 1793)
Paromola cuvieri (Risso, 1816)
Fam. LATREILLIIDAE
Latreillia elegans elegans P. Roux, 1830
Fam. CYMONOMIDAE
Cymonomus granulatus (Norman in Wyville Thomson, 1873)
Fam. MAJIDAE
Dorhynchus thomsoni Wyville Thomson, 1873
Ergasticus clouei A. Milne-Edwards, 1882
Eurynome aspera (Pennant, 1777)
Inachus communissimus Rizza, 1839
Inachus dorsettensis (Pennant, 1777)
Inachus thoracicus P. Roux, 1830
Macropodia linaresi Forest and Zariquiey Álvarez, 1964
Macropodia longipes (A. Milne-Edwards and Bouvier, 1899)
Macropodia rostrata (Linnaeus, 1761)
Maja crispata Risso, 1827
Lissa chiragra (J.C. Fabricius, 1775)
Pisa armata (Latreille, 1802)

TABLE 3 (Cont.). – Crustacean species captured on the shelf, upper and middle slope along the Spanish Mediterranean during the MEDITS_ES cruises (1994-1999).

Pisa nodipes (Leach, 1815)	*Liocarcinus maculatus* (Risso, 1827)
Rochinia carpenteri (Wyville Thomson, 1873)	*Macropipus tuberculatus* (Roux, 1830)
Fam. DORIPPIDAE	*Polybius henslowi* Leach, 1820
Ethusa mascarone (Herbst, 1785)	Fam. PARTHENOPIDAE
Medorippe lanata (Linnaeus, 1767)	*Parthenope angulifrons* Latreille, 1825
Fam. LEUCOSIIDAE	*Parthenope macrochelos* (Herbst, 1790)
Ebalia cranchii Leach, 1817	*Parthenope massena* (P. Roux, 1830)
Ebalia nux A. Milne-Edwards, 1883	Fam. XANTHIDAE
Fam. CALAPPIDAE	*Monodaeus couchii* (Couch, 1851)
Calappa granulata (Linnaeus, 1758)	*Xantho granulicarpus* Forest, 1953
Fam. ATELECYCLIDAE	Fam. PILUMNIDAE
Atelecyclus rotundatus (Olivi, 1792)	*Pilumnus spinifer* H.-M. Edwards, 1834
Fam. GERYONIDAE	Fam. GONEPLACIDAE
Geryon longipes A. Milne-Edwards, 1882	*Goneplax rhomboides* (Linnaeus, 1758)
Fam. PORTUNIDAE	Fam. PINNOTHERIDAE
Bathynectes maravigna (Prestandrea, 1839)	*Nepinnotheres pinnotheres* (Linnaeus, 1758)
Liocarcinus arcuatus (Leach, 1814)	Fam. GRAPSIDAE
Liocarcinus corrugatus (Pennant, 1777)	*Euchirograpsus liguricus* H. Milne Edwards, 1853
Liocarcinus depurator (Linnaeus, 1758)	

geographical and geomorphological characteristics: (1) Western Alborán Sea (WALB), from Gibraltar to Nerja; (2) Eastern Alborán Sea (EALB), from Nerja to Cape Gata; (3) Vera Gulf (VERA), from Cape Gata to Cape Palos; (4) Alacant (ALAC), from Cape Gata to Cape La Nao; (5) Eivissa Island (EIVI); (6) Valencia (VALE), from Cape La Nao to Castelló; (7) Ebro delta region (DELT), from Castelló to Tarragona, and (8) Northern Catalonia (NCAT), from Tarragona to Cape Creus (Fig. 1, Table 1). Sectors WALB, EALB, VERA, ALAC and EIVI are located in the Algerian Basin of the Western Mediterranean and receive a stronger Atlantic influence than the rest of sectors (VALE, DELT and NCAT), located in the Catalano-Balearic Sea and strongly influenced by the Liguro-Provençal-Catalan slope current.

In order to ascertain biogeographical similarities among geographical sectors, cluster analysis based on the faunistic composition resemblance between geographical sectors has been performed using Yule's coefficient as a similarity index and UPGMA (Unweighted Pair Group Method using Arithmetic Averages) aggregation algorithm. Yule's index has been chosen since it adequately summarizes presence/absence data in biogeographical analyses (Macpherson, 1991). Jackson *et al.* (1989) indicated that this index reduced the size-influence associated with frequency of occurrence. Yule's index was used because it adequately summarized the major groupings of samples (sectors). Identical groupings were obtained using Jaccard's similarity index. Species with less than three occurrences have been excluded from the analysis due to the little information afforded. Samples from the Eivissa Island sector have also been excluded due to the extreme scarceness of samples taken on the continental shelf in that sector (Table 2) which would preclude a proper analysis of the data. A resulting matrix of 92 species and seven geographical sectors encompassing the whole Iberian Peninsula Mediterranean coasts has been used in the analysis.

RESULTS

A total of 115 crustacean species was identified during the six studied cruises (Table 3), including 1 cirripede, 2 stomatopods, 1 mysid, 1 euphausiid, 1 isopod and 108 decapod crustacean species, including 12 Dendrobranchiata, 26 Caridea, 1 Stenopodidea, 1 Eryonidea, 4 Palinuridea, 2 Nephropidea, 2 Thalassinidea, 19 Anomura and 42 Brachyura.

Biogeographical analysis

The geographical sector with the highest species richness was the Ebro delta sector, with 82 species, followed by Eastern Alborán and Vera Gulf sectors, with 79 species each (Table 4). Eivissa Island was the sector with the fewest number of species, with 49 species recorded, but very few samples were obtained at depths shallower than 200 m (Table 2) and data were therefore not directly comparable. Alacant with 58 species was therefore the sector with the fewest recorded species.

The percentage occurrence of each species within each geographical sector (Table 4), allows the characterization of the geographical sector(s) in which a species was more frequently recorded. One main pattern was found, in which some

TABLE 4. – Percentage occurrence of the different species in the different geographical sectors. WALB: Western Alborán Sea; EALB: Eastern Alborán Sea; VERA: Vera Gulf; ALAC: Alacant; EIVI: Eivissa Island; VALE: Valencia; DELT: Ebro delta region; NCAT: Northern Catalonia. (See Fig. 1 for location of the geographical sectors).

					SECTOR				
SPECIES	WALB	EALB	VERA	ALAC	EIVI	VALE	DELT	NCAT	Occurrences
Acanthephyra eximia	0.0	25.0	25.0	0.0	0.0	0.0	0.0	50.0	4
Acanthephyra pelagica	18.8	18.8	12.5	6.3	6.3	18.8	0.0	18.8	16
Aegaeon cataphractus	0.0	7.7	1.9	24.5	0.0	30.2	20.8	13.2	52
Aegaeon lacazei	23.8	14.4	8.8	13.1	7.5	1.3	5.6	25.6	159
Alpheus glaber	20.9	12.3	5.5	12.9	3.7	9.2	11.0	24.5	163
Alpheus macrocheles	0.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	1
Alpheus platydactylus	25.0	50.0	25.0	0.0	0.0	0.0	0.0	0.0	4
Anapagurus bicorniger	20.0	0.0	20.0	0.0	0.0	0.0	20.0	40.0	5
Anapagurus laevis	0.0	33.3	0.0	0.0	0.0	33.3	0.0	33.3	3
Aristeomorpha foliacea	0.0	0.0	0.0	42.9	57.1	0.0	0.0	0.0	7
Aristeus antennatus	17.8	16.7	12.2	15.6	10.0	6.7	2.2	18.9	90
Atelecyclus rotundatus	20.0	20.0	6.7	6.7	0.0	6.7	0.0	40.0	15
Bathynectes maravigna	54.8	32.3	0.0	6.5	3.2	3.2	0.0	0.0	31
Calappa granulata	4.8	14.3	31.0	19.0	0.0	9.5	4.8	16.7	42
Calcinus tubularis	0.0	33.3	0.0	33.3	0.0	0.0	0.0	33.3	3
Calocarides coronatus	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2
Calocaris macandreae	19.8	10.5	2.3	10.5	16.3	2.3	3.5	34.9	86
Caridion steveni	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0	1
Chlorotocus crassicornis	16.0	9.3	10.7	29.3	4.0	10.7	2.7	17.3	75
Natatolana borealis	41.2	8.8	2.9	8.8	0.0	0.0	8.8	29.4	34
Cymonomus granulatus	50.0	50.0	0.0	0.0	0.0	0.0	0.0	0.0	2
Dardanus arrosor	21.8	14.5	7.6	15.3	0.0	5.8	16.0	18.9	275
Dardanus calidus	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	4
Dorhynchus thomsoni	22.2	44.4	0.0	0.0	33.3	0.0	0.0	0.0	9
Dromia personata	0.0	0.0	11.1	11.1	0.0	0.0	44.4	33.3	9
Ebalia cranchii	0.0	0.0	50.0	0.0	0.0	0.0	50.0	0.0	2
Ebalia nux	50.0	50.0	0.0	0.0	0.0	0.0	0.0	0.0	2
Ergasticus clouei	33.3	66.7	0.0	0.0	0.0	0.0	0.0	0.0	3
Ethusa mascarone	0.0	20.0	0.0	10.0	0.0	10.0	20.0	40.0	10
Euchirograpsus liguricus	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	1
Eurynome aspera	16.7	50.0	33.3	0.0	0.0	0.0	0.0	0.0	6
Funchalia woodwardi	0.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	3
Galathea dispersa	0.0	0.0	0.0	33.3	0.0	0.0	33.3	33.3	3
Galathea intermedia	20.0	10.0	0.0	20.0	0.0	0.0	30.0	20.0	10
Galathea nexa	0.0	0.0	50.0	50.0	0.0	0.0	0.0	0.0	2
Gennadas elegans	15.4	7.7	7.7	15.4	15.4	5.8	3.8	28.8	51
Geryon longipes	33.3	22.6	4.3	14.0	12.9	7.5	0.0	5.4	93
Goneplax rhomboides	22.0	8.5	4.0	9.6	2.3	10.2	16.4	27.1	177
Homarus gammarus	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0	1
Homola barbata	14.3	35.7	14.3	7.1	0.0	0.0	14.3	14.3	14
Hymenopenaeus debilis	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1
Inachus communissimus	7.7	23.1	0.0	15.4	0.0	7.7	23.1	23.1	13
Inachus dorsettensis	19.0	9.5	19.0	9.5	0.0	4.8	14.3	23.8	21
Inachus thoracicus	0.0	37.5	0.0	62.5	0.0	0.0	0.0	0.0	8
Latreillia elegans	0.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0	1
Ligur ensiferus	0.0	33.3	0.0	16.7	0.0	0.0	0.0	50.0	6
Liocarcinus arcuatus	0.0	33.3	33.3	0.0	0.0	0.0	0.0	33.3	3
Liocarcinus corrugatus	0.0	0.0	66.7	33.3	0.0	0.0	0.0	0.0	3
Liocarcinus depurator	16.2	5.2	2.9	21.4	0.6	12.4	22.5	18.8	346
Liocarcinus maculatus	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0	2
Lissa chiragra	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	1
Lophogaster typicus	30.6	10.2	14.3	14.3	8.2	2.0	8.2	12.2	49
Macropipus tuberculatus	10.9	5.8	10.2	21.2	6.6	3.6	24.8	16.8	136
Macropodia linaresi	0.0	33.3	0.0	66.7	0.0	0.0	0.0	0.0	3
Macropodia longipes	20.2	4.8	3.6	14.3	0.0	16.1	26.8	14.3	168
Macropodia rostrata	12.5	37.5	12.5	12.5	0.0	0.0	0.0	25.0	8
Maja crispata	0.0	33.3	0.0	0.0	0.0	0.0	0.0	66.7	3
Medorippe lanata	1.7	2.5	5.0	17.6	0.0	15.1	30.3	27.7	119
Meganyctiphanes norvegica	20.6	14.7	4.4	22.1	7.4	1.5	4.4	25.0	68
Monodaeus couchii	29.4	19.3	4.6	13.8	3.7	2.8	5.5	21.1	109
Munida intermedia	4.3	4.3	0.0	24.3	8.6	7.1	4.3	47.1	70
Munida rutllanti	13.8	2.1	14.9	33.0	9.6	5.3	20.2	1.1	93
Munida tenuimana	1.5	0.0	0.0	23.9	23.9	9.0	4.5	37.3	67
Nephrops norvegicus	16.1	11.8	2.5	21.1	9.9	5.0	9.3	24.2	161
Nepinnotheres pinnotheres	50.0	0.0	0.0	0.0	0.0	0.0	50.0	0.0	2
Paguristes eremita	0.0	9.1	0.0	21.2	0.0	0.0	48.5	21.2	33
Pagurus alatus	36.4	20.2	2.0	17.2	4.0	2.0	2.0	16.2	99
Pagurus anachoretus	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	1
Pagurus cuanensis	5.3	7.9	0.0	10.5	0.0	21.1	50.0	5.3	38

TABLE 4 (Cont.). – Percentage occurrence of the different species in the different geographical sectors. WALB: Western Alborán Sea; EALB: Eastern Alborán Sea; VERA: Vera Gulf; ALAC: Alacant; EIVI: Eivissa Island; VALE: Valencia; DELT: Ebro delta region; NCAT: Northern Catalonia. (See Fig. 1 for location of the geographical sectors).

					SECTOR				
SPECIES	WALB	EALB	VERA	ALAC	EIVI	VALE	DELT	NCAT	Occurrences
Pagurus excavatus	11.2	6.4	1.6	15.2	0.0	16.8	20.8	28.0	125
Pagurus forbesii	0.0	50.0	0.0	50.0	0.0	0.0	0.0	0.0	2
Pagurus prideaux	23.8	21.3	5.0	18.8	3.8	0.0	10.0	17.5	80
Palinurus elephas	0.0	16.7	16.7	16.7	0.0	33.3	0.0	16.7	6
Palinurus mauritanicus	0.0	25.0	50.0	0.0	0.0	0.0	0.0	25.0	4
Pandalina profunda	19.0	9.5	9.5	9.5	4.8	4.8	9.5	33.3	21
Parapenaeus longirostris	21.5	13.1	16.8	25.2	6.5	6.5	1.9	8.4	107
Paromola cuvieri	0.0	0.0	0.0	27.3	54.5	9.1	0.0	9.1	11
Parthenope angulifrons	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	3
Parthenope macrochelos	0.0	0.0	0.0	50.0	0.0	0.0	25.0	25.0	4
Parthenope massena	0.0	0.0	25.0	25.0	0.0	0.0	25.0	25.0	4
Pasiphaea multidentata	25.6	17.9	7.7	12.8	10.3	5.1	4.3	16.2	116
Pasiphaea sivado	33.1	14.2	8.7	14.2	5.5	1.6	5.5	17.3	127
Penaeopsis serrata	0.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	1
Melicertus kerathurus	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	1
Periclimenes granulatus	0.0	33.3	33.3	0.0	0.0	0.0	0.0	33.3	3
Philocheras echinulatus	35.1	17.5	5.3	12.3	12.3	1.8	1.8	14.0	57
Pilumnus spinifer	10.0	20.0	6.7	30.0	0.0	6.7	6.7	20.0	30
Pisa armata	0.0	58.3	16.7	16.7	0.0	0.0	0.0	8.3	12
Pisa nodipes	0.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0	1
Pisidia longicornis	16.7	12.5	4.2	16.7	0.0	12.5	8.3	29.2	24
Plesionika acanthonotus	23.7	18.4	8.8	17.5	11.4	5.3	2.6	12.3	113
Plesionika antigai	38.2	0.0	26.5	11.8	17.6	2.9	2.9	0.0	34
Plesionika edwardsii	14.8	18.0	18.0	32.8	4.9	6.6	4.9	0.0	60
Plesionika gigliolii	13.1	13.9	12.3	28.7	11.5	3.3	4.1	13.1	121
Plesionika heterocarpus	23.8	11.3	10.0	26.9	3.1	8.8	3.8	12.5	160
Plesionika martia	27.4	17.4	7.9	14.2	9.5	4.2	3.2	16.3	189
Plesionika narval	15.4	0.0	11.5	38.5	7.7	11.5	3.8	11.5	26
Polybius henslowi	88.9	11.1	0.0	0.0	0.0	0.0	0.0	0.0	9
Polycheles typhlops	26.6	13.7	2.2	15.8	11.5	5.0	3.6	21.6	139
Pontophilus norvegicus	0.0	0.0	0.0	0.0	25.0	50.0	0.0	25.0	4
Pontophilus spinosus	30.8	13.8	6.2	18.5	4.6	1.5	3.1	21.5	64
Processa canaliculata	23.5	12.8	6.7	19.5	7.4	2.0	4.7	23.5	148
Processa nouveli	20.0	20.9	12.7	12.7	5.5	1.8	7.3	19.1	109
Richardina fredericii	0.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	1
Rissoides pallidus	9.1	0.0	18.2	31.8	18.2	9.1	4.5	9.1	21
Rochinia carpenteri	69.6	30.4	0.0	0.0	0.0	0.0	0.0	0.0	46
Scalpellum scalpellum	0.0	0.0	0.0	0.0	0.0	0.0	25.0	75.0	4
Scyllarides latus	0.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0	1
Scyllarus arctus	50.0	0.0	0.0	0.0	0.0	0.0	0.0	50.0	2
Sergestes arachnipodus	5.4	2.7	8.1	21.6	18.9	0.0	8.1	35.1	37
Sergestes arcticus	25.2	12.2	6.5	14.4	10.1	2.9	5.8	23.0	138
Sergia robusta	28.2	17.6	9.9	14.5	9.9	4.6	3.1	12.2	130
Solenocera membranacea	28.4	16.6	9.0	12.8	5.2	4.3	5.7	18.0	210
Squilla mantis	7.5	1.5	0.0	16.4	0.0	29.9	43.3	1.5	67
Xantho granulicarpus	0.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	1
Number of samples	96	61	111	34	26	104	55	111	
Number of species present	71	79	79	58	49	67	82	68	

species were only recorded in the westernmost geographical sectors - western and eastern Alborán Sea and Vera Gulf (Alborán Sea) - and were absent from the rest of Mediterranean sectors sampled (Northwest Mediterranean). This group of species, exclusive from the Alborán Sea, was mainly formed by the crabs *Rochinia carpenteri, Polybius henslowi, Ergasticus clouei* and *Eurynome aspera*, and by the benthic caridean shrimp *Alpheus platydactylus*. Some other, occasional species, such as the solenocerid shrimp *Hymenopenaeus debilis,* the axiid shrimp *Calocarides coronatus*, or the crabs *Cymonomus granulatus*, *Ebalia nux* and *Euchirograpsus liguricus,*

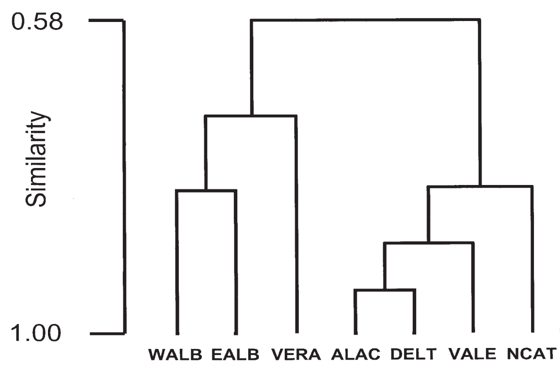

FIG. 2. – Dendrogram of similarities among geographical sectors based on their faunistic resemblance using Yule's similarity index and the UPGMA aggregation algorithm. WALB: Western Alborán Sea; EALB: Eastern Alborán Sea; VERA: Vera Gulf; ALAC: Alacant; EIVI: Eivissa Island; VALE: Valencia; DELT: Ebro delta region; NCAT: Northern Catalonia.

TABLE 5. – Depth range, mean depth of occurrence, and percentage occurrence of each species within each depth interval. Species are presented in alphabetical order.

SPECIES	Depth Min	Depth Max	Mean	Depth stratum 1-50	51-100	101-150	151-200	201-300	301-400	401-500	501-600	601-700	701-800	Occurrences
Acanthephyra eximia	421	704	601.4	0.0	0.0	0.0	0.0	0.0	0.0	2.3	0.0	5.3	4.8	4
Acanthephyra pelagica	506	798	697.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.2	10.5	47.6	16
Aegaeon cataphractus	26	90	63.0	25.0	20.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	52
Aegaeon lacazei	43	775	423.2	3.6	0.5	8.4	25.9	45.7	75.0	79.5	55.6	50.0	19.0	159
Alpheus glaber	33	704	286.4	12.5	20.9	18.1	22.2	31.4	77.3	50.0	36.5	13.2	4.8	163
Alpheus macrocheles	51	54	52.5	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1
Alpheus platydactylus	120	791	569.5	0.0	0.0	1.2	0.0	0.0	0.0	0.0	0.0	2.6	9.5	4
Anapagurus bicorniger	33	123	58.9	7.1	0.0	1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5
Anapagurus laevis	55	81	70.5	0.0	1.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3
Aristeomorpha foliacea	453	600	527.0	0.0	0.0	0.0	0.0	0.0	0.0	4.5	7.9	0.0	0.0	7
Aristeus antennatus	414	798	618.7	0.0	0.0	0.0	0.0	0.0	0.0	18.2	52.4	76.3	95.2	90
Atelecyclus rotundatus	25	123	53.6	17.9	1.6	2.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	15
Bathynectes maravigna	241	790	573.0	0.0	0.0	0.0	0.0	2.9	2.3	4.5	23.8	21.1	19.0	31
Calappa granulata	25	712	187.6	16.1	7.0	3.6	14.8	5.7	11.4	4.5	4.8	0.0	4.8	42
Calcinus tubularis	26	78	49.8	3.6	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3
Calocarides coronatus	553	760	658.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.6	0.0	4.8	2
Calocaris macandreae	316	775	545.2	0.0	0.0	0.0	0.0	0.0	15.9	47.7	54.0	47.4	28.6	86
Caridion steveni	96	98	97.0	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1
Chlorotocus crassicornis	80	526	270.7	0.0	1.6	12.0	25.9	57.1	63.6	13.6	1.6	0.0	0.0	75
Natatolana borealis	235	720	492.7	0.0	0.0	0.0	0.0	2.9	11.4	22.7	22.2	7.9	4.8	34
Cymonomus granulatus	562	621	592.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.6	2.6	0.0	2
Dardanus arrosor	25	698	165.8	76.8	57.2	42.2	48.1	51.4	68.2	38.6	12.7	10.5	0.0	275
Dardanus calidus	25	28	26.4	7.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4
Dorhynchus thomsoni	447	754	609.0	0.0	0.0	0.0	0.0	0.0	0.0	2.3	4.8	7.9	9.5	9
Dromia personata	25	110	62.6	7.1	1.6	2.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9
Ebalia cranchii	58	187	123.0	0.0	0.5	0.0	3.7	0.0	0.0	0.0	0.0	0.0	0.0	2
Ebalia nux	519	563	538.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.2	0.0	0.0	2
Ergasticus clouei	475	661	565.0	0.0	0.0	0.0	0.0	0.0	0.0	2.3	1.6	2.6	0.0	3
Ethusa mascarone	25	53	37.8	16.1	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10
Euchirograpsus liguricus	620	621	620.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.6	0.0	1
Eurynome aspera	52	124	86.6	0.0	1.6	3.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6
Funchalia woodwardi	587	730	636.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.2	0.0	4.8	3
Galathea dispersa	80	97	89.7	0.0	1.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3
Galathea intermedia	33	82	53.4	10.7	2.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10
Galathea nexa	51	86	67.0	0.0	1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2
Gennadas elegans	400	790	590.0	0.0	0.0	0.0	0.0	0.0	0.0	13.6	39.7	34.2	33.3	51
Geryon longipes	335	798	616.4	0.0	0.0	0.0	0.0	0.0	2.3	6.8	65.1	76.3	90.5	93
Goneplax rhomboides	29	671	245.0	44.6	25.7	18.1	14.8	25.7	61.4	52.3	31.7	15.8	0.0	177
Homarus gammarus	36	39	37.5	1.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1
Homola barbata	43	621	176.0	3.6	1.6	6.0	3.7	0.0	2.3	2.3	0.0	2.6	0.0	14
Hymenopenaeus debilis	668	679	673.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.6	0.0	1
Inachus communissimus	25	89	45.2	19.6	1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	13
Inachus dorsettensis	26	244	96.9	3.6	6.4	6.0	3.7	2.9	0.0	0.0	0.0	0.0	0.0	21
Inachus thoracicus	40	93	59.3	7.1	2.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8
Latreillia elegans	158	160	159.0	0.0	0.0	0.0	3.7	0.0	0.0	0.0	0.0	0.0	0.0	1
Ligur ensiferus	400	680	490.6	0.0	0.0	0.0	0.0	0.0	0.0	9.1	1.6	2.6	0.0	6
Liocarcinus arcuatus	25	82	51.7	3.6	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3
Liocarcinus corrugatus	44	54	47.8	3.6	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3
Liocarcinus depurator	25	740	158.5	64.3	82.9	63.9	59.3	68.6	75.0	38.6	11.1	7.9	9.5	346
Liocarcinus maculatus	33	43	38.3	3.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2
Lissa chiragra	26	28	27.0	1.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1
Lophogaster typicus	94	535	316.8	0.0	0.5	6.0	11.1	22.9	45.5	22.7	3.2	0.0	0.0	49
Macropipus tuberculatus	53	679	276.9	0.0	10.2	26.5	29.6	71.4	72.7	45.5	11.1	7.9	0.0	136
Macropodia linaresi	47	88	63.7	1.8	1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3
Macropodia longipes	38	640	134.5	16.1	47.6	42.2	40.7	22.9	20.5	6.8	3.2	5.3	0.0	168
Macropodia rostrata	26	190	62.0	8.9	1.1	0.0	3.7	0.0	0.0	0.0	0.0	0.0	0.0	8
Maja crispata	25	49	32.5	5.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3
Medorippe lanata	26	651	104.2	53.6	35.3	10.8	7.4	5.7	9.1	9.1	1.6	2.6	0.0	119
Meganyctiphanes norvegica	75	780	406.8	0.0	0.5	0.0	7.4	34.3	43.2	36.4	20.6	7.9	9.5	68
Monodaeus couchii	44	760	465.9	1.8	1.6	6.0	0.0	20.0	38.6	47.7	54.0	39.5	28.6	109
Munida intermedia	118	641	379.3	0.0	0.0	3.6	7.4	31.4	50.0	52.3	12.7	2.6	0.0	70
Munida rutllanti	40	587	260.8	1.8	4.3	22.9	29.6	68.6	40.9	20.5	9.5	0.0	0.0	93
Munida tenuimana	286	798	551.6	0.0	0.0	0.0	0.0	2.9	4.5	45.5	46.0	18.4	38.1	67
Nephrops norvegicus	58	740	423.9	0.0	3.2	6.0	3.7	34.3	81.8	100.0	77.8	15.8	9.5	161
Nepinnotheres pinnotheres	43	83	63.5	1.8	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2
Paguristes eremita	25	139	52.8	37.5	5.3	2.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	33
Pagurus alatus	187	791	574.4	0.0	0.0	0.0	3.7	0.0	11.4	31.8	55.6	81.6	61.9	99
Pagurus anachoretus	27	27	27.0	1.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1
Pagurus cuanensis	26	139	71.7	19.6	13.4	2.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	38

TABLE 5 (Cont.). – Depth range, mean depth of occurrence, and percentage occurrence of each species within each depth interval. Species are presented in alphabetical order.

SPECIES	Depth Min	Max	Mean	Depth stratum 1-50	51-100	101-150	151-200	201-300	301-400	401-500	501-600	601-700	701-800	Occurrences
Pagurus excavatus	26	378	92.1	41.1	36.9	26.5	22.2	5.7	6.8	0.0	0.0	0.0	0.0	125
Pagurus forbesii	40	49	43.5	3.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2
Pagurus prideaux	25	515	112.4	42.9	16.0	15.7	18.5	0.0	9.1	6.8	1.6	0.0	0.0	80
Palinurus elephas	41	78	61.8	1.8	2.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6
Palinurus mauritanicus	304	510	368.9	0.0	0.0	0.0	0.0	0.0	6.8	0.0	1.6	0.0	0.0	4
Pandalina profunda	238	605	404.2	0.0	0.0	0.0	0.0	8.6	15.9	15.9	4.8	2.6	0.0	21
Parapenaeus longirostris	64	588	249.7	0.0	7.0	15.7	59.3	74.3	63.6	22.7	1.6	0.0	0.0	107
Paromola cuvieri	452	747	595.6	0.0	0.0	0.0	0.0	0.0	0.0	2.3	9.5	5.3	9.5	11
Parthenope angulifrons	25	27	25.8	5.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3
Parthenope macrochelos	80	453	193.4	0.0	0.5	2.4	0.0	0.0	0.0	2.3	0.0	0.0	0.0	4
Parthenope massena	26	123	72.3	3.6	0.5	1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4
Pasiphaea multidentata	235	798	591.3	0.0	0.0	0.0	0.0	2.9	2.3	34.1	77.8	81.6	90.5	116
Pasiphaea sivado	138	735	425.0	0.0	0.0	1.2	11.1	40.0	81.8	81.8	36.5	31.6	9.5	127
Penaeopsis serrata	469	469	469.0	0.0	0.0	0.0	0.0	0.0	0.0	2.3	0.0	0.0	0.0	1
Melicertus kerathurus	80	80	80.0	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1
Periclimenes granulatus	309	342	331.7	0.0	0.0	0.0	0.0	0.0	6.8	0.0	0.0	0.0	0.0	3
Philocheras echinulatus	114	676	381.9	0.0	0.0	2.4	0.0	20.0	50.0	40.9	11.1	2.6	0.0	57
Pilumnus spinifer	25	188	54.7	30.4	5.9	1.2	3.7	0.0	0.0	0.0	0.0	0.0	0.0	30
Pisa armata	27	146	62.7	8.9	2.7	2.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12
Pisa nodipes	44	46	45.0	1.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1
Pisidia longicornis	25	80	47.8	25.0	5.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	24
Plesionika acanthonotus	421	798	604.9	0.0	0.0	0.0	0.0	0.0	0.0	22.7	81.0	86.8	90.5	113
Plesionika antigai	98	477	241.3	0.0	0.5	6.0	25.9	40.0	11.4	4.5	0.0	0.0	0.0	34
Plesionika edwardsii	166	632	376.9	0.0	0.0	0.0	3.7	34.3	47.7	45.5	7.9	2.6	0.0	60
Plesionika gigliolii	235	681	428.5	0.0	0.0	0.0	0.0	45.7	75.0	81.8	49.2	13.2	0.0	121
Plesionika heterocarpus	45	468	222.0	3.6	8.6	49.4	88.9	85.7	79.5	27.3	0.0	0.0	0.0	160
Plesionika martia	267	798	538.5	0.0	0.0	0.0	0.0	8.6	50.0	97.7	100.0	97.4	100.0	189
Plesionika narval	64	403	248.7	0.0	1.1	4.8	11.1	22.9	18.2	2.3	0.0	0.0	0.0	26
Polybius henslowi	43	629	321.2	1.8	1.1	0.0	0.0	2.9	4.5	0.0	3.2	2.6	0.0	9
Polycheles typhlops	241	798	577.1	0.0	0.0	0.0	0.0	11.4	6.8	45.5	92.1	86.8	100.0	139
Pontophilus norvegicus	682	798	737.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.6	14.3	4
Pontophilus spinosus	69	663	300.8	0.0	4.3	6.0	11.1	28.6	52.3	25.0	4.8	2.6	0.0	64
Processa canaliculata	63	723	429.0	0.0	1.1	3.6	11.1	42.9	75.0	86.4	66.7	28.9	4.8	148
Processa nouveli	72	610	401.8	0.0	1.1	3.6	3.7	42.9	61.4	63.6	52.4	0.0	0.0	109
Richardina fredericii	545	545	545.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.6	0.0	0.0	1
Rissoides pallidus	117	523	365.0	0.0	0.0	1.2	7.4	2.9	13.6	22.7	1.6	0.0	0.0	21
Rochinia carpenteri	132	791	584.4	0.0	0.0	1.2	3.7	2.9	4.5	4.5	19.0	50.0	38.1	46
Scalpellum scalpellum	80	607	240.0	0.0	1.1	0.0	3.7	0.0	0.0	0.0	1.6	0.0	0.0	4
Scyllarides latus	46	46	46.0	1.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1
Scyllarus arctus	26	367	196.5	1.8	0.0	0.0	0.0	0.0	2.3	0.0	0.0	0.0	0.0	2
Sergestes arachnipodus	279	620	484.6	0.0	0.0	0.0	0.0	5.7	13.6	20.5	28.6	5.3	0.0	37
Sergestes arcticus	160	798	495.0	0.0	0.0	0.0	3.7	11.4	59.1	81.8	71.4	47.4	38.1	138
Sergia robusta	309	798	589.7	0.0	0.0	0.0	0.0	0.0	4.5	40.9	87.3	92.1	95.2	130
Solenocera membranacea	43	790	386.4	3.6	13.4	10.8	14.8	54.3	93.2	86.4	76.2	57.9	9.5	210
Squilla mantis	26	367	62.9	50.0	18.2	4.8	0.0	0.0	2.3	0.0	0.0	0.0	0.0	67
Xantho granulicarpus	51	54	52.5	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1
Number of samples/stratum				56	187	83	27	35	44	44	63	38	21	

also belonged to this group of species. Other species, such as the portunid crab *Bathynectes maravigna*, were mainly, but not exclusively, recorded in this area. Conversely, rather common species in other sectors, such as the squat lobster *Munida tenuimana* or the crab *Medorippe lanata*, were very scarcely recorded in the westernmost geographical sectors, or not recorded at all, like the crangonid shrimp *Pontophilus norvegicus* or the crab *Paromola cuvieri*.

The peculiar faunistic characteristics of the Alborán Sea are further emphasized by the cluster analysis performed among geographical sectors based on the resemblance obtained with the qualitative Yule's index, which is based on presence/absence analysis of the species by geographical sector (Fig. 2). By using this approach, two main groups of geographical sectors were clearly obtained: one, in which the two Alborán Sea sectors, plus Vera Gulf, are grouped together (Alborán Sea cluster), and the other, which encompassed the rest of geographical sectors north of Palos Cape: Alacant, Valencia, Delta and northern Catalonia (Northwestern Mediterranean cluster). Identical groupings were obtained using Jaccard's similarity index.

Bathymetrical patterns of occurrence

The overall depth range, mean depth of occurrence and the percentage occurrence of each species within each depth stratum are presented in Table 5. This table provides detailed information on the depth strata in which each species was most frequently found throughout the study area. Thus, for example, the portunid crab *Macropipus tuberculatus* was present in over 70% of the samples taken between 200 and 400 m; the species showed decreasing occurrence values at depths shallower and deeper than these strata, reaching zero values at the shallowest and deepest. As another example, the red shrimp *Aristeus antennatus* clearly showed an increasing occurrence with depth, being absent at depths shallower than 400 m and reaching occurrences of 95.2% within the deepest sampled stratum (700-800 m).

From these data, information on the commonest species within each depth stratum can be obtained (Table 6). Thus, very few species were commonly found on the continental shelf bottoms, which were mainly dominated by the portunid crab *Liocarcinus depurator* and the hermit crab *Dardanus arrosor*. Caridean and penaeid shrimps, such as *Plesionika heterocarpus* and *Parapenaeus longirostris*, together with the portunid crabs *Liocarcinus depurator* and *Macropipus tuberculatus*, were the commonest species on the upper slope bottoms between 150 and 300 m. A large number of species with high occurrence values was present in the 300-400 m depth interval, in which nektobenthic and benthopelagic shrimps such as *Solenocera membranacea* and *Pasiphaea sivado*, together with the burrowing benthic lobster *Nephrops norvegicus*, were the most characteristic species. At depths of over 400 m, the nektobenthic shrimp *Plesionika martia* was the species most frequently occurring in the hauls; other deep-sea species, such as the benthic polychelid lobster *Polycheles typhlops*, the bathypelagic shrimp *Sergia robusta,* or the nektobenthic shrimp *Plesionika acanthonotus,* were also present with high occurrence values. Species such as the red shrimp *Aristeus antennatus*, the crab *Geryon longipes*, the benthopelagic shrimp *Pasiphaea multidentata* and the hermit crab *Pagurus alatus*, clearly increased their percentage occurrence towards the deepest strata.

Differences between the depth occurrence patterns among the different large groups of decapod crustaceans are clearly apparent when analysing the depth distribution range and the mean depth of occurrence of each species within each taxonomic group.

Dendrobranchiate shrimps (Fig. 3A) are species clearly living on the middle slope bottoms (400-800 m), with only three, out of twelve, species present on the continental shelf; two of those, however, *Parapenaeus longirostris* and *Solenocera membranacea*, presented their mean depth of occurrence in the upper slope (200-400 m). Some species, such as *P. longirostris, S. membranacea* or *Sergestes arcticus* presented large bathymetrical occurrence depth ranges.

Most caridean shrimps (Fig. 3A) showed large occurrence depth ranges and were clearly continental slope dwelling species, both in the upper (approx. 200-500 m) and in the middle slope (>500 m). Only three species (two of them occasional) presented their mean depth of occurrence on the continental shelf, of which the commonest was the crangonid *Aegaeon cataphractus*. It is worth noting the large number of pandalid and crangonid species occurring throughout the study area which often show a marked interspecific bathymetrical segregation that can be more clearly observed when analysing their percentage occurrence by depth strata (Table 5).

Anomuran crabs (hermit crabs and squat lobsters) presented a shallow continental shelf distribution (Fig. 3B). Only one species of hermit crab (*Pagurus alatus*) and occasional specimens of *Dardanus arrosor* and *Pagurus prideaux* were present on the middle continental slope, at depths of over 400 m. Three species of the genus *Munida* were present on the continental slope, with a rather marked bathymetrical segregation between them: *M. rutllanti, M. intermedia* and *M. tenuimana*.

Brachyuran crabs (Fig. 3C) are also a typical group of species on the continental shelf. Most of the species recorded in the current surveys presented their mean depth of occurrence within the continental shelf, some of the commonest being, for example, *Atelecyclus rotundatus, Pilumnus spinifer* or *Inachus dorsettensis*. Some species had their mean depth of occurrence on the continental shelf but were also rather commonly found on the upper slope and sometimes in the middle, such as *Medorippe lanata*, *Macropodia longipes*, *Liocarcinus depurator*, *Homola barbata* or *Calappa granulata*. A few species presented their mean depth of occurrence on the middle slope but were rather commonly found on the shelf and sometimes on the upper slope, such as *Goneplax rhomboides* and

TABLE 6. – Species whose percentage occurrence within each depth stratum is larger than 50%.

000-050 m Species	%occ	050-100 m Species	%occ	100-150 m Species	%occ	150-200 m Species	%occ	200-300 m Species	%occ
Dardanus arrosor	76.8	*Liocarcinus depurator*	82.9	*Liocarcinus depurator*	63.9	*Plesionika heterocarpus*	88.9	*Plesionika heterocarpus*	85.7
Liocarcinus depurator	64.3	*Dardanus arrosor*	57.2			*Liocarcinus depurator*	59.3	*Parapenaeus longirostris*	74.3
Medorippe lanata	53.6					*Parapenaeus longirostris*	59.3	*Macropipus tuberculatus*	71.4
Squilla mantis	50.0							*Liocarcinus depurator*	68.6
								Munida rutllanti	68.6
								Chlorotocus crassicornis	57.1
								Solenocera membranacea	54.3
								Dardanus arrosor	51.4

300-400 m Species	%occ	400-500 m Species	%occ	500-600 m Species	%occ	600-700 m Species	%occ	700-800 m Species	%occ
Solenocera membranacea	93.2	*Nephrops norvegicus*	100.0	*Plesionika martia*	100.0	*Plesionika martia*	97.4	*Plesionika martia*	100.0
Pasiphaea sivado	81.8	*Plesionika martia*	97.7	*Polycheles typhlops*	92.1	*Sergia robusta*	92.1	*Polycheles typhlops*	100.0
Nephrops norvegicus	81.8	*Solenocera membranacea*	86.4	*Sergia robusta*	87.3	*Polycheles typhlops*	86.8	*Sergia robusta*	95.2
Plesionika heterocarpus	79.5	*Processa canaliculata*	86.4	*Plesionika acanthonotus*	81.0	*Plesionika acanthonotus*	86.8	*Aristeus antennatus*	95.2
Alpheus glaber	77.3	*Pasiphaea sivado*	81.8	*Nephrops norvegicus*	77.8	*Pasiphaea multidentata*	81.6	*Plesionika acanthonotus*	90.5
Liocarcinus depurator	75.0	*Plesionika gigliolii*	81.8	*Pasiphaea multidentata*	77.8	*Pagurus alatus*	81.6	*Pasiphaea multidentata*	90.5
Aegaeon lacazei	75.0	*Sergestes arcticus*	81.8	*Solenocera membranacea*	76.2	*Geryon longipes*	76.3	*Geryon longipes*	90.5
Plesionika gigliolii	75.0	*Aegaeon lacazei*	79.5	*Sergestes arcticus*	71.4	*Aristeus antennatus*	76.3	*Pagurus alatus*	61.9
Processa canaliculata	75.0	*Processa nouveli*	63.6	*Processa canaliculata*	66.7	*Solenocera membranacea*	57.9		
Macropipus tuberculatus	72.7	*Goneplax rhomboides*	52.3	*Geryon longipes*	65.1	*Aegaeon lacazei*	50.0		
Dardanus arrosor	68.2	*Munida intermedia*	52.3	*Aegaeon lacazei*	55.6	*Rochinia carpenteri*	50.0		
Parapenaeus longirostris	63.6	*Alpheus glaber*	50.0	*Pagurus alatus*	55.6				
Chlorotocus crassicornis	63.6			*Monodaeus couchii*	54.0				
Processa nouveli	61.4			*Calocaris macandreae*	54.0				
Goneplax rhomboides	61.4			*Processa nouveli*	52.4				
Sergestes arcticus	59.1			*Aristeus antennatus*	52.4				
Pontophilus spinosus	52.3								
Munida intermedia	50.0								
Philocheras echinulatus	50.0								
Plesionika martia	50.0								

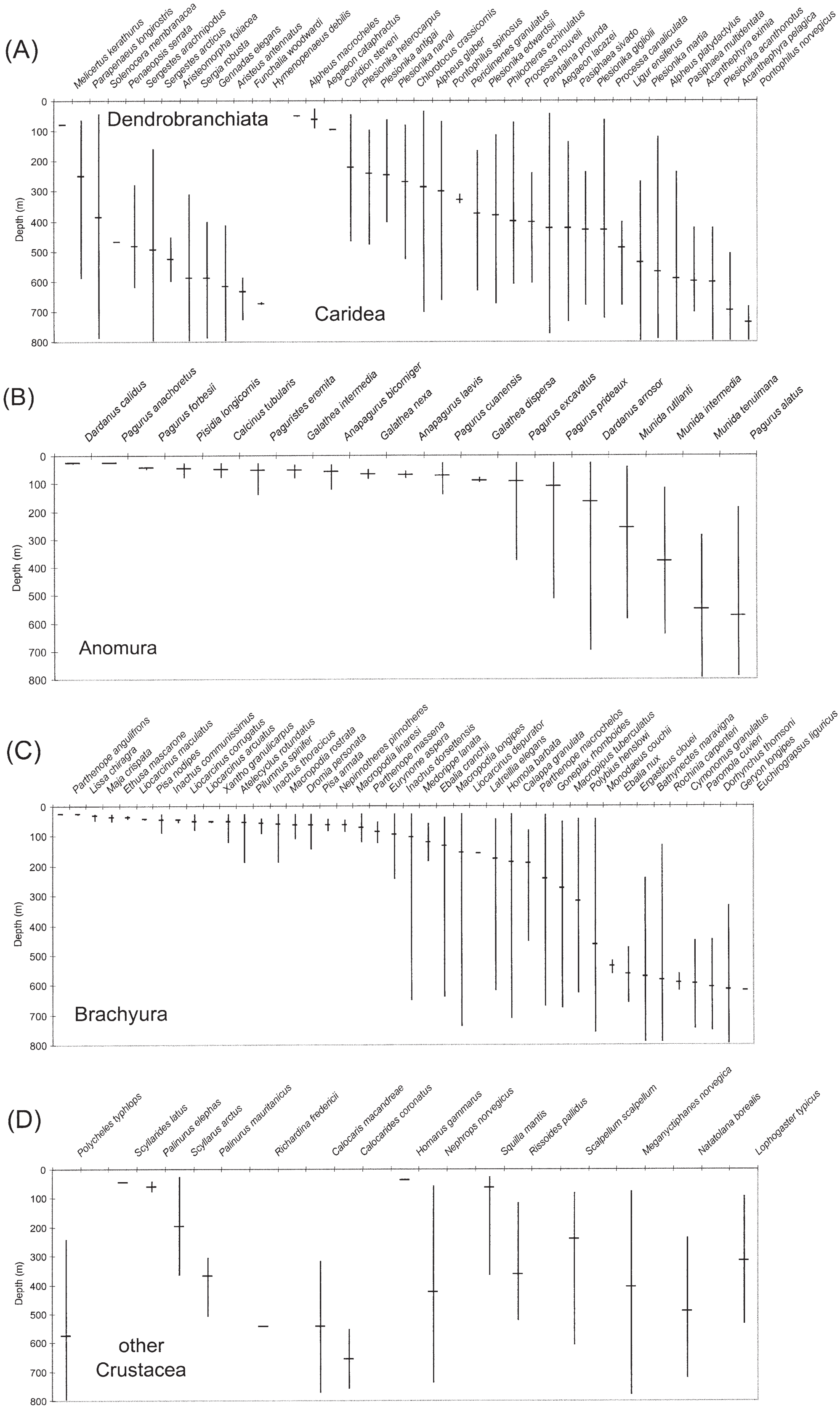

FIG. 3. – Bathymetric distribution of the crustaceans collected during the MEDITS trawl surveys performed along the Iberian Peninsula Mediterranean coasts, ranked according to their mean depth of occurrence. (A) Dendrobranchiata and Caridea; (B) Anomura; (C) Brachyura; (D) Other Crustacea groups.

Macropipus tuberculatus or the benthopelagic crab *Polybius henslowi* whose distribution was restricted to the Alborán Sea. *Monodaeus couchi* was rather common throughout the middle and upper slope, but presented also some occurrences on the continental shelf. A few species appeared as characteristic of the middle slope, at depths of over 500 m, of which the commonest were *Geryon longipes*, *Dorhynchus thomsoni* and *Paromola cuvieri*. Some of these deep-sea species presented their distribution area exclusively (or almost exclusively) restricted to the Alborán Sea geographical sector, such as *Ergasticus clouei*, *Bathynectes maravigna*, *Rochinia carpenteri*, *Cymonomus granulatus* and *Euchirograpsus liguricus*.

Other crustacean taxonomic groups (Fig. 3D) presented a much smaller number of species. Thus, eryoneid polychelid lobsters were only represented by *Polycheles typhlops*, present in the middle and, sometimes, upper slope. Palinurid lobsters appeared scarcely, the commonest species being *Palinurus elephas* on the continental shelf and *Palinurus mauritanicus* on the slope. Stenopodid shrimps (*Richardina fredericii*) were only recorded once in the middle slope. The commonest thalassinid shrimp was *Calocaris macandreae*, frequently recorded on the slope. Nephropid lobsters were mainly represented by *Nephrops norvegicus*, recorded on the upper continental slope, with some occurrences on the shelf. Stomatopods were represented by *Squilla mantis* on the shelf, and by *Rissoides pallidus* on the upper slope. Other crustacean groups appeared more scarcely in the samples.

DISCUSSION

The detailed analysis of the patterns of occurrence of epibenthic and benthic crustaceans on the Mediterranean coasts of the Iberian Peninsula has allowed proper delineation of the bathymetric distribution range of the commonest species, as well as provided valuable information on scarcer species. Also, the wide geographical range of the samples studied, of well over a thousand km (from the Straits of Gibraltar in the south-west to Cape Creus in the north-east), has objectively delimited broad biogeographical boundaries along the regional sectors studied. The actual faunistical composition of the Mediterranean Sea is a product of its geological oceanographical changes, and, given the characteristics of it being a semi-enclosed sea with rather different oceanographic characteristics from those of the neighbouring Atlantic Ocean, has favoured speciation in many decapod families (Zariquiey-Álvarez, 1968; Almaça, 1985a,b, 1988; Pérès, 1985).

Thus, one of the most relevant findings of the present study has been the identification of the Alborán Sea as a biogeographically distinct unit which can be separated from the rest of the analysed western Mediterranean sectors by a boundary, or biotone, around Palos Cape. The western and eastern Alborán Sea, together with Vera Gulf, share a number of geomorphological and oceanographic characteristics, namely the virtual absence of a continental shelf and the strong influence of the Atlantic currents entering the Mediterranean through the Straits of Gibraltar on the upper levels of the water column, and of the Mediterranean waters exiting the basin into the Atlantic at the deeper levels (Hopkins, 1985; Millot, 1987; García-Ladona *et al.*, 1996). The well-documented stable presence of the Almería-Orán hydrographical front (Millot, 1987, 1999; Font *et al.*, 1998) undoubtedly contributes to the biogeographical differentiation between the two identified areas, one southwest of Palos Cape, characterized by the occurrence of species with strong Atlantic affinities (i.e. *Rochinia carpenteri, Polybius henslowi, Ergasticus clouei, Bathynectes maravigna*, etc.), and the other northeast of that area. The present results provide, therefore, strong evidence for the Alborán Sea to be considered a distinct separate management unit when dealing with demersal fisheries from an ecosystem point of view (Caddy, 1998).

The particular geomorphological and associated oceanographical characteristics of the Alborán Sea make this region a distinct transition zone between Mediterranean and Atlantic faunas. The overlap area between the three classical marine biogeographical regions of the northeastern Atlantic (Mauritanian, Lusitanian and Mediterranean) is found in the Alborán Sea. According to Pérès and Picard (1964), this region is characterised by the rarity or absence of certain Mediterranean endemisms and by the presence of Atlantic species that are not found in other Mediterranean regions. The Alborán Sea basin has been previously identified as a region of great biogeographical importance in several faunistic groups, such as sponges (Templado *et al*., 1986; Maldonado, 1992; Boury-Esnault *et al*., 1994; Maldonado and Uriz, 1995; Pansini, 1996), bryozoans (Harmelin and D'Hondt, 1993), pycnogonids (Stock, 1987) or hydrozoans (Medel and López-González, 1996). Bouchet and Taviani (1992), working on marine gastropods, established the hypothesis of Atlantic species establishing pseudopopulations, non-able to succesfully reproduce, in the Mediterranean basins. Harmelin and D'Hondt (1993) also stated that several endemic Atlantic bryozoan species or morphotypes can live in conditions of typical Mediterranean water (high temperature and salinity) but do not spread beyond the eastern limits of either the Gibraltar Straits or the Alborán Sea. Concerning decapod crustaceans, García-Raso (1984, 1996) reported that the Alborán Sea fauna showed a higher similarity with that of the northern Ibero-Moroccan Bay, suggesting an influence of the Mediterranean outflow on the benthic fauna. Additionally, several deep-sea decapod species with epipelagic larvae able to overcome the Gibraltar sill with the inflowing surface currents have only been reported to date in the westernmost basin of the Mediterranean Sea (i.e. the Alborán Sea region), such as *Penaeopsis serrata* or *Hymenopenaeus debilis* (Abelló and Torres, 1998; Cartes *et al.*, 2000).

In addition to bathymetrical boundaries, which constitute the most evident results arising from crustacean faunistic assemblages studied at small geographical scales (e.g. Abelló *et al.*, 1988; Cartes, 1993; Cartes and Sardà, 1993; Cartes *et al.*, 1994; Haedrich *et al.*, 1975, 1980; Ungaro *et al.*, 1999), large-scale geographical and latitudinal boundaries have been identified in a much fewer number of studies on distribution data (e.g. Mas-Riera *et al.*, 1990; Macpherson, 1991; Williams *et al.*, 2001). Indeed, important faunistic differences, dealing mainly with different relative abundance composition of both faunistic groups and feeding guilds, have been identified in the western Mediterranean at scales of a few hundreds of km (Moranta *et al.*, 1998; Maynou and Cartes, 2000). On the other hand, seasonality may also affect the faunistic composition and structure of demersal assemblages (e.g. Wenner and Wenner, 1989; Demestre *et al.*, 2000), although given the limited temporal characteristics of the analysed trawl surveys this aspect cannot be analysed with the present data.

In agreement with previous faunistic studies restricted to the Catalano-Balearic Sea, the northernmost part of the Iberian Peninsula Mediterranean (Abelló and Valladares, 1988; Abelló *et al.*, 1988; Cartes, 1993; Cartes and Sardà, 1993; Cartes *et al.*, 1994), the present results have shown that brachyuran crabs constitute the Infraorder of decapod crustaceans with the highest species richness along the coasts of the Iberian western Mediterranean, followed by caridean shrimps and anomuran crabs. Notwithstanding, neither of those species constitute an important fraction of commercial catches in the western Mediterranean and many of them are discarded. Only a few crab and pandalid shrimp species are commercialized and hardly ever constitute the target species of any fishery (with the exception of *Plesionika edwardsi*, for which a targeted pot fishery takes place (García-Rodríguez *et al.*, 2000)). The important target crustaceans in the Mediterranean belong to the Dendrobranchiata suborder, a decapod crustacean group that is not represented by many species in the Mediterranean (the coastal penaeid *Melicertus kerathurus* and the deep water shrimps *Aristeus antennatus*, *Aristeomorpha foliacea* and *Parapenaeus longirostris*), together with *Nephrops norvegicus* which belongs to the infraorder Nephropidea, with only two species occurring in the Mediterranean.

Concerning the depth distribution of the species, the present results support and expand the findings reported by several authors from the Catalano-Balearic Sea (e.g. Abelló *et al.,*1988; Cartes, 1993; Cartes and Sardà, 1992, 1993; Cartes *et al.*, 1993; Maynou and Cartes, 2000). Previously published data based on trawl surveys were practically missing from the Alborán Sea and the southern part of the Catalano-Balearic basin (Gil de Sola, 1993; García-Raso, 1996).

Some interesting bathymetrical distribution features can be identified from present data (Table 5), such as the occurrence in several benthic species, mainly with burrowing or burying habits, of clear bimodal peaks of occurrence, one clearly on the continental shelf at depths shallower than 100-150 m, and another on the continental slope at depths of 300-500 m, clearly avoiding the shelf-slope break. Species showing this bimodal depth distribution patterns are some crabs such as *Goneplax rhomboides*, *Medorippe lanata*, *Monodaeus couchii*, or the Norway lobster *Nephrops norvegicus*. To a lesser extent, this pattern is also shown by the crabs *Liocarcinus depurator* and *Calappa granulata*, and by the hermit crabs *Dardanus arrosor* and *Pagurus prideaux*.

Phylogenetical constraints on distribution characteristics can also be debated based on the differential patterns presented by the several large groups of decapods present in the study area (Fig. 3). Thus, dendrobranchiate shrimps thrive in deep water in the middle continental slope, deeper than 400 m, and are very scarce on the continental shelf. Caridean shrimps, mainly species with nektobenthic habits, are also clearly inhabitants of the continental slope, usually shallower than dendrobranchiate shrimps. Several species are found on the upper slope, between 200-400 m, but very few still occur on the continental shelf. Hermit crabs are clearly a shallow continental shelf group of species, with only two to three species being present on the upper and middle slope. Squat lobsters present two groups of species, with *Galathea* species present on the shallow continental shelf and *Munida* species on the upper and middle slope. It is worth remarking the common occurrence of *Munida rutllanti* in the studied samples, taken in the decade of the 1990's, in contrast with the scarceness reported by other authors in previous decades (Sardà and Palomera, 1981; Abelló *et al.*, 1988). Brachyuran crabs are also clearly a shallow continental shelf group of species, with some of them occupying the upper continental slope; the middle slope is characterized by a distinct grouping of crab species, most of them very scarce.

As a concluding remark, it is worth noting that trawl surveys, as exemplified by present results, can be very useful, not only to study the distribution and recruitment patterns and population characteristics of the target species of a fishery, but also to establish, from an ecological and biodiversity point of view, the geographical areas and depth strata sharing common characteristics which could therefore be managed under common policy rules (Caddy, 1998). Detailed studies on biodiversity characteristics, faunal assemblages and autoecology of non-commercial, but important species in the food webs, can also be performed and be useful for appropriate and sustainable management.

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