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Local changes in the composition and community structure of suprabenthic peracarid crustaceans on the bathyal Mediterranean: influence of environmental factors

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Abstract Deep-water assemblages of suprabenthic peracarids were analyzed in the SW Balearic Islands (Algerian Basin, southwestern Mediterranean) between 249 and 1,622 m depth; the patterns of species composition, possible zonation, and trophic structure found in this area were compared with those exhibited by peracarids in the mainland side of the Catalan Sea slope (northwestern Mediterranean). One hundred and four peracarid species (plus one leptostracan) were identified on the Balearic Islands slope, amphipods being the most diversified taxon (45 species). On the Balearic slope, two distinct depth assemblages were distinguished: one at the upper slope (US), between 249 and 402 m depth and the second at the deep slope, between 543 and 1,620 m depth. A remarkable species substitution occurred at depths between 402 and 638 m. In the Catalan Sea, in addition to the US assemblage occupying depths between 208 and 408 m, a second boundary of faunal change was found around 1,250 m. Suprabenthos biomass increased from 242 to approximately 500 m. Suprabenthos attained the highest biomass values (100 g wet weight/10,000 m²) at intermediate depths between 504 and 1,211 m, as also occurred with the associated zooplankton collected with suprabenthos (peak biomass between 502 m and 898 m). Suprabenthos biomass did not show any significant correlation with any environmental water-column variable. In contrast, zooplankton (especially small fish and decapod

crustaceans) showed a significant positive correlation with fluorometry and turbidity at different levels of the water column. The feeding guilds of species showed important differences between the two areas only on the US, with a higher abundance of deposit feeders in the Catalan Sea (20.4%) than in the Balearic Islands (4.2%). The low contribution of deposit feeders in the SW Balearic Islands may ultimately be a consequence of the lack of river discharges in this area.

Introduction

Most studies dealing with the organization of deep-sea communities focus only on the megafauna fraction, especially fish, which represents the dominant taxon. The establishment of depth-related patterns of diversity and the delimitation of boundaries between communities has been the main goals of most of these studies (Rowe and Menzies 1969; Haedrich et al. 1980; Smith and Hamilton 1983; Haedrich and Merrett 1990; Cartes and Sardà 1993; Stefanescu et al. 1993). However, due to sampling and taxonomic constraints, small macrofauna has been generally neglected. For instance, in a station situated at 2,100 m depth in the North Atlantic, only 6.5% of the estimated existent species were identified (Smith et al. 1998).

Faunal turnover along depth gradients depends on the taxa considered (Haedrich et al. 1980; Rowe et al. 1982; Gage 1986). It may be more apparent in the case of higher trophic levels, e.g. food selecting species such as croppers or predators, than in infaunal deposit feeders, e.g. polychaetes (see Gage and Tyler 1991). Therefore, studies focusing on macrofaunal assemblages belonging to trophic levels other than megafauna could contribute to our more complete understanding of the organization of deep-sea communities.

Peracarid crustaceans are a dominant faunal component of the vagile macrofauna (the called suprabenthos or hyperbenthos) in deep-sea assemblages, being a

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key taxon linking lower trophic levels with top predators such as fish (Cattrijsse et al. 1994; Cartes 1998; Carrasón and Cartes 2002). There is some information available on the bathymetric distribution (Reyss 1971; Bellan-Santini 1985, 1990; Ledoyer 1987; Cartes and Sorbe 1993), and on the assemblage composition of deep peracarids (Dickinson 1978; Dickinson and Carey 1978; Brandt 1997). However, the study of the relationships between community structure and environmental gradients such as depth, or food supply (e.g. bottom type, surface phytoplankton pigment concentration) has rarely been attempted (Brandt 1995, 1997), and the results obtained remain often inconclusive (Watts et al. 1992; Thurston and Bett 1993).

Boundaries for invertebrate faunal changes have been described in bathyal and abyssal depths. In general, though with important local variations, a faunal renewal between upper and middle slope mega-invertebrate assemblages appears recurrently between 300 and 700 m depth (Haedrich et al. 1980). A similar faunal turnover occurs at approximately 500 m depth in the deep Catalan sea (northwestern Mediterranean) (Abelló et al. 1988; Cartes et al. 1994). In addition, the occurrence of a second boundary between 1,000 and 1,400 m has been established elsewhere (Wenner and Boesch 1979; Haedrich et al. 1980; Gage 1986; Hecker 1990; Cartes and Sardà 1993; Gage et al. 2000). In the deep Mediterranean, it separates the middle and the lower slope assemblages (Cartes and Sardà 1993). Changes in assemblage composition with depth have been poorly documented both in deep-sea peracarids and in suprabenthos in general (Rowe and Menzies 1969; Rex 1977; Bellan-Santini 1985, 1990; Elizalde et al. 1991; Dauvin and Sorbe 1995; Cartes and Sorbe 1997). In the deep-bathyal Mediterranean, a decrease in species richness below 1,300 m has been reported to occur in amphipod assemblages (Cartes and Sorbe 1998). This seems in accord to the community change cited as occurring around 1,000 m depth in peracarid taxocoenoses of the same area (Ledoyer 1987; Bellan-Santini 1990). In the Catalan Sea, deep-water peracarid crustacean assemblages have been extensively studied regarding their depth distribution, dominant species, and diversity patterns related to depth (Cartes and Sorbe 1993, 1998). However, studies trying to relate changes in suprabenthic assemblages with environmental variables that could explain possible zonation patterns are almost nonexistent.

Two oceanographic cruises were carried out on the SW slope of the Balearic Promontory, off Formentera (northern Algerian Basin, southwestern Mediterranean) (Fig. 1). This is an open sea area placed far away from the mainland, differing markedly in primary production and sediment granulometry from the Catalan Sea reference area, approximately 350 km to the north and showing terrigenous influences. One of the goals of these cruises was to compare the species composition, zonation, and trophic structure patterns exhibited by deep communities of the SW Balearic slope with those

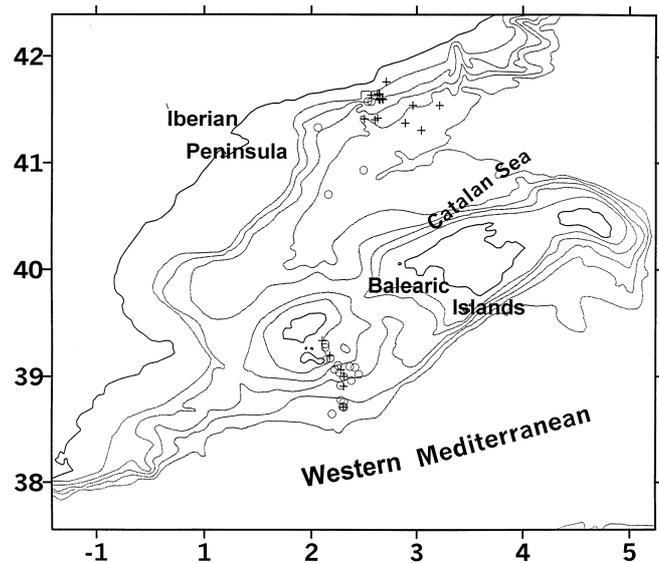


Fig. 1 Map of the study area with indications of samples collected in the SW Balearic Islands and in the Catalan Sea. Plus signs (+) Macer-GIROQ samples, circles (O) samples obtained with plankton nets attached to a bottom trawl

of the Catalan Sea. The latter area has been studied extensively regarding the depth distribution, dominant species, and diversity patterns related to depth of suprabenthic peracarids (Cartes and Sorbe 1993, 1998). The objectives of this paper were: (1) to relate the suprabenthos distribution to some environmental variables; and (2) to compare, at a local or sub-regional spatial scale, the species composition, zonation, and trophic structure patterns exhibited by peracarid assemblage in the Balearic Islands and in the Catalan Sea.

Materials and methods

Suprabenthos-zooplankton sampling

Two oceanographic cruises (Q1 in October 1996 and Q2 in May 1998) were carried out in the SW Balearic Islands (Algerian Basin, southwestern Mediterranean) (Fig. 1).

Suprabenthos-zooplankton were collected with a Macer-GIROQ sledge and with a net attached to a bottom trawl. During Q1, a Macer-GIROQ sledge was used. This gear, with three superimposed nets (500 μ m mesh size) of 40 \times 80 cm rectangular mouth aperture (for a detailed description of the gear, see Cartes et al. 1994), is equipped with a mechanical system that closes off the nets when the sledge does not contact the sea floor. The gear samples the near-bottom water column up to 1.5 m above the bottom. The area sampled by the sledge during each haul was calculated from the towed distance measured by flowmeters placed at the mouth of the nets. Additional details on the sampling method have been published elsewhere (Cartes et al. 1994). Additional semi-quantitative samples of suprabenthos-zooplankton were gathered during Q1 and Q2 using a net (40 \times 60 cm mouth aperture, 500 μ m mesh size) attached to a bottom trawl (see Cartes and Sorbe 1993).

Eighteen suprabenthos-zooplankton samples were taken (six with the Macer-GIROQ sledge and 12 with the attached net) in the SW Balearic Islands. Although the initial sampling schedule included the entire depth range 249–1,622 m (see Map, Fig. 1 and

details in Cartes et al. 2001), in practice some gaps remained, namely at the depth intervals 268–384 m, 402–543 m, 694–802 m, 900–1,015 m, 1,049–1,204 m, and 1,204–1,503 m.

Specimens were immediately fixed in buffered formaldehyde. Peracarids (excluding Hyperiidæ) were identified to the lowest possible taxonomic level and counted. A data matrix composed of species and samplings was built.

Wet weight (WW) (g) was measured at Order level for the four dominant peracarid taxa (Mysidacea, Amphipoda, Isopoda, and Cumacea). WW was also obtained for the whole suprabenthos compartment, including, in addition to peracarids, taxa detailed in Cartes et al. (2001). Also, and for comparative purposes, WW was measured for zooplankton, both considering total biomass and biomass for the dominant taxa of Euphausiacea, Decapoda Natantia (mainly Sergestidae), and Pisces (e.g. *Cyclothone* spp.) collected simultaneously with suprabenthos.

Environmental variables

Two conductivity-temperature-depth (CTD) transects, one per cruise, were completed using a Seabird-25 profiler furnished with a Seatech fluorometer and a transmissometer. Thirteen CTD profiles (five for Q1 and eight for Q2) on or close to 13 of the 18 supra-benthos-zooplankton stations were performed. In each profile we measured the following parameters: surface temperature and salinity, fluorometry, and light transmission (Lt). Data were treated as in Cartes et al. (2001). Fluorometry data considered in the analyses were composites for each station determined by summing up the values obtained at each 1-m interval of the water column. Lt, which is the inverse of turbidity, was determined at each station using three distinct estimates: (1) Lt recorded from surface to 180 m depth, where the signal from the sensor often stabilized close to a (low) constant value; (2) Lt recorded from surface to the sea floor; and (3) Lt recorded at the first 50 m above the sea floor. In both cruises, the position of the CTD profiles was approximately coincident with the corresponding suprabenthos-zooplankton sampling site.

Data treatment

Identification of possible boundaries where faunal turnover occurs, i.e. zonation patterns, was performed by analyzing the cumulative appearance and disappearance of species of the main peracarid taxa (mysids, amphipods, isopods and cumaceans) along the entire depth range. Data on abundance of peracarids used to identify the main assemblages were further analyzed by clustering analysis. Based on the correlation matrix generated by clustering, multi-dimensional scaling (MDS) was applied. Species appearing less than twice in all samples, and one sample where only two supra-benthic species were collected, were removed from data matrices. The similarity index used in both cluster and MDS ordination was $(1-r)$, where r is Pearson's correlation coefficient. The aggregation algorithm was the unweighted-paired group method average. MDS dimensions were correlated to environmental variables that were determined simultaneously (depth, fluorometry, and Lt) in order to establish possible relationships between an assemblage's structure and existing environmental gradients.

Finally, we searched for correlations between biomass ($\text{g}/10,000 \text{ m}^2$) per taxon and environmental variables (fluorometry, Lt, salinity and temperature). We standardized the biomass collected with plankton nets by multiplying the distance trawled by the net mouth aperture ($40 \times 60 \text{ cm}$). This rough estimate allowed us to combine the sledge and net samples to construct depth-biomass profiles. The distance trawled was exactly determined using a SCANMAR system attached to the bottom trawl (Maynou and Cartes 2000). In addition to the biomass of peracarids (permanent suprabenthos), we also considered the biomass of macroplankton—decapod crustaceans, fish and euphausiids—for comparative purposes.

Comparisons with the Catalan Sea area

In order to establish comparisons we used only those samples from the Catalan Sea series (Cartes and Sorbe 1993; Cartes et al. 1994, 2001) coincident in season and depth range with those of the SW Balearic slope (May and October), namely SP89-P89 (16 October 1989, 20 October 1989 and 21 October 1989, five plankton net samples), R1 (25 April 1991, three sledge samples), R2 (9 December 1991, five sledge samples), BT1 (22 March 1994, one sledge at 1,859 m), Pr96 (13 October 1996 and 28 October 1996, four sledge samples) and BBC2 (23 September 1998, 5 sledge samples; see Fig. 1). As occurred with the Balearic slope sampling, several sampling gaps remained in the Catalan area. The broader ones, exceeding 100 m depth, were 208–402 m, 644–862 m, 989–1,258 m, 1,355–1,478 m, and 1,645–1,772 m.

Comparisons between both areas were performed with respect to: (1) zonation patterns (boundaries where faunal turnover occurs); (2) dominant species (abundance, number of specimens per $1,000 \text{ m}^2$); and (3) feeding guilds based on previous feeding studies performed for the dominant peracarids in the Catalan Sea (Cartes et al. 2002). Among peracarids, meiofaunal predatory species, filter feeders and deposit-feeders were recognized, suggesting the existence of more than one trophic level in the suprabenthos compartment.

Zonation patterns in the Catalan Sea were also analyzed by cluster analysis and MDS using the same distance and aggregation algorithm as in the SW Balearic slope analysis. Abundances (number of specimens per $1,000 \text{ m}^2$) of the dominant species were determined for three different depth zones (upper, middle, and lower slope). Comparison of dominant species and feeding guilds was mainly based on the quantitative Macer-GIROQ sledge samplings, combined with net sampling with species richness similar to that found using sledges. This resulted in 12 samples for the SW Balearic slope (six of them sledge samples) and 22 for the Catalan Sea (18 sledge samples). The percentage of deposit feeders, and three different measures of diversity (species richness, Shannon's diversity index using $\log_2(H)$ and dominance using the Simpson index) were calculated by depth zones and areas.

Results

SW Balearic Islands

Faunistic composition

A total of 4,853 specimens of peracarid crustaceans (Hyperiidæ excluded) pertaining to 104 species (plus one Leptostracan) were collected in the Balearic slope (Table 1). Gammaridean amphipods were the most diversified taxon (45 species) followed by cumaceans (24), isopods (18) and mysids (16). Only one species of tanaidacean and one of leptostracan were collected. Twelve species had not been collected previously in the Catalan Sea area (three mysids: *Leptomysis megalops*, *Siriella norvegica* and *Parerythrotraps lobiancoi*; five amphipods: *Iphimedia obesa*, *Acidostoma sarsi*, *Lepidocreum subclypeatum*, *Podoprion bolivari*, *Sophrrosyne hispana*, and *Stegocephaloides christianensis*; and three cumaceans: *Campylaspis verrucosa*, *Mesolamprops denticulatus* and *Makrokyllindrus gibraltarensis*).

Biomass distribution versus depth

Suprabenthos and zooplankton biomass followed a similar pattern (Fig. 2), with the highest values

Table 1 Crustaceans (Peracarida plus Leptostraca) collected in the SW Balearic Islands

| | <i>n</i> ^a | Frequency (%) ^b | Depth range (m) |
|---|-----------------------|----------------------------|-----------------|
| Mysidacea | | | |
| <i>Anchialina agilis</i> G.O. Sars, 1877 | 6 | 8.3 | 249 |
| <i>Gastrosaccus lobatus</i> Nouvel, 1951 | 430 | 16.7 | 249–402 |
| <i>Boreomysis arctica</i> (Kröyer, 1861) | 1030 | 75.0 | 601–1624 |
| <i>Boreomysis megalops</i> G.O. Sars, 1872 | 11 | 16.7 | 249–402 |
| <i>Calyptomma puritani</i> Tattersall, 1909 | 137 | 50.0 | 601–1594 |
| <i>Dactylamblyops</i> sp. | 7 | 33.3 | 802–1594 |
| <i>Erythroops neapolitana</i> Colosi, 1929 | 30 | 50.0 | 601–1624 |
| <i>Eucopia hanseni</i> (W.-Suhm, 1875) | 4 | 8.3 | 601–603 |
| <i>Hemimysis</i> sp. (D) | 10 | 41.7 | 601–1594 |
| <i>Leptomysis</i> cf. <i>gracilis</i> (G.O. Sars, 1864) | 1 | 8.3 | 249 |
| <i>Leptomysis megalops</i> Zimmer, 1915 ^c | 1 | 8.3 | 249 |
| <i>Paramblyops rostrata</i> Holt and Tattersall, 1905 | 10 | 41.7 | 601–1594 |
| <i>Parapseudomma callophura</i> (Holt and Tattersall, 1905) | 14 | 16.7 | 601–1204 |
| <i>Parerythroops lobiancoi</i> W. Tattersall, 1909 ^c | 77 | 41.7 | 617–1594 |
| <i>Pseudomma</i> sp. (D) | 10 | 25.0 | 601–1204 |
| <i>Siriella norvegica</i> G.O. Sars, 1869 ^c | 1 | 8.3 | 249 |
| Amphipoda Gammaridea | | | |
| <i>Acidostoma sarsi</i> Lincoln, 1979 ^c | 1 | 8.3 | 1586–1594 |
| <i>Ampelisca</i> sp. | 1 | 8.3 | 1586–1594 |
| <i>Andaniexis mimonectes</i> Ruffo, 1975 | 146 | 58.3 | 398–1594 |
| <i>Arrhis mediterraneus</i> Ledoyer, 1983 | 21 | 41.7 | 398–1594 |
| <i>Bathymedon acutifrons</i> Bonnier, 1896 | 10 | 33.3 | 601–1594 |
| <i>Bathymedon banyulsensis</i> Ledoyer, 1983 | 35 | 33.3 | 601–1204 |
| <i>Bathymedon monoculodiformis</i> Ledoyer, 1983 | 4 | 16.7 | 802–900 |
| <i>Bruzelia typica</i> Boeck, 1871 | 36 | 50.0 | 398–1594 |
| <i>Epimeria parasitica</i> G.O. Sars, 1858 | 3 | 25.0 | 249–1204 |
| <i>Eusirus leptocarpus</i> G.O. Sars, 1895 | 15 | 33.3 | 398–1594 |
| <i>Eusirus longipes</i> Boeck, 1861 | 9 | 41.7 | 601–1594 |
| Gammaridea unid. (D) | 7 | 16.7 | 1015–1594 |
| <i>Harpinia dellavallei</i> Chevreux, 1910 | 3 | 16.7 | 398–804 |
| <i>Harpinia</i> sp. (D) | 1 | 8.3 | 1015–1049 |
| <i>Halice abyssii</i> Boeck, 1871 | 39 | 41.7 | 601–1594 |
| <i>Halicoides anomala</i> Walker, 1896 | 5 | 16.7 | 601–804 |
| <i>Idumella pirata</i> Krapp-Schickel, 1975 | 2 | 8.3 | 1204 |
| <i>Ilerastroe ilergetes</i> (J.L. Barnard, 1964) | 110 | 58.3 | 601–1594 |
| <i>Iphimedia obesa</i> Rathke, 1843 ^c | 1 | 8.3 | 1204 |
| <i>Lepechinella manco</i> Barnard, 1973 | 4 | 16.7 | 896–1049 |
| <i>Lepidocreum subclypeatum</i> Ruffo and Schiecke, 1977 ^c | 1 | 8.3 | 802–804 |
| <i>Leucothoe lilljeborgi</i> Boeck, 1861 | 1 | 8.3 | 398–402 |
| Lysianassidae indet. | 12 | 33.3 | 601–1049 |
| <i>Monoculodes packardii</i> Boeck, 1871 | 9 | 33.3 | 617–1594 |
| <i>Nicippe tumida</i> Bruzelius, 1859 | 1 | 8.3 | 601–603 |
| <i>Oediceropsis brevicornis</i> Lilljeborg, 1865 | 11 | 50.0 | 398–1594 |
| <i>Oediceroides pilosus</i> Ledoyer, 1983 | 39 | 33.3 | 896–1594 |
| Oedicerotidae (D) | 15 | 41.7 | 398–1594 |
| <i>Orchomenella nana</i> (Kroyer, 1846) | 21 | 25.0 | 398–1204 |
| <i>Pardalisca mediterranea</i> Bellan-Santini, 1985 | 18 | 41.7 | 802–1594 |
| <i>Podoprion bolivari</i> Chevreux, 1891 ^c | 1 | 8.3 | 802–804 |
| <i>Pseudotiron bouvieri</i> Chevreux, 1895 | 44 | 41.7 | 617–1594 |
| <i>Rhachotropis caeca</i> Ledoyer, 1977 | 708 | 83.3 | 398–1594 |
| <i>Rhachotropis</i> cf. <i>gracilis</i> Bonnier, 1896 | 4 | 16.7 | 802–1204 |
| <i>Rhachotropis grimaldii</i> (Chevreux, 1888) | 6 | 25.0 | 601–1204 |
| <i>Rhachotropis integricauda</i> Carausu, 1948 | 1 | 8.3 | 398–402 |
| <i>Rhachotropis rostrata</i> Bonnier, 1896 | 35 | 41.7 | 601–1594 |
| <i>Scopelocheirus hopei</i> (A. Costa, 1851) | 32 | 33.3 | 294–804 |
| <i>Sophrosyne hispana</i> (Chevreux, 1888) ^c | 1 | 8.3 | 802–804 |
| <i>Stegocephaloides christianensis</i> (Boeck, 1871) ^c | 1 | 8.3 | 802–804 |
| <i>Synchelidium maculatum</i> Stebbing, 1906 | 6 | 25.0 | 398–804 |
| <i>Syrrhoe affinis</i> Chevreux, 1908 | 2 | 8.3 | 1015–1049 |
| <i>Syrrhoites pusilla</i> Enequist, 1949 | 1 | 8.3 | 896–900 |
| <i>Bathymedon longirostris</i> Jaume, Cartes and Sorbe, 1998 | 225 | 58.3 | 398–1594 |
| <i>Tmetonyx similis</i> (G.O. Sars, 1891) | 4 | 25.0 | 601–1204 |
| <i>Tryphosella</i> cf. <i>longidactyla</i> Ruffo, 1985 | 6 | 8.3 | 1204 |
| <i>Trischizostoma nicaeense</i> (A. Costa, 1855) | 1 | 8.3 | 398–402 |
| <i>Tryphosites alleni</i> Sexton, 1911 | 5 | 16.7 | 802–900 |
| <i>Tryphosites longipes</i> (Bate and Westwood, 1861) | 2 | 8.3 | 802–804 |

Table 1 (Contd.)

| | <i>n</i> ^a | Frequency (%) ^b | Depth range (m) |
|---|-----------------------|----------------------------|-----------------|
| Isopoda | | | |
| Anthuridae (D) | 1 | 8.3 | 1024 |
| <i>Belonectes parvus</i> (Bonnier, 1856) | 43 | 33.3 | 601–1594 |
| <i>Chelator chelatus</i> Stephensen, 1915 | 8 | 33.3 | 398–1594 |
| Desmosomatidae indet. | 1 | 8.3 | 398–402 |
| <i>Desmosoma lineare</i> (G.O. Sars, 1859) | 2 | 8.3 | 802–804 |
| <i>Disconectes cf. furcata</i> (G.O. Sars, 1864) | 3 | 16.7 | 802–1204 |
| <i>Disconectes latirostris</i> (G.O. Sars, 1864) | 2 | 16.7 | 802–900 |
| <i>Disconectes phallangium</i> (G.O. Sars, 1864) | 33 | 33.3 | 398–1594 |
| <i>Pseudogorda</i> sp. | 3 | 33.3 | 249–900 |
| Eurycopidae sp. A | 147 | 58.3 | 398–1594 |
| <i>Eurydice grimaldii</i> Dollfus, 1888 | 1 | 8.3 | 1620–1624 |
| <i>Gnathia</i> sp. (larvae) | 120 | 58.3 | 249–1594 |
| <i>Ilyarachna calidus</i> George and Menzies, 1968 | 13 | 33.3 | 1204–1624 |
| <i>Ilyarachna longicornis</i> (G.O. Sars, 1864) | 138 | 58.3 | 617–1594 |
| <i>Ilyarachna sekhari</i> George and Menzies, 1968 | 4 | 25.0 | 802–1594 |
| <i>Ischnomesus bispinosum</i> G.O. Sars, 1865 | 4 | 33.3 | 601–1594 |
| <i>Janirella</i> sp. | 21 | 25.0 | 802–1204 |
| <i>Munnopsurus atlanticus</i> (Bonnier, 1896) | 330 | 83.3 | 398–1624 |
| <i>Natatolana borealis</i> (Lilljeborg, 1851) | 4 | 25.0 | 398–1204 |
| Tanaidacea | | | |
| <i>Apseudes spinosus</i> (M. Sars, 1858) | 5 | 33.3 | 802–1204 |
| Cumacea | | | |
| <i>Bathycuma brevisrostris</i> (Norman, 1879) | 62 | 25.0 | 802–1594 |
| <i>Campylaspis glabra</i> G.O. Sars, 1878 | 30 | 41.7 | 617–1594 |
| <i>Campylaspis horridoides</i> Stephensen, 1915 | 10 | 25.0 | 1024–1594 |
| <i>Campylaspis sulcata</i> G.O. Sars, 1870 | 1 | 8.3 | 398–402 |
| <i>Campylaspis vitrea</i> Calman, 1906 | 13 | 25.0 | 896–1594 |
| <i>Campylaspis verrucosa</i> G.O. Sars, 1866 ^c | 3 | 16.7 | 601–804 |
| <i>Cumella gracillima</i> Calman, 1905 | 3 | 16.7 | 802–1024 |
| <i>Cumellopsis puritani</i> Calman, 1906 | 12 | 33.3 | 601–1594 |
| <i>Cyclaspis longicaudata</i> G.O. Sars, 1865 | 8 | 16.7 | 1204–1594 |
| <i>Diatylis jonesi</i> Reyss, 1972 | 87 | 58.3 | 617–1594 |
| <i>Diatyloides serrata</i> (G.O. Sars, 1865) | 1 | 8.3 | 1586–1594 |
| <i>Eudorella truncatula</i> (Bate, 1856) | 1 | 8.3 | 398–402 |
| <i>Hemilamprops</i> sp. | 10 | 33.3 | 601–1594 |
| <i>Mesolamprops denticulatus</i> Ledoyer, 1983 ^c | 1 | 8.3 | 398–402 |
| <i>Leptostylis macrura</i> (D) G.O. Sars, 1870 | 1 | 8.3 | 398–402 |
| <i>Leucon affinis</i> Fage, 1951 | 8 | 16.7 | 802–900 |
| <i>Leucon macrorhinus</i> Fage, 1951 | 3 | 8.3 | 896–900 |
| <i>Leucon profundus</i> Hansen, 1920 | 1 | 8.3 | 1204 |
| <i>Leucon cf. tener</i> Hansen, 1920 | 5 | 8.3 | 1586–1594 |
| <i>Makrokylindrus</i> sp. | 1 | 8.3 | 802–804 |
| <i>Makrokylindrus gibraltarensis</i> (Bacescu, 1961) ^c | 1 | 8.3 | 802–804 |
| <i>Makrokylindrus longipes</i> (G.O. Sars, 1871) | 12 | 25.0 | 1204–1594 |
| <i>Platysympus typicus</i> (G.O. Sars, 1870) | 88 | 41.7 | 802–1594 |
| <i>Procampylaspis bonnieri</i> Calman, 1906 | 80 | 33.3 | 896–1594 |
| <i>Procampylaspis armata</i> Bonnier, 1896 | 24 | 41.7 | 601–1594 |
| <i>Procampylaspis</i> sp. (D) | 61 | 58.3 | 601–1594 |
| Nebaliacea | | | |
| <i>Sarsinebalia typhlops</i> (Sars, 1870) | 2 | 16.7 | 601–804 |

^aNumber of specimens^bPercentage frequency of occurrence^cSpecies not collected previously in the Catalan Sea (Cartes and Sorbe 1993, 1997)

attained at intermediate depths (between 504 and 1,211 m for suprabenthos and between 502 and 898 m for zooplankton). Total biomass increased going from 242 m to 402–502 m, reaching values of 100 g WW/10,000 m². Highest values were attained between 502 and 898 m, with peaks of 146.6 g WW/10,000 m². Biomass decreased with depth beneath 898 m to reach the lowest value of 26.7 g WW/10,000 m² at 1,709 m.

Faunal turnover with depth

Several boundaries of faunal renewal arose in the cumulative curves of appearance/disappearance of species with depth (Fig. 3). Mysids were the most abundant peracarid taxon in the depth range studied, showing the highest rate of species appearance between 543 and 638 m, while species disappearance with depth was hardly noticeable. Amphipods, the most diversified

peracarid taxon, showed a sharp increase in species appearance between 402 and 601 m, and a more progressive appearance of new species with depth thereafter.

On the other hand, species disappeared rather gradually with depth, showing a sharp decrease in species number only at the 802–896 m depth interval. Isopods also increased in number of species between 402 and 638 m, but isopod species did not show any sharp decrease along the entire depth gradient. Cumaceans showed a sharp appearance in our samples between 402 and 638 m, with a gradual increase in species with depth thereafter. Hence, the bathymetric range between 402 and 638 m was the only range where a remarkable turnover of species occurred in the four main peracarid taxa considered in this study.

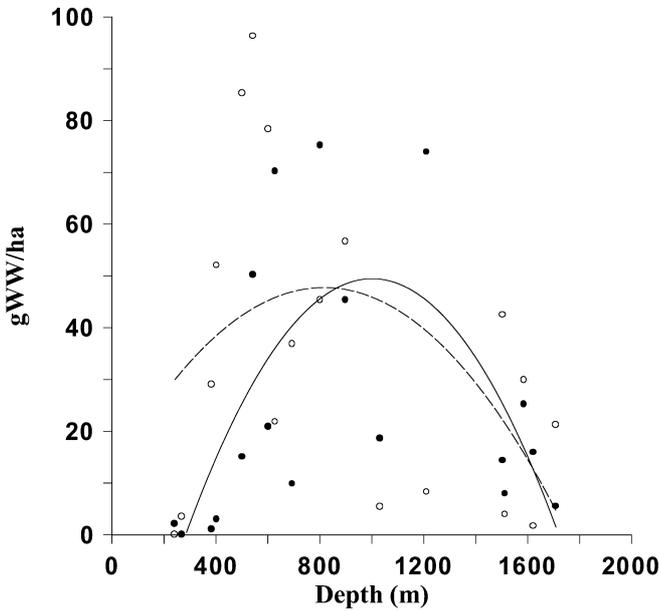


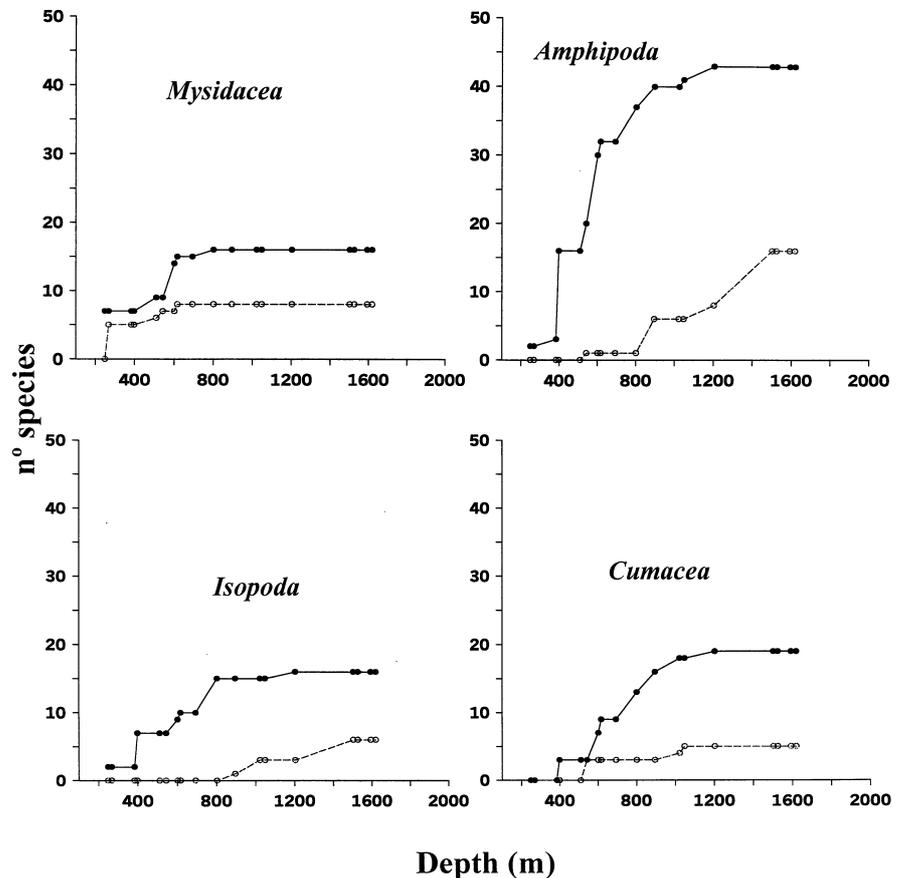
Fig. 2 Biomass profiles combining October 1996 and May 1998 cruises from the SW Balearic Islands. *Open circles* (○) zooplankton biomass, *solid circles* (●) suprabenthos biomass. Lines are degree-2 polynomial functions deduced from data

Environmental variables

Our CTD casts confirmed the thermal and saline stability of the deep Mediterranean below approximately 200 m; temperature ranged between 13.0 and 13.5°C, and salinity between 38.3 and 38.5 ppt in all stations from 200 m to the bottom. In stations sampled for suprabenthos/zooplankton, slight oscillations of surface temperature (20.8–21.1°C in October and 17.1–17.3°C in May), and salinity (37.3–37.8 ppt in October and 36.8–37.1 ppt in May) were recorded. Lower values of temperature 20.8–20.9°C were recorded in mid-oceanic waters (at stations 540–1,200 m depth) in October.

None of the 14 stations considered in this study (coincident with those where suprabenthos/zooplankton

Fig. 3 Faunal renewal. *Solid circles* (●) cumulative appearance, *open circles* (○) disappearance of species with depth in the SW Balearic Islands



were sampled) presented any bathymetric trend in fluorometer readings (voltage); maximum values were detected in profiles at the 242–268 m and 694–898 m depth intervals. Both Lt(0–180 m) and Lt (50 m above bottom) were always higher at intermediate depths (between 384 and 900 m) either in October or May. Lt(all water column) increased with depth (due to decreased particle concentration) in October. Both Lt(all water column) and Lt(50m above bottom) were positively correlated with depth (Table 2).

Results of cluster and MDS analysis

Cluster analysis (Fig. 4) evidenced two differentiated groups of samples: (1) an upper slope assemblage (US) comprising four hauls taken between 249 and 402 m depth; and (2) a deep-slope assemblage comprising the rest of hauls, taken between 543 and 1,620 m depth. Similarity between both groups was very low (r close to zero). Dimension 1 (D1) of the MDS analysis was significantly correlated with depth (Spearman $r = -0.710$, $P = 0.0014$; Pearson $r = -0.704$, $P = 0.0016$), and with the number of species per haul (Spearman $r = -0.503$, $P = 0.039$; Pearson $r = -0.471$, $P = 0.046$). D1 was also (negatively) correlated with water turbidity (see Table 2), though this variable was also correlated with depth. Dimension 2 (D2) was not correlated with any variable (Table 2), though correlations with the number of species per haul were close to the significance level of 0.05 (Spearman $r = 0.454$, $P = 0.067$; Pearson $r = 0.466$, $P = 0.056$).

Correlation with environmental variables

We did not find any significant correlation between suprabenthos biomass and the environmental variables considered, except for amphipods and turbidity in the depth range 0–180 m (Table 3). On the contrary, zooplankton, and especially fish and decapod crustaceans, showed a significant (generally positive) correlation with fluorometry and turbidity at all levels of

the water column (Table 3) except for the 50-m water layer immediately above the sea floor. Zooplankton (excluding euphausiids) also showed a positive correlation with surface temperature, whereas suprabenthos was always negatively correlated. Mesopelagic decapods also showed a significant positive correlation with salinity.

Depth-zonation patterns in the Catalan Sea area

The cluster analysis (Fig. 5) revealed a reduced set of two samples (208–214 m and 405–408 m depth) clearly separated and very dissimilar (similarity close to zero) to the rest of the (deeper) hauls. A second dichotomy separated a middle slope (MS) cluster (13 hauls taken at depths between 402 and 989 m) from a lower slope (LS) cluster comprising the remaining hauls, taken between 1,258 and 1,859 m depth. The latter appeared to be very homogeneous in the MDS analysis (Fig. 5). On the other hand, the sample scores on D1 of the MDS analysis were significantly correlated with depth (Spearman $r = -0.710$, $P = 0.0014$; Pearson $r = -0.704$, $P = 0.0016$).

As regards the pattern of species appearance/disappearance, most peracarids behaved as eurybathic in the depth range considered, although some layers concentrating faunal turnover could be identified (Fig. 6). With respect to mysids, the only remarkable feature was the disappearance of some species around 401–450 m depth whereas the only sharp decrease occurred below 1,660 m. Amphipods showed a sharp increase in species appearance around 400 m (18 species), with a progressive appearance of new species with depth. Amphipod species disappeared rather gradually along the depth gradient studied, showing only a sharp decrease in species number at 1,258–1,287 m (13 species). Isopods also showed an increase in species number at 400–406 m. Cumaceans appeared continuously along the entire depth range, with only some minor increases (at 400–406 m, 552–644 m, 862–989 and 1,258–1,287 m); species decreased sharply in number at 1,258–1,287 m depth.

Table 2 Correlations between dimensions (D1, D2) of multi-dimensional scaling analysis performed on peracarid crustaceans and environmental variables

| | Spearman r | P | Further analysis ($n = 13$) |
|------------------------------------|--------------|-----------------|--|
| D1 | | | |
| Fluorometry (voltage) | 0.176 | NS ^a | – |
| Lt (0–180 m) ^b | –0.451 | NS ^a | – |
| Lt (all water-column) ^b | –0.624 | 0.02 | $r = 0.581$ ($P = 0.03$) with depth |
| Lt (50 mab) ^{bc} | –0.569 | 0.04 | $r = 0.581$ ($P = 0.03$) with depth |
| Temperature (5 m) | 0.647 | 0.02 | $r = -0.744$ ($P = 0.02$) with turbidity (all water column); $r = -0.711$ ($P = 0.03$) with turbidity (50 mab) ^c |
| Salinity (5 m) | 0.401 | NS ^a | – |
| D2 | | | |
| Fluorometry (voltage) | 0.220 | NS ^a | – |
| Lt (0–180 m) ^b | 0.198 | NS ^a | – |
| Lt (all water-column) ^b | 0.358 | NS ^a | – |
| Lt (50 mab) ^{bc} | 0.352 | NS ^a | – |
| Temperature (5 m) | –0.611 | 0.03 | $r = -0.744$ ($P = 0.02$) with turbidity (all water column); $r = -0.711$ ($P = 0.03$) with turbidity (50 mab) ^c |
| Salinity (5 m) | –0.084 | NS ^a | – |

^aNot significant ($P = 0.05$)

^bLight transmission

^cMetres above bottom

Fig. 4 Results of the cluster analysis (UPGMA/1-Pearson r) and multi-dimensional scaling (MDS) analysis (stress = 0.109) for peracarid crustaceans collected in the SW Balearic Islands

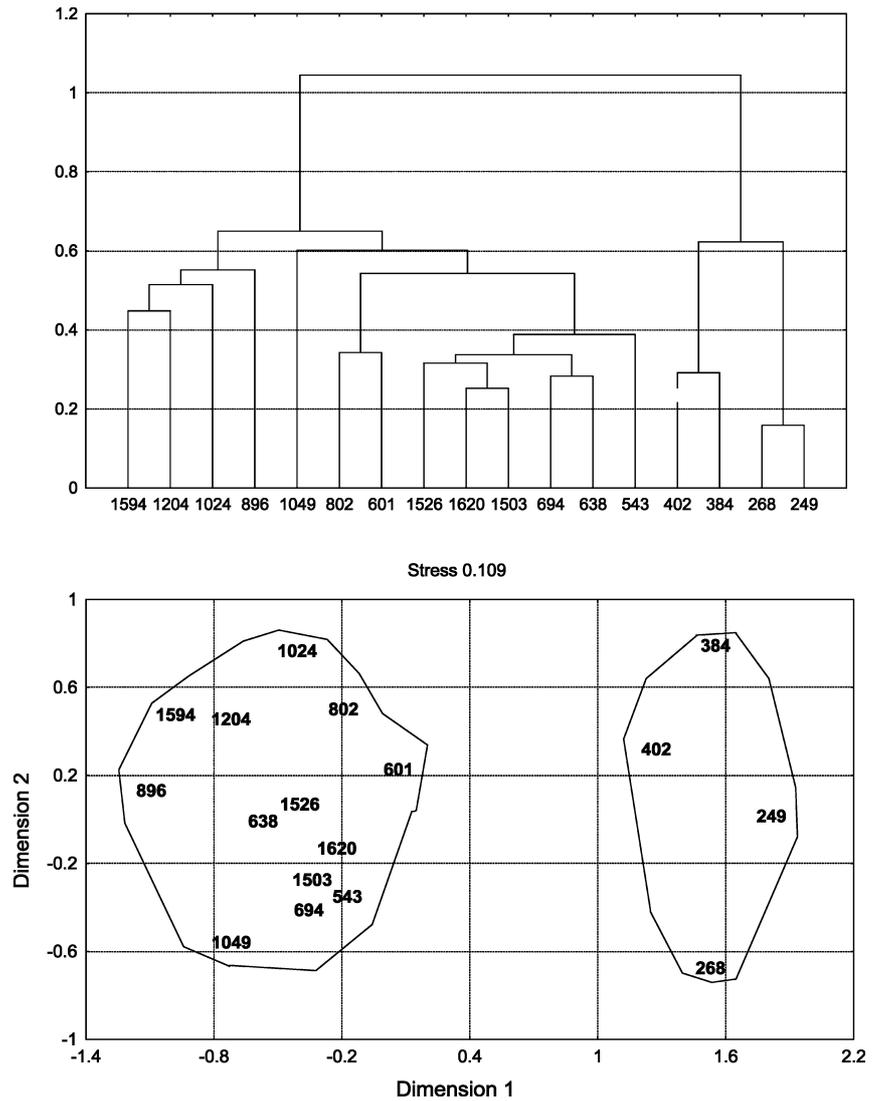


Table 3 Correlations between suprabenthos and zooplankton biomass with environmental variables along the depth range sampled

| | Fluorometry | | Lt (0–180 m) ^a | | Lt (all column) ^a | | Lt (50 mab) ^{ab} | | Temperature (5 m) | | Salinity (5 m) | |
|---------------|-------------|-----------------|---------------------------|-----------------|------------------------------|-----------------|---------------------------|-----------------|-------------------|-----------------|----------------|-----------------|
| | r | P | r | P | r | P | r | P | r | P | r | P |
| Mysids | -0.069 | NS ^c | 0.142 | NS ^c | -0.0010 | NS ^c | -0.419 | 0.08 | -0.510 | 0.07 | 0.074 | NS ^c |
| Amphipods | -0.067 | NS ^c | 0.509 | 0.03 | 0.2870 | NS ^c | -0.161 | NS ^c | -0.107 | NS ^c | 0.388 | NS ^c |
| Isopods | -0.011 | NS ^c | 0.396 | NS ^c | 0.1590 | NS ^c | -0.175 | NS ^c | -0.105 | NS ^c | 0.490 | 0.09 |
| Cumaceans | -0.107 | NS ^c | 0.233 | NS ^c | 0.2077 | NS ^c | -0.133 | NS ^c | -0.187 | NS ^c | -0.062 | NS ^c |
| Suprabenthos | -0.059 | NS ^c | 0.295 | NS ^c | 0.1664 | NS ^c | -0.313 | NS ^c | -0.303 | NS ^c | 0.209 | NS ^c |
| Euphausiids | -0.547 | 0.02 | -0.208 | NS ^c | -0.3504 | NS ^c | -0.315 | NS ^c | -0.190 | NS ^c | -0.091 | NS ^c |
| Decapods | 0.390 | NS ^c | 0.656 | 0.003 | 0.7222 | 0.0007 | 0.328 | NS ^c | 0.621 | 0.02 | 0.445 | NS ^c |
| Fish | 0.472 | 0.04 | 0.705 | 0.001 | 0.4822 | 0.04 | 0.076 | NS ^c | 0.436 | NS ^c | 0.697 | 0.008 |
| Zooplankton | 0.197 | NS ^c | 0.637 | 0.004 | 0.417 | 0.09 | 0.005 | NS ^c | 0.386 | NS ^c | 0.545 | 0.05 |
| Total biomass | 0.154 | NS ^c | 0.643 | 0.004 | 0.410 | 0.06 | -0.082 | NS ^c | 0.085 | NS ^c | 0.537 | 0.06 |

^aLight transmission

^bMetres above bottom

^cNot significant ($P > 0.05$)

Hence, the bathymetric range at which most faunal changes occur in the Catalan Sea is between 400 and 450 m, and secondarily between 1,258 and 1,287 m.

Comparing the dominant species per depth layer in both areas, a radically different picture arises for the upper part of the slope (between 208 and 408 m;

Fig. 5 Results of the cluster analysis (UPGMA/1-Pearson r) and MDS analysis (stress = 0.145) for peracarid crustaceans collected in the Catalan Sea area

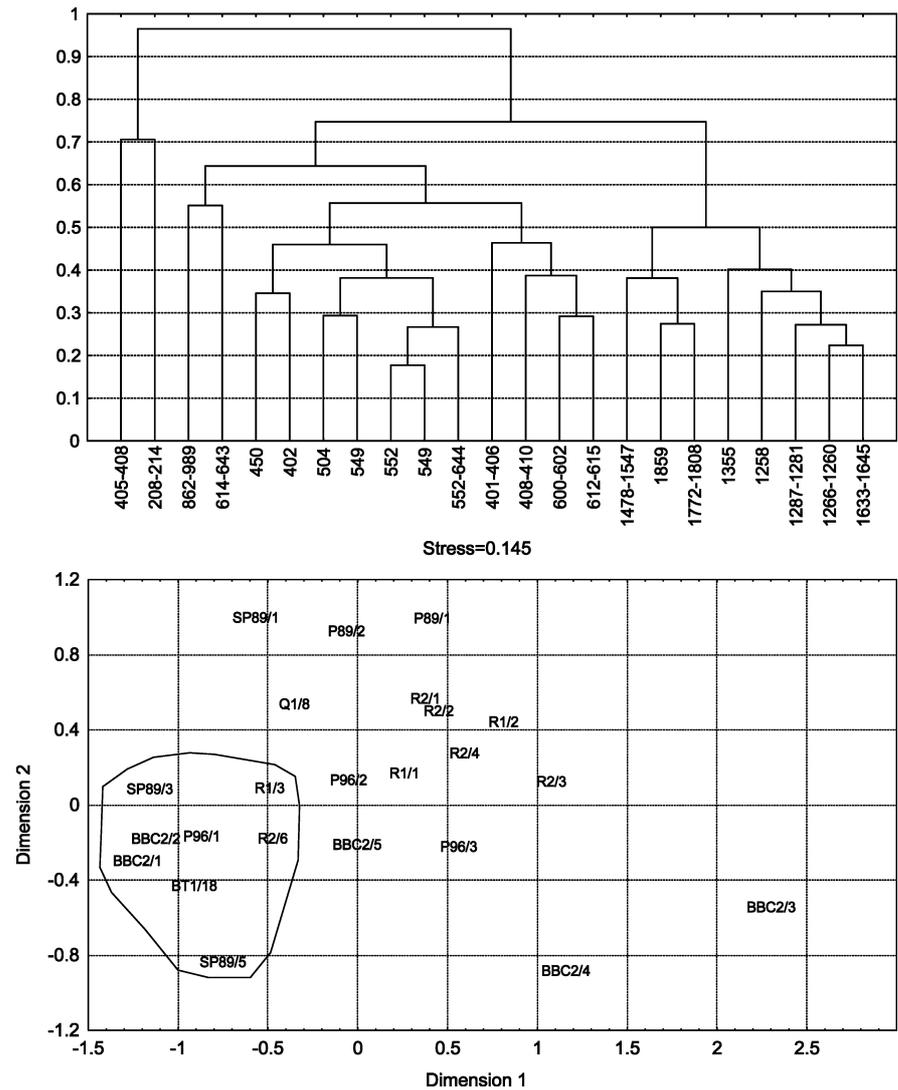


Table 4). Mysids (basically *Gastrosaccus lobatus*) heavily outnumber the rest of taxa in the SW Balearic slope, while amphipods (*Rhachotropis integricauda*, *Syncheliidium maculatum*, etc.) with some mysids co-dominant in the continental part of the Catalan Sea. The middle and LS of both areas appeared basically dominated by the same two species (*Boreomysis arctica* and *Rhachotropis caeca*), with faunistic differences involving only secondary species.

Concerning species diversity, both in the Catalan Sea and in the SW Balearic Islands, minimum H values (and consequently, higher dominance) were found at the US. Comparing both areas by each of the three bathyal zones, H was always higher in the Catalan Sea than in the SW Balearic Islands, particularly at the US.

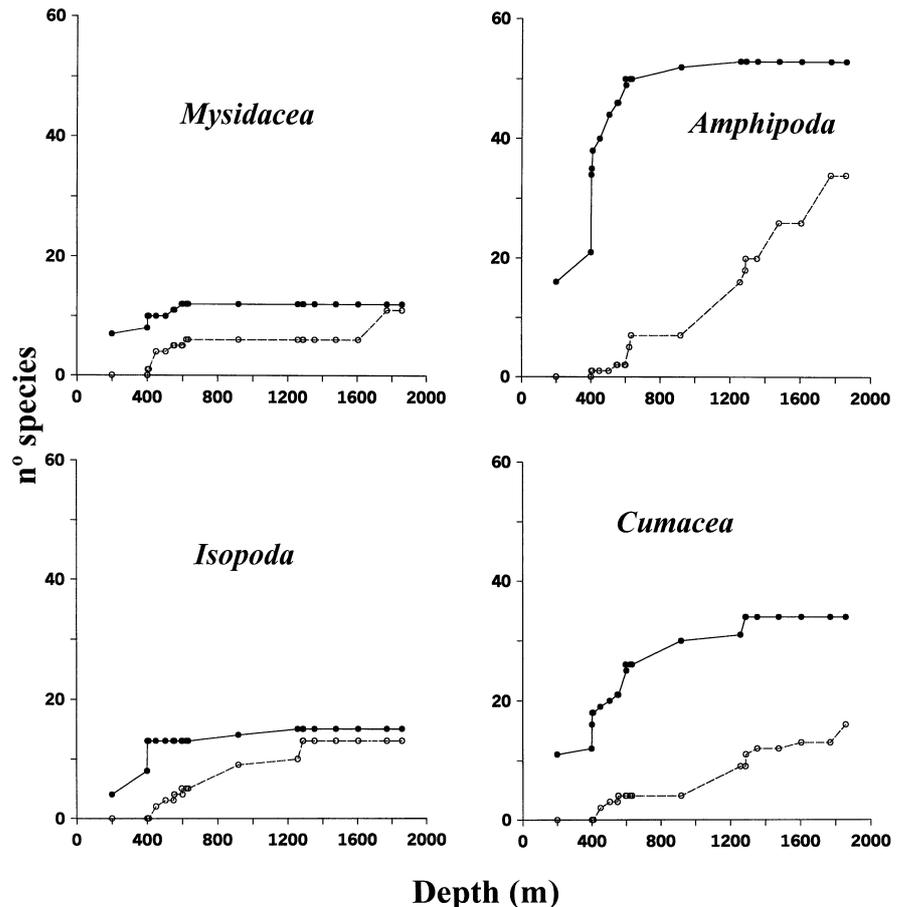
The foregoing trend in species composition is paralleled by that followed by the feeding guilds. Thus, the percentage of deposit feeders differed strongly in both areas at the US, being higher in the Catalan Sea (21.3%) than in the Balearic SW slope (4.1%). Affinity increases progressively with depth (13.9% compared to 21.2%

respectively at the MS) until attaining a very similar proportion of deposit feeders (around 20%) at the LS.

Discussion

The hyperbenthic peracarid crustacean assemblages of the SW Balearic slope and the northern Catalano-Balearic Basin appear quite similar in species composition (Cartes and Sorbe 1993, 1998; J.E. Cartes, unpublished data on isopods). Only 11.6% of the species found in the SW Balearic slope had not been reported previously in the Catalan Sea. Of these, only the mysid *Siriella norvegica*, the cumaceans *Mesolamprops denticulatus* and *Makrokyllindrus gibraltarensis*, and the amphipods *Iphimedia obesa* and *Lepidocream subclypeatum* seem to be effectively absent from the northwestern sector of the western Mediterranean Basin (Tattersall and Tattersall 1951; Ledoyer 1987; Diviacco and Ruffo 1989). The homogeneity in species composition manifested by peracarid assemblages along the different basins of the deep

Fig. 6 Faunal renewal (cumulative appearance/disappearance of species) with depth in the Catalan Sea area



Mediterranean was advanced by Ledoyer (1987) for the Cumacea, and later on by Bellan-Santini (1990) for the Amphipoda, who suggested, however, that the small differences between the eastern and western basins should be attributed only to differences in sampling effort.

The most remarkable feature arising after comparison of the peracarid assemblages of the SW Balearic and the continental-Catalan Sea slopes is the impoverished condition of the former. Though this could be partially attributed to differences in sampling effort, there are 68 species in the Catalan Sea slope that are apparently absent from the SW Balearic slope. Furthermore, four of six amphipods found only in the SW Balearic slope are large lysianassids (viz. *Acidostoma sarsi*, *Podoprion bolivari*, *L. subclypeatum*, and *Sophrrosyne hispana*). Both the reduced species richness and the occurrence of opportunistic scavenging lysianassids adapted to cope with irregular episodes of abundance and to stand periods without food (Sainte-Marie 1992) could be features related to the extreme oligotrophic condition of the SW Balearic slope (see below).

The bathymetric faunistic discontinuities reported herein show that the deep-water suprabenthic peracarid assemblages of the two areas adjust to three more or less clearly delimited faunistic belts: (1) a US belt above approximately 400 m, where species diversity and

biomass are low; (2) a MS belt (approximately 400–1,200 m), where both diversity, and particularly biomass, attain maximum values; and (3) a LS belt (below approximately 1,200 m), where diversity and biomass decrease with depth. Based on the first appearance of characteristic species, two main peracarid faunal discontinuities have been traditionally recognized in the deep Mediterranean, located at around 1,000 and 2,000 m respectively (Ledoyer 1987; Bellan-Santini 1990). The latter has been suggested to correspond to the upper distributional limit of the true abyssal fauna. In addition, Bellan-Santini (1990) suggested the occurrence of a third boundary at around 400 m for gammaridean amphipods, marking the limit of penetration of eurybathic species of the shelf into the slope. However, in our analyses the middle and lower slope assemblages are hardly indistinguishable from each other particularly in the SW Balearic Islands. The zonation pattern arising from our analyses departs from that followed by fish and decapod crustaceans in the SW Balearic slope (Moranta et al. 1998; Maynou and Cartes 2000) and in the Catalan Sea (Stefanescu et al. 1993). The pattern followed by the megafauna in the SW Balearic slope indicates the presence of main discontinuities at 626–694 m (decapod crustaceans) (Maynou and Cartes 2000) and 800 m (fish) (Moranta et al. 1998). However, the faunal boundary placed around 1,300–1,400 m in the deep-Catalan Sea

Table 4 Species composition on the slope of the SW Balearic Islands and the Catalan Sea. Samples considered for this comparison came from all the Macer-GIROQ sledges plus ten net samples (six from the SW Balearic Islands and four from the Catalan Sea) in which species richness was similar to that found in sledge samples

| | Abundance (ind/1000 m ²) | Percentage abundance | Derived values |
|--|--------------------------------------|----------------------|----------------|
| SW Balearic Islands, upper slope, 249–402 m (<i>n</i> = 2) ^a | | | |
| 1. <i>Gastrossacus lobatus</i> | 302.3 | 78.5 | |
| 2. <i>Gnathia</i> sp. | 37.4 | 9.7 | |
| 3. <i>Scopelocheirus hopei</i> ^b | 15.7 | 4.1 | |
| 4. <i>Boreomysis megalops</i> | 7.5 | 1.9 | |
| Percentage deposit feeders | | | 4.1 |
| Number of species | | | 34 |
| Shannon diversity | | | 1.368 |
| Simpson dominance | | | 0.628 |
| Catalan Sea, upper slope, 208–408 m (<i>n</i> = 2) ^a | | | |
| 1. <i>Rhachotropis integricauda</i> | 227.7 | 21.0 | |
| 2. <i>Erythropis neapolitana</i> | 170.3 | 15.7 | |
| 3. <i>Synchelidium maculatum</i> | 136.2 | 12.6 | |
| 4. <i>Weswoodilla rectirostris</i> ^b | 101.22 | 9.3 | |
| 5. <i>Disconectes</i> sp. ^b | 46.0 | 4.2 | |
| 6. <i>Campylaspis sulcata</i> | 38.8 | 3.6 | |
| 7. <i>Gastrossacus lobatus</i> | 34.7 | 3.2 | |
| 8. <i>Scopelocheirus hopei</i> ^b | 34.5 | 3.2 | |
| 9. <i>Leptostylis macrura</i> ^b | 34.1 | 3.1 | |
| 10. <i>Gnathia</i> sp. | 33.7 | 3.1 | |
| 11. <i>Mysideis parva</i> | 22.1 | 2.0 | |
| 12. <i>Cheirocratus</i> sp. ^b | 21.2 | 2.0 | |
| 13. <i>Ampelisca</i> spp. | 20.2 | 1.9 | |
| Percentage deposit feeders | | | 21.3 |
| Number of species | | | 52 |
| Shannon diversity | | | 4.034 |
| Simpson dominance | | | 0.095 |
| SW Balearic Islands, middle slope, 601–1049 m (<i>n</i> = 6) ^a | | | |
| 1. <i>Boreomysis arctica</i> | 106.7 | 39.0 | |
| 2. <i>Rhachotropis caeca</i> | 25.4 | 9.3 | |
| 3. <i>Andaniexis mimonectes</i> ^b | 18.9 | 6.9 | |
| 4. <i>Munnopsurus atlanticus</i> | 16.4 | 6.0 | |
| 5. <i>Gnathia</i> sp. | 11.3 | 4.1 | |
| 6. <i>Halice abyssi</i> ^b | 7.2 | 2.6 | |
| 7. <i>Procampylaspis armata</i> | 7.0 | 2.6 | |
| 8. Eurycopidae sp. A ^b | 6.1 | 2.2 | |
| 9. <i>Belonectes parvus</i> ^b | 5.9 | 2.2 | |
| Percentage deposit feeders | | | 13.9 |
| Number of species | | | 81 |
| Shannon diversity | | | 3.974 |
| Simpson dominance | | | 0.175 |
| Catalan Sea, middle slope, 402–989 m (<i>n</i> = 13) ^a | | | |
| 1. <i>Boreomysis arctica</i> | 352.7 | 14.8 | |
| 2. <i>Parapseudomma calloplura</i> | 173.2 | 7.3 | |
| 3. <i>Ilyarachna longicornis</i> ^b | 126.3 | 5.3 | |
| 4. <i>Rhachotropis caeca</i> | 108.6 | 4.6 | |
| 5. <i>Synchelidium maculatum</i> | 107.3 | 4.5 | |
| 6. <i>Munnopsurus atlanticus</i> | 99.1 | 4.2 | |
| 7. <i>Erythropis neapolitana</i> | 92.4 | 3.9 | |
| 8. <i>Rhachotropis glabra</i> | 86.4 | 3.6 | |
| 9. <i>Chelator chelatus</i> ^b | 75.2 | 3.2 | |
| 10. <i>Rhachotropis grimaldii</i> | 72.1 | 3.0 | |
| 11. <i>Andaniexis mimonectes</i> ^b | 69.2 | 2.9 | |
| 12. <i>Diastylodes serrata</i> ^b | 64.7 | 2.7 | |
| 13. <i>Halice abyssi</i> ^b | 63.1 | 2.7 | |
| 14. <i>Leucon longirostris</i> ^b | 62.9 | 2.6 | |
| 15. <i>Gnathia</i> sp. | 57.8 | 2.4 | |
| 16. Eurycopidae sp. A ^b | 41.7 | 1.9 | |
| Percentage deposit feeders | | | 21.2 |
| Number of species | | | 144 |
| Shannon diversity | | | 5.164 |
| Simpson dominance | | | 0.047 |
| SW Balearic Islands, lower slope, 896–1624 m (<i>n</i> = 4) ^a | | | |
| 1. <i>Rhachotropis caeca</i> | 103.2 | 19.9 | |
| 2. <i>Boreomysis arctica</i> | 92.6 | 17.9 | |

Table 4 (Contd.)

| | Abundance (ind/1000 m ²) | Percentage abundance | Derived values |
|--|--------------------------------------|----------------------|----------------|
| 3. <i>Munnopsurus atlanticus</i> | 47.7 | 9.2 | |
| 4. <i>Bathymedon longirostris</i> | 34.6 | 6.7 | |
| 5. <i>Calyptomma puritani</i> | 22.9 | 4.4 | |
| 6. Eurycopidae sp. A ^b | 21.7 | 4.2 | |
| 7. <i>Ilyarachna longicornis</i> ^b | 17.9 | 3.5 | |
| 8. <i>Ilerastroe ilergetes</i> ^b | 15.4 | 3.0 | |
| 9. <i>Andaniexis mimonectes</i> ^b | 12.8 | 2.5 | |
| 10. <i>Platysympus typicus</i> ^b | 12.3 | 2.4 | |
| 11. <i>Procampylaspis bonnieri</i> | 12.2 | 2.4 | |
| 12. <i>Cyclaspis longicaudata</i> ^b | 11.7 | 2.3 | |
| 13. <i>Parerythroptis lobiancoi</i> | 11.2 | 2.2 | |
| 14. <i>Bathycuma brevirostre</i> ^b | 9.5 | 1.8 | |
| Percentage deposit feeders | | | 19.7 |
| Number of species | | | 78 |
| Shannon diversity | | | 4.334 |
| Simpson dominance | | | 0.095 |
| Catalan Sea, lower slope, 1258–1859 m (n = 7) ^a | | | |
| 1. <i>Boreomysis arctica</i> | 266.6 | 19.9 | |
| 2. <i>Rhachotropis caeca</i> | 215.6 | 16.2 | |
| 3. <i>Cyclaspis longicaudata</i> ^b | 117.9 | 8.8 | |
| 4. <i>Bathymedon longirostris</i> | 91.4 | 6.8 | |
| 5. <i>Munnopsurus atlanticus</i> | 48.6 | 3.6 | |
| 6. <i>Calyptomma puritani</i> | 38.8 | 2.9 | |
| 7. <i>Makrokyllindrus longipes</i> ^b | 36.1 | 2.7 | |
| 8. <i>Belonectes parvus</i> ^b | 33.5 | 2.5 | |
| 9. <i>Bathycuma brevirostre</i> ^b | 31.0 | 2.3 | |
| 10. <i>Ilerastroe ilergetes</i> ^b | 26.9 | 2.0 | |
| 11. Eurycopidae sp. A ^b | 26.7 | 2.0 | |
| Percentage deposit feeders | | | 20.3 |
| Number of species | | | 82 |
| Shannon diversity | | | 4.513 |
| Simpson dominance | | | 0.086 |

^aNumber of samples^bSpecies considered as deposit feeders

(Stefanescu et al. 1993) has been recognized only for fish in the SW Balearic slope. Aside of local heterogeneity in environmental conditions (slope inclination, existence of deep currents), differences in zonation patterns may also depend of the trophic level of the taxa considered, with zonation rates increasing with trophic level (Rex 1977; Cartes and Carrassón, unpublished). The lower zonation rates shown by peracarids compared to fish and decapods, particularly in the Catalan Sea area, are thus in agreement with the expected trend, since peracarids belong to a lower trophic level than fish (Polunin et al. 2001).

All the environmental data considered in our study refer to features of the water column (down to approximately 10 m above the sea floor). In general, zooplankton biomass (e.g. small fish such as *Cyclothone braueri* and euphausiids) was positively correlated with fluorometry and Lt, the trophic variables of the water column. The positive correlation found with temperature also seems to have an ecological meaning since production and temperature are positively correlated (Morin and Bourassa 1992). The lack of correlation found between suprabenthos biomass and these environmental variables suggests that suprabenthic fauna relies on trophic resources other than those derived directly from the water column, probably linked to the

sediment or the sediment-water interface. Though deep-water macrofauna exploits mainly the marine snow generated in the epipelagic zone, the response of benthic (and suprabenthic) fauna to the trophic conditions of the water column is not immediate, but occurs with a time lag compared to zooplankton. Thus, a simultaneous sampling as carried out in our study seems inadequate to prove coupling processes between trophic variables and suprabenthic biomass.

As with the community composition, the feeding guilds also showed important differences between both areas. Differences, however, affected only the US assemblages, with higher abundance of deposit feeders in the Catalan Sea (21.3%) compared to the SW Balearic slope (4.1%). This is probably linked to differences in sediment composition in both areas, as pointed out by Cartes et al. (2001) when comparing the trophic structure of peracarid assemblages of the Catalan Sea and the SW Bay of Biscay. The low contribution of deposit feeders in the SW Balearic slope could be a result of both the high hydrodynamism of the bottom water layers, as occurred in the Bay of Biscay (Cartes et al. 2001), and the lack of river discharges in the area. The lowest diversity of peracarid assemblages found at the US might also be a consequence of higher hydrodynamism (low environmental stability) there, according to the

general scheme of depth-diversity patterns for deep-sea communities under the stability-time hypothesis (Gage and Tyler 1991). Water masses around the Balearic Islands are characterized by higher mesoscale variability than US of the Catalan Sea (Millot 1987; Garcia-Ladona et al. 1996), with eddies detached from the main cyclonic gyre of the Alboran Sea. Hydrodynamic conditions are the major factor controlling sediment granulometry (Etcheber et al. 1999), and high hydrodynamism could determine the low proportion of mud at the upper part of the slope and the low proportion of deposit feeders in the sediment. Mud is dominant below 200 m in the slope off Barcelona (it represents 64.8–96.1% of the sediment fraction < 63.25 μm), and its percentage increases progressively with depth. Also, there is an increase in different organic matter parameters, such as hydrolyzable amino acids and lipids, and in some taxa of suprabenthos (e.g. Cumacea) below 1,000 m, attributable to lateral advection via submarine canyons in the continental side of the Catalan Sea (Cartes et al. 2002). This effect of lateral advection on food availability for suprabenthos has already been suggested to depths to 2,680 m off east Greenland (Brandt 1997). On the contrary, though no data comparable in detail to those of the Catalan slope are available for the SW Balearic slope, the sediment there consists mainly of detrital material of biogenic origin derived from the Balearic shelf (Emelyanov 1972). Because terrigenous sediments are absent from the area, the most logical cause for this difference seems to be the absence of river discharges. The proportion of deposit feeders increased progressively with depth below 400 m in both areas (13.9% to 21.2% at the MS) suggesting more similar bottom structure at this level. In open oceanic areas SW off the Balearic Islands, the sediment is mainly composed of muddy-biogenous material of planktonic origin (Emelyanov 1972), with some suprabenthos samples including large amounts of planktonic foraminiferans (*Orbulina universa*, personal observation). As a general conclusion, the trophic structure of deep-water benthopelagic communities can vary at a local (< 300 km) scale, even in a stable environment such as the deep Mediterranean.

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