ISSN: 0001-5113 AADRAY	ACTA ADRIAT., 46 (1): 27 - 40, 2005	UDC: 595.3 (262.3) Original scientific paper

Distribution of demersal crustaceans in the southern Adriatic Sea

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Occurrence, distribution, and assemblage of crustaceans in the southern Adriatic Sea were determined from data collected during five seasonal (summer) trawl surveys carried out during 1996-2000. Trawls were conducted at a bathymetric range of 10-800 m, by the same vessel and same sampling gear in the framework of the E.U. Project, MEDITS. Fifty-two benthic-epibenthic, and nektonic species (three stomatopods, 49 decapods) were caught. Species density data (individuals per km^2) were processed according to multivariate techniques to describe the composition and distribution of main species assemblages. The assemblages were consistent throughout the surveyed area with some differences between the western and eastern zones, mostly those found on shelf bottoms. The influence of oceanographic features, other than depth, is discussed.

Key words: decapod crustaceans, stomatopods, demersal assemblages, multivariate analysis, Adriatic Sea

INTRODUCTION

Species distribution and assemblages have been studied in several areas of the Mediterranean Sea to explain the space-time distribution patterns of demersal species versus environmental characteristics (depth, substratum, etc.) and anthropic impacts (fisheries, etc.). Until 1996, information on assemblages of dermersal species was reported only for the western side of the Adriatic (UNGARO *et al.*, 1995, 1998). Since 1996, an annual experimental trawl survey (part of the Mediterranean International Trawl Survey, MEDITS) was conducted in the late spring-early summer in the central and western Mediterranean Basin. The same sampling scheme, vessel, and gear were used during the survey in the southern Adriatic between the Italian (south-western Adriatic) and Albanian (south-eastern Adriatic) sides (BERTRAND *et al.*, 1997). Therefore, information on demersal species in the entire southern Adriatic is now available (UNGARO *et al.*, 1999; UNGARO & MARANO, 2001).

Crustaceans are an important fraction of the total catch in the southern Adriatic (PETRUZZI *et al.* 1988; PASTORELLI *et al.*, 1996; MARSAN *et* *al.*, 2000) and Mediterranean (RELINI-ORSI & RELINI, 1972; ABELLÓ *et al.*, 1988; RIGHINI & AUTERI, 1989; CARTES & SARDÀ, 1992; MURA & CAU, 1992; PIPITONE & TUMBIOLO, 1993; TURSI *et al.*, 1993; RINELLI *et al.*, 1998; SPANÒ, 1998). Some of the species are valuable for fishery exploitation (e.g., *Nephrops norvegicus, Parapenaeus longirostris, Aristeus antennatus, Aristaeomorpha foliacea*) and therefore require assessment and management (RELINI *et al.*, 1999). The links between the above-mentioned zoological group and the trophodynamics of the marine environment were postulated by several authors (ABELLÓ *et al.*, 1988; CARTES *et al.*, 1994; UNGARO *et al.*, 1999).

In the present work, data from the 1996-2000 MEDITS trawl surveys were processed to create a list of and quantify crustacean species on the trawlable bottoms of the southern Adriatic and to identify the composition and distribution of the main assemblages. The gathered information will be useful in defining crustacean biodiversity and local fish assemblages, important for the environmental management of the Mediterranean basin (CADDY, 1998).

MATERIAL AND METHODS

Crustacean samples came from trawl surveys conducted in an area of about 24000 km^2 in the southern Adriatic Sea (Fig. 1). A large deep trench in the middle of the surveyed area (1230 m deep - the deepest area in the Adriatic) roughly separated the trawlable bottoms of the western and eastern sides. The bottoms on both sides of the basin were trawled at 112 stations during the spring and summer of 1996-2000 on the shelf and the upper slope (16-588 m depth). One haul (60 square nautical miles) was sampled at each station during each survey (72 hauls in the western area, 40 hauls in the eastern per year; 560 hauls during the 5-year survey) using an otter trawl net (length approx. 40 m, wing spread approx. 18 m) with 10 mm mesh at the cod end. During the first survey (1996), the sampling design was randomly stratified into five bathymetric strata: 10-50 m, 51-100 m, 101-200 m, 201-500 m, and 501-800 m (BERTRAND *et al.*, 1997, 2002). The same sampling stations were sampled in following years. The tow duration was one hour on slope bottoms and 0.5 h on shelf bottoms.

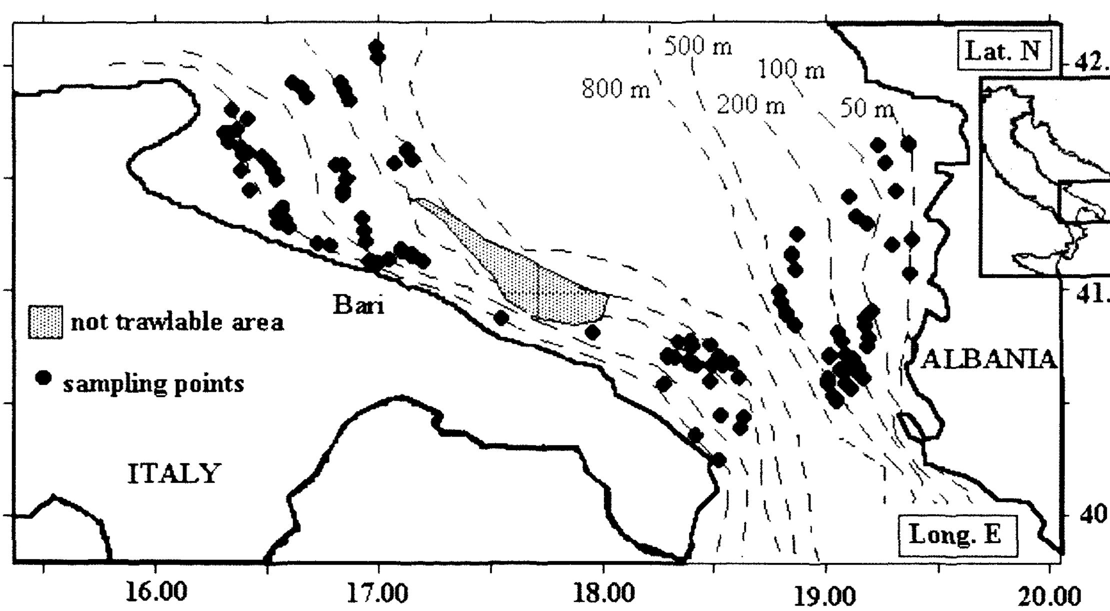

Fig. 1. The study area

All crustacean species collected by the net were identified according to ZARIQUIEY-ALVAREZ (1968) and FALCIAI & MINERVINI (1992) and a list per haul was recorded (true plankton species were excluded). Species abundance data were standardized to kg km^{-2} and no. km^{-2} by the swept-area method (SPARRE & VENEMA, 1992). Occurrence, biomass and density indices, and bathymetric ranges were calculated for each species. Species abundances per sampling station matrix were processed using multivariate techniques such as cluster analysis (hierarchical agglomerative clustering; group average; LEGENDRE & LEGENDRE, 1987) and multi-dimensional scaling (MDS; KRUSKAL, 1964). Before processing, the data were double-root transformed to avoid a strong influence by the most abundant species in the samples (CLARKE & GREEN, 1988). Non-metric MDS (ARDISSON *et al.*, 1990) and two-dimensional space ordination were performed. The similarity among samples was evaluated with the BRAY-CURTIS coefficient, after excluding species with an abundance value below 1% from each sample to minimize 'noise' elaboration. Data analysis was carried out with PRIMER software (CARR, 1996). The same analysis was performed for the 'species mean abundance per depth stratum' matrices to summarize information according to sampling scheme (western and eastern areas; five depth strata) and determine differences between species assemblages and distributions per survey, depth, and area.

RESULTS

The five surveys produced 52 benthic or nektobenthic crustacean species (3 stomatopods and 49 decapods). Thirty zoological families were identified, with Pandalidae, Galathcidae, and Paguridae being the most represented (7, 4, and 4 species, respectively; Table 1).

Table 1.Crustacean species collected during MEDITS 1996-2000 surveys in the Southern Adriatic Sea:sampling area and geographic position of 112 hauls (72 and 40 samples on Western and Eastern trawable bottoms, respectively)

ORDER	FAMILY	SPECIES
	Squillidae	*Rissoides desmaresti* (Risso, 1816)
		Rissoides pallidus (Gesbrecht, 1910)
		Squilla mantis (Linnaeus, 1758)
ASTACIDEA	Nephropidae	*Homarus gammarus* (Linnaeus, 1758)
		Nephrops norvegicus (Linnaeus, 1758)
BRACHYRHYNCHA	Portunidae	*Bathynectes maravigna* (Prestandrea, 1839)
		Liocarcinus depurator (Linnaeus, 1758)
		Macropipus tuberculatus (Roux, 1830)
	Geryonidae	*Geryon longipes* A.Milne Edwards, 1881
	Goneplacidae	*Goneplax rhomboides* (Linnaeus, 1758)
	Xanthidae	*Monodaeus couchii* (Couch, 1851)
		Philumnus hirtellus, (Linnaeus, 1761)
		Xantho pilipes A. Milne Edwards, 1867
CARIDEA	Alpheidae	*Alpheus glaber* (Olivi, 1792)
	Pandalidae	*Chlorotocus crassicornis* (Costa, 1871)
		Plesionika acanthonotus (S.I.Smith, 1882)
		Plesionika antigai Zariquiey Alvarez, 1955
		Plesionika edwarsii (Brandt, 1851)

Table 1. Cont'd

		Plesionika gigliolii (Senna, 1903)
		Plesionika heterocarpus (Costa, 1871)
		Plesionika martia (A. Milne Edw., 1883)
	Pasiphaeidae	*Pasiphaea multidentata* Esmark, 1866
		Pasiphaea sivado (Risso, 1816)
	Crangonidae	*Pontocaris lacazei* (Gourret, 1887)
		Pontophilus spinosus (Leach, 1815)
	Processidae	*Processa canaliculata* Leach, 1915
DROMIACEA	Homolidae	*Homola barbata* (Fabricius,1793)
		Paromola cuvieri (Risso, 1816)
	Latreillidae	*Latreillia elegans* Roux, 1830
GALATHEIDEA	Galatheidae	*Munida intermedia* A.Mil.Edw.& Bouv., 1899
		Munida iris Zariquiey Alvarez, 1952
		Munida perarmata A.Mil.Edw.& Bouv., 1894
		Munida rugosa (Fabricius, 1775)
OXYRHYNCHA	Majidae	*Anamathia rissoana* (Roux, 1828)
		Macropodia longipes (A.Mil.Edw.& Bouv., 1899)
	Phartenopidae	*Parthenope macrocheles* (Herbst,1790)
OXYSTOMATA	Calappidae	*Calappa granulata* (Linnaeus, 1767)
		Calappa turkayana n. sp.
	Dorippidae	*Medorippe lanata* (Linnaeus, 1767)
PAGURIDEA	Diogenidae	*Dardanus arrossor* (Herbst, 1796)
	Paguridae	*Pagurus alatus* Fabricius, 1775
		Pagurus cuanensis, Bell 1846
		Pagurus excavatus (Herbst, 1791)
		Pagurus prideaux Leach, 1815
PALINURIDEA	Palinuridae	*Palinurus elephas* (Fabricius, 1787)
	Polychelidae	*Polycheles typhlops* Heller, 1862
PENAEIDEA	Aristeidae	*Aristeomorpha foliacea* (Risso, 1827)
		Aristeus antennatus (Risso, 1816)
	Penaeidae	*Parapenaeus longirostris* (Lucas, 1846)
	Solenoceridae	*Solenocera membranacea* (Risso, 1816)
SERGESTOIDEA	Sergestidae	*Sergestes robustus* S.I.Smith, 1882
		Sergestes articus (Kröier, 1855)

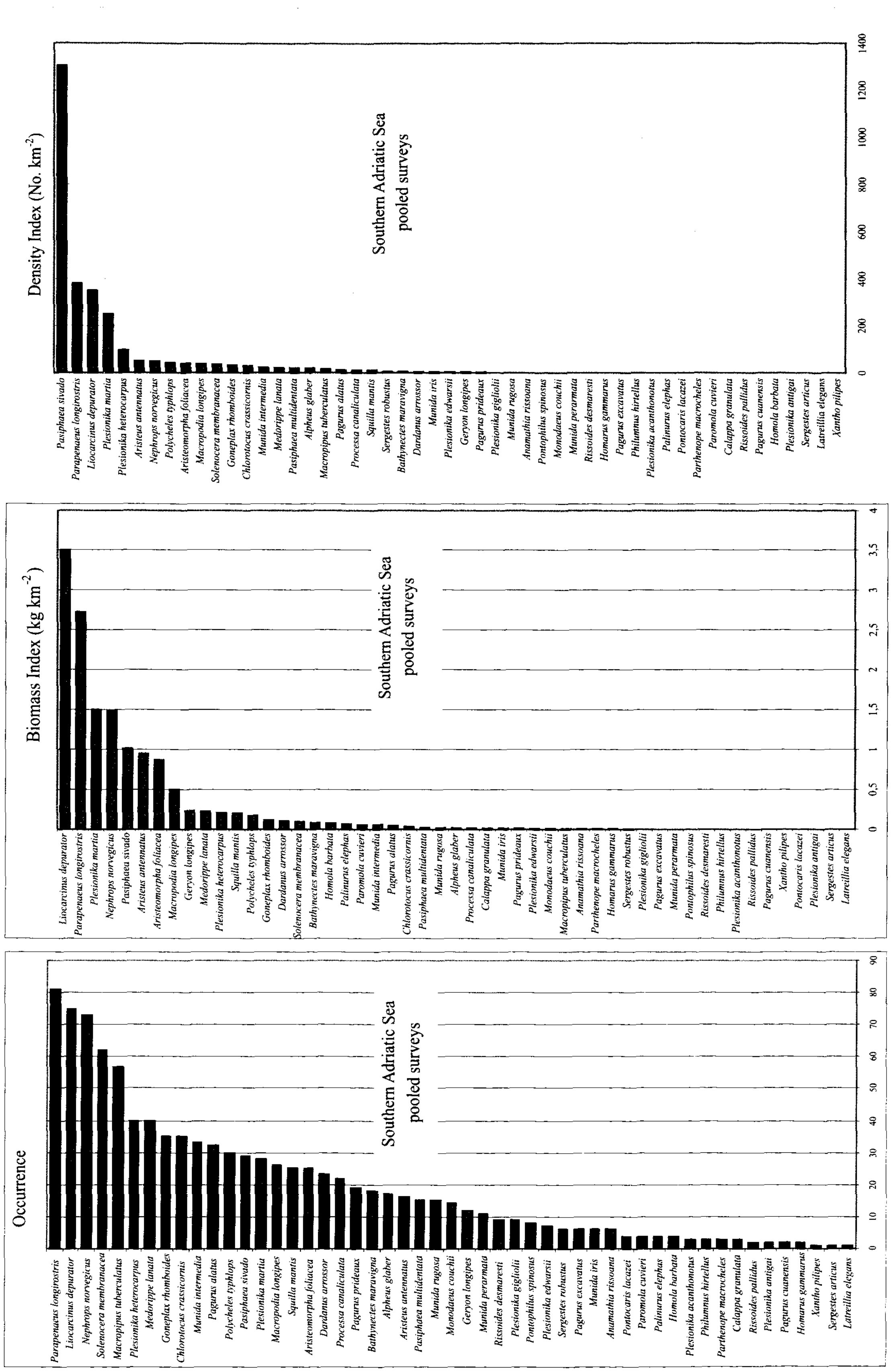

Fig. 2. Occurrence and abundance indices of the collected crustaceans species (pooled surveys)

The occurrence values and biomass and density indices were determined for pooled data from the five surveys. The most prevalent species were the penaeid *Parapenaeus longirostris*, caridean shrimps of the genus *Plesionika,* portunid crabs *Liocarcinus depurator* and *Macropipus tuberculatus,* and astacidean *Nephrops norvegicus,* which accounted for most of total biomass in the area (Fig. 2) and were found at different depths (Fig. 3). *Liocarcinus depurator* was found on shelf bottoms while *P. longirostris*, *Plesionika* spp., and *M. tuberculatus* were found mostly on the shelf border and upper slope bottoms.

When carried out separately for the western and eastern areas, the analyses were slightly different. The western area was mostly characterized by the presence and abundance of Reptantia and burrowing species such as *L. depurator* and *N. norvegicus*, while the eastern area was characterized by Natantia species such as *P. longirostris* and *Plesionika* spp. (Figs. 4 and 5).

Sampling stations were clustered using a "species density per sampling station" matrix. Density indices per station were averaged for the overall period (all five surveys) to reduce the influence of occasional catches. Multivariate analysis resulted in four main clusters at the second level of ramification. The first cluster included most of the sampling stations deeper than 350 m (on both the western and eastern sides), the second one included mostly shelf and upper-slope stations in the eastern zone. The remaining two clusters included sampling stations in the western zone at 115-233 m and 21-125 m depths (Fig. 6).

According to the stratification of sampling scheme of the MEDITS protocol, classification and ordination (MDS) of data referring to the defined bathymetric strata (species mean density x depth strata, pooled surveys) per geographic area (southwestern and southeastern Adriatic) was performed. The differences between the western and eastern shelf areas were again revealed, while the slope zones appeared to be

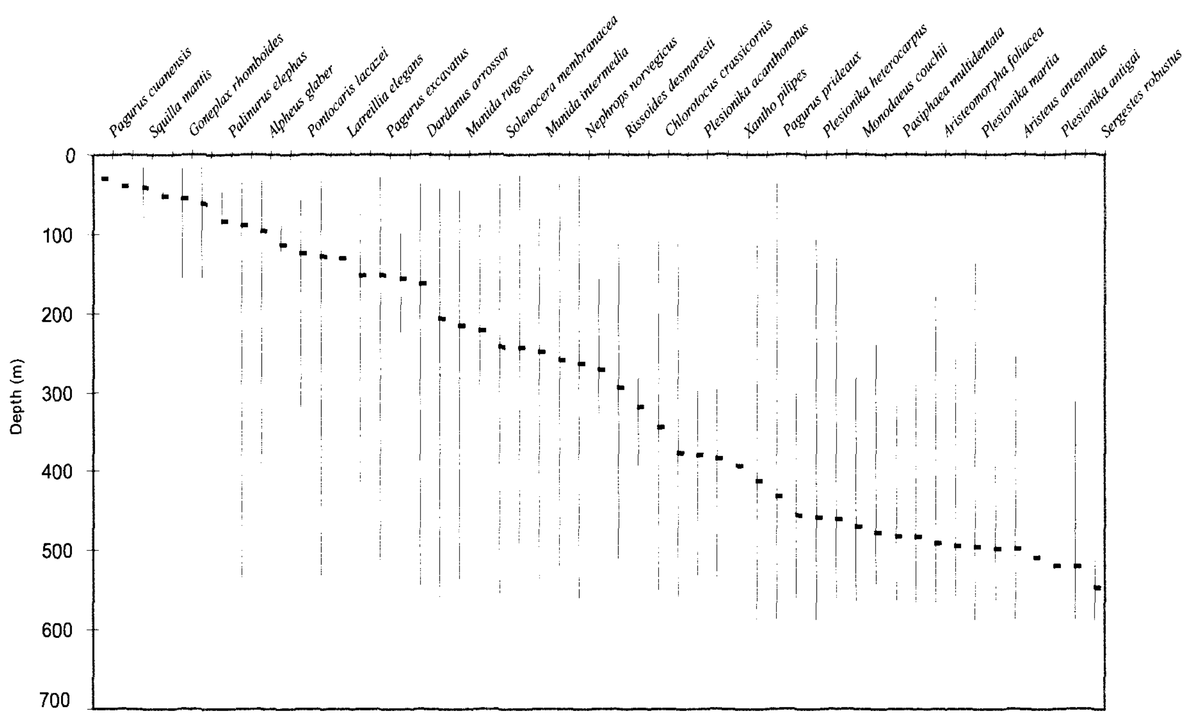

Fig. 3. Bathymetric ranges and centroid distribution of the collected crustacean species

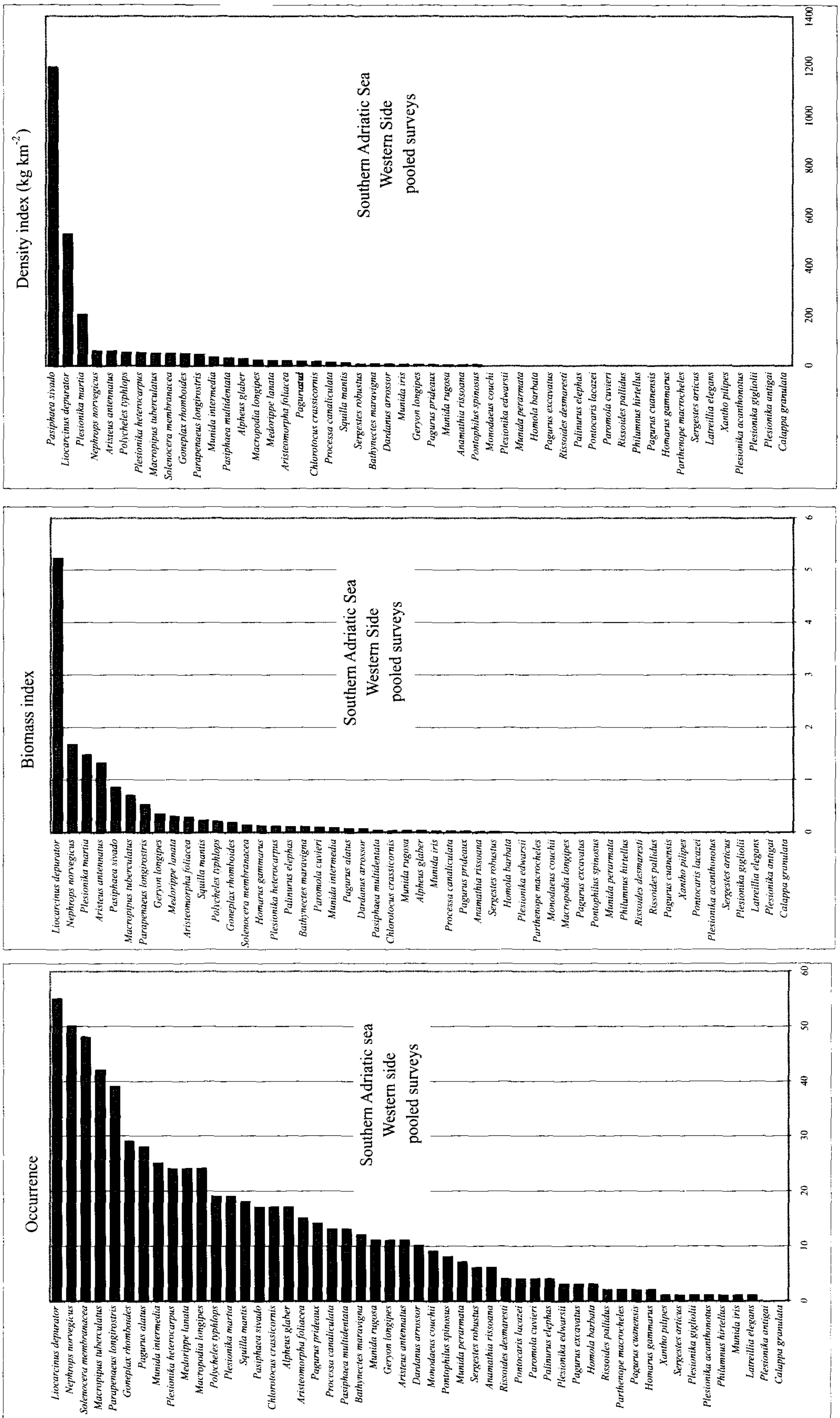

Fig. 4. Western zone: occurrence and abundance indices of the collected crustacean species (pooled surveys)

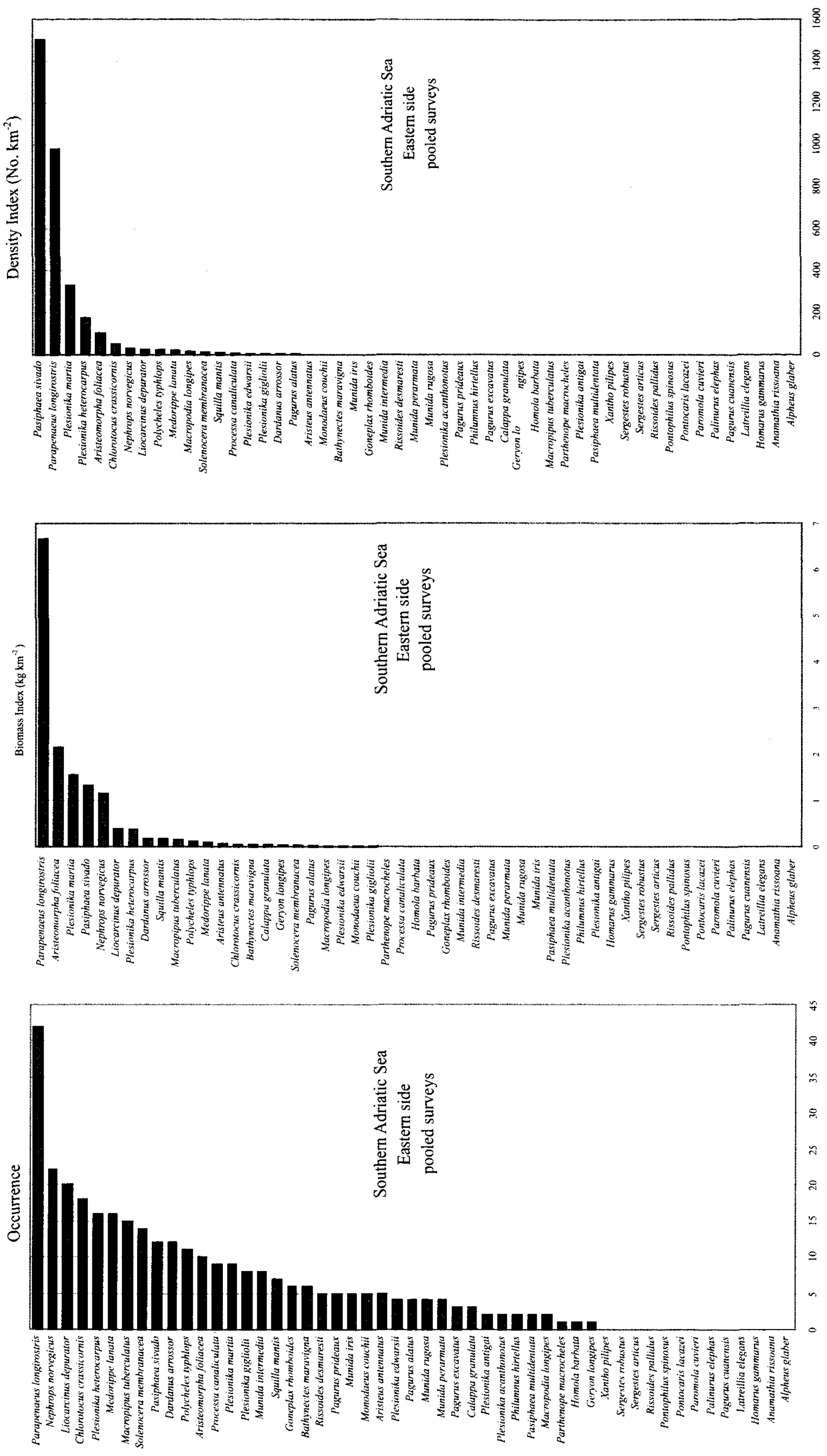

Fig. 5. Eastern zone: occurrence and abundance of indices the collected crustacean species (pooled surveys)

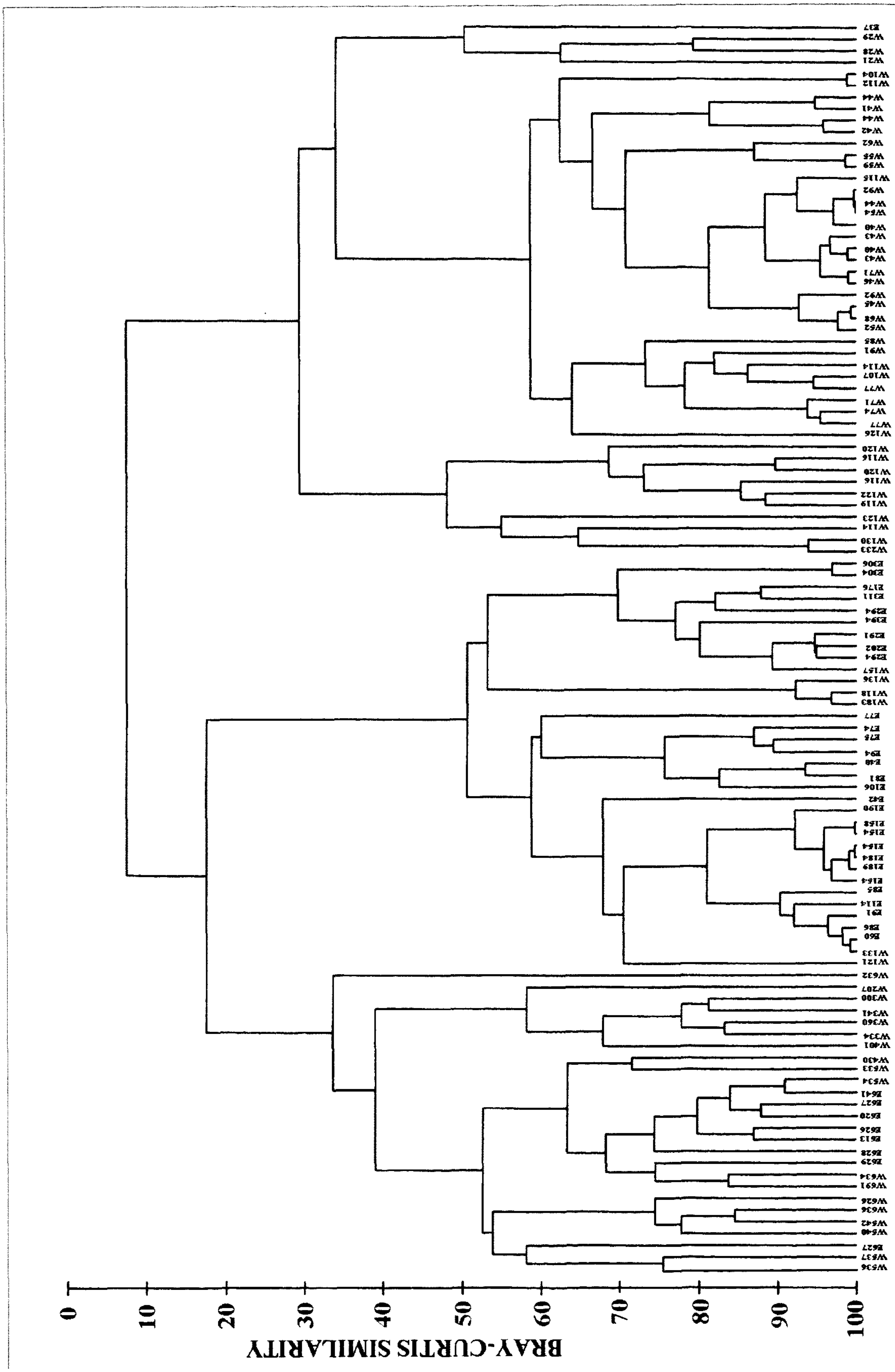

Fig. 6. Clustering of sampling stations from MEDITS 1996-2000 survey; crustaceans' density indices per station (no. km^{-2}) were averaged on the overall period (five surveys); sampling stations are codified by mean depth and geographic area (W=western side; E=eastern side)

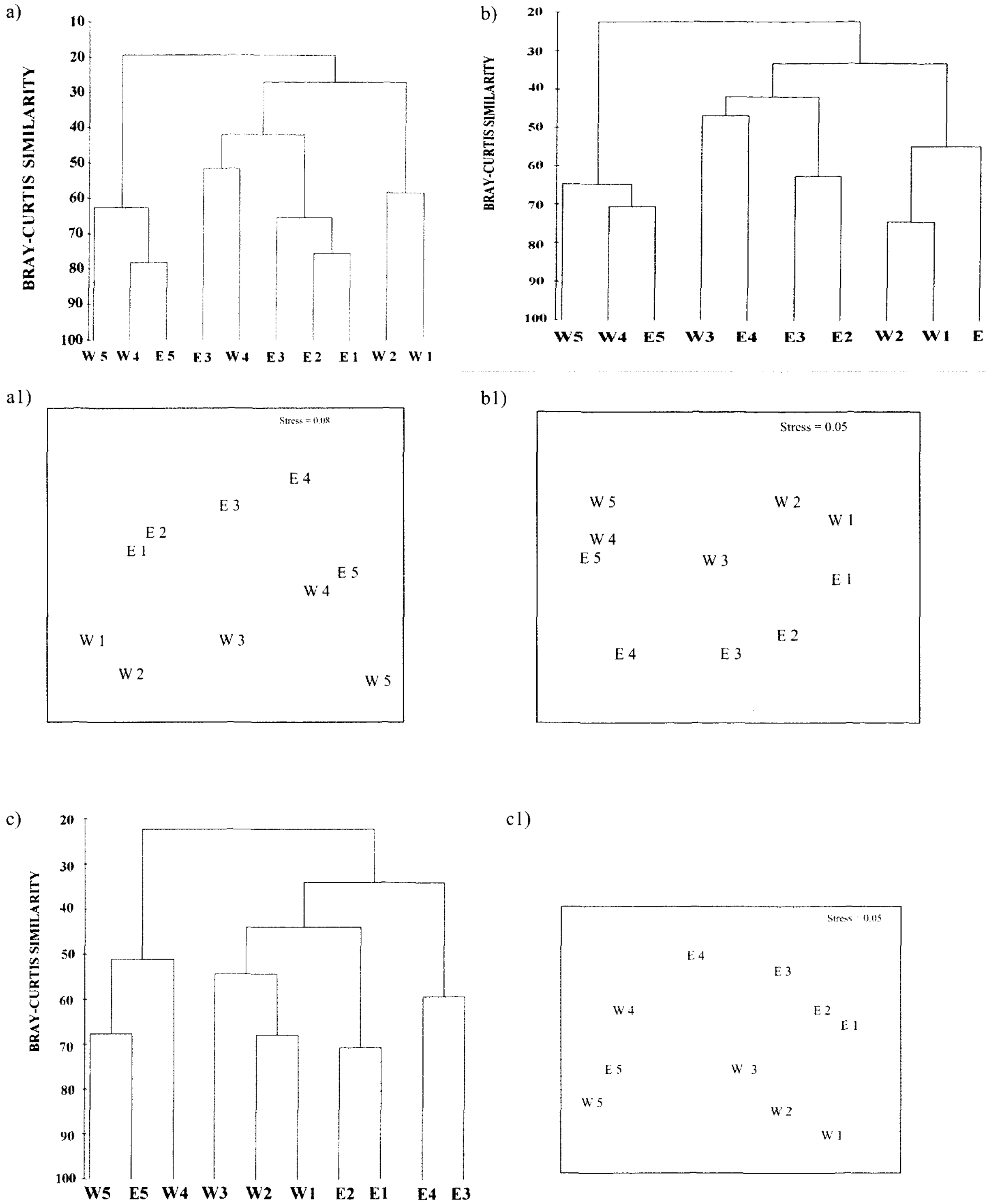

Fig. 7. Classification and ordination of crustacean assemblages on trawable bottoms of southern Adriatic Sea (W=western side; E=eastern side): mean density values per depth stratum (1=10-50 m; 2=51-100 m; 3=101-200 m; 4=201-500 m; 5=501-800 m); a) data averaged on the overall period (five surveys); b) data from 1996 MEDITS survey c) data from 2000 MEDITS survey

quite homogeneous (Fig. 7a). The same analysis was carried out for each yearly survey. Small inter-annual variations in the distribution of the main crustacean assemblages were detected only between the1996 and 2000 surveys (Figs. 7b,c), confirming the persistence of assemblages in the investigated area.

The most abundant species on shelf bottoms in the western (*L. depurator* and *Goneplax rhomboidaes*) and eastern (*P. longirostris*) areas strongly contributed to the difference between the opposite sides of the southern Adriatic. The homogeneity on the slope bottoms was mostly due to the occurrence and abundance of *P. martia*, *Pasiphaea sivado*, *Aristaeomorpha foliacea*, and *Polycheles typhlops* on both sides.

DISCUSSION AND CONCLUSION

The list of species agrees with bibliographic information from the same geographic zone (PETRUZZI *et al.*, 1988; VASO & GJIKNURI, 1993; PASTORELLI *et al.*, 1996; MARSAN *et al.*, 2000) and other Mediterranean areas, as well as the bathymetric ranges of distribution (RELINI-ORSI & RELINI, 1972; ABELLÓ *et al.*, 1988; RIGHINI & AUTERI, 1989; CARTES & SARDÀ, 1992; MURA & CAU, 1992; PIPITONE & TUMBIOLO, 1993; TURSI *et al.*, 1993; RINELLI *et al.*, 1998; SPANÒ, 1998). All the species in our study were included in lists regarding the whole Mediterranean basin (ŠTEVČIĆ & GALIL, 1994; FROGLIA, 1995). *Munida iris* Zariquiey Alvarez 1952 and *Calappa turkayana* PASTORE 1995 (PASTORE, 1995) were new findings for the southern Adriatic. They are added to *Paromola cuvieri* (RISSO, 1816) recently found in the same area (BELAMARIĆ *et al.*, 1995; UNGARO, 2000). The crustacean assemblages, as defined by multivariate analysis of the data, appeared to be rather stable over the years throughout the investigated area, as it is for most demersal species groups (GAERTNER *et al.*, 1998; UNGARO *et al.*, 1998).

The depth gradient can be very important for the distribution of fish assemblages in the southern Adriatic (UNGARO *et al.*, 1998, 1999) as it is worldwide but bathymetry, in addition, partially explains the distribution in this area. Slope assemblages were homogeneously distributed throughout the area, while differences between the western and eastern zones were mostly on the shelf bottoms that are influenced by other variables as well as depth. The difference was probably due to geomorphic and oceanographic features, as the Adriatic Sea is a semi-enclosed basin characterized by latitudinal (south to north) as well as longitudinal (east to west) gradients (PIGORINI, 1968; ZORE-ARMANDA, 1968; ALFIREVIĆ, 1981; BREGANT *et al.*, 1992). Typical cyclonical movements are reported in the Adriatic (ARTEGIANI *et al.*, 1997) where dense cold water (north Adriatic dense water, NADW) flows from the north to the south along the western continental shelf, deep water (Adriatic deep water, ADW) forms in the southern Adriatic pit, and warmer more saline water (Levantine intermediate water, LIW) inflows northward along the eastern side of the Adriatic from the Ionian Sea in the Otranto Strait (MANCA *et al.*, 2001). The LIW makes the bottom water on the eastern side of the south Adriatic warmer than on the western side (ARTEGIANI *et al.*, 1997). Thus, the general water circulation in the basin as well as differences in the geomorphology can explain the distributional pattern of some of the crustacean species. On the other hand, a link between species distribution and talassographic parameters has been supposed (ABELLÓ *et al.*, 1988; CARTES *et al.*, 1994; UNGARO *et al.*, 1999), and new information from the southern Adriatic supports the probable role of bottom temperature for crustacean species distribution (UNGARO & MARANO, 2002; Fig. 8).

The results highlight the importance of research and study of the relationship between oceanographic features and the distribution of biological resources. Such study increases information on the marine ecosystem that can be used to manage the environment and exploitation of natural resources (e.g., fisheries).

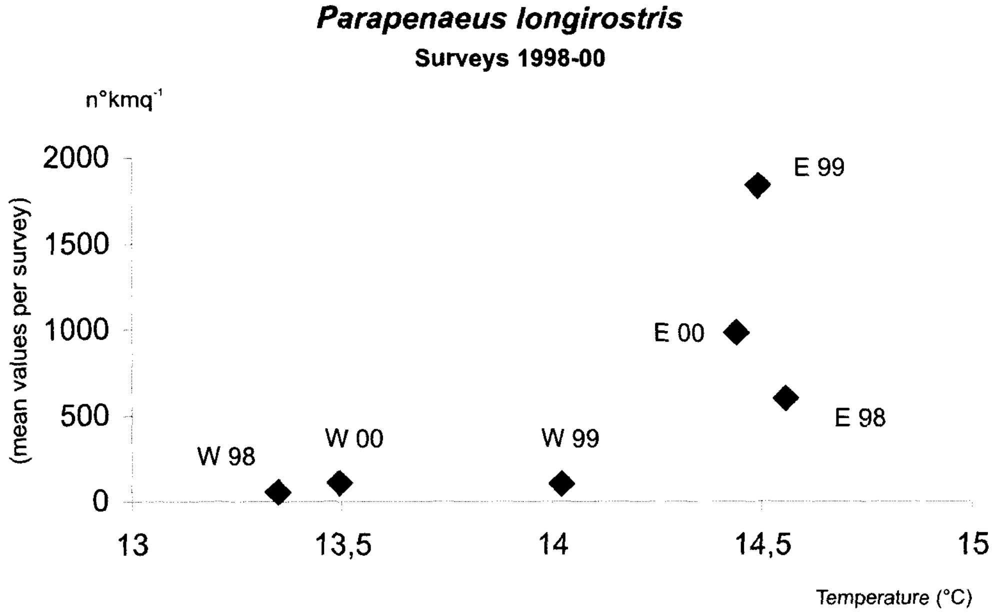

Fig. 8. Relationship between abundance of P. longirostris *and bottom temperature (mean values per survey, depths below 100 m; (W=western side; E=eastern side) (from UNGARO & MARANO, 2002)*

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