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MEDITERRANEAN MARINE DEMERSAL RESOURCES: THE MEDITS INTERNATIONAL TRAWL SURVEY (1994-1999).
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Geographical patterns in abundance and population structure of *Nephrops norvegicus* and *Parapenaeus longirostris* (Crustacea: Decapoda) along the European Mediterranean coasts*

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SUMMARY: The main characteristics concerning distribution, size structure and total mortality of two of the most important decapod crustaceans of commercial interest in the Mediterranean Sea, *Nephrops norvegicus* and *Parapenaeus longirostris,* are studied along the European Mediterranean coasts. The study is based on data collected during a series of six trawl surveys performed in spring from 1994 to 1999 from the Gibraltar Straits to the Aegean Sea. The population size structure identified in the different geographical sectors is analysed taking into account two bathymetric sectors: continental shelf and upper slope. Differences in *N. norvegicus* population demographic structure among geographical sectors, as well as in total mortality, appear to be highly related to different exploitation levels. Size structure in *P. longirostris* also shows a great heterogeneity throughout the different geographical sectors. Considering that both species are heavily exploited all along the studied area, the observed differences can be interpreted as different responses to exploitation related to the widely differing life history characteristics of the mentioned species. In fact, *N. norvegicus* is a long-lived, benthic, burrowing species with low growth and mortality rates, and *P. longirostris* an epibenthic short-lived species characterised by higher rates of growth and mortality.

Key words: *Nephrops norvegicus*, *Parapenaeus longirostris*, distribution, population structure, Mediterranean Sea.

INTRODUCTION

The Norway lobster *Nephrops norvegicus* and the deep-water pink shrimp *Parapenaeus longirostris* are two of the main target species of the commercial fisheries in the Mediterranean continental shelf and upper slope and have been the subject of important biological and fishery studies (e.g. Ardizzone *et al*., 1990; Maynou and Sardà, 1997; Maynou *et al*., 1996; Sardà, 1995, 1998a,b; Sardà and Lleonart, 1993; Tom *et al*. 1988; Tursi *et al.*, 1998). Their population dynamics have been thoroughly studied and overexploitation of the *N. norvegicus* stocks has been reported for some areas of the Mediterranean (Abella *et al*., 1999; Jukic, 1971, 1974; Levi and Giannetti, 1973; Sardà and Abelló, 1984; Sardà, 1998c; Sardà *et al*., 1998), while in some other fishing grounds the species is

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exposed to a lower fishing pressure (Abella and Righini, 1998). Since the life histories of the two species show different characteristics, especially concerning their lifespan and growth rates, the study of their different responses to exploitation will be of valuable interest.

Nephrops norvegicus is a sedentary lobster which inhabits burrows constructed in muddy substrates throughout the continental shelf and upper slope of the north-eastern Atlantic and Mediterranean (Farmer, 1975; Chapman, 1980; Froglia and Gramitto, 1981). The species spends large periods of time inside the burrows, from which it emerges periodically giving rise to diurnal and seasonal fluctuations in the catches (Jukic, 1971, 1974; Atkinson and Naylor, 1976; Chapman and Howard, 1979; Naylor, 1988). In some areas characterised by a wide continental shelf, such as the Adriatic Sea or close to the Ebro delta in the western Mediterranean, populations of *N. norvegicus* are usually found much shallower than in most other areas and have been the object of several biological and ecological studies (Gauss-Garady, 1912; Pesta, 1918; Karlovac, 1953; Abelló *et al.*, 1988, 2000; Maynou and Sardà, 1997). The spatial component seems to have an important role in the definition of the species population structure. This is known to take place between different regions throughout their distribution area (Karlovac, 1953; Chapman and Howard, 1988; Tully and Hillis, 1995; Tuck *et al.*, 1997). Patchiness in population structure characteristics has been detected and appears to be related with heterogeneity in the characteristics of the sediment as well as with variations in fishing effort (Fariña *et al.*, 1994; Tully and Hillis, 1995; Maynou *et al.*, 1996).

Parapenaeus longirostris is also one of the most important commercial crustaceans in the Mediterranean. The species inhabits muddy or sandy-muddy bottoms on the upper slope at depths of 150-400 m. Its distribution area encompasses the Mediterranean Sea and the eastern North-Atlantic Ocean (Maurin, 1968; Holthuis, 1987; Ribeiro-Cascalho and Arrobas, 1987; Ardizzone *et al.*, 1990; Sardà, 1995; Sardà *et al.*, 1982; Levi *et al.*, 1995). It shows a marked size-dependent distribution by depth, with small individuals being found at the edge of the continental shelf. Investigations on *P. longirostris* based in trawl surveys have been performed in the Adriatic Sea (Karlovac, 1953) and in some other areas of the Mediterranean (Bombace, 1972; Froglia, 1982; Ardizzone *et al.*, 1990; Tom *et al*. 1988; D'Onghia *et al.*, 1998; Lembo *et al*., 1999, 2000; Mori *et al*., 2000). Some investigations have also been performed along the NW coasts of Africa and off Portugal (e.g. Bravo de Laguna, 1985; Dos Santos, 1998; Ribeiro-Cascalho and Arrobas, 1987; Sobrino and García, 1994).

The aim of the present paper is to analyse the distribution pattern of both *N. norvegicus* and *P. longirostris* along the European Mediterranean coasts, as well as to study the differences in the size structure of their populations related to depth range and geographical sector. All samples were taken during daylight hours, with identical fishing gear, equal fishing procedures, all cruises being performed in the same season (spring), with the coverage of the entire depth range where the species is distributed (Bertrand *et al.*, 2000, 2002). These characteristics of the sampling scheme (homogeneity of sampling gear, season and timing) facilitate the comparison of results among the so widely different geographical areas included in this study but, in the other hand, makes it impossible to analyse any seasonal change in spatial distribution or population structure that are likely to occur.

MATERIAL AND METHODS

The samples analysed originate from a total of 6336 hauls performed during day-light hours between 30 and 800 m in spring (May-June) 1994 to 1999 on board several research vessels within the framework of the European Union research project "MEDITS" (Bertrand *et al.*, 2000, 2002). The surveys took place along the European coasts of the Mediterranean Sea from the Straits of Gibraltar to the Aegean Sea, and extended to Morocco since 1999. The sampling procedures were standardised according to a common protocol. The bottom trawl used had a 4 m vertical opening and a 20 mm codend mesh size. Tows were performed at a speed of 3 knots. A random sampling stratified by depth, with proportional allocation of tows taking into account the area of each depth interval and geographical sector was used. Further details on the survey methodology and defined geographical sectors can be found in Bertrand *et al.* (2000, 2002). In order to analyse the distribution patterns, two depth intervals have been used: shelf (depth <200 m), and slope (depths comprised between 200 and 800 m).

The allocation of trawl stations by geographical sector and year (1994-1999) can be found in Bertrand *et al.* (2000, 2002).Total catch for both

TABLE 1. – Percentage of the total number of occurrences of *N. norvegicus* and *P. longirostris* on the continental shelf and slope in each of the geographical sectors analysed.

Geographical sector	Code	*Nephrops norvegicus* shelf	slope	total occurrences	*Parapenaeus longirostris* shelf	slope	total occurrences	No. samples
Alborán Sea - Alicante - Catalan Sea	ESP	7.5	92.5	159	39.3	60.7	107	614
Morocco	MAR	-	100.0	16	26.7	73.3	30	63
Gulf of Lions – Corsica	FRA	14.2	85.8	169	15.7	84.3	70	548
Sardinia	ITA-M2	0.5	99.5	208	17.4	82.6	201	729
Ligurian, N and Central Tyrrhenian Seas	ITA-M1	3.8	96.2	395	45.6	54.4	399	918
S Tyrrhenian Sea – Sicilian Channel	ITA-M3	1.8	98.2	326	39.1	60.9	470	846
N Adriatic – Slovenia	SLO	-	-	0	-	-	0	8
NE Adriatic – Croatia	HRV	91.5	8.5	59	82.9	17.1	35	151
NW and Central Adriatic Sea	ITA-M5	86.2	13.8	224	55.2	44.8	67	515
SE Adriatic – Albania	ALB	19.2	80.8	52	51.5	48.5	103	160
NW Ionian	ITA-M4	35.3	64.7	320	30.2	69.8	291	876
E Ionian Sea – Argosaronikos	GRC-G2	25.9	74.1	58	48.2	51.8	114	241
N Aegean Sea	GRC-G1	19.5	80.5	118	39.9	60.1	148	344
S Aegean Sea	GRC-G3	7.0	93.0	57	17.5	82.5	126	323

species in the samples was weighed and all individuals counted and measured (carapace length, CL, in mm). Abundance and biomass are presented for each year as mean number of individuals and kg · km^{-2} by depth stratum and geographical sector, respectively.

Size frequency distributions were reconstructed for each sector and depth stratum (shelf/slope). Mean size values have been estimated for every geographical sector and year. Correspondence analysis (Greenacre, 1984) has been applied to size frequency distributions in order to detect assemblages of samples based in the resemblance among their size structure. This is a useful multivariate method to summarise information when gradients, rather than strong groupings are found among samples (Badia and Do Chi, 1976; Bouchard *et al.*, 1986).

In order to obtain an index of fishing pressure exerted on each sector, an analysis of the relative size structure using the length converted catch curve (Pauly, 1983) was performed. The analysis allowed to obtain an estimate of the instantaneous total mortality rate Z. Results for the different areas can be comparable if similar rates of natural mortality are assumed to occur in all the studied sectors. The results of the mentioned analysis can be useful for a better understanding of the causes of observed differences in demographic structure among sectors that can not be explained by environmental conditions. The analysis, however, was performed without distinction of sex. Considering that a single couple of Von Bertalanffy's growth parameters L_{inf} and K were used for each species, this choice may have produced a light overestimation of the Z values obtained. For *Nephrops norvegicus*, values of L_{inf}= 72 mm and K=0.17 were used. In the case of *Parapenaeus longirostris*, chosen values were L_{inf} = 47 mm and K=0.49.

RESULTS

Nephrops norvegicus

Distribution

The presence of *N. norvegicus* was detected in 2161 hauls (470 on the shelf, at depths shallower than 200 m, and 1691 on the continental slope, deeper than 200 m). By computing the percentage occurrence of *N. norvegicus* on the continental shelf and slope for all the geographical sectors considered (Table 1), it can observed that the highest proportions of *N. norvegicus* on the continental shelf were found in the Adriatic Sea, especially in the northern (91.5% of the occurrences) and central sectors, as well as in the E Ionian Sea and Argosaronikos. In the rest of the considered geographical sectors, *N. norvegicus* was mainly found on the continental slope, with the exception of the N Aegean Sea and the Gulf of Lions - Corsica sectors, where a fair proportion of occurrences was found on the shelf.

The highest values of abundance, both in number of individuals and in biomass, were located in the 200-500 m depth stratum, especially in the Catalan Sea, Gulf of Lions, E Corsica, NE and W Sardinia, NE and SW Adriatic, E Ionian Sea and N Aegean Sea (Tables 2 and 3). High densities were also located in the 500-800 m depth stratum, especially so in E Corsica, NE and W Sardinia, E Ligurian and N Tyrrhen-

TABLE 2. – *Nephrops norvegicus*: Mean abundance (individuals km^{-2}) estimated from the MEDITS trawl surveys per depth stratum, geographical sector and year (1994-1999). Not sampled strata are indicated by '*'. Values higher than 800 individuals km^{-2} are presented in bold.

Sector code	Sector	1994 Depth (m)					1995 Depth (m)					1996 Depth (m)				
		10-50	50-100	100-200	200-500	500-800	10-50	50-100	100-200	200-500	500-800	10-50	50-100	100-200	200-500	500-800
111a	Alborán Sea	0	0	0	37	3	0	0	0	56	6	0	0	0	93	3
112a	Alicante	0	0	12	261	57	0	0	0	153	162	0	0	0	216	120
113a	Catalan Sea	0	0	0	**976**	172	0	11	16	**998**	362	0	3	0	**1598**	131
114a	W Morocco	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
114b	E Morocco	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
121a	W Gulf of Lions	0	0	0	514	0	0	1	0	**1842**	171	0	3	0	**1909**	62
121b	E Gulf of Lions	0	0	0	791	104	0	5	0	**1700**	263	0	0	0	**960**	58
131a	NE Corsica	*	0	0	728	549	*	0	0	491	471	*	0	0	**889**	781
131b	SE Corsica	*	0	0	**975**	**1090**	*	0	0	599	255	*	0	0	**989**	**1307**
132a	N Ligurian Sea	0	0	0	132	143	0	0	0	148	61	0	0	0	328	195
132b	E Ligurian Sea	0	0	10	242	482	0	0	3	191	160	0	0	0	459	643
132c	N Tyrrhenian	0	0	0	569	264	0	0	312	373	380	0	0	2	315	557
132d	C Tyrrhenian	0	0	0	129	183	0	0	0	274	200	0	0	3	227	194
133a	SE Sardinia	0	0	0	0	124	0	0	0	4	153	0	0	0	4	87
133b	NE Sardinia	0	0	0	152	290	0	0	0	658	**952**	0	0	0	240	630
133c	N Sardinia	0	0	0	70	22	0	0	0	212	50	0	0	0	421	119
133d	NW Sardinia	0	0	0	76	66	*	0	0	147	142	0	0	0	229	67
133e	W Sardinia	0	0	0	65	0	0	0	0	103	147	0	0	0	134	587
133f	SW Sardinia	0	0	0	202	48	0	0	0	24	367	0	0	0	142	223
133g	S Sardinia	0	0	0	143	7	0	*	0	0	178	0	0	0	229	265
134a	SE Tyrrhenian	0	0	0	55	40	0	0	0	50	45	0	0	2	42	19
134b	SW Tyrrhenian	0	0	0	16	33	0	0	0	27	7	0	0	0	18	4
134c	Sicilian Chan.	0	0	11	127	97	0	0	2	345	82	0	0	6	397	182
211a	N Adriatic Sea	3	0	*	*	*	20	33	*	*	*	0	143	*	*	*
211b	Central Adriatic	0	0	133	559	0	0	192	479	564	0	0	166	554	461	273
211c	N Adriatic-Slov	*	0	*	*	*	0	*	*	*	*	0	*	*	*	*
211d	NE Adri Croatia	*	0	*	*	*	*	*	*	*	*	0	68	209	**4910**	*
221a	E Sicily	0	0	0	4	0	0	0	0	16	19	0	0	0	0	0
221b	NW Ionian Sea	0	0	0	0	127	0	0	0	3	63	0	0	0	8	33
221c	N Ionian Sea	0	0	0	112	14	0	0	0	101	3	0	0	0	44	17
221d	N Ionian Sea	*	0	12	66	101	0	0	62	135	23	0	19	108	161	23
221e	SW Adriatic	0	0	0	115	84	*	0	3	280	2	0	0	90	716	21
221f	SW Adriatic	0	0	42	55	29	0	0	12	148	10	0	7	80	222	0
221g	SW Adriatic	0	0	21	*	129	0	15	209	*	30	0	33	433	*	59
221h	SW Adriatic	0	0	3	0	155	0	22	47	0	319	0	11	241	10	41
221i	SE Adriatic	*	0	*	*	*	*	*	*	*	*	0	0	28	140	81
222a	E Ionian Sea	0	0	0	**861**	0	0	0	0	520	0	0	0	8	375	0
223a	Argosaronikos	0	0	0	272	0	0	0	0	263	0	0	0	87	229	0
224a	N Aegean Sea	0	0	3	**803**	174	0	14	7	239	10	0	8	31	333	14
225a	S Aegean Sea	0	0	0	3	0	0	0	0	158	18	0	0	15	74	3

Sector code	Sector	1997 Depth (m)					1998 Depth (m)					1999 Depth (m)				
		10-50	50-100	100-200	200-500	500-800	10-50	50-100	100-200	200-500	500-800	10-50	50-100	100-200	200-500	500-800
111a	Alborán Sea	0	0	0	212	3	0	0	0	38	15	0	0	0	62	3
112a	Alicante	0	0	0	414	181	0	0	0	425	74	0	0	3	155	48
113a	Catalan Sea	0	0	0	**1569**	259	0	0	3	*	10	0	1	2	530	46
114a	W Morocco	*	*	*	*	*	*	*	*	*	*	0	0	0	74	0
114b	E Morocco	*	*	*	*	*	*	*	*	*	*	0	0	0	337	0
121a	W Gulf of Lions	0	6	0	**946**	80	0	4	365	788	50	0	2	0	**1271**	206
121b	E Gulf of Lions	0	0	0	308	0	0	0	0	**1417**	25	0	0	0	**1752**	*
131a	NE Corsica	*	0	*	259	258	*	0	9	**923**	328	*	0	0	**1467**	662
131b	SE Corsica	*	0	354	897	*	*	0	0	**1813**	**1091**	*	0	0	**1131**	622
132a	N Ligurian Sea	0	0	0	239	298	0	0	0	289	176	0	0	11	390	105
132b	E Ligurian Sea	0	0	0	471	355	0	0	1	734	520	0	0	1	612	97
132c	N Tyrrhenian	0	0	6	336	281	0	0	12	407	509	0	0	10	369	255
132d	C Tyrrhenian	0	0	0	147	68	0	0	0	230	153	0	0	0	197	94
133a	SE Sardinia	0	0	0	0	122	0	0	0	8	182	0	0	0	10	32
133b	NE Sardinia	0	0	0	64	325	0	0	0	57	770	0	0	0	60	220
133c	N Sardinia	0	0	0	397	234	0	0	0	232	33	0	0	0	180	218
133d	NW Sardinia	0	0	0	127	12	0	0	6	135	108	0	0	0	20	30
133e	W Sardinia	0	0	0	79	221	0	0	0	400	710	0	0	0	619	**1189**
133f	SW Sardinia	0	0	0	62	23	0	0	0	53	59	0	0	0	12	17
133g	S Sardinia	0	0	0	134	81	0	0	0	36	52	0	0	0	114	24
134a	SE Tyrrhenian	0	0	0	63	48	0	0	0	146	34	0	0	0	143	35
134b	SW Tyrrhenian	0	0	0	24	6	0	0	0	48	8	0	0	0	32	37
134c	Sicilian Chan.	0	0	0	187	48	0	0	0	232	45	0	0	8	312	103

TABLE 2 (Cont.). – *Nephrops norvegicus*: Mean abundance (individuals km^{-2}) estimated from the MEDITS trawl surveys per depth stratum, geographical sector and year (1994-1999). Not sampled strata are indicated by '*'. Values higher than 800 individuals km^{-2} are presented in bold.

		1997 Depth (m)					1998 Depth (m)					1999 Depth (m)				
Sector code	Sector	10-50	50-100	100-200	200-500	500-800	10-50	50-100	100-200	200-500	500-800	10-50	50-100	100-200	200-500	500-800
211a	N Adriatic Sea	0	65	*	*	*	0	52	*	*	*	0	200	*	*	*
211b	Central Adriatic	0	16	250	442	29	0	67	730	471	*	0	47	297	101	*
211c	N Adriatic-Slov	0	*	*	*	*	0	*	*	*	*	0	*	*	*	*
211d	NE Adri Croatia	0	84	26	**2179**	*	0	174	72	664	*	0	*	*	*	*
221a	E Sicily	0	0	0	4	0	0	0	0	4	31	0	0	0	22	47
221b	NW Ionian Sea	0	0	0	0	45	0	0	0	7	11	0	0	0	15	36
221c	N Ionian Sea	0	0	55	200	0	0	0	74	170	0	0	0	118	131	0
221d	N Ionian Sea	0	0	60	174	56	0	0	512	491	36	0	23	91	368	4
221e	SW Adriatic	0	7	22	260	0	0	22	5	319	0	0	15	0	295	0
221f	SW Adriatic	0	7	66	**1219**	0	0	8	73	385	0	0	7	72	537	0
221g	SW Adriatic	0	46	14	*	14	0	0	48	*	48	0	15	0	*	54
221h	SW Adriatic	0	65	13	82	67	0	59	49	51	9	0	69	3	139	14
221i	SE Adriatic	0	0	2	62	20	0	0	19	111	30	0	2	72	41	49
222a	E Ionian Sea	0	0	0	679	0	0	2	0	264	11	0	0	0	47	35
223a	Argosaronikos	0	23	15	125	16	0	0	18	35	221	0	0	40	79	508
224a	N Aegean Sea	0	11	38	340	80	0	0	20	271	129	0	4	32	251	120
225a	S Aegean Sea	0	0	10	33	43	0	0	5	85	52	0	0	0	83	79

TABLE 3. – *Nephrops norvegicus*: Mean biomass (kg km^{-2}) estimated from the MEDITS trawl surveys per depth stratum, geographical sector and year (1994-1999). Not sampled strata are indicated by '*'. Values higher than 25 kg km^{-2} are presented in bold.

		1994 Depth (m)					1995 Depth (m)					1996 Depth (m)				
Sector code	Sector	10-50	50-100	100-200	200-500	500-800	10-50	50-100	100-200	200-500	500-800	10-50	50-100	100-200	200-500	500-800
111a	Alborán Sea	0	0	0	2.2	0.1	0	0	0	2.8	0.4	0	0	0	6.2	0.2
112a	Alicante	0	0	0.8	4.7	1.9	0	0	0	4.8	7.6	0	0	0	10.0	3.7
113a	Catalan Sea	0	0.2	0	21.7	4.9	0	0.7	0.4	20.3	11.4	0	0.5	0	**40.3**	3.4
114a	W Morocco	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
114b	E Morocco	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
121a	W Gulf of Lions	0	0	0	17.3	0	0	0.1	0	**49.1**	7.0	0	0.1	0	**49.7**	1.8
121b	E Gulf of Lions	0	0	0	**30.8**	5.0	0	0.3	0	**74.4**	8.8	0	0	0	**43.2**	3.5
131a	NE Corsica	*	0	0	**34.7**	14.9	*	0	0	22.3	14.4	*	0	0	**40.1**	**27.5**
131b	SE Corsica	*	0	0	**39.9**	**42.0**	*	0	0	**25.4**	6.0	*	0	0	**49.9**	**59.1**
132a	N Ligurian Sea	0	0	0	7.5	4.7	0	0	0	5.4	2.6	0	0	0	11.3	7.8
132b	E Ligurian Sea	0	0	0.5	11.7	17.0	0	0	0.2	8.2	5.6	0	0	0	20.0	**25.3**
132c	N Tyrrhenian	0	0	0	**33.7**	8.5	0	0	6.8	12.8	10.4	0	0	0.1	8.9	15.5
132d	C Tyrrhenian	0	0	0	4.7	6.9	0	0	0	8.4	7.1	0	0	0.1	7.1	7.1
133a	SE Sardinia	0	0	0	0	2.5	0	0	0	0.1	4.5	0	0	0	0.2	2.7
133b	NE Sardinia	0	0	0	7.6	12.0	0	0	0	**28.4**	**37.8**	0	0	0	8.9	23.4
133c	N Sardinia	0	0	0	4.4	1.1	0	0	0	10.6	2.0	0	0	0	18.2	4.0
133d	NW Sardinia	0	0	0	2.7	2.7	*	0	0	6.3	6.6	0	0	0	5.5	2.9
133e	W Sardinia	0	*	0	2.4	0	0	0	0	4.8	6.0	0	0	0	5.3	24.3
133f	SW Sardinia	0	0	0	8.7	2.7	0	0	0	1.0	13.2	0	0	0	4.8	7.3
133g	S Sardinia	0	0	0	9.3	0.2	0	*	0	0	7.8	0	0	0	11.4	11.5
134a	SE Tyrrhenian	0	0	0	2.4	1.3	0	0	0	2.0	1.7	0	0	0.0	1.7	0.6
134b	SW Tyrrhenian	0	0	0	0.9	1.7	0	0	0	1.4	0.2	0	0	0	1.6	0.5
134c	Sicilian Chan.	0	0	0.2	3.9	4.0	0	0	0.0	7.9	2.9	0	0	0.3	9.0	6.0
211a	N Adriatic Sea	0.4	0.1	*	*	*	2.1	2.6	*	*	*	0.2	5.5	*	*	*
211b	Central Adriatic	0	0.7	2.8	16.3	0	0	7.1	9.5	11.3	0	0.3	5.1	9.3	9.7	13.5
211c	N Adriatic-Slov	*	*	*	*	*	0	*	*	*	*	0	*	*	*	*
211d	NE Adri Croatia	*	*	*	*	*	*	*	*	*	*	1.8	2.6	6.4	**82.1**	*
221a	E Sicily	0	0	0	1.0	0	0	0	0	1.0	0.8	0	0	0	0	0
221b	NW Ionian Sea	0	0	0	0	8.4	0	0	0	0.1	4.6	0	0	0	0.2	2.3
221c	N Ionian Sea	0	0	0	5.1	0.6	0	0	0	2.7	0.1	0	0	0	1.2	0.7
221d	N Ionian Sea	*	0	0.1	1.4	3.4	0	0	3.6	2.8	0.9	0	0.2	5.5	2.6	1.0
221e	SW Adriatic	0	0	0	4.1	2.8	*	0	0.0	6.7	0.2	*	0	1.7	15.3	0.9
221f	SW Adriatic	0	0	1.9	2.0	0.5	0	0	0.8	9.6	0.4	0	0.2	4.8	10.5	0
221g	SW Adriatic	0	0	0.6	*	6.9	0	1.4	4.7	*	0.8	0	2.8	10.7	*	2.1
221h	SW Adriatic	0	1.5	0.1	0	6.1	0	1.4	1.0	0	10.1	0.2	0.6	4.8	0.5	1.4
221i	SE Adriatic	*	*	*	*	*	*	*	*	*	*	0	0	0.9	5.4	3.1
222a	E Ionian Sea	0	0	0	15.5	0	0	0	0	**30.7**	0	0	0	0.2	13.4	0
223a	Argosaronikos	0	0	0	8.5	0	0	0	0	11.0	0	0	0	2.3	8.1	0
224a	N Aegean Sea	0	0.4	0.0	24.2	10.2	0	1.0	0.2	10.8	1.1	1.5	0.6	1.0	13	1.0
225a	S Aegean Sea	0	0	0	0.4	0	0	0	0	5.0	0.9	0	0	0.4	3.2	0.1

TABLE 3 (Cont.). – *Nephrops norvegicus*: Mean biomass (kg km^{-2}) estimated from the MEDITS trawl surveys per depth stratum, geographical sector and year (1994-1999). Not sampled strata are indicated by '*'. Values higher than 25 kg km^{-2} are presented in bold.

Sector code	Sector	1997 Depth (m)					1998 Depth (m)					1999 Depth (m)				
		10-50	50-100	100-200	200-500	500-800	10-50	50-100	100-200	200-500	500-800	10-50	50-100	100-200	200-500	500-800
111a	Alborán Sea	0	0	0	8.7	0.2	0	0	0	1.6	0.3	0	0	0	2.2	0.2
112a	Alicante	0	0	0	11.3	8.4	0	0	0	11.7	1.8	0	0	0.2	4.8	1.7
113a	Catalan Sea	0	0	0	**35.6**	7.1	0	0	0.2	*	0.1	0	0.2	0.4	8.2	1.2
114a	W Morocco	*	*	*	*	*	*	*	*	*	*	*	0	0	6.1	0
114b	E Morocco	*	*	*	*	*	*	*	*	*	*	0	0	0	12.1	0
121a	W Gulf of Lions	0.2	0.4	0	**28.4**	1.5	0	0.2	8.8	**44.5**	1.1	0	0.1	0	**46**	5.7
121b	E Gulf of Lions	0	0	0	9.7	0	0	0	0	**41.7**	0.3	0	0	0	**85.3**	*
131a	NE Corsica	*	0	*	14.3	7.9	*	0	0.6	**30.8**	9.1	*	0	0	**36.0**	24.2
131b	SE Corsica	*	0	**25.5**	**45.8**	*	*	0	0	**81.4**	**36.5**	*	0	0	**51.0**	**26.0**
132a	N Ligurian Sea	0	0	0	8.6	9.8	0	0	0	9.7	4.7	0	0	0.1	16.2	3.4
132b	E Ligurian Sea	0	0	0	18.2	14.4	0	0	0.0	**26.2**	20.9	0	0	0.0	22.7	3.7
132c	N Tyrrhenian	0	0	0.1	12.6	9.9	0	0	0.6	14.7	15.3	0	0	0.7	12.4	8.4
132d	C Tyrrhenian	0	0	0	4.9	2.3	0	0	0	8.1	6.7	0	0	0	7.5	3.8
133a	SE Sardinia	0	0	0	0	5.2	0	0	0	0.6	6.9	0	0	0	1.2	2.1
133b	NE Sardinia	0	0	0	2.5	10.3	0	0	0	2.9	**33.8**	0	0	0	3.9	8.7
133c	N Sardinia	0	0	0	16.4	4.1	0	0	0	10.2	1.6	0	0	0	9.2	11.4
133d	NW Sardinia	0	0	0	5.4	0.4	0	0	0.6	4.3	3.3	0	0	0	0.5	0.8
133e	W Sardinia	0	0	0	4.2	9.2	0	0	0	15.4	**27.7**	0	0	0	22.8	**54.5**
133f	SW Sardinia	0	0	0	2.0	0.6	0	0	0	2.0	2.7	0	0	0	0.5	0.6
133g	S Sardinia	0	0	0	6.7	4.5	0	0	0	2.7	2.2	0	0	0	5.1	1.1
134a	SE Tyrrhenian	0	0	0	2.6	1.9	0	0	0	5.1	1.2	0	0	0	5.2	1.3
134b	SW Tyrrhenian	0	0	0	0.8	0.3	0	0	0	2.4	0.4	0	0	0	1.7	0.9
134c	Sicilian Chan.	0	0	0	4.1	1.7	0	0	0	6.2	2.0	0	0	0.4	9.0	4.1
211a	N Adriatic Sea	1.5	2.5	*	*	*	0.2	2.6	*	*	*	0.3	6.9	*	*	*
211b	Central Adriatic	0	0.6	4.4	10.4	2.7	0.1	3.0	10.0	11.0	*	0.1	2.1	4.7	1.7	*
211c	N Adriatic-Slov	0	*	*	*	*	0	*	*	*	*	0	*	*	*	*
211d	NE Adri Croatia	0.8	2.7	0.7	21.4	*	0	4.9	1.2	17.7	*	0	*	*	*	*
221a	E Sicily	0	0	0	0.1	0	0	0	0	0.2	2.4	0	0	0	4.0	4.8
221b	NW Ionian Sea	0.2	0	0	0	3.9	0	0	0	0.2	0.4	0	0	0	1.2	1.6
221c	N Ionian Sea	0	0	1.1	3.3	0	0	0	1.1	3.8	0	0	0	2.3	2.4	0
221d	N Ionian Sea	0	0	2.0	3.8	2.2	0	0	13.7	5.4	0.8	0	0.1	1.7	5.9	0.1
221e	SW Adriatic	*	0.3	0.7	5.7	0	*	0.8	0.2	6.1	0	*	0.5	0	10.6	0
221f	SW Adriatic	0	0.3	2.9	15.1	0	0	0.6	3.1	12.0	0	0	0.5	2.1	16.0	0
221g	SW Adriatic	0	1.4	0.5	*	1.2	0	0	1.4	*	4.6	0	0.4	0	*	3.5
221h	SW Adriatic	0	2.1	2.5	1.3	4.0	0	1.9	1.3	1.2	0.6	0	1.8	0.1	3.2	1.5
221i	SE Adriatic	0	0	0.0	1.6	1.4	0	0	0.7	3.9	1.4	0	0.1	0.7	1.3	3.0
222a	E Ionian Sea	0	0	0	**24.9**	0	0	0.1	0	8.9	0.7	0	0	0	1.8	2.7
223a	Argosaronikos	0	1.1	0.4	4.6	0.5	0	0	0.6	1.3	9.4	0	0	1.0	3.3	20.9
224a	N Aegean Sea	0	0.7	1.1	14.8	7.3	0	0	0.5	9.2	7.9	0	0.4	0.9	9.7	9.4
225a	S Aegean Sea	0	0	0.4	1.7	2.2	0	0	0.3	3.6	2.1	0	0	0	3.1	3.4

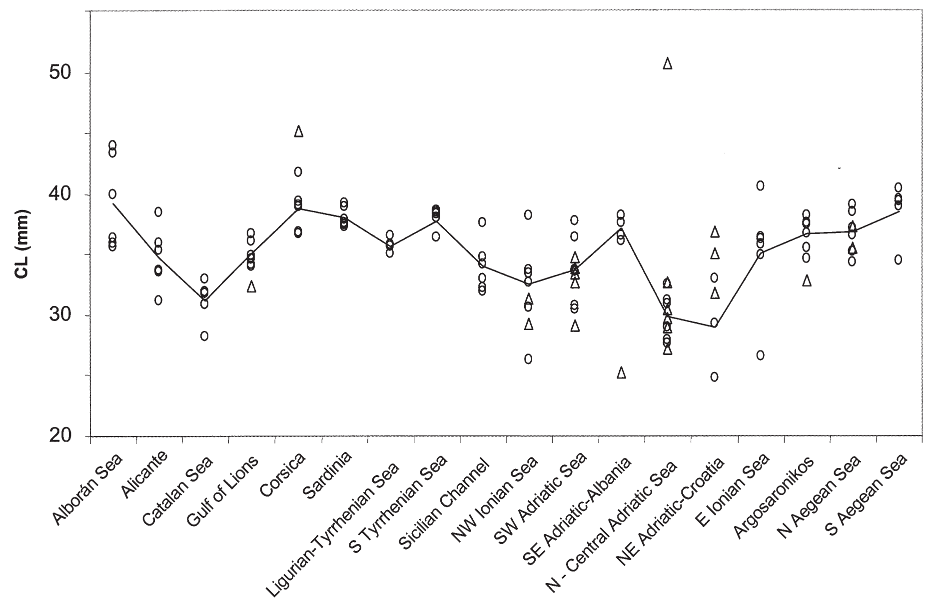

FIG. 1. – Mean sizes (CL, in mm) of *Nephrops norvegicus* obtained in 1994-1999 in the different geographical sectors.Triangle: shelf samples; open circle: slope samples. The black line follows the mean values of the slope populations.

ian Seas. In the Adriatic Sea, the highest densities were also located on the 200-500 m depth stratum, but important densities were also located on the shelf. Interannual fluctuations in recorded densities were high, but in general, the patterns were similar throughout the years within each geographical sector.

Population size structure

Figure 1 shows the mean size of *N. norvegicus* obtained in the different years in each geographical sector, separately for the shelf and slope. Data analysed refer to sample sizes larger than 20 individuals. Some increasing-decreasing trends can be observed between different geographically adjacent zones. Thus, a clearly decreasing trend in mean size of the individuals from the slope is found along the Spanish Mediterranean waters from the Alborán Sea towards the East, through Alicante and the Catalan Sea. Mean size clearly increases from the Catalan Sea to the Gulf of Lions and Corsica. The mean size in Sardinia is similar to that of Corsica. The Ligurian-Tyrrhenian Sea has slightly smaller sizes whereas mean size in the S Thyrrenian Sea increases slightly. There is also a clear decreasing trend from the S Thyrrenian Sea passing through the Sicilian Channel to NW Ionian Sea. In the Adriatic Sea, the smallest mean sizes are found in the N-Central Adriatic (Italy) and in the NE Adriatic (Croatia) and the largest ones in the SW Adriatic (Italy) and the SE (Albania). In Greek waters, an increasing trend in mean size can be found from the E Ionian Sea to the S Aegean Sea through Argosaronikos and the N Aegean Sea.

Correspondence analysis has been applied to the matrix of size frequency distributions by geographical sector. As an example, Figure 2 shows the results of the analyses for two representative years: 1997 and 1999. Only samples larger than 60 individuals were analysed. Samples and size classes are presented in relation to the first two inertia axes. Correlative size classes are strongly associated to the first inertia axis and are found along a gradient. Samples (geographical sectors) are also found associated to the gradient of sizes. Thus, some sectors are found associated to large sizes, such as Corsica and the N Aegean in 1997 and S Adriatic-Albania, N Aegean, Sardinia, Corsica and S Aegean in 1999. Other geographical sectors appear associated to small sizes, such as N Adriatic (Croatia and Italy (both shelf and slope)), Sicily Channel and Catalan Sea in 1997 and Catalan Sea, N Ionian, N Adriatic

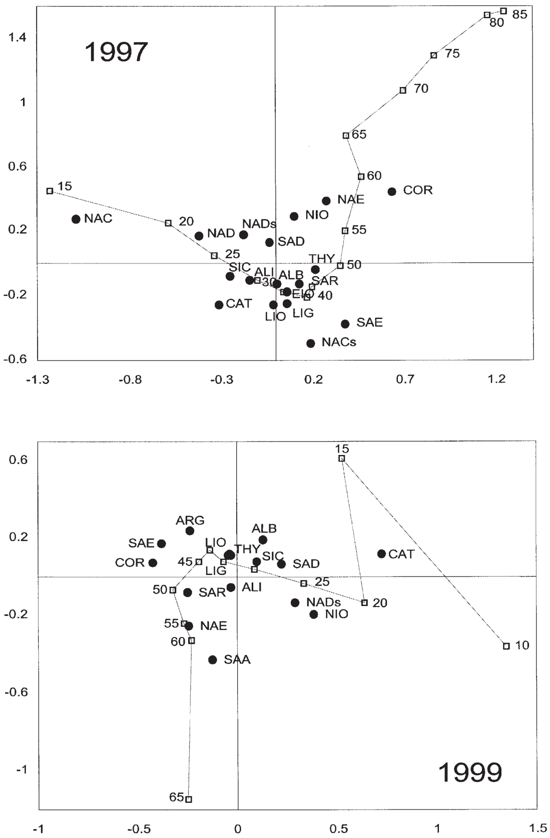

FIG. 2. – *Nephrops norvegicus*: Correspondence analysis. Ordination of the samples and size classes as a function of the first two inertia axes. Samples obtained in 1997 and 1999 are presented as an example. Squares correspond to sizes; black circles to samples. ALB: Alborán Sea, ALI: Alicante sector, CAT: Catalan Sea, MOR: Morocco, LIO: Gulf of Lions, COR: Corsica, LIG: Ligurian-Thyrrenian Sea, SAR: Sardinia, THY: S Thyrrenian Sea, NAD: N-Central Adriatic, NAC: N Adriatic – Croatia, NIO: NW Ionian Sea, SAD: S Adriatic, SAA: S Adriatic –Albania, EIO: E Ionian Sea, ARG: Argosaronikos, NAE: N Aegean, SAE: S Aegean. NACs and NADs correspond to shelf samples.

shelf and S Adriatic) in 1999. Clearly, areas such as the N Adriatic and the Catalan Sea, among others, although geographically isolated and quite distant, are close-by placed in the analyses, indicating that their size structure was similar.

Mortality estimates

The estimates of total mortality derived from the analysis of the length transformed catch curve (Table 4) are shown in Figure 3. Total mortality was found significantly ($p<0.05$) and negatively correlated with the mean size obtained in each of the geographical sectors (Fig. 4). High mortality related to small mean sizes was particularly evident in the Catalan Sea, whereas the inverse relationship was found in the Alborán Sea and Corsica.

TABLE 4. – Total mortality estimates (Z) for *Nephrops norvegicus* in the different years and Mediterranean Sea subareas sampled, based on population size structure. sd= standard deviation; CV= coefficient of variation (%).

	1994	1995	1996	1997	1998	1999	average	sd	CV	n
Alborán Sea	-	-	0.71	0.58	0.53	-	0.61	0.09	3.10	3
Alicante	0.95	0.82	0.91	0.98	1.51	1.19	1.06	0.27	4.55	6
Catalan Sea	-	1.86	1.29	1.47	1.70	1.54	1.57	0.22	4.36	5
Gulf of Lions	0.90	0.84	0.89	1.29	0.97	0.77	0.94	0.18	3.04	6
Corsica	0.87	0.49	0.76	0.41	0.70	0.81	0.67	0.18	3.06	6
Ligurian N Tyrrh	0.94	0.88	0.90	0.94	0.94	0.86	0.91	0.04	0.59	6
Sardinia	0.80	0.89	0.88	0.75	0.90	0.90	0.85	0.06	1.05	6
S Tyrrhenian	0.89	0.89	0.64	0.79	0.58	0.84	0.77	0.13	2.20	6
Sicilian channel	0.77	0.85	0.92	1.28	1.01	0.80	0.94	0.19	3.14	6
NC Adriatic	0.91	1.17	0.61	0.62	0.81	-	0.82	0.23	4.53	5
NE Adriatic	-	-	-	-	-	-	-	-	-	-
NW Ionian	0.58	0.70	0.61	0.69	0.93	0.73	0.71	0.12	2.06	6
SW Adriatic	-	0.94	0.68	0.49	0.67	0.56	0.67	0.19	3.70	5
SE Adriatic	-	-	0.61	0.80	0.72	-	0.71	0.10	1.59	6
E Ionian	-	1.14	0.66	0.91	1.03	-	0.94	0.21	5.15	4
Argosaronikos	-	-	-	-	-	0.48	0.48	-	-	-
N Aegean	0.70	0.48	0.58	0.45	0.50	0.50	0.54	0.09	1.53	6
S Aegean	-	-	-	-	-	-	-	-	-	-

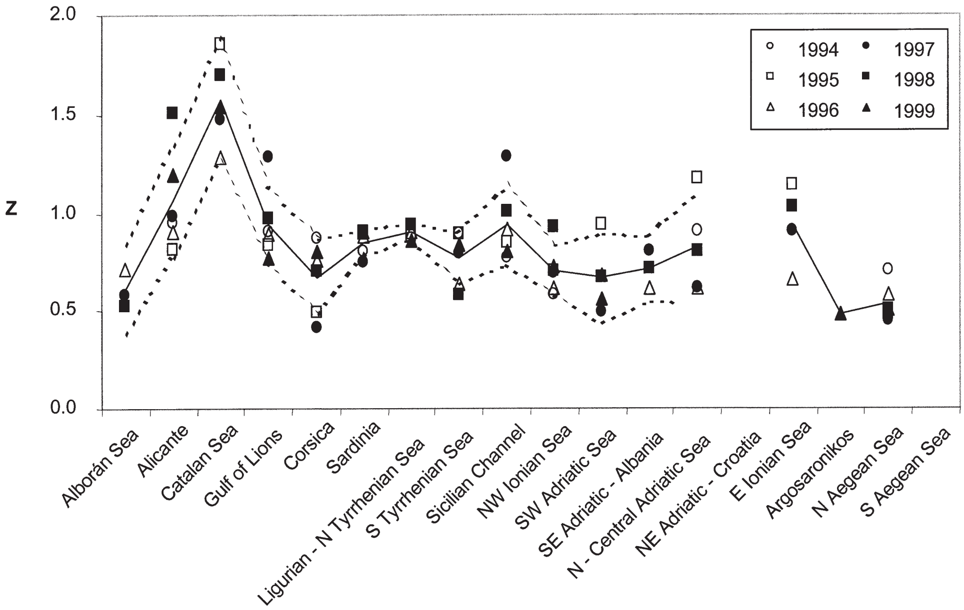

FIG. 3. – Total mortality (Z) estimates for *Nephrops norvegicus* in the different years (1994-1999) and geographical sectors studied. Lines indicate mean values (black line) and 95% confidence intervals (dotted lines).

The estimated mortality rates seem coherent with the available information on fleet importance and exerted fishing pressure in each sector. For each sector, estimates of Z in different years have shown very small differences, making results more reliable and suggesting equilibrium situations related to fishing effort and stable population structures. Sectors such as the Alborán Sea, Corsica, Argosaronikos and N Aegean showed lower values of total mortality and these findings look consistent with the modest fishing pressure on *Nephrops* that, according to available information, is exerted in the mentioned areas. An increase from West to East in total mortality (as well as in number of boats per unit area) is observed for the three contiguous sectors of the Spanish coast. The highest Z values were found in the Catalan Sea, in which a high fishing pressure on the species is recorded. This positive trend is very coherent with the negative trend observed in mean size along the three sectors (Fig. 4). For some sectors, the samples were too small and did not allow a proper estimation of Z.

Some contrasts found in some sectors between mortality rates and available information on exerted fishing pressure can be explained by a lacking of homogeneity inside them. This phenomenon may

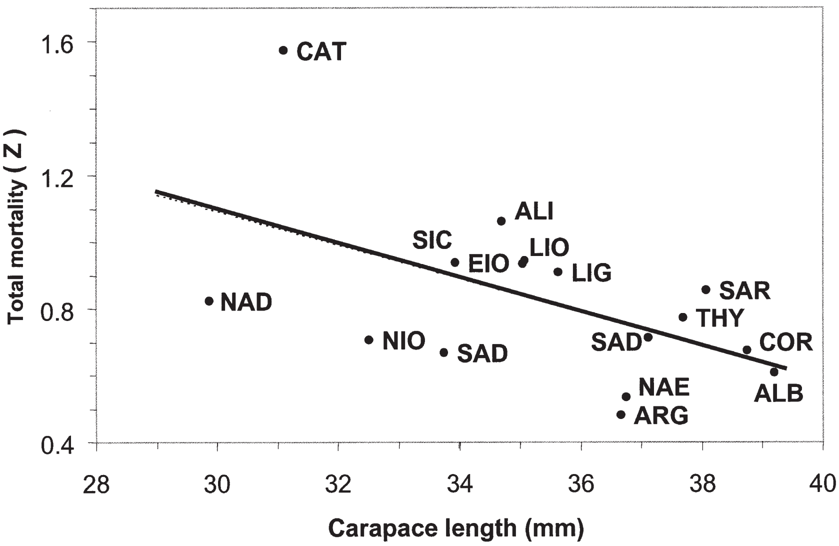

FIG. 4. – Relationship between mean carapace length and mean total mortality (Z) estimates for *Nephrops norvegicus* upper slope populations (200-500 m depth strata) for the different geographical sectors.

depend on the environmental characteristics or on the spatial distribution of fishing pressure inside a sector. For instance, the northern portion of the Ligurian-North Tyrrhenian sector is characterised by a very narrow shelf. The shelf becomes wider towards the south (especially around the Tuscan archipelago area). In the southern portion, more suitable grounds for the species are present and they occupy larger surfaces. Inside the mentioned sector, many fleets from several ports do operate. These fleets, of quite different importance, exert their fishing pressure on the grounds positioned inside the sector, especially on those closer to the ports from which they come from. In consequence, some fishing grounds (or some sub-sectors) will be more highly exploited than others.

Parapenaeus longirostris

Distribution

A total of 2161 presences of *P. longirostris* (805 caught at depths shallower than 200 m, and 1356 deeper than 200 m) have been analysed. The percentage occurrence of *P. longirostris* on the continental shelf and slope for all the considered geographical sectors (Table 1), shows that the species was mainly found on the continental shelf in the N, Central and SE Adriatic Sea and in the E Ionian Sea-Argosaronikos, whereas in the rest of the considered geographical sectors, *P. longirostris* was mainly found on the continental slope, especially so in the Gulf of Lions-Corsica, Sardinia and S Aegean Sea.

Overall, very low densities were found in the western Mediterranean, whereas the highest values were found in the Central and Eastern Mediterranean. Bathymetrically, the highest values of abundance in number of individuals were located in the 100-200 m and 200-500 m depth stratum, especially off Sardinia, S Tyrrhenian, Sicilian Channel, E Sicily, NW and E Ionian Sea, Argosaronikos and Aegean Sea (Tables 5 and 6). Biomasses were, however, usually higher in the 200-500 m depth stratum than in the 100-200 m stratum, in accordance with the depth-related size trend found in this species. Interannual variability was high and there seems to be a general increasing trend in the abundance of the species throughout the study period (Table 5).

Population size structure

Figure 5 shows the mean size of *P. longirostris* obtained in the different years in each geographical sector, separately for shelf and slope subgroups. Mean sizes on the shelf were clearly smaller than on the slope. No clear-cut trends can be found among the different geographical zones, except for the fact that the smallest mean sizes were found in the waters around Sicily and in the Greek sectors. In the western Mediterranean and Adriatic Sea, the mean sizes on the slope were higher than in the previously mentioned sectors.

As for *Nephrops*, correspondence analysis was applied to the matrix of size frequency distributions by geographical sector. Figure 6 shows the results of the analysis for two representative years: 1997 and

TABLE 5. – *Parapenaeus longirostris*: Mean abundance (individuals km^{-2}) estimated from the MEDITS trawl surveys per depth stratum, geographical sector and year (1994-1999). Not sampled strata are indicated by '*'. Values higher than 1000 individuals km^{-2} are presented in bold.

Sector code	Sector	1994 Depth (m)					1995 Depth (m)					1996 Depth (m)				
		10-50	50-100	100-200	200-500	500-800	10-50	50-100	100-200	200-500	500-800	10-50	50-100	100-200	200-500	500-800
111a	Alborán Sea	0	0	0	6	0	0	87	120	50	0	0	0	172	278	0
112a	Alicante	0	8	62	67	0	0	11	48	120	0	0	0	414	47	0
113a	Catalan Sea	0	0	0	13	0	0	0	0	5	0	0	0	0	18	0
114a	W Morocco	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
114b	E Morocco	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
121a	W Gulf of Lions	0	0	0	16	0	0	0	0	9	2	0	0	0	4	0
121b	E Gulf of Lions	0	0	0	9	0	0	0	5	0	0	0	0	0	0	0
131a	NE Corsica	*	0	0	32	0	*	0	0	104	0	0	0	0	76	3
131b	SE Corsica	*	0	0	152	19	*	0	0	20	0	0	0	0	83	5
132a	N Ligurian Sea	0	0	12	33	1	0	0	13	33	0	0	0	0	63	1
132b	E Ligurian Sea	0	0	21	29	7	0	3	17	40	0	0	0	6	102	0
132c	N Tyrrhenian	0	0	50	204	0	0	0	69	225	0	0	12	87	158	0
132d	C Tyrrhenian	0	14	77	172	7	0	39	121	233	0	0	25	42	153	0
133a	SE Sardinia	0	0	0	157	64	0	0	0	127	0	0	0	0	559	11
133b	NE Sardinia	0	0	0	128	0	0	0	0	142	118	0	0	0	49	8
133c	N Sardinia	0	0	0	6	22	0	0	0	26	0	0	0	48	39	0
133d	NW Sardinia	0	0	0	340	0	*	0	0	168	0	0	0	0	422	0
133e	W Sardinia	0	*	0	76	0	0	0	0	80	86	0	0	0	235	7
133f	SW Sardinia	0	0	76	251	90	0	0	124	96	35	0	0	141	169	29
133g	S Sardinia	0	0	0	113	3	0	*	0	242	54	0	0	13	349	0
134a	SE Tyrrhenian	0	0	166	136	2	0	86	417	143	0	0	19	350	127	0
134b	SW Tyrrhenian	0	0	425	513	172	0	58	**1674**	552	77	0	45	**1252**	208	9
134c	Sicilian Chan.	0	88	**1817**	**2013**	54	0	517	**1686**	**2961**	28	0	608	**5928**	**3637**	42
211a	N Adriatic Sea	3	0	*	*	*	20	2	*	*	*	0	0	*	*	*
211b	Central Adriatic	0	0	0	134	0	0	0	47	215	0	0	0	38	470	118
211c	N Adriatic-Slov	*	*	*	*	*	0	*	*	*	*	0	*	*	*	*
211d	NE Adri Croatia	*	*	*	*	*	*	*	*	*	*	0	8	231	631	*
221a	E Sicily	0	253	331	892	0	0	76	**1444**	990	0	0	**1493**	**2610**	**4238**	0
221b	NW Ionian Sea	0	0	**1353**	**4322**	65	0	66	**1319**	**6692**	111	0	**2581**	984	**2635**	97
221c	N Ionian Sea	0	0	643	**1298**	18	0	0	325	**2121**	0	0	0	237	569	10
221d	N Ionian Sea	*	0	245	**1513**	106	0	0	206	**3442**	9	0	0	34	**1474**	1
221e	SW Adriatic	0	0	0	70	32	*	0	10	245	0	0	0	64	192	3
221f	SW Adriatic	0	0	0	22	0	0	0	0	25	0	0	0	0	56	0
221g	SW Adriatic	0	0	4	*	0	0	0	0	*	0	0	0	0	*	0
221h	SW Adriatic	0	0	3	54	3	0	0	0	0	2	0	0	6	6	3
221i	SE Adriatic	*	*	*	*	*	*	*	*	*	*	0	745	**3541**	**6052**	156
222a	E Ionian Sea	0	9	0	878	0	0	0	210	629	0	0	108	**1195**	**2789**	0
223a	Argosaronikos	0	0	0	301	0	0	**5042**	**1801**	774	0	0	165	**13307**	**3683**	0
224a	N Aegean Sea	0	36	18	333	0	0	200	182	784	3	0	**8067**	**3151**	**3139**	9
225a	S Aegean Sea	0	43	0	533	0	0	108	181	871	23	0	40	**1849**	**4613**	897

Sector code	Sector	1997 Depth (m)					1998 Depth (m)					1999 Depth (m)				
		10-50	50-100	100-200	200-500	500-800	10-50	50-100	100-200	200-500	500-800	10-50	50-100	100-200	200-500	500-800
111a	Alborán Sea	0	29	218	855	0	0	725	**1523**	551	0	0	38	281	392	0
112a	Alicante	0	0	23	100	0	0	0	38	79	2	0	3	238	100	0
113a	Catalan Sea	0	0	0	0	0	0	0	9	*	0	0	0	0	48	0
114a	W Morocco	*	*	*	*	*	*	*	*	*	*	0	**1794**	**4194**	**1760**	7
114b	E Morocco	*	*	*	*	*	*	*	*	*	*	0	0	**13747**	**1766**	0
121a	W Gulf of Lions	0	0	0	3	0	0	1	5	0	0	0	4	0	17	279
121b	E Gulf of Lions	0	0	0	0	0	0	0	0	0	0	0	0	5	7	*
131a	NE Corsica	0	0	*	80	0	0	0	0	116	0	0	0	0	357	0
131b	SE Corsica	0	0	73	21	*	0	0	0	28	0	0	0	0	202	5
132a	N Ligurian Sea	0	0	48	22	0	0	0	499	338	0	0	0	96	443	0
132b	E Ligurian Sea	0	0	31	75	0	0	0	14	271	2	0	3	92	874	0
132c	N Tyrrhenian	0	16	402	142	0	0	27	**1361**	686	1	0	0	680	**1864**	91
132d	C Tyrrhenian	0	200	632	230	2	0	442	**1048**	837	1	0	247	462	**1150**	3
133a	SE Sardinia	0	0	0	885	16	0	0	0	**1147**	45	0	0	667	**1453**	4
133b	NE Sardinia	0	0	0	72	0	0	0	0	185	0	0	0	0	667	0
133c	N Sardinia	0	0	0	182	0	0	0	37	372	0	0	0	158	726	478
133d	NW Sardinia	0	0	80	**1138**	0	0	0	178	**5769**	482	0	0	305	**2532**	13
133e	W Sardinia	0	0	0	**1470**	4	0	0	4	**12153**	529	0	0	0	**1559**	475
133f	SW Sardinia	0	0	933	**1285**	7	0	0	912	**3754**	292	0	0	**1851**	**3752**	293
133g	S Sardinia	0	0	0	**1257**	0	0	0	0	615	44	0	0	195	**5983**	341
134a	SE Tyrrhenian	0	148	**1353**	205	1	0	213	**1429**	537	1	0	413	**2501**	824	3
134b	SW Tyrrhenian	0	251	**2205**	818	51	0	78	**1773**	**1881**	81	0	535	**3732**	**2652**	27
134c	Sicilian Chan.	0	144	**3642**	**2887**	50	0	**1957**	**5670**	**6560**	79	0	**1271**	**8591**	**9661**	94

TABLE 5 (Cont.). – *Parapenaeus longirostris*: Mean abundance (individuals km^{-2}) estimated from the MEDITS trawl surveys per depth stratum, geographical sector and year (1994-1999). Not sampled strata are indicated by '*'. Values higher than 1000 individuals km^{-2} are presented in bold.

		1997 Depth (m)					1998 Depth (m)					1999 Depth (m)				
Sector code	Sector	10-50	50-100	100-200	200-500	500-800	10-50	50-100	100-200	200-500	500-800	10-50	50-100	100-200	200-500	500-800
211a	N Adriatic Sea	0	0	*	*	*	0	0	*	*	*	0	0	*	*	*
211b	Central Adriatic	0	0	31	553	107	0	0	45	448	*	0	5	89	87	*
211c	N Adriatic-Slov	0	*	*	*	*	0	*	*	*	*	0	*	*	*	*
211d	NE Adri Croatia	0	0	133	**1491**	*	0	2	132	**3965**	*	0	*	*	*	*
221a	E Sicily	0	366	**1840**	**1349**	0	0	**2860**	**1530**	**11119**	15	0	0	**4515**	**4133**	0
221b	NW Ionian Sea	0	120	**1661**	**9225**	256	0	**1580**	**2205**	**7488**	52	0	312	**2544**	**2006**	0
221c	N Ionian Sea	0	0	485	**1719**	23	0	0	253	**1810**	14	0	0	203	263	0
221d	N Ionian Sea	0	0	20	**2193**	124	0	0	7	**1251**	64	0	0	23	626	2
221e	SW Adriatic	0	0	8	369	0	0	0	71	129	3	0	0	231	95	0
221f	SW Adriatic	0	0	0	66	0	0	0	20	73	0	0	0	4	387	0
221g	SW Adriatic	0	0	0	*	28	0	0	14	*	0	0	8	112	*	0
221h	SW Adriatic	0	0	0	271	88	0	0	6	195	39	0	0	16	285	43
221i	SE Adriatic	0	233	263	**2821**	315	0	364	**1548**	**3184**	890	0	116	255	908	718
222a	E Ionian Sea	0	14	0	**2350**	48	0	155	**1440**	977	23	0	339	**1520**	**2174**	277
223a	Argosaronikos	0	327	**6208**	**1837**	903	0	19	**2844**	703	247	0	82	**2624**	438	945
224a	N Aegean Sea	0	**3409**	**4904**	**3358**	59	0	**1441**	**4374**	**3499**	111	0	**3453**	**6290**	**6126**	142
225a	S Aegean Sea	0	25	340	**2523**	463	0	0	774	**2220**	942	0	38	**2734**	**4091**	638

TABLE 6. – *Parapenaeus longirostris*: Mean biomass (kg km^{-2}) estimated from the MEDITS trawl surveys per depth stratum, geographical sector and year (1994-1999). Not sampled strata are indicated by '*'. Values higher than 10 kg km^{-2} are presented in bold.

		1994 Depth (m)					1995 Depth (m)					1996 Depth (m)				
Sector code	Sector	10-50	50-100	100-200	200-500	500-800	10-50	50-100	100-200	200-500	500-800	10-50	50-100	100-200	200-500	500-800
111a	Alborán Sea	0	0	0	0.1	0	0	0.1	1.0	0.5	0	0	0	0.6	2.4	0
112a	Alicante	0	0.1	0.2	0.8	0	0	0.0	0.3	1.3	0	0	0	3.3	0.4	0
113a	Catalan Sea	0	0	0	0.2	0	0	0	0	0.1	0	0	0	0	0.2	0
114a	W Morocco	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
114b	E Morocco	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
121a	W Gulf of Lions	0	0	0	0.3	0	0	0	0	0.2	0.1	0	0	0	0.1	0
121b	E Gulf of Lions	0	0	0	0.2	0	0	0	0.1	0	0	0	0	0	0	0
131a	NE Corsica	*	0	0	0.3	0	*	0	0	1.4	0	*	0	0	1.0	0.0
131b	SE Corsica	*	0	0	2.6	0.4	*	0	0	0.5	0	*	0	0	1.7	0.1
132a	N Ligurian Sea	0	0	0.1	0.6	0.1	0	0	0.0	0.5	0	0	0	0	0.9	0.0
132b	E Ligurian Sea	0	0	0.3	0.5	0.2	0	0.0	0.2	0.7	0	0	0	0.1	1.3	0
132c	N Tyrrhenian	0	0	0.9	3.4	0	0	0	0.9	3.4	0	0	0.0	0.7	2.5	0
132d	C Tyrrhenian	0	0.1	1.2	2.5	0.2	0	0.1	0.8	3.3	0	0	0.1	0.3	1.9	0
133a	SE Sardinia	0	0	0	0.9	0.7	0	0	0	0.9	0	0	0	0	4.5	0.3
133b	NE Sardinia	0	0	0	2.2	0	0	0	0	2.0	1.8	0	0	0	0.8	0.2
133c	N Sardinia	0	0	0	0.1	0.8	0	0	0	0.4	0	0	0	0.7	0.6	0
133d	NW Sardinia	0	0	0	3.4	0	*	0	0	2.1	0	0	0	0	4.6	0
133e	W Sardinia	0	*	0	0.9	0	0	0	0	1.0	1.7	0	0	0	2.0	0.2
133f	SW Sardinia	0	0	0.7	2.6	1.1	0	0	1.7	1.1	0.5	0	0	0.9	1.8	0.3
133g	S Sardinia	0	0	0	1.6	0.1	0	*	0	1.7	1.0	0	0	0.1	2.5	0
134a	SE Tyrrhenian	0.6	0	1.3	1.9	0.1	0	0.2	1.3	1.7	0	0	0.1	1.4	1.5	0.0
134b	SW Tyrrhenian	0	0	3.0	5.1	2.0	0	0.2	5.5	5.9	0.9	0	0.3	4.5	2.4	0.1
134c	Sicilian Chan.	0	0.4	9.1	15.5	0.5	0	1.1	6.8	**21.4**	0.4	0	1.4	**20.1**	**23.7**	0.4
211a	N Adriatic Sea	0	0	*	*	*	0	0.0	*	*	*	0	0	*	*	*
211b	Central Adriatic	0	0	0	1.0	0	0	0	0.5	2.5	0	0	0	0.4	5.7	2.4
211c	N Adriatic-Slov	*	*	*	*	*	0	*	*	*	*	0	*	*	*	*
211d	NE Adri Croatia	*	*	*	*	*	*	*	*	*	*	0	0.1	2.0	7.1	*
221a	E Sicily	0	1.1	1.8	**10.3**	0	0	0.2	5.5	7.1	0	0	1.8	5.4	**15**	0
221b	NW Ionian Sea	0	0	6.3	**31.6**	1.2	0	0.1	3.0	**48.9**	1.6	0	3.0	3.0	**23.2**	1.2
221c	N Ionian Sea	0	0	4.0	**11.1**	0.6	0	0	1.0	**21.1**	0	0	0	0.6	6.5	0.1
221d	N Ionian Sea	*	0	1.8	**14.0**	1.8	0	0	1.2	**30.6**	0.1	0	0	0.2	**13.9**	0.0
221e	SW Adriatic	0	0	0	0.9	0.4	*	0	0.1	3.3	0	*	0	0.5	2.8	0.0
221f	SW Adriatic	0	0	0	0.3	0	0	0	0	0.4	0	0	0	0	0.5	0
221g	SW Adriatic	0	0	0.0	*	0	0	0	0	*	0	0	0	0	*	0
221h	SW Adriatic	0	0	0.0	0.2	0.1	0	0	0	0	0.1	0	0	0.2	0.1	0.0
221i	SE Adriatic	*	*	*	*	*	*	*	*	*	*	0.0	3.9	**16.7**	**36.8**	2.5
222a	E Ionian Sea	0	0.3	0	**12.3**	0	0	0	0.2	**14.4**	0	0	1.1	5.2	**21.2**	0
223a	Argosaronikos	0	0	0	3.4	0	0	**20.4**	8.0	4.8	0	0	0.9	**50.2**	**25.9**	0
224a	N Aegean Sea	0	0.6	0.1	3.2	0	0	1.7	0.9	4.7	0.0	**16.5**	**34.5**	**19.4**	**26.0**	0.1
225a	S Aegean Sea	0	0.6	0	5.1	0	0	0.3	3.6	**20.0**	0.2	0	0.3	8.7	**23.0**	5.7

TABLE 6 (Cont.). – *Parapenaeus longirostris*: Mean biomass (kg km^{-2}) estimated from the MEDITS trawl surveys per depth stratum, geographical sector and year (1994-1999). Not sampled strata are indicated by '*'. Values higher than 10 kg km^{-2} are presented in bold.

		1997 Depth (m)					1998 Depth (m)					1999 Depth (m)				
Sector code	Sector	10-50	50-100	100-200	200-500	500-800	10-50	50-100	100-200	200-500	500-800	10-50	50-100	100-200	200-500	500-800
111a	Alborán Sea	0	0.1	1.4	6.2	0	0	1.7	7.1	4.7	0	0	0.1	1.0	3.9	0
112a	Alicante	0	0	0.2	1.0	0	0	0	0.2	1.0	0.0	0	0.0	1.6	1.2	0
113a	Catalan Sea	0	0	0	0	0	0	0	0.1	*	0	0	0	0	0.5	0
114a	W Morocco	*	*	*	*	*	*	*	*	*	*	*	7.4	**29.1**	**17.6**	0.2
114b	E Morocco	*	*	*	*	*	*	*	*	*	*	0	0	**53.6**	**19.0**	0
121a	W Gulf of Lions	0	0	0	0	0	0	0	0.1	0	0	0	0.0	0	0.2	2.8
121b	E Gulf of Lions	0	0	0	0	0	0	0	0	0	0	0	0	0.1	0.1	*
131a	NE Corsica	*	0	*	0.5	0	*	0	0	0.8	0	*	0	0	3.5	0
131b	SE Corsica	*	0	0.9	0.5	*	*	0	0	0.3	0	*	0	0	1.8	0.1
132a	N Ligurian Sea	0	0	0.4	0.2	0	0	0	2.4	3.6	0	0	0	0.8	6.3	0
132b	E Ligurian Sea	0	0	0.2	0.9	0	0	0	0.1	3.2	0.1	0	0.0	0.8	9.1	0
132c	N Tyrrhenian	0	0.2	2.2	2.2	0	0	0.2	7.6	6.9	0.0	0	0	4.5	**23.0**	1.7
132d	C Tyrrhenian	0	0.5	2.5	2.5	0.2	0	2.4	5.5	8.8	0.0	0	1.2	2.3	**15.6**	0.1
133a	SE Sardinia	0	0	0	6.2	0.3	0	0	0	6.3	0.8	0	0	2.6	**13.8**	0.1
133b	NE Sardinia	0	0	0	0.4	0	0	0	0	1.6	0	0	0	0	7.9	0
133c	N Sardinia	0	0	0	1.6	0	0	0	0.4	2.9	0	0	0	1.0	8.6	7.3
133d	NW Sardinia	0	0	0.3	7.0	0	0	0	1.7	**28.6**	5.9	0	0	1.1	**15.2**	0.2
133e	W Sardinia	0	0	0	**10.0**	0.1	0	0	0.0	**60.0**	6.0	0	0	0	**15.6**	**10.4**
133f	SW Sardinia	0	0	5.6	8.6	0.1	0	0	5.1	**24.6**	3.7	0	0	**13.9**	**29.9**	3.7
133g	S Sardinia	0	0	0	5.1	0	0	0	0	3.8	0.8	0	0	0.9	**55.0**	4.7
134a	SE Tyrrhenian	0	0.6	4.7	2.5	0.0	0	1.0	7.1	5.5	0.0	0	1.4	**11.2**	8.7	0.1
134b	SW Tyrrhenian	0	0.8	8.3	7.7	0.7	0	0.3	7.2	**15.0**	1.0	0	1.7	9.7	**22.1**	0.6
134c	Sicilian Chan.	0	0.7	**13.1**	**15.8**	0.5	0	7.7	**23.0**	**30.9**	0.7	0	2.8	29.8	55.0	0.7
211a	N Adriatic Sea	0	0	*	*	*	0	0	*	*	*	0	0	*	*	*
211b	Central Adriatic	0	0	0.4	6.2	2.1	0	0	0.4	4.1	*	0	0.0	0.7	0.8	*
211c	N Adriatic-Slov	0	*	*	*	*	0	*	*	*	*	0	*	*	*	*
211d	NE Adri Croatia	0	0	1.0	6.1	*	0	0.0	1.2	**31.2**	*	0	*	*	*	*
221a	E Sicily	0	0.9	7.8	7.3	0	0	4.7	6.8	**50.6**	0.2	0	0	8.5	**23.4**	0
221b	NW Ionian Sea	0	0.4	5.5	**48.1**	3.9	0	3.2	5.9	**54.9**	0.8	0	0.7	7.8	**19.9**	0
221c	N Ionian Sea	0	0	1.2	**12.1**	0.4	0	0	0.5	**20.7**	0.2	0	0	0.4	3.0	0
221d	N Ionian Sea	0	0	0.2	**17.2**	2.2	0	0	0.0	**14.3**	1.0	0	0	0.1	7.5	0
221e	SW Adriatic	*	0	0.1	5.6	0	*	0	0.7	1.7	0.0	*	0	2.5	1.4	0
221f	SW Adriatic	0	0	0	1.1	0	0	0	0.1	0.9	0	0	0	0.0	4.6	0
221g	SW Adriatic	0	0	0	*	0.5	0	0	0.1	*	0	0	0.0	0.4	*	0
221h	SW Adriatic	0	0	0	2.9	1.4	0	0	0.1	3.3	0.6	0	0	0.1	3.1	0.7
221i	SE Adriatic	0.2	1.5	1.3	**14.0**	5.1	0.5	2.3	8.2	**27.1**	**10.8**	4.9	0.9	1.8	7.0	8.6
222a	E Ionian Sea	0	0.1	0	**21.3**	0.2	0	1.1	9.8	9.2	0.3	0	1.7	6.3	**10.5**	1.5
223a	Argosaronikos	0	3.0	**40.0**	**17.1**	6.9	0.1	0.2	**10.7**	6.1	2.1	0	0.5	**18.3**	1.8	7.8
224a	N Aegean Sea	0	**28.3**	**41.1**	**36.0**	0.9	0.1	**13.0**	**28.9**	**27.6**	1.0	0.1	**17.1**	**31.5**	**37.8**	1.4
225a	S Aegean Sea	0	0.2	2.1	**13.9**	3.3	0	0	4.2	**13.5**	6.5	0	0.1	7.1	**18.0**	3.5

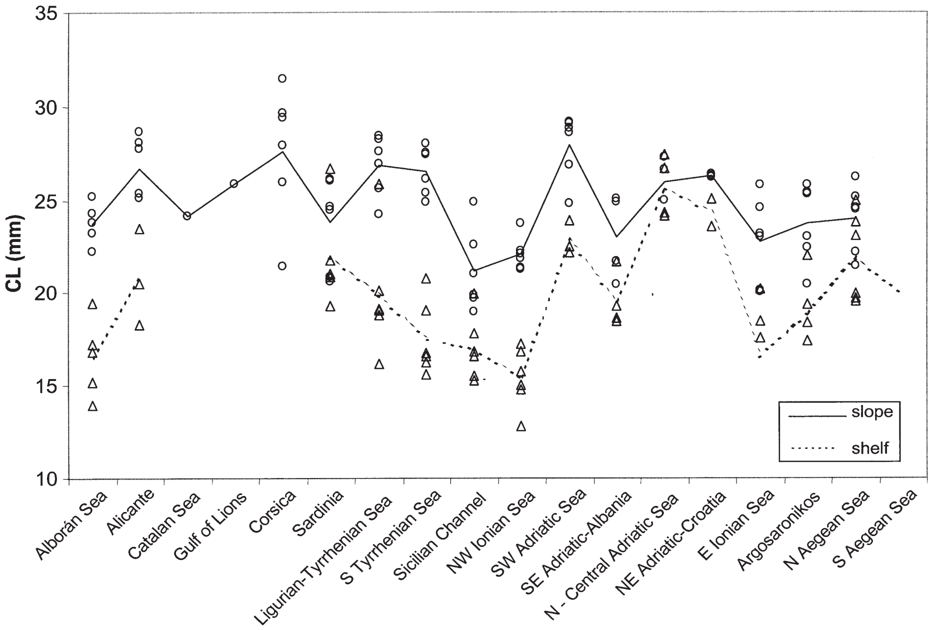

FIG. 5. – Mean sizes of *Parapenaeus longirostris* obtained in 1994-1999 in the different considered geographical sectors. Triangle: shelf samples; open circle: slope samples. The black line indicates the mean values of the slope populations, whereas the dotted line follows those on the shelf.

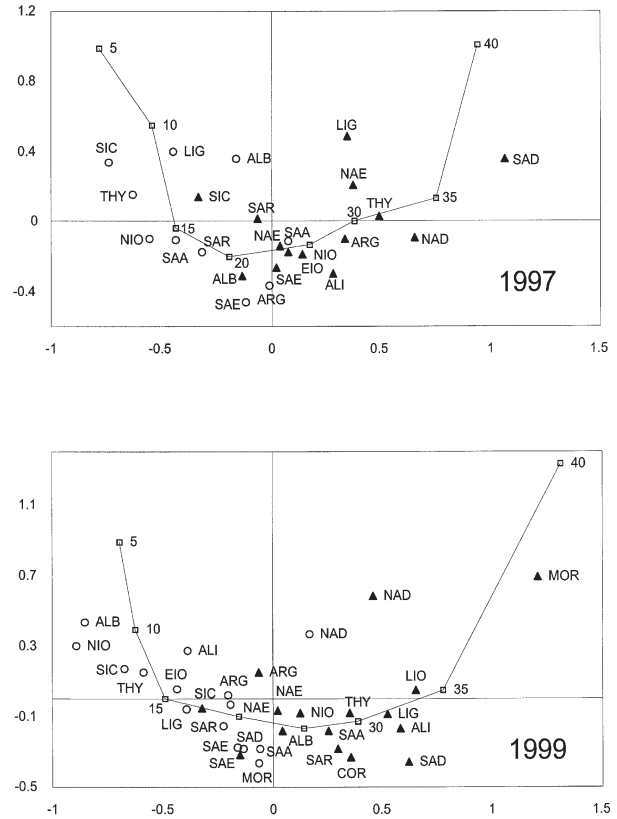

FIG. 6. – *Parapenaeus longirostris*: Correspondence analysis. Ordination of the samples and size classes as a function of the first two inertia axes. Samples obtained in 1997 and 1999 are presented as an example. Open circles indicate shelf samples; black triangles indicate slope samples. Squares correspond to sizes; black circles to samples. ALB: Alborán Sea, ALI: Alicante sector, CAT: Catalan Sea, MOR: Morocco, LIO: Gulf of Lions, COR: Corsica, LIG: Ligurian-Thyrrenian Sea, SAR: Sardinia, THY: S Thyrrenian Sea, NAD: N-Central Adriatic, NAC: N Adriatic – Croatia, NIO: NW Ionian Sea, SAD: S Adriatic, SAA: S Adriatic –Albania, EIO: E Ionian Sea, ARG: Argosaronikos, NAE: N Aegean, SAE: S Aegean. NACs and NADs correspond to shelf samples.

1999. Correlative size classes are strongly associated to the first inertia axis and the samples are associated to the gradient of sizes. Shelf samples are strongly related to small size classes, whereas slope samples appear much closely related to intermediate and large sizes. Assemblages of samples appear more related to the depth of sampling than to geographical areas.

Mortality estimates

The estimates of total mortality derived from the analysis of the length transformed catch curve (Table 7) are presented for *P. longirostris* in Figure 7. Mortality rates for *P. longirostris* have shown very wide differences among sectors but also a high internal variability in each sector among years. This variability can be attributed more to imprecise estimates of Z due to the low quality of the samples (small sample size in some areas due to low densities) than to a real variability in natural mortality rates or in changes in fishing pressure in time. Total mortality was significantly ($p<0.05$) and negatively correlated with the mean size obtained in each of the geographical sectors (Fig. 8). High mortality related to small mean sizes was particularly evident in Sicily and the South Aegean, whereas the inverse relationship was found in the Ligurian and South Adriatic seas.

For several areas (Alicante, Catalan Sea, Gulf of Lions, Corsica, NE Adriatic-Croatia), the reduced size of the samples made impossible the estimation of mortality rates. The highest values of total mortality were found in the Sicilian channel sector. This

TABLE 7. – Total mortality estimates (Z) for *Parapenaeus longirostris* in the different years and Mediterranean Sea subareas sampled, based on population size structure. sd= standard deviation; CV= coefficient of variation (%).

	1994	1995	1996	1997	1998	1999	average	sd	CV	n
Alborán Sea	-	-	2.78	3.65	4.13	-	3.52	0.68	22.81	3
Alicante	-	-	-	-	-	-	-	-	-	-
Catalan Sea	-	-	-	-	-	-	-	-	-	-
Gulf of Lions	-	-	-	-	-	-	-	-	-	-
Corsica	-	-	-	-	-	-	-	-	-	-
Ligurian N Tyrrh	1.28	1.47	1.51	1.29	2.46	-	1.60	0.49	9.81	5
Sardinia	2.61	2.07	2.33	2.30	2.53	-	2.37	0.21	4.24	5
S Tyrrhenian	2.37	2.35	1.63	1.97	1.70	-	2.00	0.35	6.98	5
Sicilian channel	3.36	2.79	3.87	2.91	-	-	3.23	0.49	12.27	4
NC Adriatic	-	-	2.30	1.71	3.58	-	2.53	0.96	31.87	3
NE Adriatic	-	-	-	-	-	-	-	-	-	-
NW Ionian	2.38	3.62	2.47	2.50	3.38	-	2.87	0.58	11.68	5
SW Adriatic	-	1.69	1.37	1.86	1.65	-	1.64	0.20	5.08	4
SE Adriatic	-	-	2.42	2.19	3.14	-	2.58	0.50	16.52	3
E Ionian	-	1.48	2.44	1.99	2.32	-	2.06	0.43	10.74	4
Argosaronikos	-	2.84	2.99	3.12	1.91	-	2.72	0.55	13.72	4
N Aegean	2.35	2.25	2.88	2.43	2.13	-	2.41	0.29	5.73	5
S Aegean	2.43	3.84	3.96	3.27	2.60	-	3.22	0.68	13.60	5

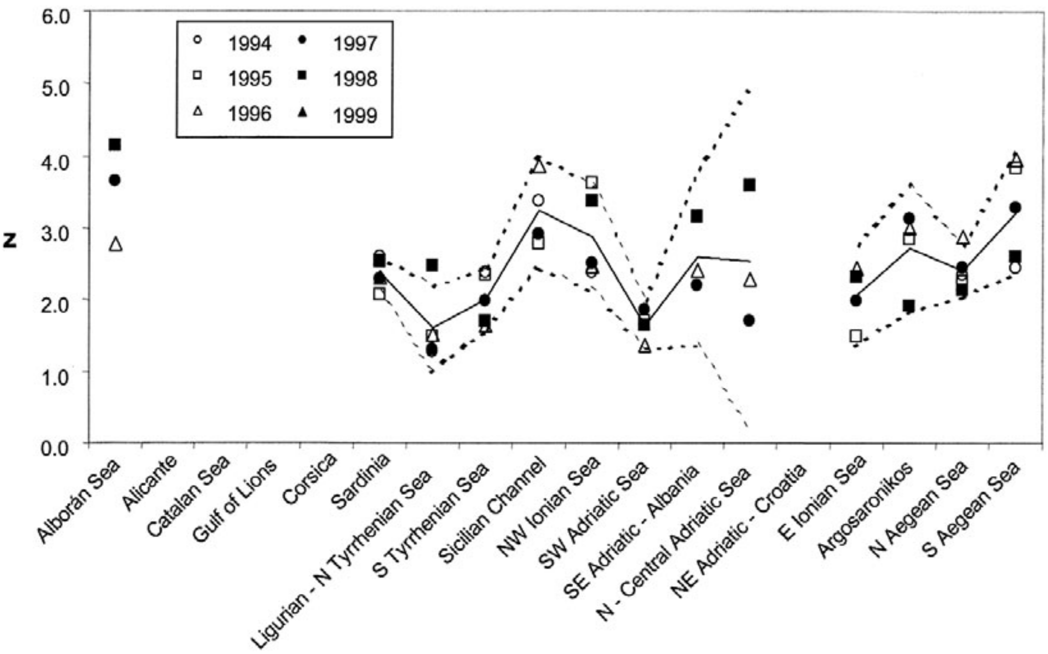

FIG. 7. – Total mortality (Z) estimates for *Parapenaeus longirostris* in the different years (1994-1999) and geographical sectors studied. Lines indicate mean values (black line) and 95% confidence intervals (dotted lines).

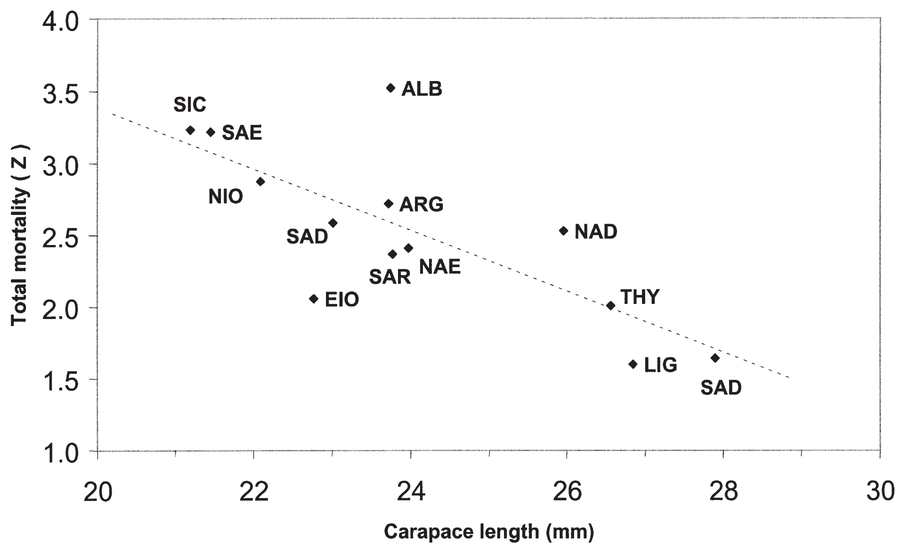

FIG. 8. – Relationship between mean carapace length and mean total mortality (Z) estimates for *Parapenaeus longirostris* upper slope populations (200-500 m depth strata) for the different geographical sectors.

looks reasonable considering the high level of effort targeted to *P. longirostris* that occurs in the area. These high values are consistent with the very low mean size observed in the same sector. In other areas, however, these consistencies do not apply. For instance, in the North-Central Adriatic, the mean size is rather high but this does not seem to be related to the fishing pressure at which the species is exposed in the area. This phenomenon may be explained by the very low catches obtained on the shelf, where generally small-sized individuals are concentrated. The analysis of the few samples considered representative of the demographic structure in these areas suggest medium to high values of mortality rates.

DISCUSSION

Different patterns are found concerning the geographical distribution and observed trends in population size structure of *Nephrops norvegicus* and

Parapenaeus longirostris. In both species, the marked differences observed among geographical sectors appear to be due to a combination of environmental characteristics and differences in fishing effort among the areas, all these coupled with the very different life history strategies of the two species, *N. norvegicus* being a benthic burrowing, long-lived species with slow growth rates, and *P. longirostris* an epibenthic, short-lived species with faster growth rates. Fishing activities differentially affect the populations of the two species.

In the case of *Nephrops*, the above mentioned differences may be correlated to ecological characteristics of the populations, but they probably also reflect actual different exploitation rates among populations. Levels of dissimilarity in size structure among *N. norvegicus* populations have been attributed to several factors, among which the most important appear to be differences in sediment characteristics as well as in exploitation rates (Chapman and Howard, 1988; Tully and Hillis, 1995; Maynou *et al*., 1996; Maynou and Sardà, 1997). In the Adriatic Sea, differences in size structure between shallow and deep fishing areas have been usually considered a consequence of environmental factors rather than of different levels of fishing effort (Froglia and Gramitto, 1987). In the present study, areas with high exploitation rates, as estimated from their fishing mortalities (Sardà et al., 1998), such as the Catalan Sea, the northern Adriatic or the Ligurian Sea, have appeared closely associated to small sizes, whereas areas with low exploitation rates, such as the Alborán Sea, Corsica or Sardinia, appear associated to large sizes. As an example of this fact, the clearly decreasing trend in mean sizes found along the Spanish Mediterranean closely matches the increasing trend in fishing effort found throughout the three Spanish sectors. Thus, according to Spanish official figures, the number of trawlers working in the Alborán Sea sector (12753 km^2 of trawlable bottoms) was 175, with a mean length of 15.9 m, 195.0 HP and 61.7 GT, the number of trawlers in Alicante sector (15928 km^2) was 263, with a mean length of 17.4 m, 275.2 HP and 66.6 GT, and the number of trawlers in the Catalan Sea (16578 km^2) was 490, with a mean length of 17.2, 304.1 HP and 62.1 GT. This figures give a fishing intensity of 1.4, 1.7 and 3.0 trawlers per 100 km^2, respectively for the Alborán, Alicante and Catalan Sea sectors.

Although differences in growth have been highlighted for *N. norvegicus* from different habitats in the same geographical area (Central Adriatic) (Froglia and Gramitto, 1987) and such differences could affect the total mortality estimates, in this paper a unique set of Von Bertalanffy parameters was adopted only as a baseline for a first analysis and comparison of total mortality in the different sectors. Notwithstanding the necessity of a deeper comparative evaluation of the growth in the different geographical sub-areas, present preliminary estimates evidenced a lower total mortality in some sectors, such as Alborán Sea, Corsica, Argosaronikos and N Aegean, where fishing pressure is also presumably lower when compared with other subareas.

For the analysis of the length converted catch curve, it is necessary that the available length frequency data be representative of the population. Data used for catch curve estimates of Z must represent an equilibrium status or stable-age distribution. This is generally obtained by reconstructing the mean size structure of the stock by pooling in a proper way samples collected all along the year and assuming that recruitment strength has varied little along the considered years. The MEDITS data, however, only furnish the size structure during a single sampling period of the year (spring). We have considered that this may not constitute a very important problem in the case of *Nephrops norvegicus*, because several cohorts are present in the catch and so, the decline in numbers with time can be analysed without major problems. In the case of *Parapenaeus longirostris*, as well as for any other short-lived fast-growing species, the use of length-based methods involves a dynamic non-equilibrium situation. In these cases, it is necessary to adequately sample in both space and time, since biomass and numbers change greatly on a seasonal basis. Smaller time intervals for samples (at least one by season) should be needed to avoid missing important events in the life history of these species. The lack of samples from other seasons than spring can be critical in the present case. Notwithstanding the problems described above, the analysis was also done for *P. longirostris*. Results, however, have to be considered, specially for this species, only as indicative and must be handled with care.

It is probable that the von Bertalanffy growth parameters used here be unsuitable for properly describing the growth performance of some of the stocks included in the analysis. Growth and natural mortality rates can change depending on food availability, competition, etc. Moreover, suitability of fishing grounds can determine differences in size structure. All these aspects should invalidate the uncritical comparison of the Z estimates, especially in the case of very distant areas.

Parapenaeus longirostris was found widely distributed throughout the outer shelf and upper portion of the continental slope. Its biomass at the border of the shelf was however lower than on the upper slope where adults concentrate, as reported in other Mediterranean areas (Audouin, 1965). In some sectors of the western Mediterranean the presence of the species was always scarce. This can not only be attributed to a low sampling density in the depth range considered optimal for the species, since these depths were fully sampled, but to an intrinsic population behavior of the species probably linked to mesoscale oceanographical processes.

Concerning the analysis of the demographic structure of the population of *Parapenaeus longirostris* by area, the highest values of total mortality rates found in the Sicilian Channel look reasonable considering the high level of effort directed to this shrimp that takes place in the area (authors unpublished data). These high values are consistent with the observed low mean size in the sector. In other areas, however, these consistencies do not apply. For instance, in the North-Central Adriatic, the mean size is rather high but this is hardly to be related to the fishing pressure at which the species is exposed in the area. This phenomenon may be better explained by the very low catches obtained on the shelf, where generally small-sized individuals are concentrated. The analysis of the few samples considered representative of the species demographic structure in these areas suggest medium to high values of mortality rates. Similar mean sizes (the smallest ones) were observed in Sicily and Greek waters, where differences in fishing pressure are expected. This could be explained by the strength of the recruitment pulses, higher in these areas than in the others (authors unpublished observations). However, hydrological factors could also be evocated. Bombace (1972) and Levi *et al.* (1995) suggested a work hypothesis based on migration as a continuous flow from east to west supported by the role that water masses (Intermediate Levantine Waters) might play.

Different levels of exploitation appear to affect the population size structure of *N. norvegicus* in a much more marked way than in *P. longirostris*, since *Nephrops* population structure is less dependent on variations in recruitment success considering that more age classes constitute the species exploitable fraction. *N. norvegicus* is a long-lived, benthic, sedentary species with slow growth and mortality rates, whereas *P. longirostris* is a short-lived epibenthic species, much more mobile being a natant shrimp and with relatively high growth and mortality rates (Farmer, 1975; Ribeiro-Cascalho and Arrobas, 1987; Sardà, 1995). It can be hypothesised that, if fishing effort is of major importance, changes may also be detectable in the demographic structure of *Parapenaeus longirostris*. Interannual differences in recruitment strength are more likely to affect the population structure of *P. longirostris*, which is also more dependent on high growth and mortality rates than that of *N. norvegicus*, which, given its habits (burrowing behaviour) and population dynamics, is expected to show more constant characteristics in both population dynamics and size structure.

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