www.trjfas.org
ISSN 1303-2712
Turkish Journal of Fisheries and Aquatic Sciences 13: 647-656 (2013) DOI: 10.4194/1303-2712-v13_4_10

Contribution to the Biology of *Parapenaeus longirostris* (Lucas, 1846) in the South Ionian and South Adriatic Sea

Kostas Kapiris[1,*], Olivera Markovic[2], Dimitris Klaoudatos[1], Mirko Djurovic[2]

[1] Hellenic Centre for Marine Research, Institute of Marine Biological Resources, 47th km Athens-Sounio, Mavro Lithari P.O. Box 712, 19013, Anavissos, Attica, Greece.
[2] Institute of Marine Biology, Dobrota P.O.Box 69, 85330 Kotor, Montenegro.

* Corresponding Author: Tel.: +21.098 56712; Fax: +21.098 11713;
E-mail: kkapir@ath.hcmr.gr

Received 2 April 2013
Accepted 20 October 2013

Abstract

Experimental trawl sampling was carried out along the South Ionian and South Adriatic Seas between 2006 and 2008 in depths from 71 to 586 m. This study investigates the available information on biology of *P. longirostris* in both areas. The length frequency distribution of the Greek specimens ranged between 7.08-38 mm CL (2-3 size groups), while between 14-37 mm CL (1-2 size groups) in the Montenegrin samples and was not significantly dependent on depth in both areas. The values of the slope (b) of the CL-W relationships in both countries were similar to those found in other Mediterranean areas and were higher in the Greek samples. The spawning period takes part in the sampling period in both areas. The smallest mature female in the Ionian Sea was 10 mm CL and 16 mm CL in South Adriatic Sea. Sex ratio was significantly higher than 1:1 in favor of males in the South Ionian Sea, while females statistically outnumbered males in the Montenegrin samples. The observed biological differences between in the two study areas could be attributed to the different sampling depth and the exploitation the ratio

Keywords: Deep water rose shrimp, biology, Ionian Sea, Adriatic Sea.

Introduction

Parapenaeus longirostris is actually the target species of an important fishery of trawlers in the Mediterranean. The deep water rose shrimp, *P. longirostris*, shows a wide geographic distribution, from the eastern Atlantic north of Spain (Holthuis, 1980; Olaso, 1990) to the southern waters of Angola (Crosnier *et al.*, 1968), as well as in the Mediterranean and its adjacent seas (Thyrrenian, Adriatic, Aegean, and the Sea of Marmara) (Massutí, 1963; Audouin, 1965).

In the Mediterranean Sea, *P. longirostris* is caught by trawl and is the most important crustacean resource along the coasts of Spain, France, Italy, Algeria, Tunisia and Turkey (Sbrana *et al.*, 2006). FAO catches and landings statistics from 1972 to 1991 indicate that the deep water rose shrimp is the fifth species in order of biomass importance among crustaceans landed in the whole Mediterranean area (Stamatopoulos, 1993). The total catch reported for this species to FAO in 2009 was 20.924 t, while the total catch ten years before (1999) was 17.778 t. (FAO, http://www.fao.org/fishery/en).

In the Mediterranean basin, the bathymetric distribution of the deep water rose shrimp ranges between 20 and 750 m, but the species is more common and abundant on sandy-muddy bottoms between 100 and 400 m (Politou *et al.*, 2005). A size-related bathymetric distribution was observed with juveniles (<20 mm CL) occurring in the shallower depths and larger specimens moving towards deeper waters (Abelló *et al.*, 2002). In the Mediterranean Sea, many studies carried out during the last years allowed the collection of detailed information on distribution, abundance, and biology (e.g. Sobrino *et al.*, 2005 and references herein; Ligas *et al.*, 2011; Kapiris, 2004), nevertheless few studies have been carried out on the exploitation state of this species (e.g. GFCM, 2011).

P. longirostris, fished in all the Greek Seas, is the most important species (in catch weight, landings, and value) among the commercial crustaceans in Greece (Mytilineou *et al.*, 2001; Kapiris *et al.*, 2007). *P. longirostris* annual catches in Greece (1990-2008) showed a great variability, with three maxima in 1992 (1.824 t), in 1997 (1.703 t) and 2005 (1.472 t). In contrast, lowest landings were recorded during the period 2001-2003 (845 and 889 t, respectively) (Hellenic Statistical Authority, ELSTAT data), indicating a weak negative trend with time at 90% significance level. The fishing gears used for *P.*

longirostris in the Greek fishery are trawls (66.79% of the total catch of this shrimp is fishing by trawls), seine nets (3.61%), ring nets (0.98%) and other gears (28.63%) (ELSTAT data). The mean annual landings of *P. longirostris* during the period 1990-2004 were 1.226.87 t (28.31% of the total crustacean landings (ELSTAT data). The annual economic value increased between 1991-2002 (ELSTAT data), ranging from 22% to 50% of the total crustacean value, indicating a similar trend with time and landings. On the other hand, the average price per year of this species showed a great variability without displaying any significant trend. The highest abundances of this species in Greece were found in the N. Ionian Sea, Argosaronikos Gulf and Aegean Sea (Abelló *et al.,* 2002). The knowledge on the exploitation state, spatial distribution and biology of this important species in the Greek seas is incomplete and is an outcome of the experimental surveys mainly carried out by the Hellenic Centre for Marine Research (Abelló *et al.,* 2002; Kapiris *et al.,* 2002, 2012; Kapiris, 2004; Politou *et al.,* 2008) in the frame of European projects.

This shrimp occurs also in the deeper central Adriatic, in the Pomo/Jabuka Pit and in the southern Adriatic. It inhabits only muddy sediments, at depths deeper than 130 m (Karlovac, 1949). In the Pomo/Jabuka Pit region, this species lives on sea bottoms from 150 to 190 m (Jukić, 1975; Županović and Jardas, 1989). In the southern Adriatic (along the Italian coast) the population is most dense at depths from 200 to 400 m (Pastorelli *et al.,* 1996). In the same period, it was discovered that this species was abundant along the Albanian coast (Pastorelli *et al.,* 1996). Off the Montenegrin coast, this species was occasionally present until the late 1990. During the 1995 MEDITS survey in the central and northern Adriatic, the average biomass index was 0.28 kg/km^2, and in the southern Adriatic (along with one part of the Ionian Sea) it was 3.72 kg/km^2 (Relini *et al.,* 1999). In the South Adriatic Sea (Montenegrin territorial waters), the demersal fishery takes place on the entire continental shelf and on a small part of the continental slope. In this area the abundance of *P. longirostris* has been very low for a long period of time (Merker-Poček, 1971). In 1998 the catches of this species increased considerably. In the following years it expanded over the entire shelf area, and during 2000 consisted the main target species of trawlers (Regner and Joksimović, 2002; Kasalica and Joksimović, 2005). At present the deep-water rose shrimp represents the main target decapod and has became one of the most important commercial species for the Montenegrin trawl fishery (Kasalica *et al.,* 2007).

The main objective of the present study is to consider the available information on biology (ageing, reproductive aspects, sex ratio, CL-water depth and CL-W relationships) and give some principal data on the fishery of this species in the S. Ionian (Greek) and South Adriatic Sea (Montenegrin) waters, in the period 2006-2008. These data could be helpful in formulating advices for fisheries management of this species in Greece and Montenegro.

Materials and Methods

Data for the South Ionian Sea were collected in the frame of the MEDITS program (International bottom trawl survey in the Mediterranean). Data from Montenegro were collected during the FAO-ADRIAMED Pilot Study Project. The sampling period was in the summer months of 2006 and 2008, in both studied areas.

The gears used for the sampling of the studied decapods had the same range of the stretched mesh size in the cod-end (20 mm), in both countries. The sampling depth ranged from 71 to 586 m in Greek and between 40-200 m in Montenegrin waters (Figure1). In the frame of the projects mentioned above, in the period 2006-2008 a total of 2,148 individuals (1,282 females, 866 males) were sampled in the South Ionian Sea and 2,221 individuals (1,593 females, 628 males) in the Adriatic waters of Montenegro.

Data from the Ionian Sea were collected in the frames of the MEDITS program (International bottom trawl survey in the Mediterranean) carried out, in the present study, in the South Ionian Sea from 2006 and 2008 covering a total sea surface of 16.823 km^2. Sampling in the Ionian Sea was performed by a chartered commercial trawler using a grid of 22 stations in the summer of each year (2006 and 2008). In 2007 the MEDITS was not performed. The MEDITS survey take place once per year (summer) and covers all trawlable areas from 10 to 800 m of the South Ionian Sea with pre-defined sampling stations (32 hauls in the study area) with the same trawl. The bottom trawl used had a 20 mm codend mesh size, the length of the trawler was 27.7 m having one 537 kW engine. 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 standardized sampling protocol can be found in Bertrand *et al.* (2000, 2002).

The samples from the Montenegrin area were collected in the frame of the Pilot study on biological and economic data collection and monitoring system in Montenegro with the support of the FAO AdriaMed and in the frame of the National project of monitoring of demersal resources, which were was carried out by the Institute of Marine Biology. For the above mentioned project the fishing activities of the most important fishing ports (Herceg Novi, Budva, Bar and Kotor) were monitored on a sampling basis. Fishery and biological data concerning the studying decapod were collected every month in 2006 and 2008 from all the above fishery ports in Montenegro. The major part of trawling in Montengrin waters takes place between Budva and Bar, in area of sandy

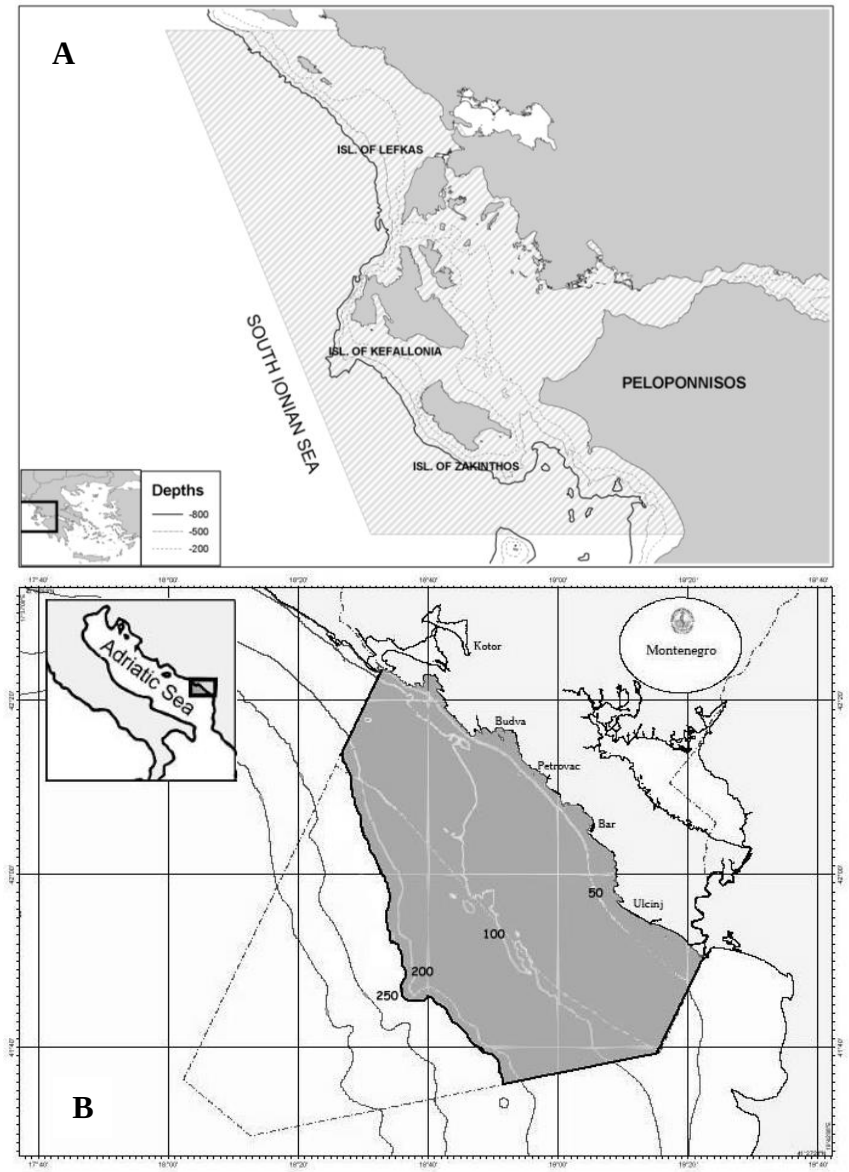

Figure 1. Map of the sampling area with the sampling stations, A: South Ionian and B: South Adriatic Sea.

bottoms, and depths ranged between 80 and 200 m. The sampling trawlers for *P. longirostris* are very old, small, underequipped and/or equipped with substandard equipment. The samples were caught by bottom trawlers using a 20 mm codend mesh size, having a length range from 7.1 to 21.39 m with 35 to 285 kW engine power. Coastal waters of Montenegro occupy about 360 km^2, territorial waters (extending 12 nautical miles, or 22.22 km, from the coastline) cover a surface of about 2,000 km^2 and the epicontinental belt occupies around 3,900 km^2. The total sea area of Montenegro is about 6,400 km^2. Catch and effort data on all the active fleet segments in the sampling ports were gathered by interviewing fishermen at the end of the fishing trip. Sampling days per port and fishing vessels sampled were randomly selected in the period 2006-2008. Biological data on deep-water rose shrimps were collected in the Institute of Marine Biology in Kotor. Carapace length (CL) was measured to the nearest 0.01 mm, from latter margin of orbit to latter hind edge of the carapace, using electronic calipers. Length–frequency distributions of males and females (1 mm intervals) were recorded for the total of the specimens caught in the period 2006-2008. Mann-Whitney and t-test were used to compare the median and mean size between sexes and areas. The sex ratio was estimated according the formula M/M+F. The weight of each specimen was recorded to the nearest *g* to calculate the length–weight relationship. The carapace length–weight relationships were based on the equation $W = aL^b$, where W is the weight (g), L the carapace length in mm, and a, b the constants for each sex separately. Comparison of the slopes (b) of the length–weight regression by sex was made by ANCOVA test.

Bhattacharya's method, implemented in the package FiSAT (Gayanilo *et al.*, 1994), was used to identify and isolate the different, normally distributed, size groups in the polymodal length–frequency distribution separately for males and females. All the

age groups were derived taking into account all the criteria (a) the values of separation index (SI) for the different age group, (b) the number of the identified age groups, and (c) the standard deviation (S.D.), described by Gayanilo *et al*. (1998).

In order to identify the various maturity stages of females, the modified method of De Ranieri et al (1986) based on the macroscopic observation of the gonads (size and color) (Stage I: immature, Stage II: maturing, Stage III: mature, Stage IV: spent) was used.

Results

The biomass index (kg/km^2) and the abundance index (N/km^2) of *P. longirostris* were increased in 200-800 m depth zone. In 2006 the mean biomass of *P. longirostris* in the South Ionian Sea was 6.46 kg/km^2 and the mean abundance was 1215 N/km^2. In 2008 were 7.03 kg/km^2 and 1466 N/km^2, respectively.

Length Frequency Distribution

The carapace length of the females ranged from 7.08 to 38 mm in the Greek waters and from 14 to 37 mm in South Adriatic area and males ranged from 8 to 29 mm in the Ionian Sea waters and from 14 to 32 mm in the South Adriatic waters. Females were statistically larger than males in both areas (Mann-Whitney test, P>0.05) (Figure 2). In general, the mean carapace length caught in Greek waters (21.39±6.43 mm for females, 18.64±4.31 mm for males) was statistically lower in comparison to the South Adriatic (26.60±4.20 mm for females, 21.08±2.56 mm for males) (t test, P<0.01 in both cases). Similarly, females were significantly heavier than males, in both areas. The weight of females (range: 0.1-21.96 g, mean=6.50±3.54 g) caught in Greek area was statistically lower than of those caught in Montenegrin waters (range: 2-21.48 g, mean=9.66±3.51 g). However the mean carapace length of the Greek males (range: 0.67-13.61 g, mean: 5.17±1.21 g) did not exhibit a statistically significant difference when compared to the Montenegrin ones (range: 0.67-13.61 g, mean: 5.37±1.82 g) (t-test, P<0.001, in both sexes).

Sex Ratio

Sex ratio (M/M+F) indicated that males were more abundant in the Greek area (0.64) during the study period (Figure 4), whereas in the South Adriatic

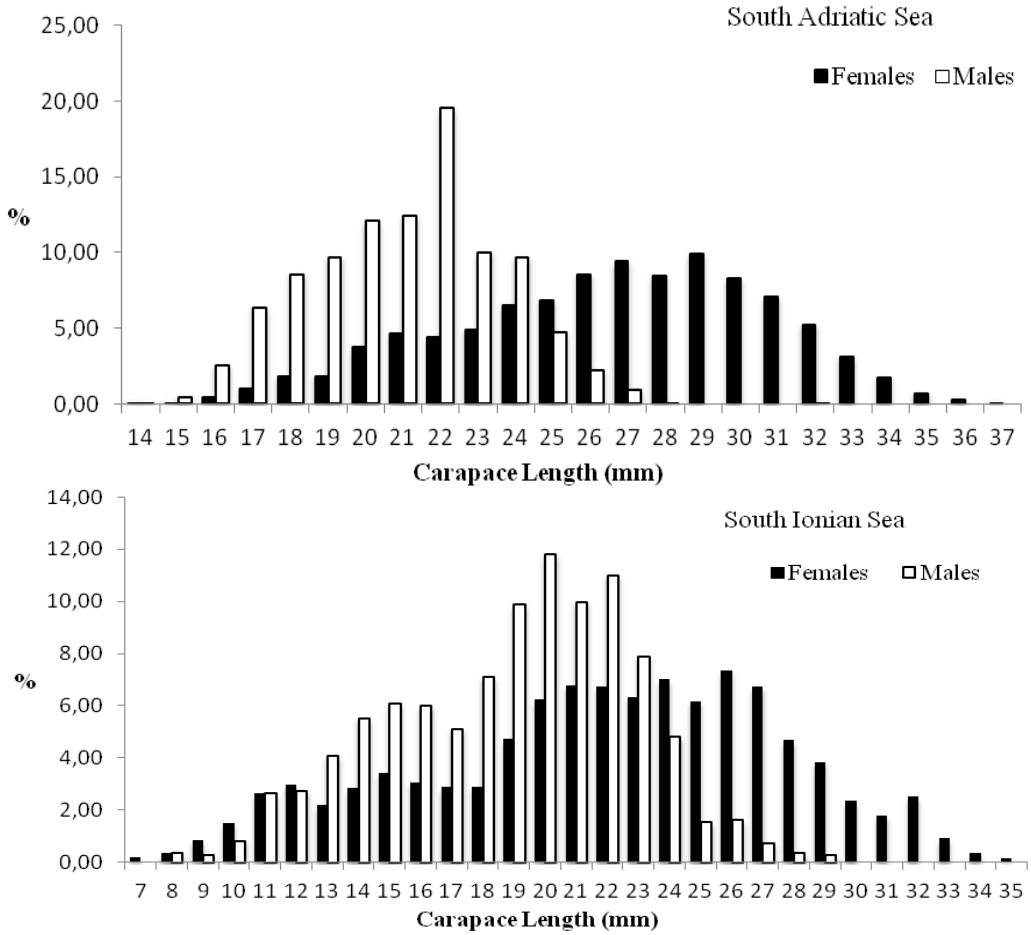

Figure 2. Length frequency distributions per sex of *P. longirostris* in South Ionian and South Adriatic Sea in the period 2006-2008.

waters (<100 m, 100-200 m) females outnumbered males (0.29). There was a statistically significant difference between the sex ratio values among the different sampling depths in the Greek waters (ANOVA, P<0.05), with males displaying higher abundance in depths over 300 m (Figure 3). The limited sampling depth in the Montenegrin waters did not permit a broad comparison between the two areas, although α different trend was observed with females being more abundant in both sampling depth zones (<100 m, 100-200 m).

Size-Depth Relationship

There was no statistically significant relationship between size-depth in both sexes and areas (ANOVA, P>0.05). The correlation coefficients of the linear model (Depth=a+b*carapace length) were low, especially in Montenegro (Table 1). It is worth noting that the average of the carapace length of both sexes in the deepest Greek samples (more than 400 m) presented higher values than the shallower ones (Figure 4) and, in the same area, the smaller individuals (7-13 mm CL) of both sexes were found in depths around 200-220 m.

Carapace Length-Weight Relationships

The results for the carapace length-weight relationships according to sex indicated an allometric growth; exhibiting values of b significantly lower than 3, especially for males. Thus, the estimated slopes (b values) of the CL-W equations were higher in females from Greece, since these specimens displayed larger sizes (2.620 and 2.389, for ♀ and ♂ respectively, caught in the Ionian Sea, 2.309 and 2.032 for ♀ and ♂, respectively caught in the Adriatic). There was a statistically significant difference among the estimated parameters between the two sexes in both areas (ANCOVA, P<0.001, F slopes=38.35 and 217.57, for Greek and Montenegrin samples, respectively). For the same carapace length females were more robust than males (Figure 5).

Age Cohorts

Bhattacharya's method (FiSAT package), was used to identify and isolate the different, normally distributed, size groups in the polymodal length–frequency distribution separately for males and females. The general pattern of the pooled data (2006 and 2008) showed that the males population exhibited 2-year cohorts in the Ionian (Greece) and 1-year cohort in the South Adriatic waters (Montenegro), while females displayed more cohorts (3 and 2-year modes for Ionian and Adriatic, respectively). The values of the modes were: males: 21 and 28 mm CL for the Ionian Sea and 21 mm CL for the Adriatic Sea, females: 13, 20, 27 mm CL for the Ionian Sea and 21, 28 mm CL for the Adriatic Sea. (Table 2).

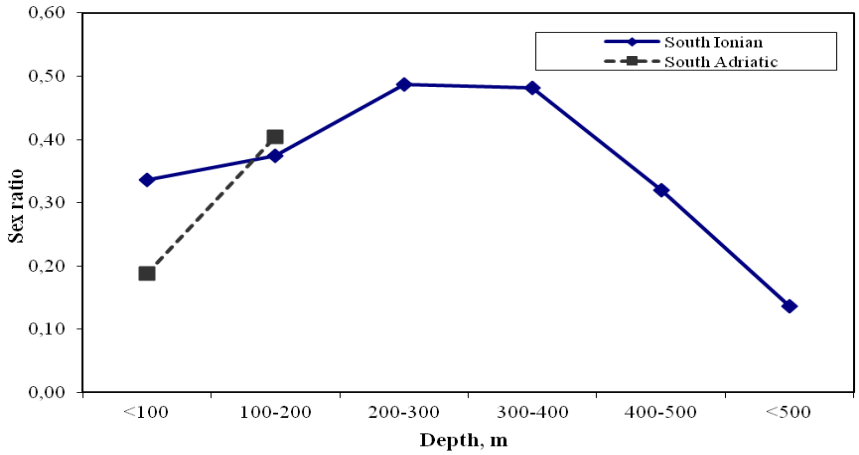

Figure 3. Sex-ratio (M/M+F) per depth zone in S. Ionian and South Adriatic Sea in the period 2006-2008.

Table 1. Estimated parameters for carapace length (CL)-depth relationship equation (Depth= a+b*CL) for each sex in the S. Ionian (Greek) and S. Adriatic Sea (Montenegrin) waters

Area	a	b	r
		S. Ionian Sea	
Males	81,98	8,33	0,34^{NS}
Females	152,65	4,15	0,20 ^{NS}
		S. Adriatic Sea	
Males	92,23	1,23	0,09 ^{NS}
Females	115,21	-0,52	-0,06 ^{NS}

NS = non significant

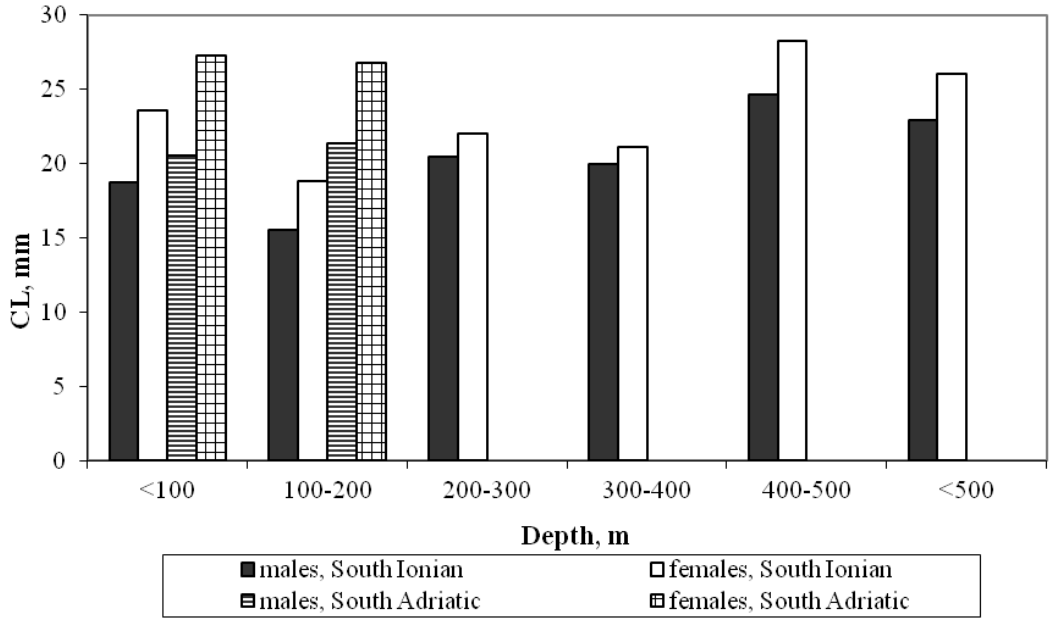

Figure 4. Mean CL per sex and sampling depth zone of *P. longirostris* in South Ionian and South Adriatic Sea in the period 2006-2008.

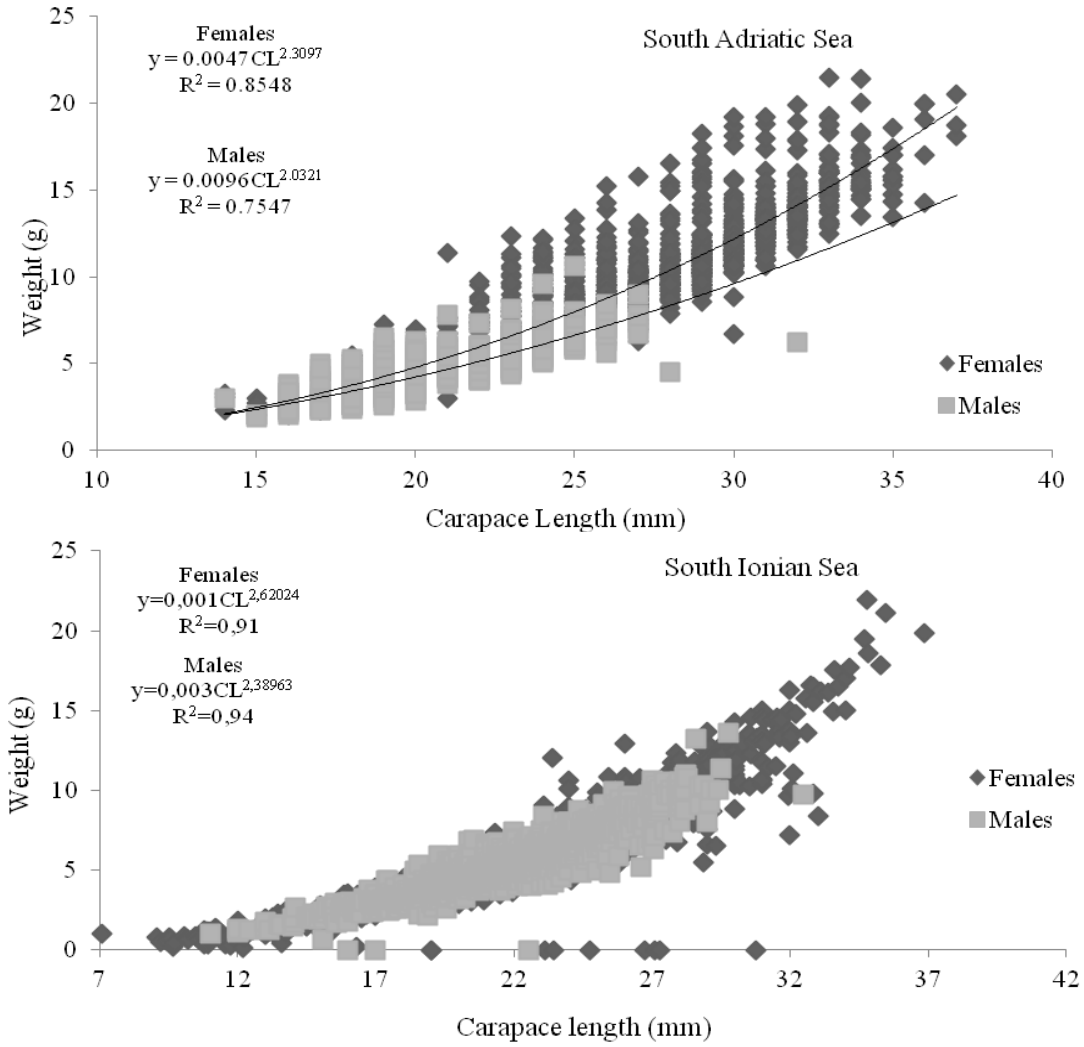

Figure 5. CL-W relationship of *P. longirostris* in South Ionian and South Adriatic Sea in the period 2006-2008.

Reproduction Aspects

In the South Ionian the spawning of the deep-water rose shrimp females' is carried out during summer. During this summer study period the immature individuals (Stage I) increased from June to August while the maturing ones (Stage II) decreased. Few mature specimens (Stage III) were found in July and spent shrimps (Stage IV) were present in July and August. In the Montenegrin waters the immature females (St I) were few in the summer months whereasthe maturing ones (Stage II) were very low in August. Mature (Stage III) females increased from June to August and spent females (Stage IV) were found in higher proportion in the summer months (Figure 6). The minimum carapace length of the mature females was much lower in the Ionian (10 mm) in comparison to the Adriatic Sea (16 mm).

Discussion

According to the present study the deep-water rose shrimp was caught mainly between 150 and 400 m in the Ionian Sea. The same depth range has also being observed in the Aegean Sea (Kapiris *et al.*, 2007). In the shallower depths in the South Adriatic Sea the species was abundant in both depth zones

Table 2. Identified age groups from the CL–frequency analysis for males and females *P. longirostris* during the period 2006-2008 in the S. Ionian and S. Adriatic Sea, using Bhattacharya's method

Area	S. Ionian Sea			S. Adriatic Sea			
Males							
Mean CL	s.d.	N	S.I.	Mean CL	s.d.	N	S.I.
21,00	1,07	236	-	21,00	1,98	625	-
28,00	1,63	1201	3,50				
Females							
13,00	1,99	338	-	21,00	1,00	236	-
20,00	2,00	311	3,50	28,00	2,01	1201	3,50
27,00	1,16	456	4,67				

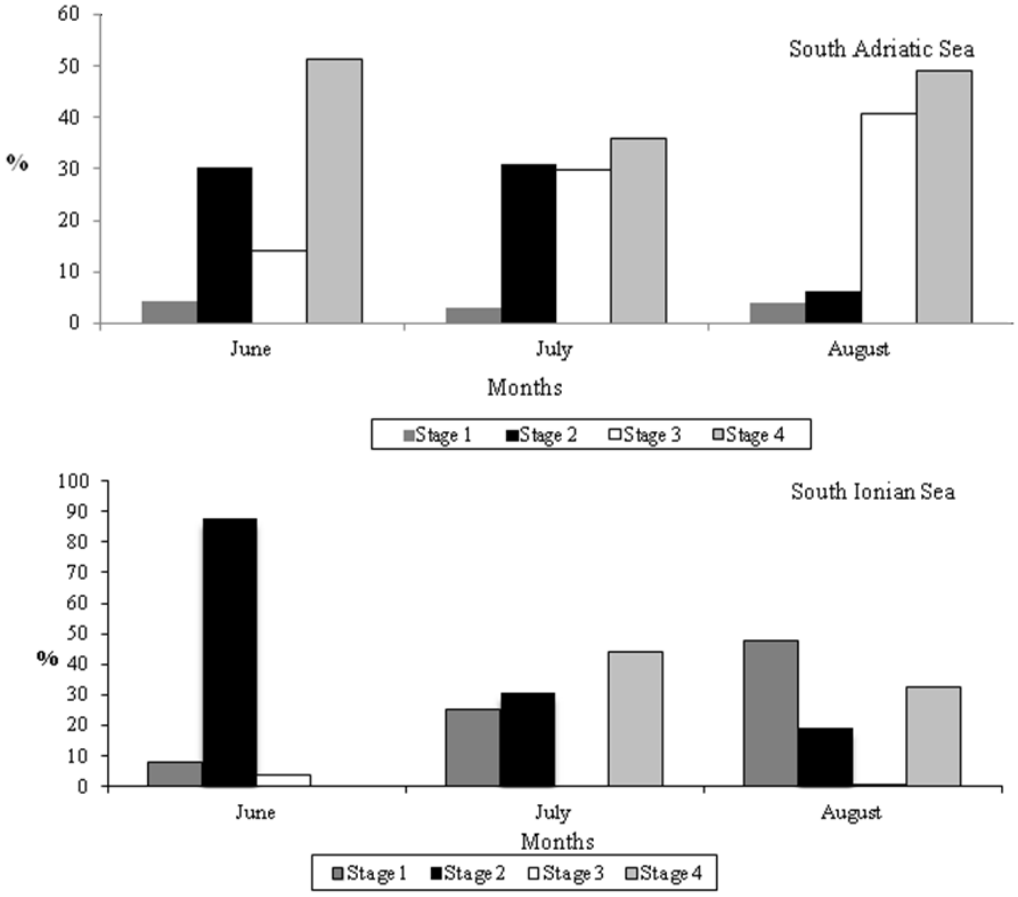

Figure 6. Females gonad maturity stage per month of *P. longirostris* in South Ionian and South Adriatic Sea in the period 2006-2008.

(<100 m, 100-200 m).

The mean sizes of the caught specimens displayed very similar ranges to those found in other studies (e.g. Sobrino *et al.,* 2005; Öztürk, 2009) carried out in the Mediterranean, further indicating a size dimorphism between sexes for the species. The lower mean carapace length of the individuals caught in the Greek waters could be attributed to the different temporal presence of the recruitment in these areas, the wider sampling depth zone in the Ionian Sea and the different sampling strategy. The existence of the smaller individuals in the summer months, at least in Ionian Sea, coincides with their abundance in the Gulf of Alicante (S.E. Spain) (García-Rondríguez *et al.,* 2009). The increased presence of the juveniles (7-13 mm CL) in the shallower depths (<220 m) in the Greek waters does not differ from their increased abundance in similar depths in Israel (Tom *et al.,* 1988), Morocco (Buurukovsky, 1981) and the Algerian coast (Audouin, 1965).

The parameters of the size-weight relationship estimated in the present study in both areas amplify the concept of the presence of such an allometry in the relative growth of this decapod crustacean in the whole Mediterranean Sea. Females were more robust than males in both areas and the estimated values of the coefficient b in Greek males and females *P. longirostris* were similar to those found in other Mediterranean areas, such as the Gulf of Alicante (García-Rondríguez *et al.,* 2009), higher to those found off South Portugal (Arrobas and Ribeiro-Cascalho, 1982) and lower than those in the Sea of Marmara (Bayhan *et al.,* 2005). Both b values estimated for the males and females from South Adriatic Sea were unexpectedly similar to those found in other areas, such as the south Portuguese coast (Arrobas and Ribeiro-Cascalho, 1982).

The larger number of the identified age groups of both sexes from the CL–frequency analysis of the Greek samples could be attributed to their wider range of the carapace length in the samples. The longevity of females (2–3-year classes), exceeded that of males (1-2-year classes), indicating a size dimorphism. The estimated age classes of both sexes in Ionian Sea presented similar rates to the females caught in Sicilian waters (Froglia, 1982), but lower than those presented in the S. Portuguese coasts (Ribeiro-Cascalho and Arrobas, 1987), the Gulf of Cadiz, Spain (Sobrino and Garcia, 1994), the Tyrrhenian Sea (Sbrana *et al.,* 2006) and the Italian Ionian Sea (D'Onghia *et al.,* 1998). These observed differences may be related to the different environmental conditions (temperature, food availability, etc.) and/or fishing pressure.

Studies carried out in the Mediterranean indicate a variable reproductive strategy for this species. Heldt (1954) described one sole spawning peak between April and November in Tunisian waters. Drobisheva (1970) found mature females only in spring in the Egyptian coast, while Abdel Razek *et al.* (2006) noted that the maximum activity was shown during November in Egyptian Mediterranean waters. In contrast to this, Levi *et al.* (1995) and D' Onghia *et al.* (1998) described a continuous spawning throughout the year, using a scale of macroscopic observations of the female gonads. Finally, Tom *et al.* (1988) related its oogenesis with the temperature and depth off the Israeli coasline The existence of two spawning annual peaks was observed in some areas, as by Ribeiro-Cascalho and Arrobas (1983, 1987) in south of Portugal, by Sobrino and Garcia (1994) in Atlantic waters off Morocco and southwestern Iberian Peninsula, respectively, in the waters off Congo Crosnier *et al.* (1970) and in the Sea of Marmara by Bayhan *et al.* (2005). The spawning season seems to be slightly more protracted in Montenegrin waters compared to Ionian waters. According to García-Rondríguez *et al.* (2009) the fluctuation of the reproductive strategy of this decapod could be related to the oceanographic and environmental conditions dominating in each study area. The slight differences in the reproductive strategy of *P. longirostris* observed between Greek and Montenegrin waters could be attributed to the shallower sampling depth of the latter area and consequently, to slightly higher water temperatures.

This is the first common study on the population biology of *P. longirostris* in the South Ionian and the South Adriatic Montenegrin waters characterized by different fishing pressure on their stocks. The slight differences in length frequency, reproduction, relationships between carapace length-depth and length-weight between the two study areas could be attributed to the different sampling depth and the different exploitation ratio of this important fishery resource in both areas. It is worth mentioning that the prevailing hydrological conditions are very similar in both study areas and they could possibly explain the minor biological differences of this decapod in both study areas. The eastern part of the South Adriatic Sea (Montenegrin waters) has higher temperature and salinity, due to the existence of the Levantine Intermediate Water (LIW) compared to the western part (Italian waters), displaying many similarities with the eastern Mediterranean waters. In addition to this, the formation of dense water which takes place in these South Adriatic waters has a relatively large mass exchange with the Ionian Sea (Russo and Artegiani, 1996). This mass (LIW) contributes to warming of the bottom water of the eastern side of the South Adriatic. For example, in the 100 m depth of the Montenegrin waters the temperature remains constant all year round at about 14-16 ^{o} C (Ungaro and Gramolini, 2006). In the South Ionian Sea the measured temperature (14-15^{o} C) and salinity (≈ 39 $\%_{o}$) values of the surface waters (0-100 m) were quite similar to those of the South Adriatic (Theocharis *et al.,* 1993). In both cases, *P. longirostris* seems to overlap with the bottom temperature pattern and a preferential range of 14-15^{o} C was identified, which

has been previously indicated in other areas of the South Adriatic Sea (Ungaro and Gramolini, 2006). According an evaluation of the exploitation state of this resource indicated a general over- or full exploitation in Greek waters (Kapiris *et al.*, 2007; MEDITS, 2007). Unlike to this, the abundance of the population of *P. longirostris* on the shelf of the South Adriatic coast is not increased and the species is not threatened by the present rate of trawler fishing (Kasalica, 2005). It would be advisable to improve the monitoring of landings and fishing effort and to investigate the less known aspects of the biology and population dynamics of this economically important species.

Acknowledgements

The authors are grateful to Mr. Kavvadas for his technical support.

References

Abdel Razek, F.A, El-Sherief, S.S, Taha, S.M. and Muhamad, E.G. 2006. Some biological aspects of *Parapenaeus longirostris* (Lucas, 1846) (Crustacea: Decapoda) in the Mediterranean coast of Egypt. Egyptian Journal of Aquatic Research, 32(1): 385-400.

Abelló, P., Abella, A., Adamidou, S., Jukic-Peladic, S., Maiorano, P. and Spedicato, M.T. 2002. Geographical patterns in abundance and population structure of *Nephrops norvegicus* and *Parapenaeus longirostris* (Crustacea: Decapoda) along the European Mediterranean coasts. Scientia Marina, 66: 125–141.

Arrobas, I. and Ribeiro Cascalho, A.. 1982. Some aspects of the fishery and biology of *Parapenaeus longirostris* off Portuguese coaStage ICES C.M. 1982/K: 5.

Audouin, J. 1965. Répartition bathymétrique des crevettes sur les côtes algériennes entre les îles Zaffarines et les îles Habibats. Commission Internationale pour l'Exploration Scientifique de la Mer Méditerranée, 18: 171-174.

Bayhan, Y.K., Ünlüer, T. and Akkaya, M. 2005. Some biological aspects of *Parapenaeus longirostris* (Lucas, 1846) (Crustacea: Decapoda) inhabiting the Sea of Marmara. Turkish Journal of Veterinary and Animal Sciences, 29: 853-856.

Bertrand, J.A., Gil de Sola, L., Papaconstantinou, C., Relini, G. and Souplet, A. 2000. An international bottom trawl survey in the Mediterranean: the MEDITS programme. In Bertrand, J. and G. Relini (Eds.), Demersal Resources in the Mediterranean. Actes de colloques 26, IFREMER, Plouzane France: 76–93.

Bertrand, J.A., Gil de Sola, L., Papaconstantinou, C., Relini, G. and Souplet, A. 2002. The general specifications of the MEDITS surveys. Scientia Marina, 66: 9–17.

Burukovsky, R. N. 1981. Etude sommaire de la biologie de *Parapenaeus longirostris* des cotes Marocaines (façade Atlantique). FAO, UNDP, COPACE/TECH/81/83 (Fr), Rome: 12-18.

Crosnier, A., de Bondy, E. and Lefevere, S. 1968. Les crevettes commercialisables de la côte ouest de l'Afrique inter-tropicale. Etat de nos connaissances sur leur biologie et leur pêche en juillet 1967. Collection Initiations Documentations Techniques. ORSTOM 7, 60 pp.

Crosnier, A., Fontana, A., Le Guen, J.C. and Wise, J.P. 1970. Ponte et croissance de la crevette Pénéide *Parapenaeus longirostris* (Lucas) dans la région de Pointe-Noire. Cahiers O.R.S.T.O.M. Série Océanographie, 8: 89-102.

De Ranieri, S., Biagi, F. and Mori, M. 1986. Note sulla biologia reprodutiva di *Parapenaeus longirostris* (Lucas) nel Tirreno settentrionale. Nova Thalassia 8: 627-628.

D'Onghia, G., Matarrese, A., Maiorano, P. and Perri, F. 1998. Valutazione di *Parapenaeus longirostris* (Lucas, 1846) (Crustacea, Decapoda) nel Mar Ionio. Biologia Marina Mediterranea, 5(2): 273-283.

Drobisheva, S.S. 1970. Study on the biology of shrimp in the south-east part of the Mediterrannean Sea with the aim to determine the perspective of fishery. Trudy Azovo-Chernomorsk. Nauchno-Issled InStage Morsk. Rybn. Khoz. Oceanogr, 30: 173-208.

Froglia, C. 1982. Contribution to the knowledge of the biology of *Parapenaeus longirostris* (Lucas) (Decapoda, Penaeoidea). Quaderni del Laboratorio della Tecnologia di Pesca, 3(2-5): 163-168.

García-Rodríguez, M., Pérez Gil, J.L. and Barcala, E. 2009. Some biological aspects of *Parapenaeus longirostris* (Lucas, 1846) (Decapoda, Dendrobranchiata) in the gulf of Alicante (S.E. Spain). Crustaceana, 82(3): 293-310.

Gayanilo, FC., Sparre, P. and Pauly, D. 1994. The FAO-ICLARM Stock Assessment Tools (FiSAT) User's Guide. FAO Computerized Information Series, Fisheries.

Gayanilo, F.C., Soriano, Jr M. and Pauly, D, editors 1998. A Draft to the Compleat ELEFAN, ICLARM Contribution 435, 65 pp.

GFSM, 2011. GFCM-SAC Sub-Committee on Stock Assessment (SCSA) Working Group on Stock Assessment of Demersal Species Chania, Crete, 24-29 October 2011, Greece: 13 pp.

Heldt, J.H. 1954. Les fonds à *Parapenaeus longirostris* (Lucas, 1846) des mers tunisiennes. Bulletin de la Station Océanographique de Salambô, 47: 11-22.

Holthuis, L.B. 1980. FAO species catalogue, 1. Shrimps and prawns of the world. An annotated catalogue of species of interest to fisheries. FAO Fish. Synopsis, 125, 1., Rome: 261 pp.

Jukić, S. 1975. Koćarska područja u srednjem Jadranu. Acta Adriatica, 17 (1): 1-86.

Kapiris, K., Mytilineou, C.H., Maiorano, P., Kavadas, S. and Capezzuto, F. 2002. Abundance and bathymetrical distribution of *Parapenaeus longirostris* in the South Ionian Sea. Fourth European Crustacean Conference, 22-26 July, Poland.

Kapiris, K. 2004. Feeding ecology of *Parapenaeus longirostris* (Lucas, 1846) (Decapoda: Penaeidae) from the Ionian Sea (Central and Eastern Mediterranean Sea). Scientia Marina, 68(2)**:** 247-256.

Kapiris, K., Mytilineou, C.H., Politou, C-Y., Kavadas, S. and Conides, A. 2007. Research on shrimps' resources and fishery in Hellenic waters. In: C. Papaconstantinou, A. Zenetos, V. Vassilopoulou, G. Tserpes (Eds.), HCMR Publications, Athens: 421-432.

Kapiris, K., Kavadas, S., Maina, I., Tserpes, G., Kallianiotis, A., Peristeraki, P. and Politou, C.Y., 2012. *Spatial distribution of deep-water rose shrimp juveniles (Parapaenaeus longirostris) in the Aegean*

and Ionian Sea using predictive habitat modeling. 12th International Congress on the Zoogeography, Ecology and Evolution of Southeastern Europe and the Eastern Mediterranean, Athens, 18-22/6/2012, Book of Abstracts, 74 p.

Karlovac, O. 1949. Le *Parapenaeus longirostris* (H. Lucas) de la haute Adriatique. Acta Adriatica, 3(12): 407-418.

Kasalica, O. 2005. Population dynamics of deep-water pink shrimp *Parapenaeus longirostris* (Lucas, 1846) on Montenegrin shelf (South Adriatic Sea). M.A. thesis, University of Belgrade.

Kasalica, O. and Joksimović, A. 2005. Area distribution and relative biomass of deep water pink shrimp *Parapanaeus longirostris* (Lucas, 1846) at Montenegrin shelf. II International Conference "Fishery", 10-12 February 2005, Belgrade.

Kasalica, O, Regner, S. and Joksimović, A. 2007**.** Percent-weight participation and CPUE of deep-water pink shrimp *Parapenaeus longirostris* (Lucas, 1846) in trawler fishing at the shelf of Montenegrin coaStage III International Conference "Fishery", 1-3 February 2007, Belgrade.

Levi, D., Anreoli, M.G. and Giusto, R.M. 1995. First assessment of the rose shrimp, *Parapenaeus longirostris* (Lucas, 1846) in the central Mediterranean. Fisheries Research, 21 (3): 375-393.

Ligas, A., Sartor, P. and Colloca, F. 2011. Trends in population dynamics and fishery of *Parapenaeus longirostris* and *Nephrops norvegicus* in the Tyrrhenian Sea (NW Mediterranean): the relative importance of fishery and environmental variables. Marine Ecology, 32 (Suppl. 1): 25–35.

Massutí, M. 1963. La pêche des Crustacés aux Baleares (Méditerrannée occidentale) et dans l'Atlantique sud (Golfe de Cadix). Débats et Documents Techniques. Conseil General des Peches pour la Méditerrannée, 7 (14): 191-202.

MEDITS, 2007. Assessment of indicator trends related to exploited demersal fish populations and communities in the Mediterranean. DCR Medits Working group. Nantes (France), 15–18 March 2005 and Kavala (Greece), 2–6 April 2006. http://www.ifremer.fr/docelec/default-en.jsp

Merker-Poček, B. 1971. Situation et distribution bathimatrique de certaines especes de Natantia dans l'Adriatique meridionale. Studia Marina, 4: 77-84.

Mytilineou, C.H., Maiorano, P., Kavadas, S., D' Onghia, G., Kapiris, K. and Capezzuto, F. 2001. Size structure comparison in some demersal species between two areas of different fishing impact in the Eastern-Central Mediterranean. NAFO SCR, Deep-sea Fisheries Symposium, 12-14 September, Cuba.

Olaso, I. 1990. Distribución y abundancia del megabento invertebrado en fondos de la plataforma Cantábrica. Publicaciones Especiales. Instituto Español Oceanografía, 5: 1-128.

Öztürk, B. 2009. Investigations of the rose shrimp *Parapenaeus longirostris* (Lucas, 1846) in the Northern Marmara Sea. Journal of Black Sea/Mediterranean Environment, 15: 123-134.

Pastorelli, A.M., Vaccarella, R., Marano, G. and Ungaro, N. 1996. I crostacei dei fondi strascicabili del basso Adriatico. Nova Thalassia, 12: 27-35.

Politou, C-Y., Maiorano, P., D'Onghia, G. and Mytilineou, C.H. 2005. Deep-water decapods crustacean fauna of the Eastern Ionian Sea. Belgian Journal of Zoology, 135: 235-241.

Politou, C-Y., Tserpes, G. and Dokos, J. 2008. Identification of deep-water pink shrimp abundance distribution patterns and nursery grounds in the eastern Mediterranean by means of generalized additive modeling. Hydrobiologia, 612: 99-107.

Regner, S. and Joksimović, A. 2002. Estimate of demersal biomass of the Montenegrin shelf (South Adriatic). Study Marine, 23(1): 33-40.

Relini, G., Bertrand, J. and Zamboni, A. editors. 1999. Synthesis of the knowledge on bottom fishery resources in Central Mediterranean (Italy and Corsica). Biologia Marina Mediterranea, 6 (supl. 1).

Ribeiro-Cascalho, A. and Arrobas, I. 1983. Further contributions to the knowledge about biology and fishery of *Parapenaeus longirostris* (Lucas, 1846) of South Portuguese coaStage ICES CM 1983/K: 26.

Ribeiro-Cascalho, A. and Arrobas, I. 1987. Observations on the biology of *Parapenaeus longirostris* (Lucas, 1846) from the south coast of Portugal. Investigacion Pesquer,a 51 (Supl.1): 201-212.

Russo, A. and Artegiani, A. 1996. Adriatic hydrography. Scientia Marina, 60 (Supplement 2): 33-43.

Sbrana, M., Viva, C. and Belcari, P. 2006. Fishery of the deep-water rose shrimp *Parapenaeus longirostris* (Lucas, 1846) (Crustacea: Decapoda) in the northern Tyrrhenian Sea (western Mediterranean). Hydrobiologia, 557: 135-144.

Sobrino, I. and García, T. 1994. Biology and fishery of the deepwater rose shrimp *Parapenaeus longirostris* (Lucas, 1846) from the Atlantic Moroccan coaStage Scientia Marina, 58(4): 299-305.

Sobrino, I., Silva, C., Sbrana, M. and Kapiris, K. 2005. Biology and fisheries of deep water rose shrimp (*Parapenaeus longirostris*) in European Atlantic and Mediterranean waters. Crustaceana, 78, 10: 1153-1184.

Stamatopoulos, C. 1993. Trends in catches and landings. Mediterranean and Black Sea fisheries: 1972-1991. FAO Fisheries Circular No 855 4. 177 pp.

Theocharis, A., Georgopoulos, D., Lascaratos, A. and Nittis, K. 1993. Water masses and circulation in the central region of the Eastern Mediterranean: Eastern Ionian, South Aegean and Northwest Levantine, 1986-1987. Deep-Sea Research II, 40: 1121-42.

Tom, M, Goren, M. and Ovadia, M. 1988. The benthic phase of the life cycle of *Parapenaeus longirostris* (Crustacea, Decapoda, Penaeidae) along the Mediterranean coast of Israel. Hydrobiologia, 169: 339-352.

Ungaro, N. and Gramolini, R. 2006. Possible effect of bottom temperature on distribution of *Parapenaeus longirostris* (Lucas, 1846) in the Southern Adriatic (Mediterranean Sea). Turkish Journal of Fisheries and Aquatic Sciences, 6: 109-116.

Županović, Š. and Jardas, I. 1989. Fauna i flora Jadrana. Logos Split, 526 pp.