

## Decapod crustacean fauna of the Argolikos Gulf (Eastern Mediterranean, Central Aegean Sea)

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*The study presents the biomass, the abundance and the depth distribution of the decapod crustaceans in Argolikos Gulf (Central Aegean Sea) from data collected in trawl surveys carried out throughout 2008. This work is the first systematic work in this important Greek area and will support the knowledge for understanding the decapods stocks' fishery in the above area. A total of 28 species of decapod crustaceans was identified from a total of 42 hauls made in three depth zones (50-100 m, 100-200 m, 500-600 m). Among decapods recorded were 6 Dendrobranchiata (5 Penaeoidea, 1 Sergestoidea), 22 Pleocyemata (9 Brachyura, 8 Caridea, 2 Anomura, 1 Palinurid, 1 Astacideum, 1 Stenopodidea). The most abundant commercial species found in both shallower depth zones (50-100 m, 100-200 m) was *Parapenaeus longirostris* while in the deepest one (500-600 m) *Aristaeomorpha foliacea* was the most numerous. Some new depth distribution records for the Eastern Mediterranean were obtained for some few species.*

**Key words:** Crustacea Decapoda, abundance, depth distribution, Aegean Sea, Greece

### INTRODUCTION

The Argolikos Gulf is a relatively shallow open gulf located in the central Aegean Sea. Its total surface is 2154,3 km<sup>2</sup> corresponding to the 1,63% of the total Greek surface. The total length of the gulf is 54 km and the maximum width is 20 km. The maximum depth of the Argolikos Bay is 820 m in the center, while the depths of over 500 m are usually found from northwest to southeast. The Argolikos Gulf represents almost the 50% of the total gross value of the fishery production of the Peloponnese Region. The total fishery production of the Argolikos Gulf, including marine fisheries, lagoons, and aquaculture, is around 8500 t annually and has remained relatively constant in the

past few years (Source: Prefectural Administration of Argolis). The majority of the registered vessels in the area are small (smaller than 12 m) inshore fishing vessels (mainly netters and long-liners); only a very small fraction belong to medium-scale fishery (1,43% purse seines, 1% trawlers) (HCMR, 2008). There are only very few and scanty scientific data on the biological resource.

The crustacean fishery in Greek waters does not constitute a particular branch of the multispecies Hellenic fishery. The most important commercial species in Greek waters are the Norwegian lobster (*Nephrops norvegicus*), the penaeid shrimps *Parapenaeus longirostris* and *Melicertus kerathurus*, the palinurid lobster *Palinurus elephas*, the homarid lobster *Homarus*

*gammarus*. Apart from these, some other species could be characterized as by-catch such as the portunid crab *Liocarcinus depurator*; the majid crab *Maja* sp., the calappoid crab *Calappa granulata*, the stomatopod *Squilla mantis* and the squat lobster *Munida* sp. The most commercial shrimp species in Greek waters of the Aegean Sea are *P. longirostris* and *M. kerathurus*, which are the most important in terms of landing and economic value (MYTILINEOU *et al.*, 2001). Furthermore, some shrimps are potentially marketable species such as the deep-water shrimps (*Pandalidae*, *Aristeidae*) or are locally important species, such as the palaemonid shrimp *Palaemon adspersus* (KAPIRIS *et al.*, 2007).

According to the last available statistical data of ETANAL (2010), the crustacean landings from Hellenic waters were 3615,2 t, representing 5,25% of the total landings; while the value is about 35% of the value of total landings (ETANAL data). The total catch of shrimps was the 85% of the crustaceans' catch, while the rest of the catch consisted of lobsters, spiny-rock lobsters, crabs, sea-spiders and freshwater crustaceans (FAO data). According to the ELSTAT data (Hellenic Statistical Authority data) the mean annual crustacean catches in Greek waters showed a continuous increase from 175 t (1928-1934) to 1.260 t (1964-1981) and from 3.181 t (1990-2002) to 3330,71 t (2003) and from 4210,40 t (2004) to 5065,02 t (2005-2007) (ELSTAT data).

The main objective of this study was to present the knowledge on the first fishery data and the depth distribution of the decapods crustaceans on the trawlable bottoms of the Argolikos Gulf. The present information will be a useful tool for the definition of the decapod crustaceans biodiversity which is a very significant assistance for the environmental management of the Mediterranean basin.

## MATERIAL AND METHODS

This study is a part of the first systematic attempt to detect the fishing resources in the Argolikos Gulf. Data were collected within the framework of the project «*Study of the sustain-*

*ability of fisheries of the Argolikos Gulf*» (EP. AL, Meter 4.4.) by trawling at the depth ranging between 58 and 596 m in the months, March, May and August of 2008. The random stratified sampling design was applied using depth for the stratification of the study area. Trawl hauls were performed in three different depth strata (50-100, 100-200, 500-600 m) by the F/R “Philia”, which belongs to the HCMR. The length of the vessel's ropes was 200 m. Length of wire (diameter 11 mm) varied depending on the depth of the station, the stretched mesh was 22 mm in the codend (from knot to knot). The horizontal opening of the net was 12 m. The towing speed for the vessels was 2,4 nm/h. 14 stations were sampled each sampling period; using a random stratified sampling design (Fig. 1). The haul duration ranged from 30 to 60 minutes. Catches (fishes, crustacean and cephalopods) were identified to the species level. The analysis of the catch composition was based on the study of the catch per unit effort (CPUE) which was expressed in kg/h and the abundance in N/h.

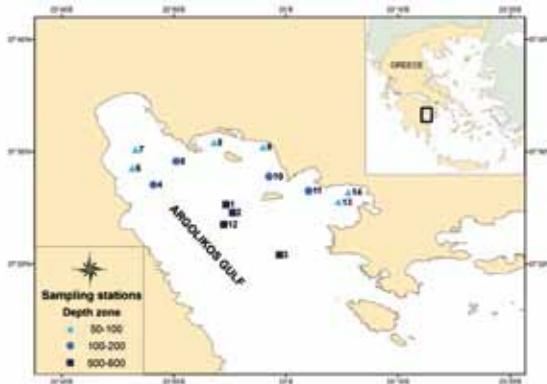


Fig. 1. Map showing sampling stations in the Argolikos Gulf

After collecting, the specimens of all decapods in the samples were preserved in freeze. Then, the specimens were counted and identified to species level, whenever possible, based on a very basic taxonomic report (FALCIAI & MINERVINI, 1996). The nomenclature of the species follows the World Register of Marine Species (WORMS, 2014).

## RESULTS

Total catch in terms of weight was composed of fish (80-90%) and crustaceans (3-5%) in all cruises and depth strata. Additionally, in terms of numbers, total catch components were similarly represented (crustaceans: 3-5%; fish: 57-75%) in all cruises and depth strata. Cephalopods' proportion was always negligible, ranging between 4% and 13% (in totally 51 cephalopod species was identified) of the total catch and 5-16% of the total weight (their total weight was 225 g). A total of 152 species was recorded from which 96 were fishes, 21 cephalopods and 27 crustaceans. Most of crustaceans were non-commercial or potentially commercial species. The highest

catch of commercial crustaceans was obtained in March, while none of possibly commercial crustaceans peaked in August.

Almost all the crustaceans were decapods (28 species) and one of them was Stomatopod, *Squilla mantis*. Among the decapods found were 6 Dendrobranchiata (5 Penaeoidea, 1 Sergestoida), 22 Pleocyemata (9 Brachyura, 8 Caridea, 2 Anomura, 1 Palinurum, 1 Astacideum, 1 Stenopodidea). *P. longirostris* was the most abundant species and it is a very common species in the Argolikos, Saronikos Gulfs, Ionian and Aegean Seas (KAPIRIS *et al.*, 1987). The mantis shrimp, *Squilla mantis* does not present any commercial interest in the Argolikos Gulf, but is a very abundant species in the sampling area.

Table 1. CPUE (kg/h), abundance (N/h) and depth range per sampling month of the decapod crustaceans found in Argolikos Gulf

Species	March			May			August		
	Depth	kg/h	N/h	Depth	kg/h	N/h	Depth	kg/h	N/h
	Range (m)			Range (m)			range		
<b>Dendrobranchiata</b>									
<i>Aristaeomorpha foliacea</i> (Risso, 1827)	510-596	3,87	268	503-597	2,09	210	412-611	7,51	613
<i>Aristeus antennatus</i> (Risso, 1816)	510-596	0,09	6						
<i>Parapenaeus longirostris</i> (Lucas, 1846)	96-596	56,04	13228	97-538	27,9	4457	87,5-611	46,67	8290
<i>Melicertus kerathurus</i> (Forsk., 1755)				43	0,04	2			
<i>Sergia robusta</i> (S.I. Smith, 1882)	536	0,01	2						
<b>Pleocyemata</b>									
<b>Brachyura</b>									
<i>Calappa granulata</i> (Linnaeus, 1758)	88	0,03	2						
<i>Dromia personata</i> (Linnaeus, 1758)				57	0,02	2	90,2	0,11	105
<i>Goneplax rhomboides</i> (Linnaeus, 1758)	510	0,01	3	503-538	0,02	6	500	0,02	3
<i>Macropodia longirostris</i> (Fabricius, 1775)				153	0,001	2	48	0,02	2
<i>Macropipus tuberculatus</i> (Roux, 1830)	88-215	0,13	11	597	0,01	1	56,8-611	0,27	59
<i>Maja squinado</i> (Herbst, 1788)	90	0,04	2	52-597	0,5	10			
<i>Paromola cuvieri</i> (Risso, 1816)				52-153	0,02	2	96,5	0,01	3
<i>Liocarcinus depurator</i> (Linnaeus, 1758)	510	0,02	1	64-503	0,003	2	87,5-210	0,02	2
<i>Geryon longipes</i> A. Milne Edwards, 1881				503	0,01	2	611	0,01	1
<b>Astacidea</b>									
<i>Nephrops norvegicus</i> (Linnaeus, 1758)	536	0,26	3	503	0,18	2	96,5-500	0,18	5

**Caridea**

<i>Crangonidae</i>	510-536	0,01	4	503-597	0,02	4	96,5-611	0,01	4
<i>Pasiphaea multidentata</i> Esmark, 1866	596	0,02	2						
<i>Pasiphaea sivado</i> (Risso, 1816)	510-596	0,02	11	538	0,01	1			
<i>Plesionika acanthonotus</i> (Smith, 1882)	596	0,01	4	503	0,01	9	412-500	0,84	324
<i>Plesionika antigai</i> Zariquiey Alvarez, 1955	215-596	0,15	17	503	0,001	2	412	0,01	6
<i>Plesionika edwardsii</i> (Brandt, 1851)	215-536	0,37	901	503	0,04	22	500	0,27	138
<i>Plesionika gigliolii</i> (Senna, 1903)	215-510	0,01	2	199	0,01	13	500	0,05	3
<i>Plesionika heterocarpus</i> (Costa, 1871)	510	0,01	6				412	0,1	16
<i>Plesionika martia</i> (A. Milne Edwards, 1883)	510-596	1,36	349	503-597	2,28	500	412-611	3,14	730

**Palinura**

<i>Polycheles typhlops</i> Heller, 1862	88-596	0,3	57	503-597	0,12	43	90-611	0,43	56
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**Stenopodidea**

<i>Stenopus spinosus</i> (Risso, 1827)	134	0,01	2						
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**Anomura**

<i>Munida rullanti</i> Zariquiey-Alvarez, 1952	155-159	0,04	7	97-597	0,02	16	500	0,03	9
<i>Munida intermedia</i> A. Milne Edwards & Bouvier, 1899	215	0,01	5				197	0,02	3

The decapods' CPUE ranged from 0,01 to 56,04 kg/h (total crustaceans' CPUE was 155,88 kg/h) and the abundance 1-13228 N/h (total crustaceans' abundance was 30591 N/h) (Table 1). Most abundant was *P. longirostris* (88,74% of CPUE and 88,94% of the crustaceans' abundance), *Plesionika martia* (6,04% of CPUE and 0,58% of the crustaceans' abundance) and *Plesionika edwardsii* (2,34% of CPUE and 2,16% of the crustaceans' abundance).

*Melicertus kerathurus* and the brachyuran crabs, *Dromia personata*, *Calappa granulata*, and *Maja squinado* were exclusively found in the middle shelf zone (50-100 m). Some other species were also found in this depth zone but even in the other ones, like the squat lobster *Munida iris* (in all the depth zones), the polychelid lobster *Polycheles typhlops*, species belonging to Crangonidae family and the Norway lobster *Nephrops norvegicus* (Astacidea) (in 500-600 m also) (Fig. 1). In terms of CPUE and abundance, the main species in the middle shelf zone (50-100 m) were *P. longirostris* (0,019-0,503 kg/h and 11-89 N/h), the portunid crab *Macropipus tuberculatus* (0,03-0,05 kg/h and 1-2 N/h) and *P. typhlops* (0,01-0,05 kg./h and 1-2 N/h) (Fig. 2).

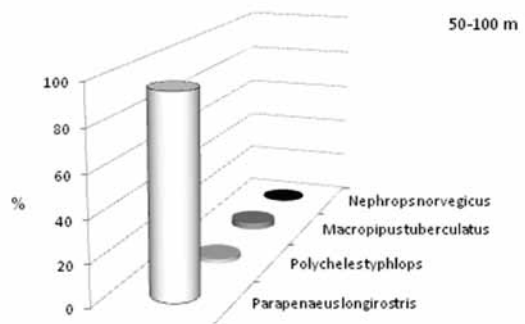


Fig. 2. CPUE of decapod crustaceans found in Argolikos Gulf in the middle shelf zone (depth zone 50-100 m)

The squat lobster *M. intermedia*, the brachyuran crab, *Macropodia longirostris* and the stenopodid shrimp *Stenopus spinosus* were exclusively found in the lower shelf (100-200 m). In terms of CPUE and abundance, the main species in the lower shelf zone (100-200 m) were the pink shrimp *P. longirostris* (21,99-43,93 kg/h and 1114-3406 N/h), the pandalid shrimp *P. edwardsii* (0,28 kg./h and 226 N/h, only in March) and the portunid crab, *M. tuberculatus* (0,06-0,09 kg/h and 2-3 N/h) (Fig. 3).

A total of 11 species of decapods was exclusively collected in the deepest depth zone (500-600 m) sampled in the Argolikos Gulf. The

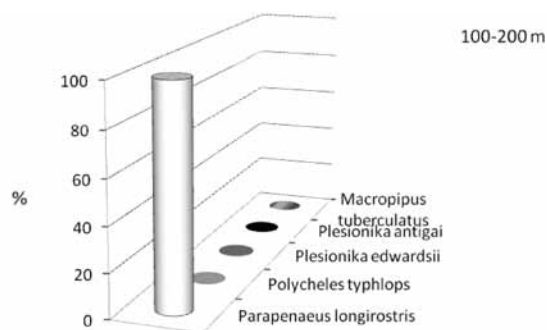


Fig. 3. CPUE of decapod crustaceans caught in Argolikos Gulf in the lower shelf (depth zone 100-200 m)

analysis of the CPUE values per species showed that, in all three cruises at the depths of 500–600 m (the middle slope), the most important species in terms of weight were *A. foliacea* (1,24-4,43 kg/h and 72-203 N/h, representing 51,17% of the total CPUE in the deepest depth). After that, *P. longirostris* (0,15–3,57 kg/h and 6,67-45,40 N/h, representing 42,55% of the total CPUE in this sampling zone), *P. martia* (0,47=1,04 kg/h), *P. typhlops* (0,04-0,12 kg/h and 15-17 N/h) and *P. edwardsii* (0,002-0,08 kg/h and 1-45 N/h). Both deep water red shrimps, *A. foliacea*, *A. antennatus* caught in the deeper zones were of special commercial interest (Fig. 4)

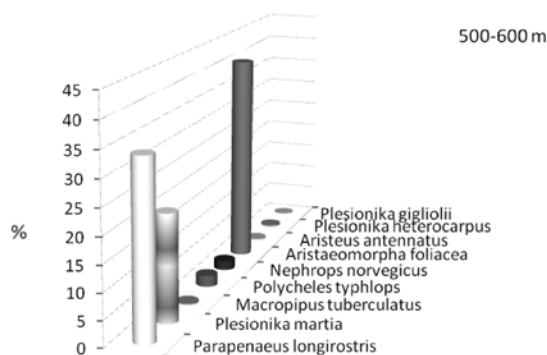


Fig. 4. CPUE of decapod crustaceans recorded in Argolikos Gulf in the middle slope (depth zone 500-600 m)

## DISCUSSION

In the recent assessment of the decapod fauna of Greek waters, a total of 250 species was recorded (KITSOS *et al.*, 2006). The most diverse, in terms of species number, are the true crabs (brachyurans) followed by caridean shrimps and anomurans (hermit crabs, squat lobsters). Dendrobranchiate shrimps and macrurans (lobsters

and relatives) contribute to a lesser extent to the decapod species diversity. (THESSALOU-LEGAKI, 2007). The decapods landings from Argolikos and Saronikos Gulfs in the last 10 years presented a modification. According to the statistical data of ETANAL the maximum landings value was in 2004 (352,1 t), but the next year (2005) an abrupt reduction appeared (179,9 t). The last years an almost stable production presented about 250 t.

Although there are several studies on the vertical distribution of the decapod crustaceans in the Greek Sea (KOUKOURAS *et al.*, 1992, 1998, 1974; POLITOU *et al.*, 1998), this study is the first attempt to analyze the fishery and the vertical distribution of decapods crustaceans in the Argolikos Gulf. The most important component of the decapods fauna of the Argolikos Gulf is brachyuran crabs and caridean shrimps (35% and 31% of the total number of decapods found, respectively). The species depth distribution was generally within the ranges already given in the related literature. Several external depth records are given for several species found in the present study. For example, *P. cuvieri* is a deep-water species and normally found at the depths between 150 m and 1000 m (PIPITONE & TUMBILOLO, 1993). In the present study, *P. cuvieri* was recorded in the shallowest zone (50-100 m). In addition to this, *P. typhlops* was similarly found in the same depth zone (50-100 m), but its usual depth distribution in the Mediterranean lies from 300 to 2000 m (ABELLÓ & CARTES, 1992).

The deep-water pink shrimp, *P. longirostris* was the most abundant decapod in all the sampling areas of Argolikos Gulf, mainly in the first two zones (50-100 m and 100-200 m), presenting the most high CPUE (Fig. 5). *P. longirostris* is one of the most important species of the Greek crustacean landings, fished mainly in depths ranging between 150 and 400 m and being very widespread both in the Aegean and the Ionian Sea (KAPIRIS *et al.*, 2007). The fishing gears used for *P. longirostris* in the Greek fishery are trawls (66,79% of the total catch), seine nets (3,61%), ring nets (0,98%) and other (28,63%) (Hellenic Statistical Authority data). The mean annual landings of *P. longirostris* during the period

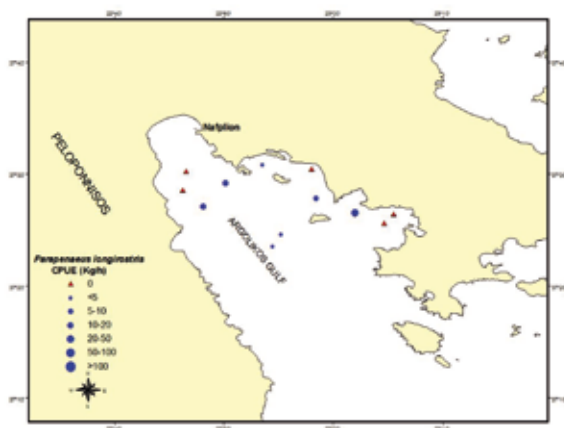


Fig. 5. Pooled CPUE (kg/h) values of *P. longirostris* caught in Argolikos Gulf

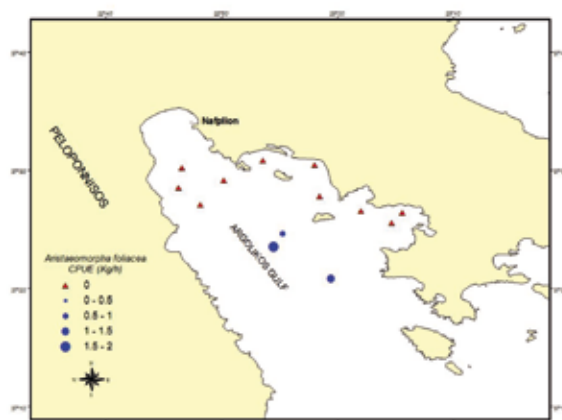


Fig. 6. Pooled CPUE (kg/h) of *A. foliacea* caught in Argolikos Gulf

1990-2004 were 1226,87 t (28,31% of the total crustaceans' landings (EL.STAT data). According to ETANAL, the mean annual landings passing through auctions were 1118,19 t (62,91% in the same period (1991-2002). In the Argolikos and Saronikos Gulfs (the southeastern Greece) the mean annual landings of *P. longirostris* in the period 2004-2007 was 214,7 t presenting an almost stable production (Hellenic Statistical Authority). The annual economic value of this species has been increased in the last years ranging from 22% to 50% of the total crustacean value, indicating a similar trend with time and landings according the Fisheries' Development COMPANY S.A. (ETANAL). On the other hand, the annual price of this species showed a great variability during the studied period without displaying any significant trend.

Although comparison of abundance of the decapods fauna in the Argolikos Gulf caught in 500-600 m with other studies is difficult, due to the different gears and methods used, the same fauna distribution found in the present study is quite similar to those found in other Greek Seas such as the Ionian Sea (POLITOU *et al.*, 2005), the Aegean Sea (KALLIANIOTIS *et al.*, 2000, KOUKOURAS *et al.*, 1992, 1998, 2000). Pandalid shrimps play an important ecological role within the various megabenthic assemblages, due to their abundance and trophic relationships. In the eastern Mediterranean, including Greek waters the species of the genus *Plesionika* have no commercial

importance with the exception of *P. edwardsii* and *P. narval*. In the frame of the MEDITS Project, *P. martia* was occasionally found in the 200-500 m depth zone, while it was the most abundant species in the depth zone 500-800 m, presenting a CPUE 99 ind/hour in the Ionian Sea and 147 ind/hour in the Saronikos area (POLITOU *et al.*, 1998) in the period 1996-1999. Another pandalid shrimp, *P. heterocarpus* was also very common in 200-500 m in both areas representing 27% of the total decapods' catch in the Ionian Sea and 8% of the total catch in the Saronikos (POLITOU *et al.*, 1998).

In the present study 7 species of decapod crustaceans have been exclusively recorded in this sampling zone (500-600 m) (*A. foliacea*, *A. antennatus*, *G. rhomboides*, *Pasiphaea. sivado*, *Pasiphaea. multidentata*, *Sergia. robusta*, *Geryon. longipes*), while in the 500-700 m of the E. Ionian Sea 27 species have been recognized (POLITOU *et al.*, 2005). The study of deep waters is not well developed in the Greek waters, but both red shrimps, *Aristaeomorpha foliacea* and *Aristeus antennatus* are very commercial species in the western and central Mediterranean Sea (KAPIRIS *et al.*, 2007). *A. foliacea* and *P. martia* were the most abundant in the deepest zone of the study area. The CPUE values of *A. foliacea* in the E. Ionian Sea ranged from 0,70 έως 2,51 kg/h, while in the Argolikos Gulf CPUE values of the same species were a little increased (Fig. 6). CPUE values of *A. antennatus* in Argolikos

Gulf were lower than those of the E. Ionian Sea, since the sampling stations in the former area did not exceeded the 600 m, where the blue-violet shrimp is abundant.

Besides, quite similar results have been also presented in the studies carried out in different areas of the Mediterranean (the Adriatic Sea; UNGARO *et al.*, 1999; Catalan waters; ABELLÓ *et al.*, 2002; Italian waters; D'ONGHIA *et al.*, 2001). The red shrimps, *A. foliacea* and *A. antennatus* are the main target species of the Mediterranean deep-water trawling (CARTES *et al.*, 1994). Both species were prevalently caught in the depth zone 500-800 m of the Mediterranean basin, mainly by Spanish and Italian fishermen, though *A. foliacea* is often found in shallower waters (200-500 m) and *A. antennatus* can be also found much deeper (> 800 m). *A. antennatus* was shown to have the potential populations to support a viable fishery in the eastern Ionian Sea (PAPACONSTANTINO & KAPIRIS, 2001, 2003) and, possibly, in the Argolikos Gulf. Several studies have been carried out

on both red shrimps biology and ecology on the Greek Ionian Sea coast (PAPACONSTANTINO & KAPIRIS, 2001, 2003; KAPIRIS & THESSALOU-LEGAKI, 2009, 2011; KAPIRIS *et al.*, 2010; GUILLEN *et al.*, 2012). The absence of fishing pressure in depths beyond 500 m in the Greek seas makes their populations an unexploited resource. Thus, the presence of a stock of potentially high commercial value in such a pristine condition is scientifically valuable because of the possibilities offered to understand their population. The general view is that these resources seem to be relatively resistant to the fishing pressure because the fishing gears used do not heavily exploit their young-of-the-year recruits (MYTILINEOU *et al.*, 2001).

Our results highlight the importance of the study of the decapod crustaceans in the Argolikos Gulf, since this knowledge will undoubtedly increase the information for the management of their stocks and the exploitation of the marine resources.

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## Dekapodni rakovi u zaljevu Argolikos (istočni dio Sredozemnog mora, središnji dio Egejskog mora)

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### SAŽETAK

U ovom radu su prikazani biomasa, abundancija i dubinska raspodjela dekapodnih rakova u Argolikos zaljevu (središnji dio Egejskog mora) dobiveni iz podataka prikupljenih povlačnim alatima tijekom 2008. godine. Ovaj rad je prvi sustavni rad, iz ovog važnog grčkog područja, koji donosi saznanja za bolje razumijevanje dekapodnih zaliha. Ustanovljeno je 28 vrsta dekapodnih rakova tijekom 42 kočarska potega na tri dubine (50-100 m, 100-200 m, 500-600 m). Zabilježene su slijedeće vrste dekapodnih rakova: 6 Dendrobranchiata (5 Penaeoidea, 1 Sergestoidea), 22 Pleocyemata (9 Brachyura, 8 Caridea, 2 Anomura, 1 Palinurid, 1 Astacideum, 1 Stenopodidea). Najbrojnija komercijalna vrsta koja je pronađena u obje pliće zone (50-100 m, 100-200 m) je *P. longirostris*, dok je u najdubljoj zoni (500-600 m) bio najbrojniji *A. foliacea*. Tijekom istraživanja u istočnom Sredozemnom moru su ustanovljeni novi nalazi o raspodjeli nekih vrsta prema dubini.

**Ključne riječi:** dekapodni rakovi, abundancija, dubinska zastupljenost, Egejsko more, Grčka

