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# Annual variability of the decapod larvae community in the shallow waters of the southern Adriatic

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*Investigations of the annual decapoda larvae variability in the shallow waters of the southern Adriatic using the ADRIATIC sampler, indicated that the individuals are not equally distributed in the water column. In the oligotrophic Lokrum Channel, very low values were noted only in the bottom layers. The species Processa spp. and* Liocarcinus *spp. dominated at this station. In the slightly antropogenic eutrophicated Gruž Bay and in the naturally eutrophicated Mali Ston Bay, a high number of individuals were recorded during the spring and summer. The large aggregations of individuals in Gruž and Mali Ston Bay were primarily caused by the vertical distribution of the dominant species* Pisidia longimana. *Significantly higher values were determined in the middle layers of Gruž Bay (P=0.003) and in the bottom layers of Mali Ston Bay (P<0.001).*

**Key words:** Decapod larvae, vertical distribution, Adriatic Sea, coastal waters

## INTRODUCTION

Little is known about the abundance and contribution of decapod larvae to the Adriatic Sea plankton community. The first qualitative-quantitative data on decapod larvae from this region were presented by KURIAN (1956). LUČIĆ (1985) and LUČIĆ and BENDER-POJATINA (1995) reported the high abundance and biomass of decapod larvae during the night at surface layers in spring and summer in the seawater inlet Veliko jezero on the island of Mljet and in Mali Ston Bay. KRŠINIĆ and LUČIĆ (1994) noted typical day-night migratory movements in some species of decapod larvae for the same area.

The aim of this paper is to present the structure, vertical distribution and population density of decapod larvae assemblages found at several locations in the shallow waters of the southern Adriatic. Most of the organisms collected were categorized according to the level of family and genus, due to the lack of taxonomic literature. "Larvae" includes all zoeae and earlier stages, not including megalope.

### Study area

Station locations are shown in Fig. 1. The oligotrophic station in the Lokrum Channel (depth of 22 m) is strongly influenced by the

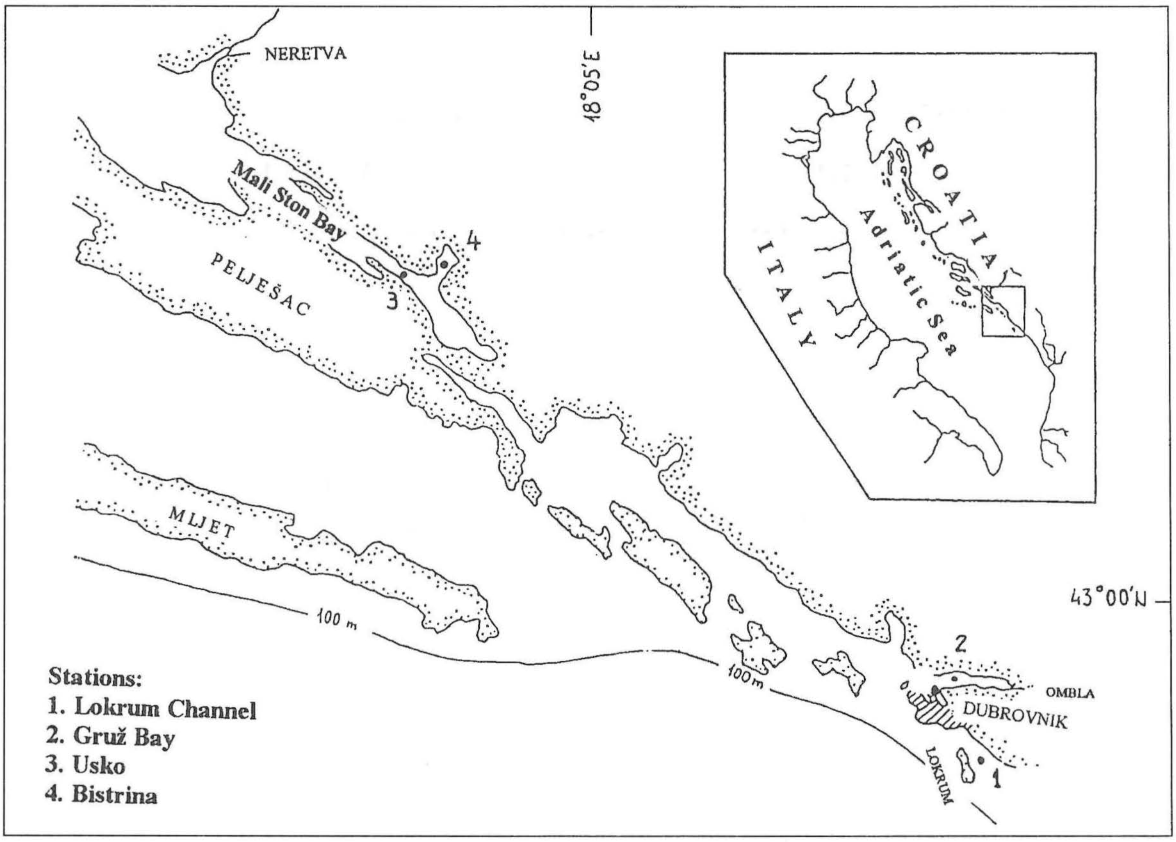


*Fig. 1. Location of the sampling stations*

east Adriatic currents from the open sea. Gruž Bay (depth of 22 m) is influenced by discharge from the river Ombla, offshore waters and slight antropogenic eutrophication (VILIČIĆ *et al.*, 1995). The naturally eutrophicated stations Usko (depth of 14 m) and Bistrina (depth of 10 m) are located in Mali Ston Bay between the mainland and the peninsula Pelješac. The water in Mali Ston Bay is strongly influenced by freshwater discharges from the Neretva River, underground springs and the occasional abundant rainfall. Mali Ston Bay abounds in numerous filter-feeding organisms and is well known as an oyster and mussel farming area. More detailed hydrographic and biological data were previously given by other authors (KRŠINIĆ, 1987; VILIČIĆ, 1989; LUČIĆ, 1996; JASPRICA and CARIĆ, 1997).

## MATERIAL AND METHODS

The investigations were carried out from aboard the R/V BALDO KOSIĆ of the Biological Institute in Dubrovnik. Thirteen daytime plankton samples were taken in the Lokrum Channel and in Gruž Bay between March 1989 and May 1990 and eleven from stations in Mali Ston Bay between March 1989 and July 1990. Samples were taken with a 250 l volume plankton sampler ADRIATIC (KRŠINIĆ, 1990), at 5-m intervals (Lokrum Channel and Gruž Bay) and 2-m intervals (Mali Ston Bay). Sampling was conducted from the surface to the bottom, using a 125 µm mesh netting gauze. All samples were preserved in 2.5% formaldehyde, neutralized with a calcium carbonate buffer. Decapod larvae were analyzed under a stereo microscope at a magnification of 50 x. Temperature and salinity were determined by a

Hydrobios LF 191 probe. The daily vertical distribution of decapod larvae was obtained using the KRUSKAL-WALLIS, test (H). Data were considered significant at the 95% level.

## RESULTS

### Hydrography

At all stations, the increase of surface temperatures in spring resulted in the thermal stratification of the water column as early as May and formatting of the thermocline in summer. During autumn, the vertical gradient weakened and a moderate temperature inversion occurred. In winter, isotherm was not registered. The temperature range was from 12.3 to 25.4°C in the Lokrum Channel, 11.3 to 23.9°C in the Gruž Bay and 11.6 to 26.6°C at stations in Mali Ston Bay. Salinity values recorded in the Lokrum Channel exceeded 37 psu at depths greater than 5 m and 38 psu at depths greater than 15 m. A minimum of 31.3 psu was recorded at the surface in August. The inflow of the Ombla River into Gruž Bay resulted in low salinity values from 0 -10 m depth, especially in spring, with a minimum of 26.7 psu at the surface in April. During the summer-autumn period, values higher than 37 psu were found at depths greater than 10 m. In Mali Ston Bay, the most pronounced variations in salinity were recorded at the surface. A minimum of 32.2 psu was noted in May and November, while in July the minimum salinity was 32.6 psu, due to the direct influence of the Neretva River. Near the bottom, salinity values were notably high (>37 psu), due to the influx of more saline open waters.

### Decapod larvae composition and population densities

Taxa identified in this study are listed in Table 1.

In the Lokrum Channel, densities greater than 10 ind.m$^{-3}$ were noted only during the spring, with the maximum of 72 ind.m$^{-3}$ in June (Fig. 2). The majority of individuals were found in layers below a depth of 15 m. Of the 18 taxa noted (Table 1), *Processa* spp. was dominant (33.0%). It was followed by *Liocarcinus* spp. (19.3%), *Galathea* spp. (12.8%), and species of the families Hippolytidae (12.7%) and Alpheidae (11.7%).

Very high population densities of decapod larvae were found in Gruž Bay from April to

*Table 1. Composition of decapoda larvae found in the coastal waters of the South Adriatic, with their mean and Std abundance (Mean ± SD, ind.m$^{-3}$), maximum values of abudance (Max., ind.m$^{-3}$) and mean percentage of the total decapoda larvae abundance (X %) during 1989/90*

| | Lokrum Channel | | | Gru ž Bay | | | Usko (Mali Ston Bay) | | | Bistrina (Mali Ston Bay) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Decapod larvae taxa | Mean ± SD | Max. | X % | Mean ± SD | Max. | X % | Mean ± SD | Max. | X % | Mean ± SD | Max. | X % |
| *Penaeus kerathurus* | | | | | | | 1.29 ± 4.03 | 18 | 3.4 | 0.33 ± 1.68 | 9 | 1.0 |
| Pandalidae | 0.09 ± 1.11 | 4 | 0.5 | | | | | | | | | |
| Alpheidae | 0.13 ± 1.11 | 9 | 11.7 | 2.21 ± 7.24 | 99 | 11.6 | 1.40 ± 5.63 | 45 | 3.7 | 0.98 ± 2.81 | 9 | 3.1 |
| Hippolytidae | 0.34 ± 2.26 | 18 | 12.7 | 2.21 ± 7.24 | 45 | 4.0 | 1.45 ± 3.86 | 18 | 3.8 | 0.49 ± 2.04 | 9 | 1.5 |
| Palaemoninae | 0.11 ± 1.05 | 4 | 0.7 | 0.41 ± 1.89 | 9 | 0.8 | 0.35 ± 1.74 | 9 | 0.9 | | | |
| *Processa* spp. | 1.65 ± 5.38 | 36 | 33.0 | 2.91 ± 6.72 | 36 | 5.3 | 1.29 ± 3.76 | 18 | 3.4 | 1.96 ± 7.62 | 54 | 6.2 |
| Crangonidae | | | | 0.14 ± 1.11 | 9 | 0.2 | | | | | | |
| *Scyllarus arctus* | | | | 0.14 ± 1.11 | 9 | 0.2 | | | | | | |
| *Jaxea nocturna* | | | | | | | 0.12 ± 1.02 | 9 | 0.3 | 0.15 ± 1.02 | 9 | 0.5 |
| Upogebiidae | 0.42 ± 1.89 | 9 | 4.3 | 4.94 ±17.74 | 105 | 8.9 | 1.99 ± 6.74 | 36 | 5.2 | 1.63 ± 6.21 | 36 | 5.2 |
| Callianassidae | 0.11 ± 1.05 | 9 | 1.0 | 0.14 ± 1.11 | 9 | 0.2 | | | | | | |
| Paguridae | 0.12 ± 1.12 | 9 | 1.7 | 2.77 ± 6.49 | 36 | 5.0 | 2.80 ± 0.08 | 72 | 7.4 | 1.45 ± 5.16 | 36 | 3.6 |
| *Galathea* spp. | 0.40 ± 1.68 | 9 | 12.8 | 1.38 ± 4.53 | 27 | 2.5 | 1.05 ± 3.83 | 18 | 2.8 | 0.49 ± 2.04 | 9 | 1.5 |
| *Pisidia longimana* | 0.28 ± 1.55 | 9 | 4.5 | 18.28 ± 48.94 | 333 | 33.3 | 25.01±48.04 | 234 | 61.0 | 19.31 ± 78.56 | 576 | 61.0 |
| *Pilumnus* spp. | 0.09 ± 1.11 | 4 | 0.5 | 2.63 ± 10.44 | 72 | 4.8 | 0.70 ± 4.29 | 36 | 0.8 | 0.16 ± 1.20 | 9 | 0.5 |
| *Xantho* spp. | 0.09 ± 1.11 | 4 | 0.5 | 0.69 ± 3.64 | 27 | 1.3 | 0.38 ± 3.06 | 27 | 0.9 | 0.16 ± 1.20 | 9 | 0.5 |
| Carcininae | | | | 0.20 ± 1.20 | 4 | 0.4 | | | | | | |
| *Liocarcinus* spp. | 0.96 ± 6.72 | 54 | 19.3 | 4.29 ± 8.01 | 36 | 7.8 | 1.75 ± 4.60 | 18 | 4.6 | 1.31 ± 3.17 | 9 | 4.1 |
| *Parthenope* spp. | 0.13 ± 1.11 | 9 | 0.7 | 0.41 ± 2.46 | 18 | 0.8 | 0.03 ± 3.99 | 27 | 2.5 | 0.16 ± 1.20 | 9 | 0.5 |
| Inachinae | 0.12 ± 1.09 | 9 | 1.5 | 6.23 ± 21.06 | 108 | 12.6 | 3.74 ± 15.10 | 108 | 10.0 | 3.60 ± 15.21 | 99 | 11.4 |
| Pisinae | 0.11 ± 1.10 | 4 | 0.5 | | | | | | | | | |
| *Maja* spp. | 0.09 ± 1.05 | 4 | 0.4 | | | | | | | | | |
| *Ethusa mascarone* | | | | 0.41 ± 2.46 | 18 | 0.8 | 0.47 ± 2.00 | 9 | 1.2 | | | |
| *Ebalia* spp. | 0.11 ± 1.05 | 9 | 0.5 | 0.14 ± 1.11 | 9 | 0.2 | | | | | | |
| *Grapsidae* | | | | 0.28 ± 2.21 | 18 | 0.5 | 0.23 ± 1.43 | 9 | 0.6 | | | |
| *Pinnotheres* spp. | | | | 0.28 ± 2.21 | 18 | 0.5 | 0.23 ± 1.43 | 9 | 0.6 | | | |

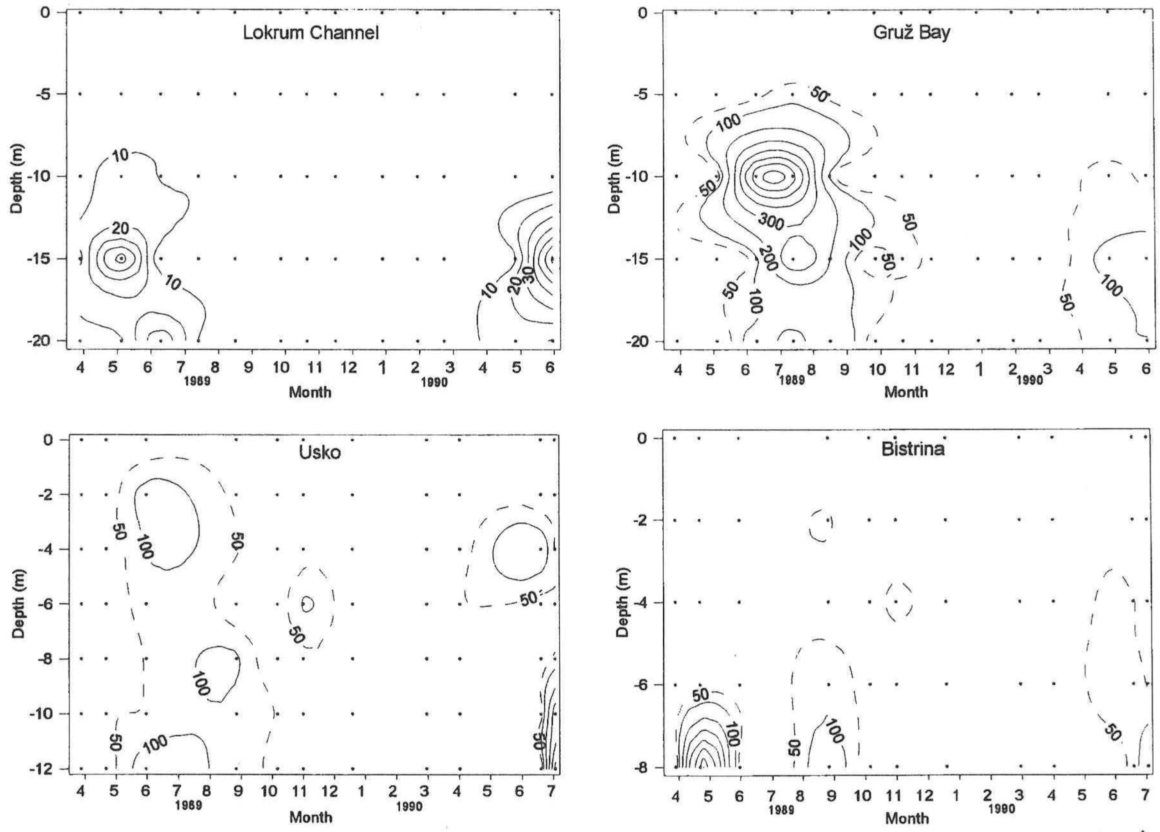


*Fig. 2. Distribution of decapoda larvae population density (No. ind.m$^{-3}$) in coastal waters of the South Adriatic during 1989/90*

September (Fig.2). An especially high number of individuals was noted in the summer at a depth of 10 m, with 666 ind.m$^{-3}$ in June and 637 ind.m$^{-3}$ in July.

In Mali Ston Bay, decapod larvae were numerous from April until the beginning of November (Fig. 2). At the Usko station, increased densities were found at all layers from 2 m down to the bottom. A maximum of 531 ind.m$^{-3}$ was in July 1990 along the bottom. At Bistrina, the majority of individuals were found in deeper layers with a maximum of 639 ind.m$^{-3}$ in April.

*Pisidia longimana* was the dominant species, averaging 33.3% in Gruž and 61% in Mali Ston Bay (Table 1). It was the only decapod that showed an increased abundance from spring until the beginning of autumn. The KRUSKAL-WALLIS test (*H*) confirmed significant differences in the vertical density distributions of this species. The majority of individuals found in Gruž Bay were from the intermediate layer at depths of 10 to 15 meters ($H$=19.902, P=0.003). At other stations, aggregations were higher towards the bottom layer (Usko, $H$=16.263, P=0.001 and Bistrina, $H$=29.769, P<0.001).

## DISCUSSION

In the coastal region of the south Adriatic, 26 taxa of decapod larvae were found, of which 9 were classified to family, 12 to genus, and only 5 up to species level. This could be explained by the lack of specific literature regarding the determination of decapod larvae. Furthermore, we were unable to compare adult species and their plankton stages in the investigation area, since the only systematic check-list of the adult decapod Crustacea, given by ŠTEVČIĆ (1990), is for the entire Adriatic Sea.

In the oligotrophic Lokrum Channel, very low values of decapod larvae were noted. On the contrary, in the slightly antropogenic eutrophicated Gruž Bay and in the naturally eutrophicated Mali Ston Bay, a high number of individuals was recorded during spring and summer. The most abundant larva was *Pisidia longimana. Pisidia* species have great capabilities in adapting their reproductive cycles to environmental changes, depending on the concentrations of suitable food available for planktonic larvae (SAMPEDRO *et al.*, 1977).

In previous decapod larvae studies, samples were collected with a standard plankton net and the larval abundance were given only in average numerical values or the total number of individuals (KURIAN, 1956; LINDLEY, 1987; LINDLEY *et al.*, 1994; GUILLÉN and GRAS, 1995; LUČIĆ and BENDER-POJATINA, 1995). Investigations of the annual decapod larvae variability using the ADRIATIC sampler indicated that the individuals are not equally distributed in the water column. With regard to these first annual investigations of decapod larvae using this new tool, there are no comparisons with the other shallow regions.

In the Lokrum Channel, decapod larvae were found only at depths greater than 10 m, while at the remaining stations, they were found in all layers except at the surface. The large aggregations of individuals in Gruž and Mali Ston Bay were primarily caused by the vertical distribution of the dominant species *P. longimana.* Significantly higher values were determined in the middle layers of the Gruž Bay ($P=0.003$) and in the bottom layers of Mali Ston Bay ($P<0.001$). The vertical distribution of decapod larvae population densities depends on daylight changes, the physical attributes of the water column and available food concentrations (LINDLEY *et al.*, 1994). Seasonal changes in temperature may exert a decisive influence on the annual succession of organisms. However, its influence on the daily vertical distribution of decapod larvae at our stations was not determined. Due to shallow depths, the water column heats up and cools down very quickly, resulting in isotherm within a very short time. In the productive Gruž and Mali Ston Bays, during spring and summer, the concentration of phytoplankton is high throughout the entire column (JASPRICA, 1994; VILIČIĆ *et al.*, 1995) and therefore does not influence the aggregation of macrozooplankton at such shallow depths. We are of the opinion that light is the main regulator of the vertical distribution of the species *P. longimana.* In Mali Ston Bay, LUČIĆ (1985) noted higher values of this species during the night by comparing day-night surface samples. Increased concentrations of detritus in the antropogenic, eutrophic Gruž Bay lessened the entry of light through the water column. Therefore, the majority of individuals of this species were found during the day in the middle layers.

The annual and seasonal changes in the population density of meroplankton are significantly greater than those of holoplankton, as a result of their dependence on physical parameter changes. Therefore, more thorough research is necessary on their composition, numbers, and horizontal and vertical distributions, in order to evaluate the quality of specific regions, as well as the possible effects of climatic change.

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# Godišnje varijabilnosti sastava ličinki dekapoda u obalnim vodama južnog Jadrana

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## SAŽETAK

Istraživanjem gustoće populacija ličinki dekapoda uređajem tipa ADRIATIC u obalnim vodama južnog Jadrana utvrđena je neravnomjerna raspodjela organizama u vodenom stupcu. U oligotrofnom Lokrumskom kanalu vrijednosti su niske, a glavnina jedinki nađena je u pridnenom sloju. Dominantne vrste su *Processa* spp. i *Liocarcinus* spp. U umjereno antropogeno eutroficiranom Gruškom zaljevu i prirodno eutroficiranom Malostonskom zaljevu zabilježen je veliki broj jedinki tijekom proljeća i ljeta. Agregacije ličinki dekapoda u Gruškom i Malostonskom zaljevu prvenstveno su uzrokovane vertikalnom raspodjelom izrazito dominatne vrste *Pisidia longimana*. Značajno više vrijednosti utvrđene su u središnjim slojevima Gruškog zaljeva (P=0.003) i u pridnenim slojevima Malostonskog zaljeva (P<0.001).