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Octopods of the Northern and Central Adriatic Sea

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ABSTRACT

The paper presents data on findings of the octopod species (order Octopoda) in the eastern part of the Northern and Central Adriatic, based on the surveys held from 1996 to 2019, and an overview of previously reported findings of this group of cephalopods in the Adriatic Sea. During the field studies a total of eight species from the superfamily Octopodoidea, were found. For all species, spatial and depth distribution, mean biomass and abundance indices (kg/km^2, N/km^2), and frequency of occurrence (%f) were presented. The commercially important species *Octopus vulgaris*, *Eledone cirrhosa* and *Eledone moschata* had the highest average biomass and abundance indices as well as the highest frequency of occurrence while all other octopods had significantly lower values. Among them, according to the frequency of occurrence, the species *Octopus salutii* (3.02) was the most common, followed by the species *Callistoctopus macropus* (1.41) and *Scaeurgus unicirrhus* (1.39). The lowest values of the frequency of occurrence were recorded for *Pteroctopus tetracirrhus* (0.25) and *Macrotritopus defilippi* (0.24) with only a few specimens of these species being found in over 20 years of surveys in the area.

Keywords: Octopods, Adriatic, distribution, frequency of occurrence, uncommon and rare species

INTRODUCTION

Octopods (order Octopoda) make a significant share of the cephalopod fauna in the Adriatic Sea. Some species, e.g. *Eledone moschata*, are abundant and commercially important, while others are less frequent and scientific information about them are scarce. In recent decades, declining catches of other fishery resources have led to increased exploitation of cephalopods, especially in Europe, but it also resulted in more intensive research and better understanding of the biology and ecology of exploited species, including octopods (De Luca *et al*., 2016). Octopods are divided into two suborders: Cirrata, which includes mainly deep-sea species with characteristic common features fins and cirri, and Incirrata, a group encompassing the majority of recent octopod species (about 85%), without fins and cirri. While ciratte octopods have no commercial

significance, a number of inciratte species are economically important. Such species is, for example, the common octopus, *Octopus vulgaris*, with world annual catches of 36.930 tonnes in 2021 (FAO, 2023).

The first scientific data on cephalopods in the Adriatic Sea dates back to the end of the 18th century (Olivi, 1792). In 1884, Ninni published a catalog of Adriatic cephalopods with eight octopods in a total of 17 species. The Octopodidae family in the Adriatic was also mentioned in the studies of several other authors in the 19th century, including Grube (1861), Stossich (1880), Kolombatović (1888, 1890, 1894) and Carus (1890). In the 20th and at the beginning of the 21st century the overall research of cephalopods intensified, and a number of studies on Adriatic teuthofauna, including new information on octopods, were published. The first comprehensive list of Adriatic cephalopods, prepared based on available data from previous research, was provided by Gamulin-Brida & Ilijanić (1972). After 1972, a number of studies on Adriatic cephalopods were published (e.g. Karlovac, 1959; Mandić, 1973; Mandić i Stjepčević, 1978, 1983; Marano *et al*., 1982; Bello & Motolese, 1983; Bello, 1984; Guescini & Manfrin, 1986). Bello (1990) updated the existing list of cephalopods with new findings, mainly from the western side of the Adriatic Sea. In recent decades, a number of teuthofauna studies in the Adriatic were published, describing, among others, the findings of octopod species from the Adriatic (e.g. Soro & Piccinetti Manfrin, 1989; Casali *et al*., 1998; Petrić *et al*., 2014; Petović *et al*., 2017; Quetglas *et al*., 2019; Gerovasileiou *et al*., 2020). Also, cephalopod assemblages based on the MEDITS surveys in the study area have been presented (Krstulović Šifner *et al*., 2005, 2011).

The aim of the present study was to describe, review and update the information on octopods inhabiting the Northern and Central Adriatic Sea, especially on the occurrence and findings of the uncommon and rare species, based on the long series of annual research surveys and on the existing historical data about this cephalopod group in the Adriatic Sea.

MATERIAL AND METHODS

All data used in this study were collected during the MEDITS programme in the eastern part of the Northern and Central Adriatic Sea. Surveys were done each year in the period from 1996 to 2019, except in 1999. In the research area the stratification covered depths: 10-50 m, 50-100 m, 100-200 m, 200-500 m. Sampling was done every year in the spring-summer period, always at the same stations selected using a stratified sampling scheme for each depth stratum. The specifically designed fishing tool used for this type of scientific research was the experimental demersal trawl GOC 73 (Fiorentini *et al*., 1999). Catches of all species were standardized per unit area using the so-called "swept area" method (Sparre & Venema, 1998), and were expressed as biomass and abundance indices (kg/km², N/km²). The horizontal and vertical mesh openings were measured using a SCANMAR ultrasound system. A detailed description of the MEDITS methodology is available in the MEDITS instruction manual (Relini *et al*., 2008).

A species identification keys were used to identify octopod species (Mangold & Boletzky, 1988; Jereb *et al*., 2014). The spatial distribution of species in the eastern part of the Northern and Central Adriatic was presented using ArcView GIS tools v. 3.2., and by ATrIS system developed within the FAO AdriaMed programme (Gramolini *et al*., 2005). Moreover, the frequency of occurrence (%f)

was calculated, representing the percentage of the number of positive stations in the total number of stations done during expeditions for the respective octopod species.

RESULTS

FINDINGS OF OCTOPODS

A total of eight species from the superfamily Octopodoidea, suborder Incirrata, were found in the eastern part of the Northern and Central Adriatic Sea from 1996 to 2019: *Octopus vulgaris*, *Octopus salutii*, *Pteroctopus tetracirrhus*, *Scaeurgus unicirrhus*, *Macrotritopus defilippi* and *Callistoctopus macropus* of the family Octopodiae, and *Eledone cirrhosa* and *Eledone moschata* from the family Eledonidae (Tab. 1). Three commercially important species *E. moschata*, *E. cirrhosa* and *O. vulgaris* had the highest average biomass indices (kg/km^2), abundance indices (N/km^2) as well as the highest frequency of occurrence (%f). This was expected given that these species are widespread and economically important in the Adriatic Sea and in the whole Mediterranean. No representatives of the superfamily Argonautoidea nor of the suborder Cirrata were registered.

Of the two *Eledone* species, *E. moschata* was much more abundant than *E. cirrhosa*. The species *O. vulgaris* was the third most common species (%f = 14.07). All other octopods had significantly lower average biomass and abundance indices and the frequency of occurrence in the study area. Among these, when considering the mean frequency of occurrence, *O. salutii* (3.02) was the most common species, followed by *C. macropus* (1.41) and *S. unicirrhus* (1.39), while the lowest values were recorded for *P. tetracirrhus* (0.25) and *M. defilippi* (0.24). *C. macropus* had the highest biomass and abundance index among the less abundant and rare species. The lowest values of the abundance index were for the species *P. tetracirrhus* (0.26 N/km^2), and of the biomass index for *P. tetracirrhus* and *M. defilippi* (for both 0.16 kg/km^2).

Table 1. List of octopods found during MEDITS expeditions in the eastern part of the Northern and Central Adriatic Sea between 1996 and 2019 with frequency of occurrence (%f), mean abundance index (N/km^2) and mean biomass index (kg/km^2).

Family	Species	%f	N/km^2	kg/km^2
Eledonidae	*Eledone moschata*	53.82	230.03	22.18
	Eledone cirrhosa	36.84	20.77	3.46
Octopodidae	*Octopus vulgaris*	14.07	7.44	3.82
	Octopus salutii	3.02	0.76	0.17
	Callistoctopus macropus	1.41	5.72	1.38
	Scaeurgus unicirrhus	1.39	0.75	0.58
	Pteroctopus tetracirrhus	0.25	0.26	0.16
	Macrotritopus defilippi	0.24	0.62	0.16

Based on the available information (Tab. 2), up to now, a total of 12 incirrate octopod species have been recorded in the Adriatic Sea (Bello, 2003) belonging to families Octopodidae, Eledonidae, Argonautidae, Ocythoidae and Tremoctopodidae. All octopods found during this study have already been registered in the Adriatic Sea.

ABUNDANT OCTOPOD SPECIES

***Octopus vulgaris* Cuvier, 1797**, the common octopus, was caught in the depth range from 37 to 235.8 m. The species is distributed along the coastal area of the eastern Adriatic and much less in the open sea, and the abundance of the fished population is the highest around the outer sides of the islands in the Northern and Central Adriatic (Fig. 1).

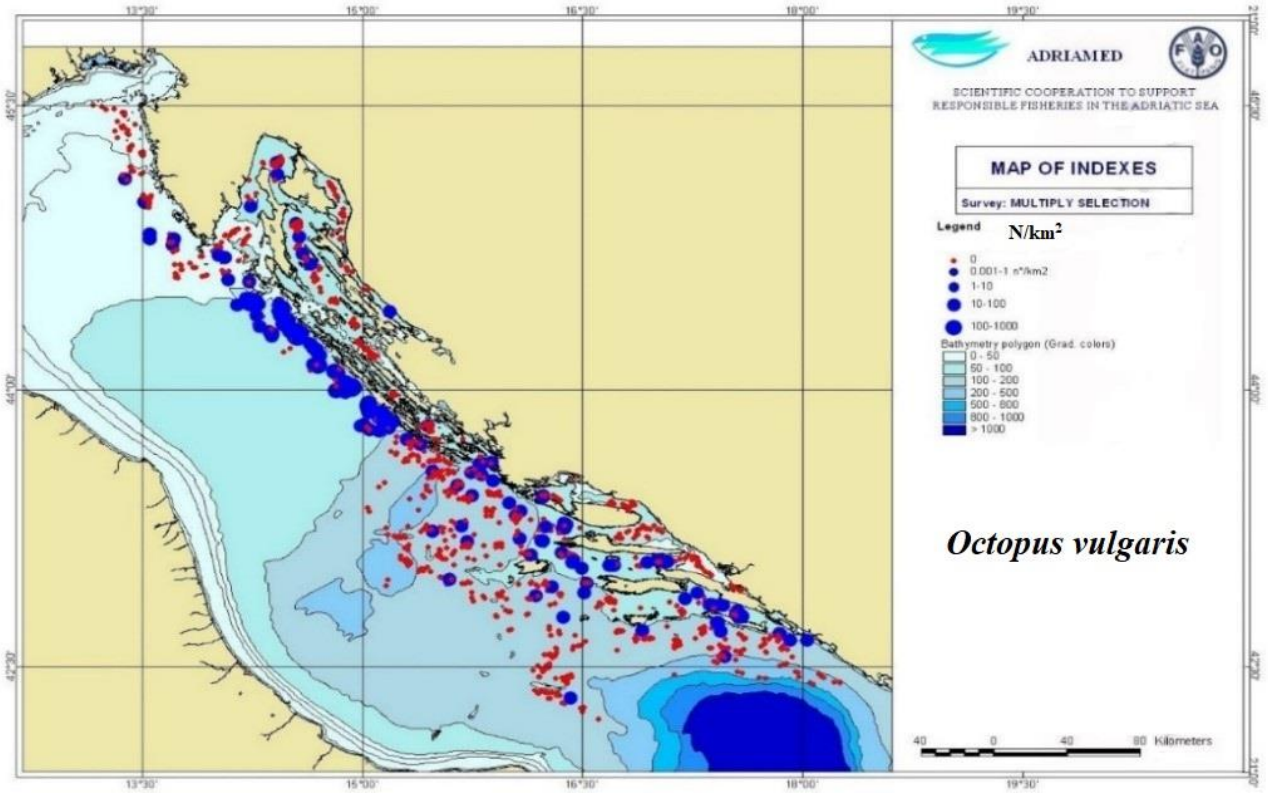

Figure 1. Spatial distribution of *Octopus vulgaris* in the eastern part of the Northern and Central Adriatic (N/km^2); MEDITS data 1996-2019; red circles - negative stations; blue circles - positive stations.

The highest mean abundance index was recorded in the stratum of 50 to 100 m (14.02 N/km^2). In the stratum 10 to 50 m, the species had a much lower average abundance index (2.55 N/km^2). Further decrease in abundance with depth is clearly visible in the depth stratum of 100-200 m (1.35 N/km^2). Out of the continental shelf, at a depth stratum of 200-500 m, catches of this species were recorded just twice, in 2002 and 2013, and only in the shallow parts of the upper continental slope, and with the lowest mean abundance index (0.24 N/km^2) (Fig. 2).

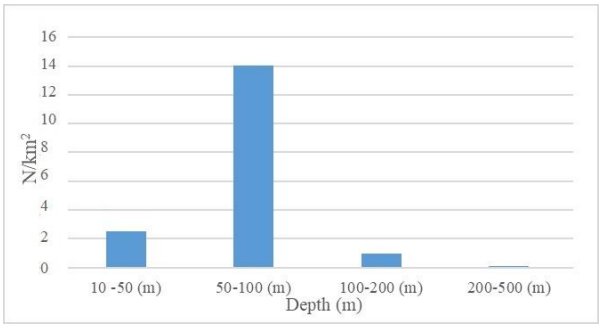

Figure 2. Mean abundance index (N/km^2) of *Octopus vulgaris* by depth stratum in the eastern part of the Northern and Central Adriatic.

***Eledone moschata* (Lamarck, 1798)**, the musky octopus, was caught in a wide area of the eastern part of the Northern and Central Adriatic: along the coast of the Istrian peninsula, in the channel areas, and on the outer sides of the islands both in the Northern and in the Central part. The depths at which the species was found ranged between 21 and 201 m (Fig. 3).

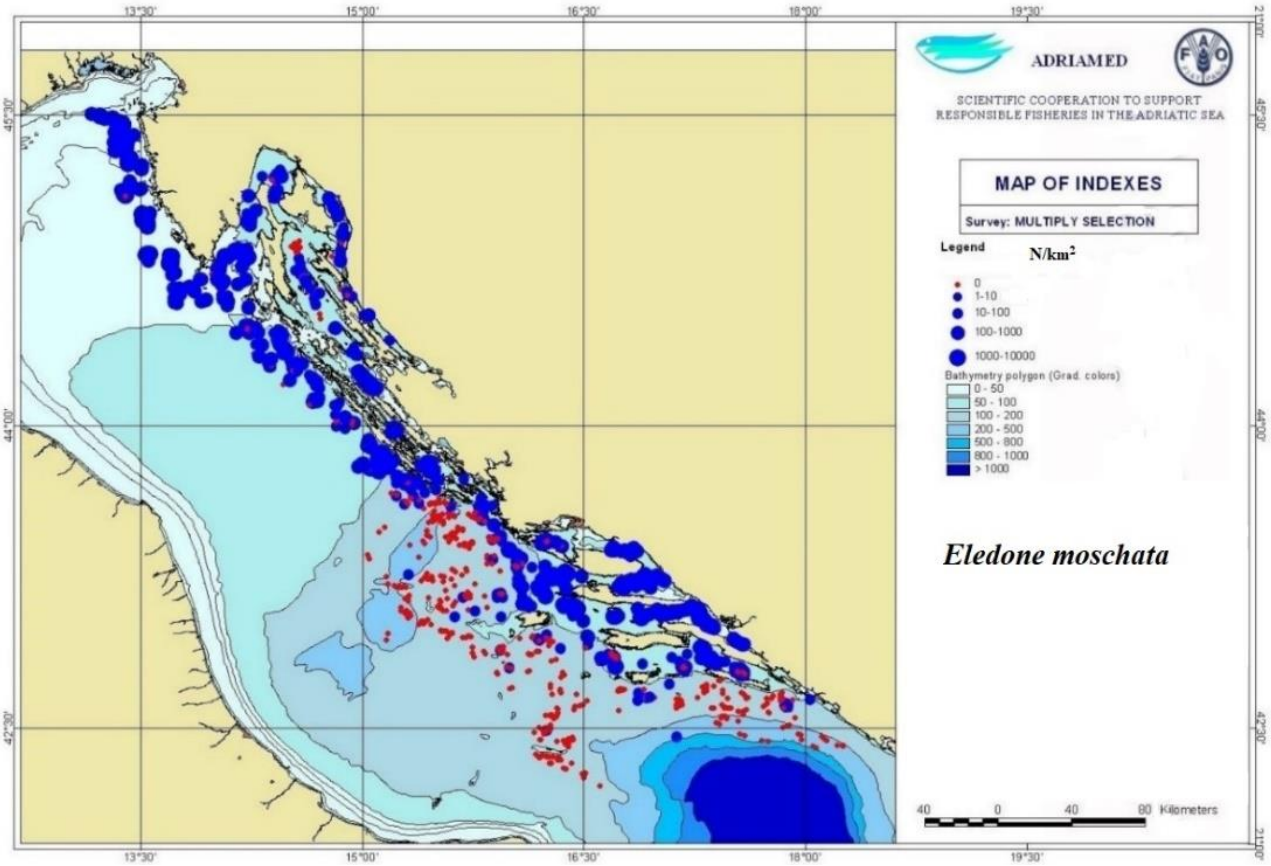

Figure 3. Spatial distribution of *Eledone moschata* in the eastern part of the Northern and Central Adriatic (N/km^2); MEDITS data 1996-2019; red circles - negative stations, blue circles - positive stations.

The species *E. moschata* prefers shallow areas and the population density decreases with increasing depth in the Northern and Central Adriatic (Fig. 4). The average abundance index was the highest in the depth stratum 10-50 m (564.64 N/km^2), followed by the depth stratum 50-100 m (209.54 N/km^2). At depths 100-200 m, the mean abundance index was much lower (15.54 N/km^2). Only once the species was caught at the border of the continental shelf and slope (201 m), and thus has a very low mean abundance index (0.7 N/km^2) in the stratum 200-500 m.

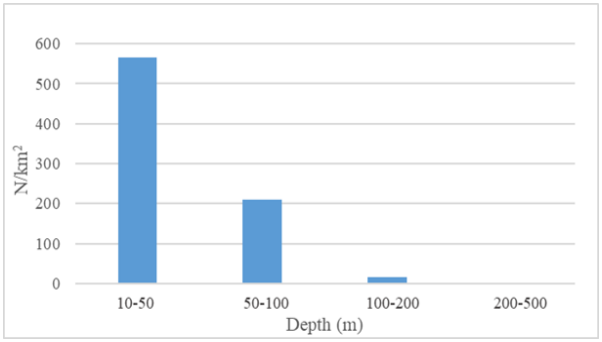

Figure 4. Mean abundance index (N/km^2) of *Eledone moschata* by depth strata in the eastern part of the Northern and Central Adriatic.

***Eledone cirrhosa* (Lamarck, 1798)**, the horned octopus, was fished in the depth range from 82 to 325 m. This species does not inhabit shallow waters of the Northern Adriatic, and the northernmost specimens were caught in the Zadar archipelago. The highest population density was recorded along the outer edges of the islands and in the open areas of the Central Adriatic (Fig. 5).

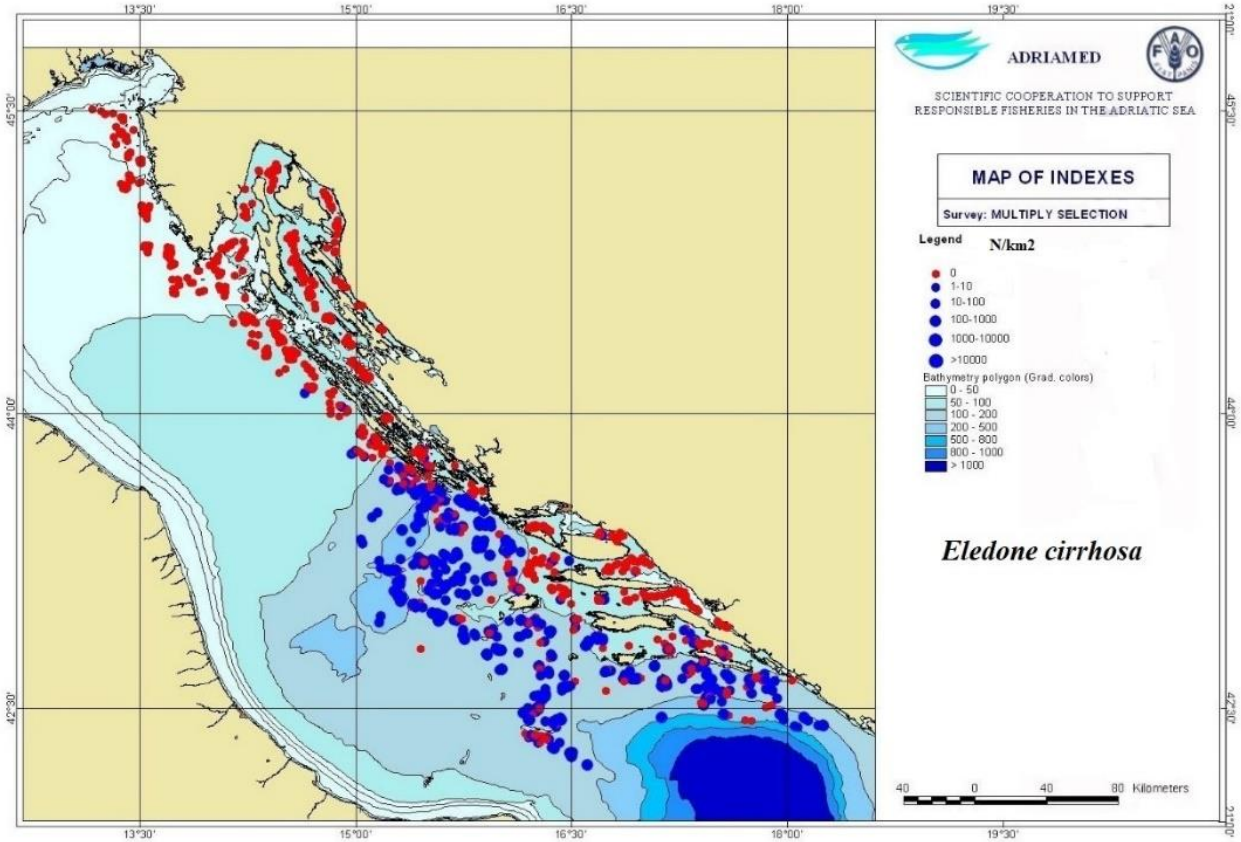

Figure 5. Spatial distribution of *Eledone cirrhosa* in the eastern part of the Northern and Central Adriatic (N/km^2); MEDITS data 1996-2019; red circles - negative stations, blue circles - positive stations.

The depth distribution showed that the species *E. cirrhosa* prefers depths greater than 100 m (Fig. 6.). The highest mean abundance index, was found in the depth stratum 100 to 200 m (68.15 N/km^2). The species was also abundant, but with a lover mean abundance index, outside the continental shelf, in the stratum 200 - 500 m (49.22 N/km^2). In the studied period, the horned octopus was not found in the depth stratum of 10 - 50 m and in the depth stratum of 50 - 100 m the average abundance index was low (3.14 N/km^2).

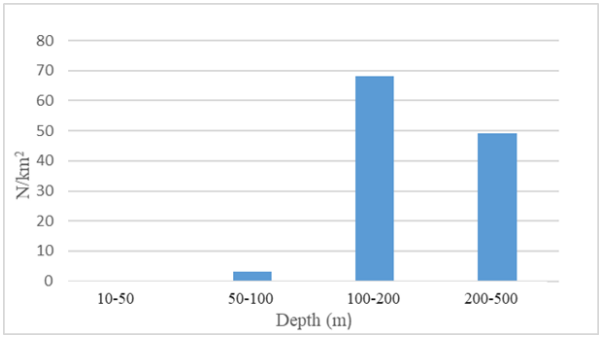

Figure 6. Average values of the abundance index (N/km^2) of *Eledone cirrhosa* species in the eastern part of the Northern and Central Adriatic by depth strata.

LESS ABUNDANT AND RARE OCTOPOD SPECIES

***Callistoctopus macropus*, Risso 1826** had the average abundance and biomass indices 5.72 N/km^2 and 1.38 kg/km^2, respectively, with an occurrence index of 1.41. The species was registered during surveys in 1996 and 1997 in the depth range between 102 to 274 m. A total of 14 specimens of *C. macropus* were caught in the open central Adriatic, and more to the south, in the border parts of the South Adriatic Pit (Fig. 7).

***Macrotritopus defilippi* (Vérany, 1851)** had the lowest occurrence index of all octopods (0.24). Mean abundance and biomass indices were also low, 0.62 N/km^2 and 0.16 kg/km^2, respectively. The species was caught during two expeditions, in 2000 and 2003, with a total of four individuals. *M. defilippi* was found in the depth range between 143 and 235 m in the open Central Adriatic and, more to the south, in the waters bordering the South Adriatic Pit (Fig. 8).

***Pteroctopus tetracirrhus* (Delle Chiaje 1830)** had a very low frequency of occurrence (0.25 %). The mean biomass and abundance indices for this species were also very low: 0.16 kg/km^2 and 0.26 N/km^2, respectively. It was found in deeper southern parts of the open eastern Central Adriatic, on the border of the South Adriatic Pit, in the depth range between 153.5 and 274 m (Fig. 9). The species was recorded only during two expeditions with a total of three specimens; the first two individuals were registered in 2001, and the second finding was from 2019 when only one specimen was found.

***Scaeurgus unicirrhus* (Delle Chiaje, 1841)** had a frequency of occurrence 1.39 while the mean biomass and abundance indices were 0.58 kg/km^2 and 0.75 N/km^2, respectively. The species was found in the depth range between 128 and 332 m. The majority of specimens were caught at the border, shallower parts of the South Adriatic Pit, while some were found further north, in the open Central Adriatic area (Fig. 10). The species was recorded in surveys 1997, 2000, 2001, 2002, 2004 and 2013. In 1997, only one individual was caught. In 2000 and 2001 four and three specimens were found, respectively. In 2002, a total of eight individuals were caught, which is the highest number of individuals of *S. unicirrhus* per survey. In 2004, only one specimen of this species was recorded, as well as during the survey 2013.

***Octopus salutii* Vérany, 1839** had a mean biomass index of 0.17 kg/km^2, abundance index was 0.76 N/km^2, and the occurrence index was 3.02. In the majority of surveys, the species was either not fished or there was just one specimen in the catches. Exceptions were the expeditions in 2000 and 2001, when a larger number of specimens were caught. In the expedition 2000, six specimens were found, and in 2001 three individuals were caught. *O. salutii* was found in a wide depth range, at depths between 69.5 and 470 m. The highest indices were recorded in the open Central Adriatic and at the shallower, marginal parts of the South Adriatic Pit (Fig. 11).

DISCUSSION

During MEDITS expeditions in the eastern Northern and Central Adriatic Sea, in the period from 1996 to 2019, a total of eight species from the order Octopoda were found, two belonging to the family Eledonidae and six species of the family Octopodidae. All found species have previously been recorded in the study area. Apart from the three economically important species (*Octopus vulgaris*, *Eledone cirrhosa*, *E. moschata*), other octopods were much less abundant and only sporadically

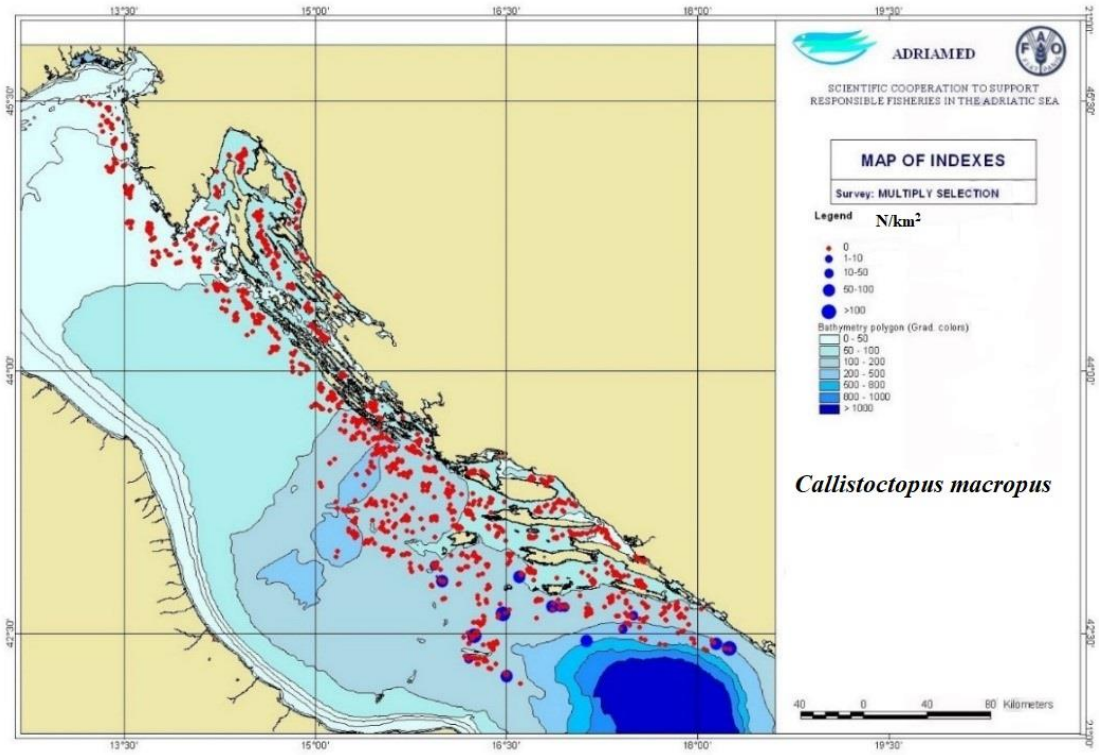

Figure 7. Spatial representation of *Callistoctopus macropus* findings in the eastern part of the Northern and Central Adriatic (N/km^2); MEDITS data 1996-2019; red circles - negative stations, blue circles - positive stations.

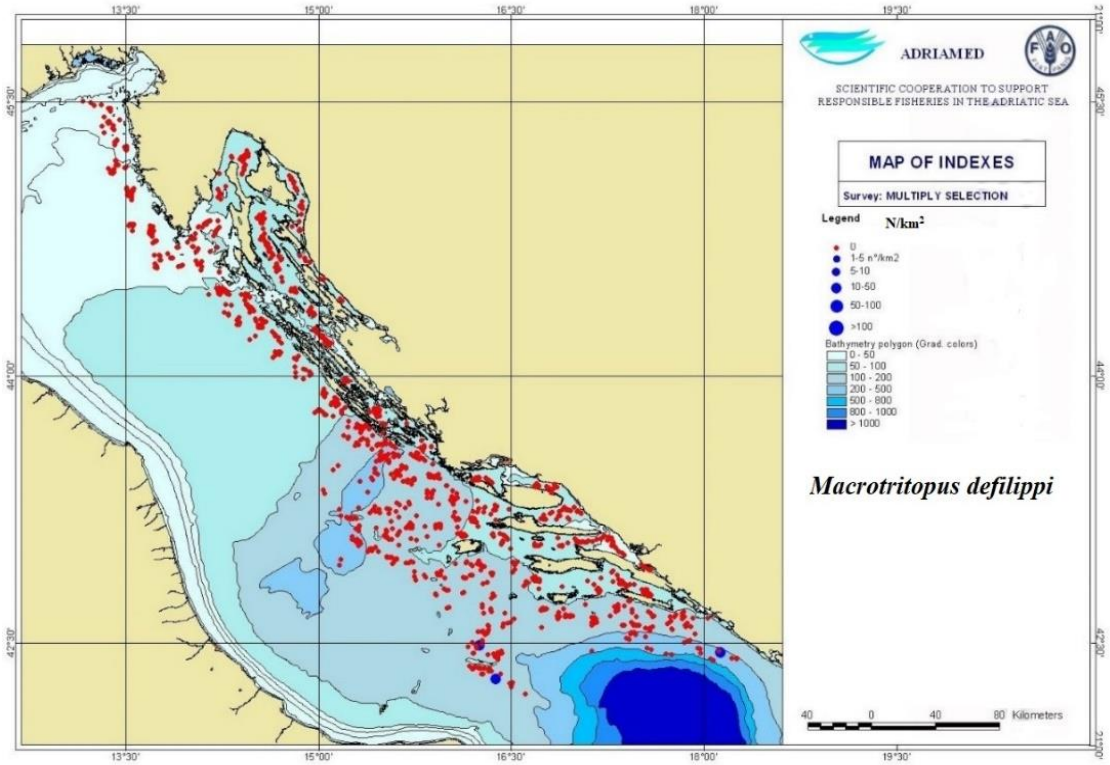

Figure 8. Spatial representation of *Macrotritopus defilippi* findings in the eastern part of the Northern and Central Adriatic (N/km^2); MEDITS data 1996-2019; red circles - negative stations, blue circles - positive stations.

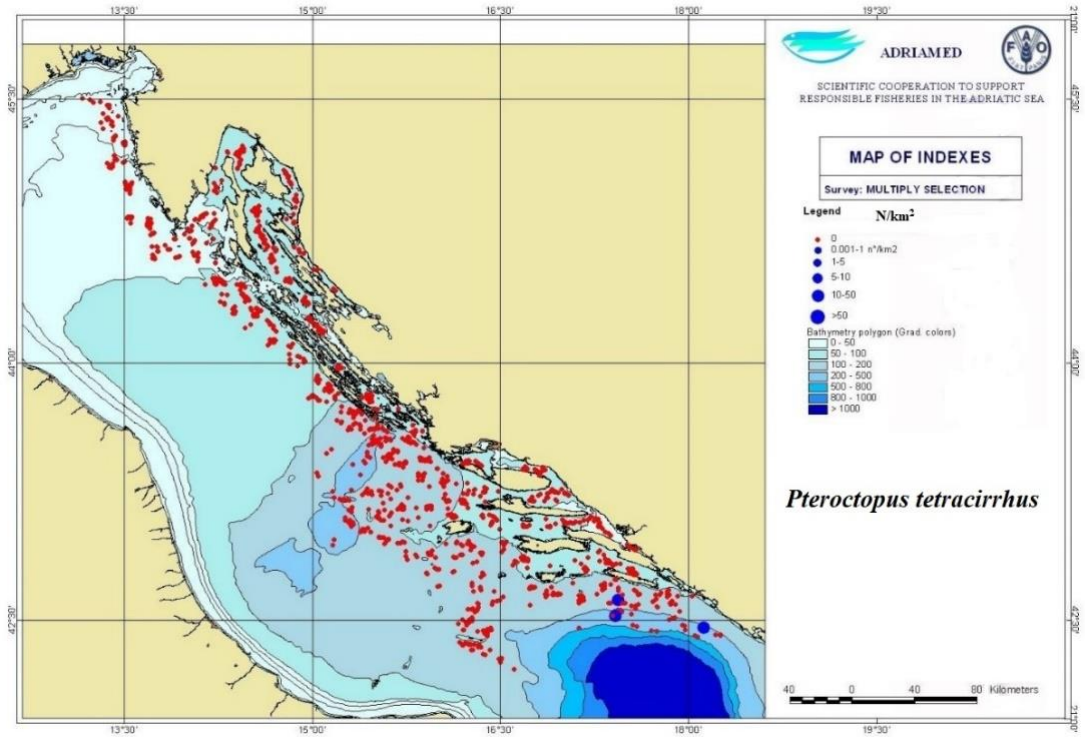

Figure 9. Spatial presentation of *Pteroctopus tetracirrhus* findings in the eastern part of the Northern and Central Adriatic (N/km^2) based on MEDITS data 1996-2019; red circles - negative stations, blue circles - positive stations.

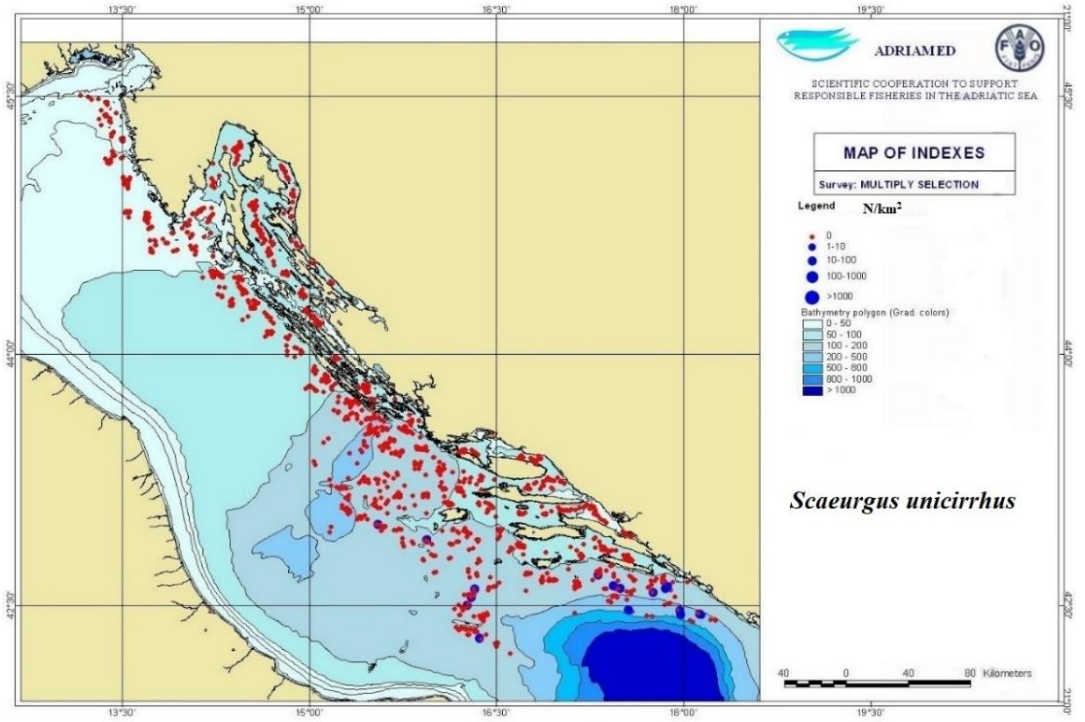

Figure 10. Spatial presentation of *Scaeurgus unicirrhus* findings in the eastern part of the Northern and Central Adriatic (N/km^2); MEDITS data 1996-2019; red circles - negative stations, blue circles - positive stations.

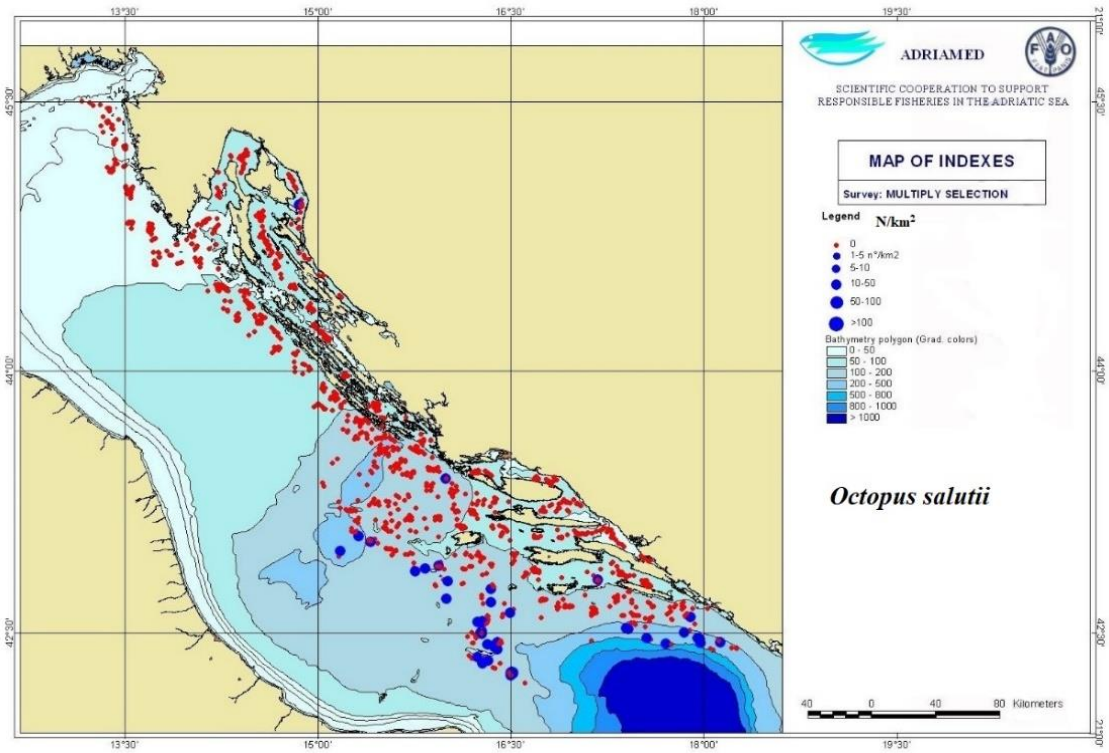

Figure 11. Spatial presentation of *Octopus salutii* findings in the eastern part of the Northern and Central Adriatic (N/km^2); MEDITS data 1996-2019; red circles - negative stations, blue circles - positive stations.

found (*Octopus salutii*, *Callistoctopus macropus*, *Scaeurgus unicirrhus*, *Pteroctopus tetracirrhus* and *Macrotritopus defilippi*). Most of the species were fished both on the continental shelf and on the slope. The species *O. salutii* was found in the widest depth range and it was the only octopod species recorded at depths greater than 400 m. Previous studies (see references in Introduction) showed that, besides these eight species, representatives of the octopod families Tremoctopodidae, Argonautidae and Ocythoidae (superfamily Argonautoidea) were previously registered in the area, namely *Tremoctopus gracilis*, *T. violaceus*, *Argonauta argo* and *Ocythoe tuberculata* (Tab. 2). However, these four pelagic species were not found during 1996-2019 surveys.

Tremoctopus violaceus delle Chiaje, 1830, was for the first time reported in the Adriatic Sea by Nardo (1847), and Verany (1851) in his descriptions of Mediteranean cephalopods refers to Nardo's findings of the species in the Northern Adriatic near Venice. Kolombatović (1888) reported findings of several specimens in the vicinity of Vis, Hvar and Split. Gamulin–Brida & Ilijanić (1972) stated that the species *T. violaceus* is not uncommon in the Central Adriatic. In his review of Adriatic cephalopods Bello (1990) lists the species *T. violaceus* as rare, without specifying the area of its distribution. In recent years several findings of female specimens from the channel areas of the central Adriatic Sea, near the islands of Hvar and Brač have been reported (Petrić *et al.*, 2023; pers. comm.).

Table 2. List of species from the order Octopoda found in the Adriatic Sea with first findings.

SUPERFAMILY/ Family	**Species**	**First findings**
OCTOPODOIDEA		
Eledonidae	*Eledone moschata* (Lamarck, 1798)	Grube, 1861
	Eledone cirrhosa (Lamarck, 1798)	Ninni, 1884
Octopodidae	*Octopus vulgaris* Cuvier, 1797	Grube, 1861
	Callistoctopus macropus Risso 1826	Stossich, 1880
	Macrotritopus defilippi (Vérany, 1851)	Casali *et al*., 1998
	Pteroctopus tetracirrhus (Delle Chiaje, 1830)	Gamulin-Brida *et al*., 1977 Mandić & Stjepčević, 1977
	Scaeurgus unicirrhus (Delle Chiaje, 1841)	Mandić, 1973
	Octopus salutii Vérany, 1839	Gamulin-Brida & Ilijanić, 1968
ARGONAUTOIDEA		
Argonautidae	*Argonauta argo* Linnaeus, 1758	Ninni, 1884
Ocythoidae	*Ocythoe tuberculata* Rafinesque, 1814	Ninni, 1884
Tremoctopodidae	*Tremoctopus violaceus* delle Chiaje, 1830	Nardo, 1847
	Tremoctopus gracilis (Souleyet, 1852)	Kramer, 1937

Tremoctopus gracilis (Souleyet, 1852) is an Indo-Pacific pelagic octopod that probably entered Mediterranean, and subsequently the Adriatic Sea, as a Lessepsian migrant, i.e. through the Suez Canal (Bello *et al*., 2020), or possibly by the ballast waters (Orsi Relini *et al*., 2004). However, there are also some findings of this species from the Atlantic (Carlini *et al*., 2001), so it also might have entered the Mediterranean and the Adriatic Sea through the Straight of Gibraltar (Petrić *et al*., 2023). *T. gracilis* was recorded for the first time in 1936 in the Northern Adriatic (Istria coast) after discharge of ballast water (Kramer, 1937). It was determined as *T. violaceus* by the author, but later Orsi Relini *et al*. (2004) showed that it was a misidentification and emended Kramer's report (Bello *et al*., 2020).

For the species *Ocythoe tuberculata* Rafinesque, 1814, Bello (1990) mentioned several localities of findings: Bol (1889), Split (1890 and 1904), Senj (1909), Jablanac (1913), Korčula (1930), Murter (1950), Olib (1950), Kvarner Bay (1960 and 1964) and Vela Luka (1979). He also stated that the distribution of this pelagic species is limited to the eastern side of the Adriatic, along the Albanian and then Yugoslav coasts which can be linked to the Adriatic circular system of sea currents, characterized by counterclockwise motion. This was also discussed and confirmed by Tutman *et al*. (2008) based on the previous records and new findings of three females of the species *O. tuberculata* along the Croatian Adriatic coast in the Central Adriatic, i.e. in waters near Donje Čelo Cove in Koločep Island, Grabovac Cove in island Hvar, and Korčula Harbour in the island of Korčula. Individual females of this species have been found sporadically in the channel areas of the Adriatic Sea on several occasions in recent years (pers. comm).

Argonauta argo Linnaeus, 1758, is a cosmopolitan pelagic species that occurs in the whole Mediterranean and also in the Adriatic Sea. It inhabits both coastal and open sea areas, mainly in the upper 100 m. Gamulin-Brida & Ilijanić (1972) found the species to be quite common in the Vis channel, and Corsini-Foka *et al*. (2011) described a female found nearshore at the water surface in Cattolica. The species is sporadically found in the pelagic

nets in different parts of the eastern Adriatic Sea (pers. comm.).

The species *Octopus vulgaris* was found in the depth range 37 to 235.8 m. It was most often caught in the depth stratum 50 to 100 m, and it was also very well represented in the shallow waters, in the stratum 10-50 m. The decrease in abundance with depth is clearly evident in the depth stratum of 100-200 m and especially in the stratum 200-500 m, where this species was caught only sporadically. The species was caught along the coastal area of the eastern Adriatic and much less in the open sea. The results are consistent with previous studies (Gamulin-Brida & Ilijanić, 1972; Krstulović Šifner *et al*., 2011, 2014). On the other hand, it has been reported that in other parts of the Mediterranean, the common octopus is mostly limited to depths down to 100 m (Belcari *et al*., 2002b).

The species *Eledone moschata* was caught at all depths from 21 to 201 m. It prefers shallow areas and with increasing depth the population density of this species in the Northern and Central Adriatic decreased, and it was the most abundant in the shallow waters (10-50 m) of the Northern Adriatic Sea. The musky octopus is widely distributed in the Adriatic, in the coastal area at depths down to 100 m but this species is not uncommon at depths over 100 m, mostly in the Central and Southern Adriatic (Gamulin-Brida & Ilijanić, 1972). Findings at depths over 150 m are rare, but sporadically *E. moschata* can be found in deeper waters and even at depths around 200 m (Krstulović Šifner, 2004, 2014). Similarly, in the Mediterranean, the species is mostly restricted to depths down to 200 but it is sometimes found at greater depths, e.g. in the Aegean Sea (Belcari *et al*., 2002a).

The species *Eledone cirrhosa* was caught at depths between 82 and 325 m. It does not inhabit shallow waters in the Northern Adriatic, and the northernmost findings are from the Zadar archipelago. The highest population density was recorded along the outer sides of the central Adriatic islands and in the open Central Adriatic Sea. The highest mean value of the abundance index was found in the stratum of 100 to 200 m. The second most represented was the depth stratum 200-500 m, while in the stratum 10-50 m no specimens were found. This agrees with previous studies according to which the horned octopus prefers depth strata 100-200 and 200-500 m (Krstulović Šifner *et al.*, 2011, 2014). It is fished at depths over 100 m, especially in the Central and Southern Adriatic (Gamulin-Brida & Ilijanić, 1972; Ikica, 2013). This species is more numerous in the southern part of the Adriatic than in its northern part (Bello, 1990).

The less abundant, i.e. uncommon and rare octopod species during this study were *Callistoctopus macropus*, *Macrotritopus defilippi*, *Pteroctopus tetracirrhus*, *Scaeurgus unichirrus* and *Octopus salutii*.

The species *Callistoctopus macropus* was found in the depth range from 106.5 to 274 m. It was caught in the open waters of the Central Adriatic and in the shallower parts bordering the South Adriatic Pit. Gamulin-Brida & Ilijanić (1972) stated that it was quite rare in the Adriatic, sometimes fished in the channels of the Central Adriatic, but depths were not indicated. During our study, the species was found only during two surveys and thus can be considered as rare. *C. macropus* is also known to be a rare species in the Mediterranean, primarily inhabiting coastal, shallower waters (Mangold & Boletzky, 1988). However, findings from deeper waters have previously been reported from the western Central Adriatic Sea by Ciavaglia & Manfredi (2009) who found this species dominantly at depths between 100 and 200 m, in a depth range of 107-336 m. Casali *et al.* (1998) also reported findings of a few individuals in front of Punta Penna in the western Central Adriatic Sea.

The species *Macrotritopus defilippi* was caught in the depth range of 143 to 235 m in open waters of the Central Adriatic and in the border parts of the South Adriatic Pit. This was the rarest of all octopods, with the lowest frequency of occurrence (0.24). It was recorded only during two surveys with a total of four specimens found during the whole study period. The species can be found on the whole continental shelf, more often at depths between 30 and 60 m (Mangold & Boletzky, 1988), and based on the findings from the Central Adriatic Sea it can also sporadically occur on the upper continental slope. Findings of this species are mentioned for the first time along the western Adriatic shores by Casali *et al*. (1998). The authors stated that this species is rare, although it is occasionally found in summer in front of Gargano (Italy) at depths from 110 to 220 m, and at depths of about 50 m in the area of Termoli (Italy). Ciavaglia & Manfredi (2009) also reported rare findings of the species (33 specimens in the period 1982-2004); it was found only in the southern parts of the central Adriatic at depths between 110 and 260 m and it was the species caught with the lowest abundance in this study. *M. defilippi* in the eastern side of the Central Adriatic was recorded for the first time by Krstulović Šifner *et al*. (2011) in depth stratum 100-200 m. Gerovasileiou *et al*. (2020) reported the finding of one specimen at 6 m in a sheltered bay in 2014, in the South-Western Adriatic Sea (province of Bari). Besides being very rare in the Adriatic, this species is also considered rare in other parts of the Mediterranean, e.g. in the Tyrrhenian Sea the species is rarely found, and at depths from 70 to 160 m (Mannini & Volpi, 1989).

The species *Pteroctopus tetracirrhus* was very rarely caught; a total of three specimens during two surveys, at depths between 153.5 and 274 m, so the frequency of occurrence was very low (0.25). Specimens of this rare species were found in the deeper parts of the open eastern Central Adriatic bordering the South Adriatic Pit. The first findings in the Adriatic are from the southern part where the species inhabits depths from 200 to 400 m (Gamulin-Brida & Ilijanić, 1977; Mandić & Stjepčević, 1977). Mandić (1984) stated that this species was caught in the area of Mole (Apulia - Italy) at a depth of 200 m and four adult specimens (3 females and 1 male) of this non-commercial species were thrown back into the sea. As this is a common practice of fishermen the authors assume that the species appears to be rarer than it really is. Bello (1990) assumed that the distribution of this species is probably limited to the deep part of the southern Adriatic. Krstulović Šifner *et al.* (2005) stated that this species was caught in the southern part of the Eastern Adriatic and in the Eastern Ionian Sea in a very wide depth range, between 77 and 551 m, but prefers deeper waters and was one of the cephalopods with the highest biomass percentage on the middle slope. Ciavaglia & Manfredi (2009) reported findings from the western part of the Central Adriatic at depths between 110 and 239 m, while Casali *et al*. (1998), in the same area sporadically found this species at depths between 150 and 400 m in front of Gargano.

The species *Scaeurgus unicirrhus* was found at depths from 128 to 332 m. The species was found during several expeditions, but most often in small numbers or only individual specimens. The majority of the fished specimens were caught at the border, shallower parts of the South Adriatic Pit and few were found further north, in the open Central Adriatic area. Mandić (1973, 1984) and Gamulin-Brida & Ilijanić (1977) stated that the species *S. unicirrhus* in the South Adriatic inhabits areas outside the continental shelf, i.e. that it lives at depths from 200 to 400 m. This species can also be found in the trawl catches in Italy (Apulia) at depths greater than

100 m, often with specimens of *E. cirrhosa* (Bello, 1990). Findings of this species are also mentioned by Casali *et al*. (1998) for the western Central Adriatic Sea at depths from 150 to 400 m. Ciavaglia & Manfredi (2009) reported findings of this species in the bathymetric range from 50 to 400 m; a total of 102 specimens in the period 1982-2004. The interesting thing is that the spatial distribution was wide and some individuals were also caught in the open sea areas of the Northern Adriatic. In the eastern parts of the Adriatic and Ionian Sea, it was registered at depths over 100 m, and in other parts of the Mediterranean, this species is found occasionally, at depths over 50 m but usually greater than 100 m (Sánchez *et al*., 1998; Krstulović Šifner *et al*., 2005). The first mention of finding of this species was relatively late (Mandić, 1973), although it appears that the species is not so rare in deep open waters of the Central and South Adriatic Sea, and could be considered as one of the less common octopod species in the study area.

Octopus salutii was the species with the highest frequency of occurrence among the noncommercial octopod species (3.02). It was not very abundant and can be considered as one of the less common octopods as it has been caught during several expeditions; usually just one specimen, and sometimes several individuals per survey. The species was mainly found in the open central part of the Adriatic and in the shallower, marginal areas surrounding the northern borders of the South Adriatic Pit. Bello (1990) stated that the species *O. salutii* is more numerous in the area of the southern Adriatic compared to the northern part. This is confirmed by several studies (see Petović *et al*., 2017). The depth range in which *O. salutii* was found was wide, between 69.5 and 470 m. In fact, the maximum depth of 470 m at which the species was registered is also the greatest depth at which any octopod species was recorded during this study. This species is known for its wide distribution and it has been previously found from depths below 50 m, e.g. in the Catalan Sea (Sánchez *et al*., 1998). However, findings of this species at depths below 100 m are rare as it primarily inhabits greater depths, both in the Adriatic and in other parts of the Mediterranean, and occurs most often in the depth range between 150 to 350 m (Mangold & Boletzky, 1988). That *O. salutii* prefers deeper waters was also previously reported in the eastern Adriatic and Ionean Sea where the species was found at depths down to 518 m and was one of the representative cephalopods on the middle slope (292-534 m) (Krstulović Šifner *et al*., 2005).

CONCLUSIONS

The results of the study showed that octopod species which are considered uncommon and rare are mainly occurring in the deeper waters of the Central Adriatic Sea. It is possible that, at least some of them, are much more abundant than it appears based on the scientific data. For instance, deeper waters in the southern parts of the Adriatic Sea are less studied and most of these species were found on the borders of the South Adriatic Pit. Besides, fishermen in their practices do not keep the octopods that are not of interest for human consumption which are, as a rule, thrown back into the sea and thus in most cases remain unregistered (e.g. it is the case for *O. salutii*, pers. comm.). Moreover, most of the research has been done using bottom trawl nets targeting benthic and semi-benthic species, and this is probably the main reason why the four pelagic octopod species known to be inhabiting the Adriatic Sea have not been found during this study. However, the research surveys done in the last decades improved

significantly our knowledge about the distribution and abundance of octopods in the Adriatic Sea, which is of great importance for understanding the dynamics of cephalopod assemblages and for sustainable management of these valuable resources.

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REFERENCES

Belcari, P., Tserpes, G., González, M., Lefkaditou, E., Marčeta, B., Piccinetti Manfrin, G. & A. Souplet (2002a): Distribution and abundance of *Eledone cirrhosa* (Lamarck, 1798) and *Eledone moschata* (Lamarck, 1798) (Cephalopoda: Octopoda) in the Mediterranean Sea. Sci. Mar., 66(S2): 143-155.

Belcari, P., Cuccu, D., González, M., Srairi, A. & P. Vidoris (2002b): Distribution and abundance of *Octopus vulgaris* Cuvier, 1797 (Cephalopoda: Octopoda) in the Mediterranean Sea. Sci. Mar., 66(S2): 157-166.

Bello, G. (1984): Sepioidei del litorale di Bari. Nova Thalassia, 6: 707-709.

Bello, G. (1990): The cephalopod fauna of the Adriatic. Acta Adr., 31(1/2): 275-291.

Bello, G. (2003): The biogeography of Mediterranean cephalopods. Biogeographia, J. Integr. Biogeogr.: 24(1): 209-226.

Bello, G. & G. Motolese (1983): Sepiolids from the Adriatic Sea (Mollusca, Cephalopoda). Rapp. Comm. Int. Mer. Médit., Monaco, 28(5): 281-282.

Bello, G., Andaloro, F. & P. Battaglia (2020): Non-indigenous cephalopods in the Mediterranean Sea: a review. Acta Adriat., 61(2): 113-134.

Carlini, D.B., Young, R.E. & M. Vecchione (2001): A Molecular Phylogeny of the Octopoda (Mollusca: Cephalopoda) Evaluated in Light of Morphological Evidence. Mol. Phylogenet. Evol. 21: 388-397.

Carus, J. (1890): Mollusca Cephalopoda Tunicata. 2 (2). Prodromus fauna Mediterrânea sive descriotio animalum maris Mediterranei incolarium (1889-1893). E. Schweizerbartsche Verlags. Stuttgart, p. 273-439.

Casali, P, Manfrin Piccinetti, G. & S. Soro (1998): Distribuzione di cephalopodi in alto e medio Adriatico. Biol. Mar. Médit., 5: 307–317.

Ciavaglia, E. & C. Manfredi (2009): Distribution and some biological aspects of cephalopods in the North and Central Adriatic, Boll. Malacol.: (suppl. 2009): 61-69.

Corsini-Foka, M., Lorenzini, P., Tirro, F., Sottile, G. & G. Kondilatos (2011): On the recent occurrence of females *Argonauta argo* (Mollusca: Cephalopoda) in the Adriatic and Aegean Seas with observations on aquarium maintenance. Vie Milieu, 61(1): 35-39.

FAO (2023): *Octopus vulgaris* Lamarck, 1798. Fisheries and Aquaculture Division [online]. Rome. (Available at: https://www.fao.org/fishery/en/aqspecies/3571/en).

Fiorentini, L., Dremière, P. Y, Leonori, I., Sala, A. & V. Palumbo (1999): Efficiency of the bottom trawl used for the Mediterranean international trawl survey

(MEDITS). Aquat. Living Resour., 12(3): 187-205.

Gamulin-Brida, H. & V. Ilijanić (1968): Contribution aux recherches des Céphalopodes au 1arge de l'Adriatique. *Octopus salutii* (Verany) l'espèce nouvelle pour l'Adriatique. Rapp. Comm. Int. Mer Médit., 19(2): 253-255.

Gamulin-Brida, H. & V. Ilijanić (1972): Contribution à la connaissance des Céphalopodes de l'Adriatique. Acta Adriat., 14(6): 1-12.

Gamulin–Brida, H. & V. Ilijanić (1977): Zoološka istraživanja na Hvaru u XIX. stoljeću. Hvar u prirodnim znanostima. Simpozij JAZU, Zagreb, 178–188.

Gamulin-Brida, H., Ilijanić, V. & M. Legac (1977): Contribution à la connaissance des Céphalopodes de l'Adriatique avec égard spécial aux espèces rares ou moins connues. Rapp. Comm. Int. Mer Médit., 24(5): 47-49.

Gerovasileiou, V., Akyol, O., Al-Hosne, Z., Alshikh Rasheed, R., Ataç, E., Bello, G., Ćetković, I., Corsini-Foka, M., Crocetta, F., Denitto, F., Guidetti, P., Gül, B., Insacco, G., Jimenez, C., Licchelli, C., Lipej, L., Lombardo, A., Mancini, E., Marletta, G., Michailidis, N., Pešić, A., Poursanidis, D., Refes, W., Sahraoui, H., Thasitis, I., Tiralongo, F., Tosunoğlu, Z., Trkov, D., Vazzana, A. & B. Zava (2020): New records of rare species in the Mediterranean Sea (May 2020). Mediter. Mar. Sci., 21(2): 340–359.

Gramolini, R., Mannini, P., Milone, N. & V. Zeuli (2005): AdriaMed Trawl Survey Information System (AtrIS): User Manual. FAO-MiPAFScitenic Cooperation to Support Responsabile Fisheries in the Adriatic Sea.GCP/RER/010/ITA/TD17. AdriaMed Technical Documents, 17, 141 pp.

Grube, A. E. (1861): Ein Ausflug nach Triest und dem Quarnero Beitrage zur Kenntinis der Thiewelt dieses Gebietes Berlin. Nicolaische Verlagsbuchhandlung, 135–138.

Guescini, A. & G. Manfrin 1986. Rinvenimento di cefalopodi rari in Adriatico: *Abralia veranyi* (Ruppell, 1844) e *Ommastrephes caroli* (Furtado, 1887). Nova Thalassia, 8(S3): 519-521.

De Luca, D., Catanese, G., Procaccini, G. & G. Fiorito (2016): *Octopus vulgaris* (Cuvier, 1797) in the Mediterranean Sea: Genetic diversity and population structure. PloS one, 11(2), e0149496.

Ikica, Z. (2013): Population dynamics of horned octopus (*Eledone cirrhosa* Lamarck, 1798) and musky octopus (*Eledone moschata* Lamarck, 1798) in the south Adriatic. PhD thesis, Univ. Split, Univ. Dubrovnik.

Jereb, P., Roper, C.F.E., Norman, M.D. & K. F. Julian (eds). (2014): Cephalopods of the world. An annotated and illustrated catalogue of cephalopod species known to date. Volume 3. Octopods and Vampire Squids. FAO Species Catalogue for Fishery Purposes. No. 4, Vol. 3. Rome, 370 pp.

Karlovac, O. (1959): Istraživanja naselja riba i jestivih beskralježnjaka vučom u otvorenom Jadranu. Hvar: izvješće, 5(1): 1-203.

Kolombatović, Gj. (1888): Cephalopodi Dibranchiati del Cirkondario maritimo di Spalato. Glasnik hrv. nar. dr. 3

Kolombatović, Gj. (1890): On mollusc (Mollusca: Cephalopoda: Dibranchiata) of coastal area of Split in Dalmatia. Godišnji Izvještaj Velike Realke u Splitu.

Kolombatović, Gj. (1894): O Navodima vrsti Méci (Cephalopoda) i Kralješnjaka (Vertebrata) Jadranskoga mora. Godišnje Izvješće Velike Realke u Splitu, 54 pp.

Kramer, G. (1937): Einige Beobachtungen an

Tremoctopus violaceus. Note Ist It-Germ Biol. Mar Rovigno, 25: 3-11.

Krstulović Šifner, S. (2004): Population dynamics of the Musky octopus, *Eledone moschata* (Lamarck, 1798), in the Adriatic Sea, PhD thesis, Univ. Zagreb.

Krstulović Šifner, S., Lefkaditou, E., Ungaro, N., Ceriola, L., Osmani, K., Kavadas, S. & N. Vrgoč (2005): Composition and distribution of the cephalopod fauna in the eastern Adriatic and eastern Ionian Sea. Isr. J. Zool., 51(4): 315-330.

Krstulović Šifner, S., Peharda, M., Vrgoč, N., Isajlović, I., Dadić, V. & M. Petrić (2011): Biodiversity and distribution of cephalopods caught by trawling along the Northern and Central Adriatic Sea. Cah. Biol. Mar., 52(3): 291-302.

Krstulović Šifner, S., Kuzmanić, D., Isajlović, I., Krželj, M., Vrgoč, N. & M. Petrić (2014): Distribution and abundance of commercially important cephalopods in the eastern Adriatic Sea. 49. hrvatski i 9. međunarodni simpozij agronoma, 16. do 21. veljače 2014, Dubrovnik, Hrvatska. Zbornik radova, 482-487.

Mandić, S. (1973): Kvalitativno-kvantitativni sastav i distibucija Cephalopoda na profilu ušća Bojane (Qualitative and quantitative composition and distribution of Cephalopods on the mouth of river Bojana). Stud. Mar., 6: 29-44.

Mandić, S. & J. Stjepčević (1977): First report on three genera of Cephalopoda new for the Adriatic Sea. Rapp. Comm. Int. Mer Médit., 24(5): 51-52.

Mandić, S. & J. Stjepčević (1978): Sastav i distribucija Cephalopoda u biocenozama litoralnog područja Crnogorskog primorja. Drugi kongres ekologa Jugoslavije, Zagreb, 1565-1575.

Mandić, S. & J. Stjepčević (1983): Ekonomski važne vrste Cephalopoda u južnom Jadranu. Stud. Mar., 13-14(1): 215-222.

Mangold, K. & S.V. Boletzky (1988): Mediterranean cephalopod fauna. In: Paleontology and neontology of cephalopods, Academic Press, 315-330.

Mannini, P. & C. Volpi (1989): Nota sulla presenza e distribuzione di alcuni Cefalopodi del Tirreno Settentrionale. Oebalia, 15: 693-701.

Marano, G., Bello, G., Pastorelli, A. M. & G. Motolese (1982): Ottopodi dell'Adraitico pugliese. Natur Siciliano, 6: 132-133.

Ninni, AP. (1884): Catalogo dei cefalopodi dibranchiati osservati nell'Adriatico. Atti Soc. Venetto-Trento Sci. Natt., 9: 1.

Olivi, G. (1792): Adriatic Zoology, Kraljevska akademija umjetnosti, Bassano, 334 pp.

Orsi Relini, L., Belluscio A. & G.D. Ardizzone (2004): Tracking the Indopacific pelagic *Tremoctopus gracilis* in the Mediterranean. Rapp. Comm. Int. Mer Médit., 37: 415.

Petović, S., Gvozdenović, S. & Z. Ikica (2017): An annotated checklist of the marine molluscs of the South Adriatic Sea (Montenegro) and a comparison with those of neighbouring areas. Turk. J. Fish. Aquat. Sci., 17(5): 921-934.

Petrić, M., Šifner, S.K., Ferri, J., Škeljo, F., Brčić, J. & M. Krželj (2014): Cephalopods in the trawl catches in the Jabuka Pit wider area. 49. hrvatski i 9. međunarodni simpozij agronoma, 16. do 21. veljače 2014., Dubrovnik, Hrvatska. Zbornik radova, 504-508.

Petrić, M., Dragičević, B., Stanić, R. & Ž. Trumbić (2023): Morphological characteristics and DNA barcoding of the rare blanket octopus *Tremoctopus violaceus* (Cephalopoda: Tremoctopodidae) in the Adriatic Sea. Diversity, 15, 794.

Quetglas, A., Valls, M., Capezzuto, F., Casciaro, L., Cuccu, D., González, M. & P. Peristeraki (2019): Long-term

spatiotemporal dynamics of cephalopod assemblages in the Mediterranean Sea. Sci. Mar., 83(S1): 33-42.

Relini, G, Carpentieri, P. & M. Murenu (2008): International bottom trawl survey in the Mediterranean Sea (Medits). Medits Instruction Manual. Biol. Mar. Medit., 6 (1): 33-34.

Sánchez, P., Belcari, P. & P. Sartor (1998): Composition and spatial distribution of cephalopods in two north-western Mediterranean areas. S. Afr. J. Mar. Sci., 20(1): 17-24.

Soro, S. & G. Piccinetti Manfrin (1989): Biologia e pesca di cefalopodi in Adriatico. Nova Thalassia, 10(S1): 493-498.

Sparre P. & SC. Venema (1998): Introduction to tropical fish stock assessment. Part 1. Manual. FAO Fish. Tech. Pap. No. 306.1, Rev. 2, 407 pp.

Stossich, M. (1880): Prospetto della Fauna del Mare Adriático; Parte 5. Boll. Soc. Adriat. Sci. Nat., Trieste, 6: 168-271.

Tutman, P, Šifner, S. K., Dulčić, J., Pallaoro, A., Gavrilović, A., Jug-Dujaković, J. & B. Glamuzina (2008): A note on distribution and biology of *Ocythoe tuberculata* (Cephalopoda: Ocythoidae) in the Adriatic Sea. Vie Milieu, 58(3/4): 215-221.

Vérany, J. B. (1851): Mollusques Méditeranéens; observés, décrits, figurés, et chromolithographiés d'après le vivant, 1ére Partie, Céphalopodes de la Méditerranée. Genoa: Imprimerie des Sourdes-Muets, p. 44.

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Oktopodi sjevernog i srednjeg Jadrana

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SAŽETAK

U radu su prikazani podaci o nalazima hobotnica (red Octopoda) u istočnom dijelu sjevernog i srednjeg Jadrana, temeljeni na istraživanjima sprovedenim od 1996. do 2019. godine, te pregled dosad prijavljenih nalaza ove grupe glavonožaca u Jadranu. Tokom terenskih istraživanja pronađeno je ukupno osam vrsta iz nadporodice Octopodoidea. Za sve vrste prikazana je prostorna i dubinska raspodjela, srednji indeksi biomase i brojnosti (kg/km^2, N/km^2) i učestalost pojavljivanja (%f). Vrste od ekonomskog interesa *Octopus vulgaris*, *Eledone cirrhosa* i *Eledone moschata* imale su najveće prosječne indekse biomase i brojnosti te najveću učestalost pojavljivanja dok su sve ostale hobotnice imale značajno niže vrijednosti. Među njima je, prema učestalosti pojavljivanja, najzastupljenija vrsta *Octopus salutii* (3,02), zatim vrste *Callistoctopus macropus* (1,41) i *Scaeurgus unicirrhus* (1,39). Najniže vrijednosti učestalosti pojavljivanja zabilježene su za vrste *Pteroctopus tetracirrhus* (0,25) i *Macrotritopus defilippi* (0,24), kojih je u više od 20 godina istraživanja pronađeno tek nekoliko primjeraka.

Ključne riječi: oktopodi, Jadran, rasprostranjenost, učestalost pojavljivanja, neuobičajene i rijetke vrste