DISTRIBUTION OF MUSKY OCTOPUS (*ELEDONE MOSCHATA* LAMARCK, 1798) (CEPHALOPODA: OCTOPODA) IN THE SOUTH-EASTERN ADRIATIC

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RASPROSTRANJENOST CRNOG MUZGAVCA (*ELEDONE MOSCHATA* LAMARCK, 1798) (CEPHALOPODA: OCTOPODA) U JUGOISTOČNOM JADRANU

Apstrakt

Procijenjene su sezonske varijacije u distribuciji i indeksima brojnosti i biomase crnog muzgavca na Crnogorskom primorju. Najveće vrijednosti zabilježene su u jesen (indeks brojnosti, 405.6 N/km^2) i zimu (indeks biomase, 26.0 kg/km^2) na dubinama manjim od 50 m, dok su na dubinama od 50 do 100 m za oba maksimumi bili u ljetnom periodu (126.0 N/km^2 odnosno 20.3 kg/km^2). Crni muzgavac nije nađen na dubinama većim od 100 m. Najveću gustoću naseljenosti pokazao je na području između Budve i Ulcinja na kojima prevladavaju dubine manje od 200 m. Postoje indikacije ograničenih sezonskih migracija, koje mogu biti uzrokovane povećanim dotokom slatke vode Bojanom u jesen i zimu.

Ključne reči: distribucija, muzgavac, Eledone moschata, Crnogorsko primorje
Keywords: distribution, musky octopus, Eledone moschata, Montenegrin coast

INTRODUCTION

Musky octopus, *Eledone moschata* (Lamarck, 1798), is an octopod cephalopod species distributed throughout the Mediterranean, including the Adriatic, southern coasts

of Portugal, the Gibraltar, and the Gulf of Cádiz in the Atlantic Ocean (Roper *et al*., 1984; Belcari & Sbrana, 1999). According to previous studies in south–eastern Adriatic, the musky octopus is found in shallow areas at depths down to 80 m, and only rarely at depths down to 100 m (Mandić *et al*., 1982; Mandić, 1984; Pastorelli *et al*., 1998; Vrgoč *et al*., 2004). Musky octopus is one of the most important cephalopod species in bottom trawl fisheries in the south–eastern Adriatic (Belcari & Sbrana, 1999; Vrgoč *et al*., 2004). *E. moschata* has been a subject of studies in different areas of the Mediterranean: Catalan Sea (Mangold–Wirz, 1963; Mangold, 1983), Gulf of Gabes (Ezzedine–Najai, 1997), Gulf of Cádiz (Silva *et al*., 2004), Aegean Sea (Önsoy & Salman, 2004; Akyol *et al*., 2007, Şen, 2007; Şen & Akyol, 2011) and the Adriatic (Krstulović Šifner, 2004; Krstulović Šifner & Vrgoč, 2009a, 2009b).

MATERIALS AND METHODS

The specimens of *E. moschata* were obtained from commercial bottom trawl catches. The hauls were trawled at 10 predetermined positions, following the MEDITS protocol (MEDITS, 2007). Sampling was done using the commercial trawl in the period between 30 minutes after sunrise and 30 minutes before sunset. The trawl was hauled for 30 minutes if the sampling depth was below 200 m, or 60 minutes at depths greater than 200 m. The codend mesh size was 20 mm, which is the legal minimum in Montenegro (Official Gazette of Montenegro, 56/09, 8/11). The sampling was performed seasonally, from April 2009. to April 2011.

Musky octopus catches were standardised according to the swept area method (Sparre & Venema, 1998) using the AtrIS computer program (AdriaMed, 2007), and the swept area was calculated according to the formula:

$$P = 0{,}001 \cdot a \cdot s$$

where P is the surface of the swept area [km^2], a is wing spread of the trawl [m], and s represents the distance travelled [km].

Obtained values of the swept area were then used to calculate biomass and abundance indices, which are used to express the catch according to area unit (kg/km^2 and N/km^2, respectively). The mean value of the catch can be expressed as:

$$\overline{X}_T = \frac{p_1\overline{X}_1 + p_2\overline{X}_2 + p_3\overline{X}_3 + \ldots + p_n\overline{X}_n}{p_1 + p_2 + p_3 + \ldots + p_n}$$

where $\overline{X}_T$ represents the mean value of the catch in the studied area (kg/km^2, N/km^2), $\overline{X}_{1,2,3,\ldots,n}$ is the mean value of the catch in a given depth stratum, and $p_{1,2,3,\ldots,n}$ is the surface area of a depth stratum (km^2).

RESULTS AND DISCUSSION

During the 2009–2011 study, the highest value of the abundance index (N/km^2) was found during the autumn season at depths down to 50 m (405.6 N/km^2), while the lowest value was found in spring (79 N/km^2) (Table 1, Fig. 1). Biomass indices (kg/km^2) at these depths ranged from 7.4 kg/km^2 in spring to 24.4 kg/km^2 in summer (Table 1, Fig. 2).

According to the results of MEDITS expedition in the north and central eastern Adriatic (1996.–2003.), done in the period between June and September (except in 2001, which started somewhat earlier, in May) (Petrić *et al.*, 2013)), the abundance index at depths up to 50 m ranged from 225 N/km^2 (1998) to 978 N/km^2 (2002), with a mean value of 623 N/km^2. The biomass index ranged from 20.36 kg/km^2 (1998) to 117.78 kg/km^2 (2002), with an average value of 65.85 kg/km^2 (Krstulović Šifner, 2004).

Table 1. Abundance (N/km^2) and biomass indices (kg/km^2) for *E. moschata* according to depth strata along Montenegrin coast, 2009–2011

Depth (m)	Index	Spring	Summer	Autumn	Winter
10–50	N/km^2	79	178.4	405.6	289.2
	kg/km^2	7.4	24.4	18.8	26.0
50–100	N/km^2	59.3	126.0	42.3	47.2
	kg/km^2	8.1	20.3	3.8	4.9

At depths between 50 and 100 m, abundance index ranged between 42.3 N/km^2 in autumn to 126 N/km^2 in summer (Table 1, Fig. 1). Biomass index ranged from 3.8 kg/km^2 in autumn to 20.3 kg/km^2 in summer (Table 1, Fig. 2). In central and northern Adriatic the biomass indices at 50–100 m depths were between 4.04 kg/km^2 (1998) and 90.07 kg/km^2 (2002), with a mean value of 24.09 kg/km^2, while the abundance index varied between 62 N/km^2 (1998) and 948 N/km^2 (2002), with an average of 295 N/km^2 (Krstulović Šifner, 2004).

During the present study, *E. moschata* was not found at depths greater than 100 m. In northern and central Adriatic, the mean biomass index at depths between 100 and 200 m was 1.73 kg/km^2, and the mean abundance index 20 N/km^2 (Krstulović Šifner, 2004).

According to Krstulović Šifner *et al.* (2005), musky octopus had greatest abundance in the north–eastern Adriatic, with mean abundance index of 240 N/km^2, and was found at depths down to 165 m. Tursi (1992) reports *E. moschata* at depths down to 400 m in the Ionian Sea, but notes that the abundance was greatest at depths under 50 m, and that the overall number of individuals in that study was very small. Belcari *et al.* (2002) note that *E. moschata* was very poorly represented or even nonexistent in the catches in the northern Ligurian Sea, north–eastern Corsica, Ionian Sea and in Moroccan waters, while catches in the north Adriatic (Slovenia) reached abundance index of 2396 N/km^2 and biomass index of 336.1 kg/km^2 (Belcari *et al.*, 2002).

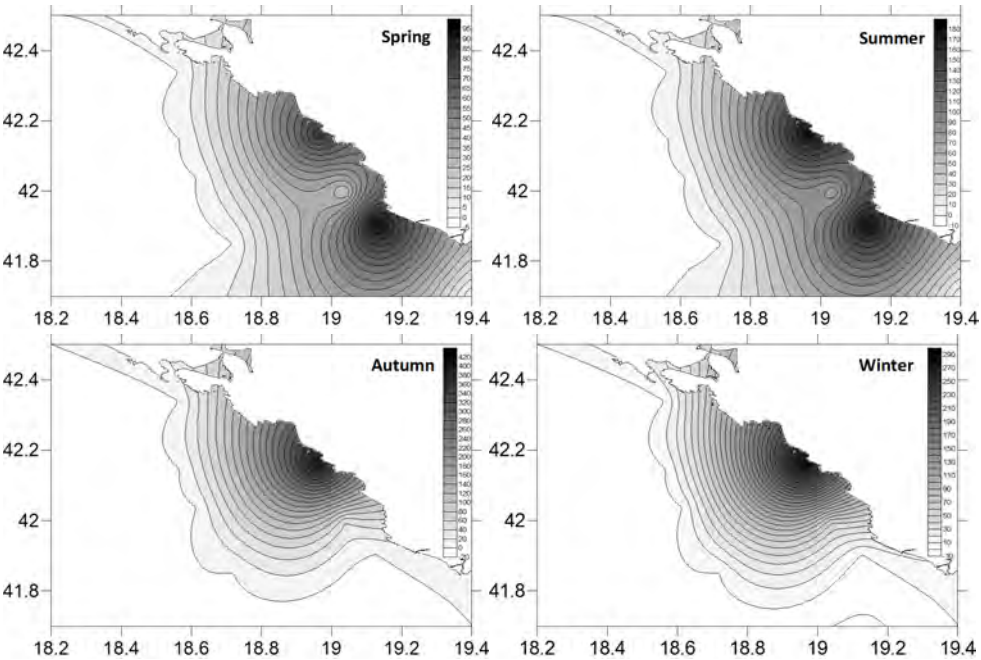

Figure 1. Distribution of *E. moschata* according to abundance index (N/km^2), by season along Montenegrin coast, 2009–2011

It should be noted that MEDITS results are not directly comparable to the results of this study because of different mesh sizes. MEDITS expeditions uses a 10 mm codend mesh size (IFREMER GOC 37 trawl type), while the legal minimum in Montenegro is twice that size (20 mm codend mesh size) (Official Gazette of Montenegro, 56/09; 8/11).

Along the Montenegrin coast, *E. moschata* had highest values in the area from Budva to the Bojana River estuary, which corresponds to the area with greatest shelf surface (depths under 200 m).

During spring and summer seasons, areas of increased values of abundance and biomass indices can be seen in front of Petrovac (Budva municipality, 41°12'20'' N, 18°56'33'' E) and the city of Ulcinj (41°55'12'' N, 19°12' E), while during autumn and winter increased values can be found only in front of Petrovac. This could indicate limited seasonal migrations, which could be explained by the increased inflow of freshwater via the Bojana river during autumn and winter. This could have a pronounced effect on these shallow areas around the city of Ulcinj (Mandić *et al*., 1982).

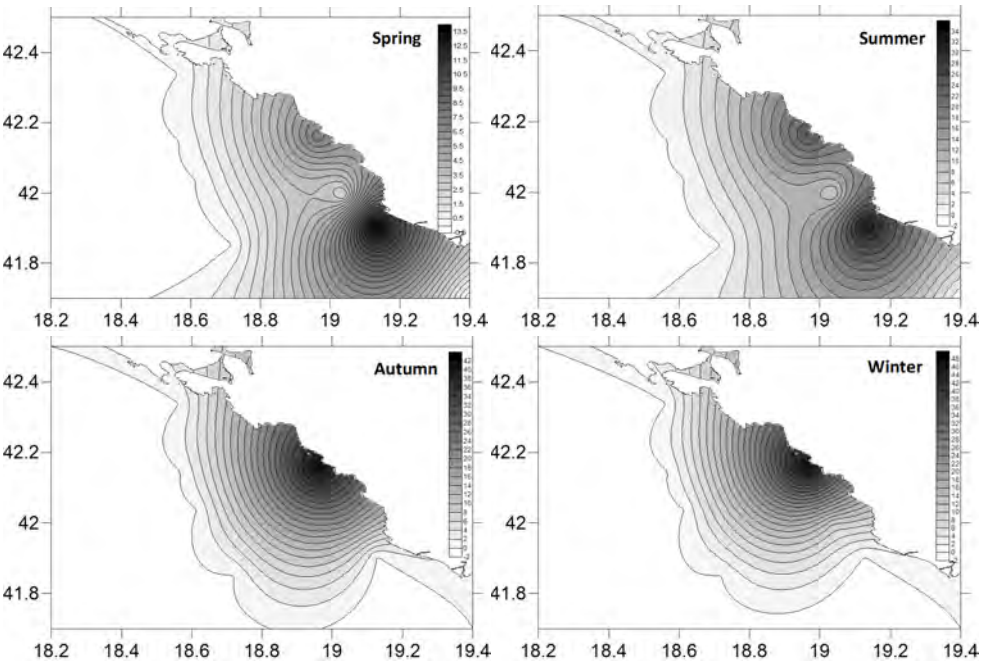

Figure 2. Distribution of *E. moschata* according to biomass index (kg/km^2), by season along Montenegrin coast, 2009–2011

CONCLUSIONS

The highest values of the abundance index for *E. moschata* were recorded in autumn and winter, and in summer and winter for biomass index, all at depths below 50 m, which is consistent with previous studies of this species, both in the Adriatic and in the Mediterranean. During this study in Montenegrin waters, musky octopus was not recorded at depths greater than 100 m. Generally, abundance and biomass indices of *E. moschata* were lower than in northern and central Adriatic. There are also indications of limited seasonal migrations. Further, more detailed studies are recommended for better understanding of distribution and biology of this economically important cephalopod species.

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