Turk J Zool
24 (2000) 165–171
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The Distribution and Fishing of two Mediterranean *Eledone* spp. (Octopoda: Cephalopoda) in the Aegean Sea

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Received: 20.04.1999

Abstract: The spatial distributions of *Eledone cirrhosa* (Lamarck, 1798) and *Eledone moschata* (Lamarck, 1798) were examined based on four seasonal trawl surverys carried out between 1991-1992 covering 20-500 meters of the Turkish and international waters in the Aegean Sea. It was found that *E. cirrhosa* inhabits all depth ranges examined in the northern part, but it was seldom observed in the south. *E. moschata,* on the other hand, has a basin-wide distribution and solely inhabits the upper 200-meter depth range.

Key Words: Octopoda, Aegean Sea, fishing, distribution, *Eledone* spp.

Akdeniz'de Yaşayan İki Eledone (Octopoda: Cephalopoda) Türünün Ege Denizi'nde Dağılımı ve Avcılığı

Özet: *E. cirrhosa* (Lamarck, 1798) ve *E. moschata* (Lamarck, 1798)'nın Ege Denizi'nde 1991-1992 yılları arasında dört mevsimlik örneklemeleri yapılmıştır. Yapılan bu örneklemeler Ege Denizi'nin Türkiye karasuları ve uluslararası sularında 20-500 m'ler arasında gerçekleştirilmiştir. İncelemeler sonucunda *E. cirrhosa*'nın tüm derinlik konturlarında ve daha yoğun olarak kuzey Ege'de *E. moschata*'nın ise maksimum 200 m derinliklere kadar tün Ege'de dağılım gösterdiği tespit edilmiştir.

Anahtar Sözcükler: Octopoda Ege Denizi, Avcılık, *Eledone spp.*

Introduction

Like most of the other Mediterranean cephalopods, *E. cirrhosa* entered the Mediterranean Sea from the east Atlantic Ocean. The remaining flew, including *E. moschata,* are of essentially Mediterranean origin, and from there diffused into the Atlantic (1). The occurence of *E. moschata* outside the Mediterranean Sea, around the Gulf ve Cadiz and Lisbon, are explained by the influence of outflowing Mediterranean waters in the Atlantic (2, 3, 1). The data from the Dardanelles and the Sea of Marmara where similar hydrographic conditions prevail, i.e., Mediterranean water enters the less haline Sea of Marmara through the Dardanelles, would be complementary to this matter, as already indicated by Mangold & Boletzky (1). In more recent studies, the occurence of *E. moschata* in the depths of the Sea of Marmara, where Mediterranean water dominates, has been reported (4), and the global distribution of this species, which had been formerly confined to the east Atlantic basin (1), was expanded. This added a quantitative dimension to the available knowledge on the cephalopod fauna of the Aegean and adjacent seas (6, 5, 7, 8, 9, 4).

Material and Methods

The distribution of *Eledone cirrhosa* and *Eledone moschata* in the international and Turkish waters of the Aegean Sea were studied during four trips in Summer 1991, Winter 1991, Spring 1992 and Autumn 1992 carried out with "R/V K. Piri Reis".

Due to complicated topographic structure, suitable trawling grounds in the southern part of the Aegean Sea located within the 0-500-meter dephth range and within the Turkish and international waters are very limited as compared to the northern part. The trawlable fishing grounds within 0-500 meters of depth in the Turkish and international waters of the Aegean Sea were divided into 3 x 3 n. mile grids. Of these, a total of 292 grids were selected randomly and sampled throughout the study. Samplings were done within 0-100, 100-200 and 200-500 m depth contours in randomly chosen quadrates

(Figure 1). The trawl net used in the study was typical Mediterranean type with 20 mm (knot to knot) code end mesh size. All hauls were done in the daytime with 2.6 n.miles/h constant speed, and actual trawling duration was always kept the 30 min. In this way, the area swept by the net was estimated at 0.0210 km^2. Samples were identified and sexed, and the mantle length (ML) of individuals was measured on board.

Results

The results of the seasonal trawl surveys are summarized in Table 1. Aside from minor differences, number of occurrence and abundance of *E. moschata* and *E. cirrhosa* were nearly the same. The main difference was the seasonal distribution pattern. The mean abundance of *E. moschata* was about 4 ind/haul throughout the year, except in spring when it dropped to 2 ind/haul. *E. cirrhosa* showed more pronounced seasonal variation in all parameters measured. The values were lowest during autumn, increasing gradually to reach peak values (8 ± 0.66 ind/haul and 1089 ± 8.12 g/haul) in summer.

The distributions of both species are mainly confined to the northern part of the Aegean Sea. Only once, during winter, a single *Eledone cirrhosa* individual was observed below 37°N. The seasonal abundance is also apparent from Table 1. *E. moschata* is less numerous during spring and its biomass is almost uniform throughout the year. The gradual increase in the abundance and biomass of *E. cirrhosa* from autumn to summer is evident in Table 2. This species shows wider distribution over the depth ranges examined in the northern part of the Aegean Sea, whereas *E. moschata* is confined to shallower waters. A better presentation of the vertical distribution of the *Eledone* species is depicted, where the total number of trawl hauls in 10 meter depth intervals and the number of hauls in which either species of *Eledone* were encountered, are grouped. *Eledone moschata* was dominant in the upper 150 meters and mainly concentrated between 50-80 meters of depth. This species was not found in depths below 200 meters.

Eledone cirrhosa was observed in nearly all of the depth ranges examined. At the lower depth ranges, *E. cirrhosa* was more frequent and was observed in nearly all of the trawl hauls in the lower depth ranges between 250-450 meters, but the main concentration in terms of biomass was found between 180-250 meters.

The biomasses of both species are standardized to unit trawling time (30 min.) and classified in different depth ranges for each season (Table 2). Similar to the vertical distribution of the occurence, the highest catch of *E. moschata* was always obtained in the upper 100 meters throughout the year, and the total catch of this species was higher than that of *E. cirrhosa* in the upper layers. On an annual basis, more than 80% was caught within the first hundred meters. There were almost no individuals below 100 meters during summer (29 ± 4.78 g/haul). In autumn, yield from 100-200 meters increased slightly and attained to 228 ± 9.11 g/haul. Only in winter,

Table 1. Overall estimation of abundance (numbers per haul), biomass (weight per haul) and number of trawl hauls in which *Eledone moschata* and *Eledone cirrhosa* were encountered in the Aegean Sea.

	Summer 91	Winter 91	Spring 92	Autumn 92	Total
Eledone moschata					
Percentage of occurrence	32%	49%	44%	48%	42%
Max. # of ind. per haul	48	56	14	46	56
Max. weight (g per haul)	8000	5000	4300	7950	8000
Mean # of ind. per haul	4±0.59	4±1.02	2±0.46	4±0.60	3±0.32
Mean weight (g. per haul)	456±6.95	532±9.89	411±7.04	535±7.57	479±3.82
Eledone cirrhosa					
Percentage of occurence	54%a	51%	41%	38%	46%
Max. # of ind. per haul	42	17	32	11	42
Max. weight (g per haul)	7200	2000	3500	1100	7200
Mean # of ind. per haul	8±0.66	3±0.68	3±0.58	1±0.29	4±0.32
Mean weight (g. per haul)	1089±8.12	290±6.99	354±6.39	33±2.50	502±3.86
Total # of trawl stations	99	41	68	84	292

Table 2. Average catch per unit trawling time (g/30 min.) and confidence limits by depth range and by season in the Aegean Sea.

Season	Depth	N	*E. cirrhosa*	*E. moschata*
	20–100	48	675 ± 12.09	928 ± 11.65
Summer 91	100–200	21	2167 ± 18.47	29 ± 4.78
	200–500	30	998 ± 12.62	–
	20–100	22	332 ± 10.86	927 ± 15.40
Winter 91	100–200	12	283 ± 11.39	83 ± 8.97
	200–500	7	171 ± 17.86	57 ± 11.37
	20–100	39	258 ± 8.46	609 ± 10.36
Spring 92	100–200	13	185 ± 10.31	323 ± 14.32
	200–500	16	725 ± 15.55	–
	20–100	45	12 ± 2.24	917 ± 11.85
Autumn 92	100–200	16	113 ± 8.84	228 ± 9.11
	200–500	23	17 ± 3.03	–
	20–100	154	327 ± 5.22	844 ± 596
Total	100–200	62	865 ± 9.35	152 ± 4.60
	200–500	76	568 ± 6.94	5 ± 1.55

a few individuals appeared in the deepest depth range, and the average catch reached 57 ± 11.37 g/haul. In spring, when the average catch was at a minimum level, nearly 30% of the catch was obtained from depths between 100-200 meters.

The vertical distribution of *E. cirrhosa* is not as discrete as that of *E. moschata.* They were caught from all depth ranges. The highest catch of this species was obtained within an interval of 100-200 meters during summer.

The mantle length vs. frequency distribution of *Eledone cirrhosa* for all four seasons are given in Figure 2. The smallest individuals were observed in autumn, and modal lengths increased gradually towards summer.

Figure 3 represents the mantle length frequency distribution of *E. moschata*. In winter, the small-sized, newly recruited individuals formed a distinct group, well isolated from the adults. During spring, the catch was dominated by larger individuals, and the young generation was represented by a very small number. In summer and autumn, the length spectrum was greater and thereafter it was not pissible to follow the growth of the components.

Although a very slight negative tendency is recognized from the regression line, no significat correlation was obtained between mantle length and depth for *E. cirrhosa*. On the other hand, a significant fit ($P<0.01$) was obtained between depth and the size distribution of *E. moschata*.

Discussion

The wide vertical extent of *E. cirrhosa* distribution observed over the depths of the Aegean Sea is a typical distribution pattern of this species throughout the Mediterranean (10, 11, 12, 13, 14, 15, 16).

During summer, when the highest values for both abundance and biomass were observed, most of the individuals were adult according to the length classification of Mangold-Wirz (17), where individuals larger than 100mm ML are considered adult. Some juveniles from the early spring generation also appeared in the catch during this season. Similarly, Relini and Orsi Relini (18) and Tursi and D'Onghia (13) provided evidence for the existence of early spring spawning of this species, while mass spawning takes place during summer and autumn in the Ligurian Sea and Ionian Sea, respectively. On the other hand, the main bulk of the year was recruited after this season. During autumn, nearly all of the catch was comprised of juveniles below 50 mm M. The large individuals of the summer completely disappeared in autumn. Similar patterns were observed in the Catalan, Ligurian and northern Tyrrhenian Seas (17,

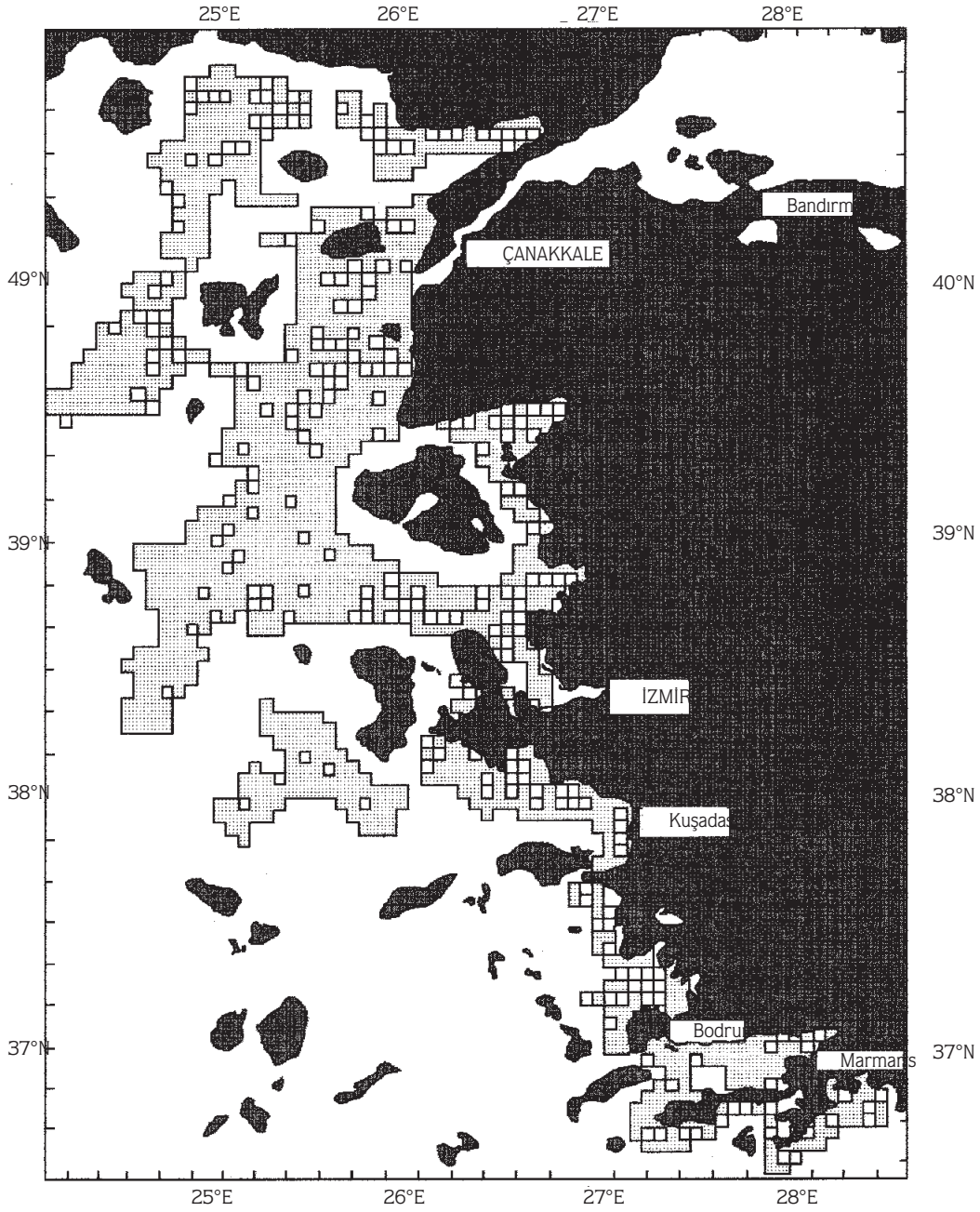

Figure 1. Trawling grounds between 0 to 500 meters depth of Turkish and international waters in the Aegean Sea (grayed area). Small squares represent randomly selected grids in which a single trawl haul was made.

18, 19), except that larger individuals after attaining sexual maturity disappear earlier in June-July.

D'Onghia et al. (10) observed two successive cohorts as the same length-frequency chart in the northern Aegean Sea. However, the mesh size used in the present study is rather selective, so newly hatched juveniles were not recognized on the length-frequency distributions. Consequently, it is not easy to determine the exact spawning season of *E. cirrhosa* from the data presented above. Consequenty, individuals are larger in the first half of a year, and the older cohort is replaced by a newer one earlier. Since the mesh sizes used in these studies are

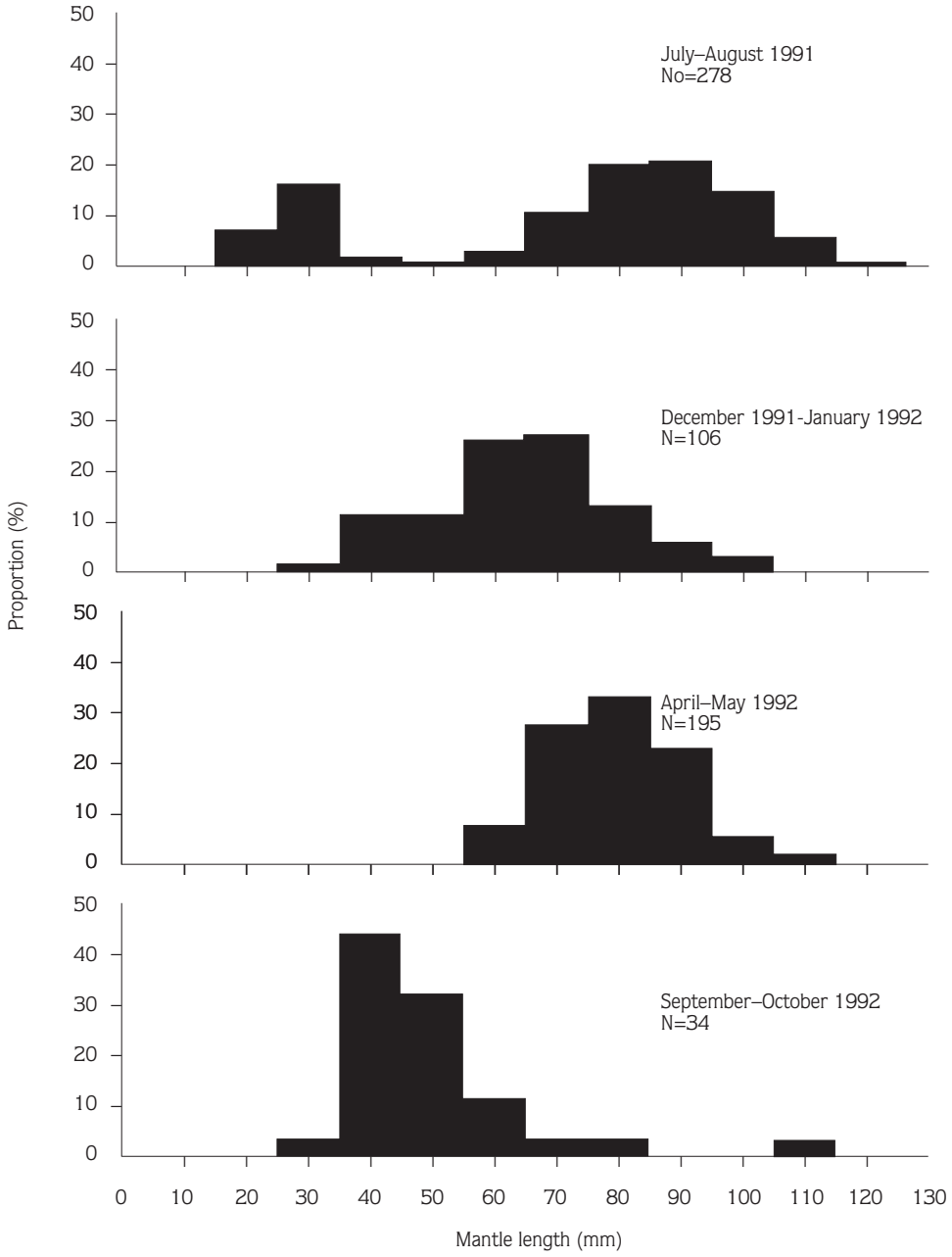

Figure 2. Seasonal distribution of *E. cirrhosa* in the Aegean Sea.

different, the length at first capture varies accordingly. However, if the 40mm modal mantle length is taken as a reference, the recruitment and, in turn, the reproduction periods occur earlier in Ligurian Sea, which is followed by the northwest and northeastern Aegean, respectively. This figure might lead one to conclude, on the lines of D'Onghia (10), that the reproduction of *E. cirrhosa* in the Aegean Sea takes place in August-September.

The years' offspring, after the planktonic larval stage, settls and eventually appears in winter. They attain a mantle length of 30-40 mm mantle length in late summer-autumn. The following year in sumer they reach sexual maturity and spawn in autumn. After this stage, most of the adults disappear. The disappearance of the arger ones is attributed to death soon after spawning (10, 16).

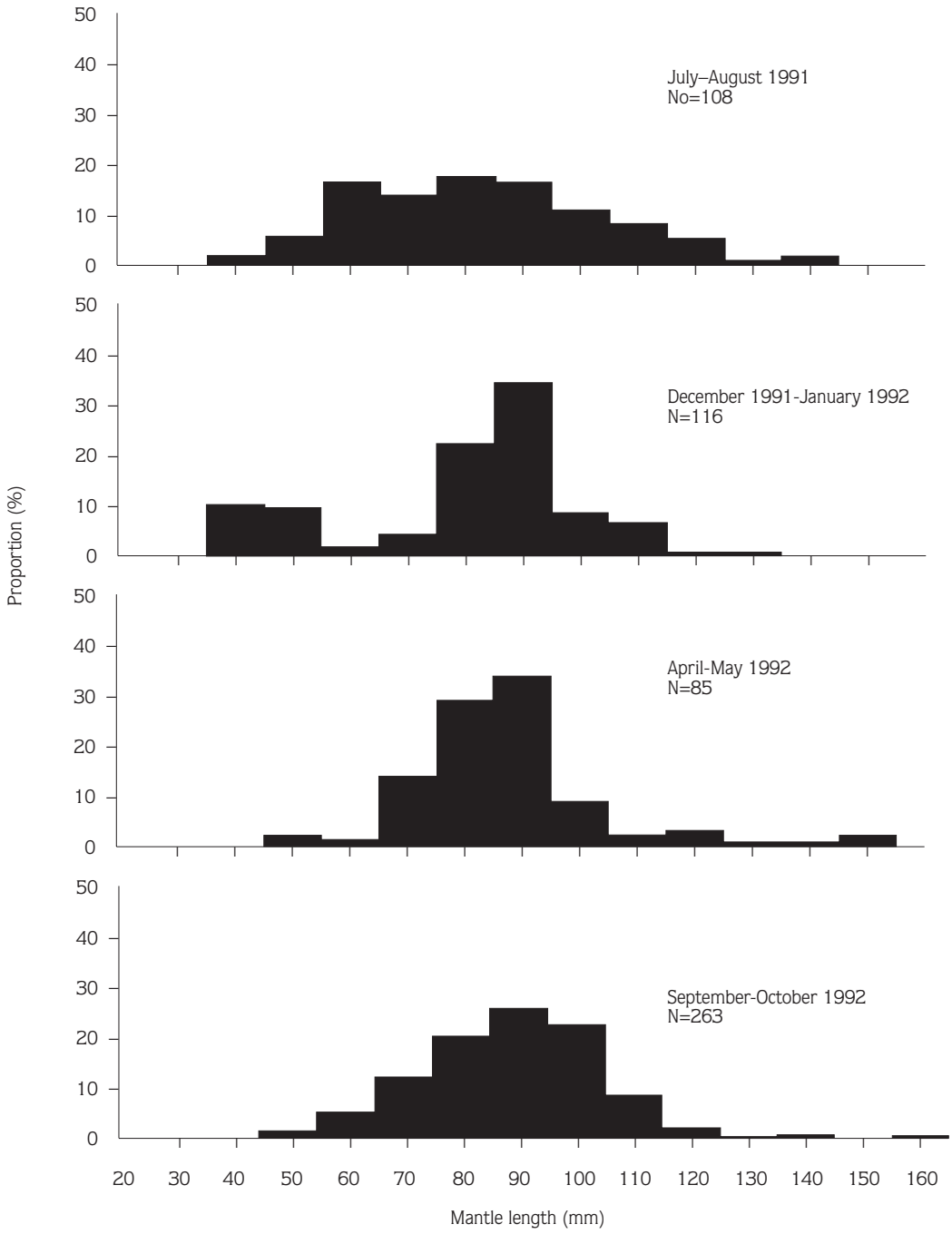

Figure 3. Seasonal distribution of *E. moschata* in the Aegean Sea.

Although there is slight increasing tendency in the abundance and biomass of *E. moschata.* in our study, athough it is observed that *E. moschata* specimens are quite abundant at depths of more than 100 meters, we found only four specimens at a maximum depth of 320 m., accordant with the similar observation of D'Onghia et al. (20) at a depth of 350 m in the northern Aegean Sea. Nevertheless, these results do not influence the wide distributions of the specis. When the total catch of this species is compared with the former, it does not appear

hat *E. moschata* is less common in the Aegean Sea, as was stated by D'Onghia et al. (10), but rather equally or even more common in the upper 100 meters.

The length-frequency chart drawn for this species is rather complicated, and no seasonal pattern is apparent. This feature, in fact, is in line with Relin & Orsi Relini's (18) statement that recruitment in *Eledone moschata* continues year round. On the other hand, it may worth noting that, unlike former species, whose distribution is confined to the northern Aegean, *E. moschata* has a wider geographical distribution over the study area. It is hard to ignore climatologic and environmental delay between the nothern tip of the Aegean Sea and Levantine basin, which fundamentally influences the study area.

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