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# Distribution and abundance of sepiolids (Mollusca : Cephalopoda) off the north-eastern Greek coasts

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ABSTRACT. Sepiolids are a lesser known group of cephalopods. This paper aims to increase knowledge of their distribution and abundance in the NE Mediterranean.

A total of 3404 sepiolids were collected off the north-eastern coasts of Greece, between 17 and 400 m of depth, during four seasonal trawl surveys carried out from November 1992 to August-September 1993. Nine species were identified *: Neorossia caroli, Rondeletiola minor, Rossia macrosoma, Sepietta neglecta, Sepietta oweniana, Sepiola affinis, Sepiola intermedia, Sepiola ligulata* and *Sepiola rondeleti*.

*S. oweniana* was the most abundant species among them, followed by *R. minor, R. macrosoma* and *S. rondeleti.* The results of multivariate analysis, based on Bray-Curtis similarity indices, showed the presence of three main groups : one related to the shallower hauls near the coast (<60m) where *S. rondeleti* and *S. intermedia* were more frequently caught, a second one consisting of hauls carried out at depths 55-105 m, in which *S. oweniana* was the dominant species, and a third one with deeper hauls characterised by the highest abundance of *S. oweniana, R.. minor* and *R. macrosoma.*

Length frequencies and maturity stages are presented by season and sex for the four most abundant species. Seasonal changes in the bathymetric distribution of these species are also discussed in relation to their life cycle.

KEY WORDS : cephalopoda, sepiolidae, Aegean, Mediterranean.

## INTRODUCTION

Sepiolids are among the least known groups of cephalopods in the Mediterranean Sea at least with regard to their distribution and life history at sea. Although they present little interest for fisheries they seem to play an important role in the marine food webs since members of this family have been frequently found in the stomach contents of various marine organisms such as dolphins, sharks, demersal and pelagic fishes (BELLO, 1991, 1996, 1999; WÜRTZ et al., 1992; BLANCO et al., 1995; ORSI-RELINI et al., 1994, 1995).

Cephalopod species of the Sepiolidae family have been recorded in the Aegean Sea quite recently (KATAGAN & KOCATAS, 1990; D'ONGHIA et al., 1991,1996; SALMAN et al., 1997, 2002; LEFKADITOU & KASPIRIS, 1998; LEFKADITOU et al., 1999; KOUTSOUBAS et al., 2000). Within the last decade, biogeographic knowledge of sepiolids has greatly increased also in other areas of the western and central Mediterranean Sea (TURSI & D'ONGHIA, 1992; VILLANUEVA, 1992; BOLETZKY, 1995, JEREB et al., 1997; CASALI et al., 1998; QUETGLAS et al., 2000; SÁNCHEZ & DEMESTRE, 2001; GONZÁLEZ & SÁNCHEZ, 2002), as well as, in the Levantine basin (SALMAN et al, 1998; 2002) and the Marmara Sea (KATAGAN et al, 1993; ÜNSAL et al., 1999).

This work concerns the distribution and abundance of the sepiolid species found at the northernmost part of the Aegean Sea. In addition seasonal distribution of the most abundant species, *Sepietta oweniana, Rondeletiola minor, Rossia macrosoma* and *Sepiola rondeleti*, was examined in relation to their size and maturity.

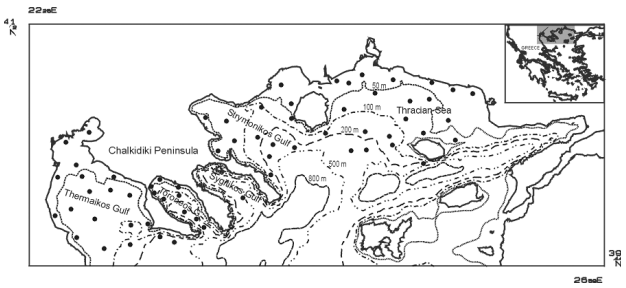


Fig. 1. – Illustration of the area investigated and the sampling stations of trawl surveys carried out from November 1992 to September 1993.

## MATERIAL AND METHODS

Samples were collected from four bottom trawl surveys carried out seasonally from November-December 1992 to August-September 1993. The geographical area investigated extends off the coasts of north-eastern Greece, consisting of Thracian Sea, Strymonikos, Sygitikos, Toroneos and Thermaikos gulfs (Fig. 1). Four depth strata, 1-50, 51-100, 101-200 and 201-400 m, were considered and sampling was based on random-stratified design. A commercial trawler (115 tons gross tonnage, 250 Hp twin engines) and the typical nylon commercial bottom trawl net (16 mm cod-end mesh size from knot to knot) were

used. Hauls were performed during daytime and ranged from 30 to 60 min in duration.

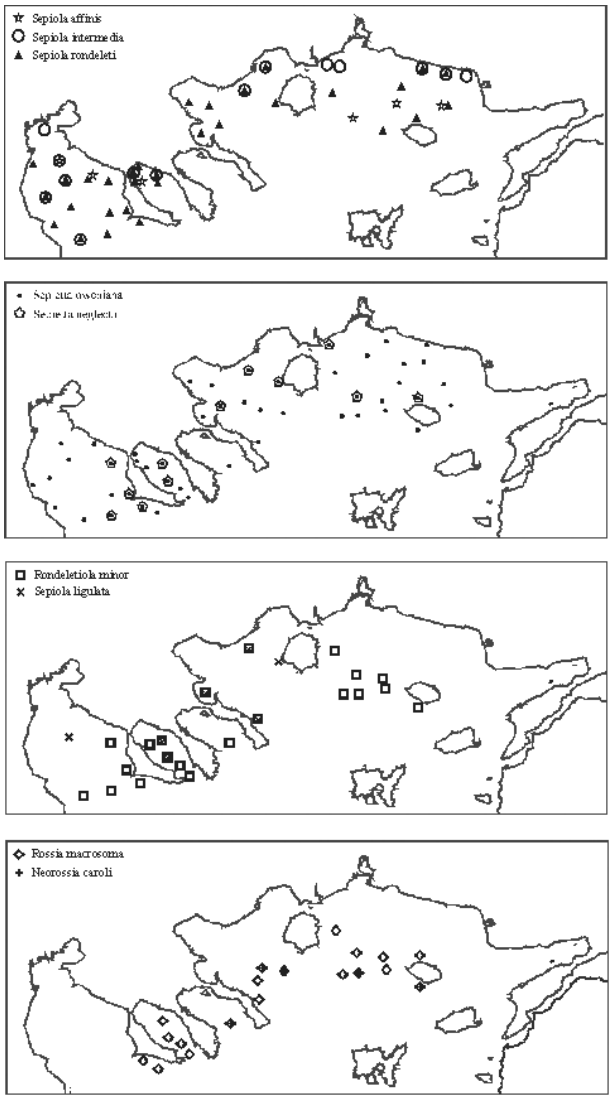


Fig. 2. – Distribution of sepiolid species in the studied area.

Sepiolids were present in 126 out of the 148 hauls performed in total. The specimens caught at each station were preserved in 5% formalin in sea water, and identified at the laboratory following the key for sepiolids in GUERRA (1992). Dorsal mantle length (in mm), weight (in g), sex and maturity stage were reported for each specimen together with the haul data (date, location, duration, depth). A three stage scale : immature, maturing, mature, (JUANICO, 1979) was used for sexual maturity.

To detect zonation patterns, the data of the survey carried out in August-September 1993 were considered because of the greater number of hauls performed during this survey. The data matrices comprising the numbers of individuals per hour of trawling of each species and station were log (x+1) transformed, and the haul-similarity percentage was calculated using the Bray-Curtis coefficient (BRAY & CURTIS, 1957) by the PRIMER-v5 software (CLARKE & GORLEY, 2001).

To investigate seasonal variation in the abundance and distribution of *Sepietta oweniana, Rondeletiola minor, Rossia macrosoma* and *Sepiola rondeleti*, the mean catch per unit of effort (CPUE) in number of individuals per fishing hour was calculated by species per depth stratum and survey, as well as the seasonal length-frequency distributions and percentages of maturity stages by species and sex.

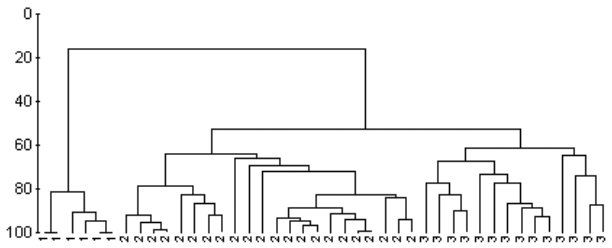


Fig. 3. – Dendrogram of the hauls carried out by bottom trawl in September 1993 off the north-eastern Greek coasts, using group-average linking of Bray-Curtis similarities calculated on log(x+1) transformed numbers of individuals of sepiolid species per fishing hour. 1 : cluster of shallower hauls (30-60m), 2 : hauls at intermediate depths (50-100m), 3 : deeper hauls cluster (over 100 m).

## RESULTS

### Taxonomic composition and species assemblages

A total of 3404 specimens comprising nine species belonging to two sepiolid subfamilies were collected between 17 and 400 m of depth (Table I). *S. oweniana* was the most abundant species followed by *R. minor, R. macrosoma* and *S. rondeleti.*

Dominant species were widely distributed over the whole study area, whereas the less frequently caught *S. affinis* was not found in Strymonikos gulf, *S. ligulata* was absent from catches in the Thracian Sea and the bathybenthic *N. caroli* did not appear in the deep hauls at Toroneos and Thermaikos gulfs (Fig. 2).

The results of the multivariate analysis, based on Bray-Curtis similarity indices, showed the presence of three main clusters (Fig. 3) : one consisting of hauls carried out at depths 30-60 m, another related with the depth stratum 50-100 m and a third one with deeper hauls (over 100 m). Although most of the species were present in several clusters, the species composition and catch rates distinguish them from each other. *S. rondeleti* and *S. intermedia* were the species more frequently caught in the shallower hauls (Table I), *S. oweniana* was the dominant species at depths between 50 and 100 m, whereas the deep-haul group (100-400 m) was characterised by the highest abundance of *S. oweniana, R. minor* and *R. macrosoma.*.

### Seasonal distribution of the most abundant sepiolids.

#### *S. oweniana*

Over all, 2411 specimens were caught during the four surveys, at depths ranging between 40 and 400 m. Higher CPUE indices were estimated for waters deeper than 100 m (Fig. 4), where smaller individuals (ML<22 mm) generally constituted the greatest part of the catches (Fig. 5). Differences in the bathymetric distribution by size

TABLE 1

Number of individuals, depth range and catch rates in each bathymetric stratum (f%, percentage frequency of appearance in hauls, CPUE in number of individuals per fishing hour) for sepiolids caught by bottom trawl off the north-eastern Greek coasts from November 1992 to September 1993.

| Species | Number of individuals | Depth range (m) | Depth stratum | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | <50 | | 50-100 | | 100-200 | | 200-400 | |
| | | | f% | CPUE | f% | CPUE | f% | CPUE | f% | CPUE |
| Sepiolinae | | | | | | | | | | |
| *Sepiola afinis* | 5 | 40-89 | 2.6 | 0.1 | 4.1 | 0.1 | | | | |
| *Sepiola rondeleti* | 155 | 24-195 | 35.9 | 1.5 | 63.3 | 3.0 | 25.0 | 1.0 | | |
| *Sepiola intermedia* | 34 | 17-113 | 17.9 | 1.2 | 2.0 | 0.1 | 3.6 | 0.3 | | |
| *Sepietta oweniana* | 2411 | 40-400 | 7.7 | 0.3 | 87.8 | 16.6 | 100.0 | 29.0 | 90.3 | 43.9 |
| *Sepietta neglecta* | 64 | 24-262 | 2.6 | 0.4 | 8.2 | 0.6 | 17.9 | 0.9 | 6.5 | 0.6 |
| *Rondeletiola minor* | 360 | 66-338 | | | 8.2 | 0.2 | 64.3 | 5.4 | 38.7 | 8.9 |
| *Sepiola ligulata* | 14 | 80-328 | | | 4.1 | 0.1 | 14.3 | 0.3 | 9.7 | 0.2 |
| Rossinae | | | | | | | | | | |
| *Rossia macrosoma* | 239 | 78-400 | | | 2.0 | 0.0 | 35.7 | 4.3 | 90.3 | 5.5 |
| *Neorossia caroli* | 124 | 237-400 | | | | | | | 32.1 | 4.0 |

TABLE 2

Maturity stages seasonal percentages and mantle length ranges of sepiolids collected off the north-eastern Greek coasts from November 1992 to September 1993

| Species | Sex | Maturity | Cruises | | | | ML (mm) | |
|---|---|---|---|---|---|---|---|---|
| | | | I | II | III | IV | range | mean |
| S. oweniana | females | immature | 19 | 20 | 26 | 54 | 11-26 | 18 |
| | | maturing | 26 | 21 | 25 | 15 | 14-29 | 21 |
| | | mature | 55 | 59 | 49 | 31 | 18-35 | 25 |
| | males | immature | 1 | 0 | 3 | 7 | 12-20 | 16 |
| | | maturing | 4 | 7 | 15 | 7 | 13-24 | 18 |
| | | mature | 95 | 93 | 82 | 86 | 14-30 | 22 |
| R. macrosoma | females | immature | 62 | 61 | 30 | 35 | 15-50 | 31 |
| | | maturing | 15 | 28 | 39 | 26 | 30-51 | 40 |
| | | mature | 23 | 11 | 31 | 39 | 38-84 | 55 |
| | males | immature | 53 | 22 | 3 | 28 | 14-33 | 22 |
| | | maturing | 12 | 6 | | 3 | 17-28 | 24 |
| | | mature | 35 | 72 | 97 | 70 | 26-51 | 39 |
| R. minor | Females | immature | | 2 | | | 12 | |
| | | maturing | 20 | 3 | 5 | 11 | 12-14 | 13 |
| | Males | mature | 80 | 95 | 95 | 89 | 13-21 | 16 |
| | | maturing | 5 | | | 1 | 10-11 | 11 |
| | | mature | 95 | 100 | 100 | 99 | 11-20 | 16 |
| S. rondeleti | females | immature | 20 | | 8 | 8 | 14-22 | 18 |
| | | maturing | 40 | | 8 | 8 | 16-20 | 18 |
| | | mature | 40 | 100 | 84 | 84 | 13-27 | 20 |
| | males | mature | 100 | 100 | 100 | 100 | 12-30 | 18 |
| N. caroli | females | immature | 75 | 90 | 20 | 60 | 15-34 | 26 |
| | | maturing | 25 | 5 | 20 | | 23-32 | 29 |
| | | mature | | 5 | 60 | 40 | 31-43 | 39 |
| | males | immature | 100 | 7 | | 67 | 17-27 | 21 |
| | | maturing | | 23 | 12 | | 22-29 | 24 |
| | | mature | | 70 | 88 | 33 | 22-40 | 31 |
| S. neglecta | females | maturing | | 10 | | | 13 | |
| | | mature | 100 | 90 | 100 | 100 | 12-23 | 17 |
| | males | immature | | 20 | 50 | 25 | 15 | |
| | | maturing | | | 50 | | 19 | |
| | | mature | 100 | 80 | | 75 | 13-23 | 18 |
| S.affinis | females | immature | | 100 | | | 16 | |
| | | mature | 100 | | | | 15 | |
| | males | mature | | 100 | | | 16 | |
| S. intermedia | females | mature | 100 | | 100 | 100 | 14-18 | 16 |
| | males | mature | 100 | 100 | 100 | | 13-21 | 16 |
| S.ligulata | females | mature | 100 | 100 | | 100 | 13-17 | 16 |
| | males | | | | | | 22-40 | 31 |

were mainly observed in summer and autumn, when larger individuals (ML>22 mm) concentrated in shallow waters. Most males caught were mature, their percentage extending to 90% in November and March. Mature females represented 44.5% of the examined specimens, with a maximum percentage in March and a minimum in September (Table II). An analysis of the occurrence of mature individuals in relation to depth, showed higher percentages of mature females at depths less than 100 m all year round, whereas, no trend was identifiable in the distribution of mature males.

### *R. minor*

This species is one of the smallest sepiolids (Table II). Mature individuals comprised over 95% of the total of 360 individuals caught (Table II). The greatest part of the population was distributed deeper than 200 m from March to September. In November '92 the species was less abundant (Fig. 4) with a lower percentage of mature males and females (Table II), and only some smaller individuals (ML<16 mm) was fished at depths 200-400 (Fig. 5)

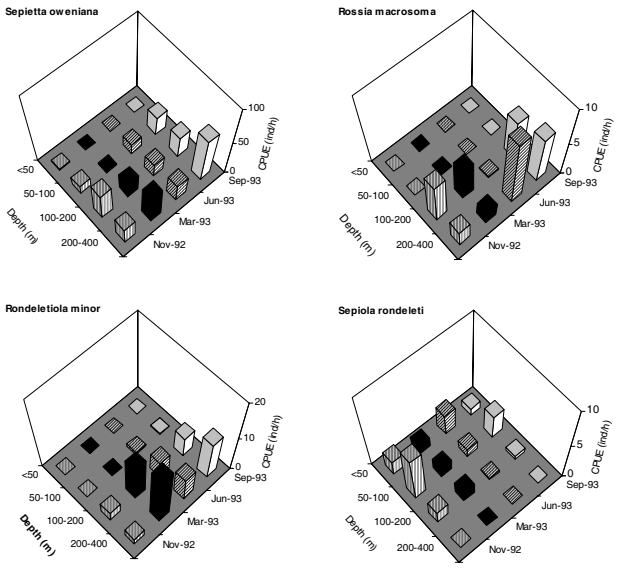


Fig. 4. – Seasonal abundance of *Sepietta oweniana, Rondeletiola minor, Rossia macrosoma* and *Sepiola rondeleti,* by bathymetric stratum in the study area, from November '92 to August-September '93.

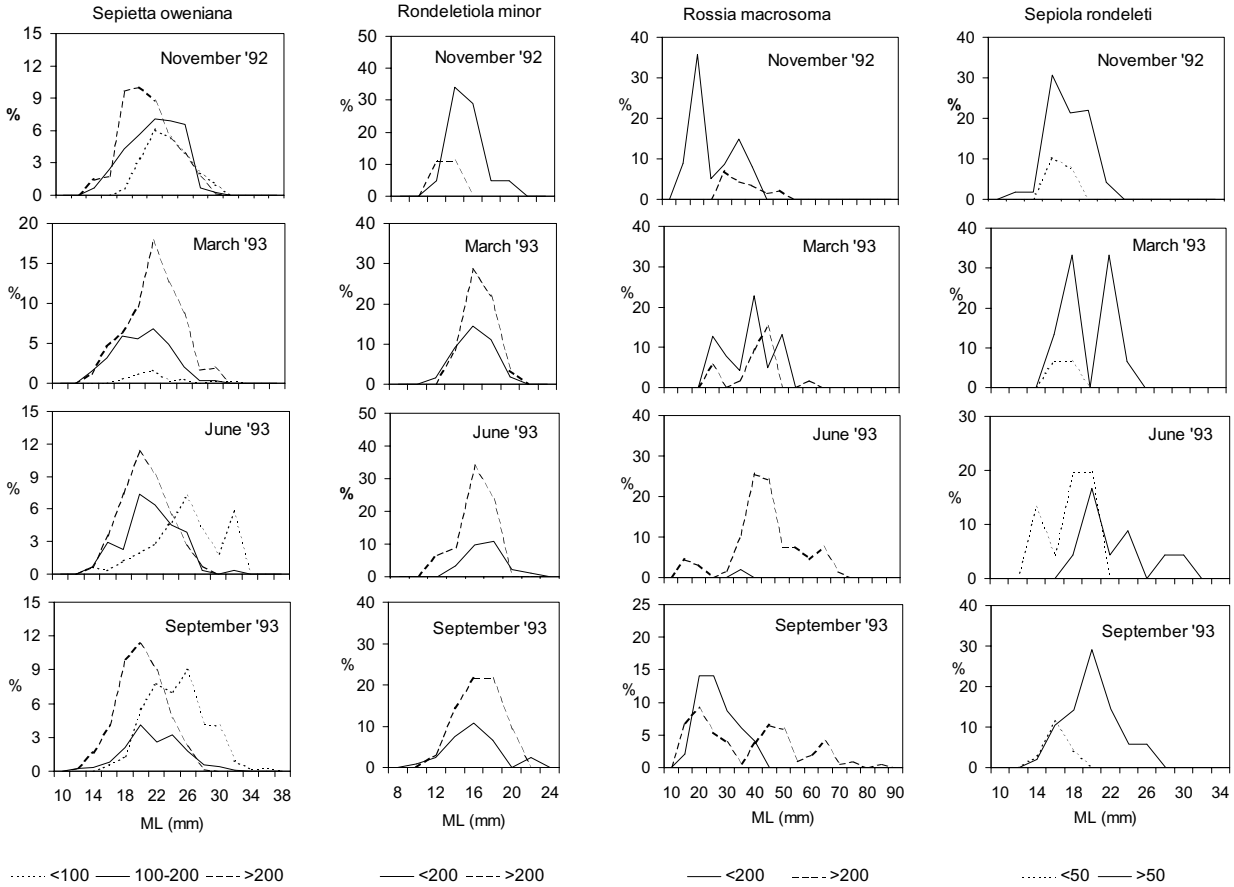


Fig. 5. – Length frequency distribution of *Sepietta oweniana*, *Rondeletiola minor*, *Rossia macrosoma* and *Sepiola rondeletti* by season and depth zone.

***R. macrosoma***

A total of 239 specimens were fished between 78 and 400 m. However findings at depths lower than 148 m were reported only in the Thracian Sea. As shown in Figs 4 and 5, in November and March the species was more abundant at depths 100-200 m, in June the population consisted mostly of larger individuals (ML>30 mm) distributed deeper than 200 m, whereas in September the strong recruitment in shallower waters resulted in almost equal abundance of the species in the two bathymetric strata, 100-200 and 200-400 m. Mature individuals of both sexes were mainly found deeper than 200 m all year, where as spawns of this species were always collected deeper than 250 m. The maximum percentage of mature females was observed in September and that of males in June.

***S. rondeleti***

This species was the most abundant of the genus *Sepiola* (Table I), with 153 individuals collected between depths 24 and 195 m. Large individuals (ML>20 mm) during all cruises were found deeper than 50 m (Fig. 5). Smaller ones were mostly recruited during early summer in shallow waters but during the rest of the year they were found deeper than 50 m. In March all males and females caught were mature.

## DISCUSSION

The nine species found off north-eastern Greek coasts cover 2/3 of the 12 sepiolids recorded from the Aegean Sea (LEFKADITOU, unppublished data). Among the sepiolid species missing from our collection, *Sepiola robusta* and *Sepietta obscura* have been rarely caught in the southern and eastern part of the Aegean Sea (SALMAN et al., 1997, 2002), whereas the pelagic *Heteroteuthis dispar* was the most common cephalopod collected by frame mid-water trawl over the trench south of Chalkidiki peninsula (LEFKADITOU et al., 1999). In the Mediterranean Sea, up to now, there are records for 15 sepiolid species (BELLO, 1995), including three more species: the infralittoral *Sepiola aurantiaca,* and the bathyal *Sepiola steenstrupiana* and *Stoloteuthis leucoptera*, which generally have been very rarely caught.

The bathymetric distribution of the identified species and their numerical consistence in the catches is generally in accordance with what has been reported for other Mediterranean areas (ORSI-RELINI & BERTULETTI, 1989; BOLETZKY, 1995; JEREB et al., 1997, 1998; SÁNCHEZ & DEMESTRE, 2001).

*S. oweniana* was the most abundant and eurybathic sepiolid species, as has been observed in other areas of the Mediterranean Sea (BOLETZKY, 1995). Seasonal changes in the species abundance by depth are related to recruitment variation in deeper grounds, as well as to migration of larger individuals in shallower waters from early summer to autumn most probably for spawning since highest percentages of mature females were found in these depths. Similar migration has been reported by MANGOLD-WIRTZ (1963) in the northern Catalan Sea, whereas there was no evidence of such migration in areas with more abrupt waters such as the North Aegean Sea (D'ONGHIA et al., 1996) and the Strait of Sicily (JEREB et al., 1997).

*R. minor* and *R. macrosoma* seem to concentrate in deeper waters during summer and early autumn, whereas recruitment is mainly observed in November at depths shallower than 200 m. Similar concentration on the slope has been noted during summer in the Ligurian Sea for *R. minor* (ORSI-RELINI & BERTULETTI, 1989) and in the lower Tyrrhenian Sea during autumn for *R. macrosoma* (BOLETZKY, 1995). However, in the northern Catalan Sea, MANGOLD-WIRTZ (1963) observed a greater abundance of mature specimens on detritic bottoms shallower than 130 m during summer, supposing a population movement towards shallower waters for reproduction. The collection of *R. macrosoma* eggs, as well as the higher percentages of mature males and females on the slope of our study area, are not in agreement with the above consideration**.** The occurrence of mature individuals of these species all year-round indicates an extended spawning period, thus suggesting that the species' seasonal migrations should be rather attributed to other reasons than reproduction. Dense waters, rich in nutrients, formed over the shallow waters of the shelf areas of the North Aegean Sea during winter, slide towards the deep cavities (GEORGOPOULOS et al., 1988). This may result in higher biological productivity in deeper waters and could probably be related to the seasonal movement of these species.

*R. minor* was the second most abundant sepiolid species, caught mostly together with *S. oweniana* and *R. macrosoma.* These three species show an aggregation-forming behaviour as also reported for other areas (BOLETZKY, 1995), although the number of caught specimens per haul very rarely exceeded 100 in the area investigated. On the contrary, species of the genus *Sepiola* presented a low frequency of occurrence in the catches, never exceeding ten individuals per haul. Among them *S. rondeleti* was most frequently caught, extending its maximum depth distribution previously recorded (GUERRA, 1982). This species has been generally poorly represented in samples from the Mediterranean Sea, most probably due to its preference for shallow waters (JEREB et al., 1997).

Mature specimens of both sexes of the species caught during this study were generally present all over the year (Table II), indicating an extended reproductive period of sepiolids. For the species of the Rossinae subfamily, a seasonal peak of spawning activity, as well as earlier maturation of males could be detected, as has also been mentioned for other areas (D' ONGHIA et al., 1993, 1994; JEREB et al., 1998). For the species of Sepiolinae subfamily, as mentioned also by other authors (JEREB et al., 1997), mature specimens represent higher percentages with no substantial differences related to seasons. However it has to be noted that the low percentages of immature individuals of the species of the Sepiolinae subfamily and especially those of smaller sizes (Table II), may be due to the low efficiency of the commercial trawl net used in capturing smaller individuals.

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