

COMPOSITION AND SPATIAL DISTRIBUTION OF CEPHALOPODS IN TWO NORTH-WESTERN MEDITERRANEAN AREAS

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The faunistic composition and the spatial distribution of the cephalopod fauna were studied and compared in two areas of the north-western Mediterranean: the Catalan Sea (Spanish coast) and the northern Tyrrhenian Sea (Italian coast). In all, 46 species were collected in the Catalan Sea and 36 in the northern Tyrrhenian Sea. The bathymetric distribution of common species does not differ notably between the two areas. In both, cephalopod abundance is greatest between 50 and 200 m deep. To compare the seasonal changes in bathymetric distribution, four representative species were selected. *O. vulgaris* is more abundant in both areas between 0 and 50 m in autumn; *E. cirrhosa* and *I. coindetii* between 50 and 200 m. Both the last species and *S. elegans* are more abundant in spring in the Catalan Sea and in autumn in the northern Tyrrhenian Sea. The results of cluster analysis show the presence, in both areas, of three clear associations: one group consists of shallow hauls, another of hauls made over the continental shelf and the third of deeper hauls.

The current study compares the faunistic composition and the spatial distribution of the cephalopod fauna in two different areas of the north-western Mediterranean: the Catalan Sea (Spanish coast) and the northern Tyrrhenian Sea (Italian coast) – see Figure 1. Studies have been carried out on the biology and fishery of cephalopods in both areas (e.g. Sánchez 1986, Wurtz *et al.* 1992, Belcari and Sartor 1993, Sánchez and Martín 1993, Belcari *et al.* in press), but this is the first time that a comparative study of the fauna of both areas has been attempted.

MATERIAL AND METHODS

The Catalan coast of north-eastern Spain is approximately 550 km long and has 28 ports, 18 of which have daily and regular fishing activity (Martín 1991). The data used herein for faunistic composition derive from six fishing research projects and 11 oceanographic fishing cruises carried out from 1976 to 1996. Data used to elucidate the bathymetric distribution and the relative abundance came from a single fishing research project carried out off the Catalan coast during 1991. Monthly sampling was undertaken with a standard otter bottom trawl. The depths at which cephalopods were caught ranged between 21 and 548 m deep.

The northern Tyrrhenian Sea, delimited to the north by the island of Elba and to the south by the island of Giannutri, covers some 7 500 km², of which more than 80% is trawlable (De Ranieri *et al.* 1988). The

Tyrrhenian Sea data used for faunistic composition came from 27 trawl surveys associated with a variety of research projects and from monthly observations of the landings, all carried out since 1985. For the same area, the data from four random stratified trawl surveys, carried out during spring and autumn of 1994 and 1995, were used to study bathymetric distribution and relative abundance. In all, 100 hauls lasting one hour each were performed in daylight from 10 to 680 m deep.

For comparative purposes between the two areas, only spring and autumn data on bathymetric distribution and relative abundance of cephalopods (number of individuals per hour trawled) were considered. To identify faunistic associations, cluster analysis was applied to the species-haul matrix of each area; again only spring and autumn data were used. In order to reduce skewness, the data were double square-root transformed. Haul-similarity percentage was calculated by means of the Bray-Curtis index (Clifford and Stephenson 1975). A group-average fusion strategy, UPGMA (Sneath and Sokal 1973), was applied to link similar samples into clusters.

RESULTS

Cephalopod fauna

In all, 47 species of cephalopods are listed, 46 for the Catalan Sea and 36 for the northern Tyrrhenian

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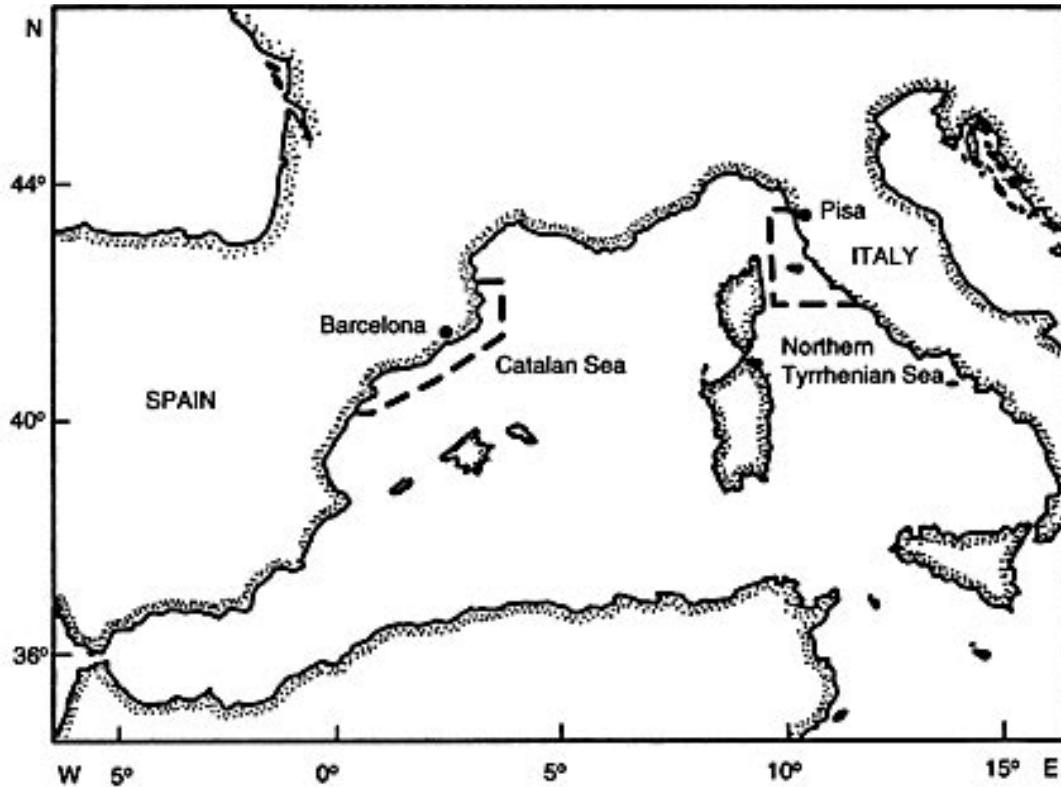


Fig. 1: Map of the western Mediterranean Sea illustrating the position of the two areas studied

Sea, 35 being common to the two areas (Table I). *Stoloteuthis leucoptera* was collected for the first time in the Catalan Sea, *Ancistroteuthis lichtensteini*, *Ctenopteryx sicula*, *Octopoteuthis sicula* and *S. leucoptera* for the first time in the northern Tyrrhenian Sea.

Abundance and spatial distribution

Although the data were not quantitatively comparable owing to different sampling design and fishing gear, certain differences between the two areas could be identified on the basis of successive studies carried out.

For both areas, cephalopod abundance (number per hour) was greatest between 50 and 200 m deep (Table II). Shallower than 50 m, abundance was greater in the Catalan Sea, whereas deeper than 350 m

there was greater abundance in the northern Tyrrhenian Sea. Some species were more abundant in one zone than in another. For example, *Loligo vulgaris* was much more abundant in the Catalan Sea than in the northern Tyrrhenian Sea, whereas the sepiolids were more abundant in the northern Tyrrhenian Sea, especially in water deeper than 350 m.

To compare seasonal bathymetric distribution, four species representative of the two areas were selected, *Octopus vulgaris*, *Eledone cirrhosa*, *Illex coindetii* and *Sepia elegans* (Fig. 2). *O. vulgaris* was more abundant in both zones between 0 and 50 m deep, in autumn, whereas *E. cirrhosa* and *I. coindetii* were most abundant between 50 and 200 m deep. *I. coindetii* was also more abundant in spring in the Catalan Sea and in autumn in the northern Tyrrhenian Sea. *S. elegans* was most abundant between 0 and 100 m deep in both areas, again in spring in the Catalan Sea and in autumn in the northern Tyrrhenian Sea.

Table I: List of the species found in the Catalan and northern Tyrrhenian seas. Species presence is noted with a .

Species	Catalan Sea	Northern Tyrrhenian Sea
<i>Sepia elegans</i>	.	.
<i>Sepia officinalis</i>	.	.
<i>Sepia orbignyana</i>	.	.
<i>Rossia macrosoma</i>	.	.
<i>Neorossia caroli</i>	.	.
<i>Heteroteuthis dispar</i>	.	.
<i>Stoloteuthis leucoptera</i>	.	.
<i>Sepiolo intermedia</i>	.	.
<i>Sepiolo ligulata</i>	.	.
<i>Sepiolo robusta</i>	.	.
<i>Sepiolo rondeleti</i>	.	.
<i>Sepietta oweniana</i>	.	.
<i>Sepietta neglecta</i>	.	.
<i>Sepietta obscura</i>	.	.
<i>Rondeletiola minor</i>	.	.
<i>Loligo vulgaris</i>	.	.
<i>Loligo forbesi</i>	.	.
<i>Alloteuthis media</i>	.	.
<i>Alloteuthis subulata</i>	.	.
<i>Abralia veranyi</i>	.	.
<i>Abraliopsis pfefferi</i>	.	.
<i>Ancistrocheirus lesueurii</i>	.	.
<i>Octopoteuthis sicula</i>	.	.
<i>Onychoteuthis banksii</i>	.	.
<i>Ancistroteuthis lichtensteini</i>	.	.
<i>Histioteuthis bommellii</i>	.	.
<i>Histioteuthis reversa</i>	.	.
<i>Chtenopteryx sicula</i>	.	.
<i>Illex coindetii</i>	.	.
<i>Todaropsis eblanae</i>	.	.
<i>Todarodes sagittatus</i>	.	.
<i>Ommastrephes bartramii</i>	.	.
<i>Chiroteuthis veranyi</i>	.	.
<i>Galiteuthis armata</i>	.	.
<i>Teuthowenia megalops</i>	.	.
<i>Opisthoteuthis agassizi</i>	.	.
<i>Octopus vulgaris</i>	.	.
<i>Octopus defilippi</i>	.	.
<i>Octopus macropus</i>	.	.
<i>Octopus salutii</i>	.	.
<i>Scaergus unicolor</i>	.	.
<i>Pteroctopus tetracirrhus</i>	.	.
<i>Eledone cirrhosa</i>	.	.
<i>Eledone moschata</i>	.	.
<i>Bathypolypus sponsalis</i>	.	.
<i>Ocythoe tuberculata</i>	.	.
<i>Argonauta argo</i>	.	.

Faunistic association

The results of the cluster analysis showed the presence of clear associations in both areas (Fig. 3). Five clusters are evident in the dendrogram of the northern Tyrrhenian Sea and just three, perhaps because the number of stations was few, in the Catalan Sea. However, in both areas, three assemblages can be identified

in broad outline: a group consisting of shallower hauls (generally up 100 m deep), another with most of the hauls carried out over the continental shelf (100–250 m) and a third for the deeper hauls (essentially deeper than 300 m).

Although some species were present in several clusters, each faunistic association was characterized to some extent by species composition and catch rates which distinguish them from each other (Table III). The coastal cluster in both areas was characterized by *Loligo vulgaris* and *Alloteuthis* spp., which make up respectively 30 and 15% of the total abundance. Also important in this cluster were *Octopus vulgaris* and *Sepia officinalis* in the northern Tyrrhenian Sea and *Sepia elegans* in the Catalan Sea.

The assemblage including mainly those hauls carried out over the continental shelf was characterized by *Alloteuthis* spp., *Eledone cirrhosa* and *Illex coindetii* in the northern Tyrrhenian Sea, and by *E. cirrhosa* (58.4% of total abundance) in the Catalan Sea.

The deep-haul group of both areas was dominated by the sepiolids, predominantly *Sepietta oweniana*. In deeper water, the overall abundance of cephalopods diminishes considerably and most of the species found are caught only occasionally. Other notable species of this group were *Todaropsis eblanae*, *Neorossia caroli* and *Pteroctopus tetracirrhus*.

DISCUSSION

Mangold and Boletzky (1988) report 59 species of cephalopods for the Mediterranean Sea. According to Morales (1958) and Mangold-Wirz (1963), three species can be added to the 46 reported in the present study for the Catalan Sea: *Sepiolo affinis*, *Octopus defilippi* and *Tremoctopus violaceus*.

The smaller number of species found in the northern Tyrrhenian Sea in comparison with the number taken in the Catalan Sea is attributable to the different sampling gears used. Cruises carried out in the Catalan Sea used, for example, plankton nets that allowed specimens of small size, such as paralarvae of *Galiteuthis armata* and *Teuthowenia megalops*, to be captured. Most of the species not reported here belong to the Mediterranean pelagic teuthofauna and as such are rarely caught by otter trawl.

Most of the cephalopod species found in the Mediterranean Sea also inhabit the eastern Atlantic. The exceptions are some of the endemic sepiolids. However, *Eledone moschata* and *Octopus salutii*, long considered endemic species in the Mediterranean Sea, have also been found in the Atlantic,

Table II: Mean abundance by depth of capture of the most abundant cephalopods caught in the Catalan and northern Tyrrhenian seas

Species	Mean abundance (number·h ⁻¹)				
	0–50 m	50–100 m	100–200 m	200–350 m	>350 m
<i>Catalan Sea</i>					
<i>Alloteuthis media</i>	82.7	33.0	45.7		
<i>Alloteuthis subulata</i>	14.7	1.0			
<i>Loligo vulgaris</i>	98.4	280.6	70.0		
<i>Illex coindetii</i>	4.1	9.1	45.5	1.3	
<i>Todarodes sagittatus</i>					2.0
<i>Todaropsis eblanae</i>			45.0	17.3	0.7
<i>Eledone cirrhosa</i>	0.5	18.3	21.9	4.1	0.6
<i>Eledone moschata</i>	6.5	6.9	0.5		
<i>Octopus salutii</i>	8.2	2.3		5.3	
<i>Octopus vulgaris</i>	12.1	3.1	1.0		
<i>Pteroctopus tetracirrhus</i>				7.2	2.6
<i>Scaevargus unicolor</i>			<0.05		
<i>Sepia elegans</i>	20.4	23.2	1.0		
<i>Sepia officinalis</i>	6.9				
<i>Sepia orbignyana</i>	2.2		6.0	1.8	
<i>Neorossia caroli</i>			<0.05		
<i>Rossia macrosoma</i>				5.8	
Other Sepiolidae	12.7	20.7	1.5	4.8	3.9
<i>Northern Tyrrhenian Sea</i>					
<i>Alloteuthis spp.</i>	8.1	41.9	69.5	2.0	
<i>Loligo forbesi</i>			11.2	4.8	0.1
<i>Loligo vulgaris</i>	21.5	10.4	0.1	0.1	
<i>Illex coindetii</i>	1.3	13.5	51.0	12.1	1.0
<i>Todarodes sagittatus</i>				0.2	0.1
<i>Todaropsis eblanae</i>		0.1	9.4	32.9	7.3
<i>Eledone cirrhosa</i>	4.5	32.1	35.4	17.8	2.4
<i>Eledone moschata</i>	2.8	1.9	0.1		
<i>Octopus salutii</i>		0.1	2.3	5.7	1.3
<i>Octopus vulgaris</i>	15.6	1.4	0.4		
<i>Pteroctopus tetracirrhus</i>			0.2	0.6	0.5
<i>Scaevargus unicolor</i>		0.1	2.8	1.8	0.2
<i>Sepia elegans</i>	0.5	9.8	1.8	2.3	
<i>Sepia officinalis</i>	11.8				
<i>Sepia orbignyana</i>		1.3	12.3	6.1	0.1
<i>Neorossia caroli</i>			0.3	0.1	1.6
<i>Rossia macrosoma</i>			2.2	5.6	0.8
<i>Rondeletiola minor</i>		0.1	0.4	3.1	0.4
<i>Sepietta oweniana</i>		2.9	4.7	37.9	72.9
Other Sepiolidae	0.1	0.6	0.1		

respectively by Guerra (1982) and Sousa Reis *et al.* (1984), and by Mangold-Wirz *et al.* (1976). The opposite is true of *Stoloteuthis leucoptera*. Only very recently was it recorded for the first time in the Mediterranean (Orsi Relini and Massi 1991). They reported it in the Ligurian Sea, so the records herein in the Catalan and northern Tyrrhenian seas are the first for either area. However, it is probably a species widely distributed throughout the whole western Mediterranean.

There were few notable differences in the patterns

of bathymetric distribution of different species between the two areas. However, it was possible to identify three spatial distribution patterns: species with a wide bathymetric range, from shallow waters to deep (e.g. *E. cirrhosa*, *I. coindetii* and *S. oweniana*), species distributed on the bottom between the shore and 150 m (e.g. *S. orbignyana*), and species that inhabit deeper waters of the continental slope (e.g. *O. salutii*, *N. caroli* and *P. tetracirrhus*). In each of these three spatially distinct groupings are representatives of all four of the systematic groups Octopodidae,

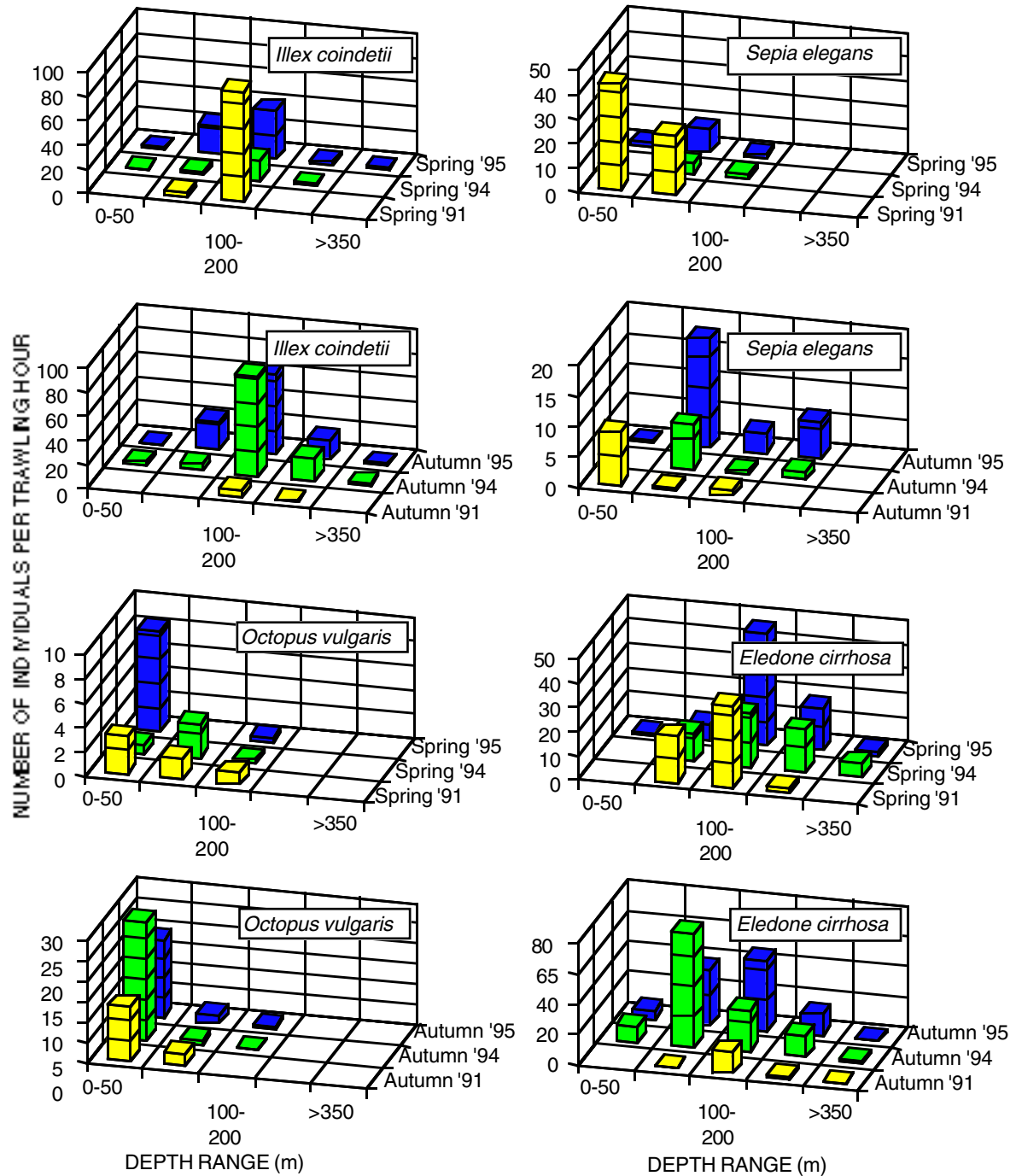


Fig. 2: Seasonal bathymetric distribution of *Illex coindetii*, *Octopus vulgaris*, *Sepia elegans* and *Eledone cirrhosa* in the Catalan Sea (spring and autumn 1991) and the northern Tyrrhenian Sea (spring and autumn 1994–1995)

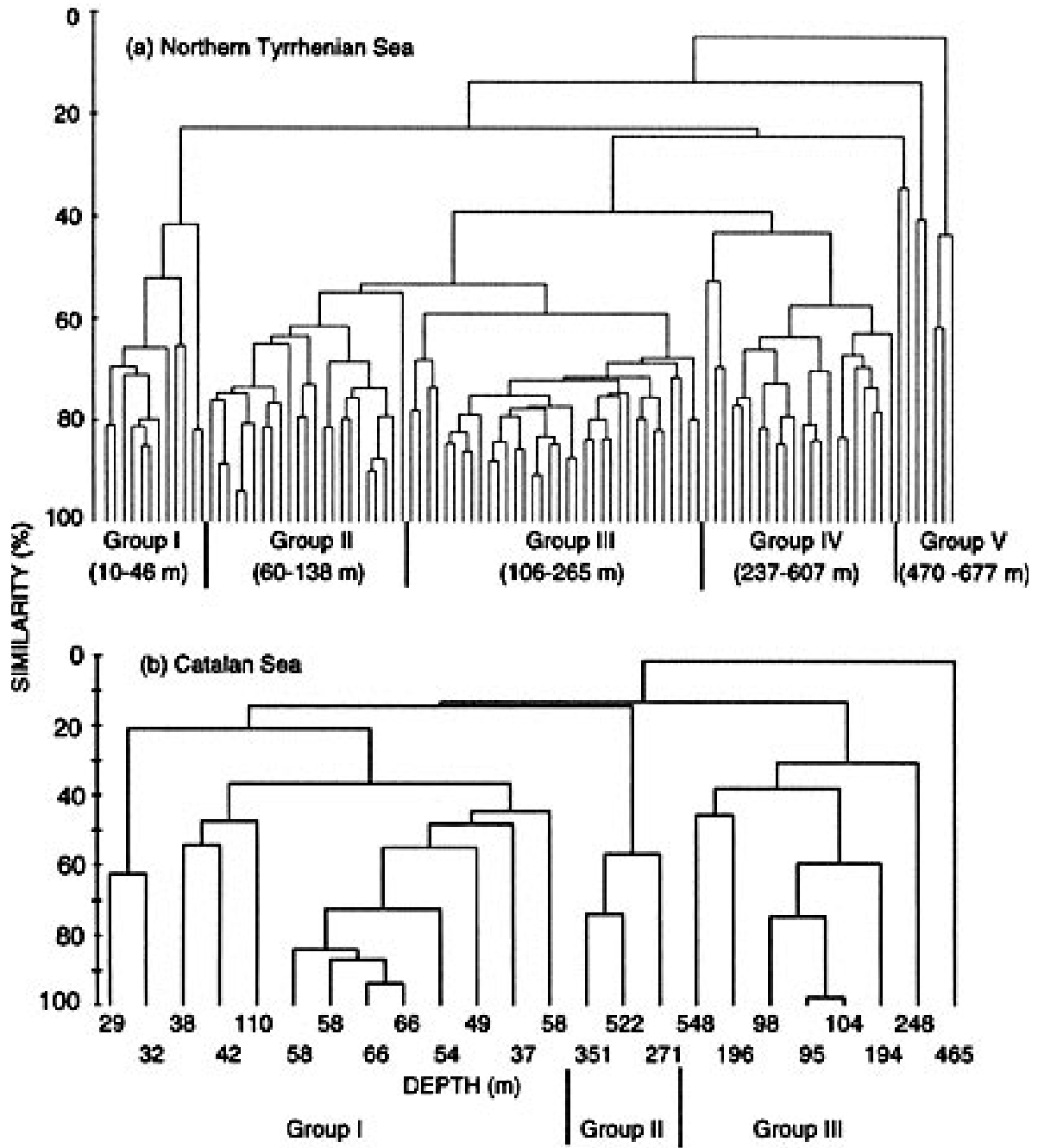


Fig. 3: Dendrograms showing similarities between hauls based on the composition and abundance of cephalopod species in (a) the northern Tyrrhenian and (b) the Catalan seas

Table III: Number of species, catch rates and the most abundant species of the cluster groups

Group and depth range	Number of species	Number per hour	SD	Five most abundant species
<i>Catalan Sea</i>				
I (21–66 m)	12	158.9	126.5	<i>L. vulgaris</i> (28.4%) <i>S. elegans</i> (23.0%) <i>Alloteuthis</i> spp. (17.9%) <i>E. cirrhosa</i> (8.2%) <i>E. moschata</i> (5.7%)
II (271–522 m)	5	21.3	12.2	Sepiolidae (43.7%) <i>P. tetracirrhus</i> (31.2%) <i>O. salutii</i> (12.5%) <i>E. cirrhosa</i> (6.3%) <i>T. sagittatus</i> (6.3%)
III (95–548 m)	16	219.7	118.6	<i>E. cirrhosa</i> (58.4%) <i>T. eblanae</i> (28.3%) <i>E. moschata</i> (3.2%) <i>O. salutii</i> (3.2%) <i>R. macrosoma</i> (3.2%)
<i>Northern Tyrrhenian Sea</i>				
I (10–46 m)	9	63.9	50.7	<i>L. vulgaris</i> (33.6%) <i>O. vulgaris</i> (22.4%) <i>S. officinalis</i> (16.9%) <i>Alloteuthis</i> spp. (12.6%) <i>E. cirrhosa</i> (7.0%)
II (60–138 m)	20	104.4	70.1	<i>Alloteuthis</i> spp. (32.1%) <i>E. cirrhosa</i> (26.8%) <i>I. coindetii</i> (15.8%) <i>S. elegans</i> (7.6%) <i>L. vulgaris</i> (7.5%)
III (106–320 m)	16	219.7	118.6	<i>Alloteuthis</i> spp. (32.9%) <i>I. coindetii</i> (20.4%) <i>E. cirrhosa</i> (12.9%) <i>L. forbesi</i> (9.8%) <i>T. eblanae</i> (8.4%)
IV (236–607 m)	17	106.2	78.4	<i>S. oweniana</i> (70.3%) <i>T. eblanae</i> (12.2%) <i>E. cirrhosa</i> (12.9%) <i>R. macrosoma</i> (2.9%) <i>O. salutii</i> (1.7%)
V (460–677 m)	11	5.3	2.7	<i>N. caroli</i> (21.6%) <i>S. oweniana</i> (21.6%) <i>T. eblanae</i> (16.2%) <i>H. reversa</i> (8.1%) <i>T. sagittatus</i> (8.1%)

Sepiidae, Ommastrephidae and Sepiolidae, indicative of spatial distinction between confamilial species, so reducing competition. In addition, the different distribution patterns of the various species are reflected by different faunistic associations that again follow the bathymetry.

The different seasonal abundances found in the

bathymetric distributions of some of the species could be due to differences in the spawning and/or recruitment periods for each species. For example, the most important recruitment peak of *I. coindetii* has been recorded in spring in the Catalan Sea (Sánchez 1986), but in late summer-early autumn in the northern Tyrrhenian Sea (Belcari 1996).

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