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Cephalopod Species Captured by Deep-water Exploratory Trawling in the Eastern Ionian Sea

by

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Abstract

The intensive exploitation of the continental shelf has lead to a search of new fisheries resources in deeper waters. Four seasonal experimental surveys were carried out on the deep-waters of the Eastern Ionian Sea by Greek and Italian commercial trawlers from September 1999 to September 2000.Potential targets included deepwater species of fishes, shrimps and cephalopods.

During the 4 cruises, a total of 26 species of cephalopods in 10 families were recorded, including 10 oegopsid squids, 3 myopsid squids, 5 octopods, 2 cuttlefishes and 6 sepiolids. Deep-water trawling resulted in the finding of some uncommon species such as *Ancistroteuthis lichtensteini, Ctenopteryx sicula* and *Galiteuthis armata,* which were recorded for the first time in the study area. Extensions of depth range were recorded for several species.

The results of multivariate analyses, based on Bray-Curtis similarity indices, showed the presence of two clear associations: one consisting of hauls carried out at depths 300-550 m, where *Sepietta oweniana, Todaropsis eblanae* and *Loligo forbesi* are the most abundant species, and another with deeper hauls (up to 770 m depth) dominated by *Neorossia caroli, Pteroctopus tetracirrhus* and *Todarodes sagittatus.*

The number of cephalopod species and the hourly yield was decreasing with depth and varied with season. The highest value of the mean cephalopod catch per hour (6 kg/h) was observed at the depth zone 300-550 m in September 1999, resulting also higher percentage (4.6 %) of cephalopods in the total catch. Between the cephalopod species collected *Loligo forbesi* and Ommastrephid squids (*Todaropsis eblanae, Todarodes sagittatus* and *Illex coindetii*) are those with the greatest commercial interest.

Keywords: cephalopods, Mediterranean Sea, exploratory surveys.

Introduction

The Ionian Sea is a deep-water basin in the Central Mediterranean Sea. Fleets of two countries, Italy and Greece, are exploiting fishery resources in this area. Commercial trawling in the eastern Ionian Sea was limited till recently on the continental shelf. In 1996, in the framework of a FAIR project for the investigation of fisheries resources in the deeper waters of the south-eastern Ionian, red prawns namely *Aristomorpha foliacea* and *Aristeus antennatus* were found in commercial quantities (Petrakis, 1998). Following to this two interregional projects, INTERREG II and RESHIO, were undertaken in 1999 and 2000 respectively, to assess the extension of the resources of red prawns, as well as, of some commercial fish and cephalopod species on a wider area of the eastern Ionian slope.

In the present study, the faunal composition, abundance and bathymetric distribution of the cephalopods collected in a depth range extending from 300 to 1200 m depth in the eastern Ionian Sea are described.

Materials and Methods

The data analysed here came from four trawl surveys carried out on the slope of the north-eastern Ionian Sea (N: 39° 54'-37°57', E: 19°18'-20°45') in September 1999, April, July and September 2000, and one survey on the south-eastern Ionian slope (N: 37°56'-36°28, E: 20°30'-22°22') in September 2000. A total of 223 hauls lasting 1 hour were performed during daytime. The sampling was based on random-stratified design. The bottom area investigated was subdivided into four depth strata: 300-500, 500-700, 700-900 and 900-1200 m (Fig. 1). The mesh size at the cod end was 20 mm (from knot to knot) in both trawl nets used by Greek and Italian commercial trawlers hired for these surveys.

Cephalopod species were identified according to Mangold and Boletzky (1987) key for the Mediterranean. Numbers of individuals and total weight by species were recorded on board together with the haul data (date, location, duration, depth). Specimens mantle length was measured to the nearest mm.

To detect zonation patterns, were considered the data of the surveys of September 2000, during which the whole study area was covered. 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 by the PRIMER software. Subsequently the similarity matrices were subjected to both clustering (employing group-average linking) and ordination (employing non-metric multidimensional scaling, MDS). The results of the cluster analysis were displayed in the form of dendrogram and those of MDS as two-dimensional map of stations in different depth zones. Species that appeared only once in these surveys were omitted from the analysis, as well as, hauls in which only one cephalopod species was found. The SIMPER routine was applied to establish the indicator species for the groups resulting from the cluster analysis and the ones, which contribute most to the dissimilarity of the groups. All posterior analyses were made considering the groups resulting from the cluster analysis.

To assess commercial potential of cephalopods, the mean cephalopod catch per hour and its percentage contribution to the total catch, as well as, the mean CPUE (g/h) by species were calculated per depth zone and survey.

Results

Cephalopod fauna and assemblages

A total of 26 species of cephalopods were identified, 25 for the northeastern and 21 for the south-eastern Ionian slope (Table I). Remains of female shells of Argonauta argo were also recorded, but since no entire individuals were caught, the species is not taken into account in this study. The most common cephalopod caught was *Sepietta oweniana*, followed by *Todaropsis eblanae, Loligo forbesi* and *Illex coindetii.* The pelagic squids *Ctenopteryx sicula, Galiteuthis armata* and two species usually inhabiting shallower waters, *Octopus vulgaris* and *Loligo vulgaris* were collected only in one occasion.

The dendogram of similarities (Fig. 2a) revealed the existence of two main groups: one related with the shallower stratum 300-500 m and another with hauls carried out in depths from 540 to 770 m. The results of the ordination (MDS) agree with the above pattern (Fig. 2b). Although some species were present in both groups, species composition and catch rates characterised to some extent the different faunal assemblages and distinguished them from each other. In the first group *Sepietta oweniana, Todaropsis eblanae, Loligo forbesi, Pteroctopus tetracirrhus* and *Illex coindetii* were the most abundant species contributing 93% of the similarity within the group. In the deeper hauls catches were dominated by *Neorossia caroli, Pteroctopus tetracirrhus* and *Todarodes sagittatus*, which contributed the 84% of similarity according to the SIMPER analysis.

Catch composition and commercial potential

Cephalopods were present in 150 (68 stations) of the total of 223 valid hauls (101 stations). The number of cephalopod species was decreasing with depth; 21, 17 and 7 species were recorded respectively at the depth zones 300-550, 550-800 and >800 m.

In waters deeper than 800 m a very low number of individuals was generally fished, the total cephalopod catch per hour not exceeding 0.1 kg at any season (Table II) The highest values of the mean cephalopod catch per hour were observed at the depth zone 300-550 m in September, resulting also higher percentages of cephalopods in the total catch.

With respect to the specific composition of the catch of cephalopods, it varied considerably both in relation to depth and in relation to season. Most of the species frequently caught (f>5 % of hauls) showed higher CPUE (g/h) values in the shallower depth zone and only *Todarodes sagittatus* and *Neorossia caroli* were caught most frequently and in greater quantities in the zone 550-800 (Table III). *Loligo forbesi* dominated the cephalopod catches in the depth zone 300-550m during summer and autumn cruises, when it also appeared among the 3 most abundant species in deeper waters. In April 2000 the highest percentage of catches in both depth zones was represented by *Pteroctopus tetracirrhus.* The ommastrephid squids *Illex coindetii* and *Todaropsis eblanae* were among the 4 most abundant species in hauls between 300 and 550 m in September of both years.

Discussion

A total of 32 cephalopod species have been known from the eastern Ionian Sea, including Atlanto-Mediterranean species and some cosmopolitan ones (Degner, 1926; Kaspiris and Tsiambaos, 1984, 1986; Sifner *et al.,* in preparation). Among the 26 cephalopod species caught some uncommon species such as *Ancistroteuthis lichtensteini, Ctenopteryx sicula* and *Galiteuthis armata* were recorded for the first time in the eastern Ionian Sea, extending the cephalopod fauna of this area to 35 species. Other species which are known to inhabit slope in the central Mediterranean Sea, such as *Abralia pfefferi, Ancistrocheirus lesueurii, Bathypolypous sponsalis, Brachioteuthis riisei, Chiroteuthis veranyi, Pyroteuthis margaritifera , Octopoteuthis sicula* (Degner, 1926; Kaspiris and Tsiambaos, 1984, 1986; Jereb and Ragonese, 1994; D'Onghia G. *et al.*, 1995,1997, 1998; Maiorano *et al*., 1999) were absent from the catches. Most of these species, with the exception of *B. sponsalis* which has been never found in the Ionian Sea (D'Onghia G. *et al.,* 1993), are mesopelagic and their capture seems to be favored by the use of trawl nets with a wide horizontal and vertical opening as shown during comparative trawling in the western Ionian Sea (Maiorano *et al*., 1999).

Deep-water trawling contributed to substantial extensions of depth ranges in two loliginid squids (*L. vulgaris, L. forbesi)* two octopod species (*O. vulgaris, P. tetracirrhus*) and two sepiolids (*S. ligulata, R.minor*) (Table I).

The separation of species assemblages by the depth gradient in the study area, is similar to that found in other areas of the Mediterranean Sea. The highest abundance levels of *Sepietta oweniana, Todaropsis eblanae, Loligo forbesi, Pteroctopus tetracirrhus* and *Illex coindetii* have been usually recorded near to the shelf break area (Mangold-Wirtz, 1963; Lumare, 1970; D'Onghia G. *et al.,* 1996; Sanchez *et al.,* 1998;). *Neorossia caroli* is a typical bathybenthic species in the Mediterranean relatively more abundant at depths greater than 400 m (Mangold-Wirtz, 1963; Lumare, 1970; Villanueva, 1992; D'Onghia G. *et al.,* 1993;), found on muddy bottoms together with *Todarodes sagittatus, Pteroctopus tetracirrhus* and *Bathypolypous sponsalis*. *Todarodes sagittatus* is a species characterized by broad vertical distribution occurring in coastal bank areas of 80-200 m depth (Wiborg and Gjøsæter, 1981) up to 1947 m (Moiseev, 1991). In the Mediterranean it has been found from 100 to 800 m and the greatest frequency of individuals appeared deeper than 400 m (Mangold-Wirtz, 1963; Quetglas, 1998).

Cephalopods represented, on average, 2.6% of the total catch during all surveys carried out from September 1999 to September 2000 on the eastern Ionian slope. The highest hourly yields, though with high variability, were obtained at depths of 300-550 m. Considering the quantity of the species in hauls, edibility and the existence of a market for the species in Europe, about 90% of cephalopod catch fished up to 800 m of depth is commercial. *Loligo forbesi* and Ommastrephid squids (*Todaropsis eblanae, Todarodes sagittatus* and *Illex coindetii*) compose the

greatest part (~ 80 %) of cephalopod catch, whereas, the rest 10% consists of sepiolids, small sized cuttlefishes and octopod (Fig. 3) of lower commercial value. The octopod *P. tetracirrhus* although is quite frequent in the catches has no interest for human consumption due to its gelatinous flesh.

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TABLE I. Cephalopod species collected on the eastern Ionian slope, size distribution (No = number of individuals, SD = standard deviation), depth ranges in the study area and deepest records of the species in other areas

Family	Species	No	Mantle length (mm)			Area		Trawl	Deepest records	
			Range	Mean	SD	NE Ionian	SE Ionian	Depth (m)	Depth	Source
Cranchiidae	*Galiteuthis armata*	1	232			+		1015	2208	Villanueva (1992)
Ctenopterygidae	*Ctenopteryx sicula*	1	66			+		956	1099	Villanueva (1992)
Enoploteuthidae	*Abralia veranyi*	11	32-45	37	3.6	+	+	339-614	750	Mangold-Wirtz (1973)]
Histioteuthidae	*Histioteuthis bonnellii*	3	34-128	77	38.7	+	+	610-779	2000	Mangold &Boletzky (1987)
	Histioteuthis reversa	5	47-75	57	9.5	+	+	655-813	1766	Villanueva (1992)
Loliginidae	*Alloteuthis media*	7				+		308-354	400	D' Onghia et al. (1996)
	Loligo forbesi	264	37-400	176	80.7	+	+	276-685	400	Mangold &Boletzky (1987)
	Loligo vulgaris	1	110				+	529	550	Mangold-Wirtz (1963)
Ommastrephidae	*Illex coindetii*	263	36-226	140	43.4	+	+	276-618	750	Mangold-Wirtz (1973)]
	Todarodes sagittatus	49	174-345	259	46	+	+	308-771	1000	Mangold-Wirtz (1963)
	Todaropsis eblanae	386	26-165	79	30.3	+	+	308-780	700	Roper et al. (1984)
Onychoteuthidae	*Ancistroteuthis lichtensteini*	3	66-130	104	27.6	+		308-896	1271	Villanueva (1992)
	Onychoteuthis banksi	2	76-94	85	9	+	+	553-764	1116	Mangold-Wirtz (1973)]
Octopodidae	*Eledone cirrhosa*	6	20-91	55	22.3	+	+	308-580	770	Massy (1928)
	Octopus salutii	3	26-52	33	10.8	+	+	317-623	800	Sanchez (1986)
	Octopus vulgaris	1	90			+		566	400	Mangold-Wirtz (1963)
	Pteroctopus tetracirrhus	72	31-125	61	26.7	+	+	276-843	750	Mangold-Wirtz (1963)
	Scaeurgus unicirrhus	55	14-85	43	12.4	+	+	308-780	800	Mangold &Boletzky (1987)
Sepiidae	*Sepia elegans*	134	23-55	39	5.5	+	+	276-463	450	Mangold &Boletzky (1987)
	Sepia orbignyana	106	23-82	58	10.4	+	+	276-479	450	Mangold &Boletzky (1987)
Sepiolidae	*Heteroteuthis dispar*	7	8-18	14	3.9	+	+	313-896	1588	Villanueva (1992)
	Neorossia caroli	170	17-64	30	8.5	+	+	463-778	1750	Guerra (1992)
	Rondeletiola minor	168	11-20	17	2.3	+	+	308-862	670	Bello (1985)
	Rossia macrosoma	99	25-61	42	10.6	+	+	308-611	600	Roper et al. (1984)
	Sepietta oweniana	1290	14-52	23	4.1	+	+	276-771	974	Villanueva (1992)
	Sepiola ligulata	22	13-16	14	1	+	+	308-390	200	Guerra (1992)

TABLE II Cephalopods frequency of occurrence (f%), average catch per unit of fishing effort (kg/h) and percentage contribution in the total catch per depth zone and survey during exploratory trawling on the eastern Ionian slope.

Survey	Depth	Number of hauls	Cephalopods f	kg/h	%
September 1999	300-550	22	100	5.9	5
	550-800	4	75	1.9	3
	>800	6	50	<0.05	0
April 2000	300-550	21	86	1.7	3
	550-800	23	30	0.1	1
	>800	6	0		
July 2000	300-550	9	89	2.4	2
	550-800	22	59	0.2	1
	>800	4	25	<0.05	<0.1
September 2000	300-550	30	100	2.7	3
	550-800	58	71	0.5	1
	>800	18	17	<0.05	<0.1

TABLE III. Frequency of occurrence (*f%*), average catch per unit effort (*g/h*) and percentage of total cephalopod catch (*W%*) for the most abundant species (f>5%) caught at the depth strata 300-500 m and 500-700 m per trawl survey in the eastern Ionian slope. The species are arranged in bathymetric order.

Species	September 1999						April 2000					
	300-550			550-800			300-550			550-800		
	f%	*g/h*	*W%*	*f%*	*g/h*	*W%*	*f%*	*g/h*	*W%*	*f%*	*g/h*	*W%*
Sepia orbignyana	27	36	1				38	74	4			
Sepia elegans	55	51	1				43	24	1			
Eledone cirrhosa	5	3	<0.5				5	10	1			
Illex coindetii	95	1536	26	50	125	6	24	110	6			
Loligo forbesi	82	2961	50	25	650	33	48	432	25			
Sepietta oweniana	86	147	3	25	10	1	76	117	7			
Rossia macrosoma	32	43	1	50	138	7	29	39	2	4	1	1
Rondeletiola minor	18	1	<0.5				38	19	1			
Scaeurgus unicirrhus	59	98	2				19	32	2	9	13	11
Todaropsis eblanae	91	933	16	25	90	5	71	399	23	4	5	4
Pteroctopus tetracirrhus	27	25	<0.5	25	11	1	57	440	25	17	83	69
Todarodes sagittatus	5	27	<0.5	50	922	47						
Abralia veranyi							14	1	<0.5	4	<0.5	0
Neorossia caroli	9	4	<0.5				10	25	1	9	17	15

Species	July 2000						September 2000					
	300-550			550-800			300-550			550-800		
	f%	*g/h*	*W%*	*f%*	*g/h*	*W%*	*f%*	*g/h*	*W%*	*f%*	*g/h*	*W%*
Sepia orbignyana	22	33	1				40	121	5			
Sepia elegans	33	44	2				7	2	<0.5			
Eledone cirrhosa	11	13	1				3	7	<0.5	2	<0.5	<0.5
Illex coindetii	11	3	<0.5				33	361	14	9	36	7
Loligo forbesi	33	1044	43	5	41	16	43	1242	47	14	129	26
Sepietta oweniana	67	154	6	9	1	<0.5	77	129	5	16	1	<0.5
Rossia macrosoma	22	73	3				23	49	2	14	8	2
Rondeletiola minor	22	21	1				7	3	<0.5			
Scaeurgus unicirrhus	33	10	<0.5				13	4	<0.5			
Todaropsis eblanae	11	33	1				67	309	12	5	6	1
Pteroctopus tetracirrhus	44	567	24	9	11	4	40	42	2	24	8	2
Todarodes sagittatus	22	389	16	18	149	60	13	370	14	28	262	52
Abralia veranyi				23	1	1	3	<0.5	<0.5	2	<0.5	<0.5
Neorossia caroli	22	1	<0.5	32	43	17				36	25	5

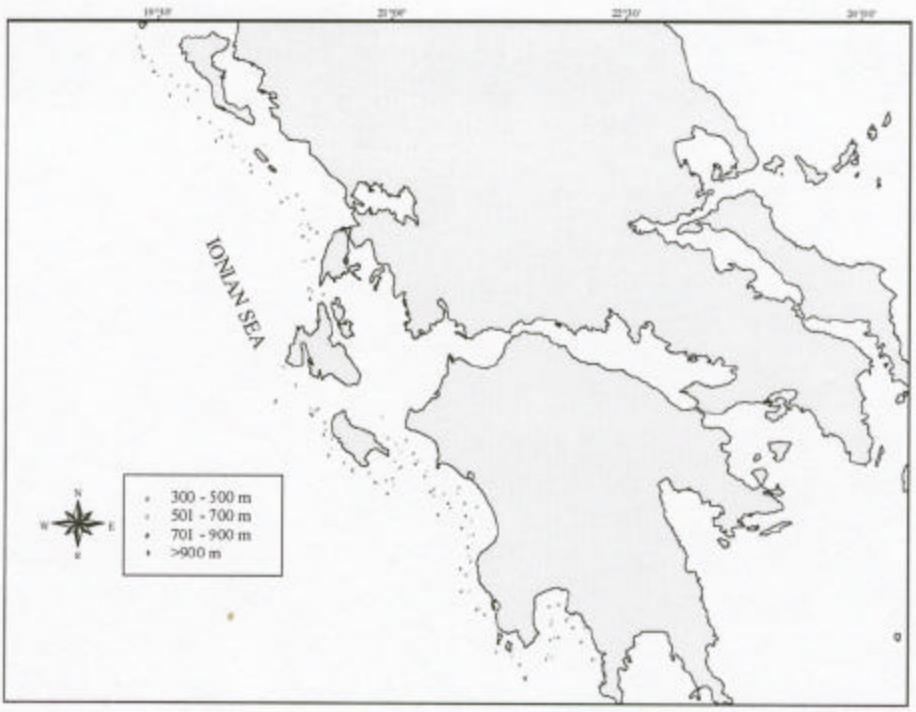

Figure 1. Map of the eastern Ionian Sea (central Mediterranean) showing the location of the sampling stations by depth zone, during the surveys of INTERREG and RESHIO carried out from September 1999 to September 2000.

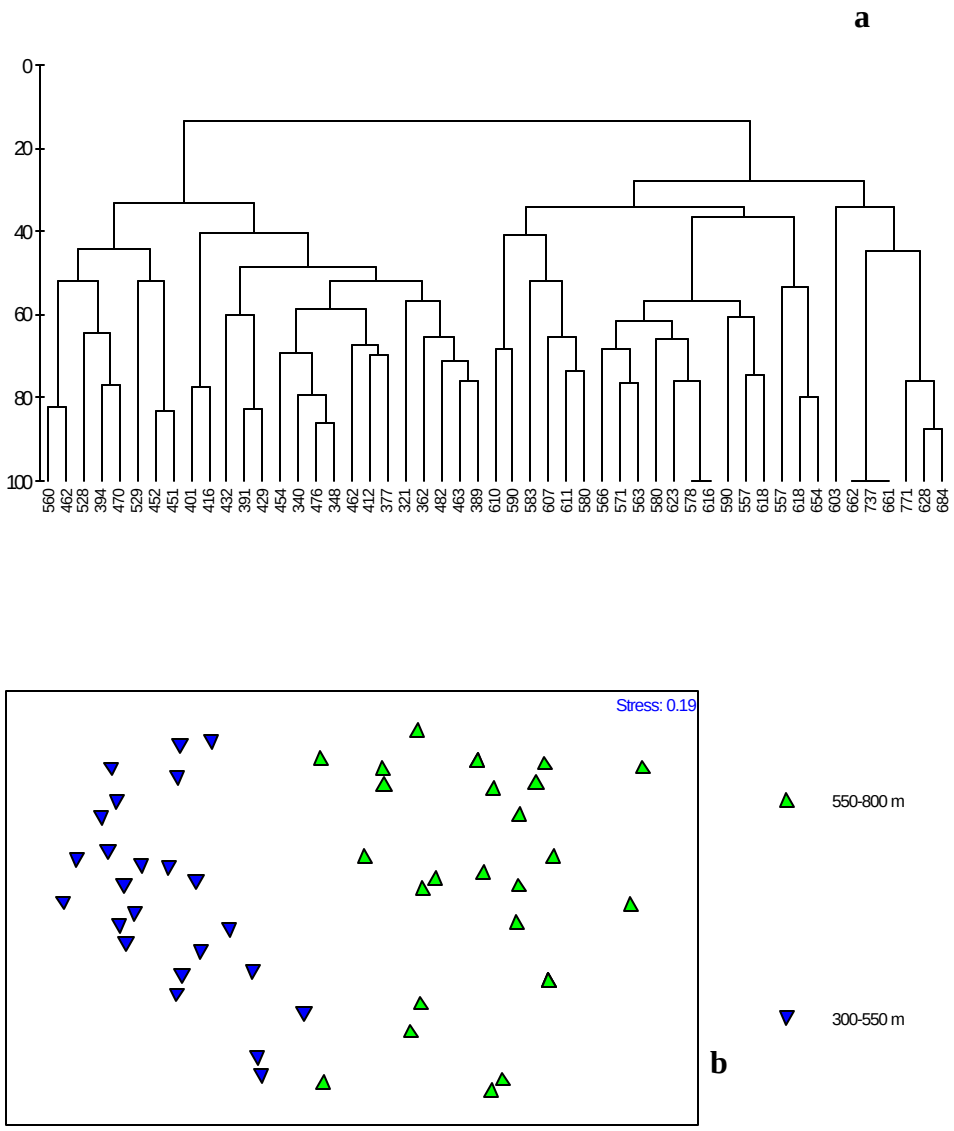

Figure 2. (a) Clustering dendrogram and (b) multidimensional scaling (MDS) ordination, of the hauls performed during the survey of September 2000 on the slope of the Eastern Ionian Sea, using group-average linking of Bray-Curtis similarities calculated on log (x+1) transformed numbers of individuals of cephalopod species per fishing hour.

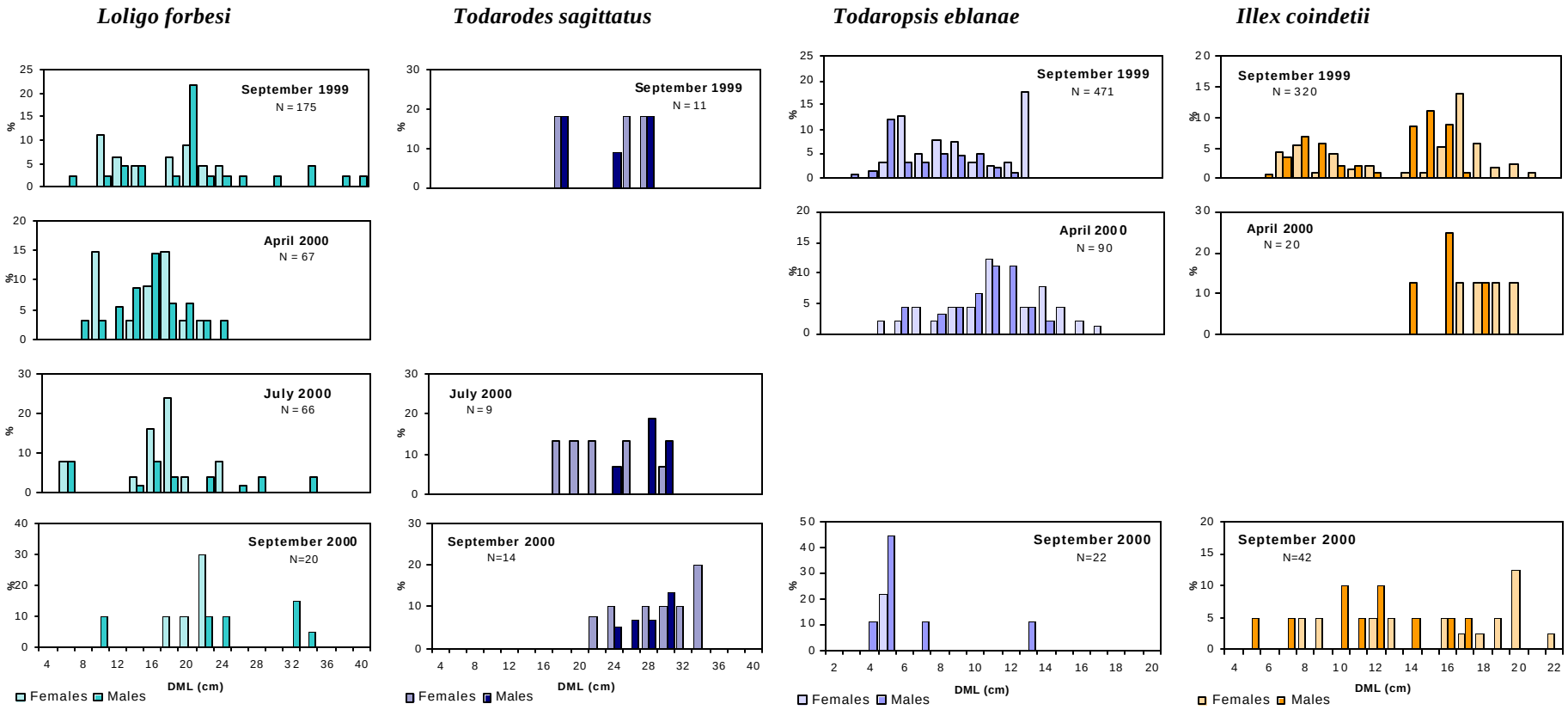

Figure 3. Length composition of *L. forbesi, T. sagitatus, T.eblanae and I. coindetii* on the north-eastern Ionian slope during the four surveys of the INTERREG project.