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CEPHALOPOD REMAINS IN THE DIET OF STRIPED DOLPHINS (*STENELLA COERULEOALBA*) AND RISSO'S DOLPHINS (*GRAMPUS GRISEUS*) IN THE EASTERN MEDITERRANEAN SEA

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CEPHALOPODA
STOMACH CONTENT
EASTERN MEDITERRANEAN

ABSTRACT. – Cephalopod remains from the stomachs of three striped dolphins (*Stenella coeruleoalba*) and two Risso's dolphins (*Grampus griseus*) taken as bycatch in the swordfish fishing in the eastern Mediterranean Sea off Turkish coast were examined. Totally 478 lower beaks were identified as belonging to 14 cephalopod species. For the striped dolphins, *Abralia veranyi* was the most common prey (51.2% of all the beaks found in this species), followed by *Onychoteuthis banksii* and *Heteroteuthis dispar*. For the Risso's dolphins, *Histioteuthis reversa* was the most common species (60.9%) and all the other species shared less than 10% of all the beaks found. In the stomachs of the striped dolphins, there were remains of some fish and shrimps, while only cephalopod remains were detected in those of the Risso's dolphins. Most prey species were oceanic cephalopods, with wide vertical distribution and diurnal movement. Many of the cephalopods identified in the diet of these dolphins are bioluminescent suggesting that these dolphins use bioluminescence as a target when feeding on cephalopods.

INTRODUCTION

Striped dolphin (*Stenella coeruleoalba*) and Risso's dolphin (*Grampus griseus*) are widely distributed in temperate to tropical seas throughout the world (Jefferson *et al.* 1993) and are common also in the Mediterranean Sea (Duguy & Robineau 1982, Notarbartolo & Demma 1994). In the Turkish coastal waters in the Aegean and generally in the Mediterranean Sea, there is little information on the distribution and ecology of these species (Jefferson *et al.* 1993), except Öztürk (1996), who mentioned that both striped and Risso's dolphins live offshore. Although cetaceans are under legal protection in Turkey since 1983, they are under threat of being a by-catch in various fishing gears, such as driftnets and bottom set gillnets used in the whole Mediterranean basin (Di Natale & Nortarbartolo 1994, UNEP 1998). The two species had been incidentally caught in the swordfish driftnet fisheries in the Aegean and Mediterranean part of Turkey (Öztürk 1996, Öztürk & Öztürk 1998, Öztürk *et al.* 2001). Currently this fishery is banned in Turkish waters.

There have been some studies on the diet of the striped dolphin and Risso's dolphin in the western and central Mediterranean Sea (Würtz *et al.* 1992, Würtz & Marrale 1993, Bello 1993, Blanco *et al.* 1995, Alessandri *et al.* 2001). However, information on the diet of these species is scarce in the eastern part of the Mediterranean Sea. The conservation of these dolphins can be enhanced by knowledge on their prey species and their availability.

The aim of this study is to identify the cephalopod components of the diets of the striped and Risso's dolphins in the Turkish coastal waters of the eastern Mediterranean Sea. In addition, we also anticipate to obtain a better picture of the cephalopod assemblages in the eastern Mediterranean Sea based on the diet of those dolphins.

MATERIAL AND METHODS

The samples were collected in the Turkish coast of the eastern Mediterranean Sea, between Marmaris and Fethiye (Fig. 1), in May and June 1999-2000. Three striped dolphins and two Risso's dolphins accidentally entangled in the swordfish driftnets were examined (Table I). The distance from the coast to the area where those dolphins were entangled in the nets was 5 to 9

No.	Date	Location	Depth (m)	Species	Sex	Length (cm)
1	10 May 1999	Off Iblis Cape	1400	Striped dolphin	♂	103
2	11 May 1999	Off Ölüdeniz	1000	Striped dolphin	♀	140
3	10 June 1999	Off Iblis Cape	1500	Striped dolphin	♂	173
4	16 June 1999	Off Yediburunla	1000	Risso's dolphin	♀	300
5	28 May 2000	Off Iblis Cape	1400	Risso's dolphin	♂	250

Table I. – Cetacean samples examined in this study.

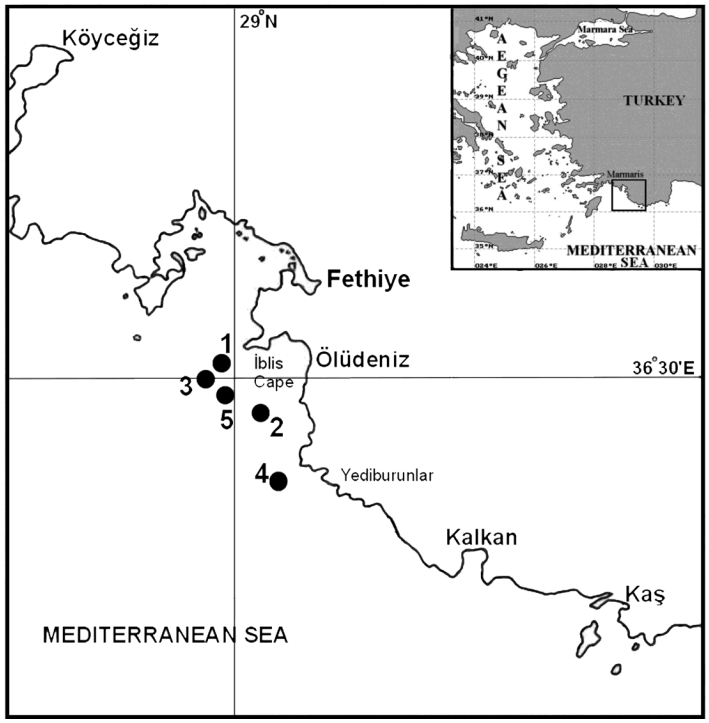

Fig. 1. – Sampling area in the eastern Mediterranean Sea. Numbers indicate the specimens listed in Table I.

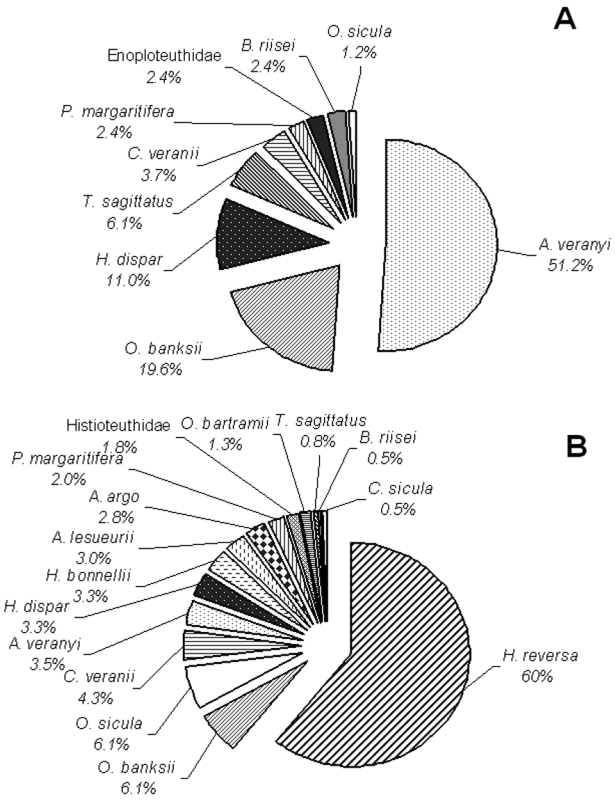

Fig. 2. – Percentage of cephalopod species found in the stomachs (A, Striped dolphins; B, Risso's dolphins).

nmiles. The five animals were caught by the same fishermen with the same driftnet, but on different occasions.

All the animals were measured and the stomachs were removed and stored in a deep-freezer. In the laboratory, the contents of each stomach were collected and flushed through a sieve with mesh size 0.4 mm. Among the stomach contents, beaks of cephalopods were separated for this study and stored in 70% ethanol. The rest of the remains was separated for other analyses.

Identification of cephalopod lower beaks in the stomach contents was carried out according to Clarke (1962, 1986), Mangold & Fioroni (1966), and Wolff (1984). All beaks were then compared to beaks of the personal collection of one of the authors (AS).

For the species belonging to orders Sepiolida and Teuthoida, lower rostral length (LRL) was measured, while for the species of the order Octopoda, hood length (HL) was measured. During specimen identification and measurement, a stereomicroscope (Olympus model SZ-60) with micrometric ocular was used.

RESULTS

In total, 14 cephalopod species were identified from 478 lower beaks in five stomachs of two cetacean species (Table II). In the stomachs of the striped dolphins, there were remains of fish (Sloane's viperfish *Chauliodus sloani*) and shrimp (golden shrimp *Plesionika martia*), while there were cephalopod remains in those of the Risso's dolphins.

Striped dolphins

In the stomachs of the three striped dolphins, there was a total of 82 lower beaks representing seven species (Table II). *Heteroteuthis dispar* and *Abralia veranyi* were

Table II. – Cephalopod beaks of the stomach contents of the striped dolphins and Risso's dolphins (LRL: Lower rostral length; HL: Hood length).

No	Dolphin species	Cephalopod species	N	LRL (mm)	HL (mm)
1	Striped dolphin	*Heteroteuthis dispar*	1	1.25	
		Enoploteuthidae	2	1.35-1.65	
		Abralia veranyi	4	0.80-1.35	
		Chiroteuthis veranii	1	3.50	
		Total	**8**		
2	Striped dolphin	*Heteroteuthis dispar*	6	0.6-0.95	
		Abralia veranyi	18	1.30-1.90	
		Pyroteuthis margaritifera	2	1.00-1.20	
		Octopoteuthis sicula.	1	3.50	
		Onychoteuthis banksii	3	1.15-1.55	
		Brachioteuthis riisei	2	2.10-2.75	
		Chiroteuthis veranii	2	2.25-2.65	
		Total	**34**		
3	Striped dolphin	*Heteroteuthis dispar*	2	1.05-1.10	
		Abralia veranyi	20	0.75-1.55	
		Onychoteuthis banksii	13	1.00-2.40	
		Todarodes sagittatus	5	0.85-1.15	
		Total	**40**		
4	Risso's dolphin	*Heteroteuthis dispar*	6	0.60-0.85	
		Abralia veranyi	2	1.35-1.50	
		Pyroteuthis margaritifera	7	0.75-1.05	
		Octopoteuthis sicula	6	6.80-9.40	
		Histioteuthis bonnellii	3	9.40-0.50	
		Histioteuthis reversa	23	1.25-3.55	
		Chiroteuthis veranii	2	4.50-3.75	
		Total	**49**		
5	Risso's dolphin	*Heteroteuthis dispar*	7	0.90-1.25	
		Abralia veranyi	12	1.10-1.55	
		Ancistrocheirus lesueurii	12	2.60-5.75	
		Pyroteuthis margaritifera	1	2.00	
		Octopoteuthis sicula.	18	2.75-10.0	
		Onychoteuthis banksii	24	2.15-3.25	
		Histioteuthis (Type A)	7	4.00-6.15	
		Histioteuthis bonnellii	10	5.30-9.40	
		Histioteuthis reversa	218	1.20-3.55	
		Chtenopteryx sicula	2	1.15-1.20	
		Brachioteuthis riisei	2	1.50-1.65	
		Todarodes sagittatus	3	2.50-3.50	
		Ommastrephes bartramii	5	3.70-9.80	
		Chiroteuthis veranii	15	1.70-4.80	
		Argonauta argo	11		2.60-6.20
		Total	**347**		
	Total number of beaks		**478**		

found in all three dolphins. When the numerical proportion of each cephalopod prey in all three individuals combined was compared, *A. veranyi* was the most common prey species, comprising about half (51.2%) of all cephalopod beaks recovered (Fig. 2A). This was followed by *Onychoteuthis banksii* (20%) and *H. dispar* (11%), although *O. banksii* was not found in all three dolphins.

For *A. veranyi*, the linear relationship of its mantle length (L) on the length of its lower beak (LRL) is (Salman unpubl data):

L = -2.103 + 24.257 * LRL (mm), (r = 0.88) (n = 24)

Fig. 3 shows the distribution of mantle length of *A. veranyi* thus estimated from the lower beaks found in the stomachs of the striped dolphins. Estimated mantle lengths were in the range of 18-45 mm, with a mode at about 33 mm.

Risso's dolphin

A total of 396 lower beaks representing 14 species were found in the stomachs of the two Risso's dolphins (Table II), among which six species (*H. dispar, A. veranyi*, *Pyroteuthis margaritifera*, *Histioteuthis bonnellii*, *Histioteuthis reversa*, and *Chiroteuthis veranii*) were common in both individuals. *H. reversa* represented 60.9% of all the squid beaks found in the stomachs of two Risso's dolphins (Fig. 2B). Each of the other prey species shared less than 10% of the diet.

For *H. reversa*, the most abundant food item of the Risso's dolphins, we estimated mantle lengths of 241 individuals from their LRL using the equation of Clarke (1986). The mantle length ranged 15-65 mm and had a single mode around 25-40 mm (Fig. 3B).

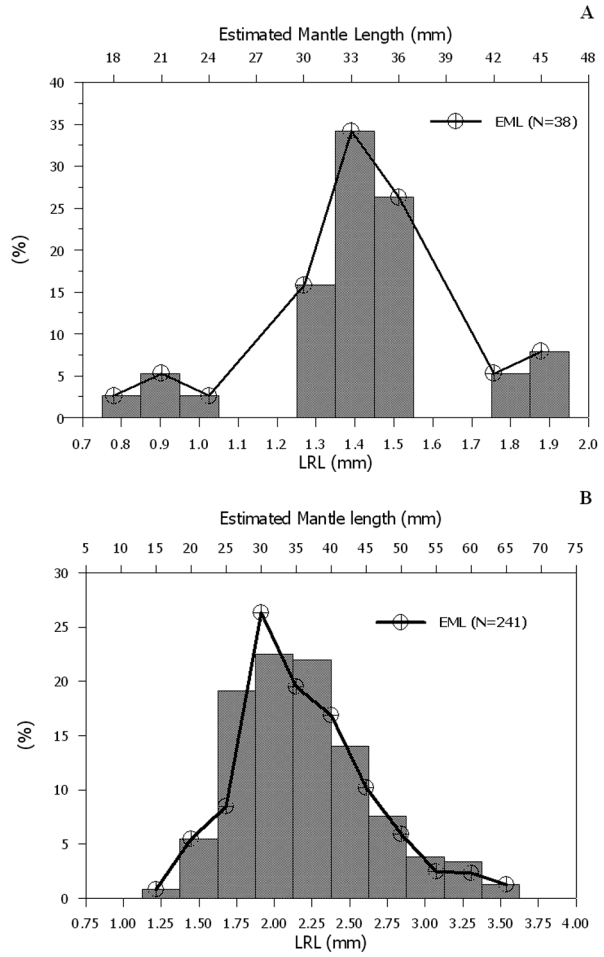

Fig. 3. – Relative distribution of estimated mantle lengths based on LRL, found in the stomachs (A, *Abralia veranyi* from striped dolphin stomach, B, *Histioteuthis reversa* from Risso's dolphin stomach).

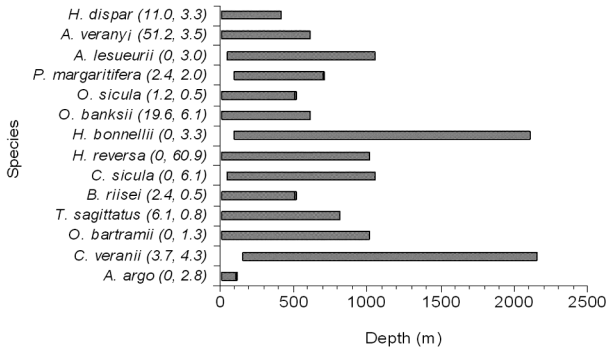

Fig. 4. – Depth distributions of prey cephalopods of the striped and Risso's dolphins. Figures in parentheses are percentages of all cephalopod beaks found in the striped and Risso's dolphins, respectively (see Fig. 2). (Adopted from Mangold & Boletzky 1987 and Guerra A 1992).

DISCUSSION

It is difficult to assume that the caught animals are representative of the population. They could be indicating for animals feeding on commercially important species in areas that fishermen frequently visit (Santos *et al.* 2001). Moreover, our sample size in this study was very limited. We found, however, some new information on the diet of the striped dolphins and Risso's dolphins in the eastern Mediterranean Sea as discussed below. Since the cetaceans in the eastern Mediterranean have been poorly studied, this information can be useful for better understanding their ecology, as well as for cephalopod assemblages.

Most cephalopod species found in the stomach contents of the two cetacean species were totally pelagic, with the exception of epipelagic species, such as *A. argo*. *Heteroteuthis dispar* is usually found near the bottom on sea mounts (Würtz *et al.* 1992). The oceanic character of prey cephalopod habitats has also been reported in previous studies on the diet of the striped dolphin and Risso's dolphin in the Mediterranean Sea (Carlini *et al.* 1992, Würtz *et al.* 1992, Bello 1992, 1993, 1996, Blanco *et al.* 1995, Alessandri *et al.* 2001).

Concerning the diversity of cephalopods in our study area, Salman *et al.* (2002) reported that there are 51 cephalopod species in the eastern Mediterranean Sea. Among them, 14 species (27.5%) were found in the stomachs of dolphins in our study. Both adult and juvenile individuals of the pelagic cephalopods we identified were found rare in the Aegean and eastern Mediterranean Sea (Salman *et al.* 2002, 2003). This implies that the cephalopod assemblage of the eastern Mediterranean is quite diverse, since top predators such as dolphins feed on cephalopods that are not commonly caught with man-made sampling or fishing gears, as previously mentioned by Bello (1996). A reverse situation was mentioned by Santos *et al.* (2001) from the northeastern Atlantic.

Calculated mantle lengths based on LRL measurements for *A. veranyi*, which was the most abundant in the stomachs of our striped dolphins, were consistent with the individuals of this species distributed in the Mediterranean Sea (Mangold & Boletzky 1987, Salman *et al.* 2002). Those for *H. reversa*, which was the most abundant in the stomachs of our Risso's dolphins, were consistent and in the range of normal distribution for this species (Voss 1969, Mangold & Boletzky 1987). This consistency suggests that some of the species found in the stomach contents of cetaceans may well reflect the composition of their mother populations in the region.

We compared the cephalopod species found in our striped dolphins to those reported previously from the Mediterranean Sea (Table III). The cephalopod species in our study mostly overlapped with those in the other parts of the Mediterranean Sea. This implies that the cephalopod species which were found both in our coastal water and in other parts of the Mediterranean, such as *H. dispar*, *A. veranyi*, and *O. banksii*, were distributed throughout the Mediterranean and fed on by striped dolphins. On the other hand, we did not find demersal cephalopods, such as *Sepia officinalis*, *Sepiola* sp., *Sepietta* sp., *Loligo* sp., *Alloteuthis* sp. and *Illex coindetii* as reported by Blanco *et*

Table III. – Cephalopod species found in the diet of the striped dolphins in the Mediterranean Sea.

Species	Carlini *et al*. 1992 Tyrrhenian Sea	Bello 1993 Ionian Sea	Blanco *et al*. 1995 Spanish coast	Alessandri *et al*. 2001 Italian coast	Würtz and Marrale 1993 Ligurian Sea	Present study Eastern Mediterranean
Sepietta sp.			+			
Sepietta oweniana	+				+	
Sepiola sp.			+			
Heteroteuthis sp.			+			
Heteroteuthis dispar	+	+			+	+
Neorossia caroli					+	
Sepia officinalis				+		
Loligo sp.			+			
Loligo forbesi					+	
Loligo vulgaris	+			+		
Alloteuthis sp.			+			
Allotheuthis media					+	
Enoploteuthidae						+
Abralia veranyi			+			+
Abraliopsis pfefferi			+			
Ancistrocheirus lesueurii			+			
Pyroteuthis margaritifera						+
Octopoteuthis sicula	+		+			+
Onychoteuthis banksii	+	+	+	+	+	+
Ancistroteuthis lichtensteini	+	+			+	
Histioteuthis sp.			+			
Histioteuthis bonnellii	+			+	+	
Histioteuthis reversa	+	+		+	+	
Brachioteuthis riisei			+			+
Ommastrephidae				+		
Illex coindetii	+			+	+	
Todarodes sagittatus	+	+	+	+	+	
Todaropsis eblanae	+		+		+	
Chiroteuthis veranii	+		+	+		+
Scaeurgus unicirrhus					+	

Table IV. – Cephalopod species found in the diet of the Risso's dolphins in the Mediterranean Sea.

Species	Carlini *et al*. 1992 Central Tyrrhenian coast	Würtz *et al*. 1992 Ligurian Sea	Bello 1996 Adriatic Sea	Alessandri *et al*. 2001 Italian coast	Present study Eastern Mediterranean
Heteroteuthis dispar	+	+	+		+
Sepia officinalis	+				
Loligo vulgaris	+				
Abralia veranyi					+
Ancistrocheirus lesueurii					+
Pyroteuthis margaritifera					+
Octopoteuthis sicula					+
Onychoteuthis banksii			+	+	+
Ancistroteuthis lichtensteinii	+	+	+		
Histioteuthis bonnellii	+	+	+	+	+
Histioteuthis reversa	+	+	+	+	+
Chtenopteryx sicula					+
Brachioteuthis riisei					+
Illex coindetii	+				
Todarodes sagittatus	+	+	+		+
Ommastrephes bartramii					+
Chiroteuthis veranii			+		+
Bathypolypus sponsalis				+	
Eledone sp.	+				
Argonauto argo	+		+		+
Ocythoe tuberculata	+		+		

al. (1995) and Alessandri *et al.* (2001). *Pyroteuthis margaritifera* was reported for the first time as a food item of the striped dolphin in the Mediterranean in the present study although only two beaks were recovered from one dolphin.

In the stomachs of the Risso's dolphins, most of the cephalopod prey species found previously in the other parts of Mediterranean Sea were identified in our study (Table IV). Our study also showed that this dolphin species has a teuthophagous tendency. We identified, however, some species, such as *A. veranyi* and *P. margaritifera*, in the stomach contents of the Risso's dolphins, which were not reported in the previous studies in the Mediterranean, although their proportions as to the total number of cephalopod beaks found in the stomachs was small (3.5% and 2%, respectively). This may be due to the difference in cephalopod fauna between the eastern Mediterranean and the rest of the Mediterranean Sea.

Bello (1993) and Blanco *et al.* (1995) mentioned that cetaceans generally feed on oceanic cephalopods which have bioluminescent organs. All the cephalopods identified in this study, except *Brachioteuthis riisei* (2.4% of the total cephalopod beaks found in the striped dolphins, 0% in the Risso's dolphins), *Todarodes sagittatus* (6.1% and 0.8%, respectively), *Ommastrephes bartramii* (0% and 1.3%, respectively), and *A. argo* (0% and 2.8%, respectively), are bioluminescent. Our study supports their observation and suggests that these dolphins may utilize the bioluminescence at feeding.

When species obtained from the stomach contents of the striped and Risso's dolphins were compared, the Risso's dolphins turned out to feed on species which show greater vertical distribution (Mangold & Boletzky 1987) than those fed on by the striped dolphins (Fig. 4), such as *P. margaritifera*, *H. bonnellii*, *H. reversa*, *Chtenopterix sicula*, and *Chiroteuthis veranii*. Particularly *H. reversa*, which was the favorite prey of our Risso's dolphins (representing 60.9% of the cephalopod beaks in their stomachs), has a greater and deeper vertical range than *A. veranyi*, *O. banksii*, or *H. dispar*, which were the favorite prey of our striped dolphins (51.2%, 19.6%, and 11.0% respectively). This suggests that Risso's dolphins may dive and feed in deeper water than striped dolphins. However, as there is little information on the feeding behavior of these dolphins, it is also likely that they feed during night, utilizing the diurnal migration of prey cephalopods. It is not yet possible to conclude given our limited samples.

We found that both the striped dolphins and Risso's dolphins feed on *H. dispar* and *A. veranyi* (Table II). *Chiroteuthis veranii* was also found common except for one striped dolphin. However, *Ancistrocheirus lesueurii*, *H. bonnellii*, *H. reversa*, *C. sicula*, *Ommastrephes bartramii* and *A. argo* were found only in the diet of Risso's dolphin. These two species apparently share the same cephalopod resource in the same habitat. However, they might also exploit a wide variety of preys depending on the availability. While the striped dolphins feed on fish and shrimps as well as on cephalopods, the Risso's dolphins may spend more effort seeking cephalopods. In the central Mediterranean, striped dolphins are almost exclusively pelagic, while Risso's dolphins are typically found in the outer slope habitat of the deepest regions, mostly where slope and coastline are closest (Notarbartolo *et al.* 1993), which may be reflected in the above difference in their apparent feeding preferences.

Roberts (2003) reported the diet of a sperm whales off the south coast of Crete, also in the eastern Mediterranean, close to our sampling area. He found seven species, all of which were also found in our study, apparently with *H. bonnellii* being the most important prey species. We can then assume that the sperm whales, which are strictly teuthophagus, also share the same resource with the striped and Risso's dolphins. It is conceivable that the abundant and diverse assemblages of cephalopods in the eastern Mediterranean are capable of supporting these marine mammals.

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