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Diets of marine mammals stranded on the northwestern Spanish Atlantic coast with special reference to Cephalopoda

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Abstract

Stomach contents from 59 marine mammals, 28 *Delphinus delphis*, 14 *Tursiops truncatus*, three *Grampus griseus*, four *Stenella coeruleoalba*, three *Globicephala melas*, one *Ziphius cavirostris*, four *Phocoena phocoena*, one *Physeter macrocephalus* and one *Balaenoptera acutorostrata* stranded on the northwestern Spanish Atlantic coast from December 1990 to March 1993 were examined.

A total of 9076 fish otoliths and 654 cephalopod upper and lower beaks were collected. The otoliths were identified only to family level, representing by number 65% Gadidae, 24% Gobiidae, 6% Atherinidae, 2% Ammodytidae, 1.5% Clupeidae and the rest Carangidae, Labridae, Argentinidae, Macroramphosidae and Bothidae. The cephalopod beaks belonged to 12 species of nine families. The cephalopod families contributing food of these marine mammals, in order of contribution by number of specimens are, the Loliginidae (56.9%), the Octopodidae (25.3%), the Ommastrephidae (11.9%), the Sepiolidae (2.4%), the Histioteuthidae (0.9%), the Chiroteuthidae (0.9%), the Cranchiidae (0.8%), the Mastigoteuthidae (0.3%) and the Gonatidae (0.15%). The great part of the cephalopods observed in the stomach contents were small in size, except for some octopods in *Grampus griseus* and *Globicephala melas*, and *Mastigoteuthis* sp. in *Physeter macrocephalus*. The results indicated that *D. delphis*, *T. truncatus* and *Phocoena phocoena* are primarily fish-eating, while *Grampus griseus*, *Globicephala melas* and *Physeter macrocephalus* had only cephalopod remains in their stomachs.

Keywords: Cephalopods, general; Feeding and nutrition; Mammals, marine; Spain

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1. Introduction

Between December 1990 and March 1993, the Galician Coordinating Body for the Study of Marine Mammals (C.E.M.MA.) compiled 59 references to marine mammals stranded on the northwestern Spanish Atlantic coast (Galician waters). Of these, one was a mysticete cetacean, the minke whale, *Balenoptera acutorostrata* Lacépède, 1804, and the other odontocete cetaceans, the common dolphin *Delphinus delphis* (Linnaeus, 1758), the bottle-nosed dolphin *Tursiops truncatus* (Montegu, 1821), the Risso's dolphin *Grampus griseus* (Cuvier, 1812), the striped-dolphin *Stenella coeruleoalba* (Meyen, 1833), the long-finned pilot-whale *Globicephala melas* (Traill, 1809), the Cuvier's whale *Ziphius cavirostris* (Cuvier, 1823), the harbour porpoise *Phocoena phocoena* (Linnaeus, 1758) and the sperm whale *Physeter macrocephalus* Linnaeus, 1758.

Clarke (1985, 1986) has indicated that a few baleen whales do eat squid. Among them, the minke whale seems to be cephalopod-eating (Clarke, 1986; Pierce, 1992).

Diets of smaller odontocete cetaceans occurring in western European water are summarised in Corbet and Harris (1991). Three species are recorded as predators of a wide range of cephalopods; the striped and the Risso's dolphins and the long-finned pilot whale. All species were listed as taking *Loligo* sp. Clarke and Pascoe (1985) examined the stomach contents of a Risso's dolphin stranded on the south Devon coast. This contained beaks from about 40 cephalopods, including *Sepia officinalis*, *Eledone cirrhosa* and *Todaropsis eblanae*. The remaining beaks were tentatively identified as *Loligo forbesi* and *Todarodes sagittatus*. The identified cephalopod remains in the stomachs of four long-finned pilot whales from the Faroes, France (Clarke, 1985), Galician coast (Sánchez-Canals and Urgorri, 1989) and Great Britain (Corbet and Harris, 1991) included Loliginidae, Sepiolidae, Sepiidae and Octopodidae species besides Ommastrephidae and specimens of seven other families of oceanic squids. Pascoe (1986) examined the stomach contents of two common dolphins caught in a commercial trawl near Plymouth. These contained bones of mackerel, a small clupeid (probably sprat), and the mantle and beaks of the ommastrephid squid, *Todaropsis eblanae*. Corbet and Harris (1991) indicate that cephalopod remains of the genera *Loligo*, *Alloteuthis* and *Sepiola* were identified in the stomach contents of common dolphins from Great Britain. Cephalopods in the diet of the bottle-nosed dolphin from Great Britain were identified as being from *Loligo* and *Sepia* (Corbet and Harris, 1991). Rae (1965) records the presence of *Loligo* sp. remains in harbour porpoise.

Many studies of the diet of sperm whale have shown that, except off Iceland (Roe, 1969; Clarke and MacLeod, 1976; Martin and Clarke, 1986) the main food of the whale comprises cephalopods (for summary see Clarke, 1980, 1986; Clarke et al., 1993). Clarke and MacLeod (1974) examined cephalopod remains in the stomach of a sperm whale caught off Vigo (northwest Spain). Beaks from approximately 80 individual cephalopods were present, the most numerous being *Histioteuthis bonnellii*. Xampeny and Filella (1976) examined the stomach contents of three sperm whales caught off Galicia (northwest Spain), remains of

Histioteuthis bonnellii and *Taningia danae* were found in two sperm whales caught, a third had an empty stomach.

According to Clarke (1985) the most important odontocete squid-eating cetaceans are members of the Ziphiidae and Physeteridae. Dolphins are primarily fish-eating, and prey on fish schools, as observed by Fitch and Brownell (1968) and Sekiguchi et al. (1992).

The present paper deals with the role of cephalopods in the diet of several species of marine mammals stranded on the northwestern Spanish coast. This is the first detailed study on this subject carried out in the Iberian Peninsula.

2. Materials and methods

The stomach content of 59 cetacean specimens stranded on the Galician coast (northwest Spain) from January 1991 to March 1993 were collected. Twenty-eight of these belonged to *Delphinus delphis* (DD), 14 to *Tursiops truncatus* (TT), three to *Grampus griseus* (GG), four to *Stenella coeruleoalba* (SC), three to *Globicephala melas* (GM), one to *Ziphius cavirostris* (ZC), four to *Phocoena phocoena* (PP), one to *Physeter macrocephalus* (PM) and one to *Balaenoptera acutorostrata* (BA).

All specimens were measured in the place they were found stranded. Contents of the digestive tract were removed, fixed in formaldehyde 4% and preserved in 70% alcohol.

Fish otoliths were identified to family level using a reference collection of otoliths from Galician waters, but also employing the guides by Chaine (1936), Chaine and Duvergier (1934), Bauzá-Rullán (1962), Schmidt (1968) and Harkönen (1986). Otoliths are perhaps the most readily identified fish structures found in digestive tracts of marine mammals, and they have been used for identification of fish eaten by seals and cetaceans (for a summary see Pierce and Boyle, 1991). Access to a reference collection of otoliths is essential for dietary studies, however, because published guides are seldom comprehensive and take little account of intraspecific variation, particularly with regard to alterations in otolith shape in the course of growth and development (Jobling and Breiby, 1986). Moreover, erosion of otoliths during passage through the digestive tract exacerbates difficulties of exact identifications (Pierce and Boyle, 1991). For these reasons, and because this paper mostly deals with the role of the cephalopods in the diet of marine mammals, fish otoliths were identified only to family level.

Guides by Clarke (1986) and Pérez-Gándaras (1986) were used to identify the cephalopod beaks. The lower rostral length (*LRL*) for squids and the lower hood length (*LHL*) for cuttlefish and octopods were measured. Measurements were taken with calipers or with a micrometer under a binocular microscope in the case of very small beaks. Weight of the animals was estimated using the regression calculated by Clarke (1986), Nixon (1973), Pérez-Gándaras (1986) and Wolff (1982).

Table 1
Range of *LRL* and *LHL* and estimated mass for each cephalopod species taken by each cetacean species
Cephalopod species

	Marine mammal species									
	Delphinus delphis ($N=28$)					*Tursiops truncatus* ($N=14$)				
	N	*LRL*	*LHL*	*EM* (g)	%	*N*	*LRL*	*LHL*	*EM* (g)	%
Sepiolo atlantica	8			36	0.3					
Loligo vulgaris	92	0.4–3.8		7673	63.3					
Alloteuthis subulata	114	0.8–0.9		539	4.5					
Todarodes sagittatus	1	4.6		164	1.4	1	3.5		76	11.3
Illex coindetii	26	1.5–2.3		2185	18	3	1.2–3.7		144	21.5
Gonatus steenstrupi	3	5.1–6.5		593	4.9					
Histioteuthis sp.										
Mastigoteuthis sp.										
Chiroteuthis sp.										
Teuthowenia megalops										
Octopus vulgaris	2		1.8–2.0	86	0.7					
Eledone cirrhosa	6		2.5–3.5	834	6.9	3		2.8–3.5	450	67.2
ETM (g)				12112					670	

N, number of specimens; *LRL*, lower rostral length; *LHL*, lower hood length; *ETM*, estimated total mass.

3. Results

Eight stomachs were empty, 23 showed fish and cephalopod remains, 20 only fish, and six only cephalopods (see Appendix for details of contents of each stomach). A total of 9076 fish otoliths were collected. The cephalopod beak collection was composed of 301 lower beaks and 353 upper beaks. Eight specimens of *Sepiola atlantica* were recovered intact from the stomach content of a common dolphin. Three mantles of *Alloteuthis subulata* and pieces of unidentifiable cephalopod flesh were also collected.

Twelve cephalopod species belonging to nine families were identified (Table 1).

The 9076 fish otoliths collected distributed in nine families: 65% of the otoliths belonging to Gadidae (mostly blue whiting *Micromesistius poutassou*), 24% to Gobiidae, 6% to Atherinidae, 2% to Ammodytidae, 1.5% to Clupeidae (mostly sardine, *Sardina pilchardus*), and the rest to Carangidae (horse mackerel, *Trachurus trachurus*), Labriidae, Argentinidae, Macroramphosidae and Bothidae (*Arnoglossus* sp.).

Of the 9076 fish otoliths recovered from the stomach contents examined, 6034 (66.5%) were found in *Delphinus delphis*, 2807 (30.9%) in *Tursiops truncatus*, 232 (2.5%) in *Phocoena phocoena*, two in *Globicephala melas* and one in *Grampus griseus*.

Grampus griseus (*N*=3)					*Globicephala melas* (*N*=3)					*Physeter macrocephalus* (*N*=1)				
N	*LRL*	*LHL*	*EM* (g)	%	*N*	*LRL*	*LHL*	*EM* (g)	%	*N*	*LRL*	*LHL*	*EM* (g)	%
6	0.7–2.6		1078	7.2	2	0.7–1.0		210	1.4					
8	3.1–3.3		314	2.1	8	3.1–3.3		422	2.8					
										1	3.1		52	0.6
										5	9–13.5		7766	89.3
										1	9.9		382	4.4
										3	5.3–5.8		348	4
8		4.3–7.7	12830	85.7	8		2.6–5.8	1585	10.5	1		3.6	148	1.7
5		2.8–4.1	743	5	59		2.7–4.9	12819	85.3					
			14965					15036					8696	

Seventy-nine isopods were found in the stomach contents, and very digested decapod crustaceans were found in six stomach contents.

The occurrence of beaks (in declining order) of the families was as follows: Loliginidae (56.9% of the samples), Octopodidae (25.3%), Ommastrephidae (11.9%), Sepiolidae (2.4%), Histioteuthidae (0.9%), Chiroteuthidae (0.9%), Cranchiidae (0.8%), Mastigoteuthidae (0.3%) and Gonatidae (0.15%).

Table 1 gives details of the range of *LRL* and *LHL* and of estimated mass (total and percentage) for each cephalopod species taken by each cetacean species. The estimated mass represented by 372 cephalopod specimens was 51.48 kg. The great part of the cephalopods observed in the cetacean stomach contents were small in size, except for some octopods in *Grampus griseus* and *Globicephala melas* and *Mastigoteuthis* sp. specimens in *Physeter macrocephalus*.

4. Discussion

The abundance and distribution of the fish otoliths between those small odontocetes indicates that the dolphins and the harbour porpoise are primarily fish-eating (see relative abundances between fish and cephalopods in Tables A1–A3), as observed by Rae (1965), Fitch and Brownell (1968) and Sekiguchi et al. (1992).

Nevertheless, *Delphinus delphis* and *Tursiops truncatus* were also found with cephalopod beaks in their stomachs. Except for *Sepiola atlantica* specimens, which were found intact in the stomach content of a common dolphin (DD2), and some large octopods, almost all the cephalopod beaks belonged to small sized cephalopods.

Remains of small prey (cephalopods in this case) in stomach contents could have been present in the stomachs of larger prey (fish in the present case), rather than ingested directly by marine mammals. This 'Russian doll' effect is a kind of contamination or a secondary ingestion which has been observed in studies on the diet of several marine mammals (see Pierce and Boyle, 1991). It is possibly an important source of error, which is difficult to avoid. However, it is possible that cephalopod schools were a suitable prey for these mammals, even though these schools were composed of small animals.

All the cephalopod species found in the stomach contents are common in this area of the Atlantic (Guerra, 1992). *Sepiola atlantica*, *Octopus vulgaris* and *Eledone cirrhosa* are benthic species, *Loligo vulgaris* and *Alloteuthis subulata* are nectobenthic, all of them living over the continental shelf. The remainder are epi-mesopelagic, and normally oceanic species (Clarke, 1966; Guerra, 1992). It was observed that the five species of cetaceans studied are not exclusive predators of squid, but also feed on octopods.

Prey species found in dolphins, porpoise and pilot-whale did not differ from those found in western European waters (Clarke and Pascoe, 1985; Pascoe, 1986; Sánchez-Canals and Urgorri, 1989; Corbet and Harris, 1991).

In our samples the common dolphin showed a wider range of prey than the bottle-nosed dolphin, the Risso's dolphin and the long-finned pilot-whale (Table 1), but all of them eat mostly neritic cephalopods. The sperm whale, however, showed a very different feeding, mainly composed of oceanic squid, which agrees with the observations for this species (Clarke and MacLeod, 1974, 1976; Clarke et al., 1993). This whale was a juvenile (700 cm long), recently weaned. It was observed being accompanied by its mother before stranding.

The variety of prey items taken suggests that some of these odontocetes take prey which they encounter rather than being selective for particular prey items, as also observed by Sekiguchi et al. (1992) in South African waters.

The mean mass of each cephalopod species can be estimated (Table 1). This indicates that, except in the case of some *Octopus vulgaris* in *Grampus griseus*, *Mastigoteuthis* sp. in *Physeter macrocephalus*, prey were small in size, specially sepiolids, loliginids and ommastrephids. This differs from the finding of Clarke and Pascoe (1985) in the case of the Risso's dolphin stranded in Devon, but coincides with the observations made by Clarke and Kristensen (1980) in two northern bottle-nosed whales (*Hyperodoon ampullatus*), one stranded in Faroe Island and the other in Jutland, the latter measuring 7.28 m. The squids eaten by *H. ampullatus* had an average estimated weight of 157 g.

Of the species eaten, four have external luminous organs and all of them were caught by the sperm whale (80%), which agrees with the observations by Clarke et al. (1993) in sperm whales from the Azores in which 77.5% of the prey had

luminous organs. Here only one species eaten (*Sepiola atlantica*) has internal luminous organs, the remainders being non-luminous species. Of the species eaten, five (*Gonatus steenstrupi*, *Histioteuthis* sp., *Mastigoteuthis* sp., *Chiroteuthis* sp. and *Teuthowenia megalops*) are neutrally buoyant. They were caught by a common dolphin and the sperm whale. In the case of the sperm whale, these features agree with the observations by Clarke et al. (1993) from 17 specimens caught in the Azores.

Apart from problems of precision attributable to the identification of the prey items found in the stomach contents, to obtain a more accurate picture of odontocete diet it is important to examine material from non-stranded animals whenever possible. A comparison of the stomach content of stranded and non-stranded dolphins showed that diets of stranded animals are likely to be somewhat biased (Sekiguchi et al., 1992).

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Appendix

Table A1
Delphinus delphis (DD) stranded in Galicia. Data of the specimens examined and summary of the stomach contents

Mammal no.	DD1	DD2	DD3	DD4	DD5	DD6	DD7	DD8	DD9	DD10
Sex	F	M	M	F	–	F	F	M	M	F
Month	Mar.	Feb.	Feb.	Mar.	Feb.	Apr.	Feb.	Apr.	Nov.	Nov.
Day-year	12-91	16-92	18-91	21-91	24-91	10-92	9-92	16-92	16-92	17-92
Length (cm)	210	179	169	173	148	161	186	190	170[a]	174
Lower and upper beaks (L/U)										
Sepiola atlantica		8/8								
Loligo vulgaris	4/4	2/2	0/2				4/5	15/21	4/8	1/1
Alloteuthis subulata		3/3	10/12	21/21				26/41	8/16	
Todarodes sagittatus					1/1					
Illex coindetii					2/1			21/20	1/1	
Gonatus steenstrupi						3/3				
Octopus vulgaris	1/0									
Eledone cirrhosa		4/5		1/1						
Total lower and upper beaks	9	35	24	44	5	6	9	144	38	2
Mass from beaks (g)	264	917	390	198	218	600	10	6500	346	120
Fish otoliths	250	36	294	1944	210	82	11	513		4
Isopods		3	20	47	2			2		
Crustacea Decapoda						1				

Mammal no.	DD11	DD12	DD13	DD14	DD15	DD16	DD17	DD18	DD19	DD20
Sex	M	M	M	F	M	–	M	M	M	M
Month	Dec.	Dec.	Dec.	Jan.	Dec.	Nov.	Dec.	Feb.	Oct.	Dec.
Day-year	31-92	4-92	5-92	30-93	5-92	21-92	8-9-2	10-91	20-91	1-91
Length (cm)	186[a]	185	170[a]	190[a]	170	–	211	169	156	176
Lower and upper beaks (L/U)										
Sepiola atlantica										
Loligo vulgaris	1/0	1/3	10/15	20/20	0/2	9/7	2/2			
Alloteuthis subulata			2/1	6/16		2/3	2/1			
Todarodes sagittatus										

Illex coindetii		1/1	1/0			0/1				
Gonatus steenstrupi										
Octopus vulgaris							1/1			
Eledone cirrhosa										
Total lower and upper beaks	1	6	29	62	2	22	9			
Mass from beaks (g)	18	318	407	1096	100	488	122			
Fish otoliths	11	335	2	196	41	4	2	4	762	2
Isopods									1	
Crustacea Decapoda										

Mammal no.	DD21	DD22	DD23	DD24	DD25	DD26	DD27	DD28		Total
Sex	M	M	F	M	M	F	M	M		
Month	Nov.	Nov.	Apr.	Nov.	Oct.	Jan.	Dec.	Dec.		
Day-year	23/91	23/91	8-92	28-92	5-92	10-93	13-92	13-92		
Length (cm)	208	190	160	194[a]	170	192	196	190[a]		
Lower and upper beaks (L/U)										8/8
Sepiola atlantica										73/92
Loligo vulgaris										80/114
Alloteuthis subulata										1/1
Todarodes sagittatus										
Illex coindetii										26/24
Gonatus steenstrupi										3/3
Octopus vulgaris										2/1
Eledone cirrhosa										5/6
Total lower and upper beaks										198/249
Mass from beaks (g)										12112
Fish otoliths	183	254	1	28	92	421	251	101		6034
Isopods										75
Crustacea Decapoda						1				2

[a] Estimated length.

Table A2
Tursiops truncatus (TT) stranded in Galicia. Data of the specimens examined and summary of the stomach contents

Mammal no.	TT1	TT2	TT3	TT4	TT5	TT6	TT7	TT8
Sex	M	–	F	F	–	F	F	F
Month	Jan.	Mar.	Jan.	Nov.	Feb.	Apr.	Dec.	Jan.
Day-year	21-91	23-91	10-92	28-92	20-91	6-91	7-91	12-92
Length (cm)	290	270	265	281	276[a]	258	265	275
Lower and upper beaks (L/U)								
Sepiola atlantica								
Loligo vulgaris								
Alloteuthis subulata								
Todarodes sagittatus			1/0					
Illex coindetii		2/1		1/1				
Octopus vulgaris								
Eledone cirrhosa	3/3							
Unidentified								
Total lower and upper beaks	6	3	1	2				
Mass from beaks (g)	450	12	43	165				
Fish otoliths	159	614	240	109	243	87	44	268
Isopods								
Crustacea Decapoda	1							1
Netting								

Mammal no.	TT9	TT10	TT11	TT12	TT13	TT14		Total
Sex	M	F	M	–	M	M		
Month	Nov.	Nov.	Jan.	Dec.	Oct.	Feb.		
Day-year	28-92	28-92	8-93	30-91	13-91	3-91		
Length (cm)	278	249	310		296	265		
Lower and upper beaks (L/U)								
Sepiola atlantica								
Loligo vulgaris								
Alloteuthis subulata								
Todarodes sagittatus								1/0
Illex coindetii								3/1
Octopus vulgaris								
Eledone cirrhosa								3/3
Unidentified					1/0			1/0
Total lower and upper beaks					1			8/5
Mass from beaks (g)								670
Fish otoliths	283	85	563	112				2807
Isopods								
Crustacea Decapoda		2						4
Netting					P	P		

[a] Estimated length.

Table A3
Marine mammals stranded in Galicia. Data of the specimens examined and summary of the stomach contents

Mammal no.	GG1	GG2	GG3	SC1	SC2	SC3	SC4	PP1	PP2
Sex	F	F	F	F	F	F	–	F	M
Month	Feb.	Feb.	Feb.	Dec.	Mar.	Dec,	Mar.	Nov.	Dec.
Day-year	15-92	10-92	3-91	29-90	29-91	05-92	03-91	27-92	05-92
Length (cm)	280[a]	268	230	165	218	207	–	190	168
Lower and upper beaks (L/U)		4/6							
Loligo vulgaris			6/4	empty	empty	empty	empty	empty	empty
Illex coindetii			1/2						
Histioteuthis sp.									
Mastigoteuthis sp.									
Chiroteuthis sp.									
Teuthowenia megalops									
Octopus vulgaris	7/7	1/1							
Eledone cirrhosa		3/3	2/2						
Unidentified									
Total lower and upper beaks	14	18	17						
Mass from beaks (g)	11536	2693	736						
Fish otoliths			1						
Isopods			4						
Crustacea Decapoda		1	3						
Netting									
Plastics			P						

Mammal no.	PP3	PP4	GM1	GM2	GM3	ZC	BA1	PM1	Total
Sex	F	F	M	M	F	F	F	M	
Month	Dec.	Feb.	Apr.	Feb.	Mar.	Jan.	Feb.	Mar.	
Day-year	12-91	14-93	4-92	22-91	28-93	19-91	11-91	04-93	
Length (cm)	155	171	430	415	263[a]	650	800	700	
Lower and upper beaks (L/U)									
Loligo vulgaris			2/1						8/5
Illex coindetii			4/2	0/1	1/0				10/11
Histioteuthis sp.								1/0	1/0
Mastigoteuthis sp.								1/5	1/5
Chiroteuthis sp.								1/1	1/1
Teuthowenia megalops								2/3	2/3
Octopus vulgaris			1/0		4/7			1/0	14/15
Eledone cirrhosa			21/21	16/23	15/10				57/59
Unidentified								1/0	1/0
Total lower and upper beaks			52	40	37			16	95/99
Mass from beaks (g)			3985	3649	7402			8696	38997
Fish otoliths	232		2						235
Isopods									3
Crustacea Decapoda									5
Netting									
Plastics									

[a] Estimated length.

GG, *Grampus griseus*; SC, *Stenella coeruleoalba*; PP, *Phocoena phocoena*; GM, *Globicephala melas*; ZC, *Ziphius cavirostris*; BA, *Balenoptera acutorostrata*; PM, *Physeter macrocephalus*.

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