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Cephalopods in the diet of marine mammals stranded or incidentally caught along Southeast and Southern Brazil (21° to 34°S).

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Abstract

Cephalopod remains in 286 stomach contents of 13 species of odontocetes and four pinnipeds were identified and measured. The stomachs were collected from stranded or incidentally caught marine mammals from Rio de Janeiro to Paraná states (21° to 26 °S) and Rio Grande do Sul (29 ° to 34°S), between 1985 and 1998. A total of 3233 upper beaks, 3521 lower beaks and remains of 55 whole animals were found and 25 species of 16 families of cephalopods were identified. Loliginid squids were the most frequent cephalopod found in the diet of the dolphins *Lagenodelphis hosei*, *Pontoporia blainvillei*, *Sotalia fluviatilis*, *Stenella frontalis*, *Steno bredanensis* and *Tursiops truncatus* and the fur seals *Arctocephalus australis*, *A. gazzella* and *A. tropicalis*. *Loligo sanpaulensis* was mainly found in those specimens collected in Rio Grande do Sul, whilst *Loligo plei* and *Lolliguncula brevis*, besides *L. sanpaulensis*, were frequent in those from Rio de Janeiro to Paraná. Oegopsids squids of the families Chiroteuthidae, Cranchiidae, Enoploteuthidae, Histioteuthidae, Lycoteuthidae, Octopoteuthidae, Onychoteuthidae and especially Ommastrephidae were found in the stomach contents of *Feresa attenuata*, *Globicephala melas*, *Kogia breviceps*, *Kogia simus*, *Orcinus orca*, *Pseudorca crassidens* and in the seals *Arctocephalus tropicalis* and *Mirounga leonina*. Ommastrephid and loliginid squids, besides the sepiolid *Semirossia tenera*, were equally important in the diet of *Delphinus delphis*. Benthic octopuses were found only in *Tursiops truncatus* and *Pontoporia blainvillei*. Pelagic octopuses, particularly *Argonauta nodosa*, were relatively frequent in the stomach contents of *Pontoporia blainvillei*. The diversity of cephalopods as prey was smaller for the inshore marine mammals. Loliginids and ommastrephids were the most frequent cephalopods in the diet of inshore and offshore marine mammals respectively.

Key words: Trophic relations, marine mammals, Southwestern Atlantic Ocean, Brazil, foodwebs, cephalopods

Introduction

The species composition and distribution of the coastal cephalopod fauna along southern and southeastern Brazil is relatively well known from commercial landings and bottom trawl survey data (Palacio, 1977; Haimovici and Perez, 1991a; Haimovici *et al.*, 1994). Far less is known on the cephalopods from the upper slope and open ocean species where only longline fishing for large pelagic fishes occurs and no surveys targeting cephalopods have been performed. Many marine mammals are cephalopod predators and can be excellent collectors of cephalopods, although generally only beaks can be recovered (Clarke, 1980; Clarke, 1986a; Clarke, 1996). Therefore, the analysis of marine mammals stomach contents can provide substantial information on cephalopod distribution and biology, since many species, particularly the oceanic ones, are rarely caught by nets and other sampling methods. On the other hand, the knowledge of the

distribution, life-style and habitat of cephalopod species found in the diet of marine mammal predators can aid the understanding of their distribution and feeding habits.

At least 23 species of odontocetes and seven of pinnipeds were recorded for southern (26°S - 34°S) and southeastern Brazil (21°S-26°S) (Pinedo *et al.*, 1992). The diet of several species was formerly studied and some of them were found feed to some degree on cephalopods: *Pontoporia blainvillei* (Pinedo, 1982); *Kogia simus* (Pinedo, 1987), *Physeter macrocephalus* (Clarke *et al.*, 1980) and more recently Kogia *breviceps* (Secchi *et al.*, 1994); *Globicephala melas* (Santos and Pinedo, 1994); *Orcinus orca* (Dalla Rosa, 1995); *Feresa attenuata* (Zerbini and Santos, 1997) and *Pontoporia blainvillei* (Ott, 1994; Bassoi, 1997).

There are several problems in the interpretation of the diet and the geographic distribution of the prey from the stomach contents of stranded animals. Beaks of cephalopods are known to remain retained undigested for longer periods than fish bones and otoliths. Clarke (1986a) suggest that cephalopods and fishes should be analysed in separate, to avoid misinterpretation in relation to the importance of both items in the diet. Other point to be considered is that stranded animals generally are unhealthy and may not be representative of the normal diet, but this cannot be considered a rule, as, in a comparative study in South Africa, no significant difference in the percentage of cephalopod in the diet between stranded and non-stranded *Delphinus delphis*, *Lagenorhynchus obscurus* and *Cephalorhynchus heavisidii* was observed (Sekiguchi *et al.*, 1992). Despite the known limitations, the use of beaks from stranded animals is well established (Clarke, 1986a, b) and some times is the only available source of information.

The material for this study were the cephalopods remains in the stomach contents of diverse marine mammals incidentally caught or stranded from Rio de Janeiro to Paraná (Zone A: 21°S to 26°S) and along Rio Grande do Sul (Zone B: 29° to 34°S) (Fig.1) and sent to us by colleagues for identification (Appendix I). The scope was to assess the relative importance of the different cephalopods in their diet and to contribute to the understanding of the distribution and trophic relations of cephalopods in the region.

Materials and methods

The cephalopods in 286 stomach contents of 13 species of odontocetes and four of pinnipeds collected between 1985 and 1998 were examined (Table 1). Cephalopod remains, consisting mainly of beaks, were identified (RAS) with help of a reference collection at the *Depto. Oceanografia* of the *Fundação Universidade do Rio Grande.*

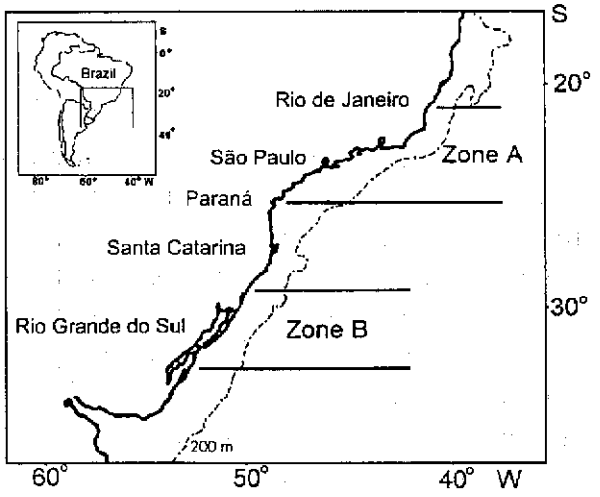

Figure 1. Study area. Zone A: Rio de Janeiro to Paraná (21°S to 26°S) and Zone B: Rio Grande do Sul (29° to 34°S)

The sizes of preyed cephalopods were estimated from measurements on the beaks: upper (URL) and lower (LRL) rostral length in squids and sepiolids and

upper (UHL) and lower (LHL) hood length in octopuses. Measures followed Clarke (1986b) to 0.1 mm. Most prey mantle length and masses were calculated from regressions relating squid rostral length and octopuses hood length with dorsal mantle length (ML, mm) and with total mass (TM, g) obtained from the specimens in the reference collections. When local data were not available, size was estimated from regressions presented in Clarke (1986b).

Table 1. Stomach contents of marine mammals collected from Zone A: Rio de Janeiro to Paraná (21° to 26 °S) and Zone B: Rio Grande do Sul (29° to 34°S) and number of families of cephalopods identified.

		Cephalopod preyed		No. stomachs	
Marine mammal species	Common name	Families	Species	Zone A	Zone B
Odontocetes					
Delphinus delphis	common dolphin	4	6	2	3
Feresa attenuata	pigmy killer whale	2	4	1	
Globicephala melas	pilot long-finned whale	7	7		5
Lagenodelphis hosei	Fraser's dolphin	2	2		4
Orcinus orca	killer whale	9	11		3
Pseudorca crassidens	false killer whale	1	2		3
Sotalia fluviatilis	estuarine dolphin	1	4	56	
Stenella frontalis	atlantic spotted dolphin	1	1	6	
Steno bredanensis	rough-toothed dolphin	1	1	1	
Tursiops truncatus	bottlenose dolphin	2	2	2	1
Pontoporia blainvillei	franciscana dolphin	4	7	57	111
Kogia breviceps	pigmy sperm whale	8	9	1	2
Kogia simus	dwarf sperm whale	11	14	2	
Pinnipeds					
Arctocephalus australis	south american fur seal	2	2		15
Arctocephalus gazzella	antarctic fur seal	2	2		1
Arctocephalus tropicalis	subantarctic fur seal	5	7		8
Mirounga leonina	southern elephant seal	3	3		1

Results

A total of 3233 upper beaks 3521 lower beaks and remains of 55 whole animals were examined in the stomach contents of 286 marine mammals, 13 odontocete and four pinniped species (Fig. 2). Twenty five species of 16 families of cephalopods were identified (Table 2).

Delphinus delphis

In the two stomachs contents of stranded specimens from from Zone A, only a few beaks of *Loligo plei* and unidentified loliginids were found. In three incidentally caught specimens from Zone B, *Loligo sanpaulensis*, the sepiolid *Semirossia tenera* and the ommastrephid *Illex argentinus* were frequent. *Hyaloteuthis pelagica* and unidentified Cranchiidae also occurred (Table 3).

Most prey were small, mean estimated mass ranged from 77 g for a few *Loligo plei* in Zone A, to 2 g for *Semirrosia tenera* in Zone B. Feeding appears to have occurred in the outer shelf and upper slope, but small *Loligo sanpaulensis* could have been eaten in the inner shelf. Sepiolidae, Loliginidae and Ommastrephidae were also found in its diet in Northwestern Spain (González *et al.*, 1994) and South Africa (Sekiguchi *et al.*, 1992).

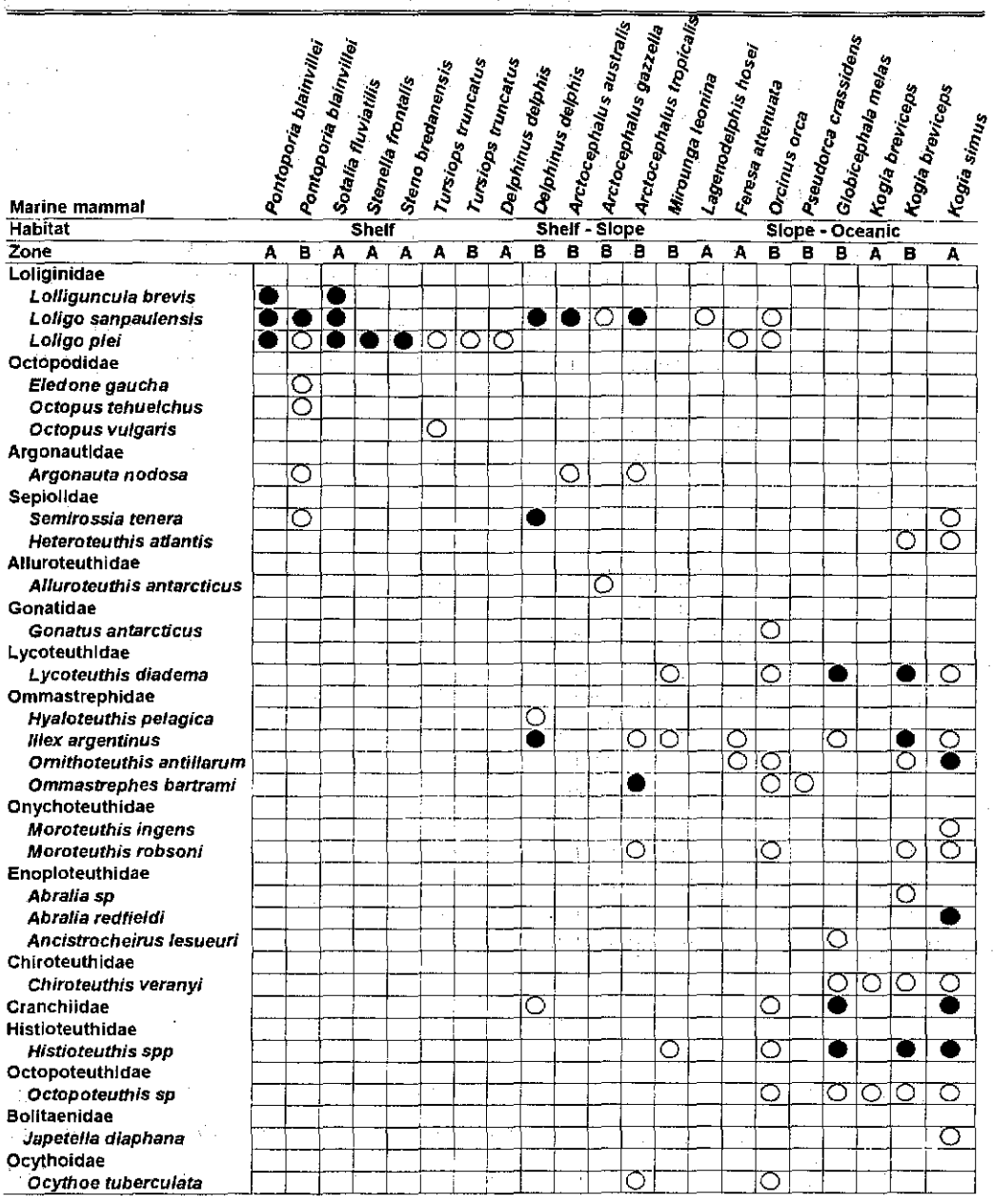

Figure 2. Cephalopods in the diet of marine mammals from Rio de Janeiro to Paraná (21° to 26°S) and Rio Grande do Sul (29° to 34°S) states. Circles indicate the presence of cephalopod in the diet, in black main cephalopod prey.

Lagenodelphis hosei

Four stomach contents of Fraser's dolphin stranded in Zone B contained mostly middle sized *Loligo sanpaulensis* (6 to 242 g). The beak of a single specimen of a 6 mm ML *Argonauta nodosa* does not seem to be part of the diet (Table 3). In South Africa oceanic cephalopods were the main prey found in the diet of Fraser's dolphin (Sekiguchi *et al.*, 1992). According to Klinowska (1991) *Lagenodelphis hosei* is a oceanic species and the presence of only neritic cephalopods in the diet probably indicate that feeding occurred on the shelf before stranding and may not represent its normal diet.

Table 2. Families and species of cephalopods observed in the diet of 13 odontocete and four pinniped species from Rio de Janeiro to Paraná (21° to 26 °S) and Rio Grande do Sul (29° to 34°S).

Families	Genera and species	Odontocete species	Pinniped species
Sepiolidae	*Semirossia tenera*	3	
	Heteroteuthis atlantis	2	
Loliginidae	*Loligo plei*	10	
	Loligo sanpaulensis	6	3
	Lolliguncula brevis	2	
	Unidentified	4	
Alluroteuthidae	*Alluroteuthis antarcticus*		1
Chiroteuthidae	*Chiroteuthis veranyi*	4	
Cranchiidae	(several species)	5	
Enoploteuthidae	*Abralia redfieldi*	1	
	Abralia sp	1	
	Ancistrocheirus lesueuri	2	
	other species	1	
Gonatidae	*Gonatus antarcticus*	1	
Histioteuthidae	*Histioteuthis spp*	4	1
Lycoteuthidae	*Lycoteuthis diadema*	4	1
Octopoteuthidae	*Octopoteuthis sp*	5	
Onychoteuthidae	*Moroteuthis ingens*	1	
	Moroteuthis robsoni	3	1
Ommastrephidae	*Illex argentinus*	5	2
	Hyaloteuthis pelagica	1	
	Ommastrephes bartrami	3	1
	Ornithoteuthis antillarum	4	
	Unidentified	8	1
Octopodidae	*Eledone gaucha*	1	
	Octopus tehuelchus	1	
	Octopus vulgaris	1	
Argonautidae	*Argonauta nodosa*	2	2
Bolitaenidae	*Japetella diaphana*	1	
Ocythoidae	*Ocythoe tuberculata*	1	1

Stenella frontalis, Steno bredanensis and *Tursiops truncatus*

In Zone A, all three species preyed mostly on small and middle sized *Loligo plei* (40 to 138 g) (Table 3). *Tursiops truncatus* also fed on a wide range of sizes of *Octopus vulgaris* (155 to 1210g). A single stomach of bottlenose dolphin examined from Zone B had two specimens of *Loligo plei* (65 and 72 g) (Table 4). Loliginidae and Octopodidae were also common in the diet of the bottlenose dolphin in other regions (Mercer, 1973; Sekiguchi *et al.*, 1992; González *et al.*, 1994).

Feresa attenuata

A single pigmy killer whale stranded in Zone A was found to have eaten two *Loligo plei* (42 to 61 g), two *Illex argentinus* (130 to 360 g) and one *Ornithoteuthis antillarum* (32 g) (Table 4).

Globicephala melas

Stomachs of the long-finned pilot whale stranded in Zone B were found to contain remains of continental slope and oceanic cephalopods (Table 4). Seventy percent of the identified specimens where neutrally buoyant *Histioteuthis* spp (53 to 287 g), *Chiroteuthis*

veranyi, Cranchiidae, *Octopoteuthis* sp. (124 to 241 g) and *Ancistrocheirus lesueuri* and the rest were Ommastrephidae, mainly middle sized to large *Illex argentinus* (67 to 693 g) and *Lycoteuthis diadema* (50 to 284 g).

Table 3. Numbers, mantle length and total masses of cephalopods preyed by *Delphinus delphis*, *Lagenodelphis hosei*, *Stenella frontalis*, *Steno bredanensis* and *Tursiops truncatus* sampled from Zone A: 21° to 26°S, and Zone B: 29° to 34°S (n= number of stomachs examined, S= number of stomachs with the cephalopod species and N= total number of individuals of each cephalopod species found).

				Mantle length (mm)			Total mass (g)		
	Cephalopod species	S	N	mean	range		mean	range	
Delphinus delphis	*Loligo plei*	2	2	180	177	183	77	74	80
(Zone A)	Loliginidae unidentified	2	2						
n=2	Oegopsida	1	2						
Delphinus delphis	*Semirossia tenera*	2	69	17	10	22	2	0.4	5
(Zone B)	*Loligo sanpaulensis*	3	58	50	28	83	8	2	22
n=3	Cranchiidae unidentified	1	5						
	Hyaloteuthis pelagica	1	1						
	Illex argentinus	2	20	59	21	276	25	1	392
Lagenodelphis hosei	*Loligo sanpaulensis*	3	19	129	51	219	75	6	242
(Zone B) n=4	*Argonauta nodosa*	1	1	6	6	6	0.1	0.1	0.1
Stenella frontalis	*Loligo plei*	6	121	89	21	220	19	1	119
(Zone A) n=6									
Steno bredanensis	*Loligo plei*	1	38	215	153	278	119	54	202
(Zone A) n=1									
Tursiops truncatus	*Loligo plei*	2	10	203	135	234	104	40	138
(Zone A) n=2	*Octopus vulgaris*	1	5	110	77	147	576	155	1210
Tursiops truncatus	*Loligo plei*	1	2	171	166	175	68	65	72
(Zone B) n=1									

The long-finned pilot whale is considered to feed heavily on squid. In the Northern Atlantic, *G. melas* was found to feed on oceanic squids of the families Ommastrephidae, Cranchiidae, Chiroteuthidae, Histioteuthidae (Sergeant, 1962; Desportes and Mouritsen, 1993). In other regions as south Argentina (Clarke and Goodall, 1994), Tasmania (Gales *et al.*, 1992) and South Africa (Sekiguchi *et al.*, 1992) neritic cephalopods were also found to be important in the diet of the long-finned pilot whale.

Orcinus orca and *Pseudorca crassidens*

The cephalopods found in the stomachs of three killer whales *Orcinus orca* stranded in Zone B included the same families found in the diet of *Globicephala melas*, but also coastal loliginids (10 to 158 g), the pelagic octopus *Ocythoe tuberculata* and the antarctic squid *Gonatus antarcticus* (143 to 203 g). This last probably eaten in cold subantarctic waters beyond the study area (Table 4). Neutral buoyant species amounted 53% of the identified specimens and other squids 46%. The squids were small to middle sized and the possibility that, at least the loliginids, could have been eaten by some killer whale's prey cannot be discarded.

In the stomach contents of the three *Pseudorca crassidens* stranded in Zone B, the identified squids were middle sized *Ommastrephes bartrami* of 206 to 1038 g (Table 4). Ommastrephidae were also found in the stomach contents of false killer whales from South Africa (Sekiguchi *et al.*, 1992).

Table 4. Numbers, mantle length and total masses of cephalopods preyed by *Feresa attenuata*, *Globicephala melas*, *Orcinus orca* and *Pseudorca crassidens* sampled from Zone A: 21° to 26°S, and Zone B: 29° to 34°S (n= number of stomachs examined, S= number of stomachs with the cephalopod species and N= total number of individuals of each cephalopod species found).

				Mantle length (mm)			Total mass (g)		
	Cephalopod species	S	N	mean	range		mean	range	
Feresa attenuata	*Loligo plei*	1	2	149	136	162	51	41	61
(Zone A)	*Illex argentinus*	1	2	227	187	267	245	130	360
n=1	*Ornithoteuthis antillarum*	1	1	131	131	131	32	32	32
	Ommastrephidae unidentified	1	1						
Globicephala melas	*Chiroteuthis veranyi*	2	7						
(Zone B)	Cranchiidae unidentified	1	10						
n=5	*Ancistrocheirus lesueuri*	2	3						
	Histioteuthis spp	3	98	56	48	115	71	53	287
	Lycoteuthis diadema	2	45	110	93	141	106	50	284
	Octopoteuthis sp	1	6	144	130	173	161	124	241
	Illex argentinus	3	6	221	150	332	246	67	693
	Ommastrephidae unidentified	1	1						
	Oegopsida unidentified	3	11						
Orcinus orca	*Loligo plei*	1	2	143	124	162	47	34	61
(Zone B)	*Loligo sanpaulensis*	1	10	126	58	185	72	10	158
n=3	Cranchiidae unidentified	1	1						
	Gonatus antarcticus	1	6	201	188	214	173	143	203
	Histioteuthis spp	2	7	96	69	137	210	101	412
	Lycoteuthis diadema	1	1	110	110	110	76	76	76
	Octopoteuthis sp	1	4	165	156	190	218	189	300
	Moroteuthis robsoni	1	3						
	Ommastrephes bartrami	1	1	287	287	287	687	687	687
	Ornithoteuthis antillarum	1	1	44	44	44	3	3	3
	Oegopsida unidentified	1	44						
	Ocythoe tuberculata	2	3						
Pseudorca crassidens	*Ommastrephes bartrami*	3	5	282	191	329	709	206	1038
(Zone B)	Oegopsida unidentified	1	1						
n=3	Cephalopoda unidentified	1	1						

Pontoporia blainvillei and *Sotalia fluviatilis*

Most of *Pontoporia blainvillei* examined were incidentally caught and were found to eat only neritic cephalopods. In the Zone A it preyed on all three loliginids of that region, *Loligo sanpaulensis* (1 to 154 g), that was the most frequent, *Loligo plei* (8 to 183 g) and *Lolliguncula brevis* (1 to 77 g). In the Zone B, from the estimated 2775 preyed cephalopods, 2686 were *Loligo sanpaulensis* measuring from 22 to 220 mm and 1 to 197 g followed by the pelagic *Argonauta nodosa*, *Loligo plei* and a few benthic sepiolids and octopuses (Table 5).

Loligo sanpaulensis is an important prey for the franciscana dolphin in all its distribution range, with high frequency of occurrence in its diet as formerly observed by Pinedo (1982), Ott (1994) and Bassoi (1997) for Rio Grande do Sul, Brownell (1975, 1989) from Uruguay and Perez *et al.* (1996) from Argentina.

Most *Sotalia fluviatilis* were also incidentally caught and occurred only in the Zone A. The cephalopods eaten by the estuarine dolphin were *Loligo sanpaulensis* (0.3 to 150

g), *Lolliguncula brevis* (1 to 17 g) and *Loligo plei* (3 to 183 g) (Table 5) of similar sizes than those eaten by *Pontoporia blainvillei* in the same zone (Fig. 3).

Table 5. Numbers, mantle length and total masses of cephalopods preyed by *Pontoporia blainvillei* and *Sotalia fluviatilis* sampled from Zone A: 21° to 26°S, and Zone B: 29° to 34°S (n= number of stomachs examined, S= number of stomachs with the cephalopod species and N= total number of individuals of each cephalopod species found).

				Mantle length (mm)			Total mass (g)		
	Cephalopod species	S	N	mean	range		mean	range	
Pontoporia blainvillei	*Loligo plei*	26	155	166	66	266	69	8	183
(Zone A)	*Loligo sanpaulensis*	41	593	51	20	219	8	1	154
n=57	*Lolliguncula brevis*	21	134	49	24	84	11	1	77
Pontoporia blainvillei	*Semirossia tenera*	2	2	38	32	45	4	2	5
(Zone B)	*Loligo plei*	17	27	154	68	211	58	9	109
n=111	*Loligo sanpaulensis*	105	2686	103	22	220	45	1	197
	Loliginidae unidentified	1	1						
	Eledone gaucha	1	1	21	21	21	1	1	1
	Octopus tehuelchus	2	3	27	24	29	5	3	6
	Argonauta nodosa	14	55	24	5	44	6	0.02	57
Sotalia fluviatilis	*Loligo plei*	28	137	152	41	266	61	3	183
(Zone A)	*Loligo sanpaulensis*	24	260	45	14	195	6	0,3	150
n=56	*Lolliguncula brevis*	28	199	41	25	60	5	1	17
	Loliginidae unidentified	11	14						

The sizes of *L. sanpaulensis* from both *Pontoporia* and *Sotalia* in the Zone A were smaller than those eaten by *Pontoporia* in the Zone B, while *Loligo plei* from both zones were small to middle sized, with mean ML around 150 mm (Fig. 3).

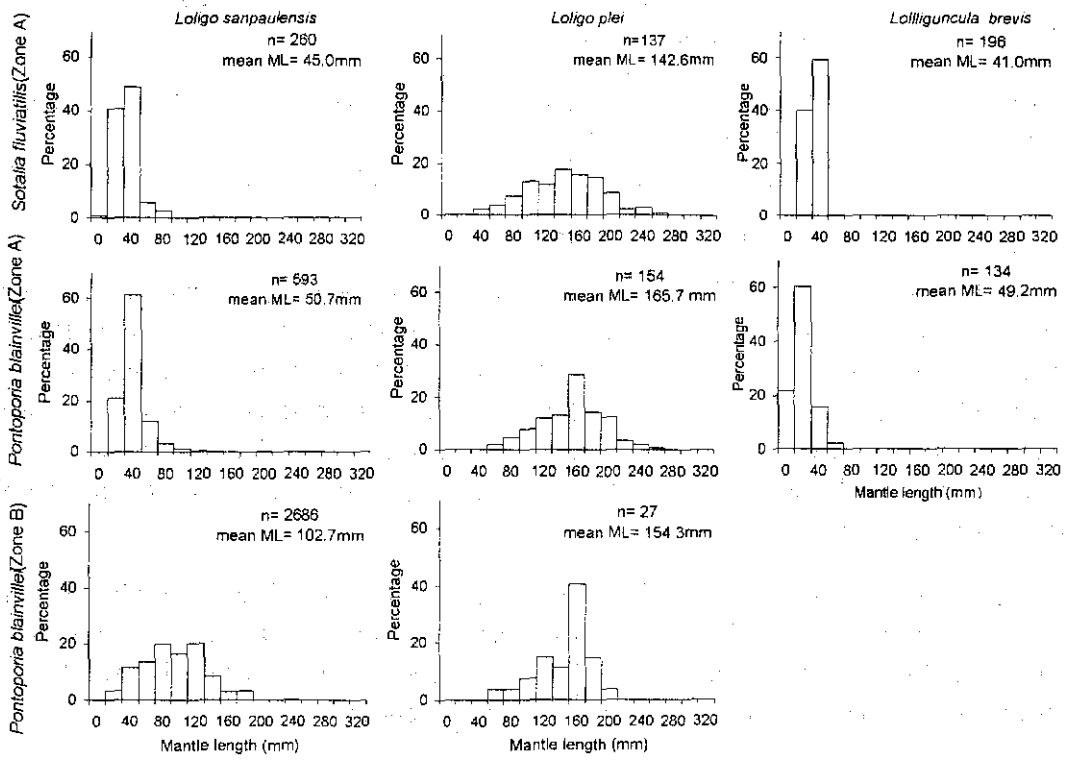

Figure 3. Mantle length distribution of *Loligo sanpaulensis*, *Loligo plei* and *Lolliguncula brevis* from the diet of *Pontoporia blainvillei* and *Sotalia fluviatilis* from Zone A: 21° to 26°S, and Zone B: 29° to 34°S. n= number of squids.

Kogia breviceps and *K. simus*

K. breviceps stranded in both zones and *K. simus* in Zone A were found to feed on continental slope and oceanic cephalopods (Table 6). Neutrally buoyant squids as *Histioteuthis* spp, *Chiroteuthis veranyi*, *Octopoteuthis* sp and Cranchiidae amounted to 65% of the specimens. Muscular families as Ommastrephidae, Lycoteuthidae and Onychoteuthidae represented 31 %. No remarkable differences in the families of cephalopods preyed between species and zones were observed and the cephalopods preyed were small to middle sized (1 to 413 g).

Cephalopods are found to be a major part of the diet of *Kogia* species (Caldwell and Caldwell, 1989). As also observed in our study, oceanic families as Chiroteuthidae, Histioteuthidae, Ommastrephidae, Onychoteuthidae, Lycoteuthidae and Octopoteuthidae were found in the diet of *Kogia breviceps* and *K. simus* from South Africa (Ross, 1979; Sekiguchi *et al.*, 1992).

Table 6. Numbers, mantle length and total masses of cephalopods preyed by *Kogia simus* and *Kogia breviceps* sampled from Zone A: 21° to 26°S, and Zone B: 29° to 34°S (n= number of stomachs examined, S= number of stomachs with the cephalopod species and N= total number of individuals of each cephalopod species found).

				Mantle length (mm)			Total mass (g)		
	Cephalopod species	S	N	mean	range		mean	range	
Kogia simus	*Semirossia tenera*	1	2	20	18	23	4	3	6
(Zone A)	*Heteroteuthis atlantis*	1	3						
n=2	*Chiroteuthis veranyi*	1	1	119	119	119	43	43	43
	Cranchiidae unidentified	2	24						
	Abralia redfieldi	1	23	29	22	36	2	1	4
	Enoploteuthidae unidentified	1	8						
	Histioteuthis spp	2	94	60	26	134	94	19	390
	Lycoteuthis diadema	1	7	94	81	109	57	28	96
	Octopoteuthis sp	1	1	147	147	147	166	166	166
	Moroteuthis ingens	1	1						
	Moroteuthis robsoni	1	3						
	Illex argentinus	1	1	224	224	224	215	215	215
	Ornithoteuthis antillarum	1	24	57	30	96	6	1	16
	Oegopsida unidentified	2	11						
	Japetella diaphana	1	1						
	Octopoda unidentified	1	1						
Kogia breviceps	*Chiroteuthis veranyi*	1	1						
(Zone A)	*Octopoteuthis sp*	1	1						
n=1	Oegopsida unidentified	1	1						
Kogia breviceps	*Heteroteuthis atlantis*	1	5						
(Zone B)	*Chiroteuthis veranyi*	1	1	104	104	104	29	29	29
n=2	*Abralia sp*	1	5	36	30	43	3	2	4
	Histioteuthis spp	2	16	71	57	93	113	72	184
	Lycoteuthis diadema	2	17	89	75	122	40	21	109
	Octopoteuthis sp	1	4	162	145	197	213	161	326
	Moroteuthis robsoni	1	2						
	Illex argentinus	2	25	217	146	281	212	64	413
	Ornithoteuthis antillarum	1	2	81	69	93	11	7	14
	Oegopsida unidentified	2	2						

Pinnipeds

All stomach contents of the three species of fur seals and the elephant seal were from Zone B (Table 7). *Arctocephalus australis* was found to eat *Loligo sanpaulensis* (5 to 157 g) and very small *Argonauta nodosa* (0.2 to 1 g). The only *Arctocephalus gazzella* sampled, besides *Loligo sanpaulensis* (46 g), ate *Alluroteuthis antarcticus*. *Arctocephalus tropicalis* fed on *Loligo sanpaulensis* (9 to 65 g), small to large *Ommastrephes bartrami* (21 to 1135 g), large *Illex argentinus* (483 to 836 g), large *Argonauta nodosa* of 71 to 439 g and *Ocythoe tuberculata*.

Young fur seals *Arctocephalus australis*, from breeding grounds off Uruguay, and vagrant adult males of *A. gazzella* and *A. tropicalis* from the Antarctic Convergence reach southern Brazil in winter (Pinedo *et al.*, 1992). *Alluroteuthis antarcticus* found in our samples, were probably eaten before the arrival to southern Brazil. All three species, fed to some degree on *Loligo sanpaulensis*, particularly large ones, only common in the inner shelf. It is probable that these neritic squids were eaten shortly before stranding. In the diet of *Arctocephalus tropicalis* from Antarctica, slope and oceanic cephalopods were also found (Bester and Laycock, 1985).

The stomach contents of a single *Mirounga leonina* had two large *Illex argentinus* (331, 351 g), one *Lycoteuthis diadema* (25 g) and one *Histioteuthis* sp (32 g) (Table 7). Cephalopods are frequent prey of the southern elephant seal (Klages, 1996). In Antarctic waters various squids and benthic octopods are frequent in its diet (Rodhouse *et al.*, 1992). The examined stomach content was of a vagrant sea elephant, well out of the usual distribution range of the species (Pinedo *et al.*, 1992) and probably is not representative of the diet of the species.

Table 7. Numbers, mantle length and total masses of cephalopods preyed by *Arctocephalus australis*, *Arctocephalus gazzella*, *Arctocephalus tropicalis* and *Mirounga leonina* sampled from Zone A: 21° to 26°S, and Zone B: 29° to 34°S (n= number of stomachs examined, S= number of stomachs with the cephalopod species and N= total number of individuals of each cephalopod species found).

				Mantle length (mm)			Total mass (g)		
	Cephalopod species	S	N	mean	range		mean	range	
Arctocephalus australis	*Loligo sanpaulensis*	15	37	98	45	185	39	5	157
(Zone B) n=15	*Argonauta nodosa*	1	3	15	10	18	1	0.2	1
Arctocephalus gazzella	*Loligo sanpaulensis*	1	1	111	111	111	46	46	46
(Zone B) n=1	*Alluroteuthis antarcticus*	1	5						
Arctocephalus tropicalis	*Loligo sanpaulensis*	3	14	93	58	135	31	9	65
(Zone B)	*Moroteuthis robsoni*	1	1						
n=8	*Illex argentinus*	1	6	332	297	359	677	483	836
	Ommastrephes bartrami	2	23	221	93	343	425	21	1135
	Ommastrephidae unidentified	3	10						
	Oegopsida unidentified	1	2						
	Argonauta nodosa	2	2	103	76	131	255	71	439
	Ocythoe tuberculata	1	1						
Mirounga leonina	*Histioteuthis sp*	1	1	53	53	53	63	63	63
(Zone B)	*Lycoteuthis diadema*	1	1	78	78	78	25	25	25
n=1	*Illex argentinus*	1	2	263	260	265	341	331	351

Discussion

Because coastal marine mammals were better represented in our samples, Loliginidae was the most frequently preyed family and *Loligo sanpaulensis* was the most frequent prey found in both regions. *Lolliguncula brevis* is a tropical estuarine and coastal species and its presence to the south of Santa Marta Grande Cape (29°S) was not confirmed in several surveys (Haimovici and Andriguetto, 1986; Haimovici and Perez, 1991a) and Museum collection revisions (Haimovici *et al.*, 1989; Perez and Haimovici, 1991). It was only preyed upon by *Pontoporia blainvillei* and *Sotalia fluviatilis* in coastal or estuarine waters in Zone A. Its absence in the stomach contents of franciscana dolphins from Rio Grande do Sul supports the assumption that the distribution limit of this species to the south is around 29°S.

Loligo sanpaulensis occurs in the shelf in the Subtropical Convergence Zone from 20° to 42°S (Roper *et al.*, 1984; Haimovici and Perez, 1991a) and is the most common coastal squid in southern Brazil (Haimovici and Andriguetto, 1986) where larger specimens occur only in the inner shelf and the small specimens can be found in the cold season up to the shelf break (Andriguetto and Haimovici, 1991; Haimovici and Perez, 1991b). Most of the coastal marine mammals, and some of the offshore species prior to stranding, fed on this squid. Its maximum sizes in the stomach contents from Zone A were smaller than those from Zone B (Fig. 3). This is consistent with observations from bottom trawl surveys in both zones (Juanico, 1979; Haimovici and Andriguetto, 1986; Andriguetto and Haimovici, 1991; Costa and Fernandez, 1993).

Loligo plei is a warm water species that is more abundant to the north of Santa Catarina (Costa and Haimovici, 1990; Perez *et al.*, 1997). Along Rio Grande do Sul it is only occasionally caught in the inner shelf but is frequent in the warm season in the outer shelf and upper slope (Haimovici and Andriguetto, 1986; Haimovici and Perez, 1991b). For this reason its presence in the stomach contents of offshore species as *Feresa attenuata* and *Orcinus orca* can be considered to be part of their normal diet in the region.

Benthic shelf octopuses and sepiolids were preyed in small numbers. This probably reflects the relative scarcity of benthic cephalopods in coastal waters of the region (Haimovici and Perez, 1991a). Few pelagic octopuses were also recorded and were unimportant in the diet of both coastal and oceanic marine mammals, found only in the diet of *Pontoporia blainvillei*, *Orcinus orca* and *Arctocephalus tropicalis* .

Ommastrephids were the most frequent offshore cephalopod prey: small and middle sized *Illex argentinus* and *Ornithoteuthis antillarum* in both zones and middle sized *Ommastrephes bartrami* in the Zone B. The presence of *Illex argentinus*, as expected, was more frequent in the stomach contents collected in the Zone B, in the cold season, when reproductive concentrations of this squid are found along the slope of southern Brazil (Santos and Haimovici, 1997). The families Histioteuthidae, Ommastrephidae, Cranchiidae, Onychoteuthidae, Lycoteuthidae and Chiroteuthidae were mostly preyed by offshore marine mammals as *Kogia breviceps*, *K. simus*, *Globicephala melas*, *Orcinus orca* and *Pseudorca crassidens*. No differences associated with latitudes that recalled our attention in the cephalopod family composition were observed between offshore marine mammals.

Cephalopod sizes varied from small to middle sized, the smaller was a *Argonauta nodosa* (0.02 g) eaten by *Pontoporia blainvillei* and the largest was a *Octopus vulgaris* (1210 g) eaten by a *Tursiops truncatus*. The mean weight of the different families of preyed cephalopods were plotted against the total length of their odontocete predators (Fig. 4). Odontocetes of less than 3 m long ingested cephalopods varying from 2 to 134 g, while odontocetes between 3 and 6 m long, fed on cephalopods of 309 g of mean TM. Differences were more evident for ommastrephids, that had mean masses of 56 to 62 g for odontocetes smaller than 3 m and 190 to 309 g in the larger specimens. Small sized squid are commonly observed in the diet of odontocetes, varying according to the types of cephalopods and regions in which they were eaten (Clarke, 1996).

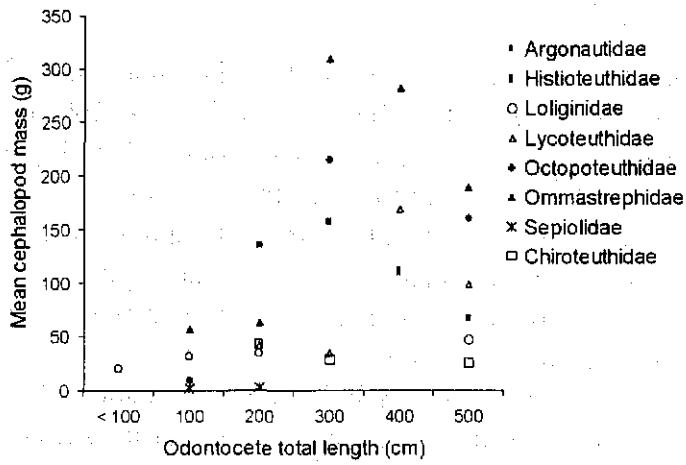

Figure 4. Mean total masses of the cephalopods of different families preyed by odontocete species of different total length.

Coastal marine mammals were frequently incidentally killed by fisherman in their gill nets (Pinedo, 1994), for this reason their stomach contents reflect better their "normal diet" than those of stranded offshore species. Despite our ignorance of the type of death and the low number of stomach contents per species and zone, some patterns were observed. The diversity of cephalopods as prey was small for shelf marine mammals and increased in upper slope and oceanic species (Fig. 2). As reported by Clarke (1996) for other regions, in southern Brazil loliginids were the most important cephalopods in the diet of inshore marine mammals and ommastrephids in diet of the offshore marine mammals. Globally, marine mammals do not seem to be important predators of cephalopods along southern Brazil compared with the far more abundant large pelagic tunas and related species fished in the region (Santos, 1992; Santos and Haimovici, in preparation).

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Appendix I. Source of stomach contents of marine mammal predators examined for predation on cephalopod species. (n= number of stomachs examined).

Marine mammal	n	Years	Source	City
Delphinus delphis	3	94-96	Eduardo Secchi, Museu Oceanográfico Prof. Eliézer Rios	Rio Grande-RS
Delphinus delphis	1	96	Marcos O. S. Santos, Universidade de São Paulo	São Paulo-SP
Delphinus delphis	1	97	Fernando Rosas, Universidade Federal do Paraná	Curitiba-PR
Feresa attenuata	1	94	Alexandre Zerbini, Universidade de São Paulo	São Paulo-SP
Globicephala melas	2	90-97	Eduardo Secchi, Museu Oceanográfico Prof. Eliézer Rios	Rio Grande-RS
Globicephala melas	3	85-93	Maria Cristina Pinedo, Fundação Universidade do Rio Grande	Rio Grande-RS
Lagenodelphis hosei	2	97	André Barreto, Fundação Universidade do Rio Grande	Rio Grande-RS
Lagenodelphis hosei	2	97	Ignácio Moreno, Grupo de Estudos de Mamíferos Marinhos	Porto Alegre-RS
Orcinus orca	3	94-98	Luciano Dalla Rosa, Museu Oceanográfico Prof. Eliézer Rios	Rio Grande-RS
Orcinus orca	1	94	Maria Cristina Pinedo, Fundação Universidade do Rio Grande	Rio Grande-RS
Pseudorca crassidens	3	96	Maria Cristina Pinedo, Fundação Universidade do Rio Grande	Rio Grande-RS
Sotalia fluviatilis	43	87-97	Ana P. Di Beneditto, Universidade Federal Norte-Fluminense	Campos-RJ
Sotalia fluviatilis	4	96-97	Marcos Oliveira S. Santos, Universidade de São Paulo	São Paulo-SP
Sotalia fluviatilis	9	97-98	Fernando Rosas, Universidade Federal do Paraná	Curitiba-PR
Stenella frontalis	5	92-97	Salvatore Siciliano, Museu Nacional do Rio de Janeiro	Rio de Janeiro-RJ
Stenella frontalis	1	97	Fernando Rosas, Universidade Federal do Paraná	Curitiba-PR
Steno bredanensis	1	97	Fernando Rosas, Universidade Federal do Paraná	Curitiba-PR
Tursiops truncatus	1	92	Salvatore Siciliano, Museu Nacional do Rio de Janeiro	Rio de Janeiro-RJ
Tursiops truncatus	1	96	Marcos O. S. Santos, Universidade de São Paulo	São Paulo-SP
Tursiops truncatus	1	91	Paulo Ott, Grupo de Estudos de Mamíferos Marinhos	Porto Alegre-RS
Pontoporia blainvillei	86	94	Manuela Bassoi, Museu Oceanográfico Prof. Eliézer Rios	Rio Grande-RS
Pontoporia blainvillei	25	92-94	Paulo Ott, Grupo de Estudos de Mamíferos Marinhos	Porto Alegre-RS
Pontoporia blainvillei	47	89-97	Ana P. Di Beneditto, Universidade Federal Norte-Fluminense	Campos-RJ
Pontoporia blainvillei	10	97-98	Fernando Rosas, Universidade Federal do Paraná	Curitiba-PR
Kogia breviceps	2	89	Eduardo Secchi, Museu Oceanográfico Prof. Eliézer Rios	Rio Grande-RS
Kogia breviceps	1	95	Robson da Silva	Santos-SP
Kogia simus	1	94	Regina Zanelatto, Universidade Federal do Paraná	Curitiba-PR
Kogia simus	1	98	Emerson Zampiroli, Centro de Estudos Mamíferos Marinhos	Santos-SP
Arctocephalus australis	12	93-94	Larissa de Oliveira, Grupo de Estudos de Mamíferos Marinhos	Porto Alegre-RS
Arctocephalus australis	3	92	Maria Cristina Pinedo, Fundação Univerdidade do Rio Grande	Rio Grande-RS
Arctocephalus gazzella	1	94	Larissa de Oliveira, Grupo de Estudos de Mamíferos Marinhos	Porto Alegre-RS
Arctocephalus tropicalis	3	94	Larissa de Oliveira, Grupo de Estudos de Mamíferos Marinhos	Porto Alegre-RS
Arctocephalus tropicalis	5	92	Maria Cristina Pinedo, Fundação Univerdidade do Rio Grande	Rio Grande-RS
Mirounga leonina	1	94	Paulo Ott, Grupo de Estudos de Mamíferos Marinhos	Porto Alegre-RS