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Insights on small cetacean feeding habits in southeastern Brazil

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Abstract

Descriptions on small cetacean feeding habits in Brazilian waters are scarce. Few studies were published and most showed only qualitative observations. In this paper, we present some insights on small cetacean feeding habits in Brazilian southeast waters. Nine stomach contents were recovered from marine tucuxi dolphins (*Sotalia fluviatilis*), one from a bottlenose dolphin (*Tursiops truncatus*), and one from a long-beaked common dolphin (*Delphinus capensis*). These specimens were found dead, floating in Cananéia estuarine waters (25°S), or stranded on beaches. Prey items were identified through the analysis of teleost fish otoliths, cephalopod beaks, as well as whole and undigested fishes and shrimps. From tucuxi stomach contents, 2,707 otoliths were recovered, belonging to 16 identified teleost species of the following families: Sciaenidae, Haemulidae, Gerreidae, Paralichtidae, Batracoididae, Trichiuridae, Engraulidae and Mugilidae. Total length varied from 32.1 mm to 330.8 mm, with modal classes varying from 32 mm to 92 mm. Demersal fishes usually associated with estuarine sandy bottoms were the main prey items. Sciaenid fishes that produce relatively loud sounds by swimbladder muscular contraction were observed as common prey items of *S. fluviatilis*. Marine tucuxis also preyed on brief squids (*Lolliguncula brevis*; Lolliginidae), as well as on shrimps (*Penaeus schmitii* and *P. paulensis*; Penaeidae). Cephalopods were the main prey items in *T. truncatus* and *D. capensis* stomach contents. *Octopus vulgaris* is reported for the first time as a prey item of *T. truncatus* in Brazilian waters. Despite the small number of stomach contents, a relatively high number of prey items was collected, quantified, and identified, providing new information on *S. fluviatilis*, *T. truncatus* and *D. capensis* feeding habits in southeastern Brazil.

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Introduction

To better comprehend the trophic dynamics of an ecosystem, it is extremely important to discern the role of each food web component. In estuarine and coastal waters around the world, cetaceans sometimes are considered the top predators. Investigation of feeding habits is one of the tools to describe ecological importance in ecosystems (Katona & Whitehead, 1988). Descriptions on small cetacean feeding habits in Brazilian waters are scarce. Few quantitative studies were conducted and remain unpublished, concerning to the following species: Franciscana, *Pontoporia blainvillei* (Pinedo, 1982; Ott, 1994; Bassoi, 1997; Di Beneditto, 2000); and the tucuxi dolphin, *Sotalia fluviatilis* (Da Silva, 1983; Di Beneditto, 2000). Other communications described qualitative insights on some species feeding habits, including the killer whale, *Orcinus orca* (Castello, 1977; Dalla Rosa, 1995; Ott & Danilewicz, 1998), the false killer whale, *Pseudorca crassidens* (Pinedo & Rosas, 1989; Moreno, 1999), the pygmy killer whale, *Feresa attenuata* (Zerbini & Santos, 1994), the dwarf sperm whale, *Kogia simus* (Pinedo, 1987), the pygmy sperm whale, *Kogia breviceps* (Secchi *et al.*, 1994), the Burmeister's porpoise, *Phocoena spinipinnis* (Pinedo, 1989), the Atlantic spotted dolphin, *Stenella frontalis* (Emerim *et al.*, 1994; Moreno, 1999), the marine tucuxi dolphin, *S. fluviatilis* (Carvalho, 1963; Borobia & Barros, 1989; Schmiegelow, 1990; Barros &

Teixeira, 1994), the franciscana dolphin, *P. blainvillei* (Schmiegelow, 1990), the Fraser's dolphin, *Lagenodelphis hosei*, the common dolphin, *Delphinus* sp., the rough-toothed dolphin, *Steno bredanensis*, and the bottlenose dolphin, *Tursiops truncatus* (Moreno, 1999). Furthermore, Secchi & Vasque-Junior (1998) presented some information on killer whales (*O. orca*) predation on tuna (*Tunnus* sp.) and swordfish (*Xiphias gladius*) longline fisheries in southern Brazil. A few other studies on small cetacean feeding habits were conducted and presented in scientific meetings in the 1990's, but remain unpublished. We present some new information on the analyses of stomach contents retrieved from nine marine tucuxis, *S. fluviatilis*, one long-beaked common dolphin, *D. capensis*, and one bottlenose dolphin, *T. truncatus*. Those specimens were found dead, floating in Cananéia estuarine waters (25°00′S, 47°50′W), or stranded on beaches along the São Paulo state southern coast and the Paraná state northern coast, Brazil.

The first available data on cetacean feeding habits in this region came from the analysis of an incidentally captured tucuxi in Cananéia estuarine waters (Carvalho, 1963). That specimen had one weakfish (*Cynoscion* sp.; Sciaenidae) in its stomach. Schmiegelow (1990) retrieved five complete and two incomplete stomach contents of stranded tucuxis found between 1986 and 1988 on coastal beaches. That author identified 65 (24.4%) of 266 fish otoliths. The most common prey were the Atlantic cutlass fish (*Trichiurus lepturus*; Trichiuridae) and drums (*Stellifer* sp.; Sciaenidae). Schmiegelow (1990) also presented observations on two franciscana stomach contents, from which he identified 85 otoliths pertaining to shortfin croakers (*Isopisthus parvipinnis*; Sciaenidae), drums (*Stellifer rastrifer*, *S. brasiliensis* and *Stellifer* sp.; Sciaenidae), and four cephalopod beaks pertaining to the squids *Dorytheuthis plei* and *Lolliguncula brevis*. No more published studies are available for the quoted region.

Materials and Methods

From August 1995 to December 1998, beach surveys to investigate cetacean strandings were conducted along Ilha Comprida (74 km) and Marujá (17 km) beaches, São Paulo state coast, as well as along Praia Deserta (24 km) at Ilha do Superagui, Paraná state coast (Fig. 1). During this period, a total of 124 cetacean strandings involving eight species (*S. fluviatilis*, *T. truncatus*, *P. blainvillei*, *S. froutalis*, *D. capensis*, *S. bredanensis*, *Balaenoptera acutorostrata* and *B. edeni*) was reported, from which the contents of 11 stomachs were recovered: *S. fluviatilis* (9), *D. capensis* (1) and *T. truncatus* (1).

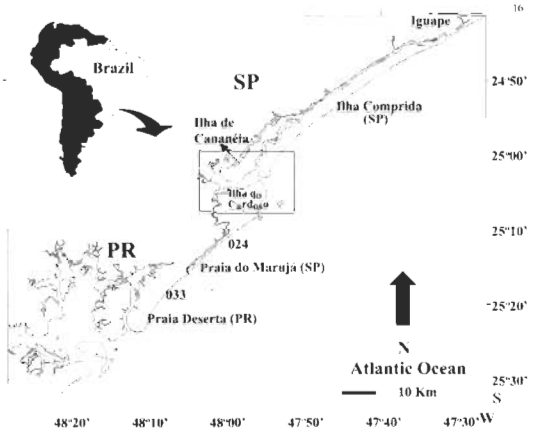

Figure 1. Sites where dead cetaceans were reported along the southern coast of São Paulo (SP) and the northern coast of Paraná (PR), Brazil, from August 1995 to December 1998. Stranding sites of one *D. capensis* (024) and one *T. truncatus* (033) are indicated by numbers, and the area where dead *S. fluviatilis* (000, 015, 020, 021, 050, 083, 095, 101 and 102) were found is indicated by a smaller box.

From the total, four tucuxi stomachs were empty. Added to the stranded specimens, four floating tucuxis were found dead in local estuarine waters, and their stomach contents were retrieved. Details of the eleven studied cetacean specimens (field number, date and site of notification, gender, total length, and age) are presented in Table 1.

Prey items were identified through the analyses of fish otoliths and cephalopod beaks, as well as whole and undigested fishes and shrimps. Whole fishes and not totally digested ones were identified based on a Brazilian fish identification guide prepared by Menezes & Figueiredo (1980). Fish otoliths and cephalopod beaks were identified through reference collections of the "Laboratório de Recursos Pesqueiros Demersais e Cefalópodes Fundação Universidade de Rio Grande" (LRPDC FURG), and also with the help of specific identification keys (Bastos, 1990; Corrêa & Vianna, 1992/3). The number of otoliths, beaks and shrimps found in each stomach content are presented in Table 1. Cetacean ages were estimated based on Growth Layer Group counts (more details in Santos, 1999), following the protocols presented by Perrin & Myrick (1980).

Both otholiths and beaks were measured to estimate the teleost fish total lengths and the cephalopod total lengths and weights, based on regression equations of the LRPDC FURG, as well as other ones presented by Bastos (1990) and by Correa & Vianna (1992/3). We used the sagittal otoliths for species identification because they show more

Table 1. Data on small cetaceans found dead along the beaches of Ilha Comprida (I.C.), Marujá and Deserta, southeastern Brazil, from August 1995 to December 1998. Number of prey items (N) found in each stomach is represented, as well as dolphins total length (TL) and growth layer groups (GLGs).

Field number	Dolphin species	Date (D/M/Y)	Reported site	TL (cm)	Age (GLGs)	Sex	Otoliths (N)	Beaks (N)	Shrimps (N)
PA-000	*S. fluviatilis*	16/08/95	I. C.	190	7	M	25		
PA-015	*S. fluviatilis*	30/07/96	I. C.	183	28	F	109	1	
PA-020	*S. fluviatilis*	05/08/96	Estuary	183		M	2223	70	1
PA-021	*S. fluviatilis*	19/08/96	I. C.	187		F	63	243	7
PA-024	*D. capensis*	20/08/96	Marujá	210	13	M		4	
PA-033	*T. truncatus*	19/09/96	Deserta	276	26			25	
PA-050	*S. fluviatilis*	10/10/96	I. C.	187		F	1		
PA-083	*S. fluviatilis*	15/07/97	Estuary	173	21	F	106	4	
PA-095	*S. fluviatilis*	11/10/97	Estuary	163	7	M	173		1
PA-101	*S. fluviatilis*	18/12/97	I. C.	156	29	F	6		
PA-102	*S. fluviatilis*	10/02/98	Estuary	178	21	M	1		

features to distinguish species and are recommended for use in piscivorous species diet studies (Lagler *et al.*, 1977). The only exception was the drums (*Stellifer* sp.), because their lapilli otoliths are relatively large and easily identifiable (Chao, 1978). These otholiths were observed in two tucuxi stomach contents (PA-020 and PA-083), but their numbers did not exceed the total number of sagittal otoliths found in both stomachs. To avoid biases, only the sagittal otoliths were used in calculating the numeric frequency. The cephalopod beaks were measured based on Clarke (1986*a*).

For each cetacean stomach, the largest number of otoliths, from the ones oriented to the right and to the left, was assumed to be the minimum number of ingested fishes. The same occurred with lower and upper cephalopod beaks. The numeric frequency (NF) of fish prey items was calculated only for *S. fluviatilis*. It was considered as the total number of identified individuals belonging to a specific *taxon*, divided by the total number of identified individuals consumed by all the analysed tucuxi specimens (Hyslop, 1980). The frequency of occurrence (FO) of fish prey was calculated for *S. fluviatilis*, and defined as the number in all stomachs of a particular *taxon*, divided by the total number of stomachs with contents (*Ibid.*).

Results

We recovered a total of 2,707 teleost fish otoliths, 347 cephalopod beaks, three whole fishes, and nine shrimps (Table 1), and identified 1,444 otoliths (53.3%) at the species level and a further 1,222 otoliths (45.2%) at the genus level. The other 41 otoliths (1.5%) could not be identified because they were almost digested. Only two cephalopod beaks could not be identified at the species level. All the identified fish and cephalopod species and genera are presented in Table 2.

Many fragments of Atlantic cutlass fishes (*T. lepturus*) were identified inside the stomachs of *D. capensis* and *T. truncatus* specimens. In the latter, a 42-cm long *T. lepturus* was observed. Three cephalopod beaks were found in the *D. capensis* stomach, pertaining to the squids *Loligo plei* (1) and to an unknown Loliginidae species (2). Five octopus (*Octopus vulgaris*) and nine squid (*L. plei*) beaks were identified as the bottlenose dolphin's prey items.

Sixteen fish species were identified as tucuxi prey items (Table 2). Those fishes belonged to the following families: Sciaenidae, Haemulidae, Gerreidae, Paralichtidae, Batracoididae, Trichiuridae, Engraulidae and Mugilidae. The largest frequency of occurrence (FO) was observed for the banded ground drum (*Paralonchurus brasiliensis*; Sciaenidae) and the rake stardrum (*Stellifer rastrifer*), that occurred in 55.6% of all investigated stomachs. The largest numeric frequency (NF) was observed for the rake stardrum, *S. rastrifer* (69.6%). The estimated total length of the fish species ranged from 32.1 mm to 330.8 mm (see Table 3), with a predominant length ranging from 32 mm to 92 mm (Fig. 2). The brief squid *Lolliguncula brevis* (Lolliginidae) was found in four stomach contents. The estimated cephalopod lengths ranged from 28.44 mm to 58.43 mm (Fig. 3). Their estimated weights ranged from 1.2 g to 9.3 g (Table 3). The shrimp species *Penaeus brasiliensis* and *P. schimitii* (Penaeidae) were reported in one marine tucuxi stomach.

Discussion

Barros & Odell (1990) discussed the validity of inferring the cetacean feeding habits based on

Table 2. Mininum number (N) of fishes, cephalopods, and shrimps observed inside the stomach of dead tucuxis along the southeast coast of Brazil from August 1995 to December 1998. The number of stomachs in which prey items were found (O) is presented, as well as the numeric frequency (NF), and the frequency of occurrence (FO).

	N	NF %	O	FO %
Teleost Fishes				
Sciaenidae				
Cynoscion jamaicencis	2	0.2	2	22.2
Cynoscion leiarchus	1	0.1	1	11.1
Cynoscion virescens	1	0.1	1	11.1
Isopisthus parvipinnis	75	7.7	3	33.3
Larimus breviceps	6	0.6	2	22.2
Macrodon ancylodon	1	0.1	1	11.1
Micropogonias furnieri	11	1.1	4	44.4
Paralonchurus brasiliensis	57	5.8	5	55.6
Stellifer brasiliensis	52	5.3	2	22.2
Stellifer rastrifer	680	69.6	5	55.6
Stellifer sp. (*)	1413		2	
Haemulidae				
Orthopristhis ruber	2	0.2	2	22.2
Pomadasys corvinaeformis	8	0.8	2	22.2
Gerreidae				
Eucinostomus argenteus	1	0.1	1	11.1
Engraulidae				
Anchoa sp.	17	1.7	3	33.3
Mugilidae				
Mugil sp.	2	0.2	1	11.1
Paralichtidae				
Paralichthys orbignyanus	1	0.1	1	11.1
Batracoididae				
Porichthys porosissimus	18	1.8	1	11.1
Trichiuridae				
Trichiurus lepturus	1	0.1	1	11.1
Unidentified fish	41	4.2	6	66.7
Total number	*977*	*100.0*		
Cephalopods				
Loliginidae				
Lolliguncula brevis	172		4	
Total number	*172*			
Crustaceans				
Penaeus paulensis	1		1	
Penaeus schmitii	7		1	
Unidentified shrimp	1		1	
Total number	*9*			

(*)Lapilli otoliths probably pertaining to the other two reported *Stellifer* species.

stranded individuals. When possible, the sampled individual health condition must be reported. However, Mead *et al.* (1980) suggested that in many cases observed in Florida, apparently healthy stranded cetaceans had not eaten before the stranding. On the other hand, it is important to take caution when reaching conclusions about stranded cetacean health, because many reported anomalies could be provoked by the stranding event (Cowan *et al.*, 1986). No apparent signs of disease or trauma were observed in all the investigated specimens.

Despite the small number of stomach contents sampled, a relatively high number of prey items was collected, identified, and quantified, providing new information on *S. fluviatilis*, *T. truncatus* and *D. capensis* feeding habits in Brazilian waters. We describe the presence of octopus (*Octopus vulgaris*) for the first time as a bottlenose dolphin prey item in Brazilian waters. The recovery of only one

Table 3. Estimated lengths (mm) of fishes (TL = Total Length) and cephalopods (ML = Mantle Length) observed in the stomach of dead tucuxis found along the southeast coast of Brazil from August 1995 to December 1998. Cephalopod estimated weights (g) are also presented. The number of individuals used to reach the estimated values is represented by (N). Data on TL/ML are represented by the average (A), the standard deviation (SD), minimum (Min), and maximum (Max) values.

	N	A	SD	TL/ML min	TL/ML max
Teleost fishes					
Cynoscion jamaicencis	2	93.5	51.62	57.0	130.0
Cynoscion leiarchus	1	248			
*Cynoscion virescens**					
Isopisthus parvipinnis	56	139.8	27.3	102.4	198.1
Larimus breviceps	6	105.1	16.0	87.1	129.8
Macrodon ancylodon	1	281.0			
Micropogonias furnieri	11	162.3	71.6	56.8	330.8
Stellifer brasiliensis	52	106.1	18.2	60.9	155.4
Stellifer rastrifer	657	61.9	9.9	34.8	108.4
Paralonchurus brasiliensis	57	149.3	39.6	39.3	208.1
Orthopristhis ruber	2	37.3	7.3	32.1	42.4
Pomadasys corvinaeformis	7	90.6	19.8	49.2	108.0
Eucinostomus argenteus	1	119.1			
Anchoa sp.	17	73.4	13.1	55.2	106.0
Mugil sp.	2	147.6	3.5	145.1	150.0
Paralichthys orbignyanus	1	93.1			
*Porichthys porosissimus***					
Trichiurus lepturus	1	182.9			
Cephalopods					
Lolliguncula brevis	172	40.1	7.9	28.4	58.4
Total weight	172	3.5	1.9	1.2	9.3

*Regression equation not available.
**Otoliths in advanced stage of digestion.

stomach for both common and bottlenose dolphins limits further conclusions on their feeding habits. Both stomachs contained many fragments of cutlass fishes and few cephalopod beaks.

The small number of marine tucuxi stomach contents analysed also do not allow the authors to make a detailed appraisal of this species' feeding habits. Some of the observed prey items were already reported in other studies along the marine tucuxi distribution (e.g., Borobia & Barros, 1989; Schmiegelow, 1990; Barros & Teixeira, 1994; Di Beneditto, 2000), but other items like the smooth weakfish (*Cynoscion leiarchus*; Sciaenidae), the roughneck grunt (*Pomadasys corvinaeformis*; Haemulidae), the spotfin mojarra (*Eucinostomus argenteus*; Gerreidae), the common flounder (*Paralichthys orbignyanus*; Paralichtidae), and the rose shrimp (*Penaeus schimitii*; Penaeidae) are

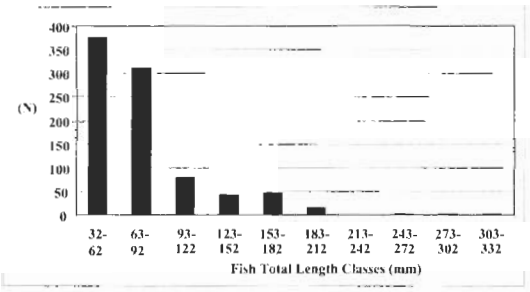

Figure 2. Distribution of the teleost fish total length classes observed as *S. fluviatilis* prey items.

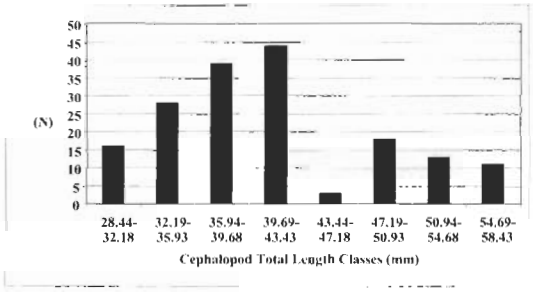

Figure 3. Distribution of the cephalopod total length classes observed as *S. fluviatilis* prey items.

described for the first time. Most of the identified fishes are demersal and associated with sandy or muddy bottoms. The total lengths of tucuxi prey (Fig. 2), added to the biological data on the identified preys, indicate a large representation of juvenile fishes, probably because of their large abundance in local estuarine waters (Besnard, 1950; Schaeffer-Novelli *et al.*, 1990; Mendonça, 1998). The sciaenid fishes represented 91.8% of all the identified teleost prey. Except for the kingfishes (*Menticirrhus* sp.), all the other sciaenid fishes have a well-developed swim bladder that acts as a resonance box to vibrations provoked by muscular contraction (Tavolga, 1964; Menezes & Figueiredo, 1980). Because local estuarine and coastal waters are relatively shallow and dark because of the constant suspension of sediments (Tessler, 1982), those fishes could be more susceptible to local tucuxis that can detect their sounds. The strategy of using sound for prey localization and capture has been published elsewhere (e.g., Myrberg, 1983; Rossbach & Herzing, 1997). Besides that, the large relative abundance of sciaenid fishes in local waters described by Mendonça (1998) could contribute to their large abundance as dolphin prey items.

The identified prey items that have the largest frequency of occurrence values are not considered as the most economically important in the area. Mendonça (1998) reported that in the last 30 years the main product caught by fishery boats was the seven-barb shrimp (*Xiphopenaeus kroyeri*; Penaeidae). There is a seasonal capture of fishes with drift and waiting nets. Usually, the main fishery operation is directed towards the king weakfish (*Macrodon ancylodon*; Sciaenidae) and to the white mullet (*Mugil curema*; Mugilidae) in the first quarter of the year, and to the whitemouth croaker (*Micropogonias furnieri*; Sciaenidae) and to sharks (Carcharhinidae) in the second quarter.

The brief squid (*L. brevis*) is common and abundant all year-round in local coastal and estuarine waters (Haimovici & Perez, 1991). However, their numbers may be overestimated when compared to other fish prey. Cephalopod beaks could have a higher tendency to accumulate inside cetacean stomachs when compared with otoliths (Clarke, 1986*b*). This is one of the drawbacks in stomach content analysis studies. Other limitations are related to incorrect identification, difficulty in identifying prey items that are almost digested, differences on the vulnerability of each prey to digestion based on their size and body structures, and scoring prey of prey ingested by cetaceans (Fitch & Brownell, 1971; Recchia & Read, 1989; Pierce & Boyle, 1991; Barros, 1993; Walker, 1996). Although the magnitude of the effect of these problems in cetacean feeding habits studies is unknown, the methodology applied in this and in many other studies is still considered one of the main tools to investigate cetaceans diet. Field observations can provide some clues about feeding habits. In photo-identification studies developed between May 1996 and July 2001, local tucuxis were observed foraging and preying on mullets (*Mugil curema* and *Mugil platanus*; Mugilidae) in shallow estuarine waters (Santos *et al.*, 2000). Pictures of mullets being thrown into the air by tucuxis and also grabbed in their mouths reveal the fish species. However, we never observed other fish species, squids, or shrimps being taken.

Based on the collected biological material, we could only present some insights of small cetaceans feeding habits. To join more precise information, it is necessary to develop a broader study involving stranding and incidental capture observation efforts in the surveyed region. Beach surveys must be conducted in shorter time intervals than 15 days, as most of the stranded cetaceans we found were in an advanced state of decomposition. A local stranding network, even in non-populated regions, could help to retrieve more fresh biological material. Most of the fishing fleet that operates along local coastal waters come from two major harbors in Santos (24°S) and in Itajaí (27°S). In 1996, only 14 boats were operating with wait and drift nets at Cananéia (Mendonça, 1998), and no efforts were developed to investigate cetacean incidental captures. Thus, the only way to get more information on local dolphins feeding habits is to add a stranding network to the local beach surveys, and to develop an incidental capture monitoring survey in southern and in southeastern Brazil.

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