Feeding habits of *Sotalia fluviatilis* in the Amazonian Estuary

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ABSTRACT. In this paper we present an analysis of the fifty *S. fluviatilis* feeding habits in the Amazonian Estuary. Animals were bycaught by the artisanal fishing fleet between 1996 and 2001. Feeding habits were analyzed by prey occurrence frequency (%F) and number percentage and stomachs contents preys similarity between marine and freshwater fish species present in the Amazonian Estuary. Thirteen fish species were identified (%F= 86.6), the most significant families were Sciaenidae (32%), Trichiuridae (26%) e Ariidae (16%), and four crustaceans species (%F=26). *S. fluviatilis* feeding habits did not differ by gender and in general, calves had higher prey diversity than juveniles and adults. The similarity was high (0.89) between estuarine *S. fluviatilis* feeding habits and the fishes species present in the Amazonian Estuary when the environment is mostly marine.

Key words: *Sotalia fluviatilis*, amazonian estuary, feeding habits of dolphins.

RESUMO. Hábitos alimentares de *Sotalia fluviatilis* no estuário amazônico. Objetivou-se descrever e analisar os hábitos alimentares de 50 golfinhos *Sotalia fluviatilis* capturados acidentalmente na frota pesqueira artesanal do Estuário Amazônico entre 1996 e 2001. As presas foram identificadas e calculadas a freqüência de ocorrência e numérica; testada a similaridade entre a diversidade de presas dos conteúdos e a diversidade de peixes marinhos e de água doce do estuário e, comparados os hábitos alimentares por sexo e categoria de maturidade. Ocorreram 13 espécies de peixes (86,6%) onde as famílias Sciaenidae (32%), Trichiuridae (26%) e Ariidae (16%) foram mais representativas e, quatro espécies de crustáceos (26%). A espécie não apresentou diferenças nos hábitos alimentares entre sexos, mas, os filhotes tiveram maior diversidade de presas que jovens e adultos. Finalmente, houve maior similaridade (0.89) entre a diversidade de presas de *S. fluviatilis* e as espécies de peixes quando o estuário apresenta características marinhas.

Palavras-chave: *Sotalia fluviatilis*, estuário amazônico, hábitos alimentares de golfinhos.

Introduction

The genus *Sotalia* was considered monospecific, and its species *S. fluviatilis* was a marine and fluvial ecotype (Borobia, 1989). However, recent studies of mitochondrial DNA sequence variation (Furtado *et al.,* 1998) and skull tridimensional morphometric analysis (Monteiro-Filho *et al.,* 2002) showed the possible existence of two species: *Sotalia fluviatilis* in the Amazonas River Basin (Silva and Best, 1994; Trujillo, 1994) and *Sotalia guianensis* in coastal waters from Nicaragua (14º35'N) (Carr and Bonde, 2000) to southern Brazil (27º35'S) (Simões-Lopes 1988). By captured animals in the Amazonian Estuary (in the Amazonas River mouth, Marajó Bay and the Amapá State coast) were analyzed in this study and *S. fluviatilis* was the nomenclature adopted for this species.

The feeding habits of *S. fluviatilis* were described by Williams (1928); Borobia and Barros (1989); Schmiegelow (1990); Di Beneditto *et al.* (2001) and Santos *et al.* (2002). Main prey items were pelagic (*Trichiurus lepturus, Pellona harroweri* and other clupeids), demersal (*Cynoscion spp., Porichthys porosissimus, Micropogonias furneri,* and other scianides), neritc cephalopods (*Loligo sp., Lolliguncula brevis, Dorytheuthis plei*), shrimps (*Penaeus brasiliensis*) and small catfishes (*Bagre bagre, Arius spixii*). Di Beneditto *et al.* (2001) reported that of 32 species of fish found in the stomachs of specimens from the north of Rio de Janeiro region, 75% were demersal, 22 were pelagic and 3% pelagic-demersal.

In contrast, *S. fluviatilis* feeds on 28 species of fish, 52% curimatids, 39% sciaenids and 9% siluriformes (82% the species were pelagic with nearly 75% being schooling fish) Silva (1983) and Silva and Best (1994). However, little is known about the feeding habits of *S. fluviatilis* in the Amazonian Estuary, although 56% of the species reported, in elsewhere, were estuarine (Di Beneditto

et al., 2001) indicate a large representation of juvenile fishes, probably because of their large abundance in local estuarine waters (Santos *et al.,* 2002).

Material and methods

In this note we present an analysis of the *S. fluviatilis* feeding habits in the Amazonian Estuary. Animals were bycaught by the artisanal fishing fleet from the town of Vigia, Pará State (aprox. 4°N to 1°S and 47°W to 51°W. Figure 1) between October 1996 and March 2001.

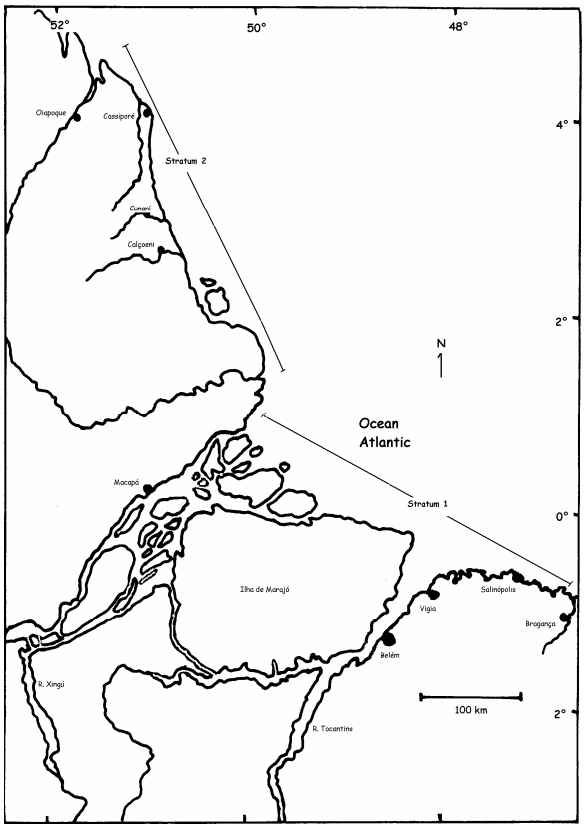

Figure 1. Strata, study and work sites of drifting gillnet artisan fishing fleets on the Amazonian estuary.

Fifty dolphins (24 females and 26 males) were examined: 18 adults (>155 cm long), 8 juveniles (120-155 cm long), and 24 calves (<120cm long). Sample stomach fullness was: Seven stomachs were full (75-100%), nine semi-full (50-74%), 29 semi-empty (5-49%) and 5 empty (0-4%). The empty stomach has otoliths, spinal columns, head bones, eye lenses and shrimps fragments. Feeding habits were analyzed by prey occurrence frequency (%F) and number percentage i(%N) (Hyslop, 1980) and stomachs contents preys similarity between marine and freshwater fish species present in the Amazonian Estuary was determined by the Baroni-Urbani and Buser coefficient (Krebs, 1989) .

Results and discussion

Stomach contents included the following: whole fish (n=96), otoliths (n=1,836 pairs), eye lenses (n=1,853 pairs), vertebrae (n=47), spines (n=36), head bones (n=103), lower jaw (n=25), spinal columns (n=142) urostyles (n=17), whole shrimp (n=75), shrimp heads (n=26) and tails (n=92) and, whole squid (n=1), squid peaks (n=1) and quills (n=1). All of which served to identify the prey.

Thirteen fish species (%F= 86.6; 1,175 preys; %N=91.2) belonging to eight families, were identified: Engraulididae (%F=8) (*Anchoa spinifer,*), Ariidae (%F=16) (*Bagre bagre, Chathrops spixii, Arius couma* and *Arius phrygiatus*), Pimelodidae (%F=4) (*Brachyplatystoma vaillantii*), Carangidae (%F=6) (*Oligoplites palometa* and *Caranx crysos*), Sciaenidae (%F=32) (*Plagioscion squamosissimus, Macrodon ancylodon, Stellifer* sp.), Mugilidae (%F=10) (*Mugil curema*) and Trichiuridae (%F=26) (*Trichiurus lepturus*). The other items were crustaceans with %F=26 and %N=8.5 (109 preys) (*Penaeus subtilis, Xiphopenaeus kroyeri, Farfantepenaeus brasiliensis* and *Lithopenaeus schmitti*) and cephalopods with %F=6.7 and %N=0.3 (*Loligo plei*) (Table 1).

Table 1. Prey in feeding habits of *Sotalia fluviatilis* in the Amazonian Estuary. %F: frequency of occurrence S: season of occurrence of the prey (YR: year round, Sum: summer, Win: winter), %N: percentage in number of the prey, G: gender the dolphins (F: female, M: male), MC: maturity category (A: adult, Y: young, C: calve).

Family (%F/%N)	Food item (number of preys)	S	%F	%N	G	MC
	Milk		4		2^{F}	2^{C}
Loliginidae (4/0.3)	*Loligo plei* (4)	YR	4	0.3	$1^{F}1^{M}$	$1^{C}1^{Y}$
Penaeidae (26/8.5)	*Penaeus subtilis.* (106)	YR	24	8.2	$7^{F}5^{M}$	$3^{C}5^{Y}4^{A}$
	Xiphopenaeus kroyeri (1)	YR	2	0.08	1^{F}	1^{F}
	Farfantepenaeus brasiliensis (1)	YR	2	0.08	1^{F}	1^{F}
	Lithopenaeus schmitti (1)	YR	2	0.08	1F	1A
Trichiuridae (26/9)	*Trichiurus lepturus* (116)	YR	26	9.0	$3^{F}10^{M}$	$3^{C}10^{A}$
Ariidae (16/37)	*Bagre bagre* (266)	Sum	16	20.6	$2^{F}6^{M}$	$6^{C}2^{A}$
	Chathrops spixii (195)	Sum	14	15.1	$2^{F}5^{M}$	$5^{C}2^{A}$
	Arius couma, (7)	Sum	8	0.5	$1^{F}3^{M}$	$3^{C}1^{A}$
	Arius phrygiatus (9)	Sum	10	0.7	$1^{F}4^{M}$	5^{C}
Pimelodidae (4/1.6)	*Brachyplatystoma vaillantii* (21)	YR	4	1.6	$1^{F}1^{M}$	2^{C}
Scianidae (32/16.3)	*Plagioscion squamosissimus* (166)	YR	20	12.9	$5^{F}5^{M}$	$6^{C}1^{Y}3^{A}$
	Macrodon ancylodon (35)	Sum	16	2.7	$4^{F}4^{M}$	$4^{C}1^{Y}3^{A}$
	Stellifer sp. (9)	Sum	4	0.7	$1^{F}1^{M}$	2^{C}
Mugilidae (10/13)	*Mugil curema* (167)	Sum	10	13	$2^{F}2^{M}$	$2^{C}2^{A}$
Carangidae (6/2.7)	*Oligoplites palometa* (34)	Win	4	2.6	$1^{F}1^{M}$	$1^{C}1^{A}$
	Caranx crysos (1)	Sum	2	0.08	1^{M}	1^{A}
Engraulididae (8/11.6)	*Anchoa spinifer* (149)	Sum	8	11.6	$2^{F}2^{M}$	$2^{C}2A$

The total number of preys were 1,288 and the prey species length ranged from: *A. spinifer* 9-11.5 cm; *B. bagre* 10-21 cm; *C. spixii* 9.5-19 cm; *B. vaillantii* 6.4-13.8 cm; *O. palometa* 17-21 cm; *C. crysos*

18.5 cm; *P. squamosissimus* 24-38 cm; *M. ancylodon* 20-33 cm; *Stellifer* sp. 7-9 cm; *M. curema* 8.5-12 cm; *T. lepturus* 35-49 cm; *P. subtilis* 4.8-10 cm.

The family Sciaenidae was the most frequent occurring prey (%F=32) and the second most on number percentage (%N=16.3). In this family, *P. squamosissimus* was the most important prey with %F=20 and %N=12.9, found in the stomachs of animals of every maturity category, and *M. ancylodon* was %F=16 but only %N=2.7.

Trichiuridae was the second most significant family in the feeding habits of *S. fluviatilis* (%F=26), and *T. lepturus* was the most frequent prey (%F=26), found in the stomachs of adult males, mainly.

The catfishes, of the family Ariidae, which were identified in the stomach content *B. bagre* (%F=16), *C. spixii* (%F=14) *A. phrygiatus* (%F=10) and *A. couma* (%F=8). This family had %F=16 and the most %N=37. *Bagre bagre* was the most important prey %N=20.6 in the feeding habits of the *S. fluviatilis* in the Amazonian Estuary, followed by *C. spixii* with %N=15.1.

The family Penaeidae was an important food item to *S. fluviatilis* in the study area, near to Sciaenidae family, with %F=26, but their number percentage was low (8.2%).

Families Mugilidae and Engraulididae were half important in *S. fluviatilis* feeding habits in the Amazonian Estuary, their occurrence frequency and the number percentage were very close to (%F=10 and %N=13 for *M. curema* and %F=8 and %N=11.6 for *A. spinifer*).

Sotalia fluviatilis feeding habits did not differ by gender, and 93,3% of the prey were both common to males and females. Two small calves (104 and 108 cm long) had a milky substance in the stomach. In general, calves had higher prey diversity than juveniles and adults (Table 1). Variation in prey diversity between the specimens can be suggesting a food selectivity, which could be related to the ability in capturing food.

Baroni-Urbani and Buser coefficient showed a similarity of 0.89 between estuarine *S. fluviatilis* feeding habits and the fishes species present in the Amazonian Estuary when the environment is mostly marine, and with a similarity of 0.33 when the Amazonian Estuary is mostly freshwaterly.

Species of family Sciaenidae were found in the Amazonian Estuary throughout the year (Barthem, 1985), thus they were always available to *S. fluviatilis*. *Plagioscion squamosissimus* is also the species most consumed by *S. fluviatilis* in Central Amazon (Silva, 1983). Fishes from the family Sciaenidae constitute an important prey item in the feeding habits of *S. fluviatilis* along its distribution (Borobia and Barros, 1989; Schmiegelow, 1990; Di Beneditto *et al.,* 2001; Santos *et al.,* 2002).

These species from the family Sciaenidae, present in the feeding habits of *S. fluviatilis*, Barthem (1985) showed that *P. squamosissimus* is present in the Amazonian Estuary throughout the year, but for during the summer, when the salinity increases from 0.5% to 2-10%, these species occur in very small numbers. The others two species are presents only during the summer.

The *T. lepturus* was of fundamental importance in the feeding habits of *S. fluviatilis* north from Rio de Janeiro (Di Beneditto *et al.,* 2001) and for the others species of dolphins with *Tursiops truncatus* and *Delphinus capensis* to southeastern (Santos *et al.,* 2002), but this specie only represented by %N=9.0 in the feeding habits of *S. fluviatilis* in the Amazonian Estuary,

The former three species (*B. bagre*, *C. spixii* and *A. phrygiatus*) were abundant in the Amazonian Estuary during the winter summer transition (between May and June) and during the summer (between August and October); while *A. couma* abounded in the Amazonian Estuary throughout the year (Barthem, 1985).

The family Pimelodidae, wasn't an important prey with %F=4 and %N=1.6. The only species found in the feeding habits of *S. fluviatilis* was *B. vaillantii*, that occurred in the Amazonian Estuary at all times, yet with higher abundance in winter (between February and April) (Barthem, 1985).

Silva (1983) indicated catfish represent an important source of energy for the *S. fluviatilis* being the second most significant group of fish in its feeding habits. For the *S. fluviatilis* to Amazonian Estuary the catfish are the most significant group in the feeding habits, following the family Sciaenidae.

The family Penaeidae was an important food item to *S. fluviatilis* in the study area. It was an important industrial and artisanal fishery shrimp in the Amazonian Estuary, with an annual capture of 8,300 tons of *P. subtilis* (Ibama, 1994; Paiva, 1997). These species are mainly distributed in slime or sand habitats, whith up to 190m deep waters; presenting a positive correlation between body length and deep. Juveniles were found in the estuaries and lagoons (Paiva, 1997).

However, according to Borobia and Barros (1989); Schmiegelow (1990); Di Beneditto *et al.* (2001) and Santos *et al.* (2002), at times they are recorded in the feeding habits of *S. fluviatilis* in other areas. This group's occurrence frequency was high and it's number percentage in the Amazonian

Estuary might be underestimated due to the specimens the high digestive process.

The main preys found in *S. fluviatilis* stomach contents were schooling fish species with pelagic and demersal habits, mostly *T. lepturus.* This species is common in inshore and estuarine waters, and the adults are schooling fish remaining on the surface and feeding during the day and, migrating to the bottom at night, whereas juveniles (prey presents in the stomach of the *S. gianensis*) remaining schooled in the middle waters during the day and migrated to the surface at night (Nakamura and Parin, 1990). In the Amazonian Estuary *T. lepturus* is one of the most frequent species between 20 and 50m of deep, and it constitutes mixed communities with *M. ancylodon* (Jica, 1998).

Both *P. squamosissimus* and the shrimp were important preys in the feeding habits of predators such as *Arius parkeri, Arius proops* and *Brachyplatystoma*. While, *M. ancylodon* was rare in the feeding habits of siluriform predators, this species was an important prey in the feeding habits of *Cynoscion acoupa* (Barthem, 1985). Stomach contents analysis of some predator fish which are also artisan fishery target species showed that they feed on the some species as *S. fluviatilis.* These showed to be otoliths of *B. bagre* and *P. squamosissimus,* heads of *M. curema*, otoliths and bodies of *M. ancylodon* and shrimp of the genus *Penaeus* (Beltrán-Pedreros, 1998).

Baroni-Urbani and Buser coefficient showed a high similarity between estuarine *S. fluviatilis* feeding habits and the fishes species present in the Amazonian Estuary when the environment is mostly marine and low similarity when the Amazonian Estuary is mostly freshwaterly. These findings showed that estuarine *S. fluviatilis* feeding habit was primarily composed of marine-estuarine species. In general, marine species were most abundant even 50 m deep, while the freshwater catfish occupied the shallow area (5-20 m) (Jica, 1998; Ibama, 1999).

It was impossible to determine the importance of prey in the feeding habits of *S. fluviatilis* in the Amazonian Estuary, because many preys were quickly digested and many stomach contained only otoliths, eye lenses, vertebrae, spines, head bones and fragments of fishes. Besides, the specimens used were the bycatch in the gill nets of the artisanal fisheries and these animals had drowned.

The ingestion the water and the regurgitation during death stress, maybe have changed actual weight data, occurrence frequency and number of preys. This methodological problem, plus the absence of biometrics relations between body length/ body weight and, body length/ of otoliths dimensions these preys, for inferring the original size and weight in the study area.

Therefore, the occurrence frequency provides a somewhat crude qualitative picture of the food spectrum whereas the number percentage offers a better indication of the amount of effort exerted in selecting and capturing different preys, yet numerical estimates overemphasize the importance of small prey items taken in large numbers (Hyslop, 1980). In general, dolphins consume the most abundant trophic resources and select the prey according to the body size and capturing facility (Matthews, 1988).

Data provided by the Amazonian Estuary fishing fleet, concerning the amount of landed species showed the 5% of them belonged to family Sciaenidae, but this percentage included all species (Paiva, 1997), however, *P. squamosissimus* represent's only 0.2% and *M. ancylodon* 0.6% of the total amount of landed fish (Jica, 1998; Ibama, 1999).

The other species landed by the artisanal fishery were *M. curema* and *P. subtilis* representing 10% and 11% respectively. All these species were main prey items for *S. fluviatilis* in the study area, indicating that these is little competition between fisheries and *S. fluviatilis* in the Amazonian Estuary, but it may get higher when both *S. fluviatilis* and the fishing fleet target species search for the some preys.

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