

ACTIVITY BUDGETS AND DISTRIBUTION OF BOTTLENOSE DOLPHINS (*TURSIOPS TRUNCATUS*) IN THE PATOS LAGOON ESTUARY, SOUTHERN BRAZIL

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Abstract: The common bottlenose dolphin, *Tursiops truncatus*, is one of the world's best known cetaceans. However, there are few studies on the activity budgets and distribution of this species along the Brazilian coast. This study aimed at describing and quantifying the behavioral activity of *T. truncatus* in the Patos Lagoon Estuary, Rio Grande do Sul state, southern Brazil (ca. 32°09'S, 52°05'W). The study area was divided into three sub-areas according to the proximity to the estuary mouth. The behavioral data were gathered every 5 minutes following a focal group sampling approach. A total of 34 boat surveys were conducted between December 2001 and January 2003, totaling 66.95h of direct observation and 672 records of behavioral activities. The first 15 minutes of each group encounter were discarded to avoid the influence of the boat approach on dolphin behavior. The most observed behavior was feeding (37.64%), followed by traveling (29.17%), travel-feeding (21.87%), socializing (5.8%), milling (4.33%) and resting (1.19%). There was not a significant difference among the frequencies of commonly observed behaviors: feeding, traveling and travel feeding ($p > 0.05$, t-test for proportions). Dependence between activity and season was detected in subareas I and II ($p < 0.001$; Pearson's X^2), as well as an association between activity and sub-areas ($p < 0.001$; Pearson's X^2). Regarding group size, 56.41% of the activities recorded were carried out by groups of 1 to 3 dolphins, 31.63% from 4 to 6, 10.25% from 7 to 10, and 1.71% by groups with more than 10 individuals. This study confirmed the importance of the Patos Lagoon Estuary as an area for bottlenose dolphins to conduct their daytime activities, in particular feeding.

Resumo: O boto ou golfinho nariz-de-garrafa, *Tursiops truncatus*, é um dos cetáceos mais bem conhecidos no mundo. Entretanto, existem poucos estudos sobre a atividade comportamental e distribuição desta espécie ao longo da costa brasileira. O objetivo deste trabalho foi descrever e quantificar os comportamentos de *T. truncatus* no Estuário da Lagoa dos Patos, Rio Grande do Sul, Brasil (32°09'S, 52°05'W). A área de estudo foi dividida em três subáreas de acordo com a proximidade da desembocadura do estuário. Os dados comportamentais foram registrados a cada 5 minutos seguindo uma metodologia de amostragem de grupo focal. Um total de 34 saídas foram conduzidas entre dezembro de 2001 e janeiro de 2003, totalizando 66,95h de observações diretas e 672 registros de atividades comportamentais. Os primeiros 15 minutos de cada grupo encontrado foram descartados a fim de evitar qualquer influência da aproximação da embarcação no comportamento dos animais. O comportamento mais observado foi alimentação (37,64%), seguido por deslocamento (29,17%), deslocamento com alimentação (21,87%), socialização (5,8%), *milling* (4,33%) e descanso (1,19%). Não houve diferença significativa entre as frequências de comportamento mais comuns: alimentação, deslocamento e deslocamento com alimentação ($p > 0,05$, teste t para proporções). Detectou-se uma dependência entre o tipo de atividade e a estação do ano nas subáreas I e II ($p < 0,001$, Pearson's X^2), assim como uma associação entre o tipo de comportamento e a subárea ($p < 0,001$, Pearson's X^2). Com respeito ao tamanho do grupo, 56,41% das atividades registradas foram realizadas por grupos de 1 a 3 indivíduos, 31,63% de 4 a 6, 10,25% de 7 a 10 e apenas 1,71% por grupos com mais de 10 indivíduos. Este estudo confirma a importância do Estuário da Lagoa dos Patos como área para os botos executarem suas atividades diurnas, em especial a alimentação.

Keywords: common bottlenose dolphin, *Tursiops truncatus*, activity budget, behavioral ecology, distribution, group size, Brazil.

Introduction

The common bottlenose dolphin (*Tursiops truncatus*) is found in temperate and tropical waters worldwide. The species is common in pelagic as well as coastal waters, where they are often found in bays and tidal creeks, and are even known to travel up rivers (Leatherwood *et al.*, 1983a; Rice, 1998; Cubero-Pardo, 2007). The existence of several nearshore populations and some long-term studies has made *T. truncatus* one of the best known cetaceans, with described coastal and offshore forms or ecotypes (Leatherwood *et al.*, 1983a; Segura *et al.*, 2006) which differ in physiology, morphology, and ecology (Duffield *et al.*, 1983; Hersh and Duffield, 1990; Mead and Potter, 1990).

In Brazilian waters, the common bottlenose dolphin has been reported from the northeastern (Alves Júnior *et al.*, 1996) to the southern (Simões-Lopes, 1991; Castello and

Pinedo, 1977) coasts. In the state of Rio Grande do Sul, southern Brazil, bottlenose dolphins are commonly found in coastal waters, forming small populations or sub-populations associated with river and estuary mouths (Möller *et al.*, 1994). However, there have been few studies on their behavior along the Brazilian coast (Pryor and Lindbergh, 1990; Möller, 1993). Bottlenose dolphins in the Patos Lagoon estuary, southern Brazil, form a small and resident population estimated at 83 dolphins (95% CI: 72-90; Dalla Rosa, 1999). A previous study on the behavioral activities of this population showed that dolphins used the area for all activities, especially feeding, and usually concentrated near the estuary mouth in small groups of up to 5 individuals (Möller, 1993).

The opportunistic feeding habits of *T. truncatus* are demonstrated by its use of various foraging strategies (Shane, 1990). Bottlenose dolphins feed upon a wide

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variety of fish, including small rays and sharks, as well as cephalopods (squid and octopus), and occasionally shrimp (Leatherwood, 1975; Barros and Odell, 1990; Mead and Potter, 1990; Cockcroft and Ross, 1990). Whereas this wide range of feeding habits has led, along with social interactions, to the documentation of several types of behavioral events, their activity budgets are generally described in terms of four major categories: feeding, traveling, socializing and resting (Shane *et al.*, 1986). Studies on behavioral ecology lead to a better understanding of habitat use and of the potential impacts of habitat degradation and incidental mortality. This is particularly important for the management of small coastal populations of cetaceans. In this paper, we present new information on activity budgets and distribution of bottlenose dolphins in the Patos Lagoon estuary.

Material and Methods

The Patos Lagoon estuary (31°50'S, 52°20'W; Figure 1) is a nursery area for several commercially important species of fish from this region, including *Micropogonias furnieri*, *Cynoscion guatucupa*, *Paralichthys brasiliensis*

and *Menticirrhus americanus* (Chao *et al.*, 1985; Vieira and Scalabrín, 1991; Vieira, 2006). Located along the coastal plain of Rio Grande do Sul state, in southern Brazil, Patos Lagoon is the largest choked lagoon in the world (Kjerfve, 1986) and is characterized by industrial and artisanal fisheries, tourism, port activities and oil refinery, fertilizer and fish processing plants (Tagliani *et al.*, 2003). The Patos Lagoon is connected to the Atlantic Ocean through a narrow channel (0.5-3km), which is secured by two rock-jetties at the estuary mouth (Seeliger *et al.*, 1997). Marine water influx at this mouth can reach 1.3 m s^{-1} , and freshwater discharge after long periods of rain can result in currents of up to $1.7\text{--}1.9\text{ m s}^{-1}$ (DNPVN, 1941)³. The marine water intrusion is favored during periods with higher temperatures, lower precipitation and southwesterly winds, leading to higher salinity values in the estuary. Increased freshwater runoff and lower salinity values are observed during periods of high precipitation or prevailing northeasterly winds (*e.g.* Möller and Castaing, 1999). Mean water temperature ranges from about 25° C in January (warmest month) to 12° C in July (coldest month) (Laboratório de Tartarugas e Mamíferos Marinhos-FURG, unpublished data).

The study area was divided into three sub-areas according to the proximity to the mouth of the estuary, being sub-area I closest and sub-area III more distant from the entrance. Sub-area I comprises approximately 10km², sub-area II 20km² and sub-area III about 10km² (Figure 1). On occasion surveys extended to the adjacent coastal waters up to about 3km north and south of the estuary mouth.

Thirty-four boat surveys were conducted from December 2001 to January 2003. We used a 5.5m aluminum boat with a 50hp outboard engine. The survey design followed a zig-zag transect from north to south along the study area to increase the chance of encountering dolphin groups. Behavioral data were collected following the Focal Group Sampling approach (Altmann, 1974), in which the behavior of a focal group, characterized by the presence of at least one animal with identifiable natural markings, was recorded every 5 minutes. Approximately 51.5% of the individuals of the Patos Lagoon population show conspicuous long-lasting marks (Dalla Rosa, 1999) facilitating the use of this methodology.

A group was defined as any number of dolphins observed in apparent association, moving in the same direction, within 30m of any individual in the group and often, but not always, engaged in the same activity (see Shane, 1990). When a group was sighted, we slowly approached the group to minimize disturbance and recorded the time, sub-area, group size and geographic position using a hand-held GPS.

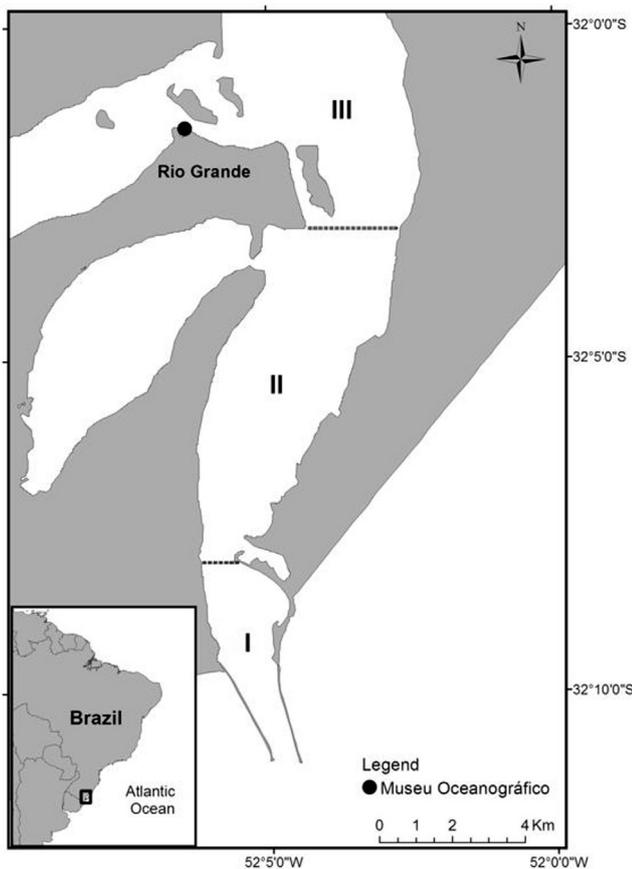


Figure 1. Map of the study area in the Patos Lagoon estuary. Roman numbers indicate the three sub-areas.

³ DNPVN (1941) Enchentes de maio de 1941. Diretoria Nacional de Portos e Vias de Navegação. Relatório Técnico, Porto Alegre.

Four major behavioral categories were considered in this study: feeding, traveling, socializing and resting (Shane, 1990). Feeding was characterized by the lack of directional movement. The animals generally surfaced and dove asynchronously while the entire group remained loosely aggregated over an area of several meters. Traveling was characterized by directional movement of a group, moving as a unit. Resting was characterized by low levels of activity during which almost no forward movement of the animals occurred. A resting animal slowly rose to the surface with its head and dorsal fin breaking the water simultaneously. Socializing animals surfaced together in a tight aggregation and often remained at or near the surface for several minutes. During this time, animals exhibited prolonged body contact, often in the form of slaps of the flukes or pectoral fins of one animal against the body of another.

Two additional categories included activities that did not fit well into the behaviors described above: milling and travel-feeding. Milling involved frequent changes in heading with movements generally lacking components of the other types of behavior (Shane, 1990). An association of traveling with feeding, travel-feeding was characterized by animals moving consistently in one direction while foraging and feeding regularly. Although this category could potentially be considered just feeding, we deemed that its frequency of occurrence and distinctive characteristics warranted a separate classification (e.g. Bearzi, 2005).

The first 15 minutes of each group encounter were discarded to avoid the influence of the boat approach on dolphin behavior. Observation periods were divided into three periods: 09:00-12:00h; 12:01-15:00h and 15:01-18:00h. Encounter rates of groups per hour of searching effort were calculated in order to adjust for unequal effort in the sub-areas, allowing us to verify area use by season and by time of the day.

The Pearson's X^2 test (Zar, 1984) was used to investigate associations among the type of behavior, season and sub-area. The t-test for difference of proportions (Zar, 1984) was used to verify if the frequencies of the observed behavioral categories were significantly different. All tests were performed using a 5% level of significance.

Results

Activity budgets

A total of 672 behavioral records were obtained during 66.95h of direct observation of dolphin

groups. Feeding was the most frequently observed activity (37.64%), followed by traveling (29.17%), travel-feeding (21.87%), socializing (5.8%), milling (4.33%) and resting (1.19%). There was no significant difference between feeding, traveling and travel-feeding frequencies (*t*-test for proportions, $p > 0.05$).

An association was observed between the activity and the sub-areas ($p < 0.001$; Pearson's X^2). All behavioral categories were observed in sub-area I, where feeding was the most frequent, followed by traveling ($n = 551$; Figure 2). Greater total effort was spent in sub-area I than in sub-areas II and III, partly as a consequence of higher encounter rates in this area (see Table 1). Only 101 behavioral observations were recorded in sub-area II, where travel-feeding was the most frequent activity (36.63%). The number of observations in sub-area III was too small to be statistically analyzed (Figure 2).

An association between activity and season was detected in sub-areas I and II ($p < 0.001$; Pearson's X^2). All behavioral categories were observed during summer, when feeding and traveling were the most frequent activities ($n = 218$; Figure 3). During fall, travel-feeding was the most frequently observed activity, whereas resting was not observed. Winter was the season with the highest relative frequency of feeding, followed by traveling and travel-feeding ($n = 124$; Figure 3). Traveling was the most frequent activity in spring, followed by feeding (Figure 3). There was no significant difference between traveling and socializing during this season (*t*-test for proportions, $p > 0.05$; Figure 3).

Regarding the distribution of activities according to the daytime periods, most observations were made in the morning (09:00-12:00h; $n = 304$), probably due to increased survey effort. Feeding was the most frequent activity during this period (Figure 4).

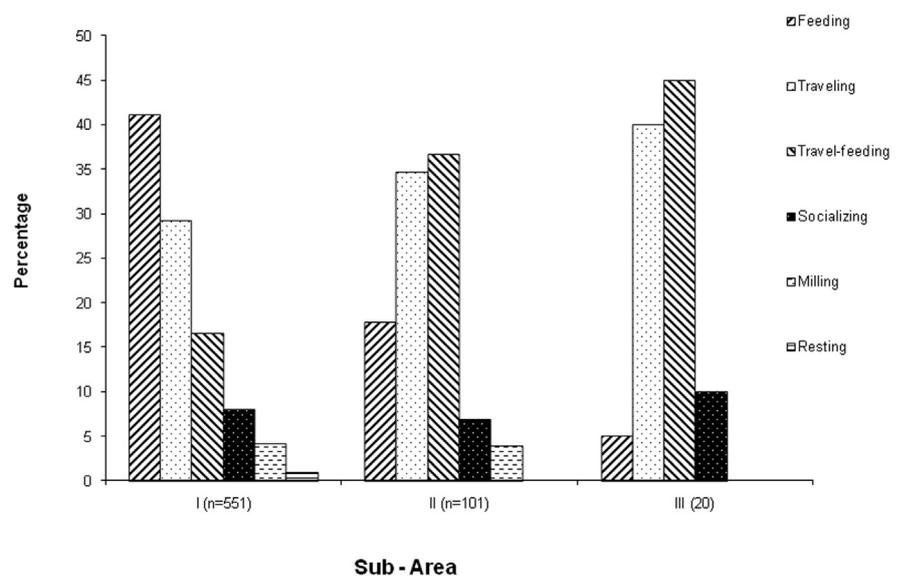


Figure 2. Activity budgets of bottlenose dolphins in the Patos Lagoon estuary, by sub-area.

Table 1. Encounter rates (groups per hour) of bottlenose dolphins in the Patos Lagoon estuary by sub-area, season and daytime period.

SUB-AREA	GROUPS	EFFORT (h)	ENCOUNTER RATE
I	102	29.02	3.51
II	11	26.01	0.42
III	4	11.54	0.34
Season			
Summer	35	16.04	2.18
Fall	34	11.47	2.96
Winter	23	13.38	1.72
Spring	25	25.68	0.97
Daytime			
09:00-12:00h	59	41.16	1.43
12:01-15:00h	40	19.21	2.08
15:01-18:00h	18	6.20	2.90

Effort refers to searching effort only.

During the 12:01-15:00h period, we observed an increase in both feeding and travel-feeding relative to the other periods (n=210; Figure 4). Feeding and traveling were the most frequent activity observed between 15:01h and 18:00h (n=158; Figure 4).

Distribution and Group Size

Bottlenose dolphins were present in the study area in all but one of the 34 surveys. A total of 117 groups were recorded between the Porto Novo of the city of Rio Grande and the mouth of the estuary, including adjacent areas. Most sightings occurred in sub-area I (Table 1; Figure 5).

The average group size was 4.05 dolphins (SD = 2.10). Group size frequencies were 25.63% for pairs, 20.66% for trios, 30.58% for groups of 4 to 6, 9.91% for 7 to 10, and 2.48% for larger groups. Lone individuals accounted for 10.74% of the sightings. Groups larger than 4 individuals were the most common in sub-area I (29%), followed by pairs and trios (20.9% each), while pairs and trios were most common in sub-areas II and III, respectively. Larger groups (>4) were also the most common during spring and summer (44 and 37.14%, respectively). Pairs predominated during fall (33.3%) and trios during winter (36.3%).

Discussion

Several techniques are available for recording animal behavior. Mann

(1999) presents a review on behavioral sampling methods for cetaceans and points out the potential biases of each method. According to this author, the focal-group sampling is not recommended because it tends to bias towards most common or conspicuous behaviors, therefore overestimating their relative importance in a group. Also, the focal-group methodology (Altman, 1974) was proposed for groups in which all individuals were continuously visible through the sampling period, and when these conditions were not met, this method should only be applied for individuals or pairs. Keeping in mind these limitations, we still chose to use this approach for several reasons. Groups, as we defined them, tend to be relatively small in our study area and engage in the same activity, minimizing the potential biases mentioned above. In addition, alternative methods also present difficulties. In particular, individuals that are visually identifiable from natural markings within a reasonable distance tend to be older and possibly males (e.g. Wilson, 1995); therefore using an individual-follow protocol would bias sampling towards this age and sex classes. Difficulties in distinguishing among unmarked animals would also potentially bias sampling methods such as scan sampling (Mann, 1999), where individuals should be sampled sequentially. And finally, for comparative purposes, we preferred to use the same method used in a previous study in the same area (see Möller, 1993). Once sampling was concluded, we compared the behavioral frequencies between groups of 1-2 individuals and groups of 3 or more individuals to verify if there was any evidence that the most common activities could have been overestimated in the larger groups, as suggested above. However, feeding actually decreased in larger groups, traveling and travel-feeding frequencies were similar and socializing and milling increased, suggesting that this type of bias was likely not important.

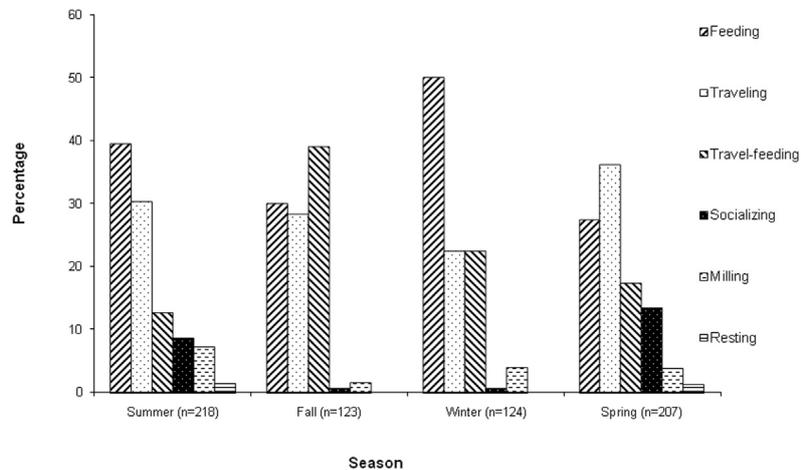


Figure 3. Activity budgets of bottlenose dolphins in the Patos Lagoon estuary, by season.

Feeding was the most common activity recorded in sub-area I. Möller (1993) also observed a higher amount of feeding in this sub-area, although with a lower relative frequency which was similar to socializing. This is not surprising because sub-area I comprises a narrow and steep channel with fast currents at the estuary mouth. Bottlenose dolphins seem to prefer narrow channels and features such as steep slopes, uneven bottom substrates and tidal eddies, which are known to attract or concentrate fish (Wilson *et al.*, 1997). By functioning as a bottleneck for fish moving through this kind of habitat, these features may help dolphins to take advantage of prey concentration, improving their foraging efficiency (Hastie *et al.*, 2004). The rocky formation of the jetties in sub-area I may also attract fish that commonly associate with rocks. Information on prey distribution and biomass would certainly improve our understanding of the behavior and distribution of bottlenose dolphins in the study area, and should therefore be pursued in future studies.

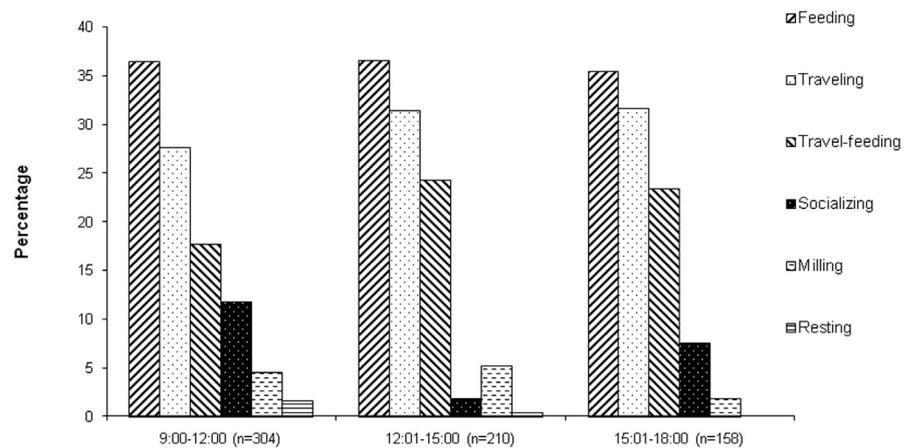


Figure 4. Activity budgets of bottlenose dolphins in the Patos Lagoon estuary, by daytime period.

Similar frequencies of socializing were observed in all sub-areas in our study, as opposed to a higher frequency of socializing observed by Möller (1993), and limited to sub-area I. Despite the constant traffic of cargo ships and fishing boats in the channel of sub-area I, resting was only observed on flat and sheltered waters that are present on the northeastern sector of this sub-area, adjacent to the channel. This finding corroborates the observations on resting made by Möller (1993).

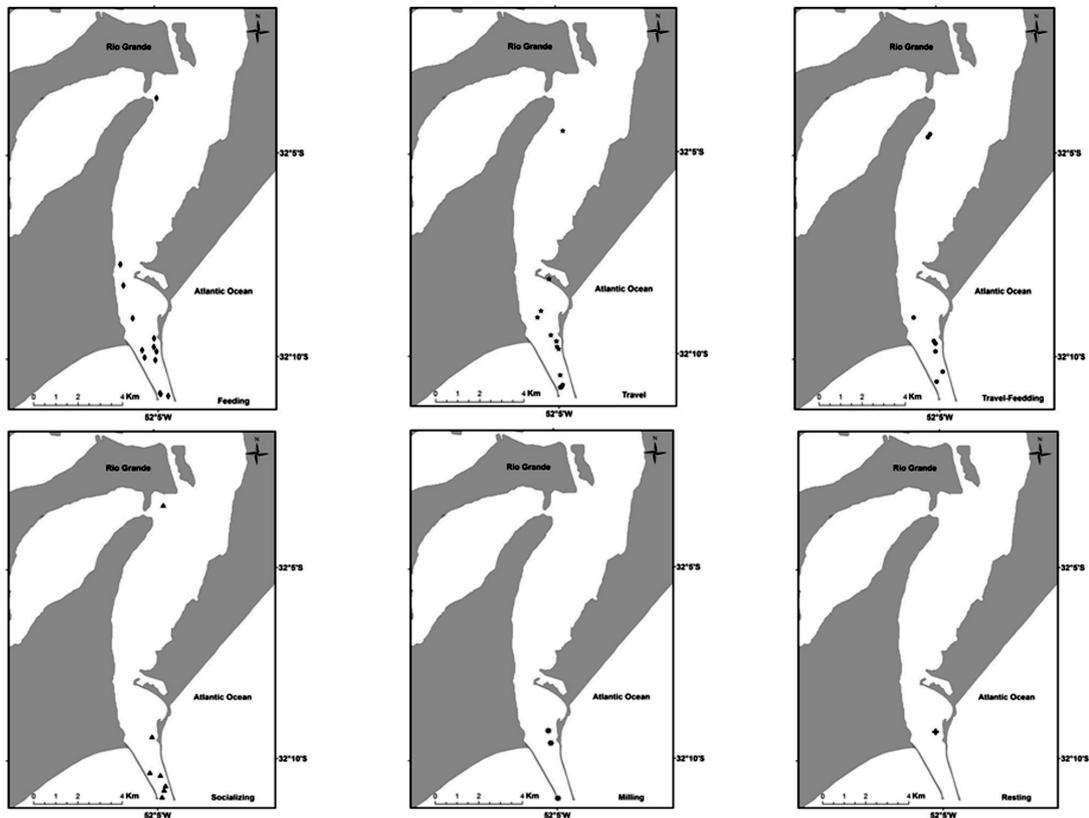


Figure 5. Distribution of the first activity recorded for each bottlenose dolphin group along the study area. Note that sampling of behavioral activities was not possible for all recorded dolphin groups.

Activity budgets also changed seasonally in sub-areas I and II. The higher relative frequency of feeding in winter, which was also observed by Möller (1993), and the predominance of travel-feeding in fall might be related to increased energy requirements in cold waters (Shane, 1990), lower prey densities in the study area or a change in diet. Pinedo (1982) reported a great amount of Scaenidae fish in the stomach contents of bottlenose dolphins stranded along the coast near the Patos Lagoon estuary. The white croaker, *Micropogonias furnieri*, accounted for nearly 80% of the absolute frequency of prey in the stomachs (Pinedo, 1982). However, the sample size was small and did not represent all seasons. Therefore, no conclusions can be drawn regarding seasonal variation in feeding preferences of this population and how it might affect their activities. From observations on surface feeding behavior, it is suggested that the cutless fish, *Trichiurus lepturus*, and the mullet, *Mugil platanus*, may also be important seasonal prey species. The Patos Lagoon estuary is a highly seasonal environment, with fish abundance and assemblage changing across the seasons (Ramos and Vieira, 2001). Specifically, fish abundance decreases drastically during the cold months, which could force the dolphins to spend more time feeding and foraging (e.g. Bearzi *et al.*, 1999). The highest frequency of socializing observed in the spring is likely due to an increase in the frequency of mating interactions. Considering that the gestation period in this species is approximately 10 to 12 months long (Wells *et al.*, 1987), this would explain the highest incidence of calves in the study area at the end of the spring and beginning of the summer (Fruct, 2008). Möller (1993) did not conduct surveys in spring; however socializing was the most frequently observed activity in the summer in her study. The few records of resting in our study were made in the spring and summer months, in contrast with the previous study, where resting was more frequent in the fall. However, the low number of resting observations should not be interpreted as an indication that this activity was not important in the study area. Given that our observation periods were limited to daylight hours, resting could be underestimated. Experiments with bottlenose dolphins in captivity suggest that resting at the surface may occupy between 50 and 70% of the nighttime in adults (Lyamin *et al.*, 2007), and telemetry data also indicate that wild bottlenose dolphins might engage in this activity predominantly at night (Mate *et al.*, 1995). Differences in activity budgets over the course of the day were not as marked as seasonal and spatial differences, at least for the most commonly observed activities. Feeding frequencies were relatively constant throughout the day, while Möller (1993) found a steady increase in feeding over the course of the day. Bottlenose dolphins in South Africa (Tayler and Saayman, 1972; Saayman *et al.*, 1973) and Texas (Shane, 1977; Shane *et al.*, 1986) fed more frequently in the early morning and late afternoon, possibly in response to the diurnal

patterns of prey. We observed a slight increase in traveling and especially travel-feeding in the early afternoon, with similar frequencies remaining in the late afternoon. Möller (1993) also observed a higher frequency of traveling in the beginning of the afternoon. Resting was more frequent in the morning, and it was not observed in the evening. Möller (1993) reported resting during the three periods, with a higher frequency in the morning, and bottlenose dolphins in Argentina also rested in the morning (Würsig and Würsig, 1979). During the present study, bottlenose dolphins were found all over the study area; however a preference for the region between the jetties in sub-area I was observed (Fig.5), similarly to previous studies in the area (Möller, 1993; L. Dalla Rosa, unpublished data). Common bottlenose dolphins tend to aggregate inside or near the entrances to estuaries, lagoons and bays (Leatherwood and Reeves, 1983b; dos Santos and Lacerda, 1987; Ballance, 1992; Fertl, 1994; Wilson *et al.*, 1997; Cortese, 2000; Garrison and Yeung, 2001; Read *et al.*, 2003), often concentrating in areas of fast tidal current (Irvine *et al.*, 1981; Shane, 1980, 1990; Harzen, 1998). Therefore, lower encounter rates in sub-areas II and III were expected. We suspect, however, that they were lower than usual. The 2002/03 warm El Niño event (McPhaden, 2004) that occurred during this study resulted in higher precipitation indices in the Patos Lagoon and salinity values below the average of the previous thirteen years (Laboratório de Ictiologia/Fundação Universidade Federal do Rio Grande, unpublished data). Salinity values in the Patos Lagoon estuary vary according to precipitation and wind-driven circulation (e.g. Calliari, 1980; Costa *et al.*, 1988), affecting the abundance and distribution of marine fish species (Garcia *et al.*, 2001) that are prey for the bottlenose dolphins. High salinity values in the inner portions of the estuary lead to increased marine fish abundance and thus have the potential to attract foraging dolphin groups further into the estuary. We assume low salinity values and decreased fish abundance would have the opposite effect, particularly in sub-areas II and III.

We must point out that we investigated the distribution of bottlenose dolphins only near the mouth of the Patos Lagoon estuary. As they also travel along the coastline, in both southward and northward directions, it would be important to carry out a larger-scale study to investigate the home range and core areas of this population.

The structure and composition of dolphin groups is based on the age, gender, kinship and reproductive condition of the individuals (Wells, 1991; Krützen *et al.*, 2003; Parsons *et al.*, 2003; Möller, 2006). Group size and composition in bottlenose dolphins varies among different populations. In the west coast of Florida, the average group size is about 10 animals (Scott and Chivers, 1990), while in California group sizes of about 18 (Hansen, 1990) and 9 (Bearzi, 2005) individuals have

been reported. In the present study, the average group size was very similar to that reported by Dalla Rosa (1999) for the same area (4.44 individuals) and by Campbell *et al.* (2002) for a Central American population, where 3.8 individuals were recorded. Flores and Fontoura (2007) reported a group size of 5.4 individuals in Baía Norte, Santa Catarina State, Brazil, for this species.

In conclusion, this study confirms the importance of the Patos Lagoon estuary for the population of bottlenose dolphins and demonstrates that the area next to the mouth of the estuary is highly used by the dolphins during the daytime and throughout the year, providing the necessary conditions for the accomplishment of vital activities such as feeding, socializing and resting.

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