

Sotalia guianensis population density estimative in the Bay of Antonina, Brazil

Estimativa da densidade populacional de Sotalia guianensis na Baía de Antonina

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Abstract

The present work aimed to estimate the population density of *Sotalia guianensis* in the Bay of Antonina, southern Brazilian coast, by linear transects, distance method. The average group size in the total area was 2.57 individuals/group. The study area is 28.1 km² and it was divided in two sub-areas, an outer area closer to the sea and another more enclosed with a higher fresh water input. In the Sector I, the one with greater marine influence, the density estimation found was $D = 3.01$ animals/km² (Variation Coefficient, VC 24.67%), whereas in Sector II there was no estuarine dolphin record. Also, during the rainy season a higher density value was found in the bay ($D = 4.99$ individuals/km², VC 15.93%). When the area division was ignored an overestimation of density was found ($D = 3.80$ animals/km²; VC 15.71%) due to the data extrapolation beyond the sampled area, including areas not much used by the dolphins. This superestimation due to the few estuarine dolphins records in the Bay of Antonina and also to the method used, which was biased by existing of sand banks at low tide which made it impossible to access all transects.

Keywords: Population density. Group. Bay of Antonina. Estuarine dolphin. *Sotalia guianensis*.

Resumo

O presente trabalho visou a estimar a densidade populacional de Sotalia guianensis na Baía de Antonina, litoral sul do Brasil, por meio de transecções lineares, método de distâncias. A área de estudo possui um total de 28,1 km² e foi setorizada em duas subáreas, sendo uma mais externa e outra com maior aporte de água doce. No Setor I, com maior influência marinha, a estimativa de densidade encontrada foi de $D = 3,01$ indivíduos/km² (CV 24,67%), ao passo que no Setor II não houve registros de botos-cinza. Ainda uma maior densidade foi encontrada na baía na estação chuvosa $D = 4,99$ indivíduos/km² (CV 15,93%), assim como no Setor I



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D = 4,01 indivíduos/km² (CV 24,49%). Quando a estratificação da área foi desconsiderada, notou-se uma superestimativa da densidade (D = 3,80 indivíduos/km²; CV 15,71%), em virtude da extrapolação dos dados para toda área amostral, inclusive para áreas pouco utilizadas pelos botos. O tamanho médio dos agrupamentos na área total foi de 2,57 indivíduos/agrupamento. O trabalho apresentou alguns dados superestimados, graças aos registros existentes na Baía de Antonina e também ao método utilizado que foi prejudicado pelos baixios arenosos existentes na maré baixa que impedia que todas as transecções fossem percorridas.

Palavras-chave: Densidade populacional. Agrupamentos. Baía de Antonina. Boto-cinza. *Sotalia guianensis*.

Introduction

The genus *Sotalia* is found from Honduras, Central America (DA SILVA; BEST, 1996) to Santa Catarina State, Southern Brazil (SIMÕES-LOPES, 1988). The acknowledgement of the two species for the genus is recent (CABALLERO et al., 2007; CUNHA et al., 2005; MONTEIRO-FILHO et al., 2002) and *S. guianensis* is reported with data deficient (DD) status by the World Conservation Union (IUCN, 2011).

Density estimation is one of the most relevant population studies because it can show increase, decrease or stability in the species number for an area (KREBS, 1989), and it is evaluated and expressed by individual numbers or population biomass per unity area or volume (ODUM, 1988). The present work was carried out with the marine species *S. guianensis*, commonly found in tropical, costal and estuary waters (CARVALHO, 1963), but it also has been recorded in rivers (NOWAK, 1999). Concerning the population estimation studies for this species it is possible to quote Edwards and Schnell's work (2001), north of its distribution, in the Cayos Miskito Reserve, Nicaragua. In addition to population estimation, the authors also gathered information about behaviour, activity and average group size.

In the south of Brazil, Geise (1991) and Geise et al. (1999) performed a work on density population estimation and populations composition of *S. guianensis* at the region estuarine-lagunar of Cananeia, São Paulo State and in the Bay of Guanabara, Rio de Janeiro State, they used not only inline transects but fixed points too. Bonin et al. (2008) surveyed density population estimation studies with this species in Cananeia region (São Paulo State) and in the Bay of Guaratuba and Bay of Paranagua (Parana State), south of Brazil. The Estuarine dolphin population density was studied

so by Flach et al. (2008) in the Bay of Sepetiba, Rio de Janeiro State, and by Havukainen et al. (2011) in Cananeia region, São Paulo State, both in southeast Brazil; and by Cremer et al. (2011) in the Bay of Babitonga, Santa Catarina State, in southern Brazil.

The Bay of Paranagua has many sectors that have not been studied yet, such as Bay of Antonina. Conversations with local inhabitants confirmed the presence of estuarine dolphins in this area, thus the present work recorded and quantified its occurrence, as well as the group average size and the animal's frequency in different times of the day and throughout the sampling months.

Materials and methods

Study area

The Parana coast has two bays, Bay of Paranagua in the north and Bay of Guaratuba in the south, both formed by marine ingressions. The Bay of Paranagua is delimited by the following coordinates: 25°20' a 25°36'S e 48°06' a 48°45'W, located north of Praia de Leste plain and includes several sectors with its own designations (BIGARELLA, 1978) one of these sectors is referred as Bay of Antonina (Figure 1) corresponding to the relief inward folding (ÂNGULO, 1993).

The regional drain, derived from small hydrographical bays of Serra do Mar and coastal plain, is very dense due to the high precipitation (its average is around 2.000 mm/ year at the coastal region). The bay's hydrographical conditions are strongly driven by the precipitation rates, which are higher on coastal plain (MAACK, 1981).

The area heterogeneity was considered as a relevant factor, thus it was divided in two sectors: sector

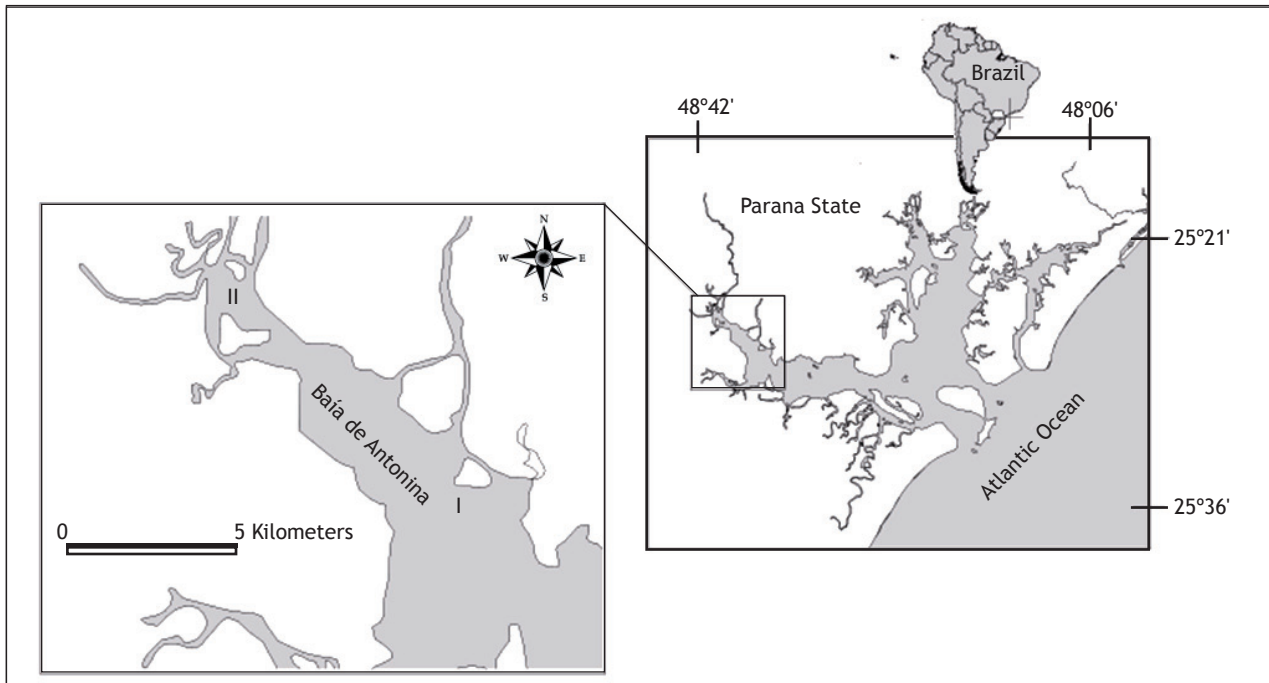


Figure 1 - Map of the Bay of Antonina, located at north of Parana State, south of Brazil, with the two sectors displayed

I with 8,5 km² comprising the inner side of the bay, and the Sector II with 19,6 km² in the outer side of the bay, more affected by the salt water that comes from the adjacent ocean, summarising a study area of 28,1 km².

Procedures

To estimate the estuarine dolphins population density in the Bay of Antonina, monthly samples were conducted in the period from 2003 May to 2004 April. Line transects were laid out in transverse position to each other and plotted in the region map. The determination of transects and length measurement were performed with nautical charts, topographic maps and GPS (Global Positioning System), what also made the location of transects easier when sampling.

The transects were chosen randomly, but factors such as boat, pilot, boat speed, observer position and weather conditions (wind < 2 km/h) were standardised and constant throughout the sampling, following the recommendations of Leatherwood (1979), Gaskin (1982) and Bonin et al. (2008).

It was considered a 90° field of vision when carrying transects out, both at starboard and portside

of the boat bow, recording the distance and the angle between the sighted estuarine dolphin and the boat (BUCKLAND et al., 1993; 2001; EBERHARDT et al., 1979). The distances were visually estimated after one calibration with telemeter before each sampling. The angles were measured with a 30 cm ray transferrer.

Group sizes

Estuarine dolphins are aggregative animals, and in this work the Monteiro-Filho (2000) definition for grouping identification was adopted: 1) the family, distinguished by the relationship and cohesion between the individuals, it can be formed with a pregnant female and one more adult; a female and its calf; one or two adults and one calf; 2) the school, distinguished by the association between families that get together for an specific propose, usually related to fish capture or changing location.

Population density estimation

Densities were estimated using the software *Distance 5.0* (THOMAS et al., 2006), with analyses

executed separately, both for different sectors and for different seasons, assuming one rainy season (from October to March) and one dry season (from April to September).

Three potential functions of detection were initially considered: uniform, half-normal and hazard-rate, along with other adjust terms. Models were compared with likelihood ratio tests and Akaike's information criterion (AIC) (BUCKLAND et al., 1993; 2001).

The animal's probability of detection at the line $g_{(0)}$ was assumed as equal to one (100%), since the average intervals that *S. guianensis* keeps submerged are short, fact that allied to the low and constant speed kept by the boat and that the study area is and estuary, it guarantees the animal exposure within the field of vision during the sampling (BUCKLAND et al., 1993; 2001).

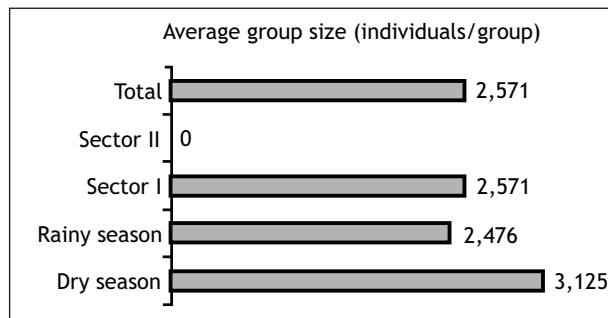
The coefficient of variation was calculated using the probability of detection, encounter rate and group size variation (BUCKLAND et al., 1993; 2001).

Results

It was performed a total of 12 field trips, beginning in 2003 May and finishing 2004 April. The sampling was carried out monthly summarizing 108 hours of sampling effort, 60 hours were spent covering the transects, with a total of 321,65 km covered.

Groups average size

Groups from 2 to 5 individuals were observed, the most frequent (61.53%) were those formed by 2 individuals. The average group size found was 2.57 individuals/group with a small variation between the two sectors and the two seasons sampled. (Graph 1).



Graph 1 - Average group size (individuals/group) of estuarine dolphin *S. guianensis* at Bay of Antonina, southern Brazil, in the period from 2003 May to 2004 April.

Source: Research data.

Population density estimation

The population density estimation of all individuals of *S. guianensis* found at Bay of Antonina (total area of 28.1 Km²) was $D = 3.80$ individuals/km² (CV 15.71%) and the groups density was $DS = 1.56$ groups/ km² (CV 24.87%). The total abundance estimated for this area was 44 individuals (CV 24.87%).

The estimator that best adjusted the population density estimation data of all animals found at the two sectors together at Bay of Antonina was the key function half-normal, with cosine adjustment term. According to the method premise that the further from the transects line the smaller the data precision, it was possible to graphically represent the probability of detection for the whole Bay of Antonina (Graph 2).

The individuals' distribution at the two sectors of the Bay of Antonina was not uniform (Table 1). The highest densities were found at the Sector I, which correspond to the outer area of the bay, closer to the ocean.

Table 1 - Estuarine dolphin's population density estimation (D), group's density (DS) and abundance (N) at the two Bay of Antonina's sectors, along with its corresponding coefficient of variation (CV)

Bay of Antonina			
Sectors	D (animal/km ²) (CV %)	DS (group/km ²) (CV %)	N (CV %)
I	3.01 (24.67)	2.13 (30.71)	42 (30.71)
II	0	0	0

Source: Research data.

Seasonality

Considering the two sectors together, both population density $D = 4.99 \text{ i/km}^2$ (CV 15.93%), group density $DS = 2.72 \text{ g/km}^2$ (CV 16.22%) and abundance $N = 77$ (CV 16.22%) were higher in the rainy season compared to the dry season: $D = 2.34 \text{ i/km}^2$ (CV 16.30%); $DS = 1.30 \text{ g/km}^2$ (CV 16.71%) and $N = 37$ (CV 16.71%).

The estimators that best adjusted the data in each season were half-normal/cosine and uniform/cosine, respectively. The probability of detection for the whole Bay of Antonina was depicted in each season (Graph 3).

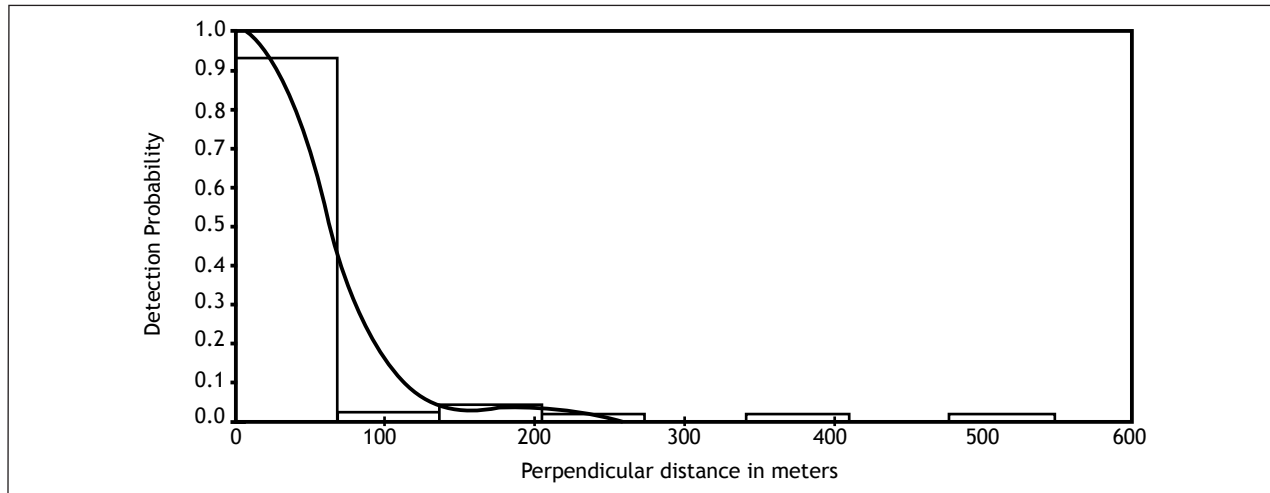
The data obtained from these analyses showed again a higher density at the Sector I (Table 2).

Frequencies along the months

The months sampled were May to December of 2003 and from January to April of 2004. The sighting frequency of estuarine dolphins varied during these periods (Graph 4).

Discussion

Sotalia guianensis is a species that lives mainly in groups, and in this work it varied from 2 to 5 individuals with an average size of 2.57 individuals/group. Groups with two or three individuals (family formation) were more frequent and there was not much variation when it is considered the



Graph 2 - Probability of detection's graphic according to perpendicular distances (meters) found at Bay of Antonina

Source: Research data.

Note: the line shows the expected pattern according to the data obtained at this area.

Table 2 - Estuarine dolphin's population density estimation (D), group's density (DS) and abundance (N) in the rainy and dry seasons at the two sectors of Bay of Antonina, along with its corresponding coefficient of variation (CV)

Bay of Antonina						
Sectors	Rainy Season			Dry Season		
	D (animal/km ²) (CV %)	DS (group/km ²) (CV %)	N (CV %)	D (animal/km ²) (CV %)	DS (group/km ²) (CV %)	N (CV %)
I	4.01 (24.49)	2.48 (25.11)	49 (25.11)	2.82 (29.36)	1.75 (30.28)	34 (30.28)
II	0	0	0	0	0	0

Source: Research data.

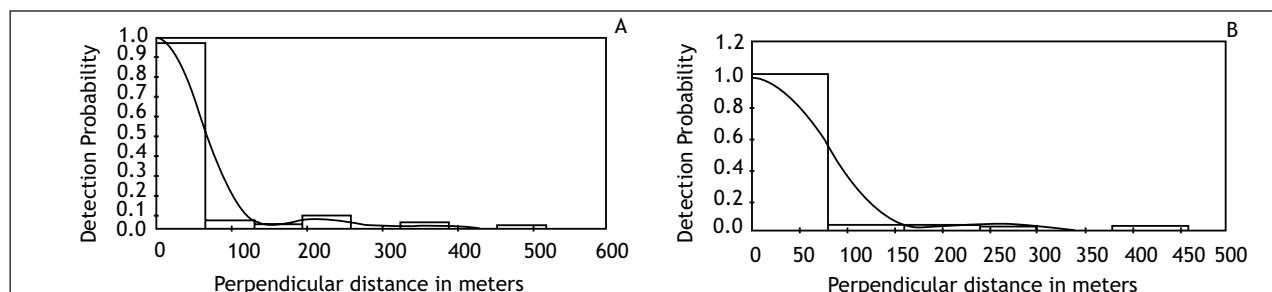
Sector I (the only one with records), and the two seasons sampled. These values can be considered similar to the ones found in the Bay of Guanabara, Rio de Janeiro (GEISE, 1991); at Cananea region, São Paulo State (BONIN et al., 2008; GEISE et al., 1999; HAVUKAINEN et al., 2011; MONTEIRO-FILHO, 2000), Bay of Paranaguá and Bay of Guaratuba, Parana State (FILLA; MONTEIRO-FILHO, 2009) and Nicaragua (EDWARDS; SCHNELL, 2001).

The small group sizes of estuarine dolphins in bays can be explained by the fact that bays are protected areas, without waves or marine currents and also because there is no predator that cause them risks, thus they do not need to form bigger groups for protection (MONTEIRO-FILHO, 2000). These similar results probably suggest an estuarine dolphin pattern that is, their groups in closed areas are smaller, but in open areas they can

be much bigger. Two exceptions happens at Bay of Paraty and Bay of Sepetiba, Rio de Janeiro, where it was recorded of the biggest group of this species (FLACH et al., 2008; LODI; HETZEL, 1998).

The group average size and individuals distribution at one area are related to a variety of facts such as prey and predators distribution. Thus populations are not to be found distributed by chance in the environment (SOLOMON, 1981), hence some caution must be taken when methods of estimative population are applied. The study area must be divided into sectors to decrease the problems of animals heterogeneous distribution; the execution of transects must be random; weather and marine (or river) conditions must be taken into consideration, as well as the observer experience and studied species behaviour (GASKIN, 1982; BONIN et al., 2008).

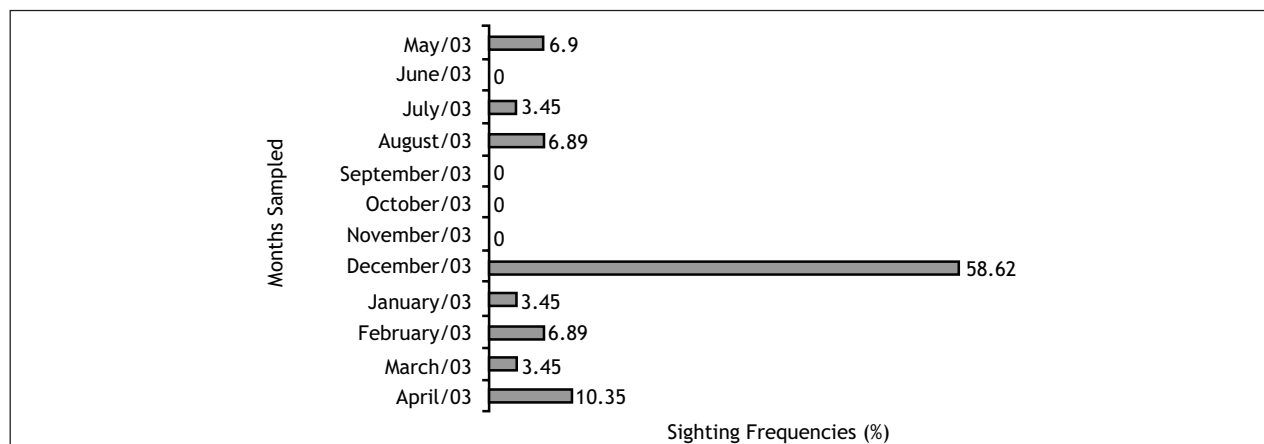
Disregarding the Bay of Antonina sectioning, the density was 3.80 i/km², however when the



Graph 3 - Probability of detection's graphic according to perpendicular distances (meters) found in Bay of Antonina; A - Rainy season; B - Dry season

Source: Research data.

Note: The line shows the expected pattern according to the data obtained at this area.



Graph 4 - Sighting frequency of estuarine dolphins *S. guianensis* at Bay of Antonina, southern of Brazil, from 2003 May to 2004 April

Source: Research data.

area sectioning was considered the data showed how different the animals distribution is at the studied area, that is, it showed an area more used by the estuarine dolphins. The Sector I was the only one with records of *S. guianensis*, therefore the density at this area was similar to the total density. Perhaps, the dolphins use this sector more because its salinity is higher than the Sector II, this allows estuarine and coastal fishes that the dolphins feed on (see OLIVEIRA et al. 2008) to stay in this area. At the Sector II the density found was $D = 0 \text{ ind./km}^2$, probably because the area is shallow, which could account for animal stranding. Also, this area has the fresh water input of rivers, which causes its salinity to drops and therefore, restricting the estuarine dolphins' preys access.

Hence, comparing the results obtained by sectioning and non-sectioning area, it is clear that there was density superestimation when the area was considered as a whole, since the records were generalised to the whole area, including the sector that the dolphins use little. The superestimation also occurred in the Chesapeake Bay (USA) (BLAYLOCK, 1988 *apud* BARCO et al., 1999) and in Cananea (SP) (GEISE, 1991), they did not consider the sectioning and overestimated their results. When these authors analysis were redone, by sectioning the area, they had results more consonant with the reality (BARCO et al., 1999; GEISE et al., 1999). Once again, it makes evident the importance of taking into account the area heterogeneity and not to consider the animals' distribution by chance, always sectioning the study area.

It was also possible to observe that the densities (total and Sector I) at Bay of Antonina were higher at the rainy season and the records frequency was higher in December, which could have been caused by the calf birth peak (ROSAS; MONTEIRO-FILHO, 2002). The seasonal variation of estuarine dolphins number in the Bay of Paraty (LODI, 2003; LODI; HETZEL, 1998) and Bay of Trapande (GEISE et al., 1999; HAVUKAINEN et al., 2011) is possibly related to changing of preys abundance and distribution, which seems to be strongly influenced by the seasons in these areas.

Therefore, estuarine dolphins use the studied area in a heterogeneous form, with a marked preferable usage of certain places, which reflects the assumption that the sampled sections are not

homogeneous and that the home range and the movements executed by the animals are ruled by the mosaic distribution of available resources, mainly food (see DEFRAN et al., 1999).

Conclusion

The groups of estuarine dolphin in the Bay of Antonina are small because the bay is a protected area, without waves or sea currents and predators. This specie probably exhibits this pattern presenting small groups in enclosed areas and bigger ones in oceanic areas.

The estuarine dolphin uses this area in a heterogeneous, with marked use in some places, probably with greater availability of food, such as Sector I of Bay of Antonina.

The line transects method (distances method) used was considered appropriate, though it was biased by the existing sand banks at low tide, which interfered with the access to some transects. Also, Bay of Antonia includes a sector little used by the dolphins and as long as the method implies high costs, it is advisable to apply the fixed point method in future studies, since the region relief is favourable to its usage, which enables the installation of fixed points at the bay's entrance. This method could be more efficient for monitoring the estuarine dolphins incomings and outgoing, as well as the time used by them.

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