

## Seasonality in the occurrence of Guiana dolphin, *Sotalia guianensis* (Cetacea: Delphinidae) in Port of Malhado, Ilhéus, Bahia, Brazil

Sazonalidade na ocorrência do boto-cinza, *Sotalia guianensis* (Cetacea: Delphinidae) no Porto do Malhado, Ilhéus, Bahia, Brasil

Estacionalidad en la ocurrencia del delfín de Guayana, *Sotalia guianensis* (Cetacea: Delphinidae) en el Puerto de Malhado, Ilhéus, Bahía, Brasil

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### Abstract

The seasonal occurrence of *S. guianensis* was analyzed in the port of Malhado, Ilhéus, Bahia, Brazil. The survey was conducted through an electronic theodolite, between December 2008 and November 2009, totaling 358.3 hours of sampling effort and 173.8 hours of effective sightings. The number of individuals, size and composition of the groups, time of arrival and departure of animals and the angles proceeding from theodolite reading were recorded. The stations were divided into summer (October to March) and winter (April to September) and periods of the day were categorized according to the angles of sunlight on the water surface. The angles from 0° to 45° was correspondent to the period between 08:00 and 14:00 h and 10:00 h and 16:00 h and the angles from 45° to 90° from 10:00 to 14:00 h. The mean size of the groups ( $\bar{x}=4.1 \pm 1.98$ ) did not vary seasonally ( $z=2.063$ ,  $p=0.039$ ), but the number of groups (34 in summer and 65 in winter), number of specimens (162 in summer and 384 in winter), the mean theodolite tracking time ( $\bar{x}=46.09$  in the summer and  $\bar{x}=122.07$  in the winter) and area occupation area (1.60 km<sup>2</sup> in the summer and 2.45 km<sup>2</sup>) were higher in winter. There was no significant variation in the number of individuals for periods of sunlight ( $z=0.30$ ,  $p=0.38$ ). It was observed that there is seasonal variation in the distribution of *S. guianensis* nearby port and this may be related to seasonal variation in prey abundance.

**Keywords:** Cetaceans; Theodolite; Tracking; Seasons.

### Resumo

A ocorrência sazonal de *S. guianensis* foi analisada no porto de Malhado, Ilhéus, Bahia, Brasil. O levantamento foi realizado por meio de teodolito eletrônico, entre dezembro de 2008 e novembro de 2009, totalizando 358,3 horas de esforço amostral e 173,8 horas de avistamentos efetivos. Foram registrados o número de indivíduos, tamanho e composição dos grupos, horário de chegada e saída dos animais e os ângulos provenientes da leitura do teodolito. As estações foram divididas em verão (outubro a março) e inverno (abril a setembro) e os períodos do dia foram categorizados de acordo com os ângulos de insolação na superfície da água. Os ângulos de 0° a 45° corresponderam ao período entre 08:00 e 14:00 h e 10:00 h e 16:00 h e os ângulos de 45° a 90° das 10:00 às 14:00 h. O tamanho médio dos grupos ( $\bar{x}=4,1 \pm 1,98$ ) não variou sazonalmente ( $z=2,063$ ,  $p=0,039$ ), mas o número de grupos (34 no verão e 65 no inverno), número de espécimes (162 no verão e 384 no inverno), o tempo médio de rastreamento do teodolito ( $\bar{x}=46,09$  no verão e  $\bar{x}=122,07$  no inverno) e a área de ocupação da área (1,60 km<sup>2</sup> no verão e 2,45 km<sup>2</sup>) foram maiores no inverno. Não houve variação significativa no número de indivíduos para os períodos de insolação ( $z=0,30$ ,  $p=0,38$ ). Observou-se que há variação sazonal na distribuição de *S. guianensis* nas proximidades do porto e isso pode estar relacionado à variação sazonal na abundância de presas.

**Palavras-chave:** Cetáceos; Teodolito; Rastreamento; Estações do ano.

## Resumen

Se analizó la ocurrencia estacional de *S. guianensis* en el puerto de Malhado, Ilhéus, Bahía, Brasil. El levantamiento se realizó a través de un teodolito electrónico, entre diciembre de 2008 y noviembre de 2009, totalizando 358,3 horas de esfuerzo de muestreo y 173,8 horas de avistamientos efectivos. Se registró el número de individuos, el tamaño y composición de los grupos, la hora de llegada y salida de los animales y los ángulos a partir de la lectura del teodolito. Las estaciones se dividieron en verano (octubre a marzo) e invierno (abril a septiembre) y los periodos del día se clasificaron según los ángulos de la luz solar sobre la superficie del agua. Los ángulos de 0° a 45° correspondieron al período comprendido entre las 08:00 y las 14:00 y las 10:00 h y las 16:00 h y los ángulos de 45° a 90° de las 10:00 a las 14:00 h. El tamaño medio de los grupos ( $= 4,1 \pm 1,98$ ) no varió estacionalmente ( $z = 2,063$ ,  $p = 0,039$ ), pero sí el número de grupos (34 en verano y 65 en invierno), número de ejemplares (162 en verano y 384 en invierno), el tiempo medio de seguimiento del teodolito ( $=46,09$  en verano y  $=122,07$  en invierno) y el área de ocupación ( $1,60 \text{ km}^2$  en verano y  $2,45 \text{ km}^2$ ) fueron mayores en invierno. No hubo variación significativa en el número de individuos por periodos de insolación ( $z = 0,30$ ,  $p = 0,38$ ). Se observó que existe una variación estacional en la distribución de *S. guianensis* cerca del puerto y esto puede estar relacionado con la variación estacional en la abundancia de presas.

**Palabras clave:** Cetáceos; Teodolito; Rastreo; Estaciones.

## 1. Introduction

The spatial and temporal distribution of cetaceans is related to various abiotic factors such as depth (Cubero-Pardo 2007; Davis et al. 1998; Hastie et al. 2003; Ingram & Rogan 2002; Karczmarski et al. 2000; Wursig & Wursig 1979), salinity (Cubero-Pardo 2007), water temperature (Reilly 1990; Wursig & Wursig 1980), tidal cycle (Harzen 1998, 2002, Mendes et al. 2002; Shane 1980), bottom characteristics (Davis et al. 1998; Hastie et al. 2003; Ingram & Rogan 2002; Karczmarski et al. 2000) and biotic factors such as availability of prey (Bailey and Thompson 2006; Cubero-Pardo 2007; Shane 1980; Wursig and Wursig 1980). Variation of these factors can cause large-scale seasonal migration, as observed in whales (Craig & Herman 1997, Kenney et al. 2001) and on a small scale, as made by dolphins (Cubero-Pardo 2007; Harzen 2002, Hastie et al. 2003; Shane 1980).

The Guiana dolphin, *Sotalia guianensis* is a small coastal cetacean that is geographically distributed throughout the Western Atlantic coast of South America and Central America, from southern Brazil (27°35'S, 48°35'W) to Nicaragua (14°35'N, 83°14'W) and possibly, Honduras (15° 58'N, 79°54'W) (Flores and Da Silva 2009). Studies on photo identification have shown that *S. guianensis* presents residence and fidelity to the habitat (Flores 1999, Flores & Bazzalo 2004, Rossi-Santos et al. 2007), thereby having daily movements on a small scale, while movement patterns vary between hot and cold seasons (Flores & Da Silva 2009).

Studies related to small-scale movements of several species of coastal dolphins have been conducted in fixed points in the land by theodolite tracking technique (Bejder & Dawson 2001, Denardo et al. 2001; Harzen 2002, Mendes et al. 2002; Wursig & Wursig 1979, 1980). This type of research has several advantages, mainly because for it noninvasively promotes accurate information regarding the geographical position of the animals (Bailey & Lusseau 2004; Harzen 2002). Moreover, it does not influence the animals' behavior once it is performed in a fixed point in the land (Wursig et al. 1991).

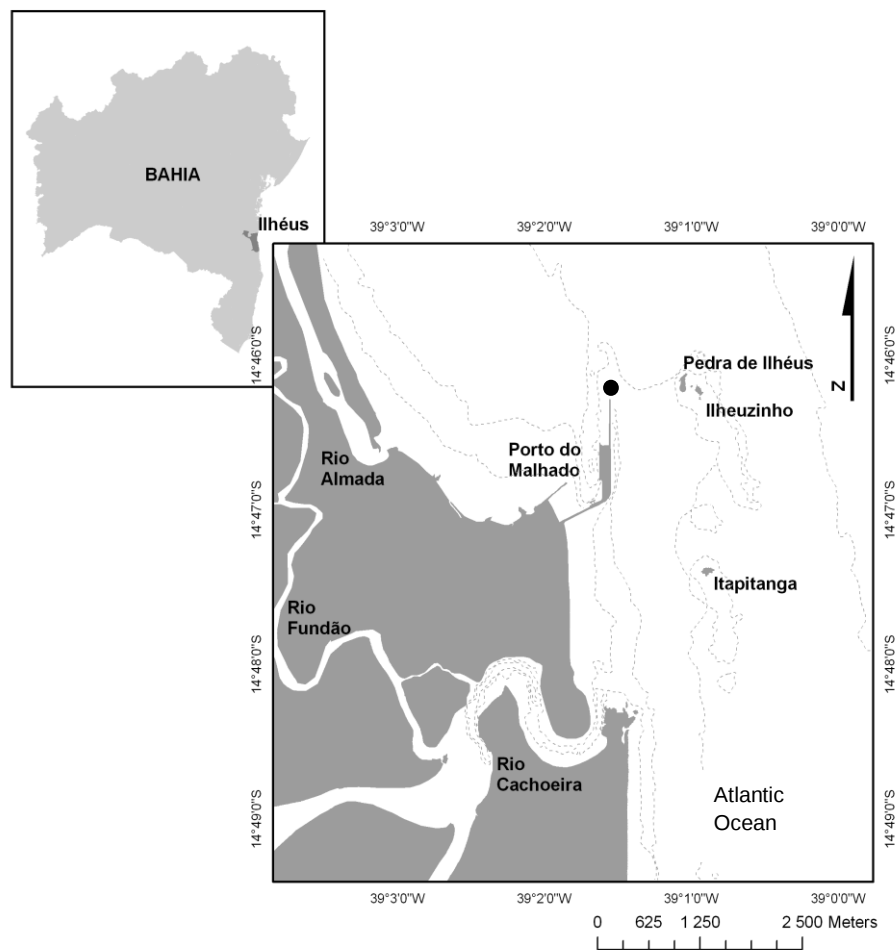
There is a population of *S. guianensis* at Port of Malhado in Ilhéus that can be sighted throughout the entire year. The animals spend long periods of the day closer extremity of the pier port, hence facilitating sightings and research through that fixed point. In this work, we used the theodolite tracking in order to determine whether there is seasonal variation in the occurrence and persistence of *S. guianensis* at Port of Malhado, Ilhéus, Bahia- Brazil.

## 2. Material and Methods

### 2.1 Study Area

The Port of Malhado ( $14^{\circ}46'08''\text{S}$  and  $39^{\circ}01'33''\text{W}$ ) is located in the Enseada das Trincheiras (Santos 2001), Ilhéus, in the Southern coast of Bahia State (Figure 1). The presence of *S. guianensis* in this area can be observed over the years, in long periods of the day. This research was conducted at a fixed point of 5.06 m, located at the extremity of the pier port. The extremity of the pier port is based on the True North (Santos 2001), having approximately 2.3 m in length and an evolution basin (place near the pier, where ships are maneuvered and anchored) of 200 m wide and 10 m depth, which allows the entry of medium draft ships (Andrade 2003). The tidal range in the port is 2.4 m (Andrade 2003) and the bottom sediment consists of fine sand.

**Figure 1** - Study area on the coast of Ilhéus Bahia State, Brazil (Source: Reuss-Strenzel and Assunção, 2008). The black circle in the pier extremity indicates the fixed point of observation.



Source: Authors.

### 2.2 Theodolite Tracking Technique

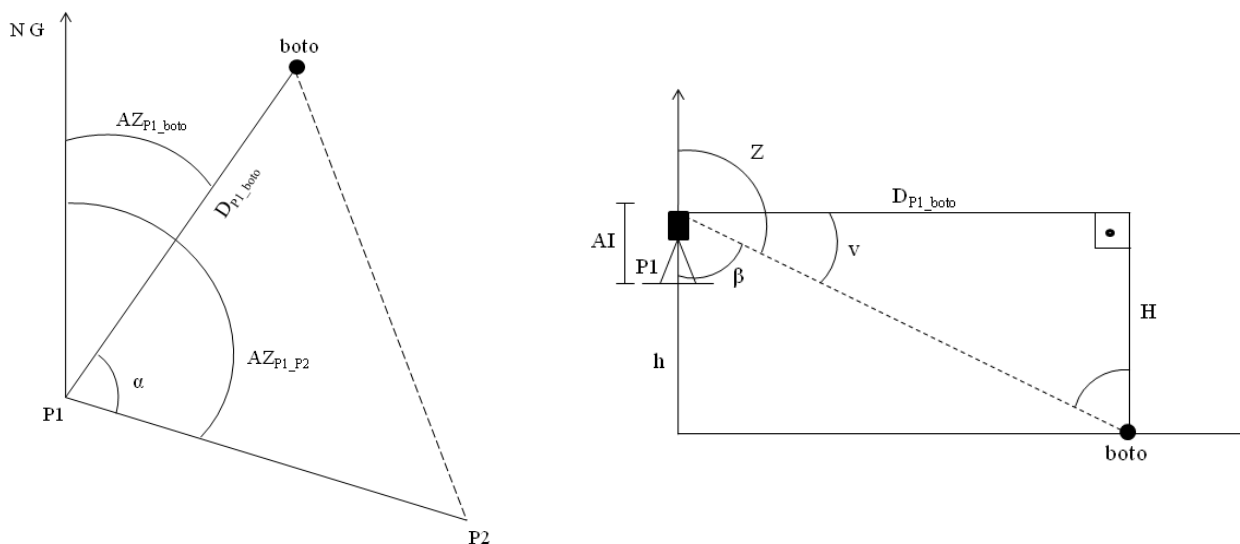
Theodolites are research tools capable of measuring horizontal and vertical angles of a target. The vertical angle is relative to gravity and the horizontal angle is relative to a reference point randomly chosen, and it originates from a known geographic position (zero angle) (Bailey & Lusseau 2004; Wursig et al. 1991). If the geographical position, height of the theodolite above the sea surface and the geographical position of zero angle are known, these angles can be transformed

through trigonometric equations in plane UTM coordinates (E, N). For greater precision in determining the theodolite height, it is necessary to understand the condition of tides, as well as for all measurements of angles during the collection period. Data regarding the coordinates are plotted in the depth maps, so that they can be used to correlate movements with physical factors such as topography (Wursig et al. 1991).

To monitor *S. guianensis* in the studied area, we used an electronic theodolite LEICA T 110, with a 10 seconds precision. The equipment was positioned at a fixed point of observation - P1 ( $14^{\circ}46'07.82683''$ S and  $39^{\circ}01'33.57041''$ W and UTM and 497,202.710 E 8,367,240.821 N) with a height of 5.06 m above the sea level. The point chosen to zero the theodolite - P2 (zero angle) ( $14^{\circ}46'08.15708''$ S and  $39^{\circ}01'33.29707''$ W and UTM and 497210.883 E and 8367230.676 N) has a height of 4.22 m above sea level. The coordinates of points P1 and P2 were tracked for a period of two hours through a High Precision Geodetic GPS (Trimble, model 5800). The GPS data were downloaded using the post-processing program TGO of Trimble. Then, we performed the post-processing and adjustment of its coordinates considering the coordinates of points known in the Brazilian Institute of Geography and Statistics (IBGE), thus obtaining an accuracy of about 2 centimeters in the horizontal and vertical coordinates. The GPS altitudes of points P1 and P2 (geometric height) were transformed into orthometric altitudes through the program MAPGEO 2004 of IBGE.

Based on the knowledge concerning the altitude of theodolite and guiana dolphin, combined with azimuth (values in sexagesimal degrees) counted from the geographical North, always clockwise - and the horizontal angle ( $\alpha$ ) concerning the alignment P1-P2 and P1-guiana dolphin, we have obtained the distance between the dolphin and the observation point by trigonometric processes (Figure 2).

**Figure 2** - Measure the distance between the theodolite and the groups of estuarine dolphins. Figure A represents view from the top, and figure B represents the side view.



Source: Authors.

Using the distance ( $D_{P1}$  – dolphin) and the azimuth from the alignment P1-dolphin (boto- $AZ_{P1}$  - dolphin) and the coordinates of P1, it is possible to calculate the UTM coordinates (E, N) of guiana dolphins on the water surface through the following equations:

$$\begin{aligned}
 (1) \quad & \beta = 180^\circ - Z \\
 (2) \quad & H = h + AI \\
 (3) \quad & tg \beta = tg (180^\circ - Z) = \frac{D_{P1\_boto}}{H} \\
 (4) \quad & D_{P1\_boto} = tg (180^\circ - Z) H \\
 (5) \quad & AZ_{P1\_boto} = AZ_{P1\_P2\_a} \\
 (6) \quad & \Delta E = sen AZ_{P1\_boto} \times D_{P1\_boto} \\
 (7) \quad & \Delta N = cos AZ_{P1\_boto} \times D_{P1\_boto} \\
 (8) \quad & N_{boto} = N_{P1} + \Delta N \\
 (9) \quad & E_{boto} = E_{P1} + \Delta N
 \end{aligned}$$

Where:

- H = Total height (of theodolite + fixed point);
- h= height of fixed point;
- AI= height of theodolite;
- Z= normal distance;
- $N_{boto}$  = north coordinate of Guiana dolphin;
- $E_{boto}$  = east coordinate of Guiana dolphin;
- $\Delta E$  = Partial projection of East coordinate (E);
- $\Delta N$  = Partial projection of North coordinate (E);
- $\alpha$ = horizontal angle; e
- $v$ = vertical angle.

### 2.3 Data Collection

Data collection was performed weekly between the months of December 2008 and November 2009, lasting up to eight hours every day (between 08:00 am and 04:00 pm), totaling 358.3 hours of sampling effort. The monitoring of the estuarine dolphins with the theodolite started when a single individual or a group was sighted; it was conducted throughout the remain of animals in the study area and it ended when individuals left or when it was no longer possible to view them due to the distance, or environmental conditions. Monitoring restarted when any individual or group was sighted.

A group was considered an aggregation of two or more individuals, in apparent association, close to each other (Azevedo et al. 2005; 2007). If new individuals appeared during tracking of a group, these were added to the size of the previous group, and if another group was formed, tracking remained in the first group. The points of the theodolite were collected from the individual located in the center of the group. The vertical and horizontal angles, time of sighting, group size and the composition of groups were recorded on standardized spread sheets. The composition of groups was classified into two categories: groups without calf (formed only by adults and adult/juvenile) and groups with calf. Its determination was based on visual estimation, considering the proportional size of the animals and the standard coloration. Calf were considered the individuals always accompanied by one or more adults, with body size medium or inferior to the size of adults, and coloration was predominantly pink, with some gray spots on the back, head and rostrum. Adults and juveniles were considered those

individuals larger than 120 cm and which coloration was more grayish, with only the belly light-colored (based on Randi et al. 2008; Rose & Barreto 2008).

## 2.4 Definition of Seasons and Periods of the Day

Seasons were divided into summer and winter (once spring and autumn are not well defined in that region), according to wind patterns that occur on the coast of Ilhéus. In summer (October to March), trade winds prevailing from the northeast region (NE) generate waves of NE; in winter, (April to September) trade winds hit the southeast coast (SE), which along with the east winds (E) on the coast of Ilhéus, generates waves of SE throughout the year (Bittencourt et al. 2000).

There is no well defined dry season in the region, whereas rainfall occurs throughout the year. The historical average rainfall in Ilhéus is 170 mm per month (EMBRAPA, 2010). Rainfall in the months concerning the two collection sites were obtained from the climatological database of the Centro de Pesquisa do Cacau (CEPEC) of the Executive Plan of Cocoa Farming (CEPLAC). In the summer months (December 2008 to March 2009 and October and November 2009) the average was 180.4 mm and for the winter months (April-September 2009) was 141.7 mm, with no significant difference between these means ( $p=0.24$ ) (Ceplac 2010).

The periods of the day were categorized according to the angles of incidence of solar radiation on the water surface in order to observe if the sunlight interferes in the spatial distribution of *S. guianensis*. In the period between 08:00 am and 10:00 am and between 02:00 pm and 04:00 pm, the incidence angles are 0° to 45°, and between the period from 10:00 am to 02:00 pm, the sunlight on the water surface is straightforward, between 45° and 90° (Esteves 1998).

## 2.5 Data Analysis

Data from the vertical and horizontal angles obtained by the theodolite were stored in databases of the Excel 2007 Program containing trigonometric equations responsible for the obtention of the UTM geographic coordinates and the distances between the fixed point of observation (P1) and the guiana dolphins (see item “theodolite tracking technique”). The corrections on the tide were made for the point collected along with theodolite, thus to obtain greater accuracy in determining the distance between the estuarine dolphins and the fixed point (P1).

The geographic coordinates UTM of the estuarine dolphins were plotted on a cartographic database containing the coastline and bathymetry maps, using the program ArcMap 9.2. To calculate the areas of spatial, seasonal and daily distribution of *S. guianensis*, we used the method of Minimum Convex Polygon (MPC), which consists of the approximation of the most extreme geographic points of distribution of dolphins in such a way to close the smallest possible polygon without allowing concavities. These points were connected and the area of the polygon calculated in km<sup>2</sup>.

The variation of the effective effort of sighting and composition of the groups between the two seasons was statistically analyzed using the chi-square test for proportions expected to be unequal. An occupancy index was calculated considering the total number of individuals observed at each season, being divided by the sampling effort of each season. The seasonal variation in the size of groups and their tracking time, distances between the fixed point of observation and the groups of *S. guianensis* and also the distance between the fixed point and estuarine dolphins, regarding the categories of solar incidence angles were analyzed through the nonparametric statistical test Mann-Whitney. Significance was established as  $p < 0.01$ .

### 3. Results

#### 3.1 Size and Composition of Groups

A total of 173.8 hours of effective sightings was conducted in 48 days of data collection. Guiana dolphin was found in the area in 91.5% of the days of research, not being sighted only for four days during the summer. There was significant difference in the time of effective sighting between the summer and winter months ( $X^2$ ,  $p < 0.0001$ ) (Table 1). 99 groups of *S. guianensis* and a total of 546 specimens were monitored. The size of groups ranged from 2 to 12 individuals, averaging 4.1 ( $\pm 1.98$ ) and mode of two. In six monitoring events solitary individuals were observed. The annual occupancy index was of 1.5 individuals per hour. With respect to composition, 47.5% ( $n = 47$ ) of groups was composed of only adults or adults/juveniles; in 33.3% ( $n=33$ ) of groups, there were calves, and in 19.2% ( $n=19$ ) of occasions, it was not possible to determine the composition of the groups. The number of groups and individuals and the occupancy index of guiana dolphins were lower in summer, when compared to winter (Tab. 1). There was no significant difference in the average group size between the two seasons ( $z = 2.063$ ;  $p = 0.039$ ) or significant seasonal variation in the number of groups with calves ( $X^2$ ,  $p = 0.196$ ) and groups without calves ( $X^2$ ,  $p = 0.279$ ).

**Table 1** - Values of sampling and effective effort, quantity of groups and specimens, occupation index, size and composition of groups between the two seasons at Porto of Malhado.

| Parameters                | Summer     | Winter     |
|---------------------------|------------|------------|
| Sampling effort (hours)   | 177.5      | 180.8      |
| Effective effort (hours)  | 35.2       | 138.5      |
| Groups number             | 34         | 65         |
| Specimens number          | 162        | 384        |
| Occupation index (ind./h) | 0.91       | 2.12       |
| Mean groups size          | 3.5        | 4.5        |
| Standard deviation        | 1.78       | 2          |
| Mode                      | 2          | 2          |
| Maximum                   | 11         | 12         |
| Mínimum                   | 1          | 1          |
| Groups with calves        | 6 (17.6%)  | 27 (41.5%) |
| Groups without calves     | 18 (52.9%) | 29 (44.7%) |
| Composition undetermined  | 10 (29.5%) | 9 (12.8%)  |

Source: Authors.

#### 3.2 Daily and Seasonal Spatial Variation

The analysis of data generated by the electronic theodolite precisely promoted the geographic location of the guiana dolphins around the extremity of the pier Port of Malhado. A total of 2088 points of vertical and horizontal angles was recorded during tracking with the theodolite, whereas 419 points referred to summer and 1669 to winter. The average tracking time per group of guiana dolphins was 97.01 minutes ( $\pm 114.5$ ) with a median of 40 minutes and maximum and minimum times of 470 and 6 minutes, respectively. There was significant difference in the mean time of tracking by group, between the two seasons ( $z = 3.855$ ,  $p < 0.0001$ , Table 2).

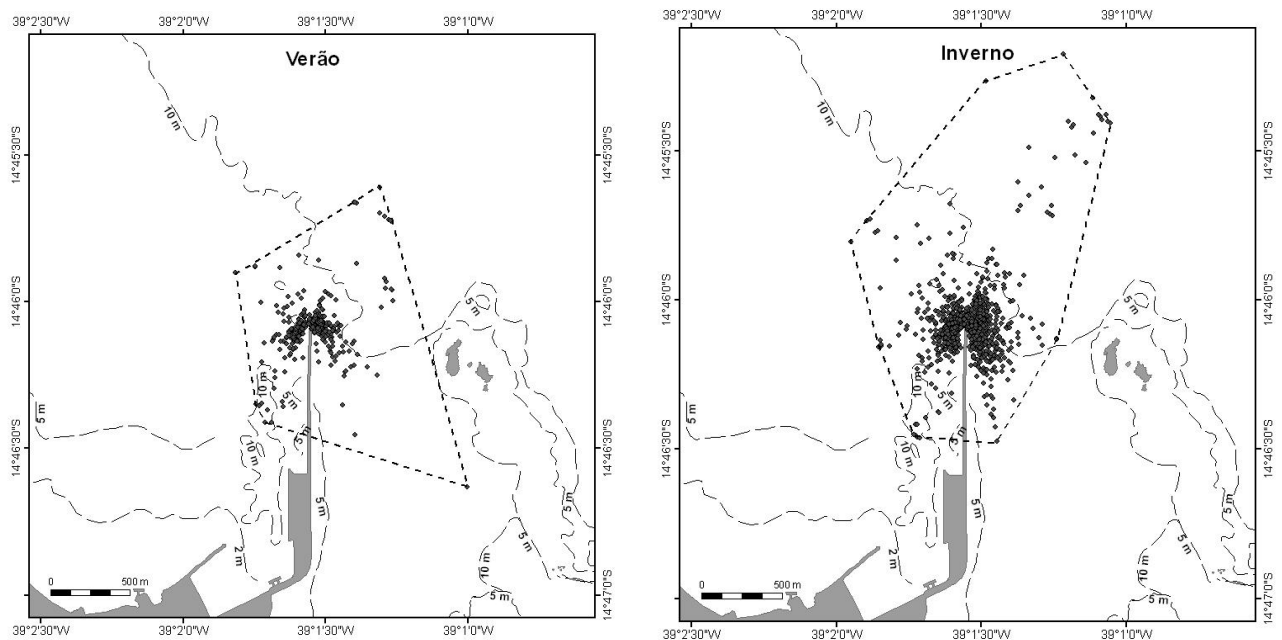
**Table 2** - Theodolite tracking time per group of *S. guianensis* in winter and summer at Porto of Malhado.

| Theodolite tracking (minutes) | Summer | Winter |
|-------------------------------|--------|--------|
| Mean                          | 46.09  | 122.07 |
| DP                            | 73.82  | 122.84 |
| Median                        | 19.5   | 76     |
| Maximum                       | 310    | 470    |
| Minimum                       | 6      | 6      |

Source: Authors.

The spatial distribution of guiana dolphins was concentrated in a small area of 3.24 km<sup>2</sup>, near the end of the extremity of the pier port. In summer, the occupation area was 1.60 km<sup>2</sup> and 2.45 km<sup>2</sup> in winter (Figure 3). As can be seen in Figure 4 most points most points are located at depths of 5 m, with some depth points of 10 m. It is also possible to observe that the concentration of *S. guianensis* in the study area varies according to the season. Then, the concentration is lower in summer, while the amount of points and the overlap between them makes it evident that there is a greater concentration of *S. guianensis* in winter (Figure 3).

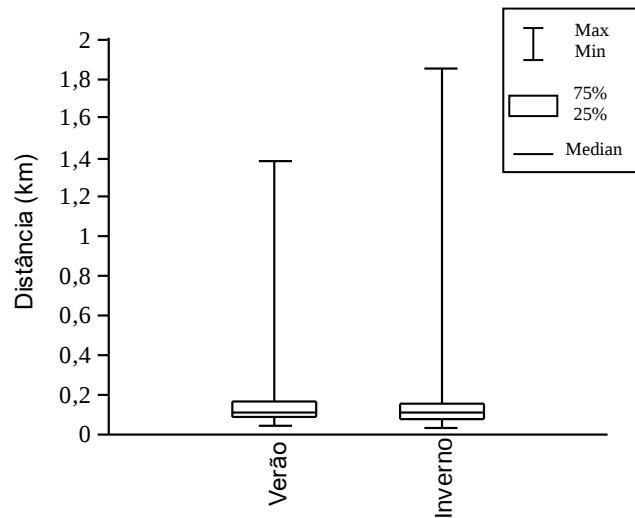
**Figure 3** - Spatial distribution of *Sotalia guianensis* groups during summer and winter at Porto do Malhado, in Ilhéus. Higher concentration of groups in 5 m deep isobaths, being some groups in isobaths of 10 m. The delineate polygon represents the MPC area of 1.60 km<sup>2</sup> in summer, and 2.45 km<sup>2</sup> in winter.



Source: Authors.

The average distance registered with the theodolite between the fixed point of observation and the estuarine dolphins was 0.16 km ( $\pm 0.18$ ), with a maximum distance of 1.85 km to north, recorded in winter, and 1, 37 km to the south, recorded in summer. The minimum distance for the two periods was 0.03 (Figure 4). There was no significant difference in the distances between the two seasons ( $z = 1.70$ ,  $p = 0.087$ ).

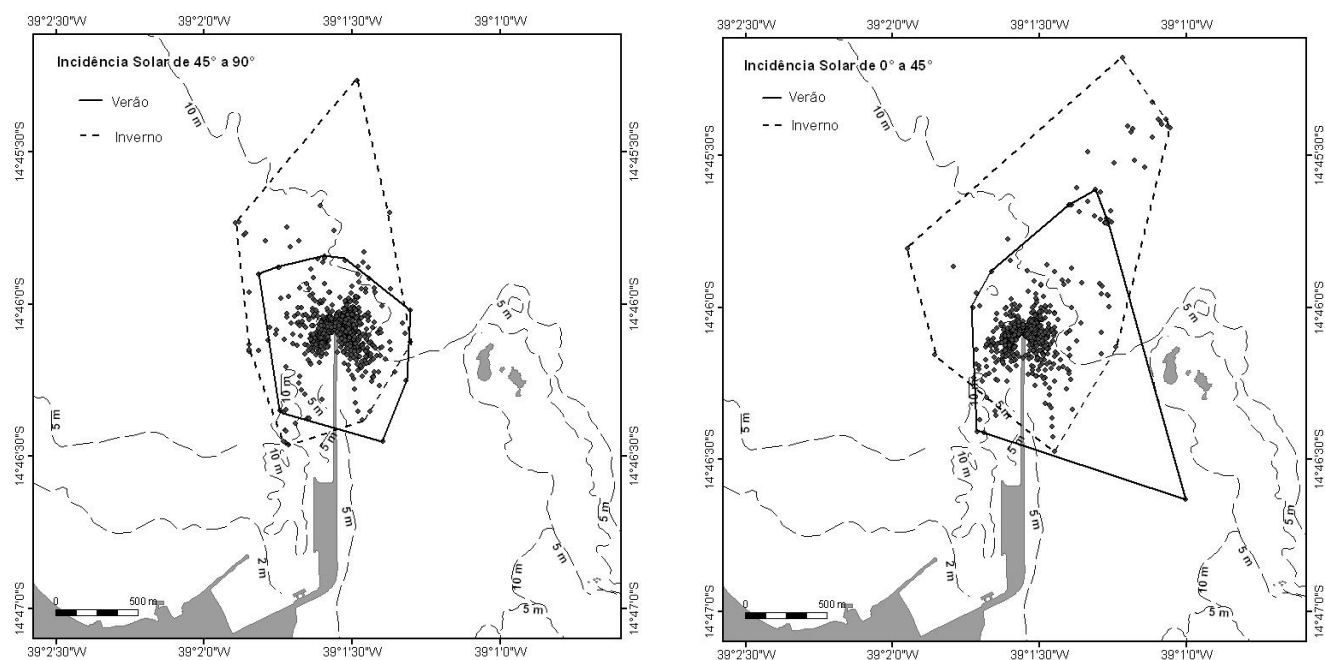
**Figure 4** - Distance between the fixed-point of observation and the groups of *S. guianensis* in summer and winter.



Source: Authors.

Of the 2088 points collected with the theodolite, 1131 were related to the sunlight period from 45° to 90° (from 10:00 am to 01:59 pm) and 957 for the period of incidence from 0° to 45° (between 08:00 am and 09:59 am, and between 02:00 pm and 04:00 pm). The number of individuals observed from 10:00 am to 01:59 pm was 286, and from 08:00 am to 09:59 am and from 02:00 pm to 04:00 pm, the number was 260. There was no significant difference in the number of individuals observed in the two periods ( $z = 0.30$ ,  $p = 0.38$ ). The distribution area of *S. guianensis* groups for the first category (45° to 90°) was 1.64 km<sup>2</sup>. The area used for this category of solar incidence was 0.78 km<sup>2</sup> in summer and 1.53 km<sup>2</sup> in winter. For the category from 0° to 45°, the area was 2.98 km<sup>2</sup>, with 1.45 km<sup>2</sup> in summer, and 2.13 km<sup>2</sup> in winter (Figure 5).

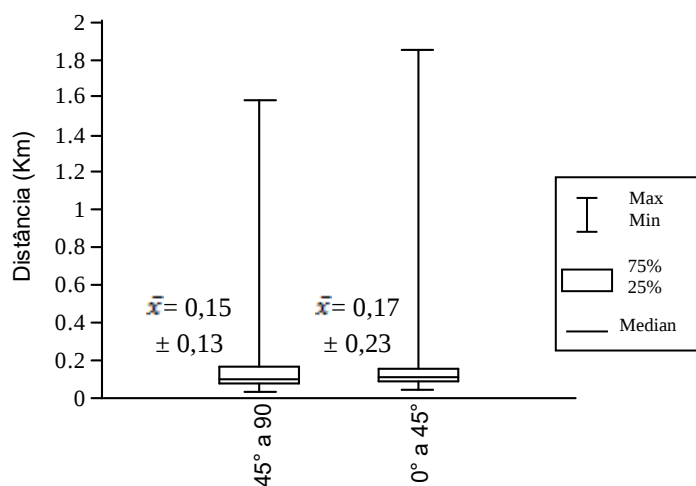
**Figure 5** - Spatial distribution of *Sotalia guianensis* groups during the solar incidence from 45° to 90° (from 10:00 am to 01:59 pm) and 0-45° (from 08:00 am to 09:59 am and between 02:00 pm and 04:00 pm) at Porto do Malhado, in Ilhéus. The polygon with the continuous line represents the MPC area in summer, and the delineate represents winter. The values of the areas in the period of incidence ranged from 45° to 90° in summer, and were 1.45 km<sup>2</sup> and 2.13 km<sup>2</sup>, respectively. For the period ranging from 0° to 45°, the areas were 0.78 km<sup>2</sup> for summer and 1.53 km<sup>2</sup> for winter.



Source: Authors.

The average distance from the fixed point of observation and the groups of guiana dolphins for the two periods of solar incidence didn't shown significant difference ( $z= 1.233$ ,  $p= 0.108$ ; Figure 6).

**Figure 6** - Distance between the fixed-point of observation and the *S. guianensis* groups regarding periods of solar incidence from 45° to 90° and 0° to 45°.



Source: Authors.

## 4. Discussion

The Port of Malhado is an area where with a daily traffic of a variety of boats, including fishing boats and large cargo and tourism crafts. This area proves to be of intense occupation by *S. guianensis*, once they can be sighted throughout the year. The occupation of the port areas has been demonstrated for this species in other regions. In Pernambuco state, the presence of *S. guianensis* was reported in the ports of Suape and Recife (Araújo et al. 2008). At Babitonga Bay, Santa Catarina State, a population of guiana dolphins was frequently observed using the port of Sao Francisco do Sul especially for foraging purposes (Cremer et al. 2009).

### 4.1 Size and Composition of Groups

The social organization of *Sotalia guianensis* at Port of Malhado was characterized by the formation of small groups ( $\bar{x}=4,1$  individuals), similar to that reported for the species in other regions, where the average size of groups ranges from two to ten individuals (Araújo et al. 2001; Azevedo et al. 2005; Edwards & Schnell 2001; Geise et al. 1999). The absence of seasonal variation in the average size of the groups was also observed for the species at Guanabara Bay (Azevedo et al. 2005) and Sepetiba Bay (Flach et al. 2008). Opposite results were found at the Paraty Bay, Rio de Janeiro State (Lodi 2003) and the North Bay of Santa Catarina State (Daura-Jorge et al 2005), where a seasonal variation was noted in the average size of groups. In the Paraty Bay, the largest groups were observed in summer, and at the North Bay they were spotted in the fall. According to Flach and collaborators (2008), these different results among the sites suggest that the seasonal variation in the size of groups may be related to the structural and environmental characteristics peculiar and restricted to each habitat.

The permanence time of the *S. guianensis* groups and the total number of individuals sighted in winter were higher than those observed during summer at Port of Malhado. The number of individuals observed in Paraty Bay was higher during summer (Lodi 2003). According to the author, this seasonal variation is probably related to physical and oceanographical characteristics of the habitat, which determine the availability and distribution of food resources.

The presence of groups with calves was observed throughout the year and it did not vary between seasons. Just as at Port of Malhado, calves can be spotted throughout the year in the Paraty Bay (Lodi, 2003), at the estuary of Cananéia (Geise et al. 1999), Guanabara Bay (Azevedo et al. 2005), North Bay of Santa Catarina (Bazzalo et al. 2008; Daura-Jorge et al. 2005) and at Golfinhos Bay (Araújo 2001). According to a study on reproductive aspects that was undertaken in Paraná State with accidentally caught animals, it was possible to observe that females of *S. guianensis* do not have a defined ovulation period, there is not therefore, a time set for the births (Rosas & Monteiro-Filho 2002). Despite the fact that calves are spotted throughout the year in some localities, that frequency of those events is higher in warmer seasons, as reported for the Bay of Paraty (Lodi 2003) and at the North Bay of Santa Catarina State (Daura-Jorge et al. 2005).

### 4.2 Daily and Seasonal Spatial Variation

The size of the area ( $3.24 \text{ km}^2$ ) used by the guiana dolphins in the Port of Ilhéus and the maximum distance (1.85 km) between animals and the fixed-point of observation is an underestimated value, once the tracking technique with theodolite presents limitations in monitoring the animals throughout the course realized by them. The estimated home range of *S. guianensis* in the North Bay of Santa Catarina State was  $13.38 \text{ km}^2$  (according to the model of the Minimum Convex Polygon) (Flores & Bazzalo 2004) and in Guanabara Bay, the guiana dolphins occupy an area of  $136.9 \text{ km}^2$  (Azevedo et al. 2007). Regarding depth, *S. guianensis* showed a preference for shallow waters (5 m), near the extremity of the pier port. In Nicaragua, the maximum depth at which *S. guianensis* can be sighted was 5 m (Edwards and Schnell 2001). A similar result was reported for the North Bay of Santa Catarina State, where animals are frequently sighted at depths below 10 m, hence being recorded

mainly in 3m isobaths (Bazzalo et al. 2008; Flores & Bazzalo 2004). Yet, depth is a factor that varies among the occurrence sites, and it is related to environmental characteristics. In Guanabara Bay, depth varies from 2 to 35 m, with an average of 11.63 m, while the largest number of groups was sighted in depths between 5.1 and 15 m. The preference for deeper waters in that locality seems to be related to water quality and availability of prey (Azevedo et al. 2007).

Guiana dolphin showed seasonal spatial variation in the study area and it was noted that the occupation area around the pier was lower in summer (1.6 km<sup>2</sup>) when compared with the area in winter (2.45 km<sup>2</sup>). At Cispatá's Bay, in the Colombian coast, guiana dolphins have a more scattered distribution in areas adjacent to the bay during the rainy season, while they concentrate on the bay's interior in the dry season (Garcia & Trujillo 2004). At North Bay, Santa Catarina state, species tend to restrict their activities to specific areas according to each season. In spring and summer, animals use the same area of smaller spatial demand (8.32 and 8.42 km<sup>2</sup>, respectively) when compared with those used during fall and winter (20.27 and 32.12 km<sup>2</sup>, respectively) (Wedekin et al. 2007). In the same place, it was observed that during the cold seasons guiana dolphins move higher distances during the cold seasons (Bazzalo et al. 2008; Daura-Jorge et al. 2004; 2005; 2007; Flowers & Bazzalo 2004).

In all studies in other regions mentioned above, the likely explanation for the seasonal variation in the spatial distribution of *S. guianensis* remains in the seasonal variation of availability, abundance and distribution of food resources. The abundance and size of fishes in the Colombian coast are larger during the rainy season outward Cispatá's Bay (Garcia & Trujillo 2004) and North Bay, the largest spatial requirements and the greater displacement intensity may be due to the scarcity of prey. The opposite occurs in the warm seasons (Bazzalo et al. 2008; Daura-Jorge et al. 2004; 2005; 2007; Bazzalo & Flores, 2004; Wedekin et al. 2007). According to Flowers and Bazzalo (2004), other possible explanations for the higher indexes of movement during winter at the North Bay of Santa Catarina state would be the demand for energy to maintain body temperature and also the traffic of crafts, which increases in summer.

For other coastal species of cetaceans, seasonal variation was also reported in the spatial distribution in response to the seasonal movement of their prey, such as *T. truncatus* (Cubero-Pardo 2007, Hastie et al. 2003; Ingran & Rogan 2002; Shane 1980), *Sousa chinensis* (Karczmarski et al. 2000), *Stenella attenuata* (Cubero-Pardo 2007) and *Lagenorhynchus obscurus* (Wursig & Wursig 1980).

According to Gonçalves (2009), the main activity developed by *S. guianensis* at Porto of Malhado, is foraging. Although we have no knowledge regarding items that compose the diet of the species in this area, the occurrence of 12 families and 28 species of fish was reported as potential food items of *S. guianensis* by surveys regarding composition, abundance and diversity of the demersal fish fauna, held along the Brazilian coast (Borobia & Barros 1989; Di Benedetto et al. 2001; Di Benedetto & Siciliano 2007; Gurjão et al. 2003). During his research, between March 2003 and February 2005, Moraes (2006) observed temporal variation in abundance of the principal fish species that occur in the region, such as *Isopisthus parvipinnis*, *Paralichthys brasiliensis*, *Larimus breviceps*, *Stellifer brasiliensis*, *Stellifer stellifer*, and *Eucinostomus gula*. These species are also present in the diet of *S. guianensis*, being more abundant during the higher rainfall (months with average rainfall exceeding 143 mm), probably due to the fact that there is a greater concentration of allochthonous organic matter in this period, which certainly interferes in the trophic dynamics of the area and the structure and composition of the existing fish communities. There was no significant variation in rainfall between the two seasons of the year of study, and still there was difference in the presence of *S. guianensis* in the area.

This study aimed to analyze the spatial variation throughout the day of *S. guianensis*, based on the incidence of solar radiation on the water surface, since the periods from 08:00 am to 10:00 am and between 02:00 pm and 04:00 pm had the incident angle around 0° to 45°. In the period between 10:00 am and 02:00 pm, the angle of incidence is perpendicular to the water surface (around 90°). The number of individuals observed and the maximum distance of sightings of groups proved to be influenced by this factor. The farthest points that increased the area used by guiana dolphins during the initial or end hours of

sampling (incidence period between 0° to 45°) may be related to the movement of entry and exit of animals at Port of Malhado. The occupancy index of *S. guianensis* at Batitonga's Bay was not influenced by the periods of the day (Cremer et al. 2009), however, in other locations, time showed influence, such as in the Bay of Paraty (Lodi 2003), north bay of Santa Catarina State (Daura-Jorge et al. 2005), Cispatá's Bay (Garcia & Trujillo 2004), Cananéia's estuary (Geise et al. 1999) and at the Golfinho's Bay (Araújo et al. 2001).

The occurrence of *S. guianensis* has been reported for other locations along the coast of Ilhéus, such as in the Pontal Bay (Santos et al. no prelo), with a distance of approximately four kilometers from Port of Malhado. In this study, it was possible to note that there is seasonal variation in the distribution of species in the adjacencies of the Port. Yet, animals were monitored from a fixed point, thus not being able to track all the movements performed by the groups. Future photoidentification researches and onboard tracking should be developed throughout the year, in order to observe the daily and seasonal dynamics of the species on the coast of Ilhéus.

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