ARTIGO ORIGINAL

Surface activity of Humpback whales *Megaptera novaeangliae* (Cetacea, Mysticeti) on the northern coast of Bahia, Brazil

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RESUMO

Atividades de superfície de baleias jubarte *Megaptera novaeangliae* (Cetacea, Mysticeti) na costa norte da Bahia, Brasil. As atividades de superfície das baleias jubarte foram estudadas durante as épocas reprodutivas de 2008, 2009 e 2010, na costa norte da Bahia, Brasil, próximo ao distrito de Praia do Forte. Os níveis de atividade de superfície exibidos por 342 grupos de baleias foram avaliados de acordo com o estado do mar (medido pela escala de Beaufort) e cobertura de nuvens. Cinco comportamentos foram registrados: saltos, batida de cabeça, batida da cauda, batida da nadadeira peitoral e cauda parada fora da água. A maioria dos avistamentos ocorreu com o estado 2 do mar na escala de Beaufort, e com uma cobertura de nuvens de 26 a 50%. O comportamento mais registrado durante as atividades de superfície foi a batida de nadadeira peitoral. Os resultados mostraram que o comportamento de superfície das baleias jubarte não parece ser influenciado pelo estado do mar ou pela cobertura de nuvens.

Palavras-chave: Cobertura de nuvens, Escala de Beaufort, Estado do mar, Fatores ambientais

ABSTRACT

Surface activities of humpback whale groups were studied during the reproductive seasons of 2008, 2009 and 2010 on the northern coast of Bahia State, Brazil, near the district of Praia do Forte. The level of surface activity exhibited by 342 groups of whales was evaluated according to the sea state (measured on the Beaufort scale) and cloud coverage. Five behaviours were recorded: breaching, head slapping, tail slapping, pectoral flipper slapping and tail breaching. Most of the sightings occurred with a sea state classified on the Beaufort scale as 2, and with a cloud coverage of 26 to 50%. The most recorded level of surface activity was pectoral flipper slapping. The results showed that humpback whale behaviours do not seem to be influenced by the sea state or by cloud coverage.

Keywords: Beaufort scale, Cloud coverage, Environmental factors, Sea state
INTRODUCTION

Humpback whales (*Megaptera novaeangliae* Borowski, 1781) are characterized by their long pectoral fins (1/3 of the total body length), small dorsal fin, and head and lower jaw covered by tubercles (Palazzo Jr. & Both, 1988; Perrin et al., 2008; Deméré, 2014). It is a cosmopolitan species, with most of the breeding activities occurring in the tropical and subtropical oceans (mainly in the coastal waters within the 200 m isobath; Zerbini et al. 2006), and feeding occurring mostly in high latitudes (Ristau et al., 2020). Their southern populations are classified in seven reproductive stocks (from A to G) (IWC, 2001), with the stock A reproducing in the South Atlantic, at Abrolhos Bank, in the Brazilian coast (Andriolo, 2010a, b).

Along the Antarctic coast, humpback whales form different populations during the foraging season in the summer (Baker et al., 1995; Rizzo & Schulte, 2009; Andrews-Goff et al., 2018), but they migrate to the tropical areas during the winter to breed in shallow and warm waters near the coast of the continents (Lunardi et al., 2008, 2010; Zerbini et al., 2011; Gonçalves et al., 2018). One of these populations migrates to the Brazilian coast, concentrating in the Abrolhos Bank (southern Bahia State), which is considered the principal breeding area of the species (Rossi-Santos et al., 2008; Wedekin et al., 2010; Ristau et al., 2020).

Humpback whales often display surface activities such as breaches and flipper slapping (caudal and pectoral) (Félix, 2004; Kavanagh et al., 2017). Surface activities are normally exhibited during the breeding season, but their function is not fully understood (Félix, 2004). Male competition, aggressiveness, sexual stimulation, wound or irritation responses, play, intra- or interspecific communication are some of the suggested functions for surface activities (Herman & Tavolga, 1980; Frankel et al., 1995; Dunlop et al., 2008; Felix & Botero-Acosta, 2012; Dunlop et al., 2017; Kavanagh et al., 2017; Schuler et al., 2019).

Surface activities are probably influenced by environmental factors, such as time of day, tidal cycle, phases of the moon and sea state (Herman & Antinoja, 1977; Félix, 2004; Pacheco et al., 2013). Humpback whales tend to display more surface activities when the sea state is classified as calm (Morete et al., 2003; Félix, 2004); the influence of the cloud coverage was never tested for humpback whales, but it diminished the number of sightings of Harbor porpoises (*Phocoena phocoena*) and mink whales (*Balaenoptera acutorostrata*) (Dolman et al., 2014) and influenced surface water temperature, diminishing the number of whales in the surface (Sheidat, 2004). Thus, this study aimed to evaluate if the surface activities of humpback whales are influenced by environmental factors (sea state and cloud coverage) in the northern breeding area in Bahia State’s coast, Brazil.
MATERIAL AND METHODS

This study was conducted in the area of the Praia do Forte (12°34′S; 37°59′W), in the Mata de São João Municipality, Bahia, northeastern Brazil (Figure 1). Observational studies of whales are common in this area. According to Castro and Miranda (1998), the water temperature in the surface of water varies between 25° and 26°C during the winter and between 27° and 28°C during the summer.

![Map of the study area](image)

Figure 1: Study area on the northern coast of Bahia State, Brazil. The black/white dot shows the location of Praia do Forte, in the Mata do São Joào Municipality.

Data collection occurred between July and October (breeding season of the humpback whales in the coastal of Brazil) in three consecutive years: 2008, 2009 and 2010. Data recordings were made from a 14m-length wooden vessel, used during whale watching. Behavioural observations were made during daily trips that varied from 58 to 280 minutes (mean duration of 163 minutes). Whales were sighted and observed by a naked eye. A minimum of 100 m was maintained between the vessel and the whale during data recordings. Behavioural data were collected using the group-follow method (Mann et al., 2000; Azevedo et al., 2018), in 30-minutes sampling periods. All procedures of approaching and permanence
followed the recommendations of the Brazilian Agency of Environment and Natural Resources (IBAMA; Ordinance IBAMA Nº 117/96, 26 December 1996).

Surface activities were defined according to Félix (2004); that is, activities other than swimming and breathing, recorded at the ocean surface, which produce non-vocal noises. Five behaviours were recorded: breaching (an acrobatic display where the humpback uses its tail to launch itself out of the water then lands on the surface with a splash); head slapping (the humpback whale lunges forward with its head raised above the water); tail slapping (the humpback whale raises its tail flukes out of the water and slaps them forcefully on the surface of the water); pectoral flipper slapping (the humpback whale slaps the water’s surface with one or both fins simultaneously); and tail breaching (an energetic display where the whale throws its tail out of the water and in the process, slaps its peduncle on the surface). Based on the number of exhibited behaviours and in the number of behavioural presentations, activity intensity levels were defined and divided in four categories: 1) highest level (level 1: if the whales exhibited one or more behaviours more than ten times during a recording session or if the whales exhibited at least three different behaviours during a recording session); 2) medium level (level 2: when the whales exhibited one or more behaviours, and they were exhibited at most nine times during a recording session); 3) low level (level 3: when the whales exhibited one or more behaviours occasionally; i.e., one or two times during a recording session); and 4) lowest level (level 4: when none behaviours were exhibited by the whales during a recording session) (Félix, 2004).

Groups of whales were separated into eight categories, based on behavioural characteristics and on observed attributes previously described for the species (Tyack & Whitehead, 1983; Baker & Herman, 1984; Clapham et al., 1992; Gómez, 2011; Félix & Novillo, 2015): (1) mother and calf (MC), (2) mother, calf and escort (MCE), (3) mother, calf and two escorts (MC2E), (4) mother, calf and more than two escorts (MCES), (5) singleton (S), (6) dyad (D), (7) triplets (T), and (8) more than three adults (MT).

Sea state and cloud coverage were measured when recording sessions started. Sea state was defined according to the Beaufort scale (Singleton, 2008) used in navigation to classify the sea surface aspect as a consequence of wind speed (Huler, 2004). This scale ranges from 0 (no wind and sea surface like a mirror) to 12 (hurricane winds and sea surface with high waves and water spray).

Cloud coverage was categorized as: 0 to 25% of coverage, 26 to 50% of coverage, 51 to 75% of coverage, and 76 to 100% of coverage. To investigate if the behaviours varied according to sea state and cloud coverage, data was analysed using a chi-square test using a level of significance of 95% (α = 0.05) (Zar, 2009).
RESULTS

Whales were sighted 342 times, being 158 (46.19%) in 2008, 115 (33.63%) in 2009, and 69 (20.18%) in 2010. Most of the groups did not exhibit surface activities (195 groups in activity intensity level 4: 57.01%). Activity intensity level 3 was observed in 65 groups (19.01%), while activity intensity level 2 was observed in 49 groups (14.33%). The highest level of surface activity (level 1) was observed in 33 groups (9.65%) (Table 1).

In 2009, the highest recording of level 4 (no surface activities) (62.61%) and the lowest recording of level 1 (highest surface activities) (6.96%) were made (Table 1). In 2010, on the contrary, it was recorded the highest level of surface activities (level 1: 11.59%) and the lowest level of no surface activities (level 4: 53.62%) of all seasons evaluated (Table 1). The variation of the activity levels, however, did not differ statistically between the years ($X^2 = 1.266$ for level 1; $X^2 = 0.804$ for level 2; $X^2 = 0.461$ for level 3 e $X^2 = 0.867$ for level 4; df = 2; $P > 0.05$ in all levels).

Table 1: Levels of surface activities of humpback whales in relation to breeding season (2008-2010) in the northern coast of Bahia, Brazil (absolute values and percentages).

<table>
<thead>
<tr>
<th>Year</th>
<th>Group</th>
<th>Level of surface activity</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>2008</td>
<td>Singleton</td>
<td>3</td>
<td>1.86%</td>
</tr>
<tr>
<td></td>
<td>Dyad</td>
<td>3</td>
<td>1.86%</td>
</tr>
<tr>
<td></td>
<td>Triplet</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>&gt; 3 adults</td>
<td>6</td>
<td>3.73%</td>
</tr>
<tr>
<td></td>
<td>Mother/calf</td>
<td>3</td>
<td>1.86%</td>
</tr>
<tr>
<td></td>
<td>Mother/calf/escort</td>
<td>1</td>
<td>0.62%</td>
</tr>
<tr>
<td></td>
<td>Mother/calf/2 escorts</td>
<td>2</td>
<td>1.24%</td>
</tr>
<tr>
<td></td>
<td>Mother/calf/+2 escorts</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>2009</td>
<td>Singleton</td>
<td>2</td>
<td>1.64%</td>
</tr>
<tr>
<td></td>
<td>Dyad</td>
<td>2</td>
<td>1.64%</td>
</tr>
<tr>
<td></td>
<td>Triplet</td>
<td>2</td>
<td>1.64%</td>
</tr>
<tr>
<td></td>
<td>&gt; 3 adults</td>
<td>1</td>
<td>0.82%</td>
</tr>
<tr>
<td></td>
<td>Mother/calf</td>
<td>2</td>
<td>1.64%</td>
</tr>
<tr>
<td></td>
<td>Mother/calf/escort</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Mother/calf/2 escorts</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Mother/calf/+2 escorts</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>2010</td>
<td>Singleton</td>
<td>2</td>
<td>2.94%</td>
</tr>
<tr>
<td></td>
<td>Dyad</td>
<td>3</td>
<td>4.41%</td>
</tr>
<tr>
<td></td>
<td>Triplet</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>&gt; 3 adults</td>
<td>2</td>
<td>2.94%</td>
</tr>
<tr>
<td></td>
<td>Mother/calf</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Mother/calf/escort</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Mother/calf/2 escorts</td>
<td>1</td>
<td>1.47%</td>
</tr>
<tr>
<td></td>
<td>Mother/calf/+2 escorts</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

Level 1: highest level (if the whales exhibited one or more behaviours more than ten times during a recording session or if the whales exhibited at least three different behaviours during a recording session); 2) medium level (when the whales exhibited one or more behaviours, and they were exhibited at most nine times during a recording session); 3) low level (when the whales exhibited one or more behaviours occasionally; i.e., one or two times during a recording session); and 4) lowest level (when none behaviours were exhibited by the whales during a recording session) (Félix, 2004).
Most of the sightings occurred with the sea classified in the Beaufort 2 (n = 141; 41.23%), followed by Beaufort 1 (n=137; 40.06%), and Beaufort 3 (n = 64; 18.71%) (Table 2). The level of surface activity exhibited in each Beaufort sea state did not differ statistically (X² = 0.453 for level 1; X² = 4.96 for level 2; X² = 0.45 for level 3 e X² = 0.861 for level 4; df = 2 and P > 0.05 in all cases).

Table 2: Levels of surface activities of humpback whales in relation to sea state (according to the Beaufort scale) in the northern coast of Bahia, Brazil, during the breeding seasons of 2008-2010 (absolute values and percentages).

<table>
<thead>
<tr>
<th>Beaufort Scale</th>
<th>Level of surface activity</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>1</td>
<td>13</td>
<td>11</td>
</tr>
<tr>
<td>2</td>
<td>15</td>
<td>27</td>
</tr>
<tr>
<td>3</td>
<td>5</td>
<td>11</td>
</tr>
<tr>
<td>Total</td>
<td>33</td>
<td>49</td>
</tr>
</tbody>
</table>

Level of surface activity 1: highest level (if the whales exhibited one or more behaviours more than ten times during a recording session or if the whales exhibited at least three different behaviours during a recording session); 2) medium level (when the whales exhibited one or more behaviours, and they were exhibited at most nine times during a recording session); 3) low level (when the whales exhibited one or more behaviours occasionally; i.e., one or two times during a recording session); and 4) lowest level (when none behaviours were exhibited by the whales during a recording session) (Félix, 2004). Beaufort scale 1: ripple with the appearance of scales are formed, but without foam crests; 2) small wavelets still short, but more pronounced; crests have a glassy appearance and do not break; 3) large wavelets; crests begin to break; foam of glassy appearance; perhaps scattered white horses (Singleton, 2008).

Most of the sightings occurred with a cloud coverage less than 50% (n = 230, 67.25%); observations with the sky covered by 26-50% of clouds were more common (n = 123, 35.96%) than observations with the sky covered by 51-75% of clouds (n = 46, 13.45%) (Table 3). Surface activity in each cloud coverage varied, but no statistical differences were found (X² = 0.409 for level 1; X² = 4.873 for level 2; X² = 1.971 for level 3 and X² = 0.335 for level 4; df = 3 and P > 0.05 in all cases).

Table 3: Levels of surface activities of humpback whales in relation to cloud coverage in the northern coast of Bahia, Brazil, during the breeding seasons of 2008-2010 (absolute values and percentages).

<table>
<thead>
<tr>
<th>Cloud coverage (%)</th>
<th>Level of surface activities</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>0-25</td>
<td>9</td>
<td>10</td>
</tr>
<tr>
<td>26-50</td>
<td>11</td>
<td>18</td>
</tr>
<tr>
<td>51-75</td>
<td>6</td>
<td>8</td>
</tr>
<tr>
<td>76-100</td>
<td>7</td>
<td>14</td>
</tr>
<tr>
<td>Total</td>
<td>33</td>
<td>50</td>
</tr>
</tbody>
</table>

Level of surface activity 1: highest level (if the whales exhibited one or more behaviours more than ten times during a recording session or if the whales exhibited at least three different behaviours during a recording session); 2) medium level (when the whales exhibited one or more behaviours, and they were exhibited at most nine times during a recording session); 3) low level (when the whales exhibited one or more behaviours occasionally; i.e., one or two times during a recording session); and 4) lowest level (when none behaviours were exhibited by the whales during a recording session) (Félix, 2004).
DISCUSSION

Sea state and cloud coverage did not influence the surface activities of humpback whales, not corroborating the results found by Herman & Antinoja (1977) and Scott & Winn (1979). These authors reported an increase in the surface activities in a rough sea, relating it to an increase in the water turbidity and in sound pressure levels due to turbulent waters, especially in the shallow waters used by the whales in the breeding season. In the present study, the highest classification of the sea state was 3, what in the Beaufort scale means light winds that provoke waves of 60 cm high at maximum (Huler, 2004). Calm waters means good possibilities to acoustic communications (Preisig, 2006; Jones, 2019), consequently, a low need to exhibit surface activities. The calm waters probably influenced the level of surface activities recorded for humpback whales during this study.

The functions of the surface activities exhibited by the humpback whales remain speculative, but many researchers suggest that they play a role in the social organization of the groups (Félix, 2004; Dunlop et al., 2017; Kavanagh et al., 2017; Schuler et al., 2019). Dunlop, Cato & Noad (2008) related that the rate of exhibition of the behaviour “breaching” was higher for solitary males or solitary whales of unidentified sex, suggesting that this behaviour have a function in the inter-group communication. “Slapping” was more recorded in groups of whales composed by mother-calf and mother-calf-escort, suggesting a function in the intra-group communication. Whitehead (1983, 1985) reported higher rates of surface activities in groups of more than two whales. Fiori et al. (2020) observed pairs, trios, and groups up to nine individuals expressing surface activities. These activities were related to agonistic behaviours and reproductive behaviours. One interesting result found by Fiori et al. (2020) was the influence of swimmers on surface activity of humpback whales: for mothers with calves, the amount of surface activity decreased significantly in the presence of swimmers, and for groups with no calves, surface activity increased significantly. These results showed the impacts of swim-with-the-whales tourism activities. In the present study, only groups of whales were recorded, but since data on group compositions were not collected, no correlations could be made.

Environmental factors certainly influence the propagation of the surface activities’ sounds through the water, but probably characteristics like temperature, depth, and salinity are more important in the rate of exhibitions than the variables studied here (Nia & Delphi, 2011; Sanjana et al., 2014), thus, further studies should be conducted to evaluate this hypothesis.
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REFERENCES


