Distribution and habitat use patterns of southern right whales, *Eubalaena australis*, off Uruguay

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ABSTRACT

Aerial surveys and behavioural observations from land were conducted 2001-03, between July and November, to evaluate the status and habitat use patterns of the southern right whale (*Eubalaena australis*) along 220km of the Uruguayan Atlantic coast. Photo-identification was carried out only during the aerial surveys, and group composition as well as spatial and temporal distribution was studied. For the analysis of distribution, the area was divided into four zones. Behaviour was studied from nine fixed points along the coast, analysing the relative frequency of three states (interacting, travelling and resting) and five events (flipper, spy hopping, tail-up, belly-up and flipper slap). Most individuals (90%) were seen from August to October (H=16.446, p=0.003) and there was no significant difference in sightings between the four zones (H=5.11, p=0.163). In 80 sightings, 174 individuals were observed, of which 8% (n=14) were cow-calf pairs and 92% (n=160) were unaccompanied whales (whales without calf). Out of these, 76.9% (n=123) were found in groups that ranged 2-13 individuals (mean=3.4; SD=2.7) and the rest (23.1%; n=37) were solitary. Sixty individuals were identified, one of which was re-identified within a season. Focal sampling on unaccompanied whales took place on ninety-three occasions; 64 on groups and 29 on solitary individuals. For groups, the most frequent behavioural state was interaction (57.8%), and all events were observed, spy hopping being the most frequent. Given the high proportion of unaccompanied whales and interacting groups recorded, Uruguay is thought to be an important social area for the species, where behaviour similar to those previously described as courtship and mating were observed. The dynamics of the different categories of individuals off the Uruguayan coast is discussed and investigation priorities are suggested.

KEYWORDS: SOUTHERN RIGHT WHALE; SOUTH AMERICA; PHOTO-IDENTIFICATION; BEHAVIOUR; SOCIAL; SOUTHERN HEMISPHERE; MOVEMENTS; ATLANTIC OCEAN; SITE FIDELITY

INTRODUCTION

Southern right whale (*Eubalaena australis*) populations were commercially hunted during the 18th and 19th centuries (IWC, 2001). Several populations are increasing at a rate of about 7% per annum or more in some areas of its distribution (Best *et al*., 2001; Cooke *et al*., 2001; Groch *et al*., 2004; IWC, 2001).

The southern right whale is a migratory species distributed between 20° and 60°S. In early winter, the whales migrate to medium and to low latitudes, where calving takes place (Best, 1990; Burnell, 2001; Rowntree *et al*., 2001). The best studied calving grounds are found off South Africa (Best, 1990;2000), Peninsula Valdes in Argentina (Bastida and Lichtschein, 1984; Payne, 1986; Payne *et al*., 1990; Rowntree *et al*., 2001), southwest, south central and southeast Australia (Bannister, 2001; Bannister, 1990; Burnell, 2001), the sub-Antarctic Campbell and Auckland Islands of New Zealand (Patenaude *et al*., 1998; Patenaude and Baker, 2001) and southern Brazil (Palazzo and Flores, 1998). Additional calving winter grounds include Tristan da Cunha, and possibly Isla Gough placed in the central Atlantic Ocean, Namibia/Angola and Mozambique/Natal, both in Africa (IWC, 2001). Seven feeding grounds are recognised, based on sightings and historical records from commercial hunting (IWC, 2001). One feeding ground extends from Brazil/False to Banks/Malvinas Island in Argentina, considered a corridor offshore Brazil, Uruguay and Argentina, between 30° and 55°S and west of 40°W (IWC, 2001; Tormosov *et al*., 1998).

In 1789, a factory was established in Punta del Este, Uruguay (35°S) by the *Real Compañía Marítima* of Spanish origin (Acosta y Lara, 1987) to capture and process southern right whales and sea lions (*Otaria bironya* and *Artocephalus australis*). Few records are available on the number of right whales captured, because the warehouses and offices of *The Real Compañía* were burned down during the British occupation in 1806 and 1807. Four southern right whales were caught in 1789, 30 whales in 1791 and 20 in 1795 in Maldonado Bay (Diaz de Guerra, 2003). American whale ships caught southern right whales and sperm whales (*Physeter macrocephalus*) off the Uruguayan Atlantic coast between 1761 and 1920. The catches were inshore in September, October and November and offshore in December and January (Townsend, 1935). Although capture records are not complete, historic accounts suggest the existence of a substantial number of right whales in Uruguayan waters during the commercial exploitation period (Diaz de Guerra, 2003; Tormosov *et al*., 1998). Tormosov *et al*. (1998) reported a substantial illegal catch of 1,356 southern right whales by Soviet whaling operations between 1960 and 1971 in the southwestern Atlantic. Since 1975, southern right whales have been incidentally recorded off Uruguay (Costa *et al*., 2005).

Historical accounts, incidental sightings and recent survey data suggest that the Uruguayan coast may be host to a number of southern right whales (Acosta y Lara, 1987; Costa *et al*., 2005; Diaz de Guerra, 2003; Townsend, 1935), but the role of the Uruguayan Atlantic coast in the ecology of southern right whales is unclear. From 2001 to 2003, a systematic survey of the species was conducted along the Uruguayan coast, to assess the status and habitat use of southern right whales in the region. This paper reports the results on the spatial and temporal distribution, photo-identification and behaviour of right whales in winter and spring and presents evidence that the Uruguayan Atlantic coast is an important winter aggregation area for southern right whales.

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METHODS

Study area and period

Uruguay (33°-35°S) is situated between two important southern right whale nursery grounds: Santa Catarina (27°-25°S, Brazil; Palazzo and Flores, 1998), and Península Valdés (42°S, Argentina); (Bastida and Lichtschein, 1984; Payne, 1986; Payne *et al*., 1990; Rowntree *et al*., 2001). The study area includes 220km of the 250km of the Uruguayan Atlantic coast, from Punta Ballena (35°02'S) to Cerro Verde (33°54'S, Santa Teresa). The aerial surveys were conducted from July to November, for the years 2001 to 2003. The area was divided into four zones of 55km each (I to IV) for the analysis of spatial and temporal distribution. Behavioural data were collected from August to November from nine fixed points along the coast, distributed among the four zones (Fig. 1).

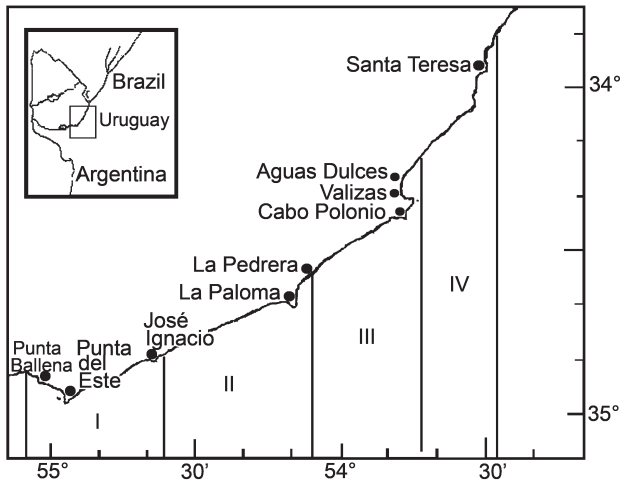

Fig. 1. Uruguayan Atlantic coast line showing distributional zones (I-IV) and the fixed points (dots).

Distribution and group composition

Fifteen aerial surveys (five per year) were carried out in a single engine aircraft, *Cessna 172*. The surveys were conducted at relatively regular intervals between each month, when the weather conditions were considered ideal for flight: calm seas, wind speed lower than 15 knots and good visibility (Bannister, 1990). For each flight, the area was surveyed twice along the same track at a constant distance from the coast of 500m, and at a constant altitude of 400m. The sighting effort was principally inside the 1,000m strip following the coastline, but some whales sighted beyond 1,000m up to 2,000m from the coast were also recorded. The aerial survey team comprised four observers, two of them (a pilot and a recorder) were in the front seats, and two observers (one also the photographer) sat in the back seat. The photographer sat behind the pilot. The number of right whales, group size and composition, along with the position taken from a GPS (global positioning system) were recorded on paper. Two whales were considered to be in a group if they were within less than two body lengths of each other. Group composition was divided into cow-calf pairs and unaccompanied whales. A cow-calf pair was defined as any pair of whales in which the length of one individual was greater than half that of the other, and the maximum distance between the pairs was not greater than the length of the mother. Unaccompanied whales were defined as all right whales that were solitary or in groups, but were not accompanied by a calf. Group composition was not categorised by age or sex. Residency time was considered to be the number of days between the first and the last photo-identification.

Photo-identification

The southern right whale has a variable pattern of callosities on its head, which is used to identify individuals through well-established photo-identification techniques (e.g. Bannister, 1990; Best, 2000; Payne *et al*., 1983). In this study, photographs of the individuals were taken (following Payne *et al*., 1983) only during the survey flights apart from an additional photo-identification flight off Punta el Este (Fig. 1) in September 2003, that took advantage of a whale aggregation in the area. Once a whale or group was seen, the aircraft descended to an altitude of 130-170m. Conventional 35mm cameras were used (*Nikon* 6006 and F65) equipped with AF *Nikkor* 70-300 zoom lens and negative colour film 400 ISO, and 1/750sec exposure.

For the analysis of the photographs, first pictures of whales that could potentially be identified were selected, i.e. those pictures in which the numbers and locations of the callosities were visible. The selected images were then scanned at high resolution in TIFF format. The quality of each selected photograph was classified as poor (a high degree of reflection, water splash and/or a bad angle), good (some reflection or water splash and a good angle) or excellent (without reflection or water splash and a good picture angle). Second, an automated system for matching the callosity patterns depicted on aerial photographs of southern right whales was used (Hiby and Lovell, 2001). The program uses the variation among shape, location and size of the callosities. The program does not replace visual comparison, but suggests the order in which the photographs should be analysed and allows the user to discard from the search those photographs with little or no potential of being matched (Hiby and Lovell, 2001). The first 20 ranked photographs were analysed by eye by at least two members of the research team. The photographs were compared and when a picture that did not match to any other was found, it was added to the photo-identification catalogue. Finally, Victoria Rowntree, an experience researcher in southern right whales photo-identification re-analysed the Uruguayan catalogue.

Behaviour

Behavioural data were recorded from the fixed locations on land (Fig. 1). In 2001, *ad libitum* (Altman, 1974) data were obtained to delineate and define behaviours and research questions, train observers and to standardise techniques. In 2002 and 2003, focal-group sampling (Altman, 1974) was carried out on unaccompanied whales. Every 15 days, eight hours (9am to 5pm) of behavioural surveys were conducted simultaneously from the nine locations. Behaviour and group size was recorded at each location by two observers using continuous sampling techniques (Altman, 1974). Three behavioural states (interacting, travelling and resting) and five behavioural events (flipper, spy hopping, tail-up, belly-up and flipper slap) were recorded. Interacting was defined as two or more active animals, separated by no less than a body length and exhibiting different movements orientated toward other animals (rolling, immersions, turns, contacts, semi-immersion with exposure of the flippers, tail or head), following the definition of Cassini and Vila (1990) for interacting groups. Resting was recorded if one or more individuals showed no apparent movement, and travel was

considered the directional movement of one or more individuals. Focal-group sampling was carried out on some interacting groups for 20 minutes to record the following behavioural events: *flipper*, exposure of the flipper; *spy hopping*, being the whale virtually perpendicular to the surface of the water; *tail-up*; *belly-up*, when a whale is in a inverted position exposing a ventral zone; and *flipper slap*.

Statistical analyses

Due to the small sample size, the non-parametric Kruskal-Wallis test was used to test whether the number of recorded individuals changed between years, months and zones. Only the highest number of individuals counted during one of the two replicate surveys was used for the analyses, with the exception of the analysis of whale distribution within a zone, in which all the sighted individuals were included and forward and backward flights were considered as replicates in each aerial survey. Group composition of the individuals sighted from the aircraft was studied through examination of relative frequencies. For observations from land, the relative frequencies of the three behavioural states and the five behavioural events were analysed and standard deviations were calculated by doing 1,000 bootstrapping runs over 60% of the samples. The proportion of time was analysed only between behavioural states.

RESULTS

Spatial and temporal distribution

Each aerial survey lasted on average for 102.2min (SD=30.45). The duration depended on wind speed and direction as well as on the number of whales sighted. The total number of groups sighted was 79 (158 individuals) over the three years. The maximum number of whales sighted per year was 63 in 2001, 44 in 2002 and 51 in 2003. The difference in the numbers between years was not significant (H=0.211, p=0.899). Individuals were sighted during all five months of the season, but 90% of the sightings were recorded from August to October (Fig. 2a), with a significant difference between months (H=16.446, p=0.003). Although the largest numbers of whales were recorded in 2001 and 2003 in zone III (Fig. 2b), there were no significant differences between the four zones for any of the three years (H=5.11, p=0.163).

Including the additional flight in September 2003, a total 174 individuals were observed in 80 sightings over the three years, 8% (n=14) of which were cow-calf pairs, and 92% (n=160) were unaccompanied whales. Of the unaccompanied whales, 76.9% (n=123) were found in groups of between two and 13 individuals (mean=3.4; SD=2.7) and the rest (23.1%; n=37) were solitary individuals. The most frequent group size of unaccompanied whales was of two and four whales (29.3%; n=36) (Fig. 3).

Photo-identification

During the three years of the study, 60 individuals were identified out of 174 sighted, one of them was re-identified within seasons and none of them between seasons. Seven were identified in 2001, 20 in 2002 and 33 in 2003. In the first months of the study in 2001, it was not possible to identify any individual in spite of the fact that all encounters were photographed when possible. After three rehearsal flights and adjustments of the technique, the first images of suitable quality for identification were obtained. The behaviour of whales influenced the probability of identification. Individuals found in interacting groups were easier to identify because they were more detectable and showed less changes in behaviour while being photographed. It is assumed that seven of the whales were females, because they were recorded as a cow-calf pairs. They were observed in October and November in 2001 and August-November in 2003. In 2002 no cow-calf pairs were observed. Six calves were about half their mothers' length, while another was less than half of its mother's length. Two cow-calf pairs were observed in the same survey (October 2001), while the rest were observed in different flights. On three occasions, cow-calf pairs were the only individuals recorded during the entire survey.

The only matching that occurred within the same season was in 2003. An unaccompanied whale was identified in zone I on 9 September and re-identified in zone II on 10 October, a period of 41 days.

Behaviour

A total of 139 whales in 96 sightings were recorded from land during 92h 10min of direct behavioural observations. Some duplicates may have been counted because the methods employed did not avoid recounting and individuals were not photo-identified. This number (n=139) differs from that of whales sighted from the air (n=174) as the scale of work was different. Despite conducting observations for eight hours from nine fixed points simultaneously, the area covered included only 55% of the total area considered in the aerial surveys. Six individuals were part of three cow-calf pairs and the rest were unaccompanied whales. The three cow-calf pairs were not observed in association with other individuals, but two pairs were observed along the same beach, interacting with each other. The three calves were about half their respective mothers' body length. Focal-group sampling was undertaken on unaccompanied whales in 93 sightings, 64 of which involved groups (70.3 hours or 75% of the total time) that ranged from 2-11 individuals (mean=2.9; SD=1.9) and 29 solitary individuals (23.7 hours or 15% of the total amount of time). Within the groups, the most frequent behavioural state was interaction (57.8%; SD=2.03, 62.5% of the observation time), followed by resting (21.9%; SD=1.83, 20.2% of the observation) and travelling (20.3%; SD=1.94, 17.3% of the observation). Solitary whales were observed to be travelling 58.6% of the time and the remaining were resting (41.4%).

Twenty one focal-group samplings were carried out on 12 different interacting groups (eight pairs and four trios) to record the behavioural events. These represent the 7.4% of the total amount of observation time. Belly-up was recorded in six groups, while the rest of the events were observed in all the groups. The most frequent event (238 out of 571) was spy hopping (Table 1).

DISCUSSION

Distribution

Southern right whales are seen close to the Uruguayan coast in winter and spring, with peak sightings (90% of individuals) occurring August-October. This seasonality is in agreement with observations in Península Valdés in Argentina (Payne, 1986) and Santa Catarina in Brazil (Palazzo and Flores, 1998).

Right whales do not appear to concentrate in any particular area along the 220km of the Uruguayan Atlantic coast. Outside the study area, they have only occasionally been recorded, both to the east (border with Brazil) and west (Río de la Plata). It is necessary to continue these surveys in order to examine whether the observed distribution is

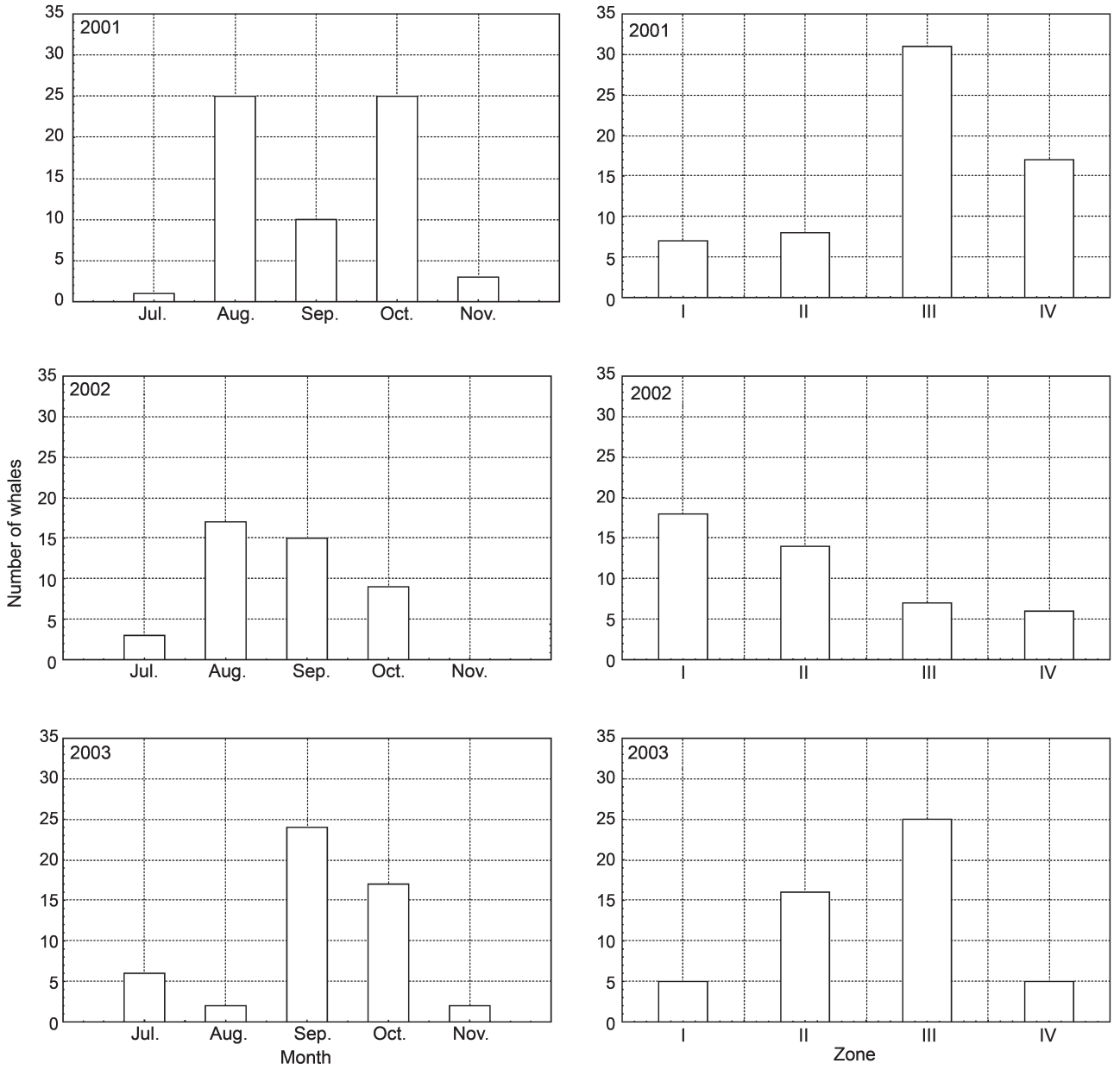

Fig. 2. Spatial and temporal distribution of southern right whales off the Uruguayan Atlantic coast in the period 2001-2003. (a) Number of whales sighted per month in each aerial survey. (b) Number of whales sighted per zone in each aerial survey.

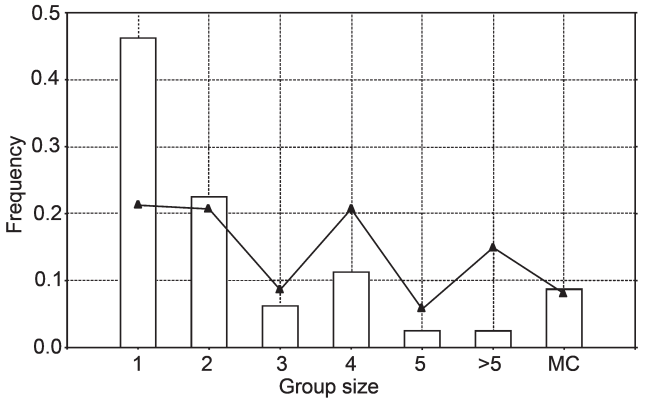

Fig. 3. Groups size of southern right whales observed off the Uruguayan Atlantic coast in the period 2001-2003. Bars show group sighting frequency, the line shows frequency of individuals of each group.

consistent in the long-term, or if there are zones with higher concentration of whales on a smaller scale, as has been observed for other right whales aggregations.

Table 1

Frequency and standard deviation bootstrapping of the five behavioural events recorded for interacting groups on the Uruguayan coast in 2002.

Events	Relative frequency	SD
Head	0.42	0.062
Flipper	0.36	0.064
Tail-up	0.16	0.047
Belly-up	0.04	0.025
Flipper slap	0.02	0.017

Relative abundance indices

The maximum number of individuals sighted in an aerial survey (25, 17 and 24 individuals in 2001, 2002 and 2003, respectively) can be used as a relative abundance index in order to assess the number of individuals occurring in the study area (Bannister, 1990). Covering the entire study area ensures a low margin of error, lower than those of temporally separated partial counts, since individuals can travel some distance in short periods of time (Bastida and

Lichtschein, 1984). Variations in the maximum number of individuals sighted in aerial surveys from year to year may be taken to infer population status (increases or decreases in abundance) until precise population parameters and abundance estimates are obtained (Hammond, 2001). When considering observations from the Australian coast, Bannister (2001) suggested that at least five years of consecutive aerial surveys are needed to calculate growth rates. However, if all the population is to be taken into account in the analysis (including unaccompanied whales), at least a five-breeding-cycle study is required, which means 15 years since the species breeds every three years on average. Taking this into consideration and the proportion of unaccompanied whales (92%) observed in this study, it is clear that to obtain robust population trend data for Uruguay will require long-term studies.

Photo-identification

The fact that there was only one re-identification of a whale within a season prevents any reliable estimate of the residence time of right whales at the Uruguayan Atlantic coast. Although one unaccompanied whale was present for 41 days the study suggests that for most of the whales, residency in the area does not exceed 30 days. In South Australia, it has been observed that individuals sometimes leave the coastal zone and move to the open sea, which may hinder the determination of residence time for individuals in the area (Burnell and Bryden, 1997). The possibility of something similar happening off Uruguay cannot be ruled out. There were no re-identifications between seasons in the present study and further work is needed to determine whether some individuals show site fidelity to the Uruguayan coast.

Cow-calf pairs

Most births of southern right whales in the western South Atlantic occur in August (Palazzo and Flores, 1998; Whitehead and Payne, 1981) but births can occur as late as October (Whitehead *et al*., 1986). Photogrammetry studies of cow-calf pairs in South Africa suggest that calves which are 40-60% of the length of the cow, are up to only a few months old and when the calf is half of its mother's length, it is about three months old at most (Best and Rüther, 1992). Thus, out of the seven cow-calf pairs identified, one calf (recorded in October) may have been born in Uruguayan waters since it was less than half of its mother length.

Cows stay longer on the nursery ground in the breeding sites, about 70 days in Peninsula Valdés and 60 days in South Africa, and are the most re-sighted individuals for a given sampling season (Best, 2000; Burnell, 2001; Burnell and Bryden, 1997; Rowntree *et al*., 2001). Although cow-calf pair residence times could not be obtained using photo-identification data, as previously mentioned, they could be suggested for two cow-calf pairs on two occasions. The first case was on 16 August 2003, when a single cow-calf pair was recorded in Valizas (zone III) during the entire land based survey. Three days later (19 August), a single cow-calf pair was recorded (zone II) and photo-identified during the entire aerial survey. As their characteristics were similar it was suggested they could be the same individuals. If this is correct they had moved about 32km south in four days.

The second case occurred some weeks later, on 8 November, when a single mother-calf pair was sighted during the whole land survey in Cabo Polonio (zone III). On the following day, in the same place, two cow-calf pairs were seen interacting. In the final aerial survey of the season (21 November), only one cow-calf pair was recorded and photo-identified along the same beach during the entire survey, so it was thought that it could have been one of the two cow-calf pairs seen on the previous land survey. If these assumptions are correct, the pair stayed in the area for more than ten days, indeed local people stated that these whales stayed for over 20 days on this beach. Clearly, the residence time of the cow-calf pairs needs further research.

The fact that all the calves were sighted only once during aerial surveys and they were half their mothers' body length, suggests that they were not born on the Uruguayan coast. These records could be results of a migration south from their natal site. A likely natal site could be Santa Catarina coast, where a high proportion of cows and small calves are often recorded (Palazzo and Flores, 1998). Best *et al*. (1993) found that three cows identified in South Brazil had been identified in Argentina with different calves in previous years. This study supports one of the hypotheses proposed by Best *et al*. (1993) to explain re-identification; some females could move between two nursery grounds in the year their calves are born. A female could give birth in South Brazil and then move south, towards Península Valdés, possibly as a part of a coastal migration towards higher latitudes as the summer arrives (Best, 1970;1981). It could also be true that females migrate north to Uruguay after being off Península Valdés.

Unaccompanied whales/groups

The high proportion of unaccompanied (i.e. no calf) whales (90%) and of interacting groups (57.8%), suggests that the Uruguayan coast may be a primary social area for adult and/or young individuals (Kraus and Hatch, 2001), where behaviour such as courting and reproduction could be observed.

It is well know that cow-calf pairs congregate in specific nursery grounds and segregate from unaccompanied whales (Best, 1990; Elwen and Best, 2004; Payne, 1986). It was suggested that this is to avoid contact with unaccompanied males, reducing the occurrence of harassment which can be fatal to the calves (Elwen and Best, 2004). The low proportion of cow-calf pairs (10% of the sighting) in this study and the fact that three of them were the only sighting in the flight along the entire study area, suggests that avoidance of unaccompanied whales is indeed occurring.

Unaccompanied individuals present higher dispersion, shorter residence times and less site fidelity to calving areas than females with calves; in fact, the winter locations of these individuals are unknown when they are not at the nursery ground (Burnell, 2001). Specific breeding grounds are not known of, but mating behaviour is commonly seen on the nursery ground (IWC, 2001). This indicates that the behavioural patterns of these individuals are more complex than cow-calf pairs.

Interacting groups, which show behavioural events such as tail and flipper slaps, spy hopping and belly up have traditionally been associated with mating groups (Payne, 1986). Kraus and Hatch (2001) and Best *et al*. (2003) defined surface active groups (SAGs) as groups of two or more individuals that interact on the surface, in which one focal individual is surrounded by other individuals. They also defined the roles of the different individuals and the sex ratio in the groups. Best *et al*. (2003) found off the South African coast the focal animal is usually an immature female surrounded mostly by males. In addition, it was recorded that the female often displayed the belly-up event, making copulation difficult and thus inciting males to compete (Cassini and Vila, 1990; Kraus and Hatch, 2001). In this

study, the belly-up position was recorded in six of the twelve groups followed; suggesting that some interacting groups could be reproductive in nature. The rest of the behavioural events recorded can appear in several contexts and be performed by individuals of both sexes and of different ages (Cassini and Vila, 1990). Studies of sex ratio and kinship within interacting groups are recommended for future investigation along the Uruguayan coast.

Observations carried out in Rio Grande do Sul State in Brazil showed that most individuals involved in mating groups were adults, while cow-calf pairs were rarely observed (Palazzo and Flores, 1998). This could indicate that the group composition of whales occurring off the Uruguayan coast could be an extension of those in Rio Grande do Sul due to its close proximity. Taking into account that conception and births occur around mid-winter (Best *et al*., 2003; Burnell, 2001; Payne, 1986) and that the behaviour observed in our study is comparable to those of courtship and breeding as already described, it is suggested that the Uruguayan coast could be an area of socialisation and breeding for southern right whales, although the age, sex and kinship of the whales are completely unknown.

It is important to continue photo-identification and long-term studies, as well as to expand studies of species off the Uruguayan Atlantic coast. Studies of social behaviour and mating strategies and genetic structure gene flow between populations from the Western South Atlantic would provide valuable data, with the aim of determining biological and/or management stocks. Finally, research into the possibility of the existence of feeding habitats in the South Western Atlantic would be of great value.

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