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Occurrence of bottlenose dolphins (*Tursiops truncatus*) in the Río Negro Estuary, Argentina, and their mid-distance movements along the northeastern Patagonian coast

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Abstract. A systematic study was carried out on bottlenose dolphins (*Tursiops truncatus*) in the Río Negro Estuary (RNE), Patagonia, Argentina, to analyze their occurrence and activity patterns in this region. The photo-identification data of this study was further compared to data from an adjacent region to gain information on the animals' movements along the northeastern Patagonian coast. Information was gathered through land-based observations between the months of March and July of 2008 up to 2011. Data on dolphin activity patterns were collected via an *ad libitum* focal-group sampling mode. At the same time, dorsal fin images were obtained from as many dolphins as possible for identification and subsequent re-identification of individuals. Total effort equaled 188h, resulting in 58h of observation of 124 dolphin groups [sightings per unit effort (SPUE) = 0.66 group/h]. Most of the groups observed contained between one and five individuals, and two main activity states could be determined, namely traveling (65%) and foraging (26%). The photo-identification effort, which started opportunistically in 2006, resulted in a catalogue of 17 individual dolphins, with a total mean re-identification rate of nine days (max. = 24 days). When comparing these pictures to the existing catalogue of Bahía San Antonio (BSA; approximately 200km west from the study area) dorsal fins of 15 individuals could be matched and most (n = 12) could be subsequently re-identified in both areas, indicating their long distance movements along the northeastern Patagonian coast during the austral autumn months. This season coincides with the lowest dolphin abundance and feeding activity in BSA. This study indicates that bottlenose dolphins enter the RNE to forage at least during autumn. It further suggests that the search for food resources is the main trigger for their movement patterns along the northeastern Patagonian coast during this season, at least for certain individuals. More research is needed to accurately confirm these hypotheses.

Resumo. Um estudo sistemático sobre ocorrência e padrões de atividade de botos (*Tursiops truncatus*) foi realizado no estuário do Rio Negro (RNE), Patagônia, Argentina. Os dados de foto-identificação deste estudo foram também comparados com dados de uma região adjacente, a fim de obter informações sobre os movimentos dos animais ao longo da costa nordeste patagônica. As informações foram obtidas através de observações com base em terra, entre março e julho de 2008 até 2011. Os dados sobre padrões de atividade de botos foram coletados por meio de amostragem de grupo focal *ad libitum*. Ao mesmo tempo, as imagens de nadadeiras dorsais foram obtidas do maior número de botos possível, para identificação e subsequente re-identificação de indivíduos. O esforço total correspondeu a 118h, resultando em 58h de observação de 124 grupos de botos [avistagens por unidade de esforço (SPUE) = 0,66 grupo/h]. A maior parte dos grupos observados continham entre um e cinco indivíduos, e dois estados de atividade principais puderam ser determinados: deslocamento (65%) e alimentação (26%). O esforço de foto-identificação, que

iniciou oportunisticamente em 2006, resultou em um catálogo de 17 indivíduos, com uma taxa média total de re-identificação de nove dias (max. = 24 dias). Comparando essas fotos com as do catálogo da Bahía de San Antonio (BSA, aproximadamente 200km a oeste da área de estudo), as nadadeiras dorsais de 15 indivíduos puderam ser reconhecidas, e a maioria (n = 12) pode ser subsequentemente re-identificada em ambas áreas, indicando seus movimentos de longa distância ao longo da costa nordeste patagônica durante os meses de outuno austral. Esta estação coincide com os menores níveis de abundância de botos e atividade de alimentação na BSA. Este estudo indica que os botos entram no estuário do Rio Negro para alimentar-se pelo menos durante o outono. O estudo sugere ainda que a busca por recursos alimentares é o principal fator para seus padrões de movimento ao longo da costa nordeste patagônica durante esta estação, pelo menos para alguns indivíduos. Pesquisas adicionais poderão confirmar adequadamente estas hipóteses.

Introduction

The bottlenose dolphin (*Tursiops truncatus*) inhabits warm and temperate coastal regions worldwide and is one of the best-studied cetacean species in the world (Bearzi, 2005) due to its frequent occurrence in coastal waters (Leatherwood and Reeves, 1990; Reynolds *et al.*, 2000). In Argentina, they are known to occur mainly from the province of Buenos Aires south to the province of Chubut, although some records have been made as far south as the province of Tierra del Fuego[1] (Perrin *et al.*, 2002; Bastida and Rodríguez, 2003). The first studies in Argentinean waters were conducted between 1970 and 1980 (Würsig, 1978; Würsig and Würsig, 1979; Bastida and Rodríguez, 2003) but these studies were discontinued due to a significant decrease in sightings. No clear explanation can be given on the reason for this apparent decline in dolphin occurrence although suggestions include increased mortality, resource depletion and environmental shifts (Coscarella *et al.*, 2012). More recently, the regular observations of the species in northeastern Patagonia have caused systematic studies to be initiated in this region in 2006, with an increased effort in Bahía San Antonio[2] (BSA; Vermeulen and Cammareri, 2009*a*, *b*; Vermeulen, 2011). The latter was recently suggested to be one of the last remaining areas in Argentina where bottlenose dolphins show a high degree of residency year-round (Vermeulen and Cammareri, 2009*a*, *b*; Vermeulen, 2011).

The present study aims to investigate the occurrence and activity patterns of bottlenose dolphins inhabiting the Río Negro Estuary (RNE), located approximately 200km east of BSA. Furthermore, photo-identification effort was initiated to gain a better understanding on the movements of the species throughout the larger area of northeastern Patagonia. Despite the fact that this species is considered the most extensively studied dolphin species, information on movements and home ranges in the Southwest Atlantic Ocean are still scarce (see Laporta *et* al., 2016 Report of the Working Group on Habitat Use, this volume). However, insight into the movement patterns of these dolphins is vital to comprehend ecological aspects of the population (Silva *et al.*, 2009), and will contribute towards the increasing conservation need in the country.

Materials and Methods

Study Area

Data were gathered in the RNE (41°03.6'S, 63°50.4'W), northeastern Patagonia, Argentina. This estuary and its surrounding areas (Figure 1) contain islands, sandbars, channels and saltmarshes. The warm turbid waters (visibility <

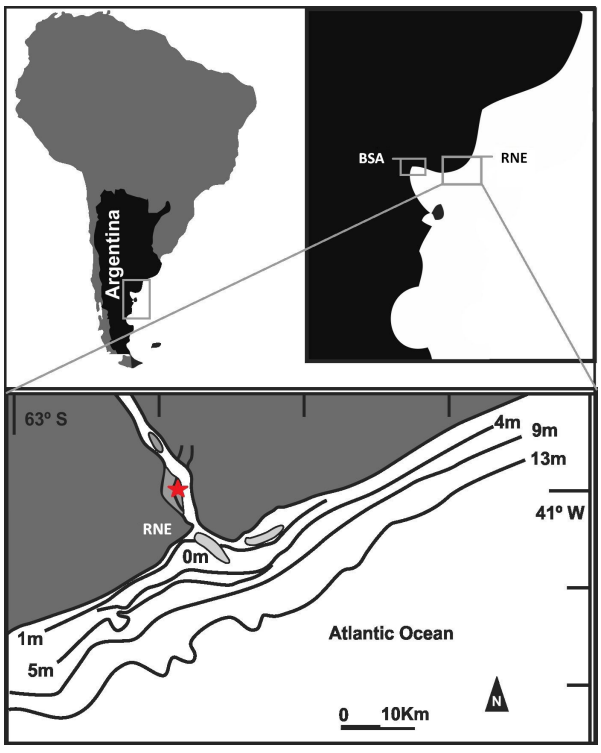


Figure 1. Map of the Río Negro Estuary (RNE), indicating the observation point (star) and the location of the Bahía San Antonio (BSA).

[1]Goodall, R.N.P., Dellabianca, N., Boy, C.C., Benegas, L.G., Pimper, L.E. and Riccialdelli, L. (2008) Review of small cetaceans stranded or incidentally captured on the coasts of Tierra del Fuego, Argentina, over 33 years. Paper SC/60/SM21 presented at the *60th annual meeting of the Scientific Committee of the International Whaling Commission*, Santiago, Chile, 1-13 June 2008

[2]Vermeulen, E., Cammareri, A. and Failla, M. (2008) A photoidentification catalogue of bottlenose dolphins (*Tursiops truncatus*) in North Patagonia, Argentina: A tool for the conservation of the species. Paper SC/60/SM1 presented at the *60th annual meeting of the Scientific Committee of the International Whaling Commission*, Santiago, Chile, 1-13 June 2008.

Figure 2. Example of a dorsal fin profile of bottlenose dolphin (designated as M43 in Table 2), photo-identified on various occasions in Bahía San Antonio (left) and the Río Negro Estuary (right).

1m) have a mean annual temperature of 19ºC (M. Failla, pers. obs.). Generally, the coast drops off steeply with depths of up to 2m at a distance of only 5m from the coastline. The Río Negro, which terminates in this estuary, is the longest river in Patagonia. The annual mean tidal amplitude is approximately 2.2m (M. Failla, pers. obs.).

Field Work

Systematic land-based surveys were conducted inside the estuary (Figure 1) by the same two observers between the months of March and July from 2008 through 2011. A bottlenose dolphin group was defined as all individuals within a 100m radius of each other, interacting or engaged in similar activities (Irvine *et al.*, 1981; Wells *et al.*, 1987; Wilson, 1995; Lusseau *et al.*, 2005). Dolphin group sizes were then classified into the following ranges: 1-5, 6-10, 11-15, 16-20 individuals and so on. When the number of animals could not be estimated accurately, group size was labelled as Not Classified (NC). Groups were further categorized as 'groups with calves' and 'groups without calves'. Calves were considered as being 2/3 or less the total length of a presumed adult and mostly swimming in close association with an adult (Shane, 1990).

Overall activity pattern was observed and recorded by means of an *ad libitum* focal group sampling mode (Altmann, 1974; Mann, 1999) using the following categories (adapted from Bearzi, 2005): (1) *traveling*: dolphins swim consistently in one direction with a slow to fast speed; (2) *feeding*: dolphins accelerate abruptly at the surface or circle around, often times synchronised and showing parallel movements; it may be possible to see fish jumping out of the water; (3) *other:* when another activity besides traveling or feeding is observed, or no clear activity pattern can be determined. During these land-based surveys, it was furthermore intended to take as many pictures as possible of the dorsal fins of all the individuals within the group at distances ≤ 100m from the coast. Additional opportunistic photo-identification effort in the region started in 2006. All pictures were taken using a digital reflex camera Canon® PowerShot IS10 with a Canon 28-560mm lens, and a Canon 30D with a Canon 100-300mm lens.

Analysis

All observations of dolphin groups that lasted ≤ 15min or were beyond 500m from the shore were not included in this analysis, as they were considered to be too short or too distant for accurate determination of the group's activity pattern, size and formation. The field effort, number of observations, number of dolphin groups and number of sightings per unit effort (SPUE; defined as the number of dolphin groups observed per hour of survey) were summarized in total and over the different survey years. The proportion of dolphin groups in each activity state was then calculated and represented graphically.

The naturally occurring marks used in this study were (adapted from Wilson, 1995) (1) *dorsal fin cuts:* pieces of tissue missing from the edge of the dorsal fin; (2) *unusual dorsal shapes:* distinctively shaped dorsal fins; (3) *major scars:* large scars and scratches on the dorsal fin or flank and (4) *deformations:* alterations of the normal body contour. These marks are considered to be unique and permanent. Photographs were graded as 'good', 'moderate', or 'poor' according to their sharpness, contrast, size of the dorsal fin relative to the frame and angle of the dorsal fin, and were analysed by an experienced researcher using FinEx and FinMatch identification systems[3]. To study the movement patterns of this species in northeastern Patagonia, only good quality pictures were used for comparison with the existing catalogue of BSA (Figure 2), which contains 63 individually identified bottlenose dolphins (Vermeulen *et al.*, 2008; Vermeulen and Cammareri, 2009*a*, *b*), by means of the same computer-assisted identification system as mentioned above.

[3]EC EuroPhlukes Initiative, University of Leiden, The Netherlands

Table 1. Land-based surveys: total survey effort (days and hours), positive effort (contact time with dolphins in hours), number of dolphin groups (DG) observed and SPUE (sightings per unit effort, dolphin group/hour) in the Río Negro Estuary, Patagonia, Argentina (March-July 2008 to 2011).

Year	Total effort (days)	Total effort (h)	Positive effort (h)	DG (nbr)	SPUE (DG/h)
2008	11	33.5	6.3 (19%)	15	0.45
2009	8	18.0	5.1 (28%)	12	0.67
2010	30	68.9	16.8 (24%)	49	0.71
2011	22	68.0	20.4 (30%)	48	0.71
Total	71	188.4	48.6	124	0.66

Results

Survey effort

A total of 71 days (188h) were dedicated to looking for dolphins in the study area. This survey effort resulted in 58h of observation of 124 groups of dolphins. The overall SPUE was 0.66 group/h (Table 1).

Activity patterns and group size

Analysing the activity patterns, it became clear that most groups were seen traveling (65%; n=124), whereas 26% were seen feeding in the study area. In the remaining 9% of the sightings, another activity state was observed or the activity could not be determined accurately.

Most of the groups observed contained between one and five individuals (37%), although occasional aggregations of up to 20 dolphins per group (2%) were recorded (Figure 3). In total, 31% of the observed groups had calves, with never more than one calf per group. Nevertheless, in 30% of the sightings, the presence of calves could not be accurately determined.

Photo-identification

Over 4200 digital pictures of dorsal fins were analysed from opportunistic and systematic photo-identification surveys (2006-2011). These pictures resulted in an identification catalogue of 17 individuals, with a maximum re-identification rate per individual of 24 days (mean = 9; Table 2). Most re-identifications occurred during the austral autumn months (April-June), and the majority of the individuals (n = 12) were re-identified within the study area in successive years with one individual present during all six annual survey periods. Five individuals were identified only once in the study area (Table 2).

When comparing these pictures to the existing catalogue from BSA, dorsal fins of 15 individuals could be positively matched and most (n = 12) could subsequently be re-identified in both areas (*e.g.* Figure 2). Six identified dolphins were resighted during the same month in RNE and BSA, with a minimum time of 14 days between sightings (E. Vermeulen, pers. obs.).

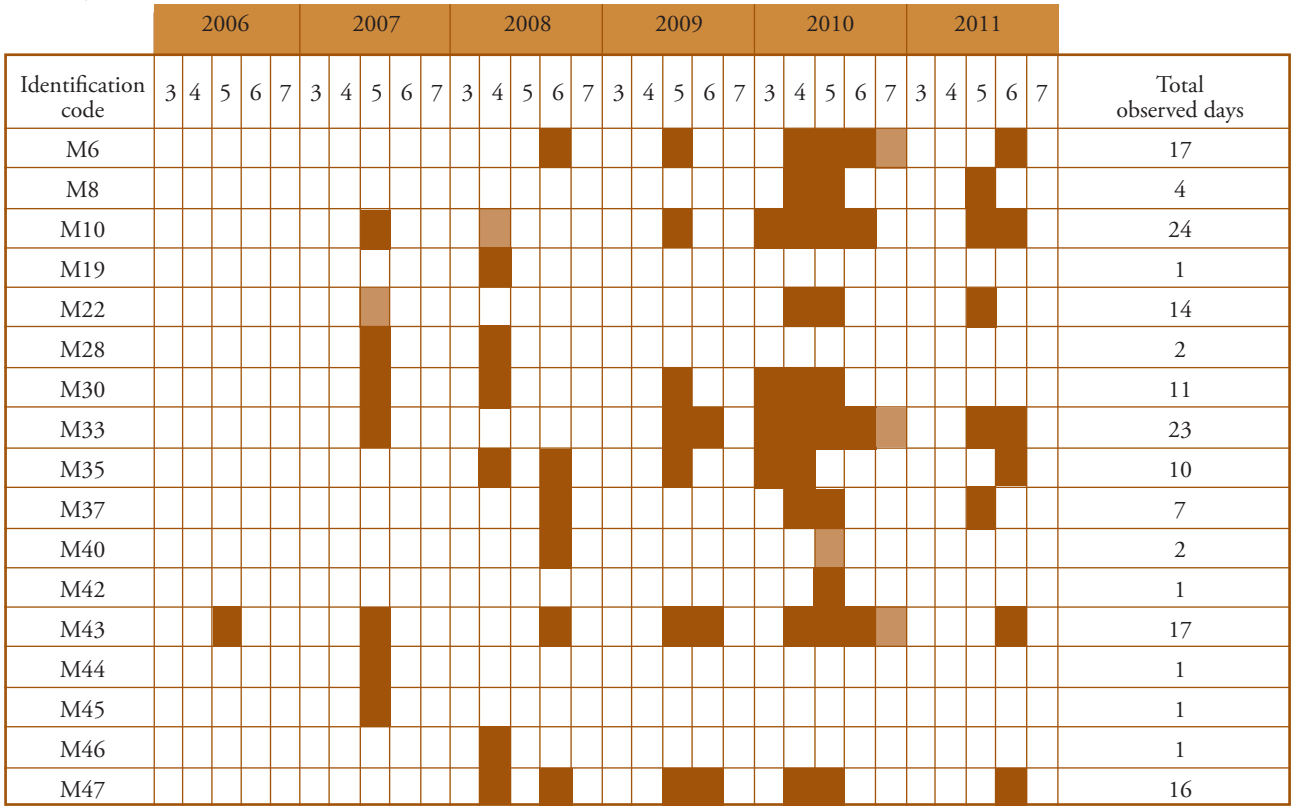
Discussion

The results from this study clearly indicate that bottlenose dolphins enter the RNE between March and July. The sizes of the dolphin groups observed during this study were relatively small, similar to those previously described for BSA (Vermeulen and Cammareri, 2009*a*) and Patos Lagoon Estuary (PLE), in southern Brazil (Mattos *et al.*, 2007). These small group sizes could indicate a relatively low predation pressure in the study area (Wells *et al.*, 1987).

The recorded activities of the observed bottlenose dolphin groups suggest that the study area is regularly used for feeding activities, similar to the Río Chubut Estuary, Patagonia, Argentina (Coscarella and Crespo, 2010) and the PLE (Mattos *et al.,* 2007). Furthermore, the study area seems to be frequently transited by the dolphins while moving up and down the Río Negro. As such, bottlenose dolphin groups have been recorded to travel up to 30km upstream in the river (near the city of Viedma, 40°48'S, 62°58'W), where they have been seen foraging in fresh and turbid waters with low visibility (M. Failla, pers. obs.). This suggests that besides the estuary itself, dolphins also use the river's freshwaters upstream as a foraging site, possibly in relation to the abundance of several fish species as southern flounder (*Paralichthys* sp.), liza (*Mugil liza*), silverside (*Odonthestes* sp.) and eels (*Chlopsis* sp.), known to transit up and down the river with the tide. All these species are caught in the area by local fishermen year-round[4] and are suggested prey species of the dolphins as they have been photographed jumping out of the water near foraging bottlenose dolphins (M. Failla, pers. obs.). In general, estuarine areas and river mouths have repeatedly been found to be sites of high bottlenose dolphin occurrence (Scott *et al.*, 1990; Berrow *et al.*, 1996; Gubbins, 2002; Zolman, 2002), and are often characterised by high levels of primary productivity and prey abundance (Acevedo, 1991). Results presented herein suggest accordingly that bottlenose dolphins

[4]Curtolo, L. and Di Giacomo, E. (2002) *Potencial pesquero de la desembocadura del Río Negro.* Informe Técnico del Instituto de Biología Marina y Pesquera Almirante Storni. San Antonio Oeste, Argentina. 60 pp.

Table 2. Resighting patterns of identified bottlenose dolphins in the Río Negro Estuary (NRE), Patagonia, Argentina (2006 to 2011).



Dark brown represents re-identification in RNE; light brown represents re-identification in both Bahía San Antonio (BSA) and RNE. Re-identifications solely in BSA are not represented. Note: 3=March; 4=April; 5=May; 6=June; 7=July.

enter the RNE mainly for foraging activities. Data were still too scarce to represent a monthly and/or yearly comparison of these results.

The re-identification of several individuals in both the BSA and the RNE, approximately 200km apart, indicates that those bottlenose dolphins move along the whole northern coast of the San Matías Gulf, northeastern Patagonia, as was reported previously (Vermeulen *et al.*, 2008). Overall, movements of coastal populations of bottlenose dolphins are known to range between short-distances of up to 100km (Ballance, 1992; Lodi *et al.,* 2008) and mid-distances of up to 300km (Würsig, 1978; Defran *et al.*, 1999; Simões-Lopes and Fabian, 1999; Bearzi *et al.*, 2011). Occasionally, long-distance movements of more than 500km (Wells *et al.*, 1990; Mate *et al.*, 1995; Defran and Weller, 1999) or even > 1000km (Wood, 1998; Wells *et al.*, 1999) have been recorded. The resighting of several individuals in both areas within the same month, and in the case of one individual within 14 days, indicates furthermore that these long-distance movements can occur in a relatively short time frame. Bottlenose dolphins have been recorded previously to travel large distances in relative short time lengths, with records of up to 50km/day (Mate *et al.,* 1995). Although the shortest recorded time frame between an animal being re-identified in both areas was 14 days, this should not be regarded as the minimum time, as subsequent re-identification is also effort dependent.

The analysis of ranging patterns of dolphins is crucial to understand several aspects of the ecology of a population (Silva *et al.*, 2009), as dispersion is a biologically important behaviour triggered by a range of key functions such as feeding, mating and finding shelter (*e.g.* Bearzi *et al.*, 2011). Generally, bottlenose dolphins living in less protected waters display extensive ranging patterns, whereas dolphins residing in protected coastal environments show a higher degree of site fidelity and residency (Wells *et al.*, 1987), as is the case in BSA (Vermeulen and Cammareri, 2009*a*). This study then raises the question of the reason behind the relatively wide-ranging dispersal of bottlenose dolphins outside BSA. Among coastal populations of bottlenose dolphins, males seem to have a wider home range than females, related to their mating strategy (Wells *et al.*, 1987). Furthermore, female ranging patterns are considered to be minimal for reasons of energetic efficiency (Sandell, 1989) and are usually thought to be more directly affected by ecological parameters such as the availability of resources and predation risk (Silva *et al.*, 2009). Accordingly, females associated with a calf were determined as being significantly more resident in BSA than individuals without calves (Vermeulen and Cammareri, 2009*a*; Vermeulen, 2011). However, in the present study, both males (confirmed

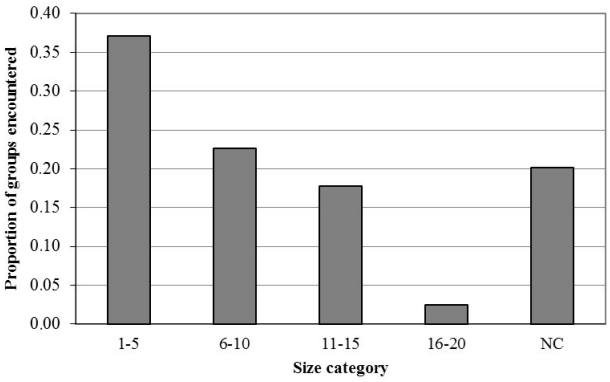


Figure 3. Proportion of different group size categories recorded for bottlenose dolphin groups observed in the Río Negro Estuary, Patagonia, Argentina (n=124; NC=not classified).

through PCR-based sex determination from biopsy samples of identified individuals from BSA)[5] and female/calf pairs were re-identified in both areas, and such a lack of differences in ranging patterns among sexes is considered to be related to environmental productivity (Fisher and Owens, 2000; Silva *et al.*, 2009). In practice, an increase in home range size with decreasing food availability/density seems to be a general result in mammals (Sandell, 1989). Interestingly, the presence of bottlenose dolphins in the RNE during the austral autumn months is consistent with the period of lowest dolphin abundance, lowest residency index and the lowest amount of feeding activity observed in BSA (Vermeulen, 2011). However, limited or no survey effort was conducted in the study area during the other seasons, preventing clear conclusions to be drawn.

It is known that a general lack of information on the dolphin's movement patterns could bias the assessment of site fidelity and residence in certain core areas, as ranges could easily be interpreted from the perspective of the study area covered by the researchers (Bearzi *et al.*, 2011). This could in turn insufficiently weigh the use of alternative areas. As such, two of the individuals observed in both BSA and RNE have been classified as year-long residents in BSA (Vermeulen and Cammareri, 2009*a*; Vermeulen, 2011).

The present study thus shows that, while bottlenose dolphins in northeastern Patagonia seem to display a high degree of residency in BSA, they can also move across extensive ranges indicating that their home range may include the whole northern coastline of the San Matías Gulf. It further suggests that a variation in productivity and prey availability is the most important factor influencing the ranging patterns of these dolphins, assuming their range increases in order to feed in the Río Negro Estuary when food availability decreases in their area of residence.

[5]P.F. Fruet, pers. comm., 01 August 2012

Additionally, it seems valuable to indicate that of the total BSA catalogue, which includes 63 individuals (Vermeulen and Cammareri, 2009*b*), only 15 individuals visited the RNE during the study periods, some year after year, whereas none of the other 48 individuals could be observed inside the estuary. Moreover, two of the individuals identified in the study area could not be positively re-identified in the study area nor in BSA. It is possible that these individuals have died or permanently emigrated to other unstudied areas, although the likelihood of misidentifications cannot be excluded. It seems clear, however, that home range size is not determined by a single factor but is more likely to be the result of the combination of several variables working simultaneously, as was suggested previously by McLoughlin and Ferguson (2000). It is thus possible that other factors as *e.g.* social learning of foraging techniques, social affiliations, existence of other potential feeding grounds, etc., play a yet unknown role in the ranging patterns of the bottlenose dolphins in this area. Further research and photo-identification effort should be conducted to accurately investigate this matter. Up to now, limited to no survey effort has been made in RNE during the winter, spring and summer months, mostly due to financial limitations and the general knowledge that bottlenose dolphins are rarely seen in the area during these seasons. Nevertheless, a year-round systematic study would be recommended to gain a better understanding of the ecology of this species in this region and the larger area of northeastern Patagonia, and possibly confirm some of the hypotheses formulated in this study.

Considering the apparent importance of the RNE as a foraging site for bottlenose dolphins, it seems important to make a comment on the regulation of the Río Negro water flow. The management of the dam upriver changes frequently during summer and autumn months, altering the water flow from 1000m³/s to 1500-2000m³/s in a matter of a few hours. This variation in water flow causes changes in salinity, tidal heights that cause floods and modify the marshes and estuarine drainage channels within hours. Mattos *et al.* (2007) evaluated the habitat use of bottlenose dolphins in the Patos Lagoon, Brazil, speculating about the high salinity values in the inner portions of the estuary that lead to increased marine fish abundance, which in turn has the potential to attract foraging dolphin groups further into the estuary. On the other hand, low salinity values and decreased fish abundance could have the opposite effect. So far the effects of the water management regime upon the presence of fish and consequently of dolphins in the RNE are unknown. More research is therefore needed in order to estimate the impact of this management scheme on the dolphins.

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