Mar Biol
DOI 10.1007/s00227-014-2430-x

ORIGINAL PAPER

Spatial segregation of calving and nursing Risso's dolphins (*Grampus griseus*) in the Azores, and its conservation implications

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Received: 13 June 2013 / Accepted: 20 March 2014

Abstract Calving can be a critical period for cetaceans. Areas providing security for vulnerable calves, and high food availability for lactating females can be critical habitats requiring specific conservation measures. Here, we test the hypothesis that calving and nursing habitat could be defined for Risso's dolphins (*Grampus griseus*). We investigated the spatial and temporal preferences of this species around Pico Island, Azores, using data gathered from land-based surveys and dedicated at-sea observations between 2004 and 2007. We divided observed pods into three groups: (1) those with newborn and young calves, (2) those with older calves or juveniles and (3) those consisting only of adults or sub-adults. We analysed eco-geographical variables and incorporated them into a presence-only spatial distribution model to evaluate differences in habitat suitability among the groups. We identified 694 pods of Risso's dolphins overall. On the 267 pods observed in the first and second groups, 136 calves or juveniles were identified, of which 22 were newborns. The peak of the calving season was between June and August. The pods with newborn calves were larger and closer to shore, whereas the other groups were more widely dispersed offshore. Our results support the definition of critical habitat areas for this species, but we suggest widening the geographical coverage for better mapping around the island and throughout the archipelago generally. Conservation measures can, nevertheless, be implemented immediately, in order to reduce human impacts on a vulnerable component of the Risso's dolphin population

Introduction

Calving is a vulnerable phase in the life history of mammals for parents and their offspring. Lactation imposes a heavy metabolic burden on adult females. For odontocete cetaceans, the extra metabolic demands of lactation are highest in the very first months after birth, when the energy intake may increase by up to 50 % compared with that of pregnancy (e.g. Cheal and Gales 1992; Amundin 1986). Calves are particularly vulnerable because of their smaller size and lower proficiency in basic survival skills. This vulnerability must be compensated for by maternal care (see, e.g., Mann and Smuts 1998). Predators are a major mortality factor. For example, Heithaus (2001) observed greater mortality of calves of bottlenose dolphins *(Tursiops spp.)* in Shark Bay, Western Australia than in Sarasota, Florida and correlated this with differences in predation by sharks. Predation on calves might even be great enough to cause changes in the seasonality of reproduction in dolphins (cf. Fearnbach et al. 2012). Similarly, young vulnerability might be greater in deep diving species, where females leave them unattended

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Communicated by B. Stewart.

Electronic supplementary material The online version of this article (doi:10.1007/s00227-014-2430-x) contains supplementary material, which is available to authorized users.

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briefly while they descend to forage. Bernard and Hohn (1989) proposed that lactating spotted dolphins (*Stenella attenuata*) shift from feeding on squid to feeding on fish in order to reduce the time they have to leave their calves alone. The aggregation of nursing females and allomaternal care has been suggested as adaptations to risks of predation in some species (e.g., sperm whales, *Physeter macrocephalus*) where long separations are inevitable (Whitehead and Mann 2000).

The Risso's dolphin, *Grampus griseus*, is a medium-sized odontocete that is widely distributed in pelagic waters but poorly studied (Kruse et al. 1999). They forage mainly at night on deep-sea cephalopods, favouring small squid (i.e., *Loligo* spp., Bearzi et al. 2010). Like other teutophagous cetaceans, they can dive deep (up to 800 m, Whitehead 2003). At present, the only information available about nursing and calving in Risso's dolphins is related to calving seasons and weaning age. Jefferson et al. (2008) report possible calving peaks in summer and autumn off Japan and in autumn and winter off California. In the North Atlantic, there appears to be a peak in calving between April and September (Evans 1987; Hartman et al. 2008; Pereira 2008). Information from infancy patterns (e.g. duration of lactation or age at weaning) is mostly reported from animals that have been captured. Bloch et al. (2012) examined 24 Risso's dolphins drive hunted in the Faroe Islands. Based on the number of lactating females and the age of the examined calves ($n = 9$, from 0 to 3 years old), these authors suggested that calves were probably weaned within 2 years of birth. Amano and Miyazaki (2004) reported a calving interval of 2.4 years or perhaps longer off Japan.

Hartman et al. (2008) suggested that female Risso's dolphins with nursing calves are selective in their use of habitats. They found two types of stable social clusters, those including only adults and those that included mothers and their dependent offspring. The authors suggested that the latter might prefer shallow areas near the island coasts to minimise dive time when foraging and consequently the risk of predation on their calves. Norris and Dohl (1980) suggested that many cetaceans move into shallow water to give birth and nurse calves because shallow water reduces exposure to predators. This is the case in bottlenose dolphins, with several studies of habitat use of female with dependent offspring suggesting the use of special nursery areas consisting of protected, shallow water and near coastal habitats. (e.g. Wang et al. 1994; Mann et al. 2000; Gibson et al. 2013; Weir et al. 2008).

A critical habitat can be designated by evaluating the spatial distribution of habitat features essential to the demographic processes of a management unit (Keller et al. 2012), such as feeding, breeding or calving (Hoyt 2011). Here, we use part of a long-term database of observations on Rissos's dolphins off Pico Island, Azores, to investigate the patterns of spatial and temporal use of marine habitats and identify critical calving and nursing habitats for Risso's dolphins.

Methods

Study area

We studied Risso's dolphins along the south coast of Pico Island, Azores (Fig. 1) with dedicated, year-round, land- and boat-based surveys from 2004 to 2007. Animals were located from 12 land-based lookout posts distributed along the south coast of Pico Island, with the main lookout at Santa Cruz das Ribeiras. Lookouts covered the coastal area from 6 up to 12 nautical miles, depending on atmospheric conditions.

Survey protocol

We realised surveys only on days when the sea state was <4 on the Douglas Sea Scale (about 4–5 on the Beaufort scale). On these days, we conducted a minimum of four land-based surveys from the main lookout, randomly distributed over time from dusk till dawn (summertime 0630–2130 hours; wintertime 0800–1800 hours). Typically, we used the other lookouts for only one scan per day and did not sample all of them every day. We collected the data using point/scan sampling (Mann 1999). To avoid

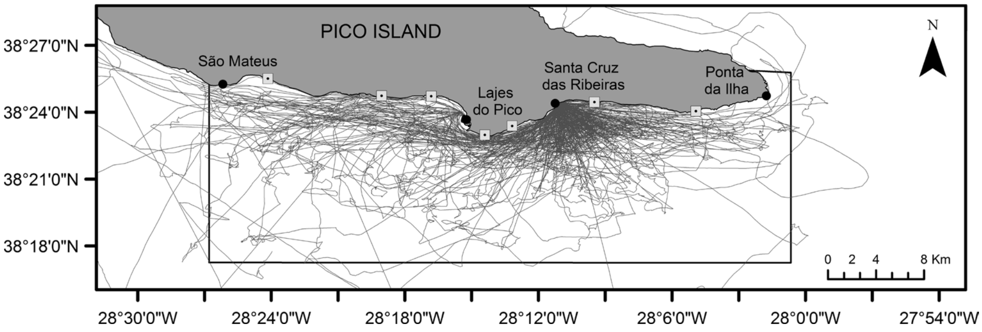


Fig. 1 Map of the study area (delimited by the *black polygon*) showing the survey tracks (2004, 2005 and 2007) and the lookouts (*small squares* and *black dots*)

double counting, surveys lasted between 15 and 20 min, with an interval of at least 90 min between observations. We scanned the area with 25 × 80 mm Steiner binoculars from left to right or vice versa and from the coast towards the horizon. This was repeated at least once during the observation.

The sea observations were directed from the land-based lookouts, using VHF radio and mobile phones to guide the research vessels towards the sighted groups. At-sea surveys were conducted by 2–4 observers using either a 4.2 metre RHIB with 25 hp outboard engine or a 6.7 fibreglass motorboat with 140 hp outboard engine. Groups of animals were typically monitored for longer than 20 min, occasionally up to several hours, using the focal group follow-protocol (Altman 1974). We defined a group as a sample of individuals that interacted socially or showed coordinated behavioural activity or both (cf. Whitehead 2003), following the chain rule after Smolker et al. (1992). Once animals were encountered, we recorded a GPS position every 5 min during the observation, the main behaviour of the group, travel direction, speed, movement and group formation. To minimise spatial autocorrelation, we took an individual's position as the coordinates of the first encounter. During each encounter, we strived to take photographs of the left and right sides of the dorsal fin of each dolphin using an SLR camera (Nikon D70 with a 70–300 mm zoom lens). Additionally, we photographed females and accompanying calves in one frame to document associations and to estimate relative body size. On average, 400 pictures were taken per sampled group, but we used only high-quality pictures (Q3, Arnbom 1987) for individual recognition, using the unique and enduring scarification patterns on the dorsal fin, together with specific features like fin shape and notches (see Hartman et al. 2008 for a detailed overview). Usually, it was possible to ensure identification of all the members of an encountered group, as work was performed without time limitations. Pods where all individuals could not be identified were excluded from this analysis. Group size was estimated at sea by two observers and verified afterwards, using photo-identification data. Median group size of Risso's dolphins in the Azores is 13 animals (Hartman et al. 2008) which represents a manageable number when working at sea, compared with the larger average group sizes of smaller delphinids (e.g. 39 in *Delphinus delphis* and 66 in *Stenella frontalis*, Quérouil et al. 2008).

Group classification

We divided pod observation data into three groups, based on the calving and nursing stage of individuals within the group. G1 are groups with newborns and calves less than one year old; these calves require the most intensive maternal care and face the greatest mortality risk (Mann and Smuts 1998; Mann et al. 2000). G2 groups are those without newborns, but including older calves and/or juveniles (accompanied by an adult); these are less vulnerable than G1s, since they have survived the most critical life history phase (Read et al. 1993; Mann et al. 2000). However, G2s still require maternal care and nursing is taking place. Groups without calves or juveniles (G3), containing

Fig. 2 Colour and scarification stages on Risso's dolphin calfs and juveniles, as illustrated by M1dc2, an animal followed since the newborn stage, in August 2007 (**a**), when it showed typical features such as light coloured snout, foetal folds, unscratched skin, and the size about 50–60 % of its mother (**b**). About a year later (**c**) the forehead has turned *light grey,* and the first linear scratches are visible. By the age of two (**d**) the calf is larger, the dorsal fin is relatively bigger and the skin has turned from *pale* to *dark grey*. Approaching 3 years (**e**, **f**) more scars are visible, the head has almost the same colour as the rest of the body and the skin is turning from *grey* to *dark brown*

exclusively sub adults and/or adults, are deemed to be the least vulnerable, since the individuals are all self-sufficient.

We used physical and behavioural characteristics (Mann and Sargeant 2003) to classify the animals into the above groups, integrating information from individuals followed over long periods of time (see example on Fig. 2). The background colour of the skin of Risso's dolphins changes with age, and it further undergoes a unique discoloration process (MacLeod 1998) through the accumulation of white scars caused mostly by the teeth of conspecific animals. Newborn calves have a yellow snout and 6-10 foetal folds or lines covering the central body. The skin is unscratched overall and pale greyish. They surface in a synchronical calf position next to the mother and measure up to 50–60 % of the size of the accompanying adults. In young calves, the snout turns light grey and the foetal folds disappear (Taylor and Saayman 1973; Jefferson et al. 2008; Mann and Sargeant 2003). Calves older than approximately one year and juveniles up to 3–4 years of age have a pale greyish to dark brown skin with a few visible and thin scratch marks. They are approximately 60–75 % of the size of the accompanying adults and mostly continue to surface synchronically next to their mother (Amano and Miyazaki 2004; Hartman et al. 2008; Bloch et al. 2012). Sub-adults have a dark brown skin with limited scarification (Amano and Miyazaki 2004; Hartman et al. 2008). Adults show moderate to very high scarification or white body coloration and mature body size. The body length of adults is about 3–4 m; sexual dimorphism is low, with males slightly larger on average than females (Perrin and Reilly 1984; Kruse et al. 1999; Amano and Miyazaki 2004; Hartman et al. 2008; Bloch et al. 2012). We have classified as females, the adults that were accompanied by at least one identified calf during the study period.

Temporal variation

We define search time as the number of hours of land-based searching when a boat was in the water or available to go out to sea and calculated an Individuals Per Unit Effort (IPUE) index by dividing the number of animals seen per 60 min. of search time. For groups G1 and G2, only the number of calves and/or juveniles was used.

We standardised the IPUE applying a delta log-normal model. Delta models are effective when analysing data where the catch (or sighting) is often zero in response to significant (non-zero) effort (Maunder and Punt 2004). The delta log-normal is a two-step model. First, a logit model is used to calculate the Zero-Catch probability (ZC). In a second step, a log-normal model is used to obtain the estimate density (or sighting rate) of the target species for surveys in which the species has been sighted. The standardised rate is the product of ZC and the estimated density (Lo et al. 1992).

We conducted most of the fieldwork between April and October, so important differences in sighting effort exist throughout the year. However, effort was similar between years. Therefore, only month and season were used as explanatory variables.

The model followed the formulae on Eqs. (1) and (2), where we applied the 1st step to the entire data set and the 2nd step only to positive data (sightings >0).

1st step (Eq. 1):

$$\begin{aligned} E[log(q/(1-q))] &= \text{Intercept} + \text{Month} + \text{Month}^2 \\ &+ \text{Season} + \text{offset}\,(log(\text{effort}))q(ratio\ of\ zero\,catch) \\ &\sim \text{Binomial}(\theta) \end{aligned}$$

2nd step (Eq. 2):

$$log(IPUE) = \text{Intercept} + \text{Month} + \text{Month}^2 + \text{Season} + \text{Error}$$

$$\text{Error} \sim N(0, \sigma^2)$$

Spatial analysis

We used a digital elevation model (DEM) with a 50 × 50 m resolution to determine eco-geographical parameters at the sites of observations (source: Department of Oceanography and Fisheries, University of the Azores). Four different variables were calculated: distance to coast, depth, slope and curvature. We calculated distance to the coast using the Euclidean distance calculator module of the SAGA GIS and clipped rasters using the cutting module of SAGA GIS to obtain the study area for analysis. Depth was directly given by the DEM. We calculated slope using Horn's method (Horn 1981; Burrough and McDonnell 1998) on the DEM Tools for ArcGIS 9.3.1 (Jeness 2012). The curvature variable reveals concave and convex areas in the bottom topography, indicating the presence of sinks or valleys and peaks or high points. We calculated it following Moore et al. (1991), using the general curvature index of the Spatial Analyst Toolbox of the ArcGIS 9.3.1.

We conducted a Kruskal-Wallis test to look at differences between the three group types in relation to the selected eco-geographical variables. For the variables in which significant differences were found, we looked for differences between the groups using a Mann–Whitney test with a Bonferroni correction (Zar 2010). We used the effect size to evaluate the significance of the test. All the analyses were conducted using the R statistical package version 3.0 with the Stats and Coin libraries.

Spatial distribution modelling

To provide a first view of the sightings distributions of each group, we applied a fixed kernel (standard bivariate normal kernel) and estimated the smoothing parameter using a least-square cross validation, following Worton (1989).

Two different utilisation distributions were applied (50 and 95) to trace the core and general areas of use.

We chose a presence-only spatial distribution model to achieve realistic results in the construction of habitat suitability maps for each group, applying a Maximum Entropy model (MAXENT). This approach estimates the target probability distribution and corrects the missing information concerning the target distribution (after Phillips et al. 2006) using a set of restrictions to obtain the probability distribution of the maximum entropy. We used the Maximum Entropy Species Distribution Modelling Interface (Version 3.3.3e) with the auto-features option, and selected random seeds, with 25 % of points designated for test purposes. We picked ten replicates for each group to ensure different random sets of points. To evaluate the model performance, we used the area under the curve (AUC) of the receiver operating characteristic (ROC) curve and analysed the relative contributions of the environmental variables for each different model using the variable contribution table and a jackknife test.

We used the niche overlap index (ENM Tools, Warren et al. 2010) to look at differences in habitat suitability among the groups. We also calculated the range overlap. This metric limits the habitat suitability to a smaller range, based on a given threshold value for the probability of the presence of each group, and then calculates the range overlap. We selected the specific thresholds using the cumulative relative frequency distribution (CRFD) curves, a technique used for hot spot identification (Bartolino et al. 2011). A CRFD curve is estimated by plotting the relative value of the variable z (habitat suitability in this case) against the frequency distribution of the same variable. The tangent with 45° slope is used as an indicator for selecting a threshold to identify hotspots. As biological processes usually have complex CRDF curves, we used only the highest x_0 corresponding to a 45° slope to select the threshold. The intersection with the x-axis of the point given by the tangent with 45° slope of the CDRF curves for all the groups was situated in the range between 0.6 and 0.7 of suitability. Based on previous studies (e.g. Warren et al. 2010), we selected three different thresholds (0.60, 0.65 and 0.70) to look for differences in distribution of the hot spots between groups.

Results

A total of 1,568 h were spent at the lookouts, with a survey boat present in the study area, during the 4 year survey period (465 h in 2004, 455 h in 2005, 427 h in 2006 and 221 h in 2007). Eighty-one per cent of the effort was made between the months of April–October, and 19 % from November to March. Most observations (83 %) were recorded between Lajes do Pico and Ponta da Ilha (an area of approximately 540 km^2), versus 16 % made between São Mateus and Lajes do Pico, and <1 % on the north and west side of the island. Risso's dolphins were observed on 333 of the 386 survey days. We selected a total of 694 groups for this study; of these 267 included calves or juveniles. From the total of 9,933 animals encountered, 1,246 were individually identified, of which 758 photo-identified from both sides.

The mean group size observed varied, depending on the presence of calves (Table 1). Groups with calves or juveniles were significantly larger than those without, with a mean group size between 17.1 (G1) and 18.7 (G2), versus 12.8 for G3 pods. The number of calves or juveniles present in the pods varied between 1 and 11, with a mean value of 1.5 calves per group. During the study period, we observed 136 calves or juveniles and identified 80 individual calves, 22 of them recorded as newborns. The highest annual number of newborn or young calves ($n = 33$) was recorded in 2006. Newborn calves were all first seen in summer, between June and August, with one single exception (November).

The probability of encountering young calves was highest from May to October, as evidenced by the curve generated by the delta-lognormal model for the G1 group (ZC probability line, Fig. 3). The G2 group followed a similar pattern, but the period with higher probability of detection was longer, starting in April and extending to the end of the year. In contrast, the G3 group curve is linear (with the exception of missing data in March), indicating a more

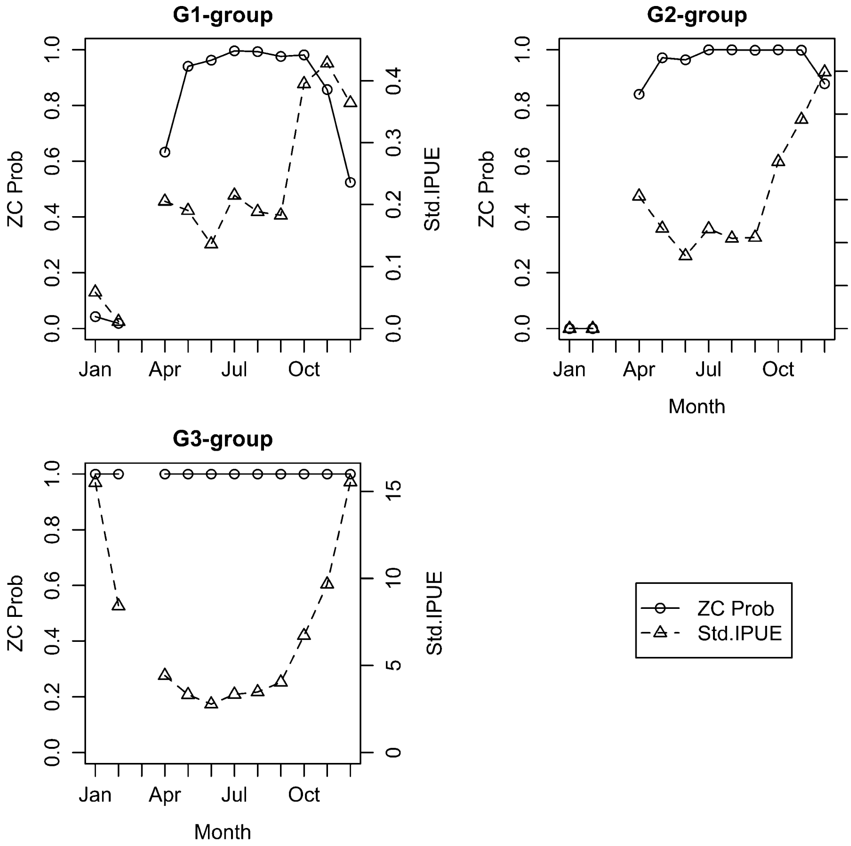
Table 1 Number of sightings, group size and number of calves observed in each group type

Groups	Nr. sightings		Group size	Num. calves/ juveniles per group
G1	107 (15 %)	Range	2–61	1–11
		Average	17.11 ± 15.86	1.77 ± 2.17
		CI	15.14–19.08	1.36–2.18
G2	160 (23 %)	Range	2–62	1–10
		Average	18.65 ± 17.01	1.36 ± 1.34
		CI	16.58–19.02	1.33–1.57
G3	427 (62 %)	Range	1–61	–
		Average	12.79 ± 10.31	
		CI	11.81–13.77	

Mann–Whitney
G1 versus G2: $H = 2.214$; $df = 1$; $P = 0.137$
G1 versus G3: $H = 80.35$; $df = 1$; $P < 0.001$
G2 versus G3: $H = 106.48$; $df = 1$; $P < 0.001$

Range: maximum and minimum group size; Average: average ± SD; CI: 95 % confidence interval; see legend of Fig. 3 or text for group composition. Mann–Whitney test is based on group sizes

Fig. 3 Monthly Zero-Catch probability model (ZC Prob) and Delta lognormal standardized Individual Per Unit Effort (Std.IPUE) for the three different group types (G1, groups with young calves; G2, groups with older calves and juveniles; G3, groups containing exclusively sub adults and/or adults). ZC probability values vary from 0 (very low probability of sightings) to 1 (very high probability of sightings)



uniform year-round presence of groups without calves or juveniles. The individual per unit effort analysis (Std. IPUE line on Fig. 3) shows a two-step increase in density in the G1 and G2 groups: one starting in April and another in October, reaching a maximum in November or December and decreasing abruptly in January. The G3 groups display the lowest values in June and the highest in December and January.

Several lines of evidence indicate that young calves tend to stay closer to shore, at shallower depths. Risso's dolphins were often sighted close to shore, on one occasion only 111 m away from land. Most observations, however, took place at distances from shore between 1.4 and 1.9 km, corresponding to depths of 760–820 m. Distance to coast and depth were the only variables where the sighting distributions of the different groups had significant differences (Kruskal–Wallis test, see results on Appendix Table A1). The groups with young calves (G1) were found significantly closer to shore and in significantly shallower water than the groups with no calves or juveniles (G3, Man-Witney test, Appendix Table A2). No significant differences were found between the G2 and G3 groups.

The kernel method (Appendix Fig. A1) showed a major overlap in home range between all groups. However, when an utilisation distribution of 50 % is applied, a differentiation becomes visible: the G3 core area is located offshore while the core areas for G1 and G2 overlap with the island.

All the spatial distribution models had a mean AUC higher than 0.8, indicating good model performance. The jackknife analysis showed distance from the coast as the most important variable, followed by depth (Appendix Table A3). The contribution of the distance to coast factor is evident in the habitat suitability maps (Fig. 4): the highest probability area for G1 was located in a coastal area. In contrast, G2 displayed maximum habitat suitability further offshore, with few areas of high probability of occurrence near the coast. The maps for G3 show no high suitability areas adjacent to the coast. This pattern is shown by the model response to the distance to coast parameter (Fig. 5): the G1 curve is bimodal in shape, with a higher peak in coastal areas and a lower peak further offshore; for G2, the trend is reversed, with a lower peak in coastal waters and a higher peak further offshore; finally for G3, there is a single peak, around 1.8 km from shore. Relatively small differences were detected between the habitat suitability distributions of the different groups. The niche overlap index varied from 0.89 (between groups G1 and G3) to 0.93 (between groups G1 and G2). However, all the groups showed meaningful differences of range overlap when reducing the threshold value

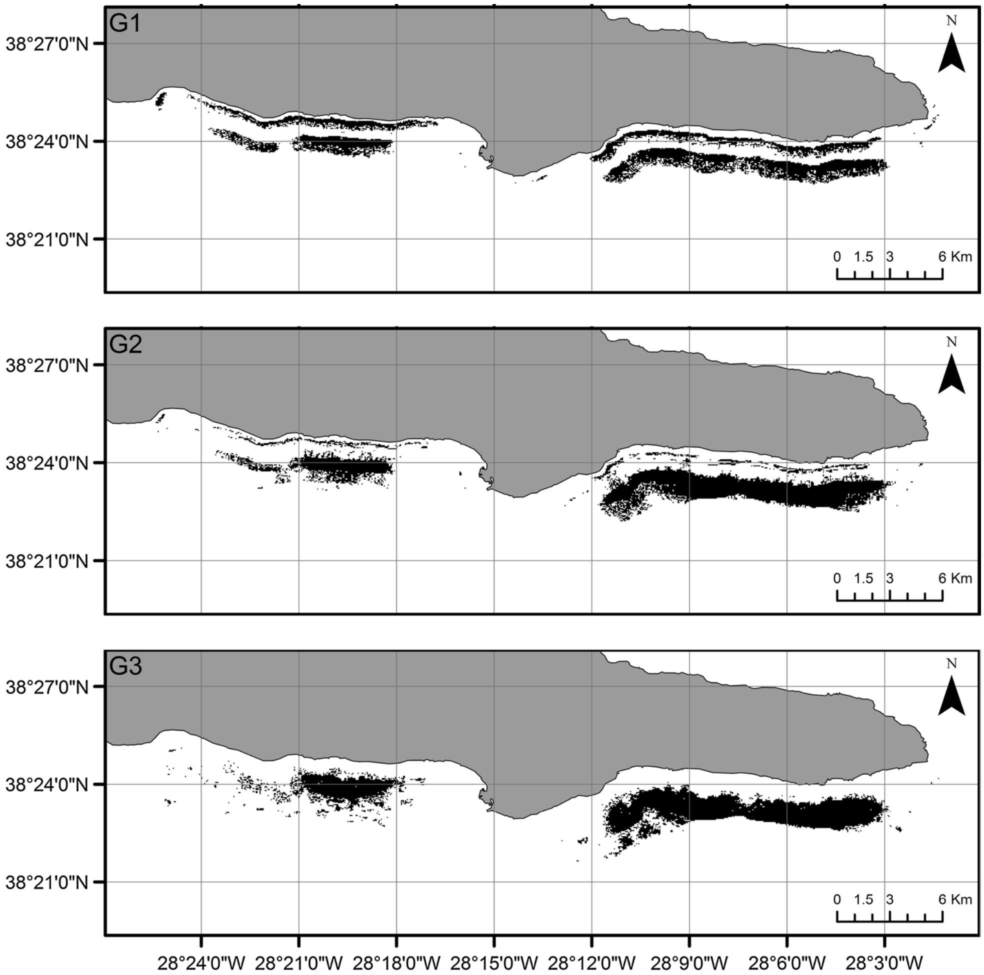


Fig. 4 High (>0.60) suitability areas (in *black*) for each of the three groups. G1, groups with young calves; G2, groups with older calves and juveniles; G3, groups containing exclusively sub adults and/or adults

of the probability of presence of each group (Table 2). The 0.6 threshold (a 60 % probability of occurrence) reduced the overlap between the G1 group and the others. Separation between G1 and G3 increases with increasing threshold, leading to only 0.08 overlap with the 0.70 threshold. In contrast, the overlap between G2 and G3 remained fairly constant for all thresholds at around 0.8.

All the results obtained from this analysis, therefore, showed strong differentiation of the high suitability areas for the G1 group. The G2 group displayed moderate to high values of overlap with the G3 group and a small (but persistent) overlap with the G1 group.

Discussion

This study confirms the preliminary observations of Pereira (2008) that births are concentrated in a summer calving season, between June and August. Our results further show a pattern of spatial segregation, with calving and nursing females closer to the coast than other social units (Fig. A2). Spending more time in shallower water may be a way for females to decrease the energy required for obtaining food, while also reducing the time spent foraging away from the calf. One likely prey of *Grampus griseus* in the Azores is *Loligo forbesii*, the veined squid, an abundant and dominant species, judging from the fact that it is the only squid fished in the Azores and that it is caught in large quantities (with a recent maximum of 720 metric tons in 2007, SREA 2013). *Loligo forbesii* is a large squid (in the Azores males can reach over 0.9 m in mantle length) which aggregates near the bottom during daytime, at depths that may exceed 1,000 m, dispersing at night throughout the water column (Nesis 1987; Jereb et al. 2010). In the Azores, it is usually fished at depths between 70 and 300 m (Gualberto Frias, personal communication; Cruz et al. 2012). In the core habitat suitability areas determined in our study, such depths are found <600 m from the shore. Reliance on the veined squid for food would

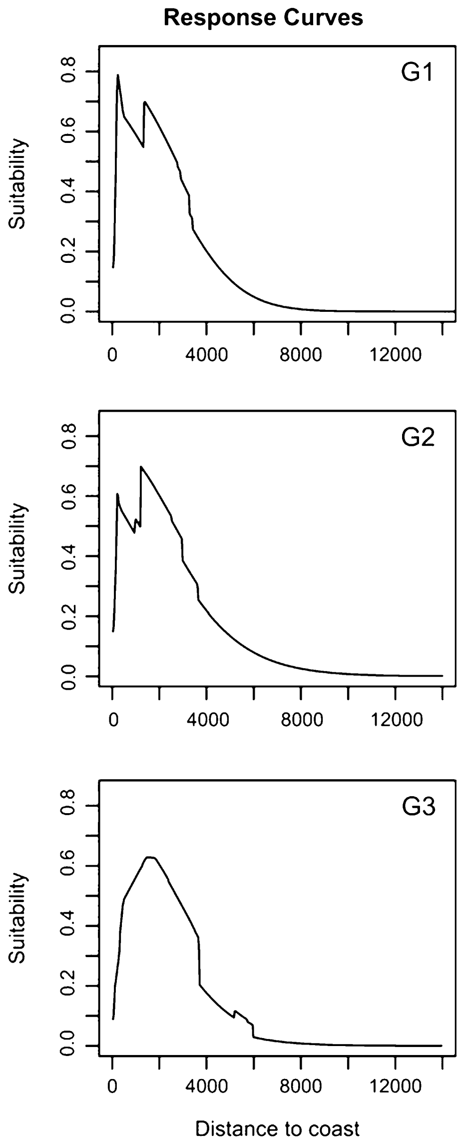


Fig. 5 Response curve of the main environmental variable (distance to the coast) for all the four group types. G1, groups with young calves; G2, groups with older calves and juveniles; G3, groups containing exclusively sub adults and/or adults

explain why Risso's dolphins are seen so near the coast, and why females with calves tend to stay so close to it during the calving season. Predation may be another factor involved in driving groups with calves to the relative protection of nearshore distribution. Various species of sharks known to prey on cetaceans, such as the tiger (*Galeocerdo cuvier*) and white sharks (*Carcharodon carcharias*) (Heithaus 2001), occur in the Azores (Santos et al. 1997). Orcas (*Orcinus orca*) and false killer whales (*Pseudorca crassidens*) are also recorded here (Silva et al. 2002, 2003, 2014).The temporal concentration of calving and the spatial segregation of calving females are indications of the particular needs and vulnerability of Risso's dolphins in this stage of their life cycle.

Table 2 Range overlap. Three thresholds (0.60, 0.65 and 0.70), were selected using the CDRF curves methodology and used to look at differences in different probabilities of suitability

Group type	G1	G2	G3
Threshold 0.60			
G1	1	0.72	0.62
G2	–	1.00	0.81
G3	–	–	1
Threshold 0.65			
G1	1	0.61	0.45
G2	–	1	0.80
G3	–	–	1
Threshold 0.70			
G1	1	0.31	0.08
G2	–	1	0.80
G3	–	–	1

Values vary from 0 (no overlap) to 1 (total overlap). See legend of Fig. 3 or text for group composition

We propose that the G1 distribution areas be considered part of the critical habitat (sensu Hoyt 2011) for this population of *Grampus griseus*. This proposal has implications for the management of the species in the Azores. All cetacean species are legally protected from hunting in Portugal and even the signs of fisheries bycatch recorded on a small number of stranded delphinids (JMNA, pers. obs.) are not significant at the population level (Silva et al. 2011). The major conservation issue in the region is, therefore, likely to be related to interference from tourist operations.

Commercial whale watching and swimming with dolphins operations in the Azores have been growing steadily since its start in 1992. In a recent study, Visser et al. (2011) found that Risso's dolphins observed off Pico Island altered their daily resting patterns in the presence of whale-watching vessels. Due to the growth in whale watching industry, anthropogenic pressure caused by marine tourism has become a serious concern for the welfare of cetaceans in many areas. Several studies have shown a range of negative behavioural reactions towards whale watching tourism in various cetacean species (Bejder et al. 2006; Lusseau 2004; Williams et al. 2006). Commercial cetacean watching is regulated by Azorean legislation, with rules for approaching the animals and for the type of activities that can be carried out with them. However, the only provisions involving calves are applied to "whales" (a broad term including the larger cetaceans, but excluding Rissos's dolphins): swimming with any species is forbidden, as are boat approaches to calves closer than 100 m. At present, it is legally possible to approach dolphin groups with calves to 50 m and to conduct swim-with-dolphins activities with them. Barradell and Ritter (2007) described the swim-with-dolphins market in the Azores and expressed concerns that commercial pressures can lead to breaches of the law and the codes of conduct. Frequent close encounters with tourist vessels in nursery areas, particularly the swim-with-dolphins activities, may have a strong influence on this species' daily energy budget with negative impacts on the build-up of energy reserves and on reproductive success.

Further studies are needed to get a more detailed knowledge of the behavioural ecology of Risso's dolphins around the Azores Islands. These should extend the geographic and temporal coverage of the present work and include other essential activities, such as breeding and feeding. Nocturnal observations would be particularly useful to investigate feeding patterns. Nevertheless, we believe the present results are sufficient basis for recommending a reduction in the anthropogenic pressure on the calving groups of Risso's dolphins. Limitations of activities could include preventing whale watching operations directed at these groups (particularly swimming with groups with calves) or introducing speed limits to boat traffic within 1 mile of the coast in areas where groups with calves are known to be present. Similar recommendations and revisions of local regulations for groups of nursing females have been suggested by Lundquist et al. (2008) for Southern right whales (*Eubalaena australis*) in Argentina and by Weir et al. (2008) for dusky dolphins in New Zealand. Sensible regulation will lead to commercial advantages by creating long-term sustainable whale and dolphin watching. This is recognised by some commercial operators employing a code of conduct where, for instance, no swimming with newborn dolphins is allowed (Gullan et al. 2012).

Acknowledgments We gratefully thank the following NGOs, companies and private persons for their financial support during our studies: The Netherlands : WWF, Greenpeace, Burgers ZOO, Stichting Lucy Burgers, Federation International Nature Conservation, Wing, Liesbeth-Feikema, Taco van der Harst, Fam. van Hooff, Anna Tiepel and Marloes Hartman. We thank Arthur Hendriks and Fleur Visser for their contribution to the setup of the long term research on Risso's dolphins in Pico. David Janiger provided us with some important literature and several colleagues, students and volunteers helped us collecting and processing data; a special thank you here for Lisa Steiner, Britta Adam and Anja Wittich. Fernando Tempera and the Department of Oceanography and Fisheries at the University of the Azores kindly shared a 50 m resolution grid for the study area. Mark Simmonds and Chris Yesson are particularly acknowledged by their useful comments on earlier versions of this manuscript and for revising the English. This project was carried out under scientific license numbers 4/CN/2004 and 9/CN/2005, issued to the Nova Atlantis Foundation by the Azorean Department of the Environment. This research was partially supported by the European Regional Development Fund (ERDF) through the COMPETE—Operational Competitiveness Programme and national funds through FCT—Foundation for Science and Technology, under the project "PEst-C/MAR/LA0015/2011". Karin Hartman is supported by the Azores Regional Fund for Science (FRC) Ph.D. Grant M3.1.2/F/014/2009. Marc Fernandez is supported with Grants M3.1.5/F/004/2009 and M3.1.2/F/028/2011.

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