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Sex differences in residency patterns of Risso's dolphins (*Grampus griseus*) in the Azores: Causes and management implications

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Abstract

Knowledge of the residency patterns of marine mammals is an important element for management and conservation strategies. Here we investigate a population of *Grampus griseus* off Pico Island, Azores. Our data set covers the period 2004–2007, based on at-sea observations of 1,250 individually identified animals, 303 of known or assumed sex. Using photo identification and GPS locations we calculated mean monthly sighting rates and lagged identification rates to analyze temporal patterns, and estimated kernel density to study the home range. Our results show site fidelity and relatively restricted home ranges, which corroborate the existence of a resident population on the study site. We further document sex differences, including a higher number of males present in the area at any given time but females staying for longer consecutive periods, and male home ranges with significantly less overlap than those of females. These observations are consistent with a mating system based on multimale pods defending areas where females periodically return. We hypothesize that squid distribution is a major factor in structuring these patterns. These findings reinforce the need for a precautionary management approach that would include limiting pressure from commercial activities.

Key words: Risso's dolphins, *Grampus griseus*, residency patterns, sex differences, site fidelity, home range.

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Knowledge of residency patterns of marine mammals is an important tool for the conservation and management of local populations (Parra *et al.* 2006). The term residency can be interpreted as the time spent by an animal in a specific geographical area (Wells 1991), while site fidelity can be defined as the tendency of an animal to inhabit or to return to a previously inhabited area after some period of time (White and Garrot 1990). Such spatiotemporal behavior is associated with habitat use, particularly of areas offering resources and conditions that stimulate occupancy by a species (Hall *et al.* 1997). One of the ways to protect a species is therefore to conserve the area where they live, or a substantial portion of it. Such critical habitat should encompass the local features essential to specific demographic processes, such as feeding, breeding, or calving (Hoyt 2011). One example of how information on residency patterns of cetaceans can be used for conservation is provided by Hooker *et al.* (1999) and Gowans *et al.* (2000), who report on how the evidence for a resident population of the deep diving Northern bottlenose whale (*Hyperoodon ampullatus*) in a deep water canyon off Nova Scotia was one of the factors leading to the creation of the Gully Marine Protected Area.

Risso's dolphins, *Grampus griseus* (Cuvier, 1812), occur worldwide in tropical and temperate waters, with a strong preference for mid-temperate waters of the continental shelf and slope (Jefferson *et al.* 2013). They are deep divers, feeding mostly on deep-water cephalopods (Clarke and Pascoe 1985, Cockroft *et al.* 1993, Pauly *et al.* 1998), presumably mainly at night (Kruse *et al.* 1999). Although residency patterns have been studied for other odontocetes (*e.g.*, killer whales, *Orcinus orca*, Bigg *et al.* 1987 and bottlenose dolphins, *Tursiops* spp., Wells and Scott 1990, Smolker *et al.* 1992, Irwin and Würsig 2004), they remain poorly described for Risso's dolphins. De Boer *et al.* (2013) report a regular seasonal occupancy with some site-fidelity for these animals off Bardsey Island, U.K., based on 24 encounters and ≤200 identified dolphins over a time span of 10 yr. Eleven animals were resighted over intervals ranging from 1 to 9 yr. Additional information is given by Remonato *et al.* (2013), based on 20 yr of data from a 25,000 km^2 area in the western Ligurian Sea. The median time between consecutive sightings of the same individual was 287 d (n = 283), with 20 individuals considered resident because they were resighted more than 11 times. No significant differences were found between the sighting frequencies of females and males.

Risso's dolphins are frequently seen off the south coast of Pico Island (Azores, Portugal) as documented by land-based observations carried out from 1992 to 2005 and reported by Pereira (2008). Hartman *et al.* (2008) studied the social structure of this population and noted more than 60 individual resightings over a 3 yr period, leading to the suggestion of a resident population. Furthermore a recent study (Hartman *et al.* 2014) identified critical habitat areas based on the spatial distribution of females with nursing calves. Taken together, these results point out the management and conservation relevance of a better understanding of the social ecology of this species. Here we further contribute to this understanding by investigating the residency patterns of male and female *G. griseus* off the south coast of Pico, using a photo-identification and distribution data set covering the period 2004 to 2007.

METHODS

Study Area and Sampling Effort

We carried out this study in the coastal waters around Pico, within approximately 6 km of the shore (Fig. 1). Using either a 7.2 m Boston Whaler powered with a 150 HP outboard water jet engine, or a 4.2 m inflatable boat with a 25 HP outboard engine, we conducted boat-based surveys during 35 sampling months between May 2004 and November 2007. Most observations (83%) occurred between Lajes and Ponta da Ilha, 16% between São Mateus and Lajes, and <1% on the north and west side of the island. The whole study area encompassed 540 km^2. On average, weather conditions were good (sea state up to 4 on the Douglas scale) between May and October but unpredictable and often turbulent from November to April. Our highest effort was therefore made in summer and spring (respectively 55% and 31% of all surveys). Autumn (9%) and winter (5%) were less adequately sampled due to adverse weather conditions. We spent 1,317 h at sea during the 4 yr survey period (272 h in 2004, 403 h in 2005, 317 h in 2006, 325 h in 2007) and encountered Risso's dolphins on 333 (86%) of the 386 boat-survey days.

Observation and Identification Protocol

We located Risso's dolphins following radio guidance from fixed look-out posts, with the main look-out located in Santa Cruz das Ribeiras. Upon reaching the animals we recorded wind force and direction, sea state, visibility, and GPS coordinates. Observations lasted from 20 min to several hours. Following Whitehead (2003) a group was defined as a sample of individuals that interacted socially and/or showed coordinated behavior (chain-rule: Smolker *et al.* 1992). Group size was estimated at sea by two observers, with estimates improved when possible using photo-identification data.

Using SLR cameras with a 70–300 mm zoom lens, we photographed as many group members as possible during each encounter. Risso's dolphins were individually identified based on long-term natural marks on their dorsal fin (shape, notches, and

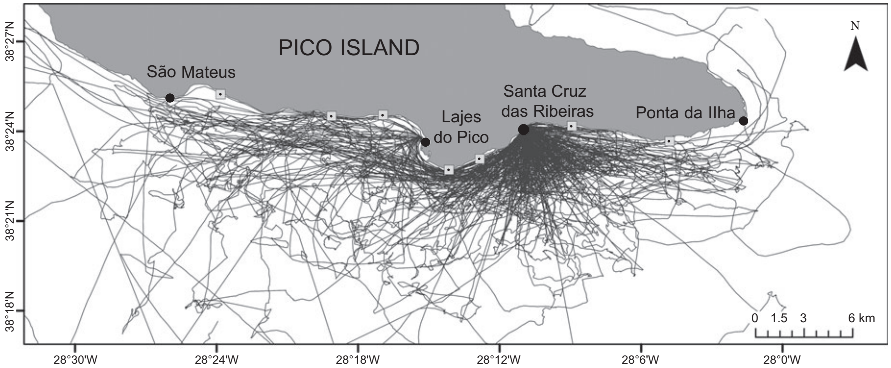

Figure 1. Main study area on the south of Pico Island, Azores, showing the locations mentioned in the text, the position of the lookouts used, and the tracks of the observation trips.

amputations), as well as on the unique scarification patterns on their dorsal fins and body (Hartman *et al.* 2008). We cropped the digital pictures around the visible part of the body and categorized them per individual, sighted group, and date. We took around 200,000 photographs, of which about 44,500 were of high quality ($Q \geq 3$, Arnbom 1987) and suitable for individual identification. We identified 1,250 individuals, of which 39% were resighted during the 9,933 recorded encounters; 66 individuals were even resighted more than 30 (and up to 80) times (Fig. 2).

We identified the calves by their specific physical characteristics (described in Hartman *et al.* 2014), *e.g.*, by being less than 75% of the adult size and by swimming synchronously next to an adult (Mann and Smuts 1999). Correspondingly, we assumed adults accompanied by a calf were females. Males, on the other hand, were defined based on the long-term absence of accompanying calves, corroborated by genital area observations, robust body build, and/or the appearance in stable pods (Hartman *et al.* 2008). We used additional information from a larger unprocessed field database (covering 2000–2013) to complement observations made during the study period, so that it was possible, for instance, to identify females without calves or males seen in only one year. We estimated the sex of 24% of the identified individuals (303 animals).

Mean Monthly Sighting Rate

We calculated a monthly sighting rate (*sensu* Parra *et al.* 2006) to look at how sighting frequency corresponded to residency patterns. The number of months in which an individual was sighted in a given year was divided by the number of months surveyed in that year. This was averaged for the 4 yr of the study, resulting in a mean monthly sighting rate (MMSR). This MMSR varies between 0 and 1, where 1 corresponds to an individual that was seen in all months surveyed during the years it was observed in the area. It is thus possible to have an MMSR of 1 in animals seen in only one year, as well as on animals seen all of the 4 yr of the study.

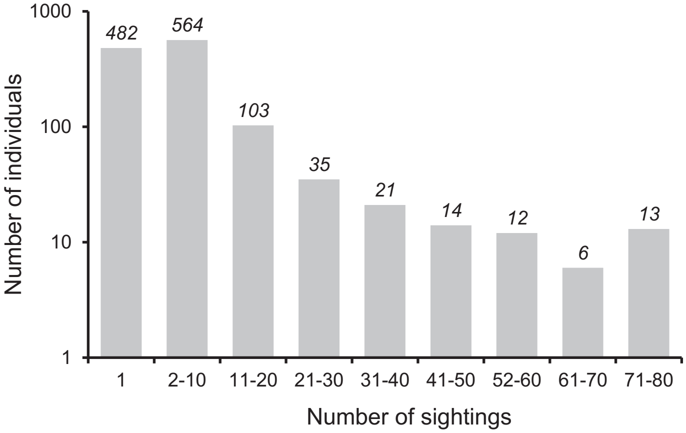

Figure 2. Sightings distribution of the 1,250 individual Risso's dolphins included in the study. Note the log scale on the *y*-axis.

Lagged Identification Rate

We further investigated temporal patterns by calculating the Lagged Identification Rate (LIR), which represents the probability that an individual identified at a given time will be identified again in the study area at a later time (Whitehead 2001). If animals are leaving the area after a certain residence period, this is reflected in a sharp drop of the LIR values, whereas in the case of permanent emigration or death, the LIR typically falls with the time lag. For permanent residents or re-immigrating individuals the LIR curve levels towards a specific value (Whitehead 2001). We fitted models of residency into our data using maximum likelihood and QAIC methods applied to determine the best fitting model (Whitehead 2007). We performed this analysis using Socprog 2.4 (Whitehead 2009) running under MATLAB R2011. We calculated the lagged identification rates and fitted the models for all adults, separated by sex and by sighting frequency (according to the number of years they were seen: "least sighted," recorded in only 1 or 2 yr, 1,005 animals; and "most sighted," seen in ≥3 yr, 245 individuals). The most sighted group contained 97 males and 40 females; in contrast, only 27 males (*vs.* 139 females) were included in the least sighted group. We used jackknife techniques to calculate 95% confidence intervals and standard errors for each model parameter (Whitehead 2001, Karczmarski *et al.* 2005).

Site Fidelity

To determine whether preferred distribution areas can be recognized we calculated the site fidelity *sensu* Spencer *et al.* (1990). For each animal with 10 or more resightings in a particular year (115 males and 37 females), we compared the broken line linking the position of each sighting with 100 other lines drawn across the study area, starting from the same initial point and composed of same length segments, but linking randomly generated positions.

Home Range Analysis

To calculate the home range we first selected the subgroup of animals sighted at least once a year in each of the 4 yr of the study period. To find the minimum number of locations required to obtain a reliable kernel estimation we then calculated the Kernel Density Estimation (KDE) asymptotes, following Laver and Kelly (2008). In our case, this corresponded to between 40 and 50 resightings. Reducing the initial subgroup to those animals seen more than 40 times would make our sample size too small. We therefore adopted a minimum of 30 resightings as suggested by Seaman *et al.* (1999). This approach has been used in several home range studies (*e.g.*, Goheen and Swihart 2005, Azevedo and Murray 2007) as a good compromise between a respectable sample size and an accurate analysis. We further divided the data set into three major groups: females with calves, females without calves, and males. Because males tend to appear in pods with strong reciprocal associations (Hartman *et al.* 2008), we represented each pod by only one individual, in order to avoid autocorrelation.

We calculated home range indexes with the Home Range Tools package for ArcGIS 9.3.1 (Rodgers *et al.* 2007). For this analysis we applied a bivariate weighted kernel with a data standardization factor, and used a value of 0.4 * h_{ref} as smoothing parameter. To obtain this value, we applied sets of different percentages of h_{ref} (reference bandwidth) until the outermost isopleth broke the points into disjoint clumps.

We then used the proportion of h_{ref} that did not cause a break-up of the home range isopleth as the smoothing parameter, to define the home range boundary and obtain an estimated area (as in Berger and Gese 2007, Jacques *et al.* 2009). Finally, to calculate the maximum range of the area used by the individuals, we applied a Minimum Convex Polygon (MCP) analysis.

To analyze the space utilization patterns of the different individuals we used the home range overlaps. Several metrics are available to conduct these calculations. Here we used the Bhattacharyya's affinity index (BA, Bhattacharyya 1943) as a general measure of similarity between Utilization Distribution (UD) estimates. This index is based on a statistical measure of affinity between two populations. It is a function of the product of the two UDs, under the assumption that individuals use the space independently of one another, ranging from 0 (no overlap) to 1 (identical UDs, Fieberg and Kochanny 2005).

Statistical Analysis

We looked for differences between groups using a Kruskal Wallis (KW) test. When significant, we applied the least significant difference by rank (LSD by rank) *post hoc* analysis to look for intragroup differences.

RESULTS

Temporal Patterns

The overall mean monthly sighting rate ranged from 0.09 to 0.86, with a median of 0.17. We found that the MMSR increased significantly with the number of years an animal was seen (KW, $H_{\text{adj}} = 315.43$, df = 3, $P < 0.001$), the set of each consecutive year having a significantly higher MMSR than the previous ones (LSD by rank). This is not a trivial observation: it means that animals seen in all 4 yr tended also to be those that were recorded more frequently within any given year. Highly significant differences (KW, $H_{\text{adj}} = 171.73$, df = 7, $P < 0.001$) also became apparent when we introduced sex into this analysis (Fig. 3). The general pattern of MMSR rising with yearly frequency of observation applies to females: those seen in only one year had a significantly lower MMSR than any other female group (LSD by rank), and females seen in 2 yr also presented a MMSR significantly lower than those seen in 3 or 4 yr. The MMSR of males, on the contrary, did not differ with yearly frequency of observation. The only difference between males and females was that males seen in all 4 yr of the study had a significantly higher MMSR than females sighted 1–3 yr.

The lagged identification rate calculated for all the individuals showed a similar pattern for both the most sighted and the least sighted individuals (Fig. 4a, b): in both cases, an Emigration with Re-Immigration and Mortality model was estimated as the best fitting option. However, at larger time lags there were substantial differences. For the animals seen in at least three years the LIR stabilized towards a constant value, while in the case of the least sighted individuals no such trend was apparent. This phenomenon was also reflected in the model parameters (Table 1). Values for the *Time In* parameter had similar ranges, while the values for the *Time Out* differed substantially (with larger values for the least sighted group).

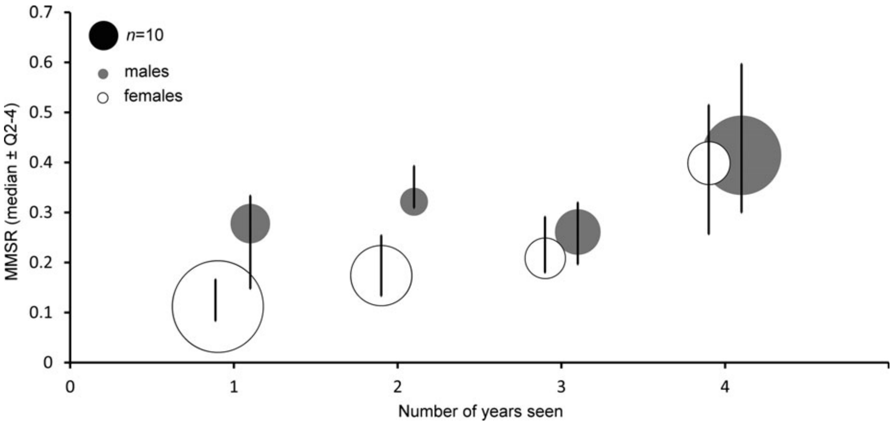

Figure 3. Mean monthly sighting rate, per number of years seen and per sex: median and interquartile error bars; diameter of the circles is proportional to the number of animals.

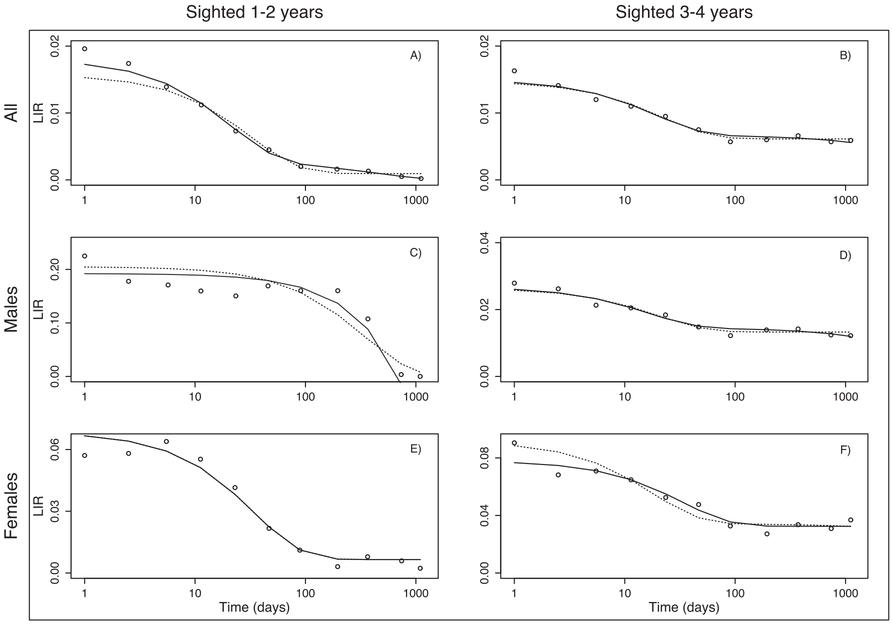

Figure 4. Lagged identification rates of least sighted and most sighted groups. The best and second best fitting models are represented, respectively, by the solid and dotted lines.

The LIR for males showed strong differences between the most sighted and least sighted groups (Fig. 4c, d). The LIR dropped at low time lags but stabilized relatively quickly in the case of the most sighted animals. Therefore, we found the Emigration with Re-Immigration to be the best fitting model for this latter group, with similar values for *Time In* (mean = 36) and *Time Out* (mean = 30) and a relatively high mean number of individuals present in the area at any given time ($n = 37$). In

Table 1. Estimated residency parameters (± SE) for resident and immigrant Risso's dolphins off the south coast of Pico Island (Azores). Values in bold represent the best fitting model.

Group	Model	Number of individuals at a given time	Mean residence time (days)	Mean emigration time (days)	Mortality	Quasi-AIC
Most sighted						
All individuals	Emigration + reimigration	67 ± 3	38 ± 2	54 ± 4	–	352,098
	Emigration + reimigration + mortality	**66 ± 3**	**34 ± 2**	**44 ± 5**	**1.50E-04**	**352,056**
Males	Emigration + reimigration	38 ± 2	41 ± 5	41 ± 5	–	246,751
	Emigration + reimigration + mortality	**37 ± 3**	**36 ± 7**	**30 ± 6**	**1.60E-04**	**246,708**
Females	**Emigration + reimigration**	**13 ± 1**	**57 ± 12**	**80 ± 12**	**–**	**126,177**
	Emigration + reimigration + mortality	11 ± 1	29 ± 18	48 ± 26	4.70E-05	126,241
Least sighted						
All individuals	Emigration + reimigration	64 ± 9	34 ± 31	545 ± 7702	–	40,192
	Emigration + reimigration + mortality	**55 ± 4**	**25 ± 2**	**149 ± 73**	**2.10E-03**	**39,884**
Males	**Closed: emigration + reimmigration**	**43 ± 0.01**	–	–	**–**	**2,394**
	Emigration/mortality	5 ± 2	340 ± 57	–	–	2,468
Females	Closed: emigration + reimmigration	1 ± 0.01	–	–	–	3,702
	Emigration + reimigration	**15 ± 2**	**38 ± 5**	**360 ± 66**	–	**3,702**

contrast, the LIR values for the least sighted animals were stable, with a drop at larger time lag values. In this case the best fitting model was a Closed Population with Emigration and Re-Immigration.

There were also differences in the LIR between the most and the least sighted females (Fig. 4e, f). The most sighted showed higher values in general, with a clear stabilization at larger time lags. An Emigration with Re-Immigration model was the best fitting option. The *Time In* value was smaller than the *Time Out* (mean of 57 and 80, respectively), with a mean number of 13 individuals present in the area at any given time. For the least sighted females the LIR was stable at the start of the observation period with an important drop around a time lag of 10 d, then stabilizing again. In this case, the Emigration with Re-Immigration model gave the best fit, with the largest *Time out* values.

Spatial Patterns

Of the 303 sexed animals, we selected for the site fidelity analysis those with more than 10 resightings ($n = 53$) in at least one year. We found a high degree of site fidelity, which was present in 94% of the selected animals (38 males and 12 females). From this subset, 42 individuals were sighted in all 4 yr with more than 30 resightings: 30 males (representing 11 pods composed of 73 animals) and 12 females (4 with and 8 without calves). We used these individuals for the home range analysis. We found that the size of the home range of male pods covered all the spectrum of observed home range sizes (Table 2). There were no significant differences in home range sizes between male and female groups, neither at 95% UD (KW, $H = 0.036$, $P > 0.05$) nor at 50% UD (KW, $H = 2.43$, $P > 0.05$). At the 50% UD level, however, females with calves or immature individuals occupied a significantly smaller area (KW, $H = 7.71$, $P < 0.01$) than females without calves (Fig. 5).

As expected, home range overlap values (Table 3) were higher at the 95% UD level. At 50% UD, groups of females with calves showed the highest overlap, whereas the lowest overlap was found between male pods. We found no significant differences in home range overlap between groups of females with or without calves, neither at 95% UD (KW, $H = 0.1$, $P > 0.05$) nor at the 50% UD (KW, $H = 3.43$, $P > 0.05$). However, home range overlap between groups of males was significantly lower than between females with calves (KW, 95%UD: $H = 16.68$, $P < 0.01$; KW, 50%UD: $H = 7.43$, $P < 0.01$) or without calves (KW, 95%UD: $H = 7.48$, $P < 0.01$; KW, 50%UD: $H = 7.75$, $P < 0.01$).

Table 2. Home range values (in km^2) for 95% and 50% utilization distribution estimates (UD, bi-weighted kernel) and minimum convex polygons (MCP), by group type. Upper line values represent the maximum and minimum area used by each group. The mean and standard deviation are given below, in parenthesis.

Group type	95% UD	50% UD	MCP
Male pods ($n = 11$)	172.16–56.9 (117.0 ± 40.1)	27.2–7.7 (14.7 ± 5.5)	212.38–55.0 (139.6 ± 25.3)
Females without calves ($n = 9$)	162.31–88.49 (117.74 ± 23.81)	26.07–13.28 (17.75 ± 4.33)	188.01–92.23 (130.11 ± 18.22)
Females with calves or immatures ($n = 4$)	151.41–90.44 (108.58 ± 28.47)	11.84–9.32 (10.66 ± 1.21)	195.43–87.23 (138.94 ± 34.18)

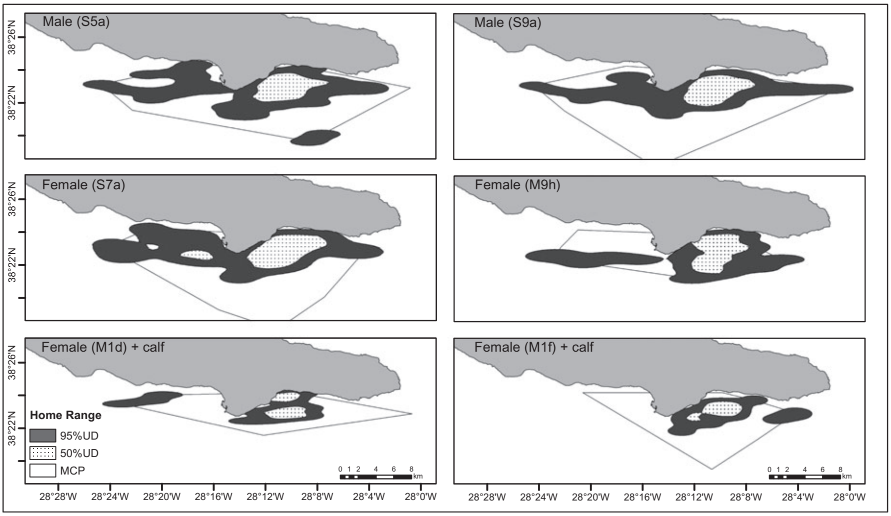

Figure 5. Examples of home ranges (for 95% and 50% utilization distribution estimates, UD, and minimum convex polygons, MCP) of different groups of Risso's dolphins: males, females without calves, and females with calves.

Table 3. Values of Bhattacharyya's affinity index for homerange overlap between male pods, females without calves and females with calves. Upper line values are the maximum and minimum overlap, on a 0–1 scale; lower line values, in parenthesis, are the mean and standard deviation. Statistical significance ($P < 0.05$, Kruskal-Wallis) is noted by *.

	Male pods	Females without calves	Females with calves
Overlap, 95% UD			
Male pods	0.99–0.73 (0.91 ± 0.06)	0.98–0.79 (0.93 ± 0.04)*	0.98–0.86 (0.93 ± 0.04)*
Females without calves	–	0.99–0.89 (0.96 ± 0.02)	0.99–0.88 (0.96 ± 0.02)
Females with calves	–	–	0.98–0.95 (0.97 ± 0.01)
Overlap, 50% UD			
Male pods	0.95–0.46 (0.78 ± 0.13)	0.95–0.55 (0.81 ± 0.1)*	0.96–0.59 (0.82 ± 0.1)*
Females without calves	–	0.93–0.67 (0.85 ± 0.07)	0.98–0.72 (0.88 ± 0.06)
Females with calves	–	–1	0.94–0.85 (0.91 ± 0.03)

Discussion

The present study corroborates the existence of a resident population of Risso's dolphins off the south coast of Pico Island, showing site fidelity and relatively restricted home ranges. The identification of a resident population in a relatively small area is an unusual circumstance. This raises the question of whether the south coast of Pico is a special case, or whether similar concentrations occur elsewhere on the inland or on other islands. Addressing this issue requires extensive field work over a period of several years. Nevertheless, existing data like that from the MONICET platform (MF, unpublished data), give some indications that Risso's dolphins are not uniformly distributed around the islands. Therefore it is possible that similar resident populations can be found elsewhere in the archipelago.

In general we found that resident animals, seen in every year of the study, were also those that were seen more frequently within each year, while most animals with low resighting rates were seen in only one of the study years. In addition, the lagged identification rate analysis showed that the most sighted individuals spent shorter periods outside the study area than the least sighted individuals. Exceptions to these patterns include animals with higher than expected sighting rates in the least sighted group. These outliers belonged to two groups. Some were whitish and apparently older dolphins which were photo-identified frequently during 2004 and 2005, but disappeared after this period. A second group was formed by younger animals that joined a stable cluster only on the last two years of the study, but were still recorded within the same pod in the years that followed it (KLH, unpublished data). In both cases, therefore, these individuals would have been included in the most sighted group if the temporal frame of the study had been wider.

Because observations were made from land we may have underestimated the home range of some individuals, obtaining more restricted areas, closer to the main base. However, since this bias affects all groups and both sexes equally, we think that the estimators used are valid for the comparative purposes of the present paper. The sampling limitations of the present study should, however, be kept in mind when comparing results with other areas.

We hypothesize that the observed residency patterns can be linked to the species' ecology and its relationship with behavior, particularly the mating system. As a deep diver, feeding mainly on deep-water cephalopods, the distribution of Risso's dolphins is likely conditioned by the areas where their food resources are accessible. This has been recorded for sperm whales (*Physeter macrocephalus*), another squid eating cetacean, in the Gulf of California, where animals changed from a uniform distribution when squid were abundant, to a clumped distribution, presumably around areas of higher squid abundance, when the squid population collapsed due to fishing activities (Jaquet and Gendron 2002). Not only site fidelity but also social behavior have been related to the predictability of prey resources in several species of teuthophagous cetaceans. On the west coast of Hawaii Island, McSweeney *et al.* (2007) documented site fidelity of Cuvier's (*Ziphius cavirostris*) and Blainville's (*Mesoplodon densirostris*) beaked whales, particularly on females of both species. The authors suggest this fidelity is linked to the relatively high abundance or predictability of prey resources in the area, most likely deep water squid. On another beaked whale, *Hyperoodon ampullatus*, Wimmer and Whitehead (2004) report a similar fidelity of females to canyons on the Scotia Slope with a reliable supply of deep water squid. In both studies a link between resource distribution and sex differences in residency patterns is noted: males move more between areas, and this is attributed to the search for receptive females.

In a recent publication on the Risso's dolphin population along the south coast of Pico it has been demonstrated that females tend to aggregate in coastal areas when calving and nursing (Hartman *et al.* 2014), and this was hypothetically linked to the availability of squid. In this population males are organized in long-term multimale alliances (Hartman *et al.* 2008). The formation of multimale groups can be expected in a situation where a core area or a female range can be defended (Clutton-Brock 1989). In this situation, groups of related males cooperate to aggressively defend the females from other male groups, whereas females may or may not defend their own territory. Multimale groups can also form even if an area cannot be defended. In this case, males rarely cooperate to defend receptive females; individual males, however, defend them against other group members as well as against intruders. Male groups in this case have strong hierarchies and the group members are seldom related to each other. Relations between groups are less hostile than in the previous mating system, and immigration is comparatively common. The aggregations of nursing females recorded in the Azores are consistent with the scenario of some degree of female range defense by male groups. The present study reinforces this hypothesis. Males showed the highest degree of site fidelity: they spent less time outside the area compared to the females, and the smallest home ranges were used by male pods. Aggression between males from different pods has been observed frequently (KLH, unpublished data), and this could explain the lowest values of home range overlap between male pods recorded in the present study. Further support for the spatial defense hypothesis could come from future evidence of genetic relatedness of members of the same male pod.

Conservation Implications

If the ecology of Risso's dolphins populations on the Azores is geographically structured, with males defending a core area to where females periodically return (*e.g.*, for feeding, giving birth and nursing), this has important management implications. Cetaceans are legally protected from hunting in the Azores, and fisheries bycatch is negligible (Silva *et al.* 2011). However, depredation by Risso's dolphins has been documented in the hand-jig squid fishery, and this may be a potential source of conflict (Cruz *et al.* 2014). A possible way to address it would be to establish time limitations to squid fishing in the core areas delineated in the present study. On the other hand, cetaceans have become the focus of a growing whale watching industry and this raises a major line of concern, since a resident population is likely more susceptible to disturbance caused by tourist-carrying boats (Parra *et al.* 2006, Stockin *et al.* 2008, Steckenreuter *et al.* 2012). In fact, the resting patterns of Risso's dolphins on the south coast of Pico have already been shown to be disrupted by the presence of whale watching vessels (Visser *et al.* 2011). The recommendations of Hartman *et al.* (2014), based on the territoriality of female groups with calves, should therefore be carefully considered. A precautionary management approach would include limiting pressure from commercial activities, *e.g.*, by reducing the number of boats present at any time or restricting swimming with dolphins. Effectiveness of such regulations should be monitored and adjusted according to evidence of negative impact.

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