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Foraging patterns of breeding Dolphin Gulls *Larus scoresbii* at Punta Tombo, Argentina

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The Dolphin Gull *Larus scoresbii* is a little-known, rare species endemic to southern South America. Knowledge of its feeding ecology is essential for development of management and conservation strategies. To obtain information on their use of food resources and on the frequency and duration of their foraging trips, we followed seven individuals by radiotelemetry during the breeding season of 2002 at the Punta Tombo Reserve, Argentina. In 99% of mapped locations (n = 4069) the Gulls were within 2.4 km of their colony. Dolphin Gulls foraged mostly at the colonies of three other species, feeding on Magellanic Penguin *Spheniscus magellanicus* and Imperial Cormorant *Phalacrocorax atriceps* regurgitates and on Southern Sea Lion *Otaria flavescens* faeces. The sea lion colony was the most frequently visited foraging area, accounting for 64% of the total (n = 260 trips). A similar trend was observed during both the incubation (60%, n = 38 trips) and the chick (64%, n = 40 trips) stages. The mean number of trips per day was 3.8 (range = 3–5), with a mean duration of 123 min (sd = ±27). Trip duration differed between foraging areas, being significantly longer at the sea lion than at the penguin and cormorant colonies. The small foraging range given by its particular feeding strategy suggests that Dolphin Gulls, in contrast to most other seabirds that range over large expanses of ocean in search of food, may be effectively conserved within protected areas during the breeding season.

Larus gulls are largely temperate-zone species that nest colonially, and many show great plasticity in their feeding requirements (Burger & Gochfeld 1996). Most species in this genus feed on a variety of prey through the use of diverse feeding methods in a wide range of habitats (Mudge & Ferns 1982, Götmark 1984, Burger 1988, Pierotti & Annett 1990). Marine gulls feed mostly on fish and invertebrates, which they obtain at intertidal habitats and in coastal or pelagic waters, although many species opportunistically include other types of food (Burger & Gochfeld 1996). In addition, many gulls change their diet between years, throughout their annual cycle and even within their breeding season in response to fluctuations in food availability, energy requirements or restrictions imposed by reproductive factors (Götmark 1984, Curtis *et al.* 1985, Braune 1987, Pierotti & Annett 1991, Bertellotti & Yorio 1999).

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The Dolphin Gull *Larus scoresbii* is restricted to the southern coasts of South America. Its breeding distribution on the Atlantic coast ranges from Tierra del Fuego north to Punta Tombo (44°02′S, 65°11′W), Argentina, including the Malvinas (Falkland) Islands, and north to Chiloe Island (42°S), Chile, on the Pacific coast (Burger & Gochfeld 1996). The total number of breeding pairs in Argentina has been estimated at fewer than 700, distributed in 26 colonies (Yorio *et al.* 1999). Dolphin Gulls weigh on average 520 g, lay a clutch of two eggs, nest in close proximity to each other, adults and chicks leave the nest shortly after hatching, and chicks form crèches (Yorio *et al.* 1996). Several authors have briefly described aspects of its feeding ecology at different locations throughout its range, although the information they present is mostly anecdotal and descriptive. These observations show that Dolphin Gull diet can include a wide variety of items, including faeces of marine mammals (Castellanos 1935, Reynolds 1935, Cawkell & Hamilton 1961, Woods 1975), intertidal mussels and invertebrates at macroalgae washed ashore after storms

(Murphy 1936, Woods 1975, Devillers 1977, Yorio *et al.* 1996), food dropped by penguins, cormorants and petrels while these birds are feeding their chicks (Reynolds 1935, Murphy 1936, Cawkell & Hamilton 1961, Woods 1975, Devillers 1977, Yorio *et al.* 1996), eggs from several penguin and cormorant species (Murphy 1936, Woods 1975, Yorio *et al.* 1996), insects (Woods 1975), carrion (Murphy 1936), and food derived from human activities such as waste in slaughterhouses and coastal refuse tips (Murphy 1936, Moynihan 1962, Woods 1975, Devillers 1977, Gandini & Frere 1998). However, no studies have yet analysed Dolphin Gull food requirements quantitatively and, particularly, their dependence on other colonial species during the breeding season.

Opportunistic observations made at Punta Tombo have shown that breeding Dolphin Gulls regularly forage at colonies of Magellanic Penguins *Spheniscus magellanicus*, Imperial Cormorants *Phalacrocorax atriceps* and Southern Sea Lions *Otaria flavescens*, and it was suggested that Gulls relied heavily on these colonial species when breeding (Yorio *et al.* 1996). However, because of the high mobility of foraging individuals it was not possible to determine whether Dolphin Gulls regularly use additional food sources. The dependence on other colonial species could have important consequences for Dolphin Gull conservation. Therefore, knowledge of the spatial and temporal foraging patterns is key not only to understanding their feeding ecology and role in coastal ecosystems, but also for the development of management and conservation strategies for this little-known species, particularly considering the low number of breeders along the Argentine coast. In this paper we analyse the foraging patterns of Dolphin Gulls breeding at Punta Tombo, Argentina. We present information on the spatial distribution and the temporal patterns of use of feeding areas during the late incubation period and early chick stage.

METHODS

Study sites

During the 2002 breeding season, we studied the use of foraging areas and feeding behaviour of the Dolphin Gull by means of radiotelemetry in a colony of 30 breeding pairs at the Punta Tombo Provincial Reserve (44°02′S, 65°11′W), Chubut, Argentina (Fig. 1). Gulls start to lay eggs during mid-November, although egg-laying continues for nearly a month, and chicks start hatching in mid-December (Yorio

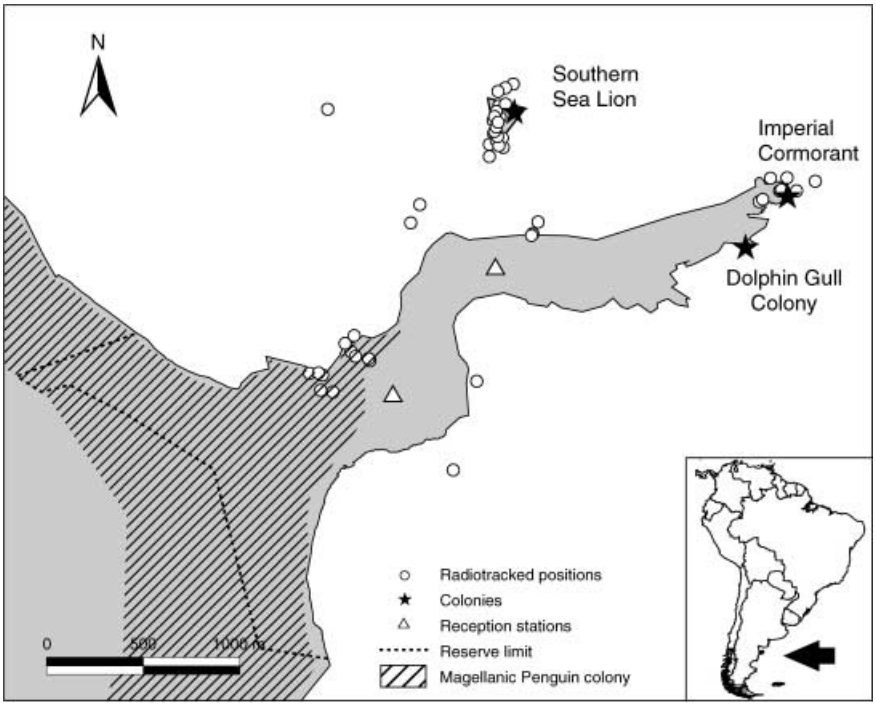

Figure 1. Location of foraging Dolphin Gulls tagged with radio-transmitters during the late incubation and early chick stages of the 2002 breeding season at Punta Tombo, Argentina.

et al. 1996). Several other seabird species breed at Punta Tombo: Magellanic Penguin, Imperial Cormorant, Rock Shag *Phalacrocorax magellanicus*, Kelp Gull *Larus dominicanus*, South American Tern *Sterna hirundinacea*, Cayenne Tern *Sterna eurygnatha* and Southern Skua *Catharacta antarctica*. The Magellanic Penguin colony consists of 175 000 nests (Yorio *et al*. 1998). Penguins lay eggs in early October, hatch chicks in mid-November and fledge chicks from late January to late February. Imperial Cormorant colony size during the study season was 315 nests. Cormorants lay eggs in early November, hatch chicks in early December and fledge chicks from late February and early March. A colony of approximately 350 Southern Sea Lions is located on a small islet about 500 m north of Punta Tombo (Reyes *et al*. 1999). Southern Sea Lions are present in the Punta Tombo area throughout the Dolphin Gull breeding season.

Deployment of instruments

A VHF radio-transmitter (Standard model, Advanced Telemetry Systems, effective range 18 km) was deployed on adults from each of seven pairs of gulls, captured using an incubation trap (Weaver & Kadlec 1970) during the late incubation period (13 and 14 December). The instruments were fixed using waterproof tape to the two central tail feathers. Gulls were ringed with metal rings on the right leg and plastic colour-rings on the left leg. For each bird, the procedure was completed in less than 10 min and the released birds flew directly to their nest or to adjacent areas from where they returned to their nest within 10 min. The average weight of the instruments was 9 g (sd = ±0.2, n = 7), which represented approximately 2% of adult body mass. All birds carrying devices continued to breed normally during the study period.

Feeding areas

Radio signals were monitored from two tracking stations 0.9 km apart and located 1.29 and 1.95 km from the Dolphin Gull colony (Fig. 1). The receiver equipment consisted of a single-channel receiver (R161A model, Advanced Telemetry Systems) connected to a null peak directional antenna. The pulse rate of the signal was 30 pulses/min.

To determine the feeding areas, gulls were monitored from the receiver stations during two periods, 15–29 December and 2–9 January. Records for each instrumented individual were obtained at 15-min intervals during periods of 8–16 h. The location of each gull was estimated by triangulation from the direction of the signals obtained from the two receiver stations. The operators at the two tracking stations were in radio contact. Records made up by one or both directions with an error equal or larger than 4° were rejected. Thus, a total of 1365 records corresponding to 101 feeding trips was obtained. In addition, opportunistic direct observations of instrumented gulls and confirmation of individual identity using telemetry were made at the foraging grounds.

To evaluate the use of each feeding area, information obtained from the receiver stations (n = 101 trips) was complemented with locations obtained with a hand-held three-element Yagi aerial (Advanced Telemetry Systems). The location of each individual was obtained every 15 min. Thus, a total of 2704 records corresponding to 169 feeding trips was obtained, which when added to those obtained from the tracking stations resulted in a total of 270 feeding trips. The presence of instrumented Gulls at the feeding areas was determined by the intersection of the signal direction with the coastline or the Penguin colony. It was assumed, from previous observations and a previous study (Yorio *et al*. 1996), that Dolphin Gulls forage at the colonies of other species or on the coastline during this stage of the breeding cycle. Simultaneous observations indicated that Dolphin Gulls did not forage inland or within the Kelp Gull colony. In addition, locations obtained with the hand-held antenna were confirmed by direct observations in 46% of trips (n = 169). Dolphin Gulls could visit one or more feeding areas during the same trip. Therefore, to compare visit rates among the different feeding areas, trips were assigned to the area where the Gull spent more than 75% of its foraging time.

Trip duration was analysed using data obtained with both types of antennae throughout the incubation and chick stages. Trip duration was calculated as the time difference between the departure from and arrival at the colony. To determine the number of feeding trips per day, the proportion of time spent in each feeding area, and the temporal pattern of trips in relation to the state of the tide and time of day, six individuals were radiotracked with the hand-held antenna during all daylight hours during 2–5 January (n = 676 records). During high tides many Sea Lions leave the small islet because it is largely covered with water and, thus, the availability of excrement would be reduced during these periods. Therefore,

the relationship between Dolphin Gull feeding trips to the Sea Lion colony and the state of the tide was evaluated by assigning each trip to one of three categories (high, mid and low tide). For the analysis, medium and low tides were then grouped. Magellanic Penguins mostly feed their chicks early and late in the day and thus the temporal pattern of Dolphin Gull feeding trips to the Penguin colony was analysed in relation to time of day, assigning each trip to one of two periods: (a) from dawn to 08:30 h and from 18:30 h to dusk, and (b) from 08:30 h to 18:30 h.

To compare the use of feeding areas and trip duration between the incubation and chick stages, trips made during 5 days in each of these stages were compared. Only data obtained, with both types of antenna, from four birds (nos. 3, 5, 9, 13) for which information at the same time of day was available were used.

Statistical analyses

Locations obtained from the receiver stations were included in a geographical information system. The spatial distribution of feeding locations was characterized using kernel density estimates (Wood *et al.* 2000). We defined three categories of activity ranges as the areas encompassing 95, 75 and 50% of locations at sea. The Kruskal–Wallis test was used to make all comparisons. Results below are given as mean ± 1 sd.

RESULTS

Feeding locations

We were able to receive a signal while the birds were absent from the colony in 99.4% of the cases (n = 4069). Dolphin Gulls foraged relatively close to their colony: the Cormorant colony (0.4 km), the high-density Penguin nesting area (2.0–2.5 km) and the Sea Lion colony (1.4 km). Ninety-nine per cent of the records (n = 4069) were less than 2.4 km from the Dolphin Gull colony.

Feeding areas were identified by means of radiotelemetry, on the basis of 119 bird locations for a total of 101 foraging trips (18 foraging trips included two locations) (Fig. 1). Kernel density estimates showed that Dolphin Gulls foraged mostly at the Southern Sea Lion, Magellanic Penguin and Imperial Cormorant colonies (Fig. 2). The highest densities were observed at the Sea Lion colony and the lowest at the Penguin colony. In only nine of the 101 foraging trips were Dolphin Gulls located at other sites along the

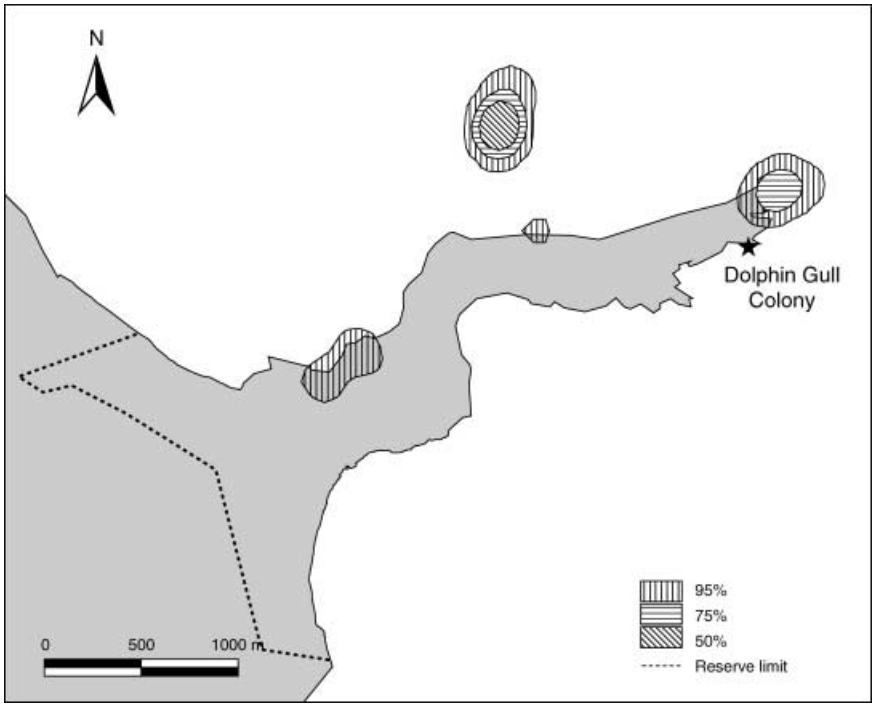

Figure 2. Density contours (resulting from kernel estimation of locations) for Dolphin Gulls breeding at Punta Tombo, Argentina. Contours encompass 50, 75 and 95% of locations.

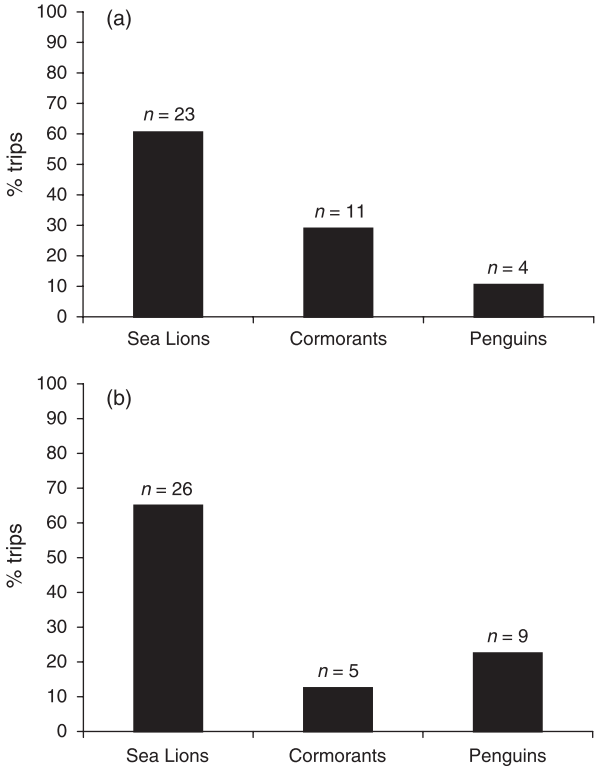

Figure 3. Percentage of Dolphin Gull feeding trips to the three main feeding areas during (a) the incubation and (b) the chick stages at Punta Tombo, Argentina.

coastline, and simultaneous direct observations showed that Gulls were feeding in the intertidal zone. In these nine trips, Gulls also visited the Sea Lion colony.

All instrumented Gulls used more than one feeding area during the study period. Whereas all seven individuals visited the Southern Sea Lion, Magellanic Penguin and Imperial Cormorant colonies throughout the 270 trips, only two of the individuals (birds 5 and 9) visited the intertidal zone. In 90% of the trips Gulls visited only one feeding area, whereas two sites were used in the rest of the trips.

The Sea Lion colony was the most visited feeding area (64% of trips), followed by the Cormorant and Penguin colonies (21 and 15%, respectively) ($\chi^2_2 = 113.4$, $P < 0.05$, $n = 270$). The higher use of the Sea Lion colony was observed during both the incubation stage (60% of trips, $\chi^2_2 = 14.58$, $P < 0.05$, $n = 38$; Fig. 3a) and the chick stage (64%, $\chi^2_2 = 18.65$, $P < 0.05$, $n = 40$; Fig. 3b). Whereas Dolphin Gulls made more visits to the Cormorant than the Penguin colony during the incubation stage, this relationship was reversed during the chick stage ($\chi^2_2 = 9.3$, $P < 0.05$) (Fig. 3a & 3b). Dolphin Gulls were absent from the colony during 44.5% of the 16 daylight hours ($n = 676$ records). Gulls spent most of the time feeding at the Sea Lion colony (74%), but spent only 17 and 9% of daylight hours feeding at the Penguin and Cormorant colonies, respectively.

Foraging trips

Dolphin Gulls made an average of 3.8 ± 0.4 feeding trips per day during the chick stage (range = 3–5, $n = 6$ birds) (Table 1). No significant differences were found among individuals (Kruskal–Wallis $H = 7.8$, $n = 24$, $P = 0.166$). Mean trip duration was 123.3 ± 27.5 min (range = 30–330 min) (Table 1), and no significant differences in the length of foraging trips to each of the feeding areas were found among individuals (Sea Lion colony: Kruskal–Wallis $H = 5.3$, $n = 87$, $P = 0.51$; Penguin colony: Kruskal–Wallis $H = 0.45$, $n = 27$, $P = 0.99$; Cormorant colony: Kruskal–Wallis $H = 6.1$, $n = 27$, $P = 0.29$). Therefore, data were pooled for all individuals to compare trip duration between feeding areas. Trip duration differed among

Table 1. Number of trips per day and trip duration (minutes) during the early chick stage by each Dolphin Gull breeding at Punta Tombo, Argentina, during 2002.

	Trip duration (min)			Trips per day ($n = 4$ days)		
Gull reference	No. of trips	Mean ± sd	Range	No. of trips	Mean ± sd	Range
1	27	100.9 ± 52.8	30–255	17	4.2 ± 0.5	4–5
3	20	116.3 ± 56.5	45–315	16	4.0 ± 0.0	4–4
5	20	121.8 ± 50.6	60–225	13	3.2 ± 0.5	3–4
7	4	183.0 ± 57.9	105–240	–	–	–
9	23	107.2 ± 36.1	45–195	14	3.5 ± 1.0	3–5
11	22	123.0 ± 69.5	45–300	16	4.0 ± 0.8	3–5
13	25	110.8 ± 62.4	45–330	16	4.0 ± 0.0	4–4
Total	141			92		
Mean		123.3 ± 27.5	30–330		3.8 ± 0.4	3–5

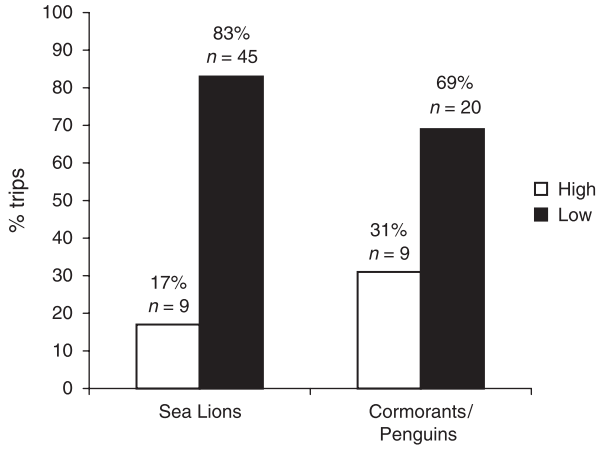

Figure 4. Proportion of Dolphin Gull foraging trips to the different feeding areas as a function of the state of the tide during the chick stage at Punta Tombo, Argentina.

areas, being significantly higher in the Sea Lion colony than in the Penguin and Cormorant colonies (133.1 ± 56.3, 107.3 ± 45.2 and 61.1 ± 17.0 min, respectively) (Kruskal–Wallis $H = 48.9$, $n = 141$, $P = 0.0001$; Kruskal–Wallis contrast t-test = 20–61, all $P < 0.05$). No significant differences were found between the duration of feeding trips in the incubation and chick stages in any of the three areas (Sea Lion colony: Kruskal–Wallis $H = 0.2$, $n = 48$, $P = 0.672$; Penguin colony: Kruskal–Wallis $H = 0.2$, $n = 13$, $P = 0.636$; Cormorant colony: Kruskal–Wallis $H = 0.1$, $n = 17$, $P = 0.793$). Dolphin Gulls foraged in the three areas during all states of the tide, although there was a greater proportion of trips during low and mid tides to the Sea Lion colony than to the other two feeding areas ($\chi^2_1 = 4.6$, $P < 0.05$) (Fig. 4). A significant association was found between the trips to the Penguin colony and time of day; trips to this area were more frequent early and late in the day ($\chi^2_1 = 13.9$, $P < 0.05$).

DISCUSSION

Dolphin Gulls fed almost exclusively in the Southern Sea Lion, Imperial Cormorant and Magellanic Penguin colonies. In only a few occasions were they recorded feeding in the intertidal zone. These observations agree with a previous study conducted in the same area during the 1986 and 1987 breeding seasons (Yorio *et al.* 1996). In that study, Dolphin Gulls were also observed feeding mostly at the colonies of the species mentioned, although they occasionally fed in the intertidal zone before Magellanic Penguin or Imperial Cormorant chicks hatched. In the present study, Dolphin Gulls took advantage of Sea Lion excrement and scraps of food dropped when Magellanic Penguins and Imperial Cormorants fed their chicks. To obtain Penguin food scraps, Gulls waited in the vicinity of Penguin nests until food was dropped, after which they quickly grabbed it. At the Cormorant colony, Dolphin Gulls flew low above the nests inducing Cormorants to regurgitate food. This behaviour has been recorded previously in the Malvinas (Falkland) Islands, where Dolphin Gulls often induce Gentoo Penguins *Pygoscelis papua* and Rock Shags to drop food while they are feeding their chicks (Cawkell & Hamilton 1961, Woods 1975).

Although earlier studies have shown the capacity of Dolphin Gulls to exploit a wide variety of food types using diverse feeding strategies (see Introduction), our study indicates that at least during the breeding season their feeding ecology is based mostly on the food obtained from other colonial species.

The almost exclusive use of food derived from seabird and marine mammal colonies during the breeding season could be the result of the particular characteristics of these sources. The three colonies where Dolphin Gulls obtain food at Punta Tombo constitute abundant and predictable sources both spatially and temporally, while also being close to the Dolphin Gull colony. At the Sea Lion and Cormorant colonies, food is more regular as Sea Lion excrements and food brought to Cormorant chicks are available throughout the day. At Punta Tombo, however, feeding trips to the Sea Lion colony varied throughout the day as the number of Sea Lions in the colony can vary considerably with the state of the tide, resulting in changes in excrement availability for the Gulls. In contrast, food from Magellanic Penguins is not available uniformly throughout the day, as most Magellanic Penguins at Punta Tombo feed their chicks early and late in the day (D. Boersma unpubl. data), and this was reflected in the temporal pattern of use of the Penguin colony by Dolphin Gulls. However, the large number of breeders at the Penguin colony probably makes this colony an attractive food source.

The consumption of food scraps at other bird colonies is probably advantageous as it consists mainly of fish. Imperial Cormorants and Magellanic Penguins are mainly piscivorous (Boersma & Williams 1995, Punta *et al.* 2003). Several studies on gulls have shown that fish is important for both egg formation and chick growth (Pierotti & Annett 1991, Bolton *et al.* 1992) and may increase lifespan and

long-term breeding performance (Annett & Pierotti 1999). Considering that Southern Sea Lions, particularly males, include fish in their diet (Kohen Alonso *et al*. 2000) it is likely that their excrement has a high content of microbial proteins and vitamin B (E. Dierenfeld pers. comm.). Thus, Sea Lion excrement could also constitute a valuable food for Dolphin Gulls while breeding. Future studies should evaluate the energetic and nutritional value of Sea Lion excrements.

Of the available feeding areas, the Sea Lion colony was most used by the Dolphin Gulls. This apparent preference for Sea Lion excrement was observed throughout the study period. The use of Sea Lion excrement by Dolphin Gulls has been reported previously in the study area (Yorio *et al*. 1996) and at other locations throughout its distribution range (Castellanos 1935, Reynolds 1935, Cawkell & Hamilton 1961, Woods 1975). The use of pinniped colonies as food sources by other gull species has been reported by Pierotti (1988), who argued that they provide food in the form of regurgitates, placenta and excrements. However, the use of excrements has been described for only a few gull species, including the Glaucous Gull *Larus hyperboreus* and the Ivory Gull *Pagophila eburnea* (Burger & Gochfeld 1996). In contrast to these cases in which pinniped excrement is used as an alternative food and in an opportunistic way, it appears to be of great importance to the Dolphin Gull population at Punta Tombo during the breeding season.

Dolphin Gulls foraged within 2.5 km of their colony, showing their low mobility during the breeding season. This is a relatively small foraging range in comparison with many other gull species, and is probably the result of their particular feeding strategy. Given the proximity of their colony to food sources, Dolphin Gulls made relatively short feeding trips. The estimated number of foraging trips per day observed in this study agrees with that previously recorded in the same study area, where the average number of brooding exchanges during daylight hours for pairs with small chicks was ten (Yorio *et al*. 1996). However, it must be borne in mind that some gull species also forage at night (Burger & Staine 1993, McNeil *et al*. 1993). As at least some Magellanic Penguins continue feeding chicks during night hours, the nocturnal feeding behaviour of Dolphin Gulls cannot be ruled out.

Our results confirm the high dependency of Dolphin Gulls on other colonial seabirds and marine mammals at Punta Tombo, during both the incubation and the chick stages. In addition, the spatial restriction in foraging activity resulting from this dependency favours the use of conservation tools such as protected areas, as a relatively small area would be enough to provide the needed protection of both nesting and feeding grounds. At Punta Tombo, Dolphin Gull foraging activity was restricted to areas within the limits of the Provincial Reserve. As a result, from its particular feeding strategy, and in contrast to most other seabirds that range widely in search of food (Boersma & Parrish 1999), Dolphin Gulls may be effectively conserved within small protected areas during the breeding season.

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