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SPATIAL AND TEMPORAL PATTERNS IN THE DIET OF THE KELP GULL IN PATAGONIA[1]

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Abstract. The Kelp Gull (*Larus dominicanus*) is an abundant and widely distributed species in coastal Patagonia, and has increased in number at many locations during the last decade. We present comparative information on diet composition between locations and diet variation throughout the breeding cycle at three Provincial Wildlife Reserves (Punta Pirámide, Punta León, and Punta Tombo), Chubut, Patagonia. We analyzed diet using regurgitated pellets. A total of 41 types of prey were identified at the three colonies. Kelp Gulls fed throughout the season mostly on intertidal invertebrates, although fish also was an important diet component, mainly during the chick stage. The diet also included garbage, insects, and other seabird offspring. Of all types of prey, 70.7% were common to the three locations, although the pattern of consumption of the main food categories differed among locations. The average consumption of garbage differed significantly among locations, with larger amounts of garbage in the diet the closer the colony to the nearest landfill. Kelp Gulls showed a marked seasonal variation in the consumption of the main food types. At Punta Tombo and Punta León, there was a change from a mostly marine invertebrate diet during the pre-laying and incubation stages to a mainly fish diet during the chick stage. The consumption of the main food categories was significantly different between seasons at Punta Pirámide but was similar at the other two colonies.

Key words: diet, feeding ecology, Kelp Gull, Larus dominicanus, *Patagonia.*

INTRODUCTION

Most *Larus* gulls forage in a wide range of habitats, use diverse feeding methods, and feed on a great variety of prey (Götmark 1984, Burger 1988) including, in many cases, food derived from human activities (Furness and Monaghan 1987). In addition, some gulls have the ability to change their diet throughout the year in response to fluctuations in food availability (Götmark 1984, Curtis et al. 1985, Braune 1987) and in response to energy requirements or restrictions imposed by reproductive factors (Pierotti and Annett 1991).

The Kelp Gull (*Larus dominicanus*) is widely distributed throughout the Southern Hemisphere (Harrison 1983). In Argentina, it nests in a great variety of habitats along the sea coast and at continental wetlands and, in coastal Patagonia, it may breed at more than 100 sites in colonies that range between a few and several thousand pairs (Yorio et al., in press). Kelp Gulls have increased in distribution and abundance in New Zealand (Fordham 1970), South Africa (Steele and Hockey 1990), Australia (Blakers et al. 1984), and at several locations in Argentina (Yorio et al., in press). Available information throughout its breeding range suggests that Kelp Gulls are food generalists, which also include food resulting from human activities such as garbage and fishing discards (Steele 1992, Coulson and Coulson 1993, Giaccardi et al. 1997).

In this study we analyzed the Kelp Gull's diet during two breeding seasons at the Punta León, Punta Tombo, and Punta Pirámide colonies, Chubut, Argentina. We present comparative information on diet composition between locations and on its variation throughout the breeding cycle and between years.

METHODS

STUDY AREA

We carried out the study at three Provincial Wildlife Reserves: Punta Pirámide (42°35′S, 64°19′W), Punta León (43°04′S, 64°02′W), and Punta Tombo (44°02′S,65°11′W) (Fig. 1). The

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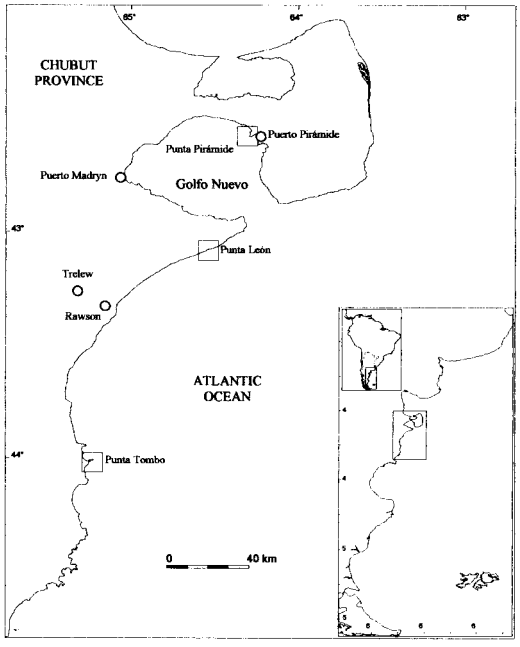

FIGURE 1. Map of coastal Chubut, Argentina, showing the location of the study sites.

Punta Pirámide Kelp Gull colony has 350 breeding pairs, which breed close to Rock Shags (*Phalacrocorax magellanicus*) (30 pairs) and, in some seasons, South American Terns (*Sterna hirundinacea*) (several hundred pairs) (Yorio et al. 1998). Kelp Gulls at Punta Pirámide start to lay in mid October, with peak egg laying occurring during mid November. Most chicks have already hatched by mid December.

Punta León is located 10 km south of the mouth of Golfo Nuevo (Fig. 1). At this location approximately 6,500 Kelp Gull pairs breed with Royal (*Sterna maxima*; 650 pairs) and Cayenne Terns (*S. eurygnatha*; 1,150 pairs), Imperial Cormorants (*Phalacrocorax atriceps*; 3,000 pairs), and Olivaceous Cormorants (*P. olivaceus*; 100 pairs) (Yorio et al. 1998). Kelp Gulls at Punta León begin egg laying during the first week of October, with peak egg laying occurring around November 10. Chicks start hatching in early November and most have already hatched by the first week of December.

Punta Tombo is a rocky peninsula approximately 4 km long and 500 m wide, where approximately 5,000 gull pairs breed together with Magellanic Penguins (*Spheniscus magellanicus*; 175,000 pairs), Imperial Cormorants (400 pairs), Rock Shags (100 pairs), Dolphin Gulls (*Larus scoresbii*; 20 pairs), and Southern Skuas (*Catharacta antarctica*; 9 pairs) (Yorio et al. 1998). Kelp Gulls at this location begin laying during the first week of November, with peak egg laying in early December. Chicks start hatching in late November and most have already hatched by early January.

DIET ANALYSIS

We carried out the diet study through the analysis of regurgitated pellets. Pellet analysis may over-emphasize the presence of types of prey with indigestible hard parts, and soft prey may not be well represented (Duffy and Jackson 1986, Brown and Ewins 1996). However, other studies have demonstrated that they appropriately reflect diet composition (Spaans 1971, Annett and Pierotti 1989) and that they are very valuable for detecting both seasonal changes and differences among locations. In addition, this method allows the analysis of diet with a minimum disturbance to breeding birds.

We collected regurgitated pellets in each colony every two weeks during the 1994 and 1995 breeding seasons. We discarded all pellets collected during the first visit to the colonies so as to eliminate old pellets from the analysis. We always collected pellets in the same study areas, which were distributed in different sectors of each colony, comprising about 1,500 m^2 at each location. The study areas at Punta León and Punta Tombo included approximately 200 nests, whereas at Punta Pirámide almost all nests (approximately 350) were sampled. We collected a total of 1,158 pellets during 1994 (340 in Punta Pirámide, 302 in Punta León, and 516 in Punta Tombo), and 1,411 pellets during 1995 (624 in Punta Pirámide, 429 in Punta León, and 358 in Punta Tombo).

During each visit when pellets were collected, we noted the general breeding status of nests within the study areas. In addition, we obtained information on the timing of the Kelp Gull's breeding cycle at each colony, by marking and following 50 nests throughout the season during 1994 at Punta Tombo and 1995 at Punta Pirámide and Punta León. We checked each nest once a week to record the presence of nesting materials, eggs, or chicks. We divided the breeding cycle into four stages: pre-laying, incubation, chicks up to four weeks of age (chick I), and chicks of more than a month of age (chick

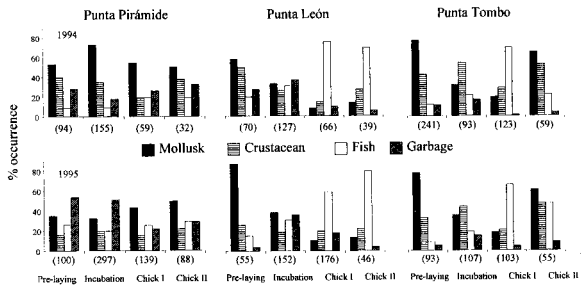

FIGURE 2. Percentage of occurrence of the main food categories (mollusks, crustaceans, fish, and garbage) at each colony during the different stages of the breeding cycle in 1994 and 1995. Sample sizes in parentheses.

II). For the analysis, we grouped pellet sampling dates within these four stages of the breeding cycle.

We broke each pellet in a tray under a zoom binocular microscope (5–20× magnification) and identified food remains to the lowest taxonomic level possible, using crustacean shell fragments and chelae, mollusk shell fragments, polychaete mandibles and chetae, fish otoliths and craneal bones, and different types of bones and feathers. We identified prey with the aid of published guides (Castellanos 1967, Boschi et al. 1992, Gosztonyi and Kuba 1996). The percentage of occurrence of each prey species was recorded. For the analysis, we grouped prey into nine categories: mollusks, crustaceans, fish, polychaetes, echinoderms, insects, garbage (chicken and lamb bones, fruit pits, olives, paper, plastic, and glass), eggs and chicks (egg remains, feathers, chick bones), and vegetable material. We made all comparisons (variations along the cycle, among years, and among locations) only for the main four food categories (mollusks, crustaceans, fish, and garbage).

STATISTICAL ANALYSES

We used *G*-tests to analyze the variation of each food category throughout the breeding cycle and to conduct comparisons among locations and between years. We analyzed the association among food category frequencies and the stages of the breeding cycle, locations, and years of sampling by means of correspondence analysis (Benzécri 1969). We used the program CANOCO (version 3.12) which generates a biplot where the distances among items in the graph corresponds to the values of chi-square. Input data were in the form of a contingency table (Legendre and Legendre 1979) where the columns corresponded to food types (mollusks, crustaceans, fish, and garbage) and the rows were a combined category of location, gull's breeding stage, and year of sampling: e.g., 1TO2 means first year of sampling at Punta Tombo during the second breeding stage (incubation).

RESULTS

Kelp Gulls at Punta Pirámide fed on a wide variety of prey, including at least 30 different types of prey during 1994 and 35 during 1995. However, 40% and 26% of these types of prey during the first and second seasons, respectively, had a percentage of occurrence smaller than 1%. Mollusks were the most frequently encountered prey throughout 1994, with maximum frequencies of occurrence during the incubation stage (Fig. 2). The consumption of crustaceans and garbage (mostly chicken and lamb remains) was relatively important throughout the breeding cycle (Fig. 2). The consumption of mollusks and crustaceans varied throughout the season (mollusks: $G_3 = 14.6$, $P < 0.01$; crustaceans: $G_3 = 8.2$, $P < 0.05$). On the other hand, the consumption of fish and garbage was similar among breeding stages. The frequencies of occurrence of polychaetes, eggs and chicks, insects, echinoderms, and vegetable material, were never greater than 15% and, in general, were less than 10%.

During 1995, Kelp Gulls at Punta Pirámide fed mainly on mollusks and garbage. Mollusks were the main prey during the chick I and II stages, whereas the consumption of garbage was more important during the pre-laying and incubation stages (Fig. 2). The consumption of mollusks and garbage varied throughout the season (mollusks: $G_3 = 10.8$, $P < 0.03$; garbage: $G_3 = 46.2$, $P < 0.001$). On the other hand, crustaceans and fish were consumed in a similar way

TABLE 1. Frequency of occurrence (%) of food categories in Kelp Gull's diet at Punta Pirámide, Punta León, and Punta Tombo during the 1994 and 1995 breeding seasons. n = number of pellets analyzed.

	Punta Pirámide		Punta León		Punta Tombo	
Food category	1994	1995	1994	1995	1994	1995
Fish	11.5	23.1	41.1	44.8	26.4	36.6
Crustaceans	33.5	18.27	27.5	20.1	39.5	37.1
Mollusks	62.1	37.3	29.5	29.8	50.4	48.9
Polychaetes	6.2	11.2	2.0	7.5	9.3	17.0
Echinoderms	5.6	8.8	0.3	0	0	0.6
Garbage	22.9	41.4	23.5	20.8	8.1	8.9
Eggs and chicks	1.8	1.4	9.3	12.6	5.2	12.0
Insects	0.9	7.9	2.0	4.9	0.4	1.7
Vegetable material	3.2	6.6	6.3	6.3	1.0	0.6
n	340	624	302	429	516	358

throughout the season. The percentage of occurrence of polychaetes, eggs, insects, echinoderms, and vegetable material, were in all cases lower than 25%, and mostly lower than 10%. The consumption of the main food categories was significantly different between seasons (G_3 = 86.8, $P < 0.001$).

The diet of Kelp Gulls at Punta León comprised at least 30 different types of prey during 1994 and 31 during 1995. Forty percent and 29% of these types of prey during the first and second seasons, respectively, had a percentage of occurrence lower than 1%. In both breeding cycles, there was a seasonal change in the proportion of the main food categories recorded in the diet. Mollusks were the most frequent prey during the pre-laying stage, whereas fish were more heavily consumed during the chick stages (Fig. 2). The consumption of mollusks, fish, and garbage varied significantly among stages of the breeding cycle in both seasons (all $G_3 > 28.0$, all $P < 0.001$). The consumption of crustaceans varied in a significant way during 1994 (G_3 = 20.2, $P < 0.001$) but was similar between stages during 1995 (G_3 = 1.3, $P > 0.70$). The frequencies of occurrence of polychaetes, insects, echinoderms, and vegetable material were mostly lower than 10%, whereas the frequencies of eggs and chicks were in general low and variable, with maximum values during the chick I stage. The consumption of the main food categories was similar between breeding seasons (G_3 = 4.8, $P > 0.10$).

Kelp Gulls at Punta Tombo fed on at least 30 different types of prey during both breeding seasons, although 27% and 20% of these types of prey during the first and second year, respectively, had a percentage of occurrence lower than 1%. The consumption of the main food categories varied between stages of the breeding cycle in both years (Fig. 2). During the pre-laying and chick II stage, mollusks were the dominant prey. During incubation, the crustaceans showed the highest frequencies of occurrence, whereas during the chick I stage fish were the main prey consumed (Fig. 2). In both years, the consumption of mollusks and fish throughout the season was highly variable (G_3, all four comparisons $P < 0.001$). Similarly, the seasonal variation in the consumption of crustaceans and garbage was significant (1994: crustaceans G_3 = 15.6, $P < 0.01$, garbage G_3 = 22.7, $P < 0.001$; 1995: crustaceans G_3 = 19.7, $P < 0.001$, garbage G_3 = 9.4, $P < 0.05$), with maximum values during the incubation stage. The percentage of garbage in pellets at this location was relatively low, mostly lower than 15% (Fig. 2). At Punta Tombo, the consumption of the main food categories was similar between years (G_3 = 6.6, $P > 0.08$).

DIFFERENCES IN DIET COMPOSITION AMONG COLONIES

Kelp Gulls fed mostly on the same types of prey in the three studied colonies (Table 1). Of the 41 identified types of prey, 70.7% were common to the three locations, while 14.6% were present in one or two of the colonies. During both years, significant differences among locations were found in the total consumption of the main food categories (G_6, both $P < 0.001$). The consumption of garbage, both seasons combined, differed significantly among locations (G_2 = 197.6, $P < 0.001$), with larger amounts of garbage in the

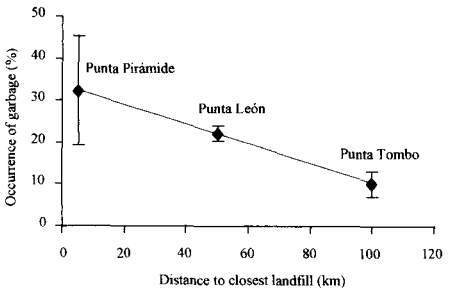

FIGURE 3. Average consumption of garbage by Kelp Gulls during both breeding seasons at each location as a function of the distance to the nearest landfill.

diet the closer the colony to the nearest landfill (Fig. 3).

The correspondence analysis showed a different association between each colony and the main food categories consumed during the different stages of the breeding cycle. The cumulative percentage variance was 60.1% in the first axis (eigenvalue = 0.202), 93.5% in the first two axes (eigenvalue = 0.112), and 100% adding the third axis (eigenvalue = 0.022). Four groups with significant associations between food types (mollusks, crustaceans, fish, and garbage) and each stage of the breeding cycle for each location and year, were identified. The Punta Pirámide colony was significantly associated with mollusks and crustaceans throughout the 1994 breeding cycle and with garbage during the pre-laying and incubation stages in 1995. During both breeding cycles, the Punta León colony was associated with mollusks during the pre-laying period, with garbage during the incubation stage, and with fish during the chick stages. The Punta Tombo colony was associated during both years with mollusks during the pre-laying and chick II stages, with crustaceans during the incubation stage, and with fish during the chick I stage (Fig. 4).

DISCUSSION

Our results show that Kelp Gulls in central coastal Patagonia are generalist and opportunistic foragers which feed on or near the coast on a wide variety of prey, mainly marine invertebrates and fish. Their opportunistic feeding behavior also allows them to include other types of prey from coastal habitats, such as garbage, insects, and eggs and chicks of other seabirds or

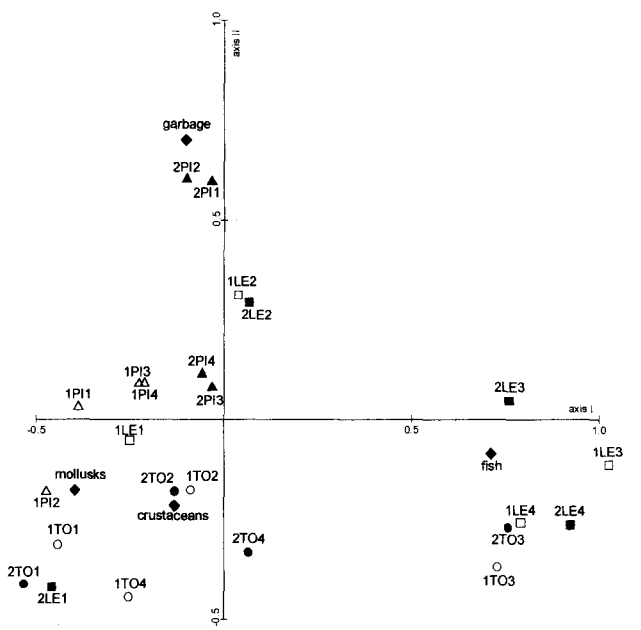

FIGURE 4. Association between food categories (mollusks, crustaceans, fish, and garbage) and the year, location, and breeding stage of Kelp Gulls during 1994 and 1995, obtained through correspondence analysis (open symbols: 1994; solid symbols: 1995). PI, LE, and TO refer to the Punta Pirámide, Punta León, and Punta Tombo colonies, respectively.

shorebirds. The prey trophic spectrum recorded represents a minimum, because the methodology used in this study does not allow the detection of soft-bodied prey with no hard parts which may remain in pellets (Duffy and Jackson 1986). However, in spite of the wide trophic spectrum recorded, most types of prey were present in low frequencies and some of them were exclusively observed in one location or season. Our results agree with those obtained for Kelp Gulls in New Zealand (Fordham 1970), Crozet Archipelago (Stahl and Mougin 1986), South Africa (Steele 1992), and Tasmania (Coulson and Coulson 1993).

As in other regions, Kelp Gulls in northern Chubut feed throughout the season, mostly on intertidal invertebrates. In South Africa, this species forages predominantly on invertebrates found on rocky shores and sandy beaches (Brooke and Cooper 1979, Steele 1992). Similarly, intertidal mollusks are the main prey consumed by Kelp Gulls at South Shetland Islands (Favero et al. 1997), Antarctic Peninsula (Fraser 1989), Marion Island (Blankley 1981), and in the central region of Chile (Bahamondes and Castilla 1986). The invertebrates consumed by Kelp Gulls in Patagonia are characteristic of different depths and types of substrata (rocky, sandy, and muddy), indicating that this species feeds in several different habitats.

Although marine invertebrates are greatly consumed throughout the season, this study shows that fishes also are an important component of the Kelp Gull's diet, mainly during the chick stage. The relative importance of fish in their diet is possibly greater than observed, because pellet analysis can not be used to evaluate the biomass of ingested prey and could also underestimate the presence of small fish due to the high digestibility of their bones and otoliths (Brown and Ewins 1996).

Kelp Gulls catch fish by dipping, surface-seizing, or plunging at sea, particularly when in association with other submarine predators (Duffy et al. 1984, Burger 1988, Steele 1992), or from intertidal pools (Favero and Silva 1998). Fish also may be stolen from other bird species (Steele 1992, Yorio et al., in press) or obtained from waste discarded during fishing operations at sea or at coastal landfills. Kleptoparasitism by Kelp Gulls on Imperial Cormorants, Magellanic Penguins, and Royal and Cayenne Terns has been frequently recorded in two of the study sites, Punta León and Punta Tombo (F. Quintana and P. Yorio, unpubl. data). In addition, some fish may be partly obtained from fish discards. Preliminary results obtained at the Rawson landfill, where discards from fish processing plants are disposed, show that *Merluccius hubbsi* is the dominant type of prey in Kelp Gull pellets (M. Bertellotti, unpubl. data). This also is one of the most frequently discarded fish at coastal fishing grounds in northern Patagonia and the species most frequently taken by gulls associated with fishing operations (M. Bertellotti and P. Yorio, unpubl. data).

More than 70% of prey were common to the three studied colonies, although the pattern of consumption of the main food categories differed among locations. Dietary differences among locations also have been reported for the Kelp Gull in South Africa (Steele 1992) and for several other gull species (Spaans 1971, Götmark 1984, Watanuki 1988). As suggested in these studies, the observed differences in prey consumption among locations are probably due to regional differences in food availability or to the use by gulls of different feeding habitats.

Kelp Gulls also showed a marked seasonal variation in the consumption of the main food types. At Punta Tombo and Punta León there was a change from a diet which mostly comprised marine invertebrates during the pre-laying and incubation stages to a diet comprised mainly of fish during the chick stage. Changes in diet composition could result from seasonal changes in food availability over the course of the breeding season (Curtis et al. 1985, Stahl and Mougin 1986, Braune 1987). However, these changes also could result from prey selection related to energetic and nutritional requirements of offspring, because fish are high in protein and fat and are more easily handled by young chicks (Annett and Pierotti 1989). In addition, fish are relatively larger prey, allowing a greater energetic return per feeding trip during a stage of great energy demands. Interestingly, while Kelp Gulls at Punta León increased the consumption of fish after chick hatching during November, incubating gulls at Punta Tombo still fed mostly on invertebrates. Similar results, where gulls changed to a fish diet during the chick stage, also were observed in the Kelp Gull in South Africa (Steele 1992) and in the Western Gull (*Larus occidentalis*) (Hunt and Hunt 1976, Annett and Pierotti 1989).

Kelp Gulls can be important predators of eggs and chicks of other marine and coastal birds (Yorio and Boersma 1994, Yorio and Quintana 1997). However, the percentage of occurrence of this food type in the present study was low. It is possible that predation is a strategy used by a great number of gulls but at low frequency, or that only a few individuals specialize in preying upon other seabird offspring. Individual specialization in the robbing of eggs and chicks has been previously shown for other gull species (Watanuki 1982, Pierotti and Annett 1987). Studies in Patagonia also show that a few Kelp Gull individuals are responsible for most of the predation on Imperial Cormorant, Royal Tern, and Cayenne Tern eggs at Punta León (Yorio and Quintana 1997, Quintana and Yorio, in press) and Imperial Cormorant eggs and chicks at Punta Tombo (P. Yorio, unpubl. data). The consumption of eggs and chicks was different among colonies. At Punta León and Punta Tombo, the presence of eggs and chicks in the gull's diet was relatively higher than at Punta Pirámide, and the higher consumption coincided with the incubation and chick stages of the other seabird species. The observed differences among locations could be due to the composition of the breeding bird assemblages at each location, as at Punta León and Punta Tombo Kelp Gulls breed together with four and five other seabird species, respectively, whereas at Punta Pirámide they breed close to only a few Rock Shag pairs (Yorio et al., 1998). Kelp Gulls appear to be taking advantage of the greater offer of eggs and chicks at some locations, in a similar way to that recorded for the Slaty-backed Gull (*Larus schistisagus*) (Watanuki 1988).

The opportunistic feeding habits also allow Kelp Gulls to include in their diet food derived from human activities, such as garbage and discards from commercial fisheries. These sources offer abundant food which is of easy access and predictable in space and time. This has possibly contributed to changes in the Kelp Gull's diet through the inclusion of supplementary food of human origin. In both study years, garbage was found in regurgitated pellets throughout the season at the three colonies and was relatively important in some stages of the breeding cycle, particularly at Punta Pirámide. In general, garbage was better represented in the diet before chick hatching. Although garbage is attractive to many bird species, its consumption during the breeding season could negatively affect breeding success (Pierotti and Annett 1987). The consumption of garbage differed among locations, being greater the shorter the distance between the colony and the closest city. The colony with the higher consumption of garbage was Punta Pirámide, which is less than 5 km from a landfill, followed by the Punta León and Punta Tombo colonies, which are 50 and 100 km, respectively, from the nearest landfill.

Kelp Gulls in Patagonia also feed on fish waste provided by commercial fisheries, both discarded at sea and at coastal landfills (Giaccardi et al. 1997, Yorio et al., in press). The Kelp Gull is one of the two most abundant species associated with coastal fishing operations, with flocks of up to 600 individuals (Yorio and Caille, in press), and has been frequently observed at offshore fisheries in Patagonia. In addition, individuals of all age classes have been recorded feeding throughout the year at all coastal landfills where fish waste is disposed, in flocks of up to several thousand individuals (Yorio et al. 1996). The use by Kelp Gulls of fishing waste also has been recorded in New Zealand and South Africa (Fordham 1970, Steele 1992) and the consumption of garbage has been recorded in New Zealand, Australia, and South Africa (Fordham 1970, Steele 1992, Coulson and Coulson 1993), indicating the ability of this species to take advantage of food sources provided by human activities throughout its distribution range.

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