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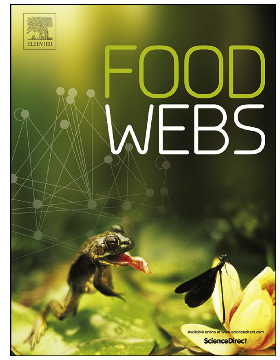

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Year-round use of anthropogenic food sources in human modified landscapes by adult and young Kelp Gulls

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Abstract

Predictable anthropogenic food subsidies attract species with generalist and opportunistic feeding habits, often resulting in conflicts with human populations. We assessed the spatio-temporal distribution and abundance of Kelp Gulls (*Larus dominicanus*) during the annual cycle at anthropogenic food sources located along 70 km of urban and agricultural-livestock landscapes in the lower Chubut River valley, Argentina. We quantified the seasonal abundance of adult and young Kelp Gulls through monthly counts from July 2021 to June 2022 at six identified anthropogenic food sources, complemented with strip transect sampling along cultivated land and cattle grazing areas. In addition, we analysed the differential use of waste types by adult and young Kelp Gulls at a mixed livestock waste dump where different food remains (cattle remains, poultry remains and urban waste) are disposed in independent pits. The total number of Kelp Gulls counted each month along the river valley was variable, with a mean number of 2,585 ± 822.7 individuals (range = 276 in December and 8,958 in June). The highest gull abundance was recorded at a pig farm (mean = 1784.5 ± 640.1 individuals). The transect survey showed a relatively low use by gulls of the cultivated land and cattle grazing areas, with a mean of 29.7 ± 11.2 individuals recorded per survey (range = 0-96). Kelp Gull abundance patterns recorded in the river valley throughout the annual cycle evidenced a contrasting seasonal use of anthropogenic food sources between the breeding and non-breeding seasons, being clearly less abundant during the former, when gulls move to their main breeding grounds and adjacent marine habitats in coastal Chubut. At the mixed livestock waste dump, Kelp Gull numbers varied among the three waste patches, with higher numbers and a significantly higher proportion of adults at the cattle remains pit. This study shows the high trophic plasticity of Kelp Gulls and their use of alternative foraging habitats. Further monitoring and evaluations of the use by Kelp Gulls of predictable anthropogenic food sources along the Chubut River valley, particularly those related to the growing livestock production, are needed to support management decisions.

Keywords: agrosystem, food subsidies, habitat use, *Larus dominicanus*, livestock remains, non-breeding

1. Introduction

In many bird species, the movement of individuals throughout the annual cycle allows them to exploit different resources as they become available (Dingle and Drake, 2007), and this movement can be influenced by environmental changes and land-use practices (Andren, 1994; Martín-Vélez et al., 2020). Many gull species of the genus *Larus* use human modified environments, taking advantage of predictable anthropogenic food subsidies, such as urban waste, fish discards or food derived from agricultural-livestock activities. Individuals may therefore use different natural and anthropogenic foraging habitats throughout the annual cycle (Baert et al., 2018; Ramirez et al., 2020), which may result from changes in the availability of food resources or environmental and reproductive constraints. Several studies found that the use of anthropogenic food resources can improve individual fitness and survival (Pons and Migot, 1995; Hüppop and Wurm, 2000; Auman et al., 2008; Steigerwald et al, 2015) and result in population growth (Garthe, 1996; Duhem et al., 2008; Oro et al., 2013). However, other studies show that anthropogenic food sources albeit overabundant are often of low nutritional quality (Annett and Pierotti, 1989; Pierotti and Annett, 2001; Faria et al., 2021a, 2023; Lopes et al., 2022). In addition, the use of anthropogenic food resources often results in conflicts with human populations, particularly in urban areas (Belant, 1997; Huig et al., 2016) or in the exposure of gull populations to pathogen infections and the ingestion of plastics and other pollutants (Plaza and Lambertucci, 2017; Sorais et al., 2020; Lopes et al. 2021). Knowledge of the distribution and abundance of opportunistic gulls at alternative anthropogenic food sources is key in the identification of potential conflicts with human populations and wildlife, and in the development of management actions (Arizaga et al., 2015; Faria et al., 2021b).

The Kelp Gull (*Larus dominicanus*) is a widely distributed species in the southern hemisphere, breeding in South America, Southern Africa, Antarctic Peninsula, sub-Antarctic islands, Australia and New Zealand (Burger and Gochfeld, 1996). It shows generalist and opportunistic feeding habits throughout its distributional range, regularly taking advantage of anthropogenic food subsidies throughout the year (Steele, 1992; Coulson and Coulson, 1993; Ludynia et al. 2005; Silva Rodríguez et al., 2005; Silva-Costa and Bugoni, 2013; Burgues et al. 2020). Although many studies have addressed the trophic ecology of this species in coastal Patagonia, Argentina, they were focused mostly on adult individuals during the breeding season. Breeding Kelp Gulls forage mainly in offshore and intertidal areas where they consume fish and marine invertebrates, but also to some extent on fishery discards at sea and on garbage at urban areas (Bertellotti and Yorio, 1999; Marinao et al., 2018; Kasinsky et al., 2018; Yorio et al., 2020; Kasinsky et al., 2021). In contrast, little is known about their feeding ecology during the non-breeding season in coastal Patagonia, but they have been reported feeding along the intertidal (Bertellotti et al., 2003), at coastal waste dumps (Giaccardi and Yorio, 2004), and behind trawl vessels (Bertellotti and Yorio, 2000; Marinao and Yorio, 2011; González-Zevallos and Yorio, 2006). Similarly, little is known about the foraging distribution of young individuals, but studies on bird assemblages associated with trawl vessels or birds feeding at coastal waste dumps show that juvenile and subadult individuals regularly use these food sources of anthropogenic origin throughout the year (e.g., Giaccardi et al., 1997; Yorio and Giaccardi, 2002; González-Zevallos et al., 2011). Like in other gull populations worldwide (Oro et al., 2013), it has been argued that the use of anthropogenic food resources has been implicated in the growth of Kelp Gull populations in the Patagonian region (Lisnizer et al., 2011). In addition, Kelp Gull activity in or near cities may result in hazards to aircraft (Yorio et al., 1998; González-Acuña et al., 2006; Crocce, 2011) and threats to human health (Yorio et al., 1996; Frere et al., 2000; Albarnaz et al., 2007; Rodríguez et al., 2012).

The lower valley of the Chubut River, which drains into the Atlantic Ocean (43°S), presents a mosaic of human modified environments, including urban areas, open dumps, irrigated agricultural areas and livestock farms, which offer a variety of predictable anthropogenic food resources to Kelp Gull populations breeding in nearby coastal areas. Previous studies showed their year-round use of urban waste dumps at two of the main cities in the valley (Giaccardi et al., 1997; Yorio and Giaccardi, 2002). In addition, a more recent study at one of the main Kelp Gull colonies in this coastal sector showed an expansion of the trophic niche of breeding adults after their dispersal from the breeding site at the end of the breeding season, indicating a more diverse diet during the non-breeding season and in some cases the incorporation of non-marine resources (Lisnizer and Yorio, 2019). This suggests their use of human modified environments along the nearby Chubut River valley, as terrestrial semi-arid habitats dominated by xerophytic vegetation in coastal Patagonia unlikely provide profitable terrestrial food resources for gulls. Knowledge on the degree to which Kelp Gull populations make use of this human-modified landscapes to take advantage of predictable anthropogenic food subsidies would help better understand the year-round trophic ecology of this opportunistic gull species and also provide baseline information on the use of these resources by age class, which may have important implications for their population dynamics. In addition, information may prove valuable in the design of waste management strategies and in the assessment of potential conflicts between Kelp Gulls and human populations.

In this study, we assessed the use of anthropogenic food sources by Kelp Gulls along the Chubut River valley. To achieve this goal, we (1) quantified the spatio-temporal distribution and abundance of Kelp Gull adult and young individuals during the annual cycle at predictable anthropogenic food sources located along 70 km of urban and agricultural-livestock landscapes, and (2) quantified the differential use by adult and young individuals of different types of anthropogenic waste at one of the main active open dumps. Based on previous studies on the Kelp Gull (e.g. Bertellotti and Yorio, 1999; Yorio and Giaccardi, 2002, Burgues et al., 2020; see above), we expected that adult and young individuals would use anthropogenic food sources along the Chubut River valley throughout the year and that numbers of foraging gulls would vary depending on the source of anthropogenic food (open urban dumps, irrigated agricultural areas and livestock farms). We also expected that numbers of adult Kelp Gulls would increase along the valley during the fall and winter months to take advantage of predictable and abundant anthropogenic food resources, when coastal nesting individuals are released from the restrictions imposed by central place foraging.

2. Material and methods

2.1. Study area

We conducted the study along the lower Chubut River valley in Chubut, Argentina (Fig. 1). This valley is about 80 km long and 7-10 km wide, totalling 600 km^2 and extending from the river mouth in the Bahía Engaño, Atlantic Ocean (43°19'S, 65°02'W), up to west of the rural town of 28 de Julio (~43°23'W, 65°50'S). Natural habitats beyond the valley area correspond to the Monte Phytogeographical Province. The human population is concentrated mainly in five urban areas, totalling more than 170 thousand inhabitants (Fig. 1). Agricultural activities based on pastures, horticulture and to a lesser extent fruit crops take place throughout the valley, while livestock farming increases to the west, predominantly for fattening cattle, sheep and pigs (Plan Ganadero de la Provincia del Chubut 2017). Due to changes in urban waste disposal practices, most of the urban waste is currently taken to a centralized landfill, located 22 km north of the city of Trelew, which receives urban waste from all the nearby urban centers, although there are still several small illegal open dumps.

During May and June 2021, we conducted preliminary surveys along the lower Chubut River valley to confirm the presence of gulls in areas with anthropogenic food sources that were identified as regularly used in the past (Giaccardi et al., 1997; Yorio and Giaccardi, 2002) and to evaluate the occurrence of gulls at additional locations with anthropogenic food resources. Based on these preliminary surveys, we identified six sites (Fig. 1) which included (1) an outdoor pig farm, located 65 km from the coast (43°21'33.02"S, 65°46'38.71"W) near the town of 28 de Julio, where livestock remains are spread along 1.5 ha to feed the animals, (2) an open urban dump in the town of Dolavon, located 59 km from the coast (43°18'7.67"S, 65°44'14.26"W), which receives small amounts of domestic garbage not taken to the centralized landfill near Trelew (see above), (3) a processing plant for livestock remains in Dolavon, located 57 km from the coast (43°18'1.77"S, 65°43'6.92"W), where liquids generated by a rendering process are disposed in ponds, (4) a livestock waste dump at Gaiman, located 40 km from the coast (43°16'52.77"S, 65°32'45.61"W), which mainly receives waste generated by cattle and poultry production from the area and, to a lesser extent, domestic garbage; cattle and poultry remains and urban waste are discarded in separate sectors of the dump, (5) a coastal urban open dump in the city of Rawson, located 8.7 km from the coast (43°16'1.64"S, 65° 4'29.15"W), which mostly receives small amounts of urban garbage not taken to the centralized landfill (see above), and (6) the fishing port at the mouth of the Chubut River, where fish and invertebrates caught by coastal trawlers are regularly discarded, either at sea after the last haul of the day a few kilometres offshore or during cleaning and unloading the catch at the port facility. This activity is seasonal, extending from September to February.

2.2. Spatial and temporal patterns of Kelp Gull abundance

We quantified the seasonal abundance of Kelp Gulls through monthly counts of individuals from July 2021 to June 2022, except for Site 1 which was first visited in September 2021. In each visit to the six sampling sites, we counted all Kelp Gull individuals using two approaches: (a) when the estimated number of individuals was lower than ~100, we counted all gulls using binoculars (10x) and/or spotting scopes (20x) from vantage points which allowed to cover the entire area of each site, or (b) when numbers were larger than ~100, we obtained a video recording (5–10 minutes per site) of the whole study site from a vantage point and then counted all individuals identified in the video back in the laboratory. Gulls were classified as adult and young (juvenile and subadult) individuals based on plumage characteristics (Bo et al., 1995).

Additionally, to assess the use of cultivated land and cattle grazing areas by Kelp Gulls, we quantified the abundance of adult and young individuals using strip transect sampling consisting of 12 transects (mean 2.6 km, SD = 1.2 km) spread between Rawson and Dolavon (Fig. 1). We conducted monthly surveys from June 2021 to February 2022 (n = 10) from a vehicle driving at a speed of 30 km/h, with two observers detecting and counting gulls within 150 m of the transect line (estimated with a rangefinder, Bushnell 10x25/5–700 m), and counted adult and young individuals using binoculars (Bushnell Falcon 10x50 mm).

2.3. Use of landfill discards by adult and young individuals

To assess the differential use of waste types by adult and young Kelp Gulls, we quantified their abundance at the Gaiman livestock waste dump (Site 4). At this dump, remains of the slaughter of cattle and poultry are discarded in two independent pits separated by 150 m. Occasionally, small amounts of domestic garbage are disposed at a different location within the dump. Gulls also roost in an open space adjacent to the dump (100-200 m), near an irrigation channel and a seasonal lagoon. In each monthly visit during the non-breeding season, we counted all adult and young individuals in each of these four sectors (pit with cattle remains, pit with poultry remains, patch of domestic waste, and roosting area) following the same methodology described above.

2.4. Statistical Analyses

To evaluate the spatial and temporal patterns of the species we analysed Kelp Gull abundance (response variable) considering the different sites, the proportion of adult and young individuals, and the season (explanatory variables) using generalized linear models (GLM). Most Kelp Gull breeders in the region start settling at their colonies in October and, depending on the colony, chicks start fledging in December or January (Yorio et al., 1994; Lisnizer et al., 2014; Kasinsky et al., 2022). Thus, considering the temporal pattern of breeding of Kelp Gulls in the study region we grouped monthly counts in two categories: breeding season (October-January) and non-breeding season (March-June). As a preliminary analysis showed overdispersion, we fitted a Negative Binomial generalized linear model (Crawley et al., 1993). Models with all possible combinations of predictor variables and their single interactions were considered and best-fitting models were selected using the Akaike's information criterion for small samples (AICc) (Akaike 1973), considering ΔAICc and associated weights values of best-fitting models (Wagenmakers and Farrell, 2009).

To evaluate the differential use by adult and young Kelp Gulls of the three waste types within the Gaiman dump (Site 4) (cattle remains, poultry remains and urban waste), we fitted a Quasibinomial GLM model to contrast the age-class proportions (adults/young; response variable) at the three different food patches (explanatory factor). We conducted statistical analyses in R, version 4.0.1 (R Core Development Team, 2020), using the "AICcmodavg" (Mazerolle, 2020), "MASS" (Venables and Ripley, 2002), "MuMIn" (Barton, 2020), "car" (Fox and Weisberg, 2011), and "ggplot2" (Wickham, 2009) packages.

3. Results

3.1. Spatial and temporal patterns of Kelp Gull abundance

The total number of Kelp Gulls counted each month along the lower Chubut River valley was variable, with a mean number for the months of July 2021 to June 2022 of 2,585 ± 822.7 (n = 12; range = 276 in December and 8,958 in June). The highest abundances of gulls were recorded at the pig farm (Site 1: mean = 1784.5 ± 640.1 individuals, range = 49-5,651, n = 10), and at the Gaiman livestock waste dump (Site 4: mean = 563.4 ± 169.3 individuals, range = 2-2,051, n = 12). These two sites, located over 40 km inland, concentrated most of the Kelp Gulls recorded in the river valley area (Table 1). Kelp Gulls at the pig farm were recorded foraging among pigs that were feeding on cattle and other organic remains (Video 1). Kelp Gulls at the Gaiman livestock waste dump were recorded feeding on the different types of waste, but mainly on cattle remains (see below). In contrast, gull abundance in the port area was relatively low and less variable (Site 6: mean = 258.8 ± 46.7 individuals, range = 0-616, n = 12) (Table 1). Kelp Gulls in the port area were recorded resting in flocks along the river bank near the moored vessels. Individuals were observed feeding on discarded fish and invertebrates from vessels. Numbers were the lowest at the Rawson urban landfill, where Kelp Gulls were observed in seven of the 12 monthly visits and in numbers always below 15 individuals (mean 4.5 ± 1.3 individuals, range = 0-15, n = 12).

The transect survey, which added to a total of 312.3 km, evidenced a relatively low use by Kelp Gulls of the cultivated land and cattle grazing areas, with a mean of 29.7 ± 11.2 (range = 0-96) individuals recorded per survey (n = 10). The mean flock size was

17.4 ± 0.3 individuals (range = 1-70; n = 17). Gulls were recorded feeding in the cultivated area in only two occasions. One flock of 47 individuals was observed taking advantage of prey in a recently ploughed field together with Brown-headed gulls (*Chroicocephalus maculipennis*), and two individuals were recorded scavenging on a Common Hare (*Lepus europeus*). The rest of the gulls recorded during the surveys were resting individually or in flocks within or close to irrigation channels. As in the six above-mentioned sampling sites, the number of Kelp Gulls decreased in the cultivated and grazing areas during the breeding season, with only 6 individuals recorded between October and January.

The best model explaining the differences in Kelp Gull numbers included season and study site as the most important variables and included their interaction, explaining 28% of the variability (GLM, AIC = 549.4, *D* = 0.28, theta = 0.89, SE = 0.20, Table 2). Both adult and young Kelp Gulls were more abundant during the non-breeding season, except for the Port area where young individuals were higher during the breeding season (Fig. 2).

3.2. Use of landfill discards by adult and young individuals

At the Gaiman livestock waste dump, Kelp Gull numbers varied among the three waste patches, with higher numbers recorded at the cattle remains pit (Fig. 3). Resting areas adjacent to the dump were used in variable numbers (mean 73.5 ± 75.3 individuals, range = 0-686, n = 10), although mostly by adults. Model parameters showed that the pit with cattle remains presented a significantly higher proportion of adults compared to those with poultry remains and urban waste (GLM, D = 0.42, Z = 10.1, $p < 0.001$).

4.1. Discussion

Results show that adult and young Kelp Gulls used a variety of anthropogenic food subsidies along the lower Chubut River valley throughout the year in numbers that varied markedly among foraging sites and months of the year, reaching relatively high numbers during winter months. Almost nine thousand adult individuals were recorded during June, which roughly correspond to over thirty percent of Kelp Gull individuals breeding at colonies within less than 100 km from the Chubut River valley (Lisnizer et al., 2011; L. Pozzi, unpubl. data). Nevertheless, Kelp Gull numbers foraging at the study area were likely underestimated, as flocks of adult individuals were regularly observed flying between the coast and the western section of the river valley at different times of the day indicating the turnover of individuals at the anthropogenic food sources. Also, small numbers of Kelp Gulls using feedlots and illegal waste dumps may have been missed given the survey design. All this information suggests that anthropogenic food resources available along the lower Chubut River valley constitute a valuable component of Kelp Gull trophic ecology at least during the non-breeding season.

Kelp Gulls have been reported foraging at urban dumps throughout their Southern Hemisphere distributional range (e.g., Fordham, 1970; Coulson and Coulson, 1993; Steele and Hockey, 1995; Ludynia et al., 2005; Lenzi et al., 2021), including Argentina (Silva et al., 2000; Frixione et al., 2012). In the past, Kelp Gulls of all age classes were recorded year-round at the main open urban and fishery waste dumps associated to the lower Chubut River valley, such as those in Rawson and Trelew, in numbers that could reach several thousand individuals in a single count (Giaccardi et al., 1997; Yorio and Giaccardi, 2002). As a result of changes in urban waste disposal practices implemented during the mid-2010's, organic urban wastes from cities along the valley are now taken to a centralized landfill located 22 km north of the city of Trelew and fishery waste is mostly processed or covered. Therefore, except for very small amounts of illegally dumped waste, there is currently no food available for Kelp Gulls at these sites. Accordingly, only a few Kelp Gulls were recorded at the Rawson urban dump. Similarly, Kelp Gulls were rarely seen at the site of the old Trelew urban dump, where urban waste is now classified and separated before being sent to the centralized landfill. In contrast, up to several hundred gulls were reported at the Dolavon open dump, which despite the current management practices continues to provide waste to these opportunistic scavengers. It should be noted that the centralized urban landfill north from the river valley is also used by Kelp Gulls, though as it was not included in the goals of this study their numbers were not quantified.

The highest Kelp Gull numbers along the valley were associated to sites providing waste from livestock production. Kelp Gulls have been reported making use of waste provided by slaughter houses at other sites in Argentina (Yorio et al., 1996, Petracci, 2004), but this is the first report of the use of this type of anthropogenic food subsidy by the Kelp Gull along the Chubut River valley. Numbers were particularly high at an outdoor pig farm where Kelp Gulls took advantage of livestock remains fed to pigs. Livestock production along the Chubut River valley has greatly increased in the last two decades. For example, the number of pigs in farms increased from 3 thousand in 2004 to

23 thousand in 2014 (Plan Ganadero de la Provincia de Chubut 2017). This has resulted in the relatively recent availability of significant amounts of anthropogenic food for Kelp gulls at sites located tens of kilometres inland, and according to local inhabitants in an increase of Kelp Gull flocks moving between the coast and the western sector of the valley. Thus, changes in the patterns of use of predictable anthropogenic food sources by Kelp Gulls in the last three decades seem to be due to both the reduction in the availability of urban and fishery waste and to the increase in alternative waste generated by livestock production activities.

Several gull species worldwide regularly forage in agricultural lands, taking advantage of grain, fruit and terrestrial invertebrates (e.g. Schwemmer and Garthe, 2008; Calvino-Cancela, 2011; Caron-Beaudoin et al., 2013; Martín-Velez et al., 2020). Kelp Gulls have been reported foraging in agricultural landscapes, where they can feed on grain fed to cattle in nearby feedlots and on insects (Silva et al., 2005; Petracci et al., 2004; Yorio et al., 2013; Marinao et al., 2018). However, only small numbers of Kelp Gulls were found during surveys conducted along the cultivated and grassland areas in the Chubut River valley, where they were observed foraging in ploughed fields or scavenging on carcasses. The relatively few Kelp Gulls recorded during surveys and their highly aggregated distribution at waste disposal sites along the valley (see above) indicate that food derived from agricultural activities could be a minor component of the trophic ecology of this opportunistic species in the study area.

Kelp Gull abundance patterns recorded throughout the annual cycle evidenced a contrasting seasonal use of anthropogenic food sources between the breeding and non-breeding seasons. Gull numbers began to decrease in October, when most breeders in the region are settling at their colonies (Yorio et al., 1994; Lisnizer et al., 2014; Kasinsky et al., 2022). During the breeding season Kelp Gulls behave as central place foragers, and thus mainly exploit natural food sources close to their breeding sites. Kelp Gulls breeding at the nearest colonies to the river valley, Punta León and Punta Tombo, feed mostly on fish, molluscs and crustacean, although they can include urban waste in their diet, particularly during incubation (Bertellotti and Yorio, 1999; Yorio et al., 2020). However, some individuals may travel more than 100 km from the colony in search of food (Kasinsky et al., 2018), and thus they could occasionally travel from the mentioned colonies to food sources along the river valley (Kasinsky et al., 2021). There is no information on the diet composition of Kelp Gulls breeding at El Salitral, a colony of >5,000 breeding individuals located inland near the mouth of the Chubut River, but they also likely depend mostly on marine resources as relatively small number of adult birds were recorded in the river valley in late spring and early summer. Once the breeding season was over, in February, Kelp Gull numbers started to increase at anthropogenic food sources along the river valley. The colony of origin of these gulls is unknown, but a previous study suggests that, after breeding is over and individuals are released from the restrictions imposed by central place foraging, some Kelp Gulls from the nearby Punta León colony increase their use of terrestrial food as the non-breeding season progresses (Lisnizer and Yorio, 2019). Further studies are needed to understand the role of anthropogenic food sources on the feeding ecology of Kelp Gulls from different colonies, which may contribute to the understanding of the demography of this generalist and opportunistic species.

As expected, adult numbers at anthropogenic food sources were in general larger, similar to what was reported in previous studies conducted at urban and fishery waste dumps in the region (Giaccardi et al., 1997; Yorio and Giaccardi, 2002; Giaccardi and Yorio, 2004). Young individuals were present at all sites, although in relatively larger numbers at sites with livestock remains, such as the pig farm and Gaiman waste dump, and at the port area. Like adults, young gulls decreased in number at western sites during the spring and summer, but increased at the port area. This may have been partly triggered by the activity of coastal trawlers which generally operate from the Rawson port between September and February, and may provide young individuals with an easy access of predictable and higher quality food. Gulls have been observed feeding not only on waste derived from port activities, but also flying a few kilometres offshore at the end of the fishing day to feed on fish and invertebrate discarded from trawlers returning to the port (C. Marinao, pers. comm.). Larger numbers in February may have also resulted from the attraction to the port area of recently fledged gulls which dispersed from nearby colonies, as has been suggested by previous results obtained from banded individuals (N. Lisnizer, unpubl. data).

Results obtained at the Gaiman landfill showed a significantly higher use by Kelp Gulls of livestock remains, likely reflecting higher amount and quality food, and a lower proportion of young Kelp Gulls at the pit with cattle remains compared to those with poultry remains and urban waste. This suggests a possible exclusion of young individuals at these food patches, possibly driven by dominance of adults over young individuals and/or the selection by young individuals of less densely occupied food patches to minimize competition or kleptoparasitism. Age-related differences in foraging strategies have been reported in several gull species, and it has been argued that they can be mediated by dominance hierarchies (Monaghan et al., 1986; Burger, 1987; Estévanez and Aparicio, 2019). The role of adult dominance in determining the distribution and abundance of young individuals at anthropogenic food sources along the valley needs further research.

Results show a significant use by Kelp Gulls of anthropogenic food sources along the Chubut River valley, where they could incorporate contaminants and pathogens and act as biovectors as reported for other gull species (Bonnedahl et al., 2009; Desjardin et al., 2019; Navarro et al., 2019; Martin-Velez et al., 2021). Kelp Gulls, in particular, can be carriers of enteric bacteria (Yorio et al., 1996; Frere et al., 2000; Albarnaz et al., 2007; López-Martín et al., 2011; Rodríguez et al., 2012; La Sala et al., 2013). In addition, avian influenza virus (H13N9 and H13 N2 subtypes) has been isolated from wild Kelp Gulls in Argentina and Peru (Pereda et al., 2008; Ghersi et al., 2009). Furthermore, these could be also a threat for wildlife, as Kelp Gulls could carry pathogens from anthropogenic food sources to freshwater lagoons used by other waterbirds or to coastal wetlands and mixed-species seabird colonies where they usually breed. The role of Kelp Gulls as vectors of organisms -particularly pathogens-, nutrients and contaminants, should be further studied.

The use of predictable and abundant food provided by human activities along the Chubut River valley may also influence Kelp Gull population dynamics in the study area. Kelp Gull populations increased in different coastal sectors in northern Patagonia between the mid 1990's and late 2000's, and these changes have been attributed to their use of predictable anthropogenic food subsidies (Lisnizer et al., 2011). Previous studies have shown that the reduction of waste available to gulls can lead to a decrease in their abundance at anthropogenic food sources (Monaghan et al., 1986; Patton, 1988; Pons, 1992). For example, a reduction in waste available to Kelp Gulls at the Rawson urban and fishery waste dump in the 1990's, because of both the covering with soil and processing waste for fishmeal, resulted in a decrease in their numbers throughout the year (Giaccardi et al., 1997). Adequate waste management at some of the study locations could thus minimize the potential negative effects resulting from Kelp Gull use of waste. Although these management measures could be easily implemented at the Gaiman and Dolavon dumps by covering waste, minimizing gull numbers at the pig farms where they forage on the food made available to farm animals may be more challenging. Further monitoring and evaluations of the use by Kelp Gulls of predictable anthropogenic food sources along the Chubut River valley, particularly those related to the growing livestock production, are needed to support management decisions.

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Permits

Field permits were obtained from the environmental agency Dirección de Fauna y Flora Silvestre, Chubut.

CRediT authorship contribution statement

Martín G. Frixione, Nora Lisnizer and Pablo Yorio conceived the idea and design. Martín G. Frixione collected data; Martín G. Frixione, Nora Lisnizer and Pablo Yorio were involved in the analyses and wrote the paper; Nora Lisnizer and Pablo Yorio provided resources for fieldwork.

References

Albarnaz, J.D., Toso, J., Corrêa, A.A., Simoes, C.M.O., Barardi, C.R.M., 2007. Relationship between the contamination of gulls (*Larus dominicanus*) and oysters (*Crassostrea gigas*) with Salmonella serovar Typhimurium by PCR-RFLP. International Journal of Environmental Health Research 17, 133–140. https://doi.org/10.1080/09603120701219816

Andrén, H., 1994. Effects of habitat fragmentation on birds and mammals in landscapes with different proportions of suitable habitat: a review. Oikos 71, 355–366. https://doi.org/10.2307/3545823

Annett, C., Pierotti, R., 1989. Chick hatching as a trigger for dietary switching in the Western Gull. Colonial Waterbirds 12, 4–11. https://doi.org/10.2307/1521306

Aparicio, S., Bracho Estévanez, C., 2019. Competitive inter-and intraspecific dominance relations in three gull species. Revista Catalana d'Ornitologia 35, 21–29. https://doi.org/10.2436/20.8100.01.10

Arizaga, J., Aldalur, A., Herrero, A., Cuadrado, J.F., Díez, E., Crespo, A., 2014. Foraging distances of a resident yellow-legged gull (Larus michahellis) population in relation to refuse management on a local scale. European Journal of Wildlife Research 60, 171–175.

Auman, H.J., Meathrel, C.E., Richardson, A., 2008. Supersize Me: does anthropogenic food change the body condition of Silver Gulls? A comparison between urbanized and remote, non-urbanized areas. Waterbirds 31, 122–126. https://doi.org/10.1675/1524-4695(2008)31[122:SMDAFC]2.0.CO;2

Baert, J.M., Stienen, E.W.M., Heylen, B.C., Kavelaars, M.M., Buijs, R.-J., Shamoun-Baranes, J., Lens, L., Müller, W., 2018. High-resolution GPS tracking reveals sex differences in migratory behaviour and stopover habitat use in the Lesser Black-backed Gull *Larus fuscus*. Sci Rep 8, 5391. https://doi.org/10.1038/s41598-018-23605-x

Barton, K., 2020. MuMIn: Multi-model inference. R package version 1.43. 17. https://Cran. R-project. org/packages=MuMIn

Belant, J.L., 1997. Gulls in urban environments: landscape-level management to reduce conflict. Landscape and Urban Planning, Wildlife Habitats in Human-Dominated Landscapes 38, 245–258. https://doi.org/10.1016/S0169-2046(97)00037-6

Bertellotti, M., Pagnoni, G., Yorio, P., 2003. Feeding behavior of the Kelp Gull (*Larus dominicanus*) during the non-breeding season at sandy beaches of Península Valdés, Argentina. El Hornero 18, 37–042.

Bertellotti, M., Yorio, P., 2000. Utilisation of fishery waste by Kelp Gulls attending coastal trawl and longline vessels in northern Patagonia, Argentina. Ornis Fennica *77*(3), 105–115.

Bertellotti, M., Yorio, P., 1999. Spatial and temporal patterns in the diet of the Kelp Gull in Patagonia. The Condor 101, 790–798. https://doi.org/10.2307/1370066

Bond, A.L., 2016. Diet changes in breeding Herring Gulls (*Larus argentatus*) in Witless Bay, Newfoundland and Labrador, Canada, over 40 Years. Waterbirds 39, 152–158. https://doi.org/10.1675/063.039.sp115

Bonnedahl, J., Drobni, M., Gauthier-Clerc, M., Hernandez, J., Granholm, S., Kayser, Y., Melhus, Å., Kahlmeter, G., Waldenström, J., Johansson, A., Olsen, B., 2009. Dissemination of *Escherichia coli* with CTX-M Type ESBL between Humans and Yellow-Legged Gulls in the South of France. Plos One 4, e5958. https://doi.org/10.1371/journal.pone.0005958

Burger, J., 1987. selection for equitability in some aspects of reproductive investment in Herring Gulls *Larus argentatus*. Ornis Scandinavica 18, 17–23.

Burger, J., Gochfeld, M., 1996. Heavy metal and selenium levels in Franklin's Gull (*Larus pipixcan*) parents and their eggs. Arch. Environ. Contam. Toxicol. 30, 487–491. https://doi.org/10.1007/BF00213400

Burgues, M.F., Lenzi, J., Machín, E., Genta, L., Teixeira de Mello, F., 2020. Temporal variation of kelp Gull's (*Larus dominicanus*) diet on a coastal island of the Rio de la Plata Estuary, Uruguay: refuse as an alternative food source. Waterbirds 43, 65–74.

Calvino-Cancela, M., 2011. Gulls (Laridae) as frugivores and seed dispersers. Plant Ecol 212, 1149–1157. https://doi.org/10.1007/s11258-011-9894-2

Caron-Beaudoin, É., Gentes, M.-L., Patenaude-Monette, M., Hélie, J.-F., Giroux, J.-F., Verreault, J., 2013. Combined usage of stable isotopes and GPS-based telemetry to understand the feeding ecology of an omnivorous bird, the Ring-billed Gull (*Larus delawarensis*). Can. J. Zool. 91, 689–697. https://doi.org/10.1139/cjz-2013-0008

Coulson, R., Coulson, G., 1993. Diets of the Pacific Gull *Larus pacificus* and the Kelp Gull *Larus dominicanus* in Tasmania. Emu - Austral Ornithology 93, 50–53. https://doi.org/10.1071/MU9930050

Crawley, M.J., 1993. GLIM for ecologists.

Desjardins, C.F., Mazerolle, M.J., Verreault, J., 2019. Is the urban-adapted ring-billed gull a biovector for flame retardants? Environmental Pollution 244, 109–117. https://doi.org/10.1016/j.envpol.2018.10.003

Dingle, H., Drake, V.A., 2007. What is migration? BioScience 57, 113–121. https://doi.org/10.1641/B570206

Duhem, C., Roche, P., Vidal, E., Tatoni, T., 2008. Effects of anthropogenic food resources on yellow-legged gull colony size on Mediterranean islands. Popul Ecol 50, 91–100. https://doi.org/10.1007/s10144-007-0059-z

Faria de, J.P., de Vaz, P., Lopes, C., Calado, J., Pereira, J., Veríssimo, S., Paiva, V., Gonçalves, A., Ramos, J., 2021a. The importance of marine resources in the diet of urban gulls. Marine Ecology Progress Series 660, 189–201. https://doi.org/10.3354/meps13599

Faria de, J.P., Paiva, V.H., Veríssimo, S., Gonçalves, A.M.M., Ramos, J.A., 2021b. Seasonal variation in habitat use, daily routines and interactions with humans by urban-dwelling gulls. Urban Ecosystems. https://doi.org/10.1007/s11252-021-01101-x

Faria de, J.P., Paiva, V.H., Veríssimo, S.N., Lopes, C.S., Soares, R., Oliveira, J., de Santos, I., Norte, A.C., Ramos, J.A., 2023. Plenty of rooftops with few neighbours occupied by young breeding Yellow-legged Gulls (*Larus michahellis*): does this occur at the expense of their health condition? Ibis. https://doi.org/10.1111/ibi.13123

Fordham, R.A., Cormack, R.M., 1970. Mortality and population change of Dominican Gulls in Wellington, New Zealand: with a statistical appendix. Journal of Animal Ecology 39, 13–27. https://doi.org/10.2307/2887

Fox, J., Weisberg, S., 2011. An {R} Companion to Applied Regression, Second Edition. Thousand Oaks CA: Sage. http://socserv.socsci.mcmaster.ca/jfox/Books/Companion

Frere, E., Gandini, P.A., Martínez Peck, R., 2000. Kelp gull (*Larus dominicanus*) as a carrier of pathogens in the patagonian coast. El Hornero 15(02), 093–097.

Frixione, M.G., Casaux, R., Villanueva, C., Alarcón, P.A.E., Frixione, M.G., Casaux, R., Villanueva, C., Alarcón, P.A.E., 2012. A recently established Kelp Gull colony in a freshwater environment supported by an inland refuse dump in Patagonia. Emu 112, 174–178. https://doi.org/10.1071/MU11031

Gamble, A., Ramos, R., Parra-Torres, Y., Mercier, A., Galal, L., Pearce-Duvet, J., Villena, I., Montalvo, T., González-Solís, J., Hammouda, A., Oro, D., Selmi, S., Boulinier, T., 2019. Exposure of Yellow-legged gulls to *Toxoplasma gondii* along the western mediterranean coasts: tales from a sentinel. International Journal for Parasitology: Parasites and Wildlife 8, 221–228. https://doi.org/10.1016/j.ijppaw.2019.01.002

Garthe, S., Camphuysen, K., Furness, R.W., 1996. Amounts of discards by commercial fisheries and their significance as food for seabirds in the North Sea. Marine Ecology Progress Series 136, 1–11. https://doi.org/10.3354/meps136001
Ghersi, B.M., Blazes, D.L., Icochea, E., Gonzalez, R.I., Kochel, T., Tinoco, Y., Sovero, M.M., Lindstrom, S., Shu, B., Klimov, A., Gonzalez, A.E., Montgomery, J.M., 2009. Avian influenza in wild birds, central coast of Peru. Emerg. Infect. Dis. 15, 935–938. https://doi.org/10.3201/eid1506.080981
Giaccardi, M., Yorio, P.M., 2004. Temporal patterns of abundance and waste use by Kelp Gulls at a urban and fishery waste tip in northern coastal Patagonia, Argentina. Ornitologia Neotropical 15, 93–102.
González-Zevallos, D., Yorio, P., 2006. Seabird use of discards and incidental captures at the Argentine hake trawl fishery in the Golfo San Jorge, Argentina. Marine Ecology Progress Series 316, 175–183. https://doi.org/10.3354/meps316175
González-Zevallos, D., Yorio, P., Svagelj, W.S., 2011. Seabird attendance and incidental mortality at shrimp fisheries in Golfo San Jorge, Argentina. Marine Ecology Progress Series 432, 125–135. https://doi.org/10.3354/meps09146
Huig, N., Buijs, R.-J., Kleyheeg, E., 2016. Summer in the city: behaviour of large gulls visiting an urban area during the breeding season. Bird Study 63, 214–222. https://doi.org/10.1080/00063657.2016.1159179
Hüppop, O., Wurm, S., 2000. Effects of winter fishery activities on resting numbers, food and body condition of large gulls *Larus argentatus* and *L. marinus* in the south-eastern North Sea. Marine Ecology Progress Series 194, 241–247. https://doi.org/10.3354/meps194241
Kasinsky, T., Suárez, N., Marinao, C., Yorio, P., 2018. Kelp Gull (*Larus dominicanus*) use of alternative feeding habitats at the Bahía San Blas Protected Area, Argentina. Waterbirds 41, 285–294. https://doi.org/10.1675/063.041.0308
Kasinsky, T., Yorio, P., Dell'Arciprete, P., Marinao, C., Suárez, N., 2021. Geographical differences in sex-specific foraging behaviour and diet during the breeding season in the opportunistic Kelp Gull (*Larus dominicanus*). Mar Biol 168, 14. https://doi.org/10.1007/s00227-020-03812-9
La Sala, L.F., Petracci, P.F., Randazzo, V., Fernández-Miyakawa, M.E., 2013. Bacterias entéricas en la Gaviota Cangrejera (*Larus atlanticus*) y la Gaviota Cocinera (*Larus dominicanus*) en el estuario de Bahía Blanca, Argentina. El Hornero 28, 059–064.
Lenzi, J., González-Bergonzoni, I., Flaherty, E., Hernández, D., Machín, E., Pijanowski, B., 2021. The relationship between urban refuse with fecundity and nestlings' success of a generalist seabird in the Río de la Plata Estuary - Uruguay. Marine Pollution Bulletin 173, 113000. https://doi.org/10.1016/j.marpolbul.2021.113000
Lisnizer, N., García-Borboroglu, P., Yorio, P., 2014. Demographic and Breeding Performance of a New Kelp Gull *Larus dominicanus* Colony in Patagonia, Argentina. Ardeola 61, 3–14. https://doi.org/10.13157/arla.61.1.2014.3
Lisnizer, N., Garcia-Borboroglu, P., Yorio, P., 2011. Spatial and temporal variation in population trends of Kelp Gulls in northern Patagonia, Argentina. Emu - Austral Ornithology 111, 259–267. https://doi.org/10.1071/MU11001
Lisnizer, N., Yorio, P., 2019. Trophic niche expansion during the non-breeding season in kelp gulls of known breeding colony. Mar Biol 166, 12. https://doi.org/10.1007/s00227-018-3460-6
Lopes, C.S., Antunes, R.C.C., Paiva, V.H., Gonçalves, A.M.M., Correia, J.J., Ramos, J.A., 2022. Fatty acids composition in yellow-legged (*Larus michahellis*) and lesser black-backed (*Larus fuscus*) gulls from natural and urban habitats in

relation to the ingestion of anthropogenic materials. Science of the Total Environment 809: 151093. https://doi.org/10.1016/j.scitotenv.2021.151093

Lopes, C.S., Paiva, V.H., Vaz, P.T., Faria de, J.P., Calado, J.G., Pereira, J.M., Ramos, J.A., 2021. Ingestion of anthropogenic materials by yellow-legged gulls (*Larus michahellis*) in natural, urban, and landfill sites along Portugal in relation to diet composition. Environmental Science and Pollution Research 28(15): 19046–19063. https://doi.org/10.1007/s11356-020-12161-5

López-Martín, J., Junod, T., Riquelme, F., Contreras, C., González-Acuña, D., 2011. Detección de especies de Salmonella y Mycobacterium en gaviotas dominicanas (*Larus dominicanus*) y gaviotas de Franklin (*Leucophaeus pipixcan*) en la ciudad de Talcahuano, Chile. Revista médica de Chile 139, 1496–1502. https://doi.org/10.4067/S0034-98872011001100017

Lovas-Kiss, Á., Sánchez, M.I., Molnár V., A., Valls, L., Armengol, X., Mesquita-Joanes, F., Green, A.J., 2018. Crayfish invasion facilitates dispersal of plants and invertebrates by gulls. Freshwater Biology 63, 392–404. https://doi.org/10.1111/fwb.13080

Ludynia, K., Garthe, S., Luna-Jorquera, G., 2005. Seasonal and regional variation in the diet of the Kelp Gull in Northern Chile. Waterbirds 28, 359–365. https://doi.org/10.1675/1524-4695(2005)028[0359:SARVIT]2.0.CO;2

Marinao, C., Kasinsky, T., Suárez, N., Yorio, P., 2018. Contribution of recreational fisheries to the diet of the opportunistic Kelp Gull. Austral Ecology 43, 861–875. https://doi.org/10.1111/aec.12627

Marinao, C.J., Yorio, P., 2011. Fishery discards and incidental mortality of seabirds attending coastal shrimp trawlers at Isla Escondida, Patagonia, Argentina. The Wilson Journal of Ornithology 123, 709–719. https://doi.org/10.1676/11-023.1

Martín-Vélez, V., Mohring, B., van Leeuwen, C.H.A., Shamoun-Baranes, J., Thaxter, C.B., Baert, J.M., Camphuysen, C.J., Green, A.J., 2020. Functional connectivity network between terrestrial and aquatic habitats by a generalist waterbird, and implications for biovectoring. Science of The Total Environment 705, 135886. https://doi.org/10.1016/j.scitotenv.2019.135886

Martín-Vélez, V., van Leeuwen, C.H.A., Sánchez, M.I., Hortas, F., Shamoun-Baranes, J., Thaxter, C.B., Lens, L., Camphuysen, C.J., Green, A.J., 2021. Spatial patterns of weed dispersal by wintering gulls within and beyond an agricultural landscape. Journal of Ecology 109, 1947–1958. https://doi.org/10.1111/1365-2745.13619

Mazerolle, M.J., 2016. AICcmodavg: Model selection and multimodel inference based on (Q)AIC(c). R package version 2.0-4. http://CRAN.R-project.org/package=AICcmodavg.

Mittelhauser, G.H., Allen, R.B., Chalfant, J., Schauffler, R.P., Welch, L.J., 2016. Trends in the nesting populations of Herring Gulls (*Larus argentatus*) and Great Black-Backed Gulls (*Larus marinus*) in Maine, USA, 1977–2013. Waterbirds 39, 57–67. https://doi.org/10.1675/063.039.sp112

Monaghan, P., Metcalfe, N.B., Hansell, M.H., 1986. The influence of food availability and competition on the use of a feeding site by Herring Gulls *Larus argentatus*. Bird Study 33, 87–90. https://doi.org/10.1080/00063658609476901

Navarro, J., Grémillet, D., Afán, I., Miranda, F., Bouten, W., Forero, M.G., Figuerola, J., 2019. Pathogen transmission risk by opportunistic gulls moving across human landscapes. Sci Rep 9, 10659. https://doi.org/10.1038/s41598-019-46326-1

Navarro, J., Grémillet, D., Afán, I., Ramírez, F., Bouten, W., Forero, M.G., 2016. Feathered detectives: real-time gps tracking of scavenging gulls pinpoints illegal

waste dumping. Plos One 11, e0159974. https://doi.org/10.1371/journal.pone.0159974
Oro, D., Genovart, M., Tavecchia, G., Fowler, M.S., Martínez-Abraín, A., 2013. Ecological and evolutionary implications of food subsidies from humans. Ecology Letters 16, 1501–1514. https://doi.org/10.1111/ele.12187
Osterback, A.-M.K., Frechette, D.M., Hayes, S.A., Shaffer, S.A., Moore, J.W., 2015. Long-term shifts in anthropogenic subsidies to gulls and implications for an imperiled fish. Biological Conservation 191, 606–613. https://doi.org/10.1016/j.biocon.2015.07.038
Patton, S.R., 1988. Abundance of gulls at Tampa Bay landfills. The Wilson Bulletin 100, 431–442.
Pereda, A.J., Uhart, M., Perez, A.A., Zaccagnini, M.E., La Sala, L., Decarre, J., Goijman, A., Solari, L., Suarez, R., Craig, M.I., Vagnozzi, A., Rimondi, A., König, G., Terrera, M.V., Kaloghlian, A., Song, H., Sorrell, E.M., Perez, D.R., 2008. Avian influenza virus isolated in wild waterfowl in Argentina: Evidence of a potentially unique phylogenetic lineage in South America. Virology 378, 363–370. https://doi.org/10.1016/j.virol.2008.06.010
Petracci, P.F., La Sala, L.F., Aguerre, G., Pérez, C.H., Acosta, N., Sotelo, M., Pamparana, C., 2004. Dieta de la Gaviota Cocinera (*Larus dominicanus*) durante el período reproductivo en el estuario de Bahía Blanca, Buenos Aires, Argentina. El Hornero 19, 23–28.
Pierotti, R., Annett, C., 2001. The ecology of Western Gulls in habitats varying in degree of urban influence, Avian ecology and conservation in an urbanizing world. Springer, pp. 307–329.
Plaza, P.I., Lambertucci, S.A., 2017. How are garbage dumps impacting vertebrate demography, health, and conservation? Global Ecology and Conservation 12, 9–20. https://doi.org/10.1016/j.gecco.2017.08.002
Pons, J.-M., 1992. Effects of changes in the availability of human refuse on breeding parameters in a herring gull *Larus argentatus* population in Brittany, France. Ardea 80, 143–150.
Pons, J.M., Migot, P., 1995. Life-history strategy of the herring gull: changes in survival and fecundity in a popoulation subjected to variours feeding conditions. Journal of Animal Ecology 64, 592–599.
Ramírez, F., Afán, I., Bouten, W., Carrasco, J.L., Forero, M.G., Navarro, J., 2020. Humans shape the year-round distribution and habitat use of an opportunistic scavenger. Ecology and Evolution 10, 4716–4725. https://doi.org/10.1002/ece3.6226
Rodríguez, F., Moreno, J., Ortega, R., Mathieu, C., García, A., Cerda-Leal, F., González-Acuña, D., 2012. Evidence for Kelp Gulls (*Larus dominicanus*) and Franklin's Gulls (*Leucophaeus pipixcan*) as carriers of salmonella by real-time polymerase chain reaction. Journal of Wildlife Diseases 48, 1105–1108. https://doi.org/10.7589/2012-04-104
Schwemmer, P., Garthe, S., Mundry, R., 2008. Area utilization of gulls in a coastal farmland landscape: habitat mosaic supports niche segregation of opportunistic species. Landscape Ecol 23, 355–367. https://doi.org/10.1007/s10980-008-9194-y
Silva, M.P., Bastida, R.O., Darrieau, C., 2000. Dieta de la Gaviota Cocinera (*Larus dominicanus*) de en zonas costeras la Provincia de Buenos Aires (Argentina). Ornitologia Neotropical 11, 331–339.

Silva Rodriguez, M.P., Favero, M., Berón, M.P., Mariano-Jelicich, R., Mauco, L., 2005. Ecology and conservation of seabirds using the coasts of Buenos Aires providence as a wintering area. El Hornero, 20, 111–130.

Silva-Costa, A., Bugoni, L., 2013. Feeding ecology of Kelp Gulls (*Larus dominicanus*) in marine and limnetic environments. Aquat Ecol 47, 211–224. https://doi.org/10.1007/s10452-013-9436-1

Sorais, M., Mazerolle, M.J., Giroux, J.-F., Verreault, J., 2020. Landfills represent significant atmospheric sources of exposure to halogenated flame retardants for urbanadapted gulls. Environ. Int. 135, 105387.

Steele, W.K., 1992. Diet of Hartlaub's Gull *Larus Hartlaubu* and the Kelp Gull *L. Dominicanus* in the Southwestern Cape Province, South Africa. Ostrich 63, 68–82. https://doi.org/10.1080/00306525.1992.9633952

Steele, W.K., Hockey, P.A.R., 1995. Factors influencing rate and success of intraspecific kleptoparasitism among Kelp Gulls (*Larus dominicanus*). The Auk 112, 847–859. https://doi.org/10.2307/4089017

Steigerwald, E.C., Igual, J.M., Payo-Payo, A., Tavecchia, G., 2015. Effects of decreased anthropogenic food availability on an opportunistic gull: evidence for a size-mediated response in breeding females. Ibis 157, 439–448.

Venables, W.N., and Ripley, B.D., 2002. Modern Applied Statistics with S. Fourth Edition. Springer, New York. ISBN 0-387-95457-0

Vergara Gómez, A., Pitart, C., Montalvo, T., Roca Subirà, I., Sabate, S., Hurtado, J.C., Planell, R., Marco Reverté, F., Ramirez, B., Peracho, V., Simon, M. de, Vila Estapé, J., 2016. Prevalence of ESBL and/or carbapenemase-producing *Escherichia coli* isolated from Yellow-Legged Gulls from Barcelona, Spain. Antimicrobial Agents and Chemotherapy. http://hdl.handle.net/2445/105107

Wagenmakers, E.J., Farrell, S., 2004. AIC model selection using Akaike weights. Psychonomic bulletin and review 11(1), 192–196.

Weller, M.W., 1999. Wetland Birds, Habitat Resources and Conservation Implications. Cambridge University Press.

Wickham, H., 2009. ggplot2: Elegant Graphics for Data Analysis. Springer-Verlag New York, 2009.

Wilhelm, S.I., Rail, J.-F., Regular, P.M., Gjerdrum, C., Robertson, G.J., 2016. Large-scale changes in abundance of breeding Herring Gulls (*Larus argentatus*) and Great Black-Backed Gulls (*Larus marinus*) relative to reduced fishing activities in Southeastern Canada. Waterbirds 39, 136–142. https://doi.org/10.1675/063.039.sp104

Yorio, P., Bertellotti, M., Gandini, P., Frere, E., 1998. Kelp Gulls *Larus dominicanus* breeding on the Argentine coast: population status and relationship with coastal management and conservation. Marine Ornithology 26, 11–18.

Yorio, P., Branco, J.O., Lenzi, J., Luna-Jorquera, G., Zavalaga, C., 2016. Distribution and trends in Kelp Gull (*Larus dominicanus*) coastal breeding populations in South America. Waterbirds 39, 114–135. https://doi.org/10.1675/063.039.sp103

Yorio, P., Marinao, C., Kasinsky, T., Ibarra, C., Suárez, N., 2020. Patterns of plastic ingestion in Kelp Gull (*Larus dominicanus*) populations breeding in northern Patagonia, Argentina. Marine Pollution Bulletin 156, 111240. https://doi.org/10.1016/j.marpolbul.2020.111240

Yorio, P., Marinao, C., Retana, M.V., Suárez, N., 2013. differential use of food resources between the Kelp Gull *Larus dominicanus* and the Threatened Olrog's Gull *L. atlanticus*. Ardeola 60, 29–44. https://doi.org/10.13157/arla.60.1.2012.29

Yorio, P.M., Giaccardi, M., 2002. Urban and Fishery Waste Tips As Food Sources for Birds in Northern Coastal Patagonia, Argentina. Ornitologia Neotropical 13, 283–292.

Table 1
Number of adult and young the Kelp Gulls at each sampling site along the Chubut Valley, Chubut, Argentina, from July 2021 to June 2022 (1. Pig farm, 2. Dolavon urban dump, 3. Dolavon livestock remains processing plant, 4. Gaiman livestock waste dump, 5. Rawson urban dump, 6. Port).

Month	*1*			*2*			*3*			*4*			*5*			*6*		
	Total	Adults	Young	Total	Adults	Young	Total	Adults	Young	Total	Adults	Young	Total	Adults	Young	Total	Adults	Young
July	-	-	-	128	74	54	98	41	57	446	370	76	0	0	0	22	16	6
August	-	-	-	22	17	5	71	30	41	576	500	76	15	15	0	352	336	16
September	2100	1659	441	245	209	36	90	16	74	741	644	97	7	7	0	304	146	158
October	146	96	50	49	27	22	82	3	79	72	49	23	10	9	1	0	0	0
November	49	20	29	0	0	0	10	0	10	2	[illegible]	1	0	0	0	258	41	217
December	51	9	42	0	0	0	1	0	1	6	6	0	0	0	0	218	17	201
January	92	65	27	4	3	1	0	0	0	34	28	6	0	0	0	246	33	213
February	670	609	61	85	70	15	2	2	0	415	358	57	3	1	2	616	316	300
March	1610	1564	46	107	70	37	142	39	103	538	474	64	3	2	1	261	203	58
April	2912	2674	238	246	174	72	77	10	67	749	642	107	4	4	0	194	160	34
May	4564	4403	161	667	455	212	111	68	43	1131	797	334	9	9	0	400	365	35
June	5651	5364	287	768	634	134	250	131	119	2051	1718	333	3	3	0	235	210	25
mean ± SE	1784.5± 640.2	1646.3± 612.7	138.2± 44.7	193.4± 75.1	144.4± 58.3	49.0± 16.6	77.8± 20.9	28.3± 11.2	49.5± 11.8	563.4± 169.3	465.6± 139.1	97.8± 33.5	4.5± 1.4	4.2± 1.4	0.3± 0.2	258.8± 46.7	153.6± 38.8	105.3± 30.3

Table 2
Best generalized linear model, full model and null model explaining Kelp Gull abundance along the lower Chubut River valley, Chubut, from July 2021 to June 2022. AICc: corrected Akaike's information criterion, Wi: AICc weights.

Model	df	AICc	Δ AICc	W_i
season * site	13	560.2	0	0.46
full model (season + site + adults/young)	9	560.6	0.41	0.37
null model	2	597.1	36.90	0.00

Figures

Fig. 1. Map of the study area showing the locations of predictable anthropogenic food sources (1. Pig farm, 2. Dolavon urban dump, 3. Dolavon livestock remains processing plant, 4. Gaiman livestock waste dump, 5. Rawson urban dump, 6. Port) and location of transects sampled monthly along the lower Chubut River valley, Chubut, Argentina from July 2021 to June 2022.

Fig. 2. Abundance of Kelp Gull adults (upper panel) and young (lower panel) by season (N-B: non-breeding and B: breeding) at each sampling site (1. Pig farm, 2. Dolavon urban dump, 3. Dolavon livestock remains processing plant, 4. Gaiman livestock waste dump, 5. Rawson urban dump, 6. Port) along the lower Chubut River valley in 2021-2022, Chubut, Argentina.

Fig. 3. Number of Kelp Gull adults and young feeding on each type of waste (cattle remains, poultry remains and urban waste) at the Gaiman livestock waste dump during the non-breeding season, Chubut, Argentina.

Declaration of competing interest

The authors declare there are no competing interests.


65°42′O
65°12′O
N
43°10′S
43°28′S
Trelew
(4)
Gaiman
(5)
(3)
(2)
Dolavon
Rawson
(6)
(1)
28 de julio
Atlantic Ocean
cities
Chubut River
irrigated area
study sites
0
5
10
15 km

Figure 1

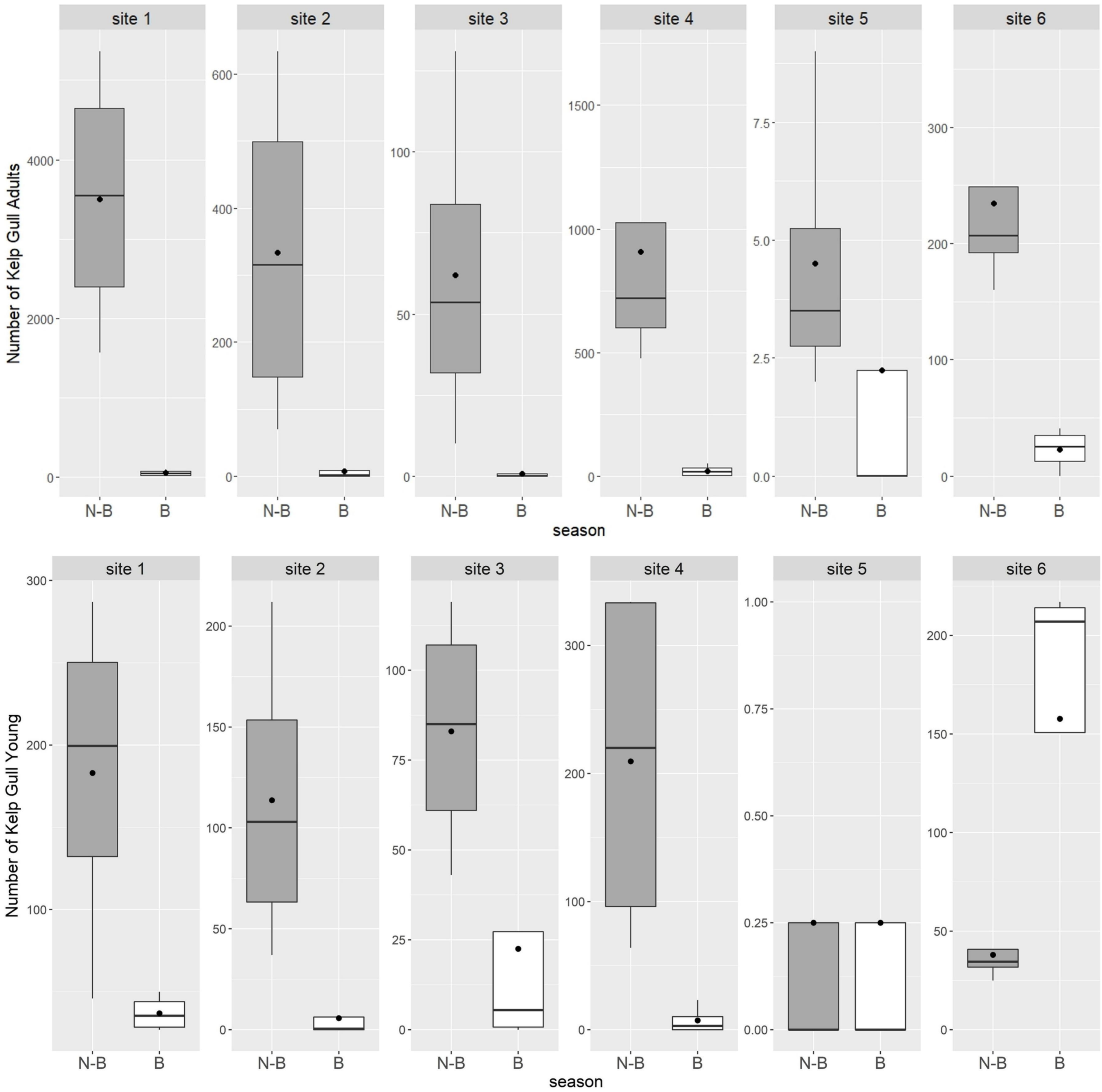
site 1
site 2
site 3
site 4
site 5
site 6
Number of Kelp Gull Adults
N-B
B
season
Number of Kelp Gull Young

Figure 2

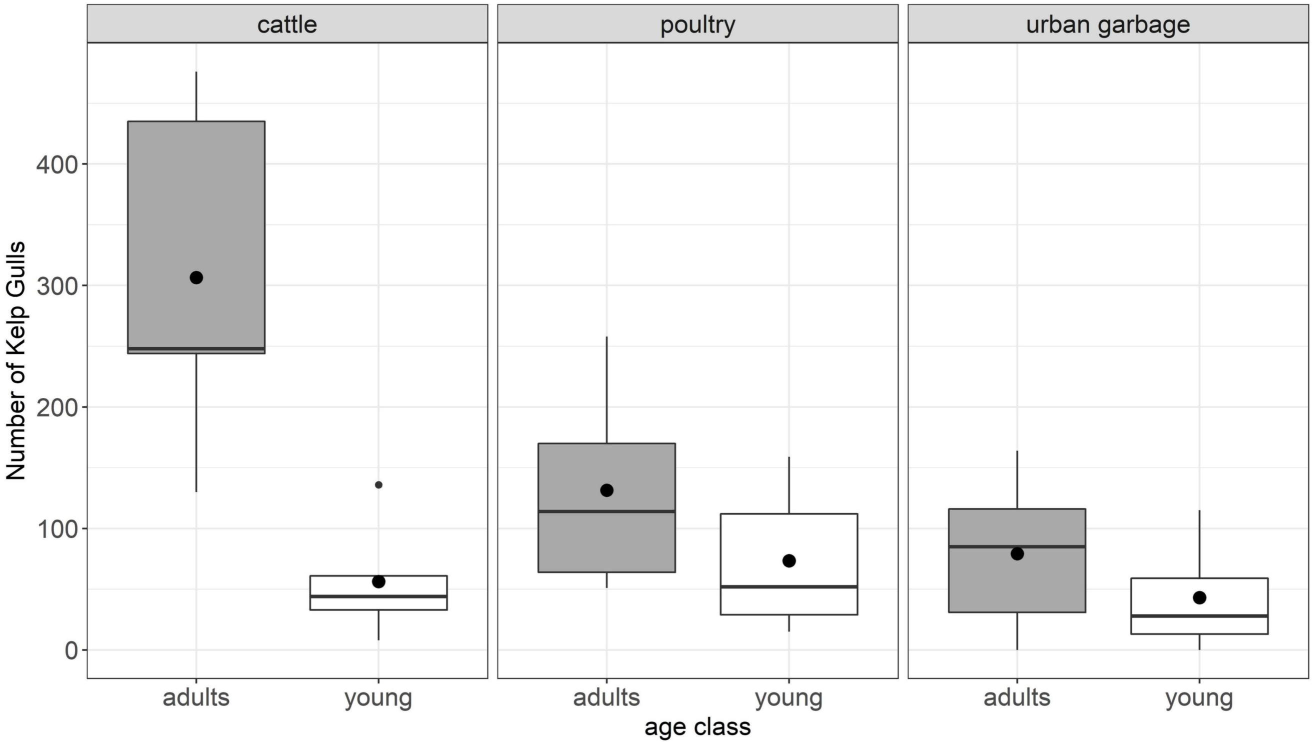
cattle
poultry
urban garbage
Number of Kelp Gulls
400
300
200
100
0
adults
young
adults
young
adults
young
age class

Figure 3