Urban Gulls Living with Humans

Joana Pais de Faria[1]
Catarina S. Lopes[1]
Louise K. Blight[2]
Ruedi G. Nager[3]

[1]University of Coimbra, MARE - Marine and Environmental Sciences Centre, Department of Life Sciences, 3000-456 Coimbra, Portugal

[2] Procellaria Research & Consulting, 944 Dunsmuir Road, Victoria, BC V9A 5C3, Canada; School of Environmental Studies, University of Victoria, Victoria, BC V8W 2Y2, Canada

[3]University of Glasgow, Institute of Biodiversity, Animal Health and Comparative Medicine, College of Medical, Veterinary Life Sciences, Glasgow G12 8QQ, Scotland, UK

Corresponding author:

Joana Pais de Faria, paisdefaria.joana@gmail.com

Abstract

The modification of natural habitats induced by increasing urbanisation, in combination with novel biotic interactions, has been favouring the colonisation of urban areas by some generalist species, promoting the encounter of humans and wildlife. When it comes to major drivers of urban gull populations, the availability of predictable anthropogenic food resources along with changes in their natural habitat were likely the strongest drivers of the increase of urban gull populations. Gulls have always been part of the human coastal landscape, where positive relationships and cultural positive connections were common between humans and gulls. Human-gull relationships have seen recent global changes, with gulls increasingly becoming a constant part of urban landscapes, causing a variety of conflicts and negative human-gull interactions. Some direct interactions can be highly complex (e.g. humans feeding wildlife to feel more connected with nature, then that wildlife deemed a ‘nuisance') and challenging to change. This chapter provides an overview of the relationships between urban gulls and humans, addressing the: (1) history of the colonisation of urban areas by gull populations using the examples of the British Isles and North America, (2) urban features that influence the success of urban gull populations, (3) main human-gull interactions within cities, and (4) the importance of management actions to minimize conflicts related to urban gulls.

Keywords:

Urban gulls, roof-nesting gull population, *Larus* sp., hatching success, fledgling success, urban drivers, human-gull interactions, gull conflicts, management, urban colonies, natural colonies.

Introduction

The increase of the human population and consequent growing urbanization have been progressively leading to the reduction and fragmentation of natural habitats, and amplifying anthropogenic pressures on ecosystems (e.g. Gosling et al. 2017). Growing urban areas, however, also offer new ecological opportunities for wildlife to modify their behaviour and successfully colonise urban environments (Lowry et al. 2013). The habitat changes induced by urbanisation, in combination with novel biotic interactions, result in selection pressures that favour certain traits in urban populations, as distinct from populations in natural habitats (Alberti et al. 2017, Ouyang et al. 2018). For example, birds have adjusted to urban environments for many years, and in some cases changed migratory patterns, breeding phenologies and phenotypic traits such as song (Garcia et al. 2017, Sepp et al. 2017, Hensley et al. 2019). Certain traits may facilitate a species' colonisation of urban environments including cognitive and problem-solving performance (Snell-Rood and Wick 2013, Audet et al. 2016, Castano et al. 2020), heightened tolerance and habituation (Lowry et al. 2013, Sol et al. 2013), and ability to shift dietary niche (Pagani-Núñez et al. 2019, Murray et al. 2020), all of which could affect survival and reproductive success in the urban environment. These adjustments are particularly evident in generalist species with higher phenotypic and behavioural plasticity such as gulls, allowing them to overcome the challenges of a novel environment by, for example, adapting and exploiting novel food and nesting site opportunities (Belant 1997, Sayol et al. 2020, Carmona et al. 2021). Ultimately, the expanding urbanisation and the colonisation of urban areas by opportunistic species will increase instances of human-wildlife encounters, causing a variety of interactions and conflicts in the cities. This chapter provides an overview of the relationships between urban gulls and humans. To address patterns of urban gull population expansion by different gull species and the challenges faced when studying the ecology of urban gulls, we overview the history of gull colonisation of urban areas in the British Isles and North America. Then we review the urban features influencing breeding success of urban gull populations and summarise the main human-gull interactions within cities. Lastly, we consider the importance of management actions to minimize conflicts related to urban gulls.

History of urban gull populations in the British Isles and North America

Studying urban gull populations comes with a variety of challenges, particularly when counting and predicting population size, because these areas rarely provide good vantage points with an unobstructed view to all surrounding nests. This results in a likely underestimation of the true size of urban gull populations worldwide (Coulson and Coulson 2015). Counting effort of urban-nesting gulls seemed to have been conducted more consistently in the British Isles than elsewhere, perhaps because it was one of the first places where gulls started nesting on roofs outside of the Black Sea region, where roof-nesting European Herring Gulls (*Larus argentatus*) (Herring Gull hereafter) were first recorded in the early 1890s (Goethe 1960, Nankinov 1992). ‘Urban nesting’ can be defined as nesting on buildings or other man-made structures such as bridges, in areas frequented by humans (Cramp 1971), and includes factory roofs and other industrial buildings outside urban centres, and that was used as definition of urban-nesting in all the censuses in the British Isles. The first known records of roof-nesting Herring Gulls in the British Isles dates from 1910 at two sites in Cornwall, southwest England (Cramp 1971). Herring Gulls nesting on buildings remained very rare before the second World War, with just six known sites in 1939 concentrated in the southwest of England, and all with less than ten breeding pairs per site (Witherby et al. 1938-1941, Cramp 1971). It is unclear what drove Herring Gulls to construct their first nest on roofs and several reasons had been considered. For example, Took (1955) speculated that long-range artillery fire during the war drove Herring Gulls off their usual nesting sites on chalk cliffs around Dover, southeast England, and onto rooftops, particularly into the city centre. It is possible that the architecture of traditional British houses, with several separate chimney stacks and small ledges and niches on the roof, provided attractive nesting sites that resembled more the Herring Gulls' natural nesting sites on cliffs than that of Lesser Black-backed Gulls that nest more on flat grounds (Goethe 1960). From the beginning of the 20th century until the early 1970s the Herring Gull population in the British Isles increased at a rate of 12-13% per annum, possibly due to reduced persecution and increased availability of anthropogenic food resources from human activities (Cramp et al. 1974). During that time, the roof-nesting habit of Herring Gulls also increased, spreading from southwest England to many coastal towns along the southern parts of the British Isles, and then expanded inland and to the north (Cramp 1971, Monaghan and Coulson 1977). In Scotland, the first roof-nesting pair of Herring Gulls was recorded in Inverness in 1965 (Parslow 1967). In 1969-70, the first census of roof-nesting gulls in the British Isles was organized as part of a national census of seabirds (Cramp et al. 1974), and by then roof-nesting Herring Gulls had spread to at least 61 sites and numbered 1,252 nests (Fig. 1a), with five sites occupied by over 100 breeding pairs, and the largest colony of roof-nesting gulls being at Dover, with 225 nests (Cramp 1971, updated by Monaghan and Coulson 1977). Although the breeding productivity of roof-nesting Herring Gulls was high, possibly due to the local availability of food from anthropogenic sources and reduced nest predation (Monaghan 1979, Rock 2005), it is unlikely that the reproductive output from local roof-top breeders alone could have sustained the large increase in numbers observed (Chabrzyk and Coulson 1976). Hence, roof-nesting colonies were likely recruiting form natural sites in the surroundings, where large Herring Gull colonies were possibly reaching saturation levels in the 1970s (Monaghan and Coulson 1977). Therefore, the increasing number of roof-nesting Herring Gulls was likely a consequence of the species' rapid population growth in the 20th century, when young breeders were forced to find alternative nesting grounds (Monaghan and Coulson 1977). In addition, or alternatively, culling and disturbance by human activities at natural sites could have dispersed Herring Gulls away from those sites and into built-up areas (Raven and Coulson 1997). At that time the only other gull species recorded breeding on roofs in the British Isles was the Lesser Black-backed Gull (*Larus fuscus*), first recorded nesting on an inland factory-roof in Glamorgan, in 1945 (Morrey Salmon 1958). By 1969-1970 the species expanded to a total roof-nesting population of at least 61 pairs in seven locations mainly confined to south Wales (Cramp 1971). The smaller numbers and slower increase of the roof-nesting Lesser Black-backed gulls was likely due to their slower rate of increase of the total British population, compared to Herring Gulls at that time.

Further censuses of roof-nesting gulls in Britain, using the same methods as the 1969 census, were organized in 1976 (Monaghan and Coulson 1977), in 1994 (Raven and Coulson 1997), in 1998-2002 (Mitchell et al. 2004); the next one is expected to be concluded in 2021.

<Figure 1 here>

Figure 1. Increase in the number of sites (histogram and left axis) and number of pairs (black line and right axis) of the four *Larus* species that have been recorded to nest on roofs in built-up areas in the British Isles, from their earliest records until the census of 1998-2002: European Herring Gulls, *Larus argentatus* (a), Lesser Black-backed Gulls, *Larus fuscus* (b), Great Black-backed Gulls, *Larus marinus* (c) and Mew Gulls, *Larus canus* (d). Note that the scale differs between vertical axis due to the large differences in numbers of roof-nests between the species. Data from Cramp (1971), Monaghan and Coulson (1977), Raven and Coulson (1997) and Mitchell et al. (2004).

Since the 1970s the population of Herring Gulls nesting at natural sites in the British Isles fell by 43% in 1985 (Lloyd et al. 1991) and a further 13% in 2000 (Mitchell et al. 2004), however the numbers of roof-nesting gulls kept increasing (Fig. 1a), but at smaller numbers than the declines at natural sites, so that the overall population of Herring Gulls in the British Isles decreased. Roof-nesting Herring Gulls had spread to at least 92 locations with a minimum of 2,968 breeding pairs in 1976, corresponding to an increase of 17% per annum (Monaghan and Coulson 1977), growing faster than populations nesting at natural sites had been growing before the 1970s (13% per annum; Chabrzyk and Coulson 1976). By 1994, at least 188 sites with 10,184 breeding pairs across most of Britain were occupied by roof-nesting Herring Gulls (Raven and Coulson 1997), and by the most recent census in 1998-2002 this further grew to at least 225 sites with 20,170 breeding pairs (Mitchell et al. 2004). Another study estimated more than 100,000 Laridae pairs nesting on roofs in 2004 (Rock 2005), but this was an extrapolation from a stronghold of roof-nesting gulls to the rest of the British Isles. Not only did roof-nesting Herring Gulls colonise new sites, including sites further away from the coast, but also the average number of nests at those sites increased. The mean size of roof-nesting colonies increased from 49 pairs in 1976 to 75 in 1994 (Raven and Coulson 1997), and to 90 pairs in 2000 (Mitchell et al. 2004). Although most urban colonies were modest in size, a few colonies became very large, such as the city of Aberdeen that had 3350 Herring Gull roof-nests in 2001 (Mitchell et al. 2004). Roof-nesting gulls increased from 0.6% to 8.2% and 13.7% of the total British Herring Gull population in 1976, 1994 and 2000, respectively. The rate of increase of roof-nesting Herring Gulls slowed down after the 1970s with 10% per annum between 1976 and 1994 (Raven and Coulson 1997), and 3% per annum between 1994 and 2000 (Mitchell et. al 2004). Increased breeding density in built-up areas might be one of the factors explaining the slowing of the expansion of roof-nesting Herring Gulls towards the end of the 20th century (Raven and Coulson 1997). The continued increase in roof-nesting Herring Gulls from the 1970s onwards despite a large decline in numbers at natural breeding sites could possibly be attributed to the deterioration foraging condition and increased predation and persecution at natural sites, leading to birds looking for refuge in built-up areas (Nager and O'Hanlon 2016), where the availability of food and nesting sites safe from predation are favourable (Monaghan and Coulson 1977, Raven and Coulson 1997, Rock 2005).

Numbers of roof-nesting Lesser Black-backed Gulls and the number of colonised sites in built-up areas also increased after 1990 (Fig. 1b) while the overall population also kept increasing, with a higher rate of increase than in Herring Gulls (Raven and Coulson 1997). In most coastal regions of the British Isles, roof-nesting Lesser Black-backed Gulls joined existing Herring Gull colonies and were outnumbered by them. However, some inland areas, for example the Forth-Clyde region of Scotland, was first colonized by Lesser Black-backed Gulls and then Herring Gulls followed later, with roof-nesting Lesser Black-backed Gulls being more numerous there than Herring Gulls (Raven and Coulson 1997). Between 1970s and 2000s, Herring Gull and Lesser Black-back Gull populations showed a different relationship between numbers nesting at natural sites and on roof-tops (Nager and O'Hanlon 2016). While for Herring Gulls the number of roof-nests increased as the number of nests in natural sites decreased, showing an apparent negative correlation between numbers at natural sites and built-up areas, Lesser Black-backed Gull populations were still expanding in natural sites, and the numbers of roof-nests also increasing, showing an apparent positive correlation number of breeding pairs at natural and urban sites. This suggests that as with observations for Herring Gulls before 1970s, young Lesser Black-backed Gulls might have been forced to disperse from saturated natural sites into built-up areas. In both cases the changes in numbers at natural sites were larger than in built-up areas.

Other gull species were slower to turn to roof-nesting in Britain and Ireland, probably due to their lower numbers and slower population increases at the time. The first roof-nesting pairs of Great Black-backed Gulls (*Larus marinus*) were recorded in 1970 for a single pair in Cornwall, and by the turn of the century this has expanded to at least 83 pairs at 26 sites (Fig. 1c) (Mitchell et al. 2004), mostly in small colonies of 1-2 pairs with other gulls on surrounding roofs (Raven and Coulson 1997). In 1971 a breeding pair of Mew Gulls (*Larus canus*) was recorded on a roof in Inverness (Cramp 1971), and by 2000 there were at least 621 roof-nesting pairs at 14 locations in Scotland (Fig. 1d) (Mitchell et al. 2004). In addition to the *Larus* spp. gulls, it is worth mentioning that Black-legged Kittiwakes (*Rissa tridactyla*) were also recorded nesting on man-made structures (mainly piers and window ledges of warehouses) from the early 1930s in south-east Scotland and spread along the British North Sea coast to seven colonies, with a total of at least 410 pairs in 1969-70 (Cramp 1971). This number increased to between 664 to 755 breeding pairs in 2007-2009 in one area of northeast England (Turner 2010), but more recent counts in other areas are not known.

Over time, large gulls have colonised cities across all of Europe, North America, Australia and Japan (Cramp 1971, Rock 2005), mostly during the late 20th century such as the first records from 1971 for Italy by Yellow-legged Gulls (*Larus michahellis*; Cignini and Zapparoli 1996) and those from the 1980s for Japan by Slaty-backed Gulls (*Larus schistisagus*; Artyukhin 2002 in Zelenskaya 2019). However, information on the history of urban-nesting gulls in regions outside Europe is scarce, with some records from North America and isolated accounts of their behaviour in other parts of the world (e.g., Turbott 1969, Villavicencio 2014, Yorio et al. 2016). North American records of roof-nesting gulls are far less detailed than those from the UK; although some jurisdictions appear to survey urban gull populations periodically (e.g., Roby et al. 2007), most urban counts result from location- or species-specific research rather than initiatives at the national scale as in the British Isles (cf. Hooper 1998, Blight et al. 2019).

The first North American record of urban-nesting gulls appears to have been of Western Gulls (*Larus occidentalis*) breeding in San Francisco, California, circa 1920 (Fisk 1978). This same species first colonized Seattle, in Washington state further north on the US Pacific coast, in 1946, nesting on buildings near the port (Eddy 1982). Further north still, the first rooftop nesting record for the Pacific coast of Canada was in 1962, in Vancouver, for a single Glaucous-winged Gull (*Larus glaucescens*) nest near the port (Oldaker 1963). The apparently rapid initial expansion of this species in the city of Vancouver was reasonably well-documented until the 1980s, with four nests described in one city neighbourhood in 1972-73 (Sanford 1974), and a total of 88 nests found at two other localities later in this same decade (Campbell 1975, Poynter 1976). By 1986, Vermeer et al. (1988) estimated that 500 pairs nested in the city on buildings near the waterfront, and about 30 years later, in 2018, this population was estimated at 1921 pairs (95% confidence intervals: 1520, 2380; Kroc et al. 2018). Interestingly, this same study's estimate for the downtown core near the waterfront (474; 430, 522) was essentially unchanged from 1988; the current Vancouver population occurs at a low density over much of the city, and no longer clusters near the harbour. In the absence of control measures it is likely to continue to grow (Kroc et al. 2018). For this same species in the nearby maritime city of Victoria, Hooper (1988) reported that in 1986, 114 pairs nested on various structures (mostly on roof-tops) near the waterfront. In 2017–2018, Blight et al. (2019) used drones to estimate a population of 346 pairs in their survey area, with an additional 102 pairs at a warehouse colony excluded from the drone survey, for a total of about 448 pairs through the downtown core and adjacent neighbourhoods. As with Vancouver, the growing population of nesting gulls in Victoria maintained a low density and spread farther into the urban area over time, rather than aggregating at increasing densities near the waterfront. Like the European Herring Gull in the British Isles after the 1970s, these two urban population increases have occurred at a time when the overall regional population was in decline, implying a shift in preferred habitats by nesting Glaucous-winged Gulls in this region of Pacific Canada (Blight et al. 2015, Blight et al. 2019).

Elsewhere on the west coast of North American, urban nesting habitat has provided a refuge for Heermann's Gulls (*L. heermanni*), which face several threats (and recent catastrophic nest failure) at their primary natural colony in Mexico (Monterey Audubon Society 2018). This species began nesting in two urban areas in southern California in the late 1970s and early 1980s, and now breeds at an urban colony in the Monterey Bay area (Howell et al. 1983, Monterey Audubon Society 2018).

Somewhat surprisingly, the first record of urban-nesting birds for the East Coast of North America (for American Herring Gulls, *Larus smithsonianus*, in Boston, USA) does not appear in the literature until 1961, although the 150 nests were thought to have become established some years earlier; these subsequently expanded by the 1970s (Paynter 1963, Fisk 1978). In the Great Lakes region, first rooftop nests were documented in Ontario, Canada, in the early 1970s, for Ring-billed *Larus delawarensis* and American Herring Gulls (Blokpoel et al. 1990), and in 1978 on the US side of the Great Lakes for these same two species (Dwyer et al. 1996). In the Canadian Great Lakes, American Herring Gulls grew in number from 440 to 1,300 pairs from 1976 to 1990, while Ring-billed Gulls increased from 56,000 to 283,000 pairs during this same period, with concerns about health and economic effects of the urban portion of these gull populations increasing apace (Blokpoel and Tessier 1991). By the mid-1990s, 4% of the US Great Lakes' growing American Herring Gull population was nesting on rooftops, as were 2% of Ring-billed Gulls in the region, for a total of 7,922 pairs of both species (Dwyer et al. 1996). Although these two gull species have been declining in the Great Lakes region since about 1990 (Morris et al. 2003, 2011, Hebert et al. 2008), the urban-nesting habit, gained in their population expansion stage, has been retained and they continue to breed in urban habitats (Morris et al. 2011; LKB and E. Kroc, unpublished data).

It seems based on disparate studies to date that gulls colonised urban habitat for nesting either while their regional population was expanding, possibly surplus individuals seeking new nesting opportunities) or while their regional populations declined (individuals finding a refuge when conditions at natural sites deteriorated). Once gulls have expanded into an urban habitat, they remain, regardless of the status of their original source populations. The reasons for this are unclear, though may be related to the greater breeding success experienced by some urban colonies (below); the geographic structuring of gull metapopulations comprised of both urban and natural colonies is clearly a direction for future research.

Factors affecting the success of urban gull populations

Many studies have reported a higher breeding success for urban gull colonies than gulls breeding at natural sites (Monaghan 1979, Kroc 2018, Zelenskaya 2019), which may be linked to the lower nest density and consequently lower intraspecific aggression from other nesting adults in the neighbourhood. This suggests that rooftop habitats may represent suitable breeding grounds of equal or higher quality than that offered by natural coastal or insular habitats at that time (Monaghan 1979). However, other studies found no differences in breeding parameters between gulls nesting at natural and urban sites.

Hooper (1988) found a high egg and chick mortality in urban-nesting Glaucous-winged Gulls in Victoria, British Columbia, which was mostly caused by the predation of Northwestern Crows (*Corvus caurinus*) and other adult gulls, leading to hatching (72%) and fledgling success (51%) that were similar to those observed at a natural site on nearby Mandarte Island (70-83% and 36-58%, respectively; Vermeer 1963, Verbeek 1986). More recently, Perlut et al. (2016) studied the breeding parameters of a roof-top breeding population of American Herring Gulls in Portland, Maine, USA, and found a lower clutch size (mean of 2.3 eggs per clutch) and hatching success (46-48%), but higher chick survival up to 30 days of age (62-73%), than for a population nesting at a natural site on Appledore Island (2.6 eggs per clutch, 56-71% hatching success and 49-53% chick survival). Nest failure in Portland was mostly caused by predation (38%), weather conditions (27%) and management interventions of nest removal during incubation (23%). There was also no evidence of a difference in breeding success between natural and urban colonies in Yellow-legged Gulls in the Venice region, Italy, possibly because these were recently established colonies assumed to be mostly composed of younger birds with a poorer breeding performance (Soldatini et al. 2008). Vermeer et al. (1988) found great variation in the breeding success of roof-nesting Glaucous-winged Gulls in downtown Vancouver, Canada, with colonial breeders having lower (35%) fledgling success than solitary and more experienced breeding pairs (73%) — although that study hints that human disturbance may have caused some chick mortality among colonial breeders as these were accessed directly by observers, while dispersed nests were observed remotely.

Numerous other factors might influence differential breeding success between natural and urban sites, such as the quality of the diet of adult breeders. Some studies have reported a higher breeding output in gulls foraging on natural marine resources

(Hunt 1972, Annett and Pierotti 1999, O'Hanlon et al. 2017), which commonly include prey with high energetic and nutritional value, particularly rich in essential fatty acids and micronutrients (Gladyshev et al. 2009, EFSA NDA Panel 2014). The view that a marine diet is beneficial to growing chicks is further supported by the observation that breeding gulls often switch their diet during the chick-rearing period to more marine prey (Annett and Pierotti 1989, Isaksson et al. 2016, Pais de Faria et al. 2021b, but see Sotillo et al. 2019 for an alternative view). However, some studies found that gulls feeding on anthropogenic food did better compared to gulls feeding on natural resourses (Pons and Migot 1995), such as the high hatching success in Lesser Black-backed Gulls (90%; Gyimesi et al. 2016) and the higher fledgling rates in European Herring Gulls (van Donk et al. 2017), when compared to gulls feeding on natural marine prey, both in the Netherlands. It is likely, however, that urban-nesting gulls use the same food resources as the birds nesting in the surrounding natural sites (e.g. Huig et al. 2016, Rock et al. 2016, Spelt et al. 2019). The higher breeding success observed in gulls with an anthropogenic diet, from both natural and urban colonies, might be a result of the higher predictability of these food recourses (Oro et al. 2013, Martinez-Abrain and Jimenez 2016). Some studies have recently shown the ability of gulls to adapt their foraging behaviour to follow predictable human habits. Spelt et al. (2021) showed that gulls breeding in Bristol, UK, matched their foraging patterns to the times when anthropogenic food becomes available at school breaks and opening hours of a waste centre. Other than matching their foraging patterns to predictable human activities, in a highly touristic area in the centre of Porto, Portugal, Yellow-legged Gulls were reported defending favourable vantage spots on the top of traffic lights near food outlets, from where they could swoop down and steal the food carried by humans coming out of the shops and waiting to cross the street (Pais de Faria et al. 2021a). Overall, the increase in the availability of anthropogenic food sources in cities and landfills, coupled with fishery discards in nearby marine areas and ports, likely contributed to the growth of urban gull populations.

Urban habitats may also provide a range of other potentially favourable conditions for gulls. Urban areas typically provide a milder microclimate than surrounding areas (Chown and Duffy 2015), with warmer temperatures in cool climates (heat island effect), and shelter from extreme weather conditions by roof-top structures (e.g. chimneys or walls), both potentially promoting the success of urban gull populations. Lower nesting density may result in roof-top colonies being less of an attractant to nest predators. General conditions in urban areas may also be favourable to gulls all year-round, in that some gulls no longer migrate and keep occupying their nesting grounds during the entire year (Rock 2005, Kroc 2018, Pais de Faria et al. 2021a). Lower disturbance levels on uninhabited buildings within the cities seem to provide suitable breeding opportunities for a range of avian species (Reynolds et al. 2019), but the effect of microclimate and availability of uninhabited buildings on roof-nesting pairs has not yet been studied in gulls.

Proximity to water bodies is another feature of urban areas that can make them attractive to gulls. Colonisation of built-up areas by gulls initially started in coastal or estuarine areas and progressively expanded to more distant inland areas (e.g. see the expansion of the British roof-nesting gull populations). For example, Zelensky (2019) studied the growth of the urban population of Slaty-backed Gulls in Magadan, Russia, and reported an increasing distance of nest sites to the coast as the population expanded. The same pattern of expansion away from the immediate shoreline was observed in Seattle, USA, from 1961 to 1982, and in Victoria, British Columbia, between the 1980s and 2000s (Eddy 1982, Blight et al. 2019). Freshwater bodies are commonly used by gulls as roosting locations (Clark et al. 2016) and their availability in or near built-up areas may also attract gulls to urban areas (Vermeer et al. 1988, Washburn et al. 2016). Although exploiting predictable anthropogenic resources would allow gulls to potentially reduce the energetic costs of foraging, urban environments are also commonly associated with an increased risk of disturbance (Møller 2008) or exposure to contaminants (Da Chen et al. 2012, Isaksson 2018, Zapata et al. 2018, Sorais et al. 2020) and pathogens (Alm et al. 2018, Smith et al. 2020), potentially jeopardizing their health condition and producing long-term negative effects for gulls and humans.

Human-gull interactions within the cities

Gulls have always been part of the human coastal landscape, where positive relationships and culturally positive connections were common between humans and gulls. Recently, however, human-gull relationships have been changing, with gulls increasingly becoming a constant part of urban landscapes worldwide (Belant 1997), causing several conflicts with the human population, such as damage to urban structures, nuisance, and spilling waste when foraging in trash containers (Fig. 2). Negative human-gull interactions seem to intensify during the gulls' breeding season, when they are constrained by breeding duties and show higher aggressive territorial behaviour near their roof-top nests, and take higher risks to obtain food (e.g. stealing food from humans; Belant 1997, Huig et al. 2016). Huig et al. (2016) quantified human-gull interactions for the Lesser Black-backed and Herring Gulls breeding at natural sites, but visiting the city of The Hague, Netherlands, during the breeding season, causing several nuisance events such as raiding rubbish bags or searching for food scraps in residential areas, especially during the chick-rearing period. However, the number of urban gulls in some cities may be larger outside the breeding season, particularly in areas of Southern Europe when migratory gulls join the local resident populations (Pais de Faria et al. 2021a).

The common use of landfills and large waterbodies by foraging and roosting gulls, raises several human public-health concerns, as gulls might end up serving as pathogen vectors (Alm et al. 2018), contributing to the dissemination of pathogens from landfills into these roosting locations, commonly shared with humans (e.g. beaches, ponds, lakes, rivers and reservoirs; Figure 3; Clark et al. 2016). In fact, several studies have reported the presence of antimicrobial-resistant (AMR) bacteria and Avian Influenza viruses in gull species from different countries (Antilles et al. 2015, Arnal et al. 2015). For example, in France, researchers found identical populations of *Escherichia coli* on Yellow-legged Gull and humans, suggesting that gulls may be contaminated in landfills and then act as an environmental reservoir of AMR pathogens (Bonnedahl et al. 2009). In Berlenga Island, Portugal, gulls are considered a major source of faecal pollution in coastal waters near a beach that is highly visited by tourists (Alves et al. 2014, Araujo et al. 2014), and to carry anti-microbial resistant *E. coli* (Radhouani et al. 2009).

<Figure 3 here>

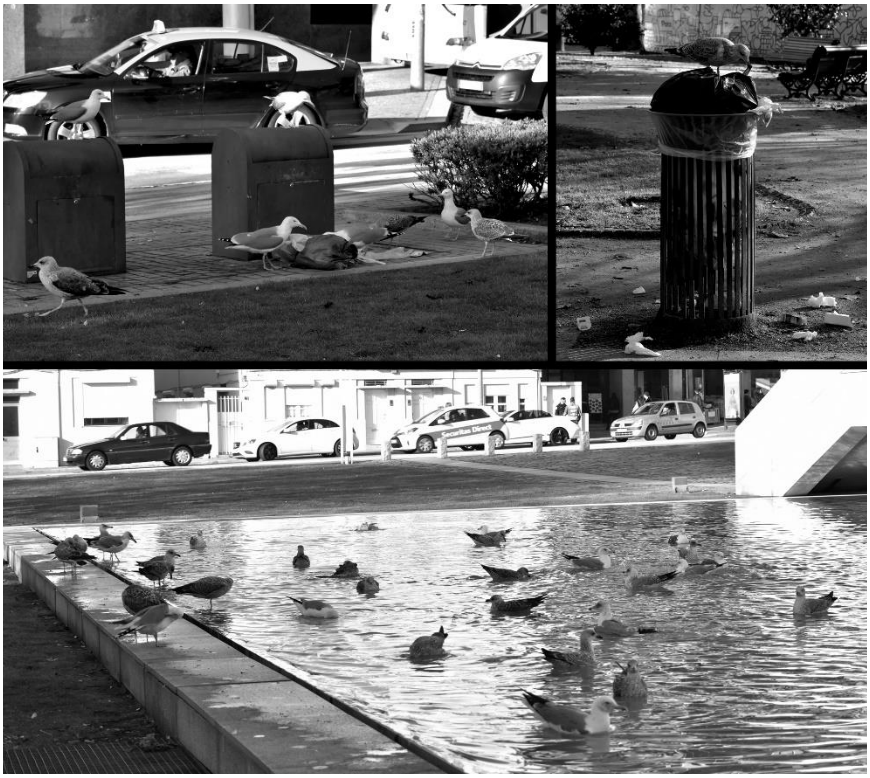

Figure 2. Gulls exploring the city, adult and immature gulls *Larus* sp. spilling

waste when foraging in trash containers in the street (top left) and in a small city park (top right), in the city of Porto, Portugal. Gulls resting in an urban pond (bottom) within the city of Matosinhos, Portugal, at the end of the day.

Human-nature interactions and associated dynamics can be highly complex (Gaston et al. 2018, Soga and Gaston 2020), exhibiting spatial and temporal variation and being commonly associated with socio-economic factors (Soga and Gaston 2020). The same complexity is applied when it comes to human-gull interactions. A great part of direct human-gull interactions is associated with the intentional and unintentional provisioning of food subsidies in urban areas (Oro et al. 2013, Newsome et al. 2015, Cox and Gaston 2018). The intentional provision of food is commonly a response to the 'extinction of experience', where people feed wildlife to experience a relationship with nature in urban areas — resulting in a positive interaction with several psychological benefits (Cox and Gaston 2016, Soga and Gaston 2016). However, these positive interactions can rapidly progress to negative ones, with opportunistic species increasing their human tolerance through a habituation process, and humans losing control over the interactions that they initially initiated (e.g. Kumar et al. 2019).

Several aspects may influence direct human-gull interactions (Soga and Gaston 2020), such as social and educational factors (e.g. lack of knowledge about the ecological consequences of wildlife feeding) or socio-economic factors, with gulls preferring to build their nests on older buildings with lower human disturbance levels (Reynolds et al. 2019, J. Pais de Faria, personal observation). Humans intentionally feeding wildlife may be often elderly and lonely citizens sharing their food (Fig. 3). This could be related to a particular orientation and/or predisposition to feed and, ultimately, take care of the 'most needed ones' (Cox and Gaston 2016, Soga and Gaston 2020), or a consequence of both being from social groups or personality types that suffer the most from loneliness, and will most frequently and subconsciously seek psychological benefits of interacting with nearby wild animals such as gulls (Cox and Gaston 2016, Cox et al. 2017, Barnes et al. 2019).

<Figure 4 here>

Figure 3. Citizen sharing his food with a group of gulls, *Larus* sp., in a city park within the city of Porto, Portugal.

Managing human-gull conflicts

The complexity of human-gull interactions underlines the need to consider the activities, routines and behaviour of humans when designing management measures aiming to decrease human-gull conflicts within cities. Pais de Faria et al. (2021a) found the number of people feeding Yellow-legged Gulls within the city of Porto to increase during the winter months, attracting large number of foraging gulls, but gull-related complaints to the City Council peaked during the breeding season, when gulls' territorial aggressive behaviour tended to increase near their rooftop nests. Therefore, efficient management measures should consider local dynamics and seasonality of human-gull interactions, while including environmental education and social awareness campaigns. Although feeding by individual humans alone is probably not enough to sustain entire urban populations, this surely contributes to human-gull conflicts driven by the increasing habituation of gulls to humans. But changing human behaviour can be extremely challenging. Clark et al. (2015) observed people repeatedly feeding gulls in parking lots after being approached during awareness campaigns, and suggested the use of community-based social marketing techniques as a possible and more efficient approach. Contrarily, the Litter Free Coast and Sea "Don't Feed the Locals" Campaign (DFLC 2017) that occurred in Weymouth, UK, seemed to be very successful in engaging the local community, tourists and local business on several activities that aimed to educate people about the reasons why they should not feed gulls.

Several management measures that have been attempted aim to: disperse gulls (e.g. pyrotechnics, broadcast of gull distress calls, blank ammunitions, hazing by trained raptors; Cook et al. 2008, Rock 2013, Thieriot et al. 2015); prevent gulls from roosting in important water bodies (Clark et al. 2013); prevent gulls from constructing their nests on roof-tops (e.g. application of wires, spikes and roof netting; hazing by trained raptors); and to reduce the availability of anthropogenic food subsidies (e.g. the use of gull-proof litter bins or closing open-air landfills; Payo-Payo et al. 2015, Steigerwald et al. 2015). However, due to gulls' extreme resilience, most of the applied measures were inefficient in the long-term, and, in some cases simply relocated gulls, and their related conflicts, to new locations (Rock 2005, 2013). The general use of scaring devices is probably one of the least efficient techniques when it comes to dispersing gulls from roosting or nesting roof-top locations, with gulls commonly observed to nest next to these devices (Rock 2013, Kroc 2018). Roof netting or wiring, on the other hand, could prevent gulls from nesting on rooftops, but only if mesh size and wire spacing is correctly considered to match the gulls' size and behaviour (Rock 2005, 2013; LKB pers. obs.). The use of a similar technique showed to be highly effective at preventing Ring-billed Gulls from roosting in wastewater treatment tanks in Millbury, USA, where single-strand stainless-steel piano wires (1 mm in diameter) were spaced at 0.9 - 3.3 m with a 136 kg tensile strength (Clark et al. 2013). On landfills, the use of trained hawks or falcons to scare and disperse foraging gulls also seems to be effective (Thieriot et al. 2015), especially when combined with other techniques to reduce gulls' habituation to a single method (Cook et al. 2008). But again, all these measures aiming to disperse gulls, even if highly effective, could just be moving the problem elsewhere. Measures aimed at reducing breeding success, such as egg oiling, do not seem to lead to the abandonment of the colony and movement to new locations or to produce any further complications (DeVault et al. 2014), but the management effort required is high, with campaigns being conducted during several consecutive breeding seasons, as gulls are long-lived and highly philopatric species so that loss of a couple of seasons of productivity does not affect population size.

Overall, changes in the availability of predictable anthropogenic food resources can affect major population trends at breeding sites (Oro et al. 2004, Duhem et al. 2008, Camphuysen 2013). In some cases, these changes may affect the gulls' average body mass, egg volume and clutch size (Pons and Migot 1995, Steigerwald et al. 2015). Although information on worldwide urban-nesting gull population trends is generally lacking, it has been shown for Europe that gulls nesting in roof-top areas forage both in landfills (Spelt et al. 2019) and fishing ports (Méndez et al. 2020). Therefore, combining measures that reduce the availability of predictable anthropogenic subsidies and those that aim to reduce urban gulls' breeding output, along with environmental education and social awareness campaigns to minimize direct human-gull conflict within cities, could potentially increase effectiveness of managing increasing urban gull populations.

References

Alberti, M., C. Correa, J.M. Marzluff, A.P. Hendry, E.P. Palkovacs and K.M. Gotanda. 2017. Global urban signatures of phenotypic change in animal and plant populations. PNAS. 114: 8951-8956. doi: 10.1073/pnas.1606034114

Alm, E.W., Q.R. Daniels-Witt, D.R. Learman, H. Ryu, D.W. Jordan, T.M. Gehring, et al. 2018. Potential for gulls to transport bacteria from human waste sites to beaches. Sci. Total Environ. 615 : 123-130. doi: 10.1016/j.scitotenv.2017.09.232

Alves, M.S., A. Pereira, S.M. Araújo, B.B. Castro, A.C.M. Correia and I. Henriques. 2014. Seawater is a reservoir of multi-resistant *Escherichia coli*, including strains hosting plasmid-mediated quinolones resistance and extended-spectrum beta-lactamases genes. Front. Microbiol. 5:426. doi: 10.3389/fmicb.2014.00426

Annett, C. and R. Pierotti. 1989. Chick hatching as a trigger for dietary switching in the western gull. Colon. Waterbirds 12: 4-11. doi: 10.2307/1521306

Annett, C.A. and R. Pierotti. 1999. Long-term reprodutive output in western gulls: consequences of alternate tactis in diet choice. Ecology 80: 288-297. doi: 10.1890/0012-9658(1999)080[0288:LTROIW]2.0.CO;2

Antilles, N., L. Garcia-Migura, K.G. Joensen, P. Leekitcharoenphon, F.M. Aarestrup, M. Cerda-Cuellar, et al. 2015. Audouin's gull, a potential vehicle of an extended spectrum beta-lactamase producing Salmonella Agona. FEMS Microbiol. Lett. 362: 4. doi: 10.1093/femsle/fnu039

Araujo, S., I.S. Henriques, S.M. Leandro, A. Alves, A. Pereira and A. Correia. 2014. Gulls identified as major source of fecal pollution in coastal waters: A microbial source tracking study. Sci. Total Environ. 470:84-91. doi: 10.1016/j.scitotenv.2013.09.075

Arnal, A., M. Vittecoq, J. Pearce-Duvet, M. Gauthier-Clerc, T. Boulinier and E. Jourdain. 2015. Laridae: A neglected reservoir that could play a major role in avian influenza virus epidemiological dynamics. Crit. Rev. Microbiol. 41: 508-519. doi: 10.3109/1040841X.2013.870967

Artyukhin, Y.B. 2002. Unusual nesting of Japanese cormorant *Phalacrocorax filamentosus* and slaty-backed gull *Larus schistisagus* in the south of the Far East. *In:* Yu. B. Artyukhin and Yu. N. Gerasimov [eds]. Biologiya i Okhrana Ptits Kamchatki (Biology and Conservation of Birds of Kamchatka). Moscow. Russia

Audet, J.-N., S. Ducatez and L. Lefebvre. 2016. The town bird and the country bird: problem solving and immunocompetence vary with urbanization. Behav. Ecol. 27: 637-644. doi: 10.1093/beheco/arv201

Barnes, M.R., M.L. Donahue, B.L. Keeler, C.M. Shorb, T.Z. Mohtadi and L.J. Shelby. 2019. Characterizing Nature and Participant Experience in Studies of Nature Exposure for Positive Mental Health: An Integrative Review. Front. Psychol. 9(2617). doi: 10.3389/fpsyg.2018.02617

Belant, J.L. 1997. Gulls in urban environments: landscape-level management to reduce conflict. Landsc. Urban Plan. 38: 245-258. doi: 10.1016/S0169-2046(97)00037-6

Blight, L.K., M.C. Drever and P. Arcese. 2015. A century of change in Glaucous-winged Gull (*Larus glaucescens*) populations in a dynamic coastal environment. The Condor 117: 108-120. doi: 10.1650/CONDOR-14-113.1

Blight, L. K., D.F. Bertram and E. Kroc. 2019. Evaluating UAV-based techniques to census an urban-nesting gull population on Canada's Pacific coast. J. Unmanned. Veh. Syst. 7: 312-324. doi: 10.1139/juvs-2019-0005

Blokpoel, H., W.F. Weller, G.D. Tessier, B. Smith, H. Gulls and R.B. Gulls. 1990. Roof-nesting by Ring-billed Gulls and Herring Gulls in Ontario in 1989. Ont. Birds 8:55-60

Blokpoel, H. and G. D. Tessier. 1991 Distribution and abundance of colonial waterbirds nesting in the Canadian portions of the lower Great Lakes System in 1990. Can. Wildl. Serv. Tech. Rep. Ser. 117

Bonnedahl, J., M. Drobni, M. Gauthier-Clerc, J. Hernandez, S. Granholm, Y. Kayser et al. 2009. Dissemination of *Escherichia coli* with CTX-M Type ESBL between Humans and Yellow-Legged Gulls in the South of France. Plos One 4: 6. doi: 10.1371/journal.pone.0005958

Camphuysen, C.J. 2013. A historical ecology of two closely related gull species (Laridae): Multiple adaptations to a man-made environment. PhD. Thesys, University of Groningen, Groningen, Netherlands

Carmona, M., R. Aymí and J. Navarro. 2021. Importance of predictable anthropogenic food subsidies for an opportunistic gull inhabiting urban ecosystems. Eur. J. Wildl. Res. 67: 9. doi: 10.1007/s10344-020-01446-2

Castano, M.V., L.M. Biondi, F. Zumpano, M. Favero and G.O. García. 2020. Behavional responses to a novel feeding problem in the Olrog's Gull *Larus atlanticus*. Mar. Ornithol. 48:149-155.

Chabrzyk, G. and J.C. Coulson. 1976. Survival and recruitment in the Herring Gull *Larus argentatus*. J. Anim. Ecol. 45: 187-203

Chávez-Villavicencio, C. 2014. Aproximación a la selección de sitios de nidificación de la Gaviota Dominicana (*Larus Dominicanus* Lichtenstein 1823) en un área urbana de la región de Coquimbo (Chile) y un nuevo sustrato de nidificación. The Biologist 12: 33-44. doi: 10.24039/rtb2014121384

Chown, S.L. and G.A. Duffy. 2015. Thermal physiology and urbanization: perspectives on exit, entry and transformation rules. Funct. Ecol. 29: 902-912. doi: 10.1111/1365-2435.12478

Cignini, B. and M. Zapparoli. 1996. Atlante degli uccelli nidificanti a Roma. Palombi Editori, Roma, Italy

Clark, D.E., S. DeStefano, K.G. MacKenzie, K.K.G. Koenen and J.J. Whitney. 2016. Roost site selection by ring-billed and herring gulls. J. Wildl. Manage. 80: 708-719. doi: 10.1002/jwmg.1066

Clark, D.E., K.K.G. Koenen, K.G. Mackenzie, J.W. Pereira and S. Destefano. 2013. Stainless-steel wires exclude gulls from a wastewater treatment plant. J. Am. Water Work. Assoc. 105: E609-E618. doi: 10.5942/jawwa.2013.105.0118

Clark, D.E., J.J. Whitney, K.G. MacKenzie, K.K.G. Koenen and S. DeStefano. 2015. Assessing gull abundance and food availability in urban parking lots. Hum. Wildl. Interact. 9: 180-190. doi: 10.26077/m3ts-7d08

Cook, A., S. Rushton, J. Allan and A. Baxter. 2008. An evaluation of techniques to control problem bird species on landfill sites. Environ. Manage. 41: 834-843. doi: 10.1007/s00267-008-9077-7

Coulson, J.C. and B.A. Coulson. 2015. The accuracy of urban nesting gull censuses. Bird Study 62: 170-176. doi: 10.1080/00063657.2015.1013523

Cox, D.T.C. and K.J. Gaston. 2016. Urban Bird Feeding: Connecting People with Nature. PLOS ONE 11: e0158717. doi: 10.1371/journal.pone.0158717

Cox, D.T.C. and K.J. Gaston. 2018. Human–nature interactions and the consequences and drivers of provisioning wildlife. Philos. Trans. Royal Soc. B: Biol. Sci. 373(1745): 20170092. doi: 10.1098/rstb.2017.0092

Cox, D.T.C., D.F. Shanahan, H.L. Hudson, R.A. Fuller, K. Anderson, S. Hancock, et al. 2017. Doses of Nearby Nature Simultaneously Associated with Multiple Health Benefits. Int. J. Environ. Res. Public Health 14: 172. doi: 10.3390/ijerph14020172

Cramp, S. 1971. Gulls nesting on buildings in Britain and Ireland. Br. Birds 64: 476–487

Cramp, S., W.R.P. Bourne and D. Saunders. 1974. The Seabirds of Britain and Ireland. Collins, London, UK

DeVault, T.L., P.M. Schmidt, F.E. Pogmore, J. Gobeille, J.L. Belant and T.W. Seamans. 2014. Influence of egg oiling on colony presence of ring-billed gulls. Hum. Wildl. Interact. 8: 22-30. doi: https://doi.org/10.26077/674e-qn50

DFLC – Don’t Feed the Locals Post Campaign Report. 2017. Weymouth, UK. http://www.litterfreecoastandsea.co.uk/wp-content/uploads/2017/05/Dont-Feed-the-Locals-Post-campign-report.pdf, accessed 15 Frbruary 2021

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

Dwyer, C.P., J.L. Belant and R.A. Dolbeer. 1996. Distribution and abundance of roof-nesting gulls in the Great Lakes region of the United States. Ohio J. Sci. 96: 9-12

Eddy, G. 1982. Glaucous-winged Gulls nesting on buildings in Seattle, Washington. The Murrelet, 63: 27–28

EFSA NDA Panel (EFSA Panel on Dietetic Products, Nutrition and Allergies) (2014) Scientific Opinion on health benefits of seafood (fish and shellfish) consumption in relation to health risks associated with exposure to methylmercury. EFSA J 12:3761. doi: 10.2903/j.efsa.2014.3761

Fisk, E. J. 1978. The growing use of roofs by nesting birds. Bird-banding 134-141

Garcia, C.M., M. Suárez-Rodríguez and I. López-Rull. 2017. Becoming Citizens: Avian Adaptations to Urban Life. *In:* E. Murgui and M. Hedblom [eds.]. Ecology and Conservation of Birds in Urban Environments. Springer, Cham. doi: 10.1007/978-3-319-43314-1_6

Gaston, K.J., M. Soga, J.P. Duffy, J.K. Garrett, S. Gaston and D.T.C. Cox. 2018. Personalised Ecology. Trends Ecol. Evol. 33: 916-925. doi: 10.1016/j.tree.2018.09.012

Gladyshev, M., M. Arts and N. Sushchik. 2009. Preliminary Estimates of the Export of Omega-3 Highly Unsaturated Fatty Acids (EPA + DHA) from Aquatic to Terrestrial Ecosystems. *In:* M. Kainz, M. Brett, & M. Arts [eds.]. Lipids in Aquatic Ecosystems. Springer, New York, USA

Goethe, F. 1960. Felsbrütertum und weitere beachtenswerte Tendenzen bei der Silbermöwe. Proc. Int. Ornithol Congress. 12: 252-258

Gosling, W.D., J. de Kruif, S.J. Norder, E.J. de Boer, H. Hooghiemstra, K.F. Rijsdijk, et al. 2017. Mauritius on fire: Tracking historical human impacts on biodiversity loss. Biotropica 49: 778-783. doi: 10.1111/btp.12490

Gyimesi, A., T.J. Boudewijn, R.J. Buijs, J.Z. Shamoun-Baranes, J.W. de Jong, R.C. Fijn, et al. 2016. Lesser Black-backed Gulls *Larus fuscus* thriving on a non-marine diet. Bird Study 63: 241-249. doi: 10.1080/00063657.2016.1180341

Hebert, C.E., D.V.C. Weseloh, A. Idrissi, M.T. Arts, R. O'Gorman, O.T. Gorman, et al. 2008. Restoring piscivorous fish populations in the Laurentian Great Lakes causes seabird dietary change. Ecology 89: 891-897. doi: 10.1890/07-1603.1

Hensley, C.B., C.H. Trisos, P.S. Warren, J. MacFarland, S. Blumenshine, J. Reece, et al. 2019. Effects of Urbanization on Native Bird Species in Three Southwestern US Cities. Front. Ecol. Evol. 7(71). doi: 10.3389/fevo.2019.00071

Hooper, T.D. 1988. Habitat, Reproductive Parameters, and Nest-Site Tenacity of Urban-Nesting Glaucous-Winged Gulls at Victoria, British Columbia. The Murrelet 69: 10-14. doi: 10.2307/3534880

Huig, N., R.-J. Buijs and E. Kleyheeg. 2016. Summer in the city: behaviour of large gulls visiting an urban area during the breeding season. Bird Study: 1-9. doi: 10.1080/00063657.2016.1159179

Hunt Jr., G.L. 1972. Influence of Food Distribution and Human Disturbance on the Reproductive Success of Herring Gulls. Ecology 53: 1051-1061. doi: 10.2307/1935417

Isaksson, C. 2018. Impact of Urbanization on Birds. pp. 235-257. *In:* D. T. Tietze [ed.]. Bird Species: How They Arise, Modify and Vanish. Cham: Springer International Publishing

Isaksson, N., T.J. Evans, J. Shamoun-Baranes and S. Akesson. 2016. Land or sea? Foraging area choice during breeding by an omnivorous gull. Mov. Ecol. 4: 14. doi: 10.1186/s40462-016-0078-5

Joint Nature Conservation Committee (JNCC). 2014. UK regional seas. JNCC, Peterborough, U.K. http://jncc. defra.gov.uk/page-1612, accessed 5 February 2021

Kroc, E. 2018. Reproductive Ecology of Urban-nesting Glaucous-winged gulls *Larus glaucescens* in Vancouver, BC, Canada. Mar. Ornithol. 46: 155-164

Kroc, E., L.K. Blight, and W. Cao. 2018. Effects of urban density and structure on the spatial distribution of urban-nesting Glaucous-winged Gulls (*Larus glaucescens*) of the Salish Sea. Poster presentation, International Ornithological Congress, Vancouver, BC.

Kumar, N., Y.V. Jhala, Q. Qureshi, A.G. Gosier and F. Sergio. 2019. Human-attacks by an urban raptor are tied to human subsidies and religious practices. Sci. Rep. 9: 10. doi: 10.1038/s41598-019-38662-z

Lloyd, C., M.L. Tasker and K. Partridge. 1991. The Status of Seabirds in Britain and Ireland. T & AD Poyser, London, UK

Lowry, H., A. Lill and B.B. Wong. 2013. Behavioural responses of wildlife to urban environments. Biol. Rev. 88: 537-549. doi: 10.1111/brv.12012

Martínez-Abraín, A. and J. Jiménez. 2016. Anthropogenic areas as incidental substitutes for original habitat. Conserv. Biol. 30: 593-598. doi: 10.1111/cobi.12644

Méndez, A., T. Montalvo, R. Aymí, M. Carmona, J. Figuerola and J. Navarro. 2020. Adapting to urban ecosystems: unravelling the foraging ecology of an opportunistic predator living in cities. Urban Ecosyst. 23: 1117-1126. doi: 10.1007/s11252-020-00995-3

Mitchell, I.P., S. Newton, N. Ratcliffe and T.E. Dunn. 2004. Seabird populations of Britain and Ireland. T & AD Poyser, London, UK

Møller, A.P. 2008. Flight distance of urban birds, predation, and selection for urban life. Behav. Ecol. Sociobiol. 63(63). doi: 10.1007/s00265-008-0636-y

Monaghan, P. 1979. Aspects of the breeding biology of Herring Gulls *Larus argentatus* in urban colonies. Ibis 121: 475-481. doi: 10.1111/j.1474-919X.1979.tb06687.x

Monaghan, P. and J.C.C. Coulson. 1977. Status of Large Gulls Nesting on Buildings. Bird Study 24: 89-104. doi: 10.1080/00063657709476538

Morrey Salmon, H. 1958. Lesser Black-backed and Herring Gulls nesting on a factory-roof inland in Glamorgan. Br. Birds 51: 399-401

Morris, R. D., D.V. Weseloh and J.L. Shutt. 2003. Distribution and abundance of nesting pairs of Herring Gulls (*Larus argentatus*) on the North American Great Lakes, 1976 to 2000. J. Great Lakes Res. 29: 400-426. doi: 10.1016/s0380-1330(03)70447-x

Morris, R.D., D.V. Weseloh, L.R. Wires, C. Pekarik, F.J. Cuthbert and D.J. Moore. 2011. Population Trends of Ring-billed Gulls Breeding on the North American Great Lakes, 1976 to 2009. Waterbirds 34: 202-212. doi: 10.1675/063.034.0209

Murray, M.H., E.W. Lankau, A.D. Kidd, C.N. Welch, T. Ellison, H.C. Adams, et al. 2020. Gut microbiome shifts with urbanization and potentially facilitates a zoonotic pathogen in a wading bird. PLOS ONE 15: e0220926. doi: 10.1371/journal.pone.0220926

Nager, R.G. and N.J. O'Hanlon. 2016. Changing Numbers of Three Gull Species in the British Isles. Waterbirds 39: 15-28

Nankinov, D.N. 1992. The nesting by the Herring Gull (*Larus argentatus*) in the towns and villages of Bulgaria. Avocetta 16: 93-94

Newsome, T.M., J.A. Dellinger, C.R. Pavey, W.J. Ripple, C.R. Shores, A.J. Wirsing, et al. 2015. The ecological effects of providing resource subsidies to predators. Glob. Ecol. Biogeogr. 24: 1-11. doi: 10.1111/geb.12236

O'Hanlon, N., R. McGill and R. Nager. 2017. Increased use of intertidal resources benefits breeding success in a generalist gull species. Mar. Ecol. Prog. Ser. 574: 193-210. doi: 10.3354/meps12189

Oldaker, R. F. 1963. Unusual nest site of the Glauc- ous-winged Gull. Can. Field-Nat. 77: 65-66

Oro, D., E. Cam, R. Pradel and A. Martínez-Abraín. 2004. Influence of food availability on demography and local population dynamics in a long-lived seabird. Proc. R. Soc. Lond. B. 271: 387-396. doi: 10.1098/rspb.2003.2609

Oro, D., M. Genovart, G. Tavecchia, M.S. Fowler and A. Martïnez-Abraín. 2013. Ecological and evolutionary implications of food subsidies from humans. Ecol. Lett. 16: 1501-1514. doi: 10.1111/ele.12187

Ouyang, J.Q., C. Isaksson, C. Schmidt, P. Hutton, F. Bonier and D. Dominoni. 2018. A New Framework for Urban Ecology: An Integration of Proximate and Ultimate Responses to Anthropogenic Change. Integr. Comp. Biol. 58: 915-928. doi: 10.1093/icb/icy110

Pagani-Núñez, E., D. Liang, C. He, X. Zhou, X. Luo, Y. Liu, et al. 2019. Niches in the Anthropocene: passerine assemblages show niche expansion from natural to urban habitats. Ecography 42: 1360-1369. doi: 10.1111/ecog.04203

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

Pais de Faria, J., P.T. Vaz, C.S. Lopes, J.G. Calado, J.M. Pereira, S.N. Veríssimo, et al. 2021b. The importance of marine resources in the diet of urban gulls. Mar. Ecol. Prog. Ser. 660: 189-201. doi: 10.3354/meps13599

Parslow, J. 1967. Changes in status among breeding birds in Britain and Ireland: part 3. Br. Birds 60: 177-202

Payo-Payo, A., D. Oro, J.M. Igual, L. Jover, C. Sanpera and G. Tavecchia. 2015. Population control of an overabundant species achieved through consecutive anthropogenic perturbations. Ecol. Appl. 25: 2228-2239. doi: 10.1890/14-2090.1.sm

Perlut, N.G., D.N. Bonter, J.C. Ellis and M.S. Friar. 2016. Roof-top Nesting in a Declining Population of Herring Gulls (*Larus argentatus*) in Portland, Maine, USA. Waterbirds 39: 68-73

Pons, J.M. and P. Migot. 1995. Life-History Strategy of the Herring Gull: Changes in Survival and Fecundity in a Population Subjected to Various Feeding Conditions. J. Anim. Ecol. 64: 592-599

Raven, S.J. and J.C. Coulson. 1997. The distribution and abundance of *Larus* gulls nesting on buildings in Britain and Ireland. Bird Study 44: 13-34. doi: 10.1080/00063659709461035

Reynolds, S.J., J.D. Ibáñez-Álamo, P. Sumasgutner and M.C. Mainwaring. 2019. Urbanisation and nest building in birds: a review of threats and opportunities. J. Ornithol. 160: 841-860. doi: 10.1007/s10336-019-01657-8

Roby, D., J.Y. Adkins, K. Bixler, K. Collins, and A. Evans. 2007. Surveys for nesting Glaucous-winged/Western Gulls and Caspian Terns in Puget Sound, Washington. 2007 Final Annual Report. Submitted to US Fish and Wildlife Service, Region 1, Migratory Birds and Habitat Programs, Portland, Ore., USA

Rock, P. 2005. Urban gulls: problems and solutions. Br. Birds 98: 338-355

Rock, P. 2013. Urban gulls. Why current control methods always fail. Riv. Ital. Orn. 82. doi: 10.4081/rio.2012.112

Rock, P., C.J. Camphuysen, J. Shamoun-Baranes, V.H. Ross-Smith and I.P. Vaughan. 2016. Results from the first GPS tracking of roof-nesting Herring Gulls *Larus argentatus* in the UK. Ringing Migr. 31: 47-62. doi: 10.1080/03078698.2016.1197698

Sayol, F., D. Sol and A.L. Pigot. 2020. Brain Size and Life History Interact to Predict Urban Tolerance in Birds. Front. Ecol. Evol. 8. doi: 10.3389/fevo.2020.00058

Smith, O.M., W.E. Snyder and J.P. Owen. 2020. Are we overestimating risk of enteric pathogen spillover from wild birds to humans? Biol. Rev. 95: 652-679. doi:10.1111/brv.12581

Snell-Rood, E.C. and N. Wick. 2013. Anthropogenic environments exert variable selection on cranial capacity in mammals. Proc. R. Soc. B. 280(1769): 20131384. doi: 10.1098/rspb.2013.1384

Soga, M. and K.J. Gaston. 2016. Extinction of experience: the loss of human–nature interactions. Front. Ecol. Environ. 14: 94-101. doi: 10.1002/fee.1225

Soga, M. and K.J. Gaston. 2020. The ecology of human-nature interactions. Proc. R. Soc. B. 287(1918): 20191882. doi: 10.1098/rspb.2019.1882

Sol, D., O. Lapiedra and C. González-Lagos. 2013. Behavioural adjustments for a life in the city. Anim. Behav. 85: 1101-1112. doi: 10.1016/j.anbehav.2013.01.023

Soldatini, C., Y.V. Albores-Barajas, D. Mainardi and P. Monaghan. 2008. Roof nesting by gulls for better or worse? Ital. J. Zool. 75: 295-303. doi: 10.1080/11250000701884805

Sorais, M., M.J. Mazerolle, J.F. Giroux and J. Verreault. 2020. Landfills represent significant atmospheric sources of exposure to halogenated flame retardants for urban-adapted gulls. Environ. Int. 135: 10. doi: 10.1016/j.envint.2019.105387

Sotillo, A., J.M. Baert, W. Muller, E.W.M. Stienen, A. Soares and L. Lens. 2019. Time and energy costs of different foraging choices in an avian generalist species. Mov. Ecol. 7: 11. doi: 10.1186/s40462-019-0188-y

Spelt, A., O. Soutar, C. Williamson, J. Memmott, J. Shamoun-Baranes, P. Rock, et al. 2021. Urban gulls adapt foraging schedule to human-activity patterns. Ibis 163: 274-282. doi: 10.1111/ibi.12892

Spelt, A., C. Williamson, J. Shamoun-Baranes, E. Shepard, P. Rock and S. Windsor. 2019. Habitat use of urban-nesting lesser black-backed gulls during the breeding season. Sci. Rep. 9: 10527. doi: 10.1038/s41598-019-46890-6

Stedt, J., J. Bonnedahl, J. Hernandez, B.J. McMahon, B. Hasan, B. Olsen, et al. 2014. Antibiotic resistance patterns in *Escherichia coli* from gulls in nine European countries. Infect. Ecol. Epidemiology 4: 21565. doi: 10.3402/iee.v4.21565

Steigerwald, E.C., J.M. Igual, A. Payo-Payo and G. Tavecchia. 2015. Effects of decreased anthropogenic food availability on an opportunistic gull: evidence for a size-mediated response in breeding females. Ibis 157: 439-448. doi: 10.1111/ibi.12252

Thieriot, E., M. Patenaude-Monette, P. Molina and J.F. Giroux. 2015. The Efficiency of an Integrated Program Using Falconry to Deter Gulls from Landfills. Animals 5: 214-225. doi: 10.3390/ani5020214

Took, G.E. 1995. Nesting of Herring Gulls on rooftops in Dover. Br. Birds 48: 88-89

Turbott, E.G. 1969. Roof nesting of black-backed gulls. Notornis 16: 187-89

Turner, D.M. 2010. Counts and breeding success of Blacklegged Kittiwakes *Rissa tridactyla* nesting on man-made structures along the River Tyne, northeast England, 1994-2009. Seabird 23: 111–126

van Donk, S., K.C.J. Camphuysen, J. Shamoun-Baranes and J. van der Meer. 2017. The most common diet results in low reproduction in a generalist seabird. Ecol. Evol. 7: 4620-4629. doi: 10.1002/ece3.3018

Vermeer, K. 1963. The breeding ecology of the Glaucous-winged Gull (*Larus glaucescens*) darte Island, B.C. British Columbia. Prov. Mus. Occ. 13:92

Vermeer, K., D. Power and G.E.J. Smith. 1988. Habitat Selection and Nesting Biology of Roof-Nesting Glaucous-Winged Gulls. Colon. Waterbirds 11: 189-201

Washburn, B.E., S.B. Elbin and C. Davis. 2016. Historical and Current Population Trends of Herring Gulls (*Larus argentatus*) and Great Black-backed Gulls (*Larus marinus*) in the New York Bight, USA. Waterbirds 39: 74-86

Witherby, H.F., F.C.R.R. Jourdain, N.F. Ticehurst and B.W. Tucker. 1938-1941. The Handbook of British Birds. H. F. & G. Witherby, London, Uk

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

Zapata, P., R. Ballesteros-Cano, P. Colomer, A. Bertolero, P. Viana, S. Lacorte, et al. 2018. Presence and impact of Stockholm Convention POPs in gull eggs from Spanish and Portuguese natural and national parks. Sci. Total Environ. 633: 704-715. doi: 10.1016/j.scitotenv.2018.03.081

Zelenskaya, L.A. 2019. Ecology of an Urban Population of the Slaty-Backed Gull (*Larus schistisagus*) in Comparison with Natural Colonies: 1. Features of Nest Location and Productivity. Biol. Bull. 46: 1108-1123. doi: 10.1134/S106235901909019X