Foraging habits, population changes, and gull-human interactions in an urban population of Herring Gulls (*Larus argentatus*) and Lesser Black-backed Gulls (*Larus fuscus*)

A thesis submitted to Middlesex University in partial fulfilment of the requirements for the degree of MSc by Research Evolutionary Behavioural Sciences

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2017

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Abstract

Introduction: There are several species of breeding gull in the UK, many of which live in urban areas. The main urban colonists are Herring gulls (HG; *Larus argentatus*) and Lesser Black-backed gulls (LB; *Larus fuscus*). In some urban areas, they are considered a nuisance, although overall gull numbers are declining, and all breeding gulls in Britain are protected by law.

Objectives: To determine how the HG and LB population and gull nuisance events in Bath, Somerset change across the breeding season, and to investigate how humans are contributing to gull nuisance behaviours.

Methods: Field ethological methods were used to study HGs and LBs across six sites in Bath for five months between March and August 2017. Five minute instantaneous scan samples were used to record gull and human abundance. Behavioural data were recorded continuously for 30 minutes at each site. A total of 129 hours of observations were conducted.

Results: Fluctuations in the mean number of gulls could partially be explained by phases in the breeding season. Mean number of gull nuisance events were low and fluctuations were not significantly linked to breeding phase. There was a strong, positive correlation between the number of humans feeding gulls and the number of gull nuisance events recorded.

Conclusion: The urban gull nuisance problem in Bath is less serious than originally thought. Nuisance events occurred infrequently throughout the breeding season and predominantly in areas where humans were feeding the gulls. Measures to avoid nuisance should focus on reducing food availability, but more longitudinal research is needed to determine long-term trends in gull population and nuisance behaviours.

Acknowledgements

I would first like to thank my Director of Studies, Professor Tom Dickins, and supervisor, Dr. Rob Spencer, of Middlesex University's Department of Psychology, for their continuous support, patience, motivation, and immense knowledge. Their guidance helped me throughout the research and writing of this dissertation.

I would also like to thank Dr. Chris Pawson of the University of the West of England's Psychology department for all of his help, guidance, and fieldwork support in Bath.

Finally, I would like to thank my partner, Kirsty Mead, to whom this work is dedicated. Kirsty has provided me with immeasurably valuable emotional support, patience, and love throughout this degree.

1. Introduction and Aims

Although gull populations seem to be on the rise in urban areas (Rock 2005), their overall populations in the UK are declining. Throughout the UK, Channel Islands, and the Isle of Man, the *Birds of Conservation Concern* (*BoCC*) report assesses 244 species of bird and assigns them to the Red, Amber, or Green lists to indicate their level of conservation concern. The assessment criteria include a number of different measures to determine a bird species' placement on the Red, Amber, or Green list, including: conservation status at global and European levels and, within the UK, historical decline, trends in population and range, rarity, localised distribution, and international importance. The *BoCC* classification provides a robust assessment of the status of all bird species that are considered an established part of the UK's avifauna. These classifications have been arrived at by using a transparent and standardised approach, based upon the best available data, and conducted by a multi-partner group drawn from relevant organisations in both governmental and non-governmental sectors. *BoCC* assessments use a set of quantitative criteria that fall into two groups for the Red and the Amber lists. All species are assessed against all of those criteria, and are placed on the highest priority list for which they qualify. If they meet none of these criteria, they are placed on the Green list (Eaton et al. 2015).

Red list criteria is as follows: the species in question must be globally threatened, have historical population decline in the UK, show severe (at least 50%) decline in UK breeding population over the last 25 years or longer-term period (the entire period used for assessments since the first *BoCC* review, starting in 1969), and show severe (at least 50%) contraction of UK breeding range over last 25 years, or the longer-term period (*The RSPB Bird Guide* 2015).

Amber list criteria is as follows: the species in question must have unfavourable conservation status in Europe (SPEC, Species of European Conservation Concern), have historical population decline, but show signs of recovering; population size has more than doubled over last 25 years, moderate (25-49%) decline in UK breeding population over last 25 years, or the longer-term period, moderate (25-49%) contraction of UK breeding range over last 25 years, or the longer-term period, moderate (25-49%) decline in UK non-breeding population over last 25 years, or the longer-term period, rare breeder; 1–300 breeding pairs in UK, rare non-breeders; less than 900 individuals, localised; at least 50% of UK breeding or non-breeding population in 10 or fewer sites, but not applied to rare breeders or non-breeders, internationally important; at least 20% of European breeding or non-breeding population in UK (*The RSPB Bird Guide* 2015).

A Green list criterion is restricted to the following definition “species that occur regularly in the UK but not qualify under any of the above criteria” (*The RSPB Bird Guide* 2015). A species should be moved to the Green list (if not qualifying against either Red or Amber criteria) if it shows continued and substantial recovery from historical decline beyond the level that qualified the species for the Amber list. When it moves to the Green list, the species should be considered as having recovered permanently and would no longer be considered against the historical decline criterion (Eaton et al. 2015).

Despite being versatile and opportunistic, both HGs and LBs are considered birds of conservation concern. According to the most recent *BoCC* report (*BoCC 4*, Eaton et al. 2015), HGs are Red listed and LBs are Amber listed. HGs and LBs have seemingly adapted well to human presence and have been nesting in urban areas on rooftops and other structures. With this expansion of their range, some populations of LBs and HGs have begun to grow. In some areas, their populations have reached a point where their numbers are so great they are considered a nuisance (Rock 2005). However, in many parts of their range, particularly in historic coastal nesting areas (herein referred to as "coastal areas"), HGs and LBs have seen detrimental declines in breeding populations. This may be due to increased competition for food, as well as changes in fishing practices that reduce the availability of discarded food, as well as the closure of landfill sites. Some populations have significantly declined due to decreasing food availability caused by competition and predation by birds such as Great Black-backed gulls (Ross-Smith et al. 2014), but it cannot be known for certain all the factors that are driving this change.

Urban gulls garnered national attention in 2015 when then-Prime Minister, David Cameron, publically urged local authorities, the public, the government, and conservation groups to engage in a "big conversation" about gulls. This announcement came after a number of gull-related incidents, including reports of pets and humans being harmed by gulls *(Gull Attacks).*

Historically, gulls have not been such a nuisance in urban areas (Rock 2005). The Clean Air Act of 1956 is often considered as the catalyst for gulls moving into urban areas in large numbers. In response to the "Great Smog" of 1952, the act was a change in health and safety legislation that made it illegal to burn rubbish at landfill sites to reduce the amount of pollution caused by burning rubbish. In lieu of burning, rubbish was to be covered with some inert material at the end of a day's tipping. HGs and LBs are generalists and, as such, do not have many specialist adaptations. These gulls have adapted to looking for new feeding opportunities, and with the passing of the Clean Air Act (1956) and implementation of rubbish tips, that is exactly what was created for them: a huge increase in food supply. It is thought that because of this readily available food source gulls started to move inland to take advantage of the feeding opportunity provided at rubbish tips (Rock 2002).

Much of the media coverage around urban gulls deals with "raids," where a gull takes food from the hands of a person or from a table where a person is eating (e.g., Ellis 2014, Parkinson 2011). In seaside tourist towns, like St. Ives, some food venders are issuing warnings to tourists to “shield their ice creams and eat somewhere out of sight,” because the gulls may steal their food and it can be “quite upsetting for those who get their food stolen,” (Ellis 2014). Business managers complain that the gulls “leave a mess, steal food, break crockery, and attack people.” Business owners complain that they risk losing revenue because the gulls are “frightening” and “come down from nowhere” scaring off potential customers (Ellis 2014).

Urban gulls have also been blamed for damage to buildings as their nests block water pipes and wreck roof insulation (Kelbie 2004). Another nuisance behaviour that is sometimes seen in urban areas is “dive bombing,” which describes the action of a gull swooping close to ground level, usually at a human who has ventured too near to the gull’s nest or chicks. This behaviour acts as a warning to humans to steer clear (Safeguard 2017). Other nuisance behaviours that are commonly complained about include disturbance or destruction of rubbish bags, raiding food scraps, or fouling of clothing or property with droppings (Huig et al. 2016).

The increase in urban gulls has not been restricted to seaside towns. Residents and business owners have leveled complaints about gulls throughout Northeast Somerset and the whole of the southwest of England (Winsper 2014). There are confirmed breeding populations across the entirety of the southwest of England, but the present study is an investigation into a population of roof-nesting gulls in Bath, Somerset. These gulls have been closely watched and studied by Peter Rock (e.g., Rock 2005, 2006) as well as researchers at the University of the West of England (UWE) due to the many complaints by citizens and businesses in the city of Bath.

The Bath and Northeast Somerset (BANES) council has invested time and resources into initiatives to study and attempt to control the gull population in the city and surrounding areas. In addition to implementing population control methods, such as nest removal and egg destruction, BANES has provided residents with reusable gull-proof rubbish sacks in an attempt to curb rubbish bag destruction by gulls. BANES has also posted 55 signs in three languages (English, French, and Mandarin) imploring the public not to feed the gulls, as that further encourages them to seek out anthropogenic food (Bathnes.gov.uk 2017).

Further efforts have been made by the city and its residents, including hiring companies to destroy gull nests before eggs hatch, erecting signs with the message “Do not feed the gulls,” cracking down on business owners who do not present their waste correctly, and roof treatments, among other strategies. Some previous tactics employed by the council have been abandoned (e.g., “fire gel,” *Fire' gel on Bath Buildings…*) because they had no demonstrable effect on the gulls (BANES Council 2015).

Large gulls predominantly cause distress for humans during the breeding season (Huig et al. 2016). This is no different for the city of Bath, where the primary nuisance gulls are HGs and LBs. During the winter months another type of gull, the Black-headed gull (BH), is most often seen in Bath, almost to the exclusion of any other *Larids* (pers. obvs.). BHs are a smaller species than HGs and LBs, and are not reported to cause nuisance events like LBs or HGs. In the summer months, BHs migrate to their breeding grounds outside of the UK and only return to Bath after the breeding season during the winter months. Because of their prominence, HGs and LBs are the only gulls that were studied in the present research.

These gulls have garnered a lot of attention from the local papers due to their perception as a nuisance animal. A recent article published in the *Bath Chronicle* urged a widespread cull of nesting gulls to try to control their population (Petherick 2017a). However, since both of these gulls are protected under the Wildlife and Countryside Act (1981), there are strict regulations around implementing a cull. Additionally, it is not known how a cull would impact on the number of gulls foraging in Bath. It is possible that some of the gulls are nesting elsewhere and simply visit Bath as a foraging patch. An example of such a situation was demonstrated in a population of ringed Dutch gulls that were nesting in a coastal colony, but were foraging in an urban area (Huig et al. 2016).

There is a large body of literature regarding the natural history of HGs and LBs in coastal foraging and nesting areas, but there is a dearth of knowledge on the ecology and behaviour of urban gulls. This gap in the urban gull literature extends to population management issues as well as behavioural interventions which may mitigate gull nuisance behaviours. The majority of studies on urban gulls have described rooftop colonies and gulls foraging on landfill sites (e.g., Rock 2005, Coulson and Coulson 2009). However, there are few studies that focus on gull behaviour in cities or how humans may be contributing to the gull-related nuisance problems.

Animals in urban habitats are often noticeably bolder in the presence of humans compared to their rural counterparts. Such boldness is frequently attributed to habituation, defined as the “gradual decrease in response to repeated stimuli,” (Anderson et al. 1999, Metcalf et al. 2002). Many studies have shown that urban-dwelling individuals have consistently shorter flight initiation distances (FID) in response to an approaching human in comparison with rural conspecifics (e.g., Møller 2008, Evans et al. 2010, McGiffin et al. 2013). Increased boldness of urban-dwelling individuals often goes hand-in-hand with elevated levels of aggression, both towards humans, other non-human animals, and conspecifics, a phenomenon recognized as an ‘urban wildlife syndrome’ (Warren et al. 2006, Evans et al. 2010).

Other behavioural alterations of urban colonizers are associated with reproducing and foraging in a highly transformed anthropogenic environment, which may include changes in nest-site selection (Yeh et al. 2007), usage of artificial nesting structures (Wang et al. 2015), earlier timing and increased duration of breeding (Beck and Heinsohn 2006), changes in diet composition (Estes and Mannan 2003), utilization of human-subsidized feeding resources (Sauter et al. 2006), changes in diurnal cycles such as avoidance of elevated human activity (Nordt and Klenke 2013) or prolonging activity into night (Russ et al. 2015), and adjustments in vocalization in response to anthropogenic noise (Slabbekoorn 2013). However, within the class of birds, behavioural responses to urban landscape have been assessed mostly for passerine species (reviewed in Miranda et al. 2013) and more work is needed in the family *Laridae* through population censes and behavioural studies.

Behavioural studies can provide important insights into the lives and motivations of urban gulls. Numerous studies have demonstrated that monitoring and studying behaviour is relevant to the management of animal populations from a conservation biology perspective (e.g., Wallace and Buchholz 2001, Shier 2006, Moore et al. 2008) and may be applied to help manage nuisance populations. Furthermore, ignoring behavioral data may lead to failure of management programs (Knight 2001).

Behaviour acts as a mediator between the animal and its environment. As such, behaviour can vary over time and space and is a function of past experience and the genetic limits resulting from past selection. Behaviour can act as an indicator of other pressures that these birds are facing which may explain their shift in nesting sites. For example, if it is difficult for these gulls to find food or viable nesting sites in coastal or offshore areas, then they will be forced to look elsewhere. Behaviour is therefore an important component of biodiversity, and like all other components of biodiversity, should be regularly addressed when managing animal populations (Berger-Tal and Saltz 2016).

Considering their status as Red and Amber listed birds of conservation concern, and their close proximity to humans, it is important to understand the behaviour and distribution of HGs and LBs. Since much of the gull population in the UK is apparently shifting to cities and towns it is important to know how these gulls are behaving and provisioning their chicks. In order to understand more about how these gulls are behaving throughout the breeding season and where in the city they are causing the most distress to humans, the following questions were investigated over the 2017 breeding season in Bath:

1. How does the abundance of gulls in the city change throughout different phases in the breeding season?
2. Is there a change in nuisance events and gull-human conflict throughout the breeding season?
3. To what extent are the nuisance problems associated with this population of gulls mediated by the behaviour of humans?

To summarise, there are many urban-nesting HGs and LBs in the UK. These gulls are large and noisy, which often prompts complaints from residents about nuisance events related to the gulls. All species of breeding gull in Britain are protected, with HGs being Red listed and LBs being Amber listed. What is known about the natural history of gulls in coastal colonies and from recent studies of urban populations of gulls has informed the following predictions about the study population in Bath:

- The abundance of gulls will peak during the rearing period (20 April - 17 May) and then remain the same until fledging (13 July – 9 August). In a study of visiting gulls from a coastal colony to an urban area, Huig et al. (2016) found that the number of visiting gulls varied significantly throughout the breeding season. Huig and her colleagues reported that visiting gull numbers dropped between the settling and laying periods and were lowest in the incubation period. In the rearing period, Huig and her colleagues reported that the number of visiting ringed gulls increased to levels similar to the settling period and remained high in the fledging period. Following from that study, it is predicted that urban population will follow a similar trajectory with regards to an increase in gull abundance during the rearing and fledging periods.

- Mating activity generally begins a bit earlier in cities, as they tend to be warmer than coastal nest sites (Huig et al. 2016). Early signs of mating activity can be seen in late February and early March when gulls begin to identify the nest sites. By early April courtship will have begun and later in the month territories will have been established. From late April into early May nests will have been made and eggs laid. Apart from courtship rituals, which can be noisy, the impact on humans at this time is not too great. However, in June the eggs start to hatch and the adults become more active as they provision for their chicks. Adult gulls with chicks become more aggressive in July and August when their chicks begin to fledge and become highly mobile, as they are very protective. The young chicks, being inexperienced, begin to roam around the streets and the parents dutifully protect them from any potential danger posed by humans. By the end of the summer, the gulls begin to disperse.
- There will be an increase in nuisance events and gull-human conflict during rearing and fledging phases (15 June – 9 August). When the need for gull parents to provision is highest and when the chicks begin to fledge correspond with the height of tourist season. Not only is the typical abundance of Bath residents present, but there will also be crowds of international students, tour groups, and travellers that pack the city in the summer

holiday period. The motivation of gull parents to provision their chicks with a lot of food and highly calorific food will coincide with patio and outdoor dining, providing more opportunities for the gulls to engage in nuisance behaviours, such as raiding. Following from the assumption that there will be more nuisance events later in the breeding season, there may also be more human initiated aggression towards gulls because humans may see more gulls in the city and more gull nuisance and try to shoo them away or dissuade the gulls from being a nuisance to them.

- Humans are mediating the perceived gull nuisance problem by feeding the gulls. The city of Bath has taken a number of actions in order to attempt to reduce gulls being fed by humans. Although there are 55 posters in three different languages throughout the city, it is still evident that humans are feeding the gulls (pers. obvs.). Urban gulls become habituated to humans, especially when they are commonly fed. This leads to some individuals grabbing food from humans who do not intend to feed them. Although gulls stealing food happens regularly, it is worth noting that individual gulls often have feeding specialisations, so not every urban bird will steal anthropogenic food. Many will fly long distances to rural and coastal areas to feed on other foodstuffs (Thaxter et al. 2011). Additionally, the majority of gull feeding takes place out of town for most urban gulls, principally at rubbish tips and large fields (Rock 2005). Far more is known about the feeding habits of urban gulls than the habits of humans who interact with gulls. The majority of papers on gull-human interactions focus on the negative impacts that gulls have on humans, and not what humans are doing to contribute to the problem or how humans are being aggressive towards the gulls.

2. Methods

2.1. Study Species

Figure 1: Adult Herring gull (summer plumage). Image © Emily Beasley

HGs are large birds. Male HGs range in size from 60-66 centimeters in length, and 1050 to 1250 grams in weight. Female HGs are slightly smaller than males, and range from 56 to 62 centimeters in length, and weigh between 800 and 980 grams. HG wingspan ranges between 137 to 146 centimeters (Harrap 2015). Given their large size, many humans find them intimidating or frightening (Ellis 2014).

Plumage in all stages of life is sexually monomorphic. Their heads and underparts are white, and they have light silvery-grey upperparts, hence their scientific name *Larus argentatus* - *Larus* meaning "gull" and *argentatus* meaning "decorated in silver" (Jobling 2010). For a full description of the natural history of HGs see Appendix E.

Figure 2: Adult Lesser Black-backed gull (summer plumage). Image © Emily Beasley

LBs are slightly smaller than HGs, and are similarly sexually monomorphic with regard to plumage pattern and colouration. As with HGs, male LBs are slightly larger than female LBs. These gulls measure between 51 and 64 cm in length, with a wingspan ranging from 124 to 150 cm. Males weigh on average 820 grams, while females weigh around 700 grams (Harrap 2015). LBs have white heads and under parts, and very dark grey upper parts, hence their scientific name *Larus fuscus* - *Larus* meaning "gull" and *fuscus* meaning "dark" or "black" (Jobling 2010). For a full description of the natural history of LBs, see Appendix E.

2.2. Field Site: Bath and Surrounding Areas

The city of Bath (51°22'53.02"N and 2°21'36.51" W), in Somerset, is located south of the river Avon. The river stretches west through rural land and a few villages. The larger city of

Bristol, with a population of 449,300, is located 18 km north-west of Bath ("*Bristol*"). 11 km west of Bristol is the river Severn and its estuary.

Bristol has historically been an important starting place for early voyages of exploration to the New World, and to this day remains an important port city. The city centre docks have been redeveloped as centres of heritage and culture and act to drive some of the tourism in the city. Bristol's modern economy encompasses more than just maritime business and is largely built on creative media, electronics, and higher education. Bristol has two universities, the University of the West of England (UWE) and the University of Bristol, as well as a variety of artistic and sporting organisations (*Visit Bristol*). Bristol is also home to a large population of urban gulls (Rock 2005).

In 1987, Bath became a UNESCO World Heritage Site because of its "outstanding universal value" and cultural attributes. It is known for the Roman remains, especially the Temple of Sulis Minerva and the baths complex ("*Bath*"). At the most recent census in 2011 Bath had a population of approximately 88,859. The city has a number of theatres, museums, and other cultural venues that have helped to make it a major centre for tourism. Annually, more than 4.8 million (1 million staying, 3.8 million day trippers) visitors turn their sights on Bath. The size of the tourist industry is reflected in the near 300 places of accommodation which are offered during peak season. In addition to the multiplicity of accommodations, there are approximately 100 restaurants and a similar number of bars and pubs (*Cultural and historical development of Bath*). Figure 3 below shows Bath in relation to Bristol, the Severn Estuary, the river Severn, and the Bristol Channel.

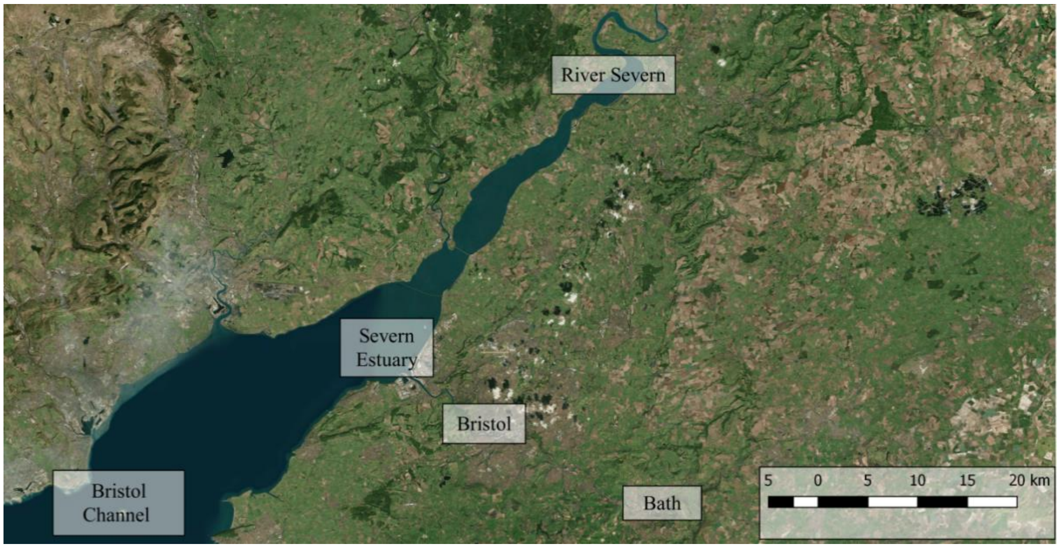

Figure 3: Bath, Bristol, and the Severn Estuary. Data by Bing.com contributors Under CC BY-SA 2.0 license

2.3. Observation Site Characteristics

A pilot study period took place between March 1 and March 31, 2017 in order to establish field sites to observe gull-human interactions. Six study sites were identified because they conformed to one or more of the following criteria: 1) there have been previous reports of gull-human interactions from a person who is not part of the research team (e.g., citizen science or complaints to the local authority), 2) one of the members of the researcher team has personally witnessed gull-human interactions, or 3) gulls were seen consistently in these areas during the pilot period. See Figure 4 (below) for a map of Bath and distribution of the six field sites.

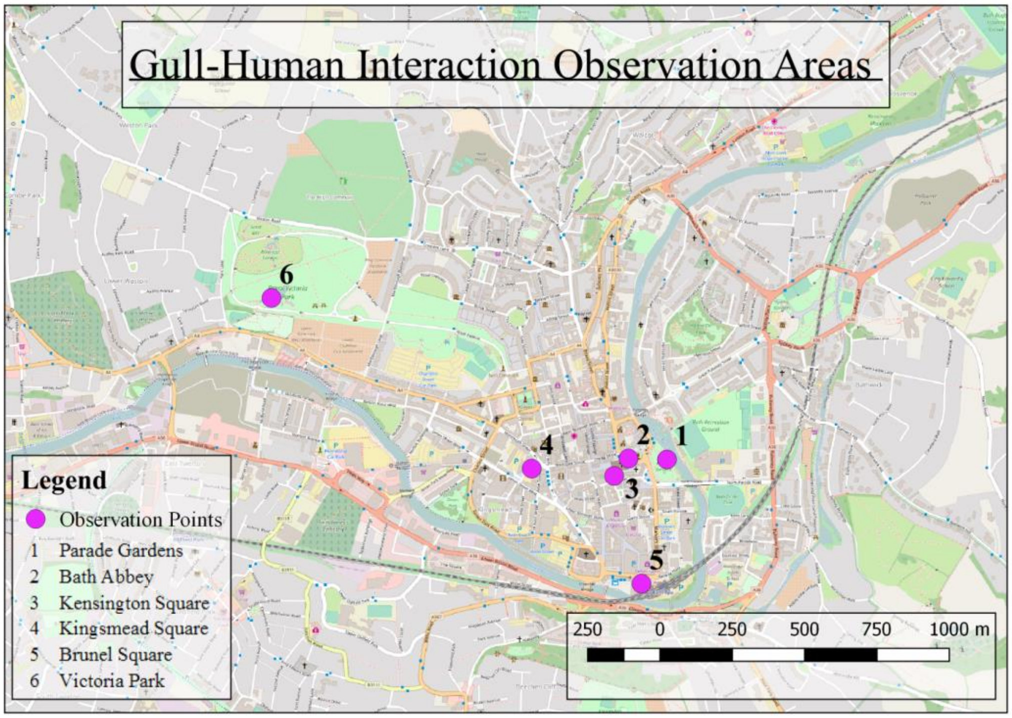

Figure 4. Gull-Human Interaction Observation Areas. Six locations (Parade Gardens, Bath Abbey, Kensington Square, Kingsmead Square, Brunel Square, and Victoria Park) in Bath where behavioural observations were conducted from April to August 2017. Data by OpenStreetMap.org contributors Under CC BY-SA 2.0 license.

The majority of the field sites were located in Bath's central business district (CBD; #1-5 in Figure 4), with Victoria Park (#6 in Figure 4) being a short distance (approximately 1.6 km) from the CBD. All six field sites are different from each other in terms of location, description, proximity to the River Avon, and availability of restaurants and/or coffee shops. The following six subsections will provide photographs and brief descriptions of the six field sites in Bath.

2.3.1. Parade Gardens

Figure 5. The Parade Gardens. © Emily Beasley

The Parade Gardens (#1 in Figure 4) consist of a large lawn, numerous flower beds, a café, and bandstand. The gardens are located centrally and the river can be seen from most vantage points throughout the garden. From June to August the Gardens are open from 10:00 to 19:00 and there is a fee to enter. From October to April the Gardens are open from 10:00 to 16:30 (*"Parade Gardens"*). The Gardens measure approximately 0.57 hectares. The Google Earth Pro (© 2016 Google) polygon tool was used to work out the area visible while conducting observations.

2.3.2. Bath Abbey/Alkmaar Gardens

Figure 6. Bath Abbey and Alkmaar Gardens. © Emily Beasley

Bath Abbey/Alkmaar Gardens (labelled "Bath Abbey" #2 in Figure 4) is comprised of a small round lawn circled by flower beds with a round obelisk in the centre. From the Gardens one can see the rear and one side of Bath Abbey, two restaurants (Browns and Garfunkles), a café, souvenir shops, Orange Grove, Pierrepont Street, and Grand Parade. All three streets (Orange Grove, Pierrepont Street, and Grand Parade) are frequently busy with pedestrian traffic. The observable area from within the Garden is 0.25 hectares. The Google Earth Pro (© 2016 Google) polygon tool was used to work out the area visible while conducting observations.

2.3.3. Kensington Square

Figure 7. Kensington Square. © Emily Beasley

Kensington Square (#3 in Figure 4) is a small square measuring 0.16 hectares. The Google Earth Pro (© 2016 Google) polygon tool was used to work out the area visible while conducting observations. Kensington Square is located along the south side of Bath Abbey. The square is open and has many benches arranged in a square with a large open space in the centre that is often used by buskers. The information centre is located on the east side of the square, there are businesses (including an ice cream and fudge shop) on the south side of the square, the Roman Baths are located on west side of the square, and the Abbey is on the north side of the square. It is a popular place for people to eat their lunch, watch the buskers, or simply sit.

2.3.4. Kingsmead Square

Figure 8. Kingsmead Square. © Emily Beasley

Kingsmead Square (#4 in Figure 4) contains many restaurants and cafés. There is a small open area in the centre with a large chestnut tree. Most days there is a produce truck and stall selling fruits and vegetables in the centre. Occasionally buskers perform, but not with any regularity. There are benches around the square and four of the restaurants have outdoor seating areas. The square measures 0.15 hectares. The Google Earth Pro (© 2016 Google) polygon tool was used to work out the area visible while conducting observations.

2.3.5. Brunel Plaza

Figure 9. Brunel Plaza. © Emily Beasley

Brunel Plaza (#5 in Figure 4) is located centrally and borders the main train station, Bath Spa Station, as well as the bus station. There are restaurants and cafés in the plaza. There is a grocery store and more restaurants across the road. Brunel Plaza is located very near to the Southgate shopping centre. There are permanent benches, temporary lawn chairs (May-August only), and outdoor restaurant seating. The plaza measures 0.22 hectares. The Google Earth Pro (© 2016 Google) polygon tool was used to work out the area visible while conducting observations.

2.3.6. Royal Victoria Park

Figure 10. Royal Victoria Park - pond. © Emily Beasley

Royal Victoria Park (#6 in Figure 4) is the most peripheral of the observational sites. The entirety of Victoria Park is 23 hectares, but the observational site at a small pond in Victoria Park measures only 0.38 hectares. The Google Earth Pro (© 2016 Google) polygon tool was used to work out the area visible while conducting observations. The pond area is surrounded by trees and grass. On one side of the pond there are two benches and on the other side of the pond there are three benches. There are often many mallards, crows, jackdaws, pigeons, and many different species of passerine that frequent the pond in addition to the gulls. There is a large children's park located very near the pond and families and individuals go to the pond to feed the birds.

2.4. Behavioural Measures

The six field sites described above were continuously scan surveyed for gull behaviours on a limited list (behavioural catalogue, see Table 1 below) pertaining to gull foraging and nuisance behaviour, and human provisioning and aggressive behaviour. Gull and human abundance was measured by counting the number of HGs, LBs, and humans present at each site upon arrival and then every 5 minutes afterwards.

Table 1 (below) is the behavioural catalogue that was used for the present research. Each of the behaviours in the catalogue was chosen to examine the foraging, nuisance, or aggressive behaviours of gulls, and the provisioning and aggressive behaviours of humans. All of the gull behaviours (producing, raiding, destruction, and gull to human aggression) are considered to be subordinate measures of nuisance.

Table 1. Behavioural Catalogue. Catalogue of the behaviours that were measured for gulls and humans, including the abbreviations used on the data collection sheet and a brief description of each behaviour.

Behaviour	Abbreviation	Description
Gull Nuisance Behaviour		
Producing	P	A gull takes consumable material into its beak that it has found on the ground, anthropogenic or natural
Raiding	R	A gull takes food directly from a human's hands or from a table where a human is eating or previously was eating
Destruction	D	A single gull or multiple gulls causing damage to human property by biting, ripping, clawing, or defecating on said property
Gull→Human Aggression	$G \rightarrow H_{AGG}$	A gull, or multiple gulls, physically interact with a human, unprovoked
Human Behaviour		
Feeding Gull(s)	F→G	A human, or multiple humans, directly feed or throw food in the direction of a gull or multiple gulls
Human→Gull Aggression	$H \rightarrow G_{AGG}$	A human, or multiple humans, physically interact with a gull, unprovoked

Producing is a behaviour that is not reported frequently in studies of urban gulls, but is equally as important as nuisance behaviours with regards to understanding how gulls are utilising human-made environments. Producing occurs when a gull makes food available by digging or otherwise exposing a food item that it then takes into its beak (Davies et al. 2012). Although *producing* is not a direct nuisance behaviour, some humans may still be unsettled by the mere presence of a foraging gull, and thus may be taken into consideration as both a foraging and nuisance behaviour.

Raiding is one of the most oft reported nuisance events in the media (further discussion on content analysis in the *Discussion* section). *Raiding* is a form of kleptoparasitism and occurs when a gull takes food directly from a human's hand or from a table where a human is eating. It is a behaviour that is clearly distressing to the human(s) involved. It is typically a conspicuous behaviour thereby facilitating its observation. The term 'raiding' is used slightly differently by researchers. Some confine the term to use only when a gull takes food directly from the hands of a human, while others have a broader definition that includes both when a gull takes food from the hands of a human or when a gull takes food from a table where a human is or was eating. Although there is variation among researchers as to what the definition of 'raiding' is, it is widely agreed that 'raiding' is the action of having food stolen. The broader definition of 'raiding' is the one used in the present research.

Destruction is a common complaint among citizens who have put their rubbish bags out on the street for pick up as is (i.e., not in a wheelie bin or gull-proof sack). *Destruction* occurs when a gull rips open or otherwise damages bin bags and human property in an attempt to access food items or resources. Although there are gull-proof sacks provided by the council (Bath &

North East Somerset Council 2016), not everyone uses them, so the gulls continue to have foraging opportunities in the form of rubbish bags.

Gull-human aggression is a behaviour that was included in the present research because it has been reported in news articles as part of the larger gull nuisance issue (e.g., Horton 2016). Animals rarely commit aggressive acts unless in defense of themselves, their territory, or their offspring, or if they are ill. Even so, gull "attacks" are a common trend in media stories pertaining to gulls. An act of *gull-human aggression* occurs when a gull physically interacts with a human for no obvious reason (i.e., unprovoked). Quantifying gull-human aggression is important to understand how often and in what contexts *gull-human aggression* is happening.

Human *feeding* behaviour is of interest because it is thought to habituate the gulls to humans and reinforces humans as a potential source of food. Human *feeding* behaviour explored the human component of gull-human interactions and to get an idea of the extent to which humans are feeding gulls.

Human-gull aggression is of interest because it has not been examined before in studies of gull-human interactions. While gull aggression is often discussed, the human aspect of aggression towards gulls has not been examined. In order to understand the issue of aggression in a balanced manner it is important to look at both the gull and human contributions to aggressive interspecific encounters.

In order to better understand how the urban gulls of Bath were being representing in the media, an exploratory content analysis was conducted using ten articles about urban gulls in Bath (see Appending H for references and links to the articles used). First, a Google search was conducted with the terms "gull," "seagull," "urban gull," "urban seagull," and "Bath." From that search, ten articles ranging from 2003-2017 from six different news outlets were selected. Each article was read and brief notes were made regarding the content. The notes were examined and each item was categorised by a description (see table I1 in Appendix I). Using the coding units that emerged from the main themes, the articles were re-read and the frequency of each coding unit was tabulated. The main themes that emerged regarding urban gulls in Bath were gull as a "threat to public health" appearing 39 times, followed by gulls creating "mess" appearing 17 times, gulls causing "damage" appearing 11 times, gulls making "noise" appearing 10 times, and "kleptoparasitism" appearing 9 times.

Although "noise" appeared as a common theme in news articles and was frequently described as a nuisance, it was not measured in the present research because 1) noise is difficult to quantify and 2) gulls have powerful voices that will carry across the city and it is sometimes difficult to pin down where a gull noise is coming from.

2.5. Procedure

The present research was conducted between April 1 and August 1, 2017. A pilot period was conducted prior to the study from March 1 to March 31, 2017. The pilot period allowed time to trial data sheets and establish gull-human interaction observation sites throughout the city. The research period covered an entire breeding season from settling to fledging (see Table 2 for further description).

Table 2. **Division of study period based on distinct phases of the breeding season (adapted from Huig et al. (2016)).** The study period was divided into five phases of equal length corresponding with major events in the breeding season.

PERIOD	DATE	BREEDING PHASE
Settling	23 March-19 April	Pair formation, courtship
Laying	20 April-17 May	Territory establishment, laying, start incubation
Incubation	18 May – 14 June	Incubation, hatching
Rearing	15 June – 12 July	Young chicks
Fledging	13 July - 9 August	Fledging of chicks, start migration

In order to answer question 1 (*How does the abundance of gulls in the city change throughout different phases in the breeding season?*), patch abundance sampling was conducted across six observation sites throughout the city (see Figure 4). Abundance counts were conducted upon arrival at each site and then every 5 minutes afterwards for 30 minutes. The number of gulls reported throughout each of the breeding phases was compared to see if there was a difference in gull abundance over the course of the breeding season.

In order to answer questions 2 (*Is there a change in nuisance events and gull-human conflict throughout the breeding season?*) and 3 (*to what extent are the nuisance problems associated with this population of gulls mediated by the behaviour of humans?*), behavioural observations took place at the six study sites in the city using the behavioural catalogue developed for the present study. Data were recorded as frequency counts continuously for 30 minute observation periods that ran concurrently with headcounts of HGs, LBs, and humans.

2.6. Analyses

The data were organized by location, so that each location acted as an individual data point, in order to address issues of potential pseudo replication. Pseudo replication was a potential concern because many of the gulls were not individually identifiable (with the exception of a few ringed individuals and two individuals with distinguishing physical characteristics). Because the gulls could not be individually identified it was not possible to know whether the same gulls were being observed or if there were different individuals at each site each day.

The data collected for all variables (variables separated over the five phases of the breeding season: gull population, gull nuisance, all gull nuisance, human population, human feeding gulls, human aggression toward gulls; and mean overall gull population, gull nuisance, all gull nuisance, human population, human feeding gulls, human aggression toward gulls) was explored to test for normality. The main difference between variables, such as all gull nuisance, and overall variables, such as overall gull nuisance, is that the former data are separated into the five phases of the breeding season, and the latter data are not separated into the five phases of the breeding season, but are analysed all together.

The Shapiro-Wilk test of normality indicated that much of the data were significantly non-normally distributed. The Shapiro-Wilk test was chosen over the Kolmogorov-Smirnov test because the Shapiro-Wilk test provides better power than the Kolmogorov-Smirnov test even after the Lilliefors correction. Power is the most frequent measure of the value of a test for normality—the ability to detect whether a sample comes from a non-normal distribution (Ghasemi and Zahediasl 2012). Since the data were already shown to violate one of the assumptions required to perform parametric stats (normality) the decision was made to use non-parametric tests for all statistical analyses. Tables showing the resultant test statistics for the test of normality are attached in Appendix F.

3. Results

The present research was divided into five phases (settling, laying, incubation, rearing, and fledging). Although each of the phases was divided into equal periods of 28 days each, because of scheduling and other time conflicts, there was variation in the number of days of observation conducted. There were 8 days of observation during the settling phase, 10 days of observation during the laying phase, 7 days of observation during the incubation phase, 10 days of observation during the rearing phase, and 8 days of observation during the fledging phase. Because of the uneven distribution of observation days across phases, the analyses were carried out using means rather than other measures of central tendency. The data were skewed, so log and z-transformations were performed in SPSS, but neither transformation significantly changed the skewedness of the data, so the untransformed data were used.

As described in section 2.3, multiple sites were used for data collection. These sites are visibly different (see Figures 5-10) and yielded different results. Multiple sites were included in data collection to get a better idea about where certain gull hotspots were located throughout town. There are some characteristics of these sites (e.g., number of restaurants and/or cafés present) that may have influenced the types of behaviours exhibited by the gulls (see section 4.5.2 for a full discussion on the use of multiple sites in the present research). For all of the below analyses, the data from each of the six sites have been combined in order to be compared across the breeding season.

Question 1: *How does the abundance of gulls found in the study sites change throughout different phases in the breeding season?*

The data collected for number of HGs and LBs were combined to give an aggregate variable of combined abundance of HGs and LBs. The data were combined because there were so few HGs observed across the study period. This new variable measured combined HG and LB abundance at each study site. This count data of gulls was explored graphically and showed an increase in gull abundance during the rearing phase of the breeding season (see Figure 11 below).

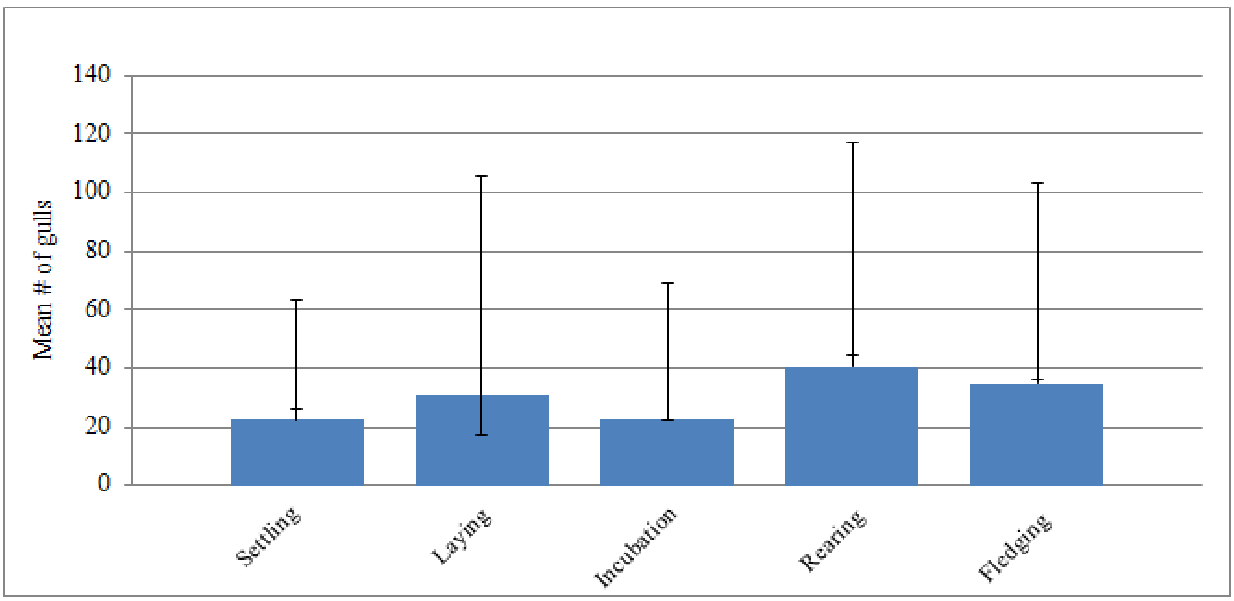

Figure 11. Gull Abundance Across the 2017 Breeding Season. Mean number of gulls observed during the study period across the five phases in the 2017 breeding season. Error bars are 95% confidence intervals.

The pattern of data in Figure 11 suggests that there may be more differences than reported using the means. The pairs that were not formally significant but show interesting differences are: Settling-Fledging (more gulls in the fledging phase than the settling phase), Laying-Rearing (more gulls in the rearing phase than the laying phase), Incubation-Fledging (more gulls in the fledging phase than the incubation phase), and Rearing-Fledging (more gulls in the rearing phase than the fledging phase). See Table 4 below for all comparisons. In order to test these observations formally, a Friedman's two-way analysis of variance was conducted to assess the differences in gull abundance across the phases in the breeding season. A two-way analysis was chosen as the present study is a repeated measures design. There was a statistically significant difference in gull abundance across phases in the breeding season, $X^2(4)=12.133$, $p=.016$. Post hoc analyses with Wilcoxon signed-rank tests were conducted with a Bonferroni correction applied. There were more gulls present in the rearing phase than in the incubation phase (Z=-2.201, $p=.028$) and there were more gulls present in the rearing phase than in the settling phase (Z=-2.201, $p=.028$). There were no significant differences between other phases in the breeding season (see Table 4 below for a summary of the Wilcoxon signed-rank test results). So, although gull abundance was highest during the rearing phase it did not differ significantly from the laying or settling phases.

Table 3. **Summary of Wilcoxon Signed-Rank Test for Changes of Gull Abundance Across Phases in the Breeding Season.** A summary of the pairwise comparisons made between the different phases in the breeding season, the resultant Z scores, and asymptotic significance.

Pair	Z	Sig.
Settling – Laying	-.105	.917
Settling – Incubation	-.105	.917
Settling – Rearing	-2.201	.028
Settling – Fledging	-1.782	.075
Laying – Incubation	-.524	.600
Laying – Rearing	-1.782	.075
Laying – Fledging	-.943	.345
Incubation – Rearing	-2.201	.028
Incubation – Fledging	-1.782	.075
Rearing – Fledging	-1.782	.075

Question 2: *Is there a change in nuisance events and gull human conflict throughout the breeding season?*

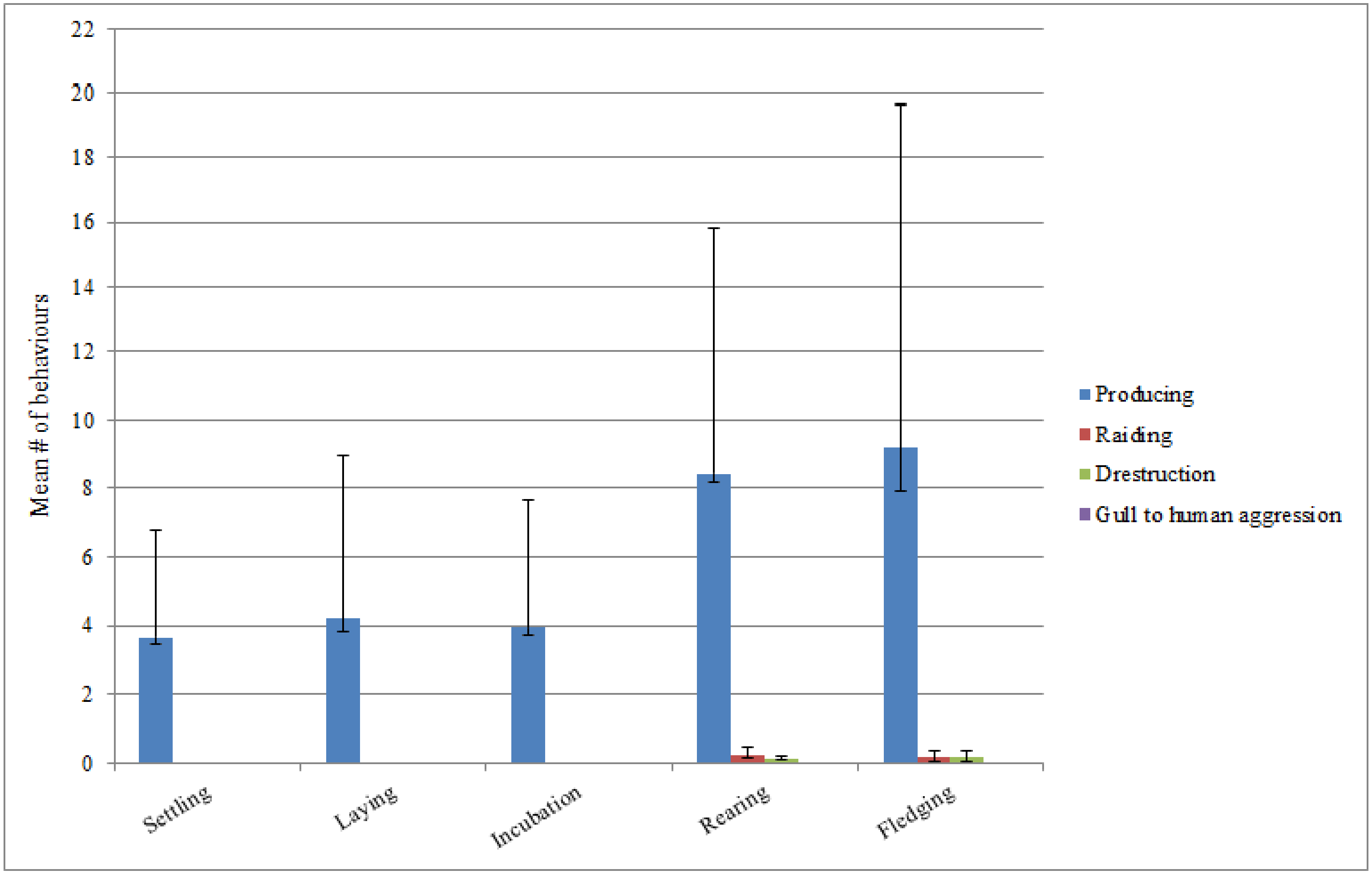

Figure 12. Mean Number of Gull Nuisance Events Across the 2017 Breeding Season. Mean number of gull nuisance behaviours observed during the study period across the five phases in the 2017 breeding season. Error bars are 95% confidence intervals.

Figure 12 above shows the mean number of nuisance events that were observed across the breeding season. It is evident that one behaviour (producing) occurred far more frequently than the other three behaviours (raiding, destructing, and gull to human aggression). For the first three phases in the breeding season the only nuisance behaviour to occur was producing, and even for the last two phases in the breeding season, the other behaviours were seen infrequently. Because there were so few observed instances of raiding or destruction behaviour, the data collected for HG raid, HG destruction, LB raid, and LB destruction were combined to give a new aggregate variable of *gull nuisance*. No gull aggression toward humans was observed during the course of sampling. The frequency data for gull nuisance behaviour was explored graphically and showed that there were no nuisance events in either the settling or laying phase, and that nuisance events occurred most frequently in the fledging phase, with some nuisance events occurring in the incubating, and the rearing phases (see Figure 13 below).

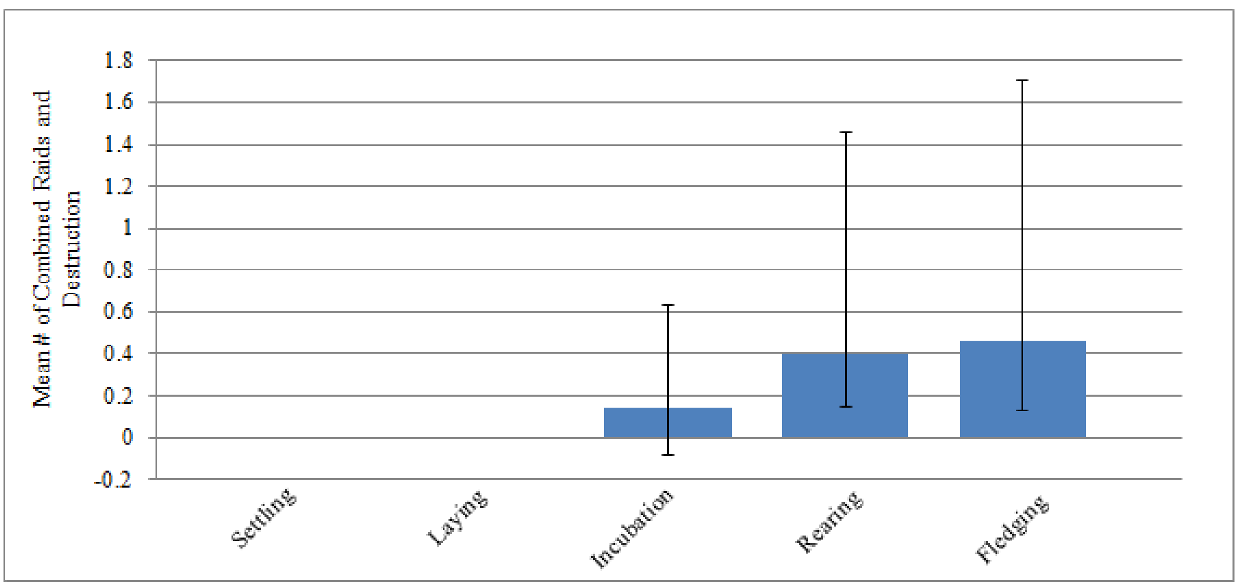

Figure 13Gull Nuisance Behaviour Across the 2017 Breeding Season. Mean combined HG and LB nuisance behaviour (measured as combined raiding and destruction by gulls) across the five phases in the 2017 breeding season. Error bars are 95% confidence intervals.

The pattern of data in Figure 13 suggests that there may be more differences than reported using the means. The pairs that were not formally significant but show interesting differences are: Settling-Incubation (more gull nuisance in Incubation than Settling), Settling-Rearing (more gull nuisance in Rearing than Settling), Settling-Fledging (more gull nuisance in Fledging than Settling), Laying-Incubation (more gull nuisance in Incubation than Laying), Laying-Rearing (more gull nuisance in Rearing than Laying), Laying-Fledging (more gull nuisance in Fledging than Laying), Incubation-Rearing (more gull nuisance in Rearing than Incubation), and Incubation-Fledging (more gull nuisance in Fledging than Incubation). In order to test these observations formally, a Friedman's two-way analysis of variance was conducted to assess the difference in gull nuisance events across the breeding season. There was no statistically significant difference in the mean number of gull nuisance events across the breeding season (X^2=7.2, p=.126). Rates of gull raiding or destruction were very low in each phase: settling ($\bar{x}$=0), laying ($\bar{x}$=0), incubation ($\bar{x}$=0.139), rearing ($\bar{x}$=0.4), and fledging ($\bar{x}$=0.458).

Data were also collected on another variable, gull producing. "Gull producing" is a measurement of HG and LB foraging behaviour at each site. Although there is no direct nuisance or disturbance to humans associated with producing behaviour, the mere presence of foraging gulls may be considered uncomfortable for some people. The data for gull producing was added to the raiding and destruction data to create an aggregate variable of *all gull nuisance*. The frequency data for all gull nuisance behaviour committed by HGs and LBs was explored graphically and showed that many nuisance events occurred in the rearing and fledging phases, and some nuisance events occurred in the settling, laying, and incubation phases (see Figure 13 below).

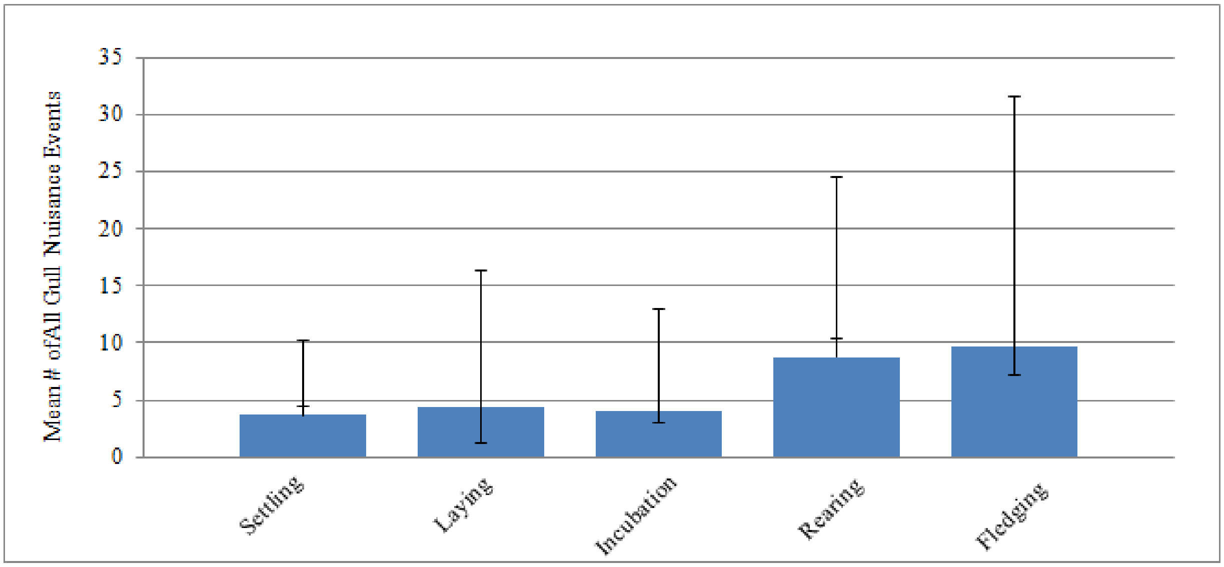

Figure 14 All Gull Nuisance Behaviour Across the 2017 Breeding Season. Mean combined HG and LB nuisance behaviour (measured as combined raiding, destruction, and production by gulls) across the five phases in the 2017 breeding season. Error bars are 95% confidence intervals.

The pattern of data in Figure 14 suggests that there may be more differences than reported using the means. The pairs that were not formally significant but show interesting differences are: Settling-Rearing (more gull nuisance in Rearing than Settling), Settling-Fledging (more gull nuisance in Fledging than Settling), Laying-Rearing (more gull nuisance in Rearing than Laying), Laying-Fledging (more gull nuisance in Fledging than Laying), Incubation-Rearing (more gull nuisance in Rearing than Incubation), and Incubation-Fledging (more gull nuisance in Fledging than Incubation). In order to test these observations formally, a Friedman's two-way analysis of variance was conducted to assess the difference in all gull nuisance events across the breeding season. There was no statistically significant difference in the mean number of all gull nuisance across the breeding season (X^2=6.487, p=.166). Rates of all gull nuisance were still low in each phase: settling ($\bar{x}$=3.646), laying ($\bar{x}$=4.4), incubation ($\bar{x}$=4.001), rearing ($\bar{x}$=8.767), and fledging ($\bar{x}$=9.667).

Data were also collected on the number of times humans initiated unprovoked aggression toward a gull (HG or LB). This was explored graphically and showed that there was some human initiated aggression across the first four phases in the breeding season, and a lot of human initiated aggression in the last phase in the breeding season (see Figure 15 below).

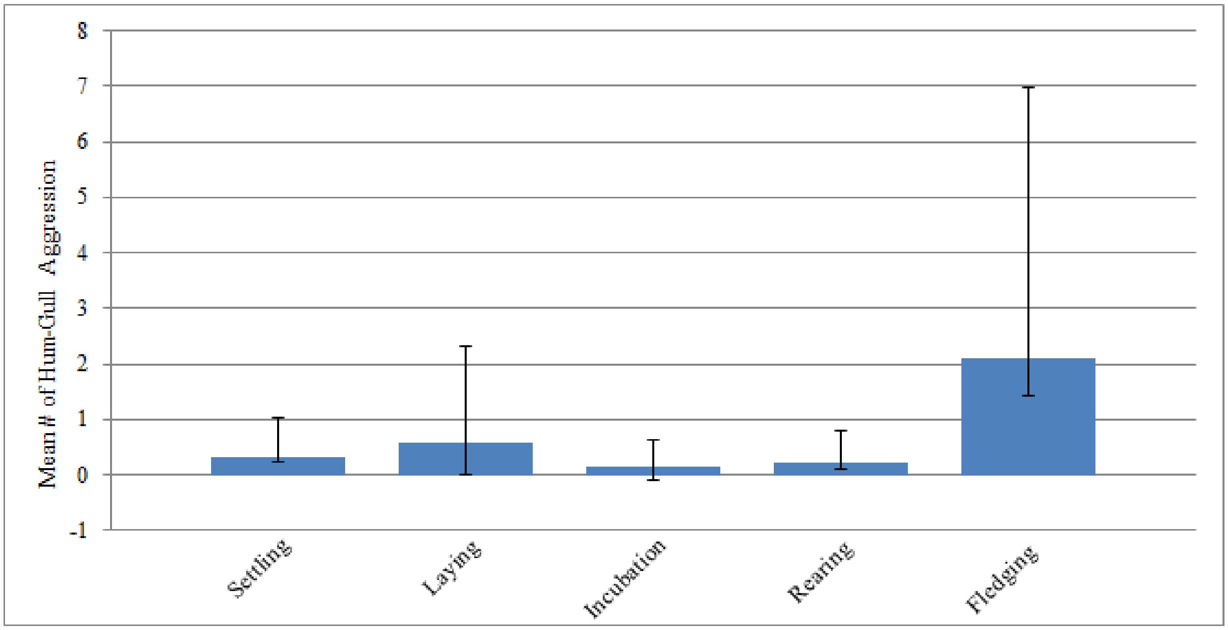

Figure 15. Human to Gull Aggression Across the 2017 Breeding Season. Mean human to gull aggression across the five phases in the breeding season. Error bars are 95% confidence intervals.

A Friedman's two-way analysis of variance was conducted to assess the difference in human aggression toward gulls across the breeding season. There was a statistically significant difference in observed human aggression toward gulls across phases in the breeding season, $X^2(4)=11.347$, $p=.023$. Post hoc analyses with Wilcoxon signed-rank tests were conducted with a Bonferroni correction applied. There were more observed instances of humans being aggressive towards gulls in the fledging phase than the settling phase (Z=-2.023, $p=.043$), the incubation phase (Z=-2.023, $p=.043$), and the rearing phase (Z=-1.992, $p=.046$). There were more observed instances of humans being aggressive towards gulls in the rearing phase than the incubating phase (Z=-2.060, p=.039). There were no significant differences between other phases in the breeding season (see Table 3 below for a summary of the Wilcoxon signed-rank test results).

Table 4. Summary of Wilcoxon Signed-Rank Test for Changes in Human Aggression Toward Gulls Across Phases in the Breeding Season. A summary of the pairwise comparisons made between the different phases in the breeding season, the resultant Z scores, and asymptotic significance.

Pair	Z	Sig.
Settling – Laying	-.365	.715
Settling – Incubation	-1.604	.109
Settling – Rearing	-.405	.686
Settling – Fledging	-2.023	.043
Laying – Incubation	-1.604	.109
Laying – Rearing	-.962	.336
Laying – Fledging	-1.483	.138
Incubation – Rearing	-2.060	.039
Incubation – Fledging	-2.023	.043
Rearing – Fledging	-1.992	.046

A Spearman's rank-order correlation was run to investigate the relationship between mean overall human population and mean overall human aggression toward gulls. There was a strong negative correlation between mean overall human population and mean overall human aggression toward gulls $r_s(4)=-.886$, $p<.05$. Other comparisons were not significant (p>.05).

Question 3: *To what extent are the nuisance problems associated with this population of gulls mediated by the behaviour of humans?*

The initial hypothesis was that certain locations might be associated with gull nuisance behaviour. Further to this it was hypothesized that human behaviour might act as a mediating variable between location and gull nuisance behaviours. For example, human feeding of gulls might increase the likelihood of gull nuisance behaviours in particular locations. However, as discussed above (see *Analyses* subsection in *Methods* section), locations were best treated as individual data points in order to yield independent data. To that end, all behavioural and population variables were organized under location. This meant that a mediation hypothesis could not be explored. However, a bivariate correlation was conducted in order to evaluate how mean overall human population, mean overall humans feeding gulls, and mean overall human aggression toward gulls correlates with mean overall gull nuisance behaviour. A Spearman's rank-order correlation was used. There was a strong, positive correlation between mean overall humans feeding gulls and mean overall gull nuisance ($r_s(4)=.829$, $p=.042$). There were no significant correlations between mean overall gull nuisance and mean overall human aggression toward gulls ($r_s(4)=.543$, $p=.266$), or between mean overall gull nuisance and mean overall human population ($r_s(4)=-.714$, $p=.111$).

A linear regression was calculated to predict mean overall gull nuisance based separately on each of the following: mean overall human feeding gulls, mean overall gull population, mean overall human population, mean overall human feeding gulls, and mean human aggression toward gulls. The only significant regression equation that was found was mean overall gull nuisance predicted by mean overall humans feeding gulls. All other linear regressions were not significant ($p>.05$). A significant regression equation was found ($F(1,4))=71.072$, $p=.001$, with an R^2 of .947 and an adjusted R^2 of .933. Predicted mean overall gull nuisance is equal to 3.222+.422 *gull nuisance* events when mean overall humans feeding gulls is measured as the mean number of times humans feed gulls. Overall gull nuisance events increased by .422 for every instance of humans feeding gulls. See Table 9 below for a summary of the coefficients.

Table 5. Coefficients. The adjusted R^2, standardized beta, lower and upper bounds of the 95% confidence interval, asymptotic significance, and the intercept of the linear regression that was calculated to predict overall gull nuisance based on mean overall human feeding gulls.

			95% CI for Beta			
Model	Adj. R^2	Std. Beta	Lower Bound	Upper Bound	Sig.	Intercept
Constant	.933	-	1.220	5.224	.011	3.222
Mean Overall human feeds	-	.973	.283	.561	.001	.422

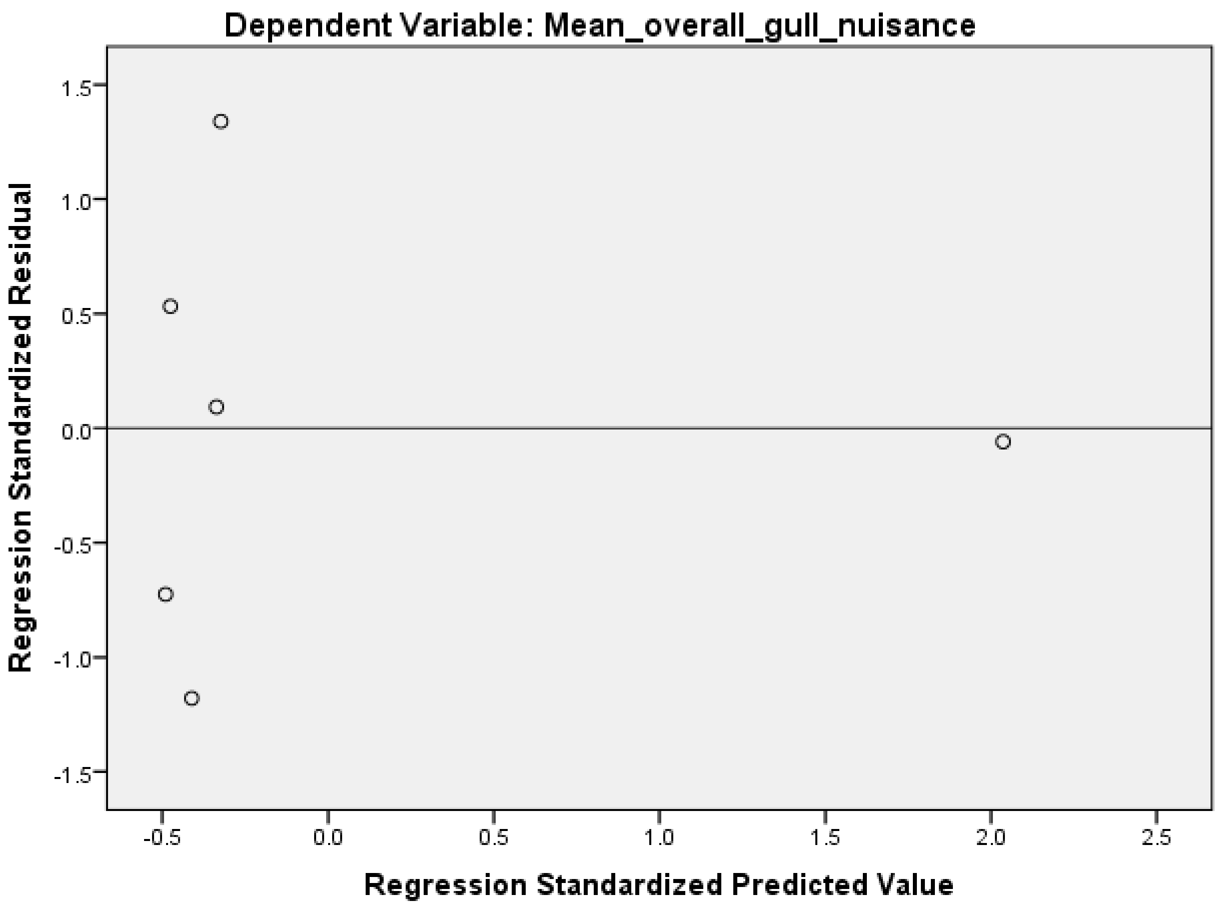

Figure 16. Residuals Plot for Relationship between Mean Overall Gull Nuisance based on Mean Overall Human Feeding Gulls.

The main purpose of examining residuals in a regression is to: "1) isolate points for which the model fits poorly, and 2) isolate points that exert an undue influence on the model," (Field 2009, p. 292). In the above graph, all of the points are clustered around the lower single digits (between -1.5 and 1.5) and there is not a clear pattern to the distribution of the points, which indicate that the relationship between X and Y is best described as linear.

4. Discussion

4.1. Population changes across the breeding season

The prediction that the abundance of gulls would peak during the rearing phase in the breeding season (20 April – 17 May) and then remain the same until fledging (20 April – 9 August) was partially supported. There were more gulls observed during the rearing phase than the settling or incubation phases, but there was no significant difference in the number of gulls observed in the rearing phase compared with the number of gulls observed in either the laying or fledging phase.

The examination of differences in gull abundance across the breeding season, conducted as part of this study, sought to test the assumptions of previous research (e.g., Huig et al. 2016) and provide insight into changes in urban gull population dynamics. This was to be achieved by examining the abundance of HGs and LBs in a city known to have a breeding population of HGs and LBs, Bath. The failure to find more differences between the phases than the ones listed above may have been a consequence of the site locations and the fewness of sites chosen. That there were more gulls observed in the rearing phase partially conforms to the original hypothesis that there would be more gulls during the rearing and fledging phases, although as originally predicted, there was not a difference between gull abundance in the rearing phase and all other phases, and there were no statistically significant differences found between the fledging phase and the other phases in the breeding season. One explanation for the lack of statistically significant differences between the fledging phase and the other phases may be that some of the adults who had already fledged chicks may have begun their migration early. Some LBs have been noted as beginning their migration as early as July (Wernham 2002).

It could also be argued that the lack of change in the abundance of gulls may indicate that the population of gulls in Bath that are exploiting the study sites are resident birds. If they are predominantly resident birds, then they are likely the same birds, or among the same birds, that are returning to each site regularly. There may not be many gulls coming into Bath from outside the city to forage as there are other foraging opportunities (e.g., crop and livestock fields, ponds, other sections of the River Avon, etc.; pers. obvs.). Since most of the gulls are not individually identifiable, it cannot be known for certain if the same gulls are 1) returning to the same sites, or 2) defending these sites, but gulls were witnessed chasing other gulls away from foraging patches throughout the breeding season. At one site, Bath Abbey/Alkmaar Gardens there was one gull that was identifiable because its left foot was permanently disfigured. This disfigured HG was witnessed repeatedly chasing other gulls away from the grassy patch of the Alkmaar Gardens throughout the breeding season.

4.2. Changes in nuisance events and gull-human conflict across the breeding season

The prediction that gull nuisance events would increase during the rearing and fledging phases was not supported. Very few nuisance events took place over the entire breeding season. It should be noted, however, that when the combined variable of gull raiding and destruction was examined, no nuisance events happened at all in the settling or laying periods and very few events transpired in the incubation phase. There was an increase in the mean number of gull raids and destruction events occurring during the rearing and fledging phases, but because so few events happened at all it was not statistically significant. A similar pattern is revealed when producing behaviour was added to the aggregate variable of gull nuisance. Although more nuisance events did happen with the inclusion of producing data, there were still few observed nuisance events and no significant differences were found.

The examination of differences in gull nuisance across the breeding season, conducted as part of this study, sought to test the assumptions of previous research (e.g., Huig et al. 2016) and provide insight into changes in urban gull nuisance behaviour. This was to be achieved by examining the nuisance and foraging behaviours of HGs and LBs in a city alleged to have a nuisance population of HGs and LBs, Bath. The failure to find a statistically significant difference is likely a consequence of a number of factors, including limitations of the present study discussed below. This was an underpowered study and perhaps with more study sites there would have been a statistically significant difference. The lack of a statistically significant difference across phases in the breeding season with regards to changes in gull nuisance behaviour may also be because Bath does not have a population of gulls that engages in a lot of nuisance behaviour. It is possible that the residents, council, and media have entered into a moral panic situation and have developed an illusory correlation where the alleged problem of gulls seems much greater than it objectively is (full discussion on moral panic and illusory correlation below).

The prediction that gull-human conflict would increase during the rearing and fledging phases was partially supported. There were more observed instances of human-to-gull aggression in the fledging phase than in the settling, incubation, or rearing phase, and there were more observed instances of human-to-gull aggression in the rearing phase than the settling phase. The initial reasoning behind the hypothesis that human to gull aggression would increase as the breeding season went on was based on the assumption that there would be more gulls at the study sites which would lead to more opportunities for gull nuisance at the study sites. It had been assumed that there would be more gulls at the study sites as the breeding season went on because there would be more pressure on the parents to provision their chicks with more food and more calorific food as the chicks grew. There were more gulls present during the rearing phase than settling or incubation phases, and there was more human to gull aggression during the rearing phase compared with the incubation phase, but there was also more human to gull aggression during the fledging phase than the settling, incubation, or rearing phases. A possible explanation for this increase later in the season, even when it does not correspond entirely with increases in gull population or nuisance behaviour, may be that humans have been primed to believe that gulls will steal their food and attack them, ideas propagated by the media. This possible explanation fits in with the idea of moral panic mentioned above and discussed below.

Another interesting observation was that human aggression towards gulls was strongly and negatively correlated with human population. The fewer humans present, the more likely that a given human would act aggressively towards the gulls. This may be because violence towards animals violates a social norm that is held in high regard in UK society: do not abuse or mistreat animals. Additionally, there is legislation, such as the Animal Welfare Act (2006) and the Wildlife and Countryside Act (1981) which offer stiff penalties to humans who injure or kill animals. Animal welfare issues have also concerned Labour (*Labour: Protecting Animals*) and Conservative (*Conservative Party Manifesto*) politicians, as reflected in their statements during the 2015 election.

4.3. Human-initiated aggression and gull-initiated aggression

As part of addressing the issue of how gull-human conflicts change across the breeding season, the plan was initially to compare human-to-gull aggression and gull-to-human aggression. However, over the course of the entire breeding season never once was gull-to-human aggression witnessed. Perpetrators of human-to-gull aggression were varied, from young children to elderly men. As part of the initial study design demographic data on perpetrators of human-to-gull aggression were not to be formally collected. Any demographic data collected were written in supplementary notes on the data sheets. It would be interesting to examine demographics of people who are aggressive towards gulls in future research.

There were two peaks in human to gull aggression, the first being near the beginning of the breeding season during the laying phase, and the second being at the end of the breeding season during the fledging phase. There were far more instances of human to gull aggression during the fledging phase ($\bar{x}$=2.104) than any other phase ($\bar{x}$<.6 for all other phases). It could be speculated that the peak of human to gull aggression in the laying phase could be due to people recognising that the gulls are returning to the city and building nests and trying to disrupt the gulls before their eggs hatch. Personal communications with multiple Bath residents (all of whom wish to remain anonymous) indicate that this happens to some extent, with some residents admitting that they have thrown shoes or other objects at nesting gulls in an attempt to get them to move.

These two peaks also correspond with increased negatively-framed gull stories in local media. As will be discussed in the *Moral Panic* subsection of the present research, media outlets contribute to residents' concern over issues, such as gull nuisance. So, increased media reports along with humans attempting to dissuade the gulls may explain why there is a peak at the beginning of the breeding season. Increased and prolonged exposure to media reports across the breeding season may explain why there is an increase in human to gull aggression at the end of the breeding season: humans think there are more gulls, they have been told that these gulls are a problem, and the humans are fighting back against an imagined threat (i.e., the gulls).

4.4. Human behaviour

The examination of gull nuisance behaviour in relation to human feeding behaviour, conducted as part of this study, sought to test the assumption that humans are in some way contributing to or mediating gull nuisance behaviour. This prediction was supported. There was a strong positive relationship between humans feeding gulls and gull nuisance behaviour. This finding should not be surprising given that one of the components of gull nuisance was producing, a measure of foraging behaviour. Gulls will forage where there is a known food source, so if there is a large gathering of gulls being fed by humans that will attract more gulls. If there are a large number of gulls foraging in an area where humans are or recently were feeding them, and assuming that producing is nuisance behaviour, then there will be more nuisance gulls where there is an abundance of food or the most reliable food source. One of the study sites, Victoria Park, was near a large playground where many kids and families were witnessed while walking to and from the Victoria Park field site. A popular activity among families appeared to be visiting the pond and feeding whatever birds (usually a mix of ducks, pigeons, corvids, and gulls) were around. Although some locations seemed to provide better opportunities for humans to feed gulls (e.g., Victoria Park) humans were witnessed feeding gulls at all six sites.

Overall, the assessment of urban gulls in Bath has failed to establish that there is a significant nuisance gull problem in Bath. Among the significant results that have been discovered throughout the course of the present study, human behaviour has figured prominently as a factor that may be contributing to some gull nuisance behaviour. Further research is required to determine the extent to which humans are contributing to gull nuisance behaviour. Future research should focus on gathering more demographic information about humans who feed or aggressively interact with gulls, as well as examining restaurant table clearing practices to see if some restaurants are more proactive in avoiding potential gull raids. More on future research will be discussed in the *Future Research* section to follow.

4.5. Limitations

4.5.1. Challenges associated with abundance counts

At the inception of the present research, it was planned to get an abundance count of the entire population of roof-nesting gulls in Bath fortnightly over the course of the entire breeding season instead of patch sampling at my six locations across the city. The most often used census unit for estimating the number of breeding pairs is either Apparently Occupied Nest (AON) or Apparently Occupied Territory (AOT). These census units prove to be challenging in some urban areas, and “in areas such as Bath, the complexity of the roofscape means that many nests are missed, even using multiple vantage points,” (Ross et al. 2016, p.11). So, the suggested census method for urban areas is to count the birds of breeding age on rooftops and to infer unseen nests from the number of adult birds (Ross et al. 2016). Following from methods described by the British Trust for Ornithology’s (BTO) review of methods for surveying urban birds (Ross et al. 2016) and recommended by Walsh et al. (1995), vantage points were investigated and transects were walked through the city during the pilot period to see if an overall population census was feasible. The route that was walked was over 20 km and covered an area of approximately 84 hectares. This was a time consuming practice and there were other challenges associated with trying to do a citywide gull census which will be discussed below.

There were a number of challenges associated with these methods of survey: one of the key challenges with surveying urban gull populations is the visibility of nests and accessibility of nesting sites to surveyors. Nests commonly occur atop residential buildings and other tall structures which means that they are often not visible from ground level. However, as urban structures are often complex (e.g., overhangs, chimney stacks, etc.), birds may be well concealed not only from the ground, but also from vantage points or remote platforms, so any counts are likely to underestimate the true numbers (Coulson and Coulson 2015). This is true in many cases even when multiple vantage points are covered. In the case of the present study, counts were attempted while walking transects through town (i.e., on the ground) and from various vantage points (e.g., on top of Bath Abbey) and there were still some rooves which could not be seen fully. Bath is comprised almost entirely of Palladian and Georgian style buildings, which are highly variable, but are typified by proportion and balance. Bath is characterised by terraced houses with peaked rooves and crescents (e.g., the Royal Crescent, Camden Crescent, and Lansdown Crescent) and there are many places where a nest could be concealed on such rooves.

In a study by Coulson and Coulson (2015) which assessed the accuracy of urban nesting gull survey methods, it was reported that vantage point and street surveys missed many nests. Vantage point surveys detected a maximum of 78% of nests, and street surveys detected a maximum of 48% of nests (Coulson and Coulson 2015). Combining both methods raised the efficiency to a maximum of 88% detection, but detection rates still varied greatly in different locations.

Buildings with a series of pitched roofs (like those in Bath) are particularly difficult to survey (Sellers and Shackleton 2011). Direct access to all of the rooftops was either restricted or unsafe, which limited the feasibility of direct sampling methods. Furthermore, there were challenges in estimating the size of the breeding population because of nest removal from a company hired by BANES and potentially from residents illegally removing nests from their property (Calladine et al. 2006). Therefore, the choice was made to use patch sampling as a method of population estimation.

There are countless areas in the city of Bath that are potential gull nuisance hotspots and it cannot be known if the patches that were chosen for the study were truly representative of the population of gulls foraging in Bath unless further research into gull nuisance is conducted in Bath. The six sites that were chosen for the present research were used because of known gull nuisance events (review section *2.3. Observation Site Characteristics* for a more detailed list of field site criteria), although there were other sites known to be gull nuisance hotspots. If there had been a larger team of researchers and research assistants, all known gull nuisance hotspots would have been covered, but there was only one researcher conducting field work for the present dissertation. With only one person in the field, it was decided that covering six main sites spread out across Bath three times per week was feasible.

4.5.2. Multiple Sites

As described in section 2.3, multiple sites were used for data collection. These sites are visibly different (see Figures 5-10) and yielded different results. As mentioned in section 3, multiple sites were included in data collection to get a better idea about where certain gull hotspots were located throughout town. Some of these sites were similar in appearance, while others differed greatly. Five of the six sites were located within the CBD, with only the Victoria Park site being found outside the CBD. Characteristics of Victoria Park, such as its openness, the inclusion of a small body of water, and its proximity to both natural and anthropogenic food sources, meant that it often attracted the greatest numbers of gulls and the greatest amount of producing behaviour.

Some of the sites were similar in terms of lay out and amenities available. Of the sites that were similar, Kingsmead Square and Brunel Plaza were among the most similar in terms of types of behaviours typically observed, numbers of gulls typically observed, and building types. While there were not typically many gulls present in either Brunel Plaza or Kingsmead Square, the majority of raiding and destruction behaviour occurred in these two sites. Both of these sites had many restaurants and cafes, as well as seating for customers to eat outside. The outdoor seating provided many opportunities for raiding.

There were very few gulls and very few nuisance behaviours observed in Parade Gardens and Kensington Square. Both areas had many benches and areas for people to sit, but even though people were observed eating food in both locations, raids were very uncommon. This may be because there were no tables on which people could put their food down or leave food scraps and most of the observed raids occurred from tables where people were eating or had recently vacated.

The Alkmaar Gardens site was interesting because it was where one of the individually identifiable gulls was often seen. This gull, a HG with a foot deformity, was often observed producing on the grass in the centre of the site. Throughout the summer, people often sat on the grass and would eat their lunches there. Many people were observed feeding this gull, which may be one of the reasons it continued to forage there. This gull was sometimes seen defending its patch and would chase some of the other gulls away. Although other gulls had been observed defending food items, it cannot be known to what extent other gulls were defending patches because most of the gulls were not distinguishable from one another.

There are many differences among the sites that were not taken note of during the present research. For example, the abundance counts were of humans that were seated or standing still in the observation site, but counts of humans walking through were not made. This may have impacted on the likelihood of a gull foraging in a given location. In a site such as Kensington Square, which is located near a prominent tourist attraction (Bath Abbey), there were many people sitting on the benches, but there were also a great number of people walking through. In a closed park, such as the Parade Gardens, this was far less likely and people generally sat on the grass or the benches, making foot traffic less of an occurrence. Although urban birds tend to have shorted FID, human movement still impacts on their ability to forage (McGiffin et al. 2013). Future research may be well served in including counts of pedestrians walking through sites to measure how this impacts on foraging.

Among other possible issues with multiple sites include differential recruitment of birds, varying size of the sites, differential access of gulls and humans to the sites, food availability and type, and species type and abundance.

The present research may have been well-served by the use of a stratified site design. Stratified site designs can be used if there is prior knowledge about a species or an area to be surveyed in order to sample more effectively. Stratification involves breaking down an area of interest into sub-areas, known as ‘strata.’ While implementation of a stratified site design often improves precision of abundance counts, selection of strata is clearly dependent upon some prior knowledge or well-founded assumptions about the distribution of the study species (Gregory et al. 2004). There was not enough known about the distribution of the population of gulls in Bath or their foraging habits to properly implement a stratified site design. With more research into the urban gulls of Bath this may be a strategy that can be implemented in future research. See Gregory et al.’s (2004) book *Bird Census and Survey Techniques* for a further discussion on stratified site designs.

4.5.3. Power

The present study was underpowered because of the modest sample size (N=6) and this may have factored into limiting the significance of some of the statistical comparisons conducted. A *post hoc* power analysis revealed that an N of approximately 57 would be needed to obtain statistical power at the .95 level (see Appendix G for the G*Power (Faul et al. 2009) output). In order for a study with 57 sites to be feasible, there would need to be more researchers and research assistants to conduct the behavioural observations. One of the consequences of the present study design, small sample size, and low power was that the confidence intervals were wide and some were negative. Any conclusions that might be drawn from this research will need to be replicated with a larger sample size. As discussed above, the number of sites chosen and the duration of observation were manageable for one person to cover in the time frame of the present study.

It should be noted that increased sample size does not necessitate an increase in behaviours. There are individual differences among the gulls which may impact on the research regardless of how many sites are surveyed. Individual differences among gulls may include differences in personality (e.g., how they vary in terms of boldness or shyness), their choice of foraging sites (e.g., more inclined to highly anthropomorphised environments such as Brunel Plaza, or more inclined to less anthropomorphised environments such as Victoria Park), and food type preferences (see Washburn et al. 2013 for a further discussion on urban-coastal food preferences among gulls).

4.5.4 Limitation of Preregistration Ambitions

The present research was preregistered (see Appendix B for preregistration document) and there were some differences in the execution of the present research with how it was initially conceived and planned. Some of the planned methods that were preregistered were shown to be difficult or unfeasible after the pilot period and were therefore changed. Below is a brief account on the differences between the preregistration ambitions and the final execution of the present research.

It had been planned to get an abundance count of the entire population of roof-nesting gulls in Bath fortnightly over the course of the entire breeding season instead of patch sampling at my six locations across the city. Because of the nature of the roofscape and time limitation, it was decided to use patch sampling as a proxy for changes in gull abundance. See subsection *4.5.1. Challenges associated with abundance counts* above for a full discussion on the challenges associated with abundance counts. Future research would be well-served by conducting smaller-scale abundance counts on sub-sections of the population of Bath gulls. This may be carried out by ringing a certain number of birds or using GPS tracking units to follow those individuals over the course of the breeding season.

4.6 General Discussion

4.6.1. Moral Panic

Moral panic is an idea originally postulated by sociologist Stanley Cohen in his (1972) book *Folk Devils and Moral Panics.* Moral panic can be defined as "a situation in which public fears and governmental interventions greatly exceed the objective threat posed to society," (Bonn 2015, p.1). The focal point of a moral panic is a particular individual or group of individuals that allegedly created some kind of threat.

Cohen (1972) stated that there are at least five sets of social actors that are involved in a moral panic: 1) Folk devils: the targeted individual or group that is allegedly responsible for creating a threat to society, 2) rule/law enforcers: people in positions of authority (e.g., police, prosecutors, policy makers) that are charged with upholding the rule of law, 3) the media: powerful actors in situations of moral panic because their coverage and framing of certain events involving alleged folk devils is distorted or exaggerated, 4) politicians: elected or appointed officials tasked with presenting themselves as protectors of the moral high ground in society, and 5) the public: people in society who react to propagation of folk devils. Moral panics arise when the media presents a distorted view of a group to create fear, reinforce stereotypes, and exacerbate pre-existing divisions between the public and the folk devils. However, a moral panic can only exist if there is an outcry from the public over the alleged threat posed by the folk devils. The public are the most important agents in the creation of a moral panic and the success of the other propagators of moral panic is contingent upon the level of concern and outrage toward the folk devils experienced by the public (Cohen 1972).

Historically, humans have always filled the role of folk devil, but there is no reason why animals (e.g., gulls) could not be considered “responsible” for creating a perceived threat. One of the distinguishing characteristics of a moral panic is that there is focused attention on the behaviour (real, exaggerated, or imagined) of a certain group of individuals. These individuals are transformed into folk devils. Urban gulls have featured extensively and almost exclusively negatively since the early 2000s (e.g., *Seagulls 2007*), with some news outlet claiming that urban gulls have been a problem in the UK since the 1970s (*The awk, awk, awk-ward squad*). Increasingly, the media has stripped gulls of all favourable characteristics and replaced them with exclusively negative ones, such as “there is a worrying threat to public health in Bath from our very large urban gull population,” (Petherick 2017a) and proclaiming that the urban gull problem has “gotten out of hand,” (*The awk, awk, awk-ward squad*). In Bath, it has even gone as far as reporting misleading statistics about the harmful nature of gull with regard to food safety (e.g., Petherick 2017a).

Another distinguishing characteristic of moral panics is that there is a gap between the concern over the alleged threat posed by folk devils and the objective threat (if there is one) that they pose. Typically, the objective threat is far less than publically perceived due to how it is presented by the media and how politicians and law enforcers respond to the supposed threat (Cohen 1972). As demonstrated in the content analysis above, “threat to public” was the most commonly occurring theme in news stories, yet the data collected for the present dissertation suggests that gull aggression, attacks, or general threat to bodily harm or physical health is very uncommon in Bath.

In 2015 the Prime Mister of the UK called for a nationwide "big" conversation about urban gulls and countless publications have vilified any and all *Larids* in the UK (e.g., Audley 2015, *Here's proof that seagulls are the devil incarnate*). In Bath, the story is no different, as demonstrated by the above content analysis. The Bath Chronicle, a local news outlet, has been a primary propagator of gulls as folk devils. Bath Chronicle has published stories about gulls with such statements as, "Eating outside in Bath is a dangerous game," (Petherick 2017b), and implying intentionality to the gull nuisance behaviour, "The sqwark is also used, to great effect, to wake up a resident whenever the gull chooses," (Petherick 2017b). As demonstrated by the results of the present study, there are very few instances of gull nuisance, even fewer when the various aspects of "nuisance" are separated out and examined individually. When gulls raid a table of food, they often wait until the people who were eating leave the table and descend before the servers can clear the table (pers. obvs.). That is not to say that gulls never swoop down and take food directly from a human's hand although this happens comparatively rarely and was only observed once throughout the entirety of the present study.

A final characterisation of moral panic is that there is often a great deal of fluctuation over time in the level of concern over the perceived threat posed by the folk devils. Upon discovery of a threat there is often a rapid rise and then peak in public concern. This concern subsequently subsides over time, but before it does public hysteria over the perceived problem often results in the passing of legislation that is highly punitive, unnecessary, and only serves those in a position of power or authority (Cohen 1972). As recently as April 2017, Bath residents and some BANES councillors have called for a city-wide gull cull (Petherick 2017a). Gulls are a protected species under the Wildlife and Countryside Act (1981) and a cull can only be instated under very specific conditions regarding public health and safety. Claims of gulls transmitting harmful bacteria have been spread in order to build a case for a gull cull (e.g., Petherick 2017a). A cull is a large scale, highly punitive, and grossly disproportionate reaction to gulls nesting in the city. There are a number of factors that contribute to higher levels of food poisoning in the summer (e.g., temperature that food is kept, eating outside, personal hygiene practices, etc.) and there has not been conclusive research demonstrating a strong link between gulls in Bath and increased bacteria in food.

Moral panic is both a public and political response to an exaggerated threat posed by a supposedly harmful group. Moral panics do not happen spontaneously, but rather result from a complex interplay among several social actors. For the Red and Amber listed gulls, being presented as folk devils could be catastrophic for their UK breeding population. The level of nuisance, violence, and amount of damage caused by urban gulls in Bath has been greatly exaggerated. If the council is successful in implementing a cull of gulls in Bath it cannot be known how 1) that will affect the reported nuisance behaviour of gulls, or 2) how that will impact on the overall population of gulls in the UK. If a cull is allowed and Bath sets a precedent for other towns to implement a cull the results could be devastating for an already-declining population of gulls.

4.6.2. Illusory Correlations

An issue related to moral panic about gulls in Bath is the concept of illusory correlation. The idea of illusory correlation was originally posited by Loren Chapman in his 1967 paper *Illusory correlation in observational report.* An illusory correlation is a type of cognitive bias wherein people tend to overestimate the relationship between two groups or types of behaviour.

Following from the results of the present study, Bath does not appear to have a problem with urban gulls that is as severe as originally thought or propagated by the media. However, residents err in making a correlation between the gulls and violence or nuisance. Salience (i.e., the availability of information) is another contributor to illusory correlation. Salience is often used to estimate how likely an event is or how often it occurs (Plous 1993). Some pairings, such as gulls and kleptoparasitism, may come more easily and vividly to the mind even if they are not especially frequent, as shown by the present study. Media contribute to the salience of an idea because their stories are often framed in a certain way and prime people to think about the gulls in a certain way. News stories about gulls are sometimes presented with evocative titles such as "Killer Seagulls: The seaside gets seriously scary," (Audley 2015) or "Here's proof that seagulls are the devil incarnate" (*Here's proof that seagulls are the devil incarnate*), or taglines like, "Bolder, and reportedly bigger and more aggressive than ever before, the flocks of gulls nesting along British coastlines this summer are more interested in blood than bacon sarnies," (Audley 2015), which only serve to incite fear into the public and prime them to think that all gulls are terrible. After being primed with the image of gulls being "the devil incarnate" or "interested in blood," it is no wonder that an illusory correlation may exist in the minds of Bath residents about gulls and the level of violence they allegedly commit. In the entire five months of piloting data sheets and data collection, never once was gull to human aggression witnessed.

4.6.3. Ecological Traps and Other Conservation Concerns

Ecological traps refer to a scenario in which human habitat modification gives the impression of suitability to a species when in fact the habitat is unsuitable or has deteriorated (Dwernychuk and Boag 1972). Adaptive evolution leads to greater success for individuals that match behaviours, such as habitat selection and patch use, with fitness. In the case of ecological traps, mismatches occur when organisms are constrained from making otherwise adaptive decisions, or when individuals misinterpret cues of habitat quality (Dwernychuk and Boag 1972, Schlaepfer et al. 2002, Hawlena et al. 2010).

A review of the literature on ecological traps by Robertson and Hutton (2006) provides guidelines for demonstrating the existence of an ecological trap. A study must show: 1) a preference for one habitat over another, and 2) that individuals selecting the preferred habitat have lower fitness. It is possible that urban gulls are in an ecological trap, but there is very little known about productivity, fitness, and longevity of gulls in urban areas compared to their coastal counterparts. What is known is that gull species in the UK (especially HGs and Kittiwakes) are seeing a severe decline in their populations (Eaton et al. 2015). It has also been reported that more gulls are moving into urban areas, feeding on anthropogenic food, and rearing chicks in the built up environment. Determining how resource use affects gulls is important, especially in anthropogenic environments which often encroach on previously natural environments. If changes result in gulls consuming foodstuffs of reduced quality, then there may be adverse effects to productivity and longevity. Figure 17 below shows an adult LB regurgitating bread for a chick. According to the RSPB, bread does not contain many of the necessary protein and fat required by birds and does not confer much nutritional benefit (*Household Scraps*). Other challenges faced by urban gulls include culling, egg oiling or destruction, motor vehicle collisions, and predation by dogs (*Canis lupus familiaris*) and urban foxes (*Vulpes vulpes*).

Figure 17. LB adult feeding chick anthropogenic food. An adult LB nesting in Bath regurgitating a bread product of unknown origins to a chick. Photo © Chris Pawson

Ecological traps possibly act in concert with other sources of population decline, so they are an important research priority when dealing with birds of conservation concern. Given the rapid rate of climate change and urbanization, ecological traps may be more prevalent than is realised and it will be important to examine the proximate and ultimate causes of traps to avoid further population decline (Kotler et al. 2016). It is only speculation at the moment that urban gulls are in an ecological trap, and long term studies will need to be conducted in order to assess urban environments as an ecological trap for gulls or it will not be known. However, as previously discussed, there are a number of challenges associated with studying and surveying urban gulls, such as difficulty estimating true population size.

In order to assess population well-being using behavioural measures, indicators used should be easy to measure, respond quickly to environmental change, and forecast the future. Measurements of population size are often used, but for urban gulls this presents many challenges and such metrics do not always respond quickly to changes in the environment. Gulls are long-lived species and, as such, may respond very slowly to changes in the environment. Additionally, many populations experience time-lagged dynamics. These time lags mean that size is a trailing indicator of current conditions and may not accurately reflect the challenges facing the gulls presently. Suggestions for behavioural indicators can be found in foraging theory (Stephens and Krebs 1986). These can be classified into behavioural indicators based on diet, patch use, or habitat selection (Kotler et al. 2016). The present study partially examined urban gull patch use, but further research must be conducted in order to understand how gulls are exploiting foraging patches in urban environments.

At the inception of the present research, diet analysis was planned to be included. However, with constraints on time and a lack of research assistants, dietary analyses were dropped from the present research. It has been noted that the gulls in Bath routinely eat anthropogenic food and regurgitate it for their chicks (e.g., Figure 17 above), with much of it being low-quality food like bread and pastry (pers. obvs.). A species-appropriate diet for a gull is a combination of marine, terrestrial, and freshwater invertebrates, as well as fish, mammals, and birds (Ross-Smith et al. 2014). If a large portion of an urban gull's diet is made up of low-quality anthropogenic food it may have negative consequences for the gull's fitness. At least one study (Hanlon et al. 2017) demonstrated that HGs raised larger broods in colonies where they consumed a higher proportion of intertidal resources, but more research is required in order to know how anthropogenic food impacts on gull fitness.

4.6.4. Future Research

There are a number of directions in which to take future research. In addition to having more observation sites and spending longer periods at each of those sites, there are a number of other ways in which the present study could be improved and expanded. In some of the sites there were restaurants with outdoor seating areas. It would be interesting to note how long it takes each restaurant to clear a vacated table of plates and left food and see if that correlates with the number of gull raids. It has been observed that some restaurant staff were quick to remove the plates once the customers had finished eating, whereas others were much slower. More than half (62%) of the raids occurred at two casual dining restaurants, and these restaurants were notably slower to clear away dishes. 37% of raids occurred at three different restaurants and the remaining 1% of raids were from pedestrians.

The interventions that BANES has implemented as part of their 2016-2019 urban gull strategy should be investigated thoroughly to see how effective their various tactics have been in reducing gull nuisance. There should also be some investigation into how Bath residents feel about the measures and how easy it is for residents to adopt the recommendations and requirements from the council. For example, the gull-proof rubbish sacks are central to the BANES strategy to try to reduce the mess associated with gulls tearing apart ordinary rubbish bags. There should be population level data collected on bag usage, bag access, and facility with which replacement bags can be ordered.

Another intervention that is central to the 2016-2019 BANES urban gull strategy is nest removal on business and residential rooves. The rationale behind the nest destruction is 1) the pair will eventually give up replacing the destroyed eggs after multiple treatments, and 2) gulls are highly philopatric, but they will abandon an area if they have an unsuccessful season (Camphuysen 2013). It is not known how nest destruction is impacting on overall roof-nesting gull populations in Bath, or where the displaced gulls are nesting in seasons following their displacement. If the roof-nesting gulls were ringed (some of which are, but most of which are not) then they could be followed and see if they simply nest on a different building still in Bath.

The present research was a study of only one subset of urban gulls during one breeding season in one city. However, there may be interesting differences between urban and coastal gulls generally in terms of their ecology, for example, the timing of breeding, productivity, survival, diet, wintering behaviour, and reaction to disturbance. There is some information to suggest that urban birds begin to nest and will hatch chicks earlier than their coastal counterparts (Huig et al. 2016, Beck and Heinsohn 2006). If there are such differences, they are likely to inform future management decisions and conservation action. Research into these areas and monitoring of urban and coastal gulls could also be implemented in other areas where there are urban and coastal populations of gulls, such as the Netherlands, where some research has already been conducted on the behaviours of urban gulls (e.g., Camphuysen 2013, Huig et al. 2016), France (Cadiou and Guyot 2012), or other regions or countries in the UK.

There has been some effort made to regularly monitor the gulls throughout the UK in places such as Cumbria (Sellers and Shackleton 2011), Gloucester (Rock 2002), Bath and North East Somerset (Rock 2005), and Cardiff (Rock 2011), but regular counts of gull colonies should be extended to cover more urban-breeding gulls more fully. Regular monitoring should also include a wider collection of productivity data and movements should be studied further to understand the relationship between colonies and the geographic scale on which populations operate more clearly, both within England and in a wider context, and how this might be changing (including comparison of types of colony - urban/coastal, declining/increasing) by a number of methods such as: analysing movement data across the UK and Ireland to look for movements into/out of England; analysing movement data on a European scale covering the sub-species occurring in Europe; analysing winter movement data to understand where birds from different colonies winter and to investigate the mechanism behind the population changes taking place in winter; collecting and analysing data collected from resightings of colour-ringed birds; carrying out more tracking studies using and collating the results from those in progress; survival rates over time should be analysed to understand their contribution to population change, allowing the production of population models (Ross-Smith et al. 2014).

5. Conclusion

Gulls are increasingly moving into urban areas to live, nest, and rear their young. The main colonists in urban areas are Herring gulls and Lesser Black-backed gulls. These gulls are large, noisy, and known to kleptoparasitise humans. These behaviours often prompt complaints from residents about nuisance events related to gulls. All breeding species of gull in the UK are considered birds of conservation concern and are protected under the Wildlife and Countryside Act (1981). There is a conflict between human residents and gull residents of cities and towns because the gulls are noisy and irritating to some people, but they are also a protected species. Bath is a town in the south-west of England that reportedly has a problem with nuisance gulls. The six study sites visited over five months during the 2017 gull breeding season were all located within or near to the central business district of Bath.

It was predicted that the abundance of gulls in the city would peak during the rearing phase (20 April -17 May) and then remain the same until fledging (13 July – 9 August). In a study of visiting gulls from a coastal colony to an urban area, Huig et al. (2016) found that the number of visiting gulls varied significantly throughout the breeding season. Huig and her colleagues reported that visiting gull numbers dropped between the settling and laying periods and were lowest in the incubation period. In the rearing period, Huig and her colleagues reported that the number of visiting ringed gulls increased to levels similar to the settling period and remained high in the fledging period.

An analysis of changes in the mean number of gulls across the 2017 breeding season in Bath found that there was a statistically significant difference in gull abundance across phases in the breeding season. There were more gulls present in the rearing phase than in the incubation or settling phase. There were no significant differences between other phases in the breeding season. So, although gull abundance was highest during the rearing phase it did not differ significantly from the laying or settling phases.

It was predicted that there would be an increase in nuisance events and gull-human conflict during "rearing" and "fledging" periods (15 June – 9 August). When the need for gull parents to provision is highest and when the chicks begin to fledge correspond with the height of tourist season. Not only is the typical abundance of Bath residents present, but there were also crowds of international students, tour groups, and independent travellers that pack the city in the summer holiday period. The motivation of gull parents to provision their chicks with a lot of food and highly calorific food coincided with patio and outdoor dining, providing more opportunities for the gulls to engage in nuisance behaviours, such as raiding.

An analysis of the change in mean number of gull nuisance (measured as raiding and destruction behaviour) found no statistically significant difference in the mean number of gull nuisance events across the breeding season. Rates of gull raiding or destruction were very low in each phase, ranging from 0 to a mean of 2.75. Since the rates of raiding and destruction were so low, a new variable of all gull nuisance was created and included raiding, destruction, and producing behaviour. Although there is no direct nuisance or disturbance to humans associated with producing behaviour, the mere presence of foraging gulls may be considered uncomfortable for some people. Again, there was no statistically significant difference in the mean number of nuisance events across the breeding season even with the addition of producing behaviour. Rates of all gull nuisance were still low in each phase, ranging from a mean of 21.88 to 58.01.

Following from the assumption that there would be more nuisance events later in the breeding season, it was predicted that there would also be more human initiated aggression towards gulls in the latter two phases of the breeding season because humans may see more gulls in the city and more gull nuisance and try to shoo them away or dissuade the gulls from being a nuisance to them.

An analysis of the change in mean number of human initiated aggression was conducted to assess the difference in human aggression toward gulls across the breeding season. There was a statistically significant difference in observed human aggression toward gulls across the five phases in the breeding season. There were more observed instances of humans being aggressive towards gulls in the fledging phase than the settling phase, the incubation phase, and the rearing phase. There were more observed instances of humans being aggressive towards gulls in the rearing phase than the incubating phase. There were no significant differences between other phases in the breeding season.

It was predicted that humans were mediating the perceived gull nuisance problem by feeding the gulls. The city of Bath has taken a number of actions in order to attempt to reduce gulls being fed by humans. Although there are 55 posters in three different languages throughout the city, it is still evident that humans are feeding the gulls. Urban gulls become habituated to humans, especially when they are commonly fed. This leads to some individuals grabbing food from humans who do not intend to feed them.

The initial hypothesis was that certain locations might be associated with gull nuisance behaviour. Further to this it was hypothesized that human behaviour might act as a mediating variable between location and gull nuisance behaviours. However, a mediation hypothesis could not be explored. A correlation was conducted in order to evaluate how mean overall human population, mean overall humans feeding gulls, and mean overall human aggression toward gulls correlates with mean overall gull nuisance behaviour. There was a strong, positive correlation between mean overall humans feeding gulls and mean overall gull nuisance. There were no significant correlations between mean overall gull nuisance and mean overall human aggression toward gulls, or between mean overall gull nuisance and mean overall human population. A significant linear relationship was also found between overall gull nuisance and overall humans feeding gulls.

It is clear from the present research that the urban gull nuisance problem in Bath is less serious than originally thought. The overreaction to urban gulls may be cause by a moral panic situation fuelled by media reports of gulls as “the devil incarnate” or other such negative connotations. The propagation of gulls as a nuisance species that is highly motivated to steal from and cause harm to humans may also contribute to an illusory correlation between gulls and nuisance behaviour. It was reported in the present research that there is, empirically, not much of a gull problem at all in Bath, and yet residents seem convinced that all gulls are a large enough problem to instate a cull. The present study was underpowered and in order to have a better idea of what is happening in Bath, future researchers should look to include many more field sites, examine more behaviours from humans and gulls, and continue work over many breeding seasons to see if there are any patterns that emerge over years as well as over phases in the breeding season. Despite what the general public thinks about gulls, their numbers are in decline and they are protected. Little is known about what is causing the declining numbers of breeding gulls in the UK. More research is needed into the possibility that urban gulls are in an ecological trap. Other studies should be conducted to examine behavioural indicators, such as diet, patch use, and habitat selection in order to assess population well-being.

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APPENDIX A

Middlesex Research Ethics Approval

Middlesex University London

Psychology REC

The Burroughs
Hendon
London NW4 4BT

Main Switchboard: 0208 411 5000

16/05/2017

APPLICATION NUMBER: 1411

Dear Emily Ruth Beasley

Re your application title: Urban Gulls

Supervisor:

Thank you for submitting your application. I can confirm that your application has been given approval from the date of this letter by the Psychology REC.

Please note the following:

1. Please ensure that you contact your supervisor/research ethics committee (REC) if any changes are made to the research project which could affect your ethics approval. There is an Amendment sub-form on MORE that can be completed and submitted to your REC for further review.

2. You must notify your supervisor/REC if there is a breach in data protection management or any issues that arise that may lead to a health and safety concern or conflict of interests.

3. If you require more time to complete your research, i.e., beyond the date specified in your application, please complete the Extension sub-form on MORE and submit it your REC for review.

4. Please quote the application number in any correspondence.

5. It is important that you retain this document as evidence of research ethics approval, as it may be required for submission to external bodies (e.g., NHS, grant awarding bodies) or as part of your research report, dissemination (e.g., journal articles) and data management plan.

6. Also, please forward any other information that would be helpful in enhancing our application form and procedures - please contact MOREsupport@mdx.ac.uk to provide feedback.

Good luck with your research.

Yours sincerely

PLEASE NOTE: Although you have been granted ethical approval, you must not collect any data or analyse until you have submitted the preregistration form for your study.

Chair

Psychology REC

APPENDIX B

Preregistration

Foraging habits, population changes, and gull-human interactions in an urban population of Herring Gulls (*Larus argentatus*) and Lesser Black-backed Gulls (*Larus fuscus*)

Emily Beasley

M00561751

Middlesex University

Aims and Motivation

Large numbers of herring gulls (*Larus argentatus;* HG) and lesser black-backed gulls (*Larus fuscus;* LBB) have begun living, nesting, and rearing their young in urban areas of the UK. In some areas, the estimated growth rate of roof-nesting gull colonies is between 13% and 20% per year, and increasing (Winsper, 2014). With the increase in the population of urban gulls, there is also an increase in nuisance events and gull-human conflict (e.g., Rock, 2005; Coulson & Coulson, 2009; Camphuysen, 2013; Ross-Smith et al., 2014; Huig et al., 2016). For effective management of these issues, it is essential to understand the spatial and temporal dynamics of urban gulls.

There are two *Larus* species that are central to the present research: Herring gulls (*Larus argentatus*) and Lesser Black-backed gulls (*Larus fuscus*). Herring gulls are among the most recognizable bird species in Western Europe. They are large birds, measuring up to 66 cm long and with a wingspan of up to 155 cm. Their Latin name, *Larus argentatus*, is an accurate description of their physical appearance – *Larus* meaning “gull” and *argentatus* meaning “decorated in silver” (Jobling, 2010), as adults in breeding plumage have light silvery-grey upper parts with black wing-tips and white mirrors (Harrap, 2015).

Lesser Black-backed gulls are another common bird along the coast in the UK. Adults in breeding plumage somewhat resemble HG, only with slate-grey upper parts instead of light grey. They also have yellow feet and legs, as compared to the pink feet and legs of the HG. LBB are slightly smaller than HG, measuring up to 58 cm in length, with a wingspan of up to 150 cm. Both HG and LBB take three to four years to develop adult plumage (Harrap, 2015).

At present, these gulls are of interest to researchers because they are increasingly being found in urban areas, often causing nuisance to humans (Huig et al., 2016). These gulls are evidently moving to urban areas due to two main factors: 1) anthropogenic (human) refuse and waste is a readily available and easy food source; and, 2) humans have built structures (e.g., houses, office buildings, churches, etc.) that mimic their natural cliff-nesting habitats, but with the added advantage of keeping the roof-nesting birds safe from ground predators and many aerial predators (Bath & North East Somerset Council, 2016). In short, gulls are thriving in cities and suburban areas as they have access to an excellent food source and there are virtually no predators.

According to the Royal Society for the Protection of Birds (RSPB) all breeding species of gull in Britain are birds of conservation concern. HG are red listed (globally threatened) due to severe declines in their national breeding populations. All other gull species in Britain are amber listed (moderate decline in UK breeding population), including the LBB (*The RSPB Bird Guide*, 2015). The cause of the declines is not known and research into breeding and foraging behaviour may contribute to a better understanding of how these gulls live and what can be done to reverse the decline in their numbers.

Field Site

The city of Bath (51°22’53.02”N and 2°21’36.51” W), in Somerset, has been chosen as the field site for the present research. Most of the city is located south of the river Avon. The river stretches west through rural land and a few villages. The larger city of Bristol, with a population of 449,300, is located 18 km north-west of Bath (“*Bristol*”). 11 km west of Bristol is the river Severn and its estuary.

Bristol has historically been an important starting place for early voyages of exploration to the New World, and to this day remains an important port city. The city centre docks have been redeveloped as centres of heritage and culture and act to drive some of the tourism in the city. Bristol’s modern economy encompasses more than just maritime business and is largely built on creative media, electronics, and higher education. Bristol has two universities, the University of the West of England (UWE) and the University of Bristol, as well as a variety of artistic and sporting organisations. Bristol is also home to a large population of urban gulls (Rock, 2005).

Bath is located in the valley of the River Avon, 156 km west of London, and 18 km south-east of Bristol. In 1987, Bath became a UNESCO World Heritage Site because of its “outstanding universal value” and cultural attributes. It is known for the Roman remains, especially the Temple of Sulis Minerva and the baths complex (“*Bath*”). Bath has a population of approximately 88,859. The city has a number of theatres, museums, and other cultural venues that have helped to make it a major centre for tourism. Annually, more than 4.8 million (1 million staying, 3.8 million day trippers) visitors turn their sights on Bath. The size of the tourist industry is reflected in the near 300 places of accommodation which are offered during peak season. In addition to the multiplicity of accommodation, there are approximately 100 restaurants and a similar number of bars and pubs ("*Cultural and historical development of Bath*").

Figure B1 below shows Bath in relation to Bristol, the Severn Estuary, the river Severn, and the Bristol Channel.

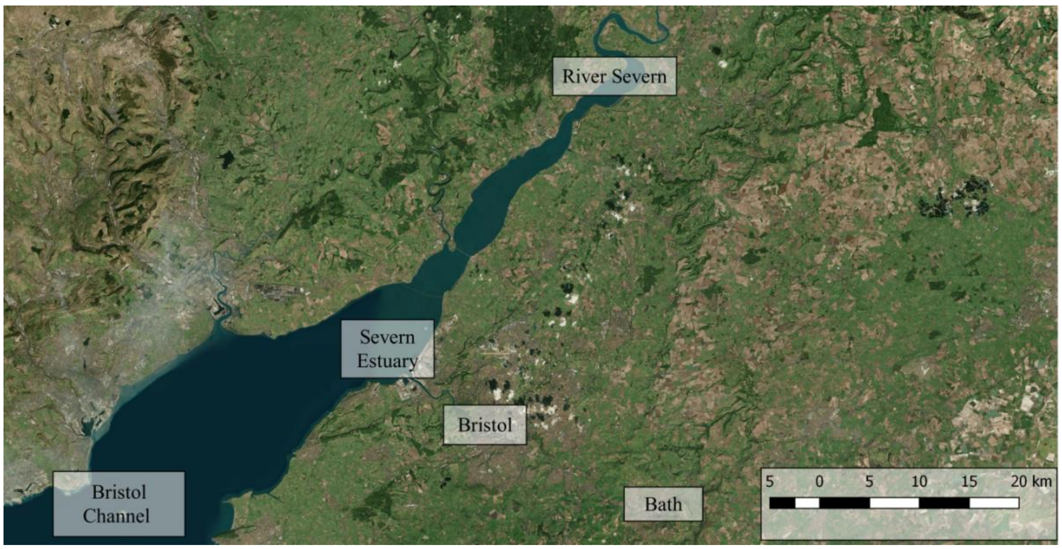

Figure B1. Bath, Bristol, and the Severn Estuary

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The urban gull population has been increasing throughout the whole of the southwest, including Bath (Winsper, 2014). There is a confirmed population of roof-nesting gulls in Bath that have been closely watched and studied by researchers at UWE. The Bath and Northeast Somerset city council has also invested time and resources into initiatives to study and control the gull population in the city and surrounding areas. In addition to implementing population control methods, such as nest removal and egg destruction, BANES has provided residents with gull-proof rubbish sacks in an attempt to curb rubbish bag destruction by gulls. BANES has also posted a number of signs in multiple languages imploring the public not to feed the gulls, as that further encourages them to seek out anthropogenic food (Bathnes.gov.uk, 2017).

The focus of the majority of studies on urban gulls has been describing rooftop colonies and gulls foraging on landfills (e.g., Rock, 2005; Coulson & Coulson, 2009). There are few studies that focus on gull behaviour in the city or how humans may be contributing to the gull-related nuisance problems. There are a number of questions to be asked to help understand the spatial and temporal dynamics of gulls in urban areas as well as factors that contribute to nuisance behaviours.

The present research is an investigation into the following questions:

1. How does the abundance of gulls in the city change throughout different phases in the breeding season?

2. Is there a change in nuisance events and gull-human conflict throughout the breeding season?
3. How frequently are humans feeding and aggressively interacting with gulls?

Methodology

The present research will be conducted between April 1 and August 1, 2017, with a pilot period from March 1 to March 31. The pilot period allowed time to trial and establish gull-human interaction observation points. The research period will cover an entire breeding season from “settling” to “fledging” (see Table B1 for further description).

Table B1. Division of study period based on distinct phases of the breeding season (adapted from Huig et al. (2016))

PERIOD	DATE	BREEDING PHASE
Settling	23 March-19 April	Pair formation, courtship
Laying	20 April-17 May	Territory establishment, laying, start incubation
Incubation	18 May – 14 June	Incubation, hatching
Rearing	15 June – 12 July	Young chicks
Fledging	13 July- 9 August	Fledging of chicks, start migration

In order to answer question 1, patch abundance sampling will be conducted across six observation points throughout the city. These areas are the same sites that will be used to analyse gull-human interactions (see Figure 2.), and abundance counts and behaviour counts will be conducted concurrently. The number of gulls reported throughout each of the breeding phases will be compared to see if there is a difference in gull abundance over the course of the breeding season.

In order to answer questions 2 and 3, careful behavioural analysis will be conducted throughout designated areas within the city. A pilot period took place between March 1 and March 31 in order to establish field sites to observe gull-human interactions. There are a number of places throughout the city that are both natural (e.g., ponds) and human-made (e.g., squares within the city) that have been designated observation sites (see Figure 2 for a map of the observation sites). Each of these areas have been chosen because they conform to one or more of the following criteria: 1) there have been previous reports of gull-human interactions from a person who is not part of the research team, 2) one of the members of the researcher team has personally witnessed gull-human interactions, or 3) gulls were seen consistently in these areas during the pilot period. The areas will be scan surveyed for gull abundance and behaviours on a limited list (Behavioural Catalogue, see Table B2. below) pertaining to gull foraging and nuisance behaviour, and human provisioning and aggression behaviour, for up 30 minutes three to four days per week.

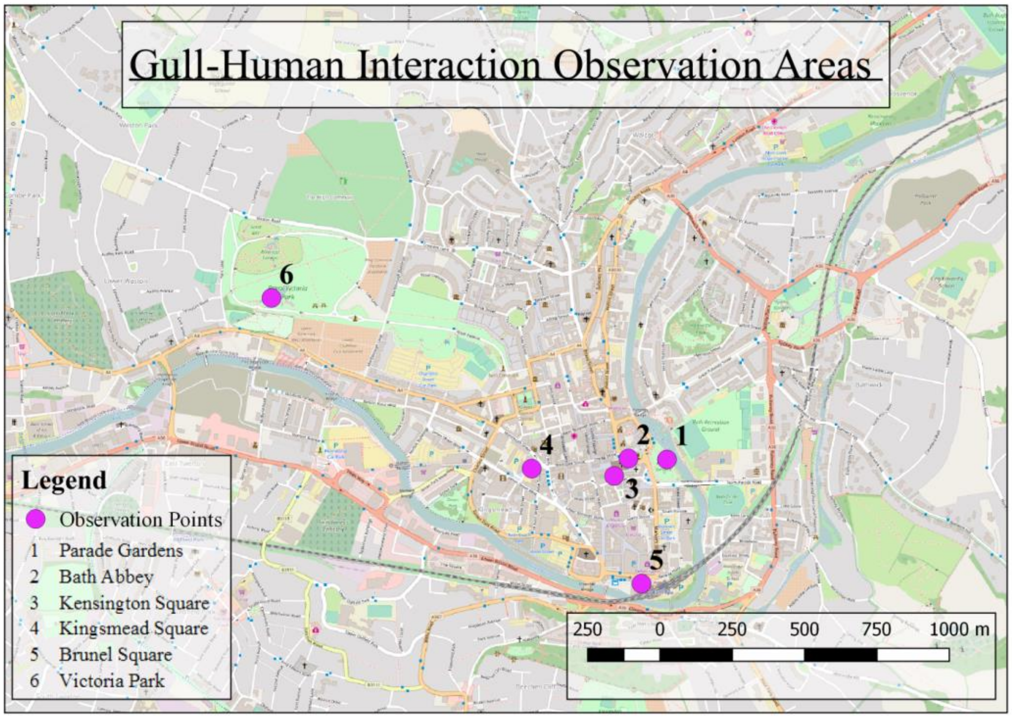

Figure B2. Gull-Human Interaction Observation Areas

Data by OpenStreetMap.org contributors Under CC BY-SA 2.0 license

Table B2 is the behavioural catalogue to be use for the present research. Each of the behaviours in the catalogue has been chosen to examine the foraging and aggressive behaviours of gulls, and the provisioning and aggressive behaviours of humans. *Raiding* is one of the most oft reported nuisance events in the media. It is a behaviour that is clearly distressing to the human involved, and is easy to categorise and observe.

Producing is a behaviour that is not reported nearly as frequently, but is equally important with regards to understanding how gulls are utilising human-made environments. *Raiding* and *Producing* are behaviours that have previously investigated by Huig et al. (2016).

Destruction is a common complaint among citizens who have put their rubbish bags out on the street for pick up as is (i.e., not in a wheelie bin or gull-proof sack). Although there are gull-proof sacks provided by the council (Bath & North East Somerset Council, 2016), not everyone uses them, so gulls continue to have foraging opportunities in the form of rubbish bags.

Gull-human aggression is an issue that may arise more often when gull parents are fledging chicks. Animals rarely aggress unless in defense of themselves, their territory, or their offspring, although gull "attacks" are a common trend in media stories regarding gulls. Quantifying gull-human aggression is important to understand how often and in what contexts it is happening.

Human *Feeding* behaviour is of interest because it habituates the gulls to humans and reinforces humans as a potential source of food. Human *Feeding* behaviour has been added to the behaviour catalogue to explore the human component of gull-human interactions and to get an idea of the extent to which humans are feeding gulls.

Human-gull aggression is of interest because it has not been examined before in studies of gull-human interactions. While gull aggression is often discussed, the human aspect of aggression towards gulls has not been examined. In order to understand the issue of aggression in a balanced manner it is important to look at both the gull and human contributions to aggressive interspecific encounters.

Table B2. Behavioural Catalogue

Behaviour	Abbreviation	Description
Gull Behaviour		
Raiding	R	A gull takes food directly from a human's hands or from a table where a human is eating
Producing	P	A gull takes consumable material into its beak that it has found on the ground, anthropogenic or natural
Destruction	D	A single gull or multiple gulls causing damage to human property by biting, ripping, clawing, or defecating on said property
Gull→Human Aggression	$G \rightarrow H_{AGG}$	A gull, or multiple gulls, physically interact with a human, not food motivated
Human Behaviour		
Feeding Gull(s)	F→G	A human, or multiple humans, directly feed or throw food in the direction of a gull or multiple gulls
Human→Gull Aggression	$H \rightarrow G_{AGG}$	A human, or multiple humans, physically interact with a gull, unprovoked

Table B3 below is the proposed data sheet for collecting information on behavioural interactions. HG refers to Herring Gulls, LBB refers to Lesser Black-backed gulls, and HUM refers to humans. The CODE column contains the abbreviated behaviour labels from the Behaviour Catalogue (Table B2).

Table B3. Proposed Data Sheet

Date:			Observer:					
Location:			Start Time:					
Weather:			End Time:					
	CODE	0	5	10	15	20	25	30
HG	#							
	R							
	P							
	D							
	$G \rightarrow H_{AGG}$							
LBB	#							
	R							
	P							
	D							
	$G \rightarrow H_{AGG}$							
HUM	#							
	F→G							
	$H \rightarrow G_{AGG}$							

Hypotheses

In a study of visiting gulls from a coastal colony to an urban area, Huig et al. (2016) found that the number of visiting gulls varied significantly throughout the breeding season. Huig and her colleagues reported that visiting gull numbers dropped between the settling and laying periods and were lowest in the incubation period. In the rearing period, Huig and her colleagues reported that the number of visiting ringed individual gulls increased to levels similar to the settling period and remained high in the fledging period. Following from that study, I think the urban population will follow a similar trajectory with regards to an increase in gull abundance during the rearing and fledging periods. I think the urban population will differ slightly in that the number of gulls will be at its highest in the city during the settling period because the gulls will be re-establishing their territories in the city, not simply visiting. The gulls Huig and her colleague were studying were likely doing the same, only their territories were not in the study area, whereas the Bath gull territories are located within the study area. That leads to Hypothesis 1:

H_1: The abundance of gulls will peak during the “laying” period (20 April -17 May) and then remain the same until “fledging” (13 July – 9 August).

Mating activity generally begins a bit earlier in cities, as they tend to be warmer than coastal nest sites (Huig et al., 2016). Early signs of mating activity can be seen in late February and early March when gulls begin to identify the nest sites. By early April courtship will have begun and later in the month territories will have been established. From late April into early May nests will have been made and eggs laid. Apart from courtship rituals, which can be noisy, the impact on humans at this time is not too great. However, in June the eggs start to hatch and the adults become more active as they provision for their chicks. Adult gulls with chicks become more aggressive in July and August when their chicks begin to fledge, as they are very protective. The young chicks, being inexperienced, begin to roam around the streets and the parents dutifully protect them from any potential danger posed by humans. By the end of the summer, the gulls begin to disperse.

When the need for gull parents to provision is highest and when the chicks begin to fledge correspond with the height of tourist season. Not only is the typical abundance of Bathonians present, but also crowds of international students, tour groups, and independent travellers that pack the city in the summer holiday periods. Following from the assumptions that 1) there will be greater pressure on gulls to provision their chicks with highly calorific food, and 2) there will be a greater abundance of humans in the city, hypothesis 2 states:

H_2: There will be an increase in nuisance events and gull-human conflict during “rearing” and “fledging” periods (15 June – 9 August).

The city of Bath has taken a number of actions in order to attempt to reduce gulls being fed by humans. Although there are 55 posters in three different languages throughout the city, it is still evident that humans are feeding the gulls (personal observations). Urban gulls become habituated to humans, especially when they are commonly fed. This leads to some individuals grabbing food from humans who do not intend to feed them. Although gulls stealing food happens regularly, it is worth noting that individual gulls often have feeding specialisations, so not every urban bird will steal anthropogenic food. Many will fly long distances to rural and coastal areas to feed on other foodstuffs (Thaxter et al., 2011). Additionally, the majority of gull feeding takes place out of town for most urban gulls, principally at rubbish tips and large fields (Rock, 2005). Far more is known about the feeding habits of urban gulls than the habits of humans who interact with gulls. The majority of papers on gull-human interactions focus on the negative impacts that gulls have on humans, and not what humans are doing to contribute to the problem or how humans are being aggressive towards the gulls. Throughout the pilot period of the present research, more humans interacted aggressively with gulls than vice versa, from those observations follows hypothesis 3:

H_3: Humans are feeding and aggressively interacting with gulls more frequently than gulls are raiding from humans and aggressively interacting with humans.

Proposed Analysis

Table B4. Hypotheses and Proposed Analyses

Hypothesis	Test	Proposed Analysis
The abundance of gulls will peak during the "laying" period (20 April -17 May) and then remain the same until "fledging" (13 July – 9 August).	GLM	To detect differences in the number of observed gulls between periods use a generalized linear model (GLM) with a negative binomial error distribution for both species with number of gulls observed per day as dependent variable, and period as a fixed factor.
There will be an increase in nuisance events and gull-human conflict during "rearing" and "fledging" (15 June – 9 August).	GLM	To detect differences in the number of observed nuisance events between periods use a generalized linear model (GLM) with a negative binomial error distribution for both species with number of nuisance events observed per day as dependent variable, and period as a fixed factor.
Humans are feeding and aggressively interacting with gulls more frequently than gulls are raiding from humans and aggressively interacting with humans.	Unsure of what test to use	Compare the frequency of: - humans feeding gulls to gulls raiding from humans - humans aggressively interacting with gulls to gulls aggressively interacting with humans - gulls raiding to gulls producing

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APPENDIX C

Data Collection Sheet

Table C1. Data Collection Sheet. "Observer" was the person who was making observations during that 30 minute section. "Location" referred to one of the six locations chosen as observation sites (Victoria Park, Kingsmead Square, Kensington Square, Bath Abbey/Alkmaar Gardens, Parade Gardens, Brunel Plaza), "Weather" was recorded as temperature (cold, mild, warm, hot) and weather (sunny, overcast, drizzle, rain), "Date" was the date the observation took place (day-month-year), "Start" and "End time" were the times that the observation began and ended, respectively. "HG" refers to Herring gulls, "LB" refers to Lesser Black-backed gulls, and HUM refers to humans. The "CODE" column contains the abbreviated behaviour labels from the Behaviour Catalogue: "#" the number of HG, LB, and HUM at the site at the beginning of that 5 minute block, "R" – raiding, "P" – producing, "D" – destruction, "$G \rightarrow H_{AGG}$" – gull initiated aggression toward a human, "$H \rightarrow G_{AGG}$" – human initiated aggression toward a gull. "Notes" at the bottom of the observation sheet was an area reserved for any notes taken during each 30 minute observation period.

Observer: Date:
Location: Start Time:
Weather: End Time:

	CODE	0	5	10	15	20	25	30
HG	#							
	R							
	P							
	D							
	$G \rightarrow H_{AGG}$							
LB	#							
	R							
	P							
	D							
	$G \rightarrow H_{AGG}$							
HUM	Number							
	F→G							
	$H \rightarrow G_{AGG}$							

Notes:

APPENDIX D

Protocol: Behavioural Observations

1. Arrive at location
2. Note the following:
    a. Date (day-month-year)
    b. observer(s)
    c. weather (cold, mild, warm, hot; sunny, overcast, drizzle, raining)
    d. start time (time at which observation begins)
    e. end time (30 minutes from the start time)
3. Count and note number of Herring gulls
4. Count and note number of Lesser Black-backed gulls
5. Count and note number of humans
6. Counts are to be made every five (5) minutes following the initial count
7. Continuously scan the site for gull behaviour, human behaviour, and gull-human interactions
8. Note if any behaviour from the behaviour catalogue occurs for Herring gulls, Lesser Black-backed gulls, and/or humans. If yes, begin a tally in the corresponding box at the corresponding time slot
9. Repeat at each of the six (6) field sites throughout Bath

APPENDIX E

Herring and Lesser Black-backed Gull Natural History

Herring Gulls (*Larus argentatus*) and Lesser Black-backed Gulls (*Larus fuscus*)

There are two *Larus* species that are central to the present research: Herring gulls (*Larus argentatus*) and Lesser Black-backed gulls (*Larus fuscus*). Herring gulls are among the most recognizable bird species in Western Europe. Lesser Black-backed gulls are another common bird along the coast in the UK.

Herring Gulls: Physical Description

Figure E1: Adult Herring gull in summer plumage. Image © Emily Beasley

Herring gulls (*Larus argentatus*) are large birds in the family *Laridae*. Plumage in all stages of life is sexually monomorphic, although slight sexual dimorphism in size does occur. Male herring gulls range in size from 60-66 centimeters in length, and 1050 to 1250 grams in weight. Female herring gulls are slightly smaller than males, and range from 56 to 62 centimeters in length, and weigh between 800 and 980 grams. Herring gull wingspan ranges between 137 to 146 centimeters (Harrap 2015). Their heads and underparts are white, and they have light silvery-grey upperparts, hence their binomial classification *Larus argentatus* - *Larus* meaning "gull" and *argentatus* meaning "decorated in silver" (Jobling 2010).

Adult herring gulls have golden eyes surrounded by a yellow-orange ring of skin. Herring gulls have yellow bills with a red spot on the lower mandible and pink legs. Their wingtips are black with white spots, otherwise known as "mirrors." Adults in winter plumage have streaks of brown colouring their heads, which gives a slightly dirty appearance to their otherwise white feathers (Harrap 2015).

Figure E2: Adult Lesser Black-backed gull in summer plumage. Image © Emily Beasley

Lesser Black-backed (*Larus fuscus*) gulls are slightly smaller than Herring gulls, and are similarly sexually monomorphic with regard to feather colouration. As with Herring gulls, Lesser Black-backed gulls are sexually dimorphic with regards the sizes of the sexes, the males being slightly larger than the females. These gulls measure between 51 and 64 cm in length, with a wingspan ranging from 124 to 150 cm. Males weigh on average 820 grams, while females weigh around 700 grams (Harrap 2015). Lesser Black-backed gulls have white heads and under parts, and very dark grey upper parts, hence their binomial classification *Larus fuscus* - *Larus* meaning “gull” and *fuscus* meaning “dark or black” (Jobling 2010).

Adult lesser black-backed gulls have a slimmer build compared to the herring gull. They have yellow rather than pink legs and smaller white mirrors at their wingtips. As with the herring gull, lesser black-backed gulls have a yellow bill with a red spot on the lower mandible which the chicks peck at the induce feeding. Adults in winter plumage have streaked brown heads, like that of the Herring gull (Harrap 2015).

Lesser Black-backed gulls develop very similarly to Herring gulls, and it likewise takes four years for them to reach maturity. In that time, they go through a variety of mottled brown plumage until they acquire the standard dark grey and white adult plumage (Harrap 2015).

Habitat

Herring gulls tend to live and breed in coastal areas. Historically, Herring gulls have only lived inland in small numbers, but there appears to be a positive trend in the number of urban roof-nesting herring gulls throughout the Europe (Huig et al. 2016). The most important habitat requirements are the nearby presence of a food source, distance from major predators, and shelter from prevailing winds. Herring gulls prefer to breed on flat ground on offshore islands. When found nesting on the mainland, these gulls prefer to nest in areas where there is less risk of exposure to predatory mammals, such as cliffs or rooftops (Rodway and Regehr 1999).

When nesting in coastal areas, Herring gulls search for food in the intertidal zone and at sea. Herring gulls usually forage within 20 kilometers, but up to 100 kilometers, from their colony; this home range is dependent on location of preferred food sources (Pierotti and Good 1994). In urban areas, however, Herring gulls will often eat anthropogenic refuse which is readily available and often highly calorific. It provides parents with food supply on which they can rely during chick rearing (Spaans 1971, Norstrom et al. 1986).

Lesser Black-backed gulls breed colonially and nest on coastal grassy slopes, preferring flat and unbroken terrain, sand-dunes, cliffs, rocky offshore islands, saltmarshes, and on inland habitats, such as the margins of lakes, high moorland, and islands in lakes and rivers. As with Herring gulls, urban buildings can be added to the aforementioned list of preferred nesting habitats. Lesser Black-backed gulls are found around the UK's coastline in the summer, on inland high moors, and increasingly in cities, both seaside and inland (Rock 2005).

Outside the breeding season, Lesser Black-backed gulls move away from colonies and a large part of the UK population migrates to southwest Europe and northwest Africa for winter. In recent decades there has been a shift to this migratory pattern and some individuals have started to remain in the UK year round (Rock 2002). The habitats occupied in winter are also diverse and include urban, rural inland, and coastal areas (Burton et al. 2013). The Lesser Black-backed gull's ability to occupy such a wide range of habitats is linked to its generalised diet, which can include marine, terrestrial and freshwater invertebrates, fish, mammals, birds, plant matter, and human refuse (Ross-Smith et al. 2014). Non-anthropogenic foods can be obtained from foraging on the ground, aerial pursuit, plunge diving, and kleptoparasitism around coasts, estuaries, and inland (Ferns 1992). Some individuals will also predate conspecific and congeneric eggs and chicks at breeding colonies (Ross-Smith et al. 2014). Herring and Lesser Black-backed gulls both actively hunt and scavenge. A Lesser's home range may be farther than a Herring gull's as they are pelagic and routinely fly 40–80 km from breeding colonies to find food. Lessers can travel over 150 km in a single foraging trip (Camphuysen et al. 2010), making a broad range of potential food sources available to any individual.

Reproduction

Herring and Lesser Black-backed gulls are typically monogamous, and pair bonds are maintained for the life of both partners. Once they have paired, males and females choose territory for egg-laying together. These gulls show high site fidelity and pairs will return to the same nesting site year after year. Pair bonds are maintained as long as both members of the pair remain alive, although there are some cases in which a pair may separate. If the pair continuously fail to hatch eggs for any reason (e.g., lack of provisioning of the female during egg formation, or lack of parental synchrony) the pair may dissolve and each will find a new mate (Pierotti and Good 1994).

Lesser Black-backed gulls nest colonially, sometimes in mixed colonies with Herring gulls. Colonies range in size from a few pairs to several thousand pairs. Gulls make lined nests on the ground, on a cliff, or on a rooftop. They fashion their nests out of mounds of seaweed, grasses, other vegetation, and general debris (Richards 1990). Typically, three eggs are laid, between May and mid-June (del Hoyo et al. 1996).

Herring and Lesser Black-backed gulls breed once yearly during spring, pairing and settling around mid-March, and laying eggs by mid-May. Females will lay 3-egg clutches over the course of four to six days. The laying period for Herring gulls begins around mid-April and carries on until mid-May (Lesser Black-backed gulls typically begin laying two-weeks later than Herring gulls), at which point incubation begins and will last for about four weeks (Huig et al., 2016). Lesser Black-backed Gulls typically arrive at their nesting sites between late February and early May, lay eggs between April and June, and hatch chicks between May and July. Incubation lasts approximately 28 days, and chicks take about five weeks to fledge (Tinbergen 1959, Ross-Smith 2009). Modal clutch size is three eggs (Ross-Smith 2009). Lesser Black-backed and Herring gulls both shows strong natal philopatry, with birds, especially males, often recruiting to the colony where they hatched (Rock 2005, Rock and Vaughan 2013) and, provided both members of a pair breed together successfully and survive, they normally return to the same partner at the same nest site each year (Rock 2005, Rock and Vaughan 2013). However, colonies may ‘export’ individuals if suitable nesting habitat is not available, and birds apparently immigrate to successful colonies (Monaghan and Coulson 1977).

Eggs are incubated by both parents, and when the chicks hatch they are fed by both parents. Parents feed their chicks regurgitated food that consists of small prey, such as small fish, insects, earthworms, and for urban gulls human refuse (Pierotti and Good 1994).Chicks are semi-nidifugous and are able to leave the nest on foot after one day. They remain in the territory where they were hatched for approximately 40 days. They leave the nesting territory initially with their first flight around 45-50 days after hatching. Chicks return to the nesting territory to rest, build strength, and be fed until they are around 12-15 weeks old (Pierotti and Good 1994). In the UK and areas with similar latitude, chicks fledge between mid-July and early-August (Huig et al. 2016).

Most chick growth occurs prior to fledging, and fledglings may even weigh more than their parents at the time of fledging, although some of this mass is likely lost while juveniles learn to forage for themselves. Some juveniles stay near to their parents even after fledging and beg for food up to six months post-fledging (Pierotti and Good 1994). In urban areas, gull chicks can be spotted foraging with their parents. Their parents are sometimes more aggressive during this time, as they are protecting their chick (pers. obvs.).

Under good conditions, breeding can be attempted every year (Cramp and Simmons 1983). However, a large proportion of the adult population has been found not to breed at some sites, and a recent study from the Netherlands recorded some birds breeding every other year (Camphuysen 2013). With this cohort of nonbreeding adults in addition to sub-adults, it is clear that non-breeding Lesser Black-backed gulls are common across the breeding range (Balmer et al. 2013).

Behaviour and Communication

Herring gulls are a colonial species and nest as such, often with congenerics as well as conspecifics. Prior to the breeding season, males will return to their colony and defend his previous territory, or establish a new territory if necessary. If a male is already paired, his mate will help defend the territory, but she does not help to initially establish the territory. Females do, however, defend the territory while the male is absent. Established pairs typically return to the same territory as long as they remain paired. If the male dies or abandons the female, the female must find a new mate and territory. If the female dies or abandons the male, the male remains on the same territory and courts another female (Pierotti 1980).

Once their territory is established in a colony, a mated pair will protect their site from neighbours, predators, or anything else that strays too near for comfort. They maintain only a small area around them (<1 m) on roosting areas during both breeding and non-breeding seasons (Pierotti and Good 1994). While there may be some protection in number (Ward and Zahavi

1973), there are also risks associated with nesting too near other birds. Herring gulls chicks, which are mobile within one day of hatching, may wander into another gull pair's territory, risking conspecific predation. Chicks and juveniles engage in play behaviour by carrying around objects and engaging in tug-of-war games (Pierotti and Good 1994). Herring gulls often develop individual preferences for food and feeding techniques which may be shaped by the environment in which they were raised (Scott et al. 2015).

Although gulls nest colonially, most social interactions between neighbours are agonistic. They appear to nest as far apart as limited space allows (Coulson 1991). Away from the breeding colony, gulls will loaf and roost together in groups and forage in loose groups that aggregate when prey is located (Pierotti and Good 1994).

Gulls generally do not have food territories. Herring gulls tend to be neritic, while Lesser Black-Backed gulls tend to be pelagic. However, both Herring and Lesser Black-Backed gulls at sea forage in scattered groups. These groups converge quickly once prey has been located partially due to their conspicuous white plumage. Their plumage offers them an advantage when it comes to finding a meal; if there is a shoal of fish that hit the surface and one bird finds it, it is not long before many others join in feeding. Their conspicuous plumage shows up at a great distance and they become a beacon to all other seabirds. This is an advantage to the birds because fish stocks are unpredictable. In the ocean there is no way of knowing for certain where the fish is going to be at all times. So, by spreading their numbers out across the sea and being able to hone in on the hotspots by spotting their neighbours, all the gulls benefit from this social information (Ward and Zahavi 1973). Gulls foraging in urban areas often converge in a similar manner. For example, at a location where there is a lot of food rubbish that has been left, one gull may find it and then many others may follow to exploit the resource as well (pers. obvs.).

In most cases, economic defendability of a resource path will be low because there is an upper threshold of resource availability beyond which defense is not economical. This upper boundary could arise because there may be no advantage of territoriality at high resource levels if the owner cannot make use of the additional resources made available by defense (Davies et al. 2012).

Herring and Lesser Black-backed gulls have a complex system of calls and gestures that they use to communicate with one another. Various calls serve to identify returning partners, demonstrate aggression, warn the colony of predators, and to dispute territory with neighboring gulls. Chicks begin making begging calls to demand food upon hatching; the call grows more intense as they grow and by 5 weeks of age, a chick begs by lifting its head with each peep and holding its head hunched against its body. In addition to the begging sound, chicks peck at the red spot on their parent's bills in order to stimulate food regurgitation. When chicks are pursued, they emit a shrill waver. The begging call and shrill waver exhibited by chicks are both similar to noises that adult gulls make (Pierotti and Good 1994).

During the four year transition to adulthood, sub-adult gulls acquire the remaining adult vocal repertoire. Three-year-old birds will long-call, trumpet, and produce warning calls. Vocalizations specifically associated with mating and chick-rearing (mew call, choking, and copulation sounds) are only observed in breeding birds, emerging, on average, between four- and five-years of age (Pierotti and Good 1994).

Food Habits

Herring and Lesser Black-backed gulls are opportunistic and omnivorous, although Lesser black-backed gulls tend to be more pelagic, foraging extensively at sea. Their diets are varied and include items such as marine invertebrates, fish, insects, other seabirds, conspecific chicks, and bird eggs. They will also scavenge the remains of dead animals and human rubbish. Individual specialization in feeding is common among gulls; a particular bird may regularly seek out the same type of food. This feeding specialization is often related to the bird's location and time of year. For example, in Newfoundland, herring gulls often eat mussels (*Mytilus edulis*) and refuse during incubation, switch to capelin (*Mallotus villosus*) when chicks hatch, and then switch to squid (*Illex illecebrosus*) later in the summer (Pierotti 1979). Herring gulls appear to choose foods according to their dietary needs, such as during egg-laying or provisioning for chicks, when sufficiently numerous food sources are available (Huig et al. 2016).

Predation

Herring and Lesser Black-backed gulls are long-lived birds, able to reach upwards of 30 years of age. However, many die at a much younger age due to other factors such as predation, ingesting contaminant or being poisoned, being shot or maimed by humans, or as a result of injuries. Gulls nesting in coastal areas often choose nest sites for their inaccessibility to predators. Although rocky off-shore islands or cliff edges may be challenging for a terrestrial predator like the red fox (*Vulpes vulpes*) or mink (*Neovision vison*), it is not safe from conspecifics that will steal an egg or predate a chick. There are other aerial predators that pose significant risk to the safety of their chicks, these include such birds as Great Black-backed gulls (*Larus marinus*), peregrine falcons (*Falco peregrinus*), and ravens (*Corvus corax*; Pierotti and Good 1994).

In urban areas, rooftops are inaccessible by nearly all of the gulls' natural predators (bar conspecifics and congenerics), but there are many other factors that contribute to gull mortality in towns and cities. Many humans have expressed a dislike for gulls of any species and have gone so far as to illegally shoot them (Shaw 2017) or to destroy their eggs. Additionally, when the gull chicks begin to fledge they may break a wing, be attacked by a dog, or get run over by a car (personal observations). While there is not much to be done about the latter, there is legislation in place dealing with the former.

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APPENDIX F

Test of Normality

Table F1: Test of Normality. SPSS output for Shaprio-Wilk test of normality for mean number of aggressive acts toward gulls by humans (phase 1-5), mean gull population (phase 1-5), mean gull nuisance (phase 1-5), mean gull raid and destroy (phase 3-5), mean human population (phase 1-5), mean number of feeds by humans (phase 1-5), mean overall gull population, mean overall gull nuisance, mean overall gull nuisance destroy and raid, mean overall all gull nuisance, mean overall human population, mean overall human feeds, and mean overall aggressive acts toward gulls.

	Shapiro-Wilk		
	Statistic	df	Sig.
Mean number of aggressive acts toward gulls by humans in phase 1	.836	6	.122
Mean number of aggressive acts toward gulls by humans in phase 2	.609	6	.001
Mean number of aggressive acts toward gulls by humans in phase 3	.496	6	.000
Mean number of aggressive acts toward gulls by humans in phase 4	.665	6	.003
Mean number of aggressive acts toward gulls by humans in phase 5	.806	6	.067
Mean gull population in phase 1	.783	6	.041
Mean gull population in phase 2	.669	6	.003
Mean gull population in phase 3	.771	6	.032
Mean gull population in phase 4	.796	6	.054
Mean gull population in phase 5	.769	6	.031
Mean gull nuisance behaviours in phase 1	.774	6	.034
Mean gull nuisance behaviours in phase 2	.627	6	.001
Mean gull nuisance behaviours in phase 3	.840	6	.130
Mean gull nuisance behaviours in phase 4	.889	6	.314
Mean gull nuisance behaviours in phase 5	.756	6	.023

Mean gull raid and destroy phase 3	.496	6	.000
Mean gull raid and destroy phase 4	.675	6	.003
Mean gull raid and destroy phase 5	.705	6	.007
Mean human population in phase 1	.916	6	.479
Mean human population in phase 2	.972	6	.908
Mean human population in phase 3	.985	6	.975
Mean human population in phase 4	.904	6	.400
Mean human population in phase 5	.874	6	.241
Mean number of feeds by humans in phase 1	.572	6	.000
Mean number of feeds by humans in phase 2	.567	6	.000
Mean number of feeds by humans in phase 3	.515	6	.000
Mean number of feeds by humans in phase 4	.703	6	.007
Mean number of feeds by humans in phase 5	.540	6	.000
Mean_overall_gull_population	.751	6	.020
Mean_overall_gull_nuisance	.732	6	.013
Mean_overall_DR	.662	6	.002
Mean_overall_human_populati on	.872	6	.232
Mean_overall_human_feeds	.560	6	.000
Mean_overall_aggressive_acts_ toward_gulls	.809	6	.071

APPENDIX G

G*Power Analysis

t tests – Means: Wilcoxon signed-rank test (matched pairs)

Options:	A.R.E. method		
Analysis:	A priori: Compute required sample size		
Input:	Tail(s)	=	Two
	Parent distribution	=	Normal
	Effect size dz	=	0.5
	α err prob	=	0.05
	Power (1–β err prob)	=	0.95
Output:	Noncentrality parameter δ	=	3.6888681
	Critical t	=	2.0053684
	Df	=	53.4309905
	Total sample size	=	57
	Actual power	=	0.9517259

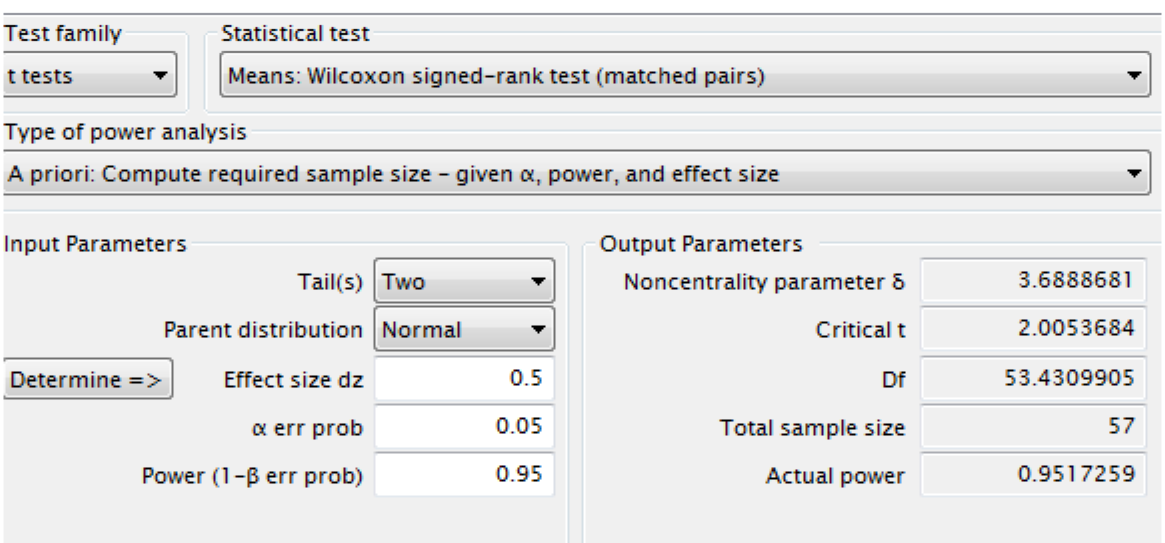

Figure G1. G*Power Output. *Post Hoc* power analysis performed using G*Power (Faul et al. 2009)

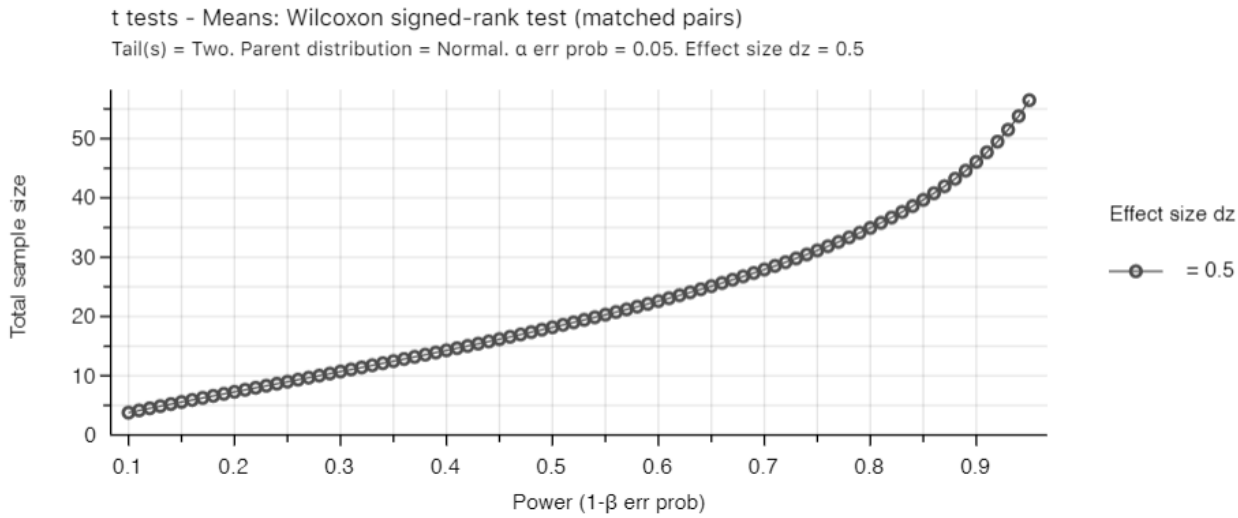

Figure G2. Power Curve. *Post Hoc* power curve graph created using G*Power (Faul et al. 2009)

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APPENDIX H

Articles used for Content Analysis

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APPENDIX I
Content Analysis Coding Units

Table I1. Content Analysis Coding Units. Descriptions and frequencies of the five coding units that emerged from the content analysis of news stories related to urban gulls in Bath.

Coding Unit	Description	Frequency
Noise	Anything referring to gull noise, onomatopoeic gull noises, and/or any mention of nuisance related to sounds that are made by gulls	10
Threat to public	Anything referring to gulls attacking humans, gulls as a threat to public health, gulls spreading bacteria, and/or gulls causing bodily harm	39
Mess	Any reference to gulls soiling human property or clothing with fecal matter or other bodily excrements, or gulls creating mess by ripping rubbish bags	17
Damage	Any reference to gulls damaging property that is not related to fouling by the bodily excrements of gulls	11
Kleptoparasitism	Any reference to gulls stealing food from humans	9