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Re-evaluation of the Role of Landfills and Culling in the Historic Changes in the Herring Gull (*Larus argentatus*) Population in Great Britain

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Abstract.—This paper examines the reasons behind the large population explosion of the Herring Gull (*Larus argentatus*) in Great Britain, which started about 1900, continued for 60-70 years and was then followed by a decline in numbers. The increase has often been associated with food obtained at landfills, but it is better explained by other causes because such sites were not used for feeding until the increase had been in progress for 50 years and for less than 20 years before gull numbers started to decline. Further, the flock and frenzy method of feeding used by Herring Gulls at landfills is not well adapted for the successful exploitation of this food source, and the frequency of use has often been exaggerated. The historic increase in Herring Gulls starting in about 1900 should be attributed to protection and then food acquired from the marine environment, including fishing offal, and increased feeding on agricultural land. Culling has contributed more to the recent decline of the population than has been previously assessed because of secrecy and lack of detail about many such events. Feeding at landfills may have been detrimental to the Herring Gull population owing to increased mortality from botulism acquired there. It is concluded that culling and botulism both contributed appreciably to the end of the population explosion that occurred around 1970, and to the subsequent decline of the Herring Gull in Great Britain. The increase and continued spread of Herring Gulls nesting in urban areas in Great Britain cannot be explained by food obtained within the towns. Observations that, in some areas, most of these gulls rarely fed at landfill sites, and so avoided botulism, may account for their continued increase in urban areas. *Received 25 April 2014, accepted 19 January 2015.*

Key words.—botulism, Britain, culling, decline, Herring Gull, landfill, *Larus argentatus*, population explosion, urban nesting.

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The causes of large population changes in the Herring Gull (*Larus argentatus*) in Britain during the 20th century have been subject to extensive comment from many sources, including popular articles, press comments, reports from local government bodies and conservation groups, and books, including those presenting the results of the series of national censuses made in 1969-1970 (Cramp *et al.* 1974), 1985-1987 (Lloyd *et al.* 1991) and 1998-2002 (Mitchell *et al.* 2004). These sources mostly attribute the huge 13% annual increase over the first 70 years of the last century (Chabrzyk and Coulson 1976; Coulson 1991) to protection, increased discards of marine fishing waste and offal (Hudson and Furness 1989; Garthe and Hüppop 1994), household rubbish dumped at landfill sites, or combinations thereof. The population increase continued until about 1970 and was followed by a decline, the latter being attributed to changes in the processing of waste at landfill sites, reduced fishing discards, and mortality from botulism caused by the bacterium *Clostridium botulinum* (Nager and O'Hanlon *in press*). Many of these explanations for population changes are based on general impressions, but are supported by little quantitative information. While some are undoubtedly correct, particularly the role of protection and marine discards, readers are repeatedly left with the impression that the use of landfills by Herring Gulls greatly contributed to their increase from the start of their recovery in about 1900.

The more recent declines in Herring Gull numbers are similarly attributed to changes in landfill practices, reduced marine fishing discards, and botulism, but few considered that culling had been important. Lloyd *et al.* (1991) commented that little is known about the effects of culling gulls on nature reserves in the 1980s, but was apparently unaware that major culling for other reasons had also occurred. Brown and Grice (2005), with the benefit of unpublished historic information available to the Nature Conservancy (now Natural England), stated that culling had no widespread effect on Herring Gulls

in England, and that the overall impact on the U.K.'s breeding and wintering populations was likely to have been slight. A similarly questionable conclusion was reached by Burton *et al.* (2005).

While the population of Herring Gulls in Britain as a whole has declined during the past 45 years, the numbers nesting on buildings in towns and cities have continued to increase even to the present time (Monaghan and Coulson 1977; Raven and Coulson 1997; Mitchell *et al.* 2004). At least 15% of all Herring Gulls nesting in England in 2000 occurred in urban areas, and that number is likely to be even higher now. Reasons for these recent opposing trends in numbers between urban and natural sites have not been convincingly explained. The widely held views of the public and many local councils is that urban nesting is primarily associated with the gulls obtaining food within towns and cities, but this is not realistic considering both the historic evidence that the early colonizers did not feed there and the large numbers now nesting in individual towns and cities.

In this paper, I consider the effects of culling and the use of landfill sites on changes in the population size of Herring Gulls in Britain over the past century. Despite what has been assumed by others, I suggest that Herring Gulls did not begin using landfills in numbers until after their population explosion had been in progress for some 50 years. On the other hand, culling has likely had a greater impact on the more recent population decline than has been previously considered. The move to landfills as feeding sites has brought the Herring Gull into much more frequent contact with the botulism bacterium. Fish offal and discards from inshore fisheries have been and still are important food sources for Herring Gulls (Hudson and Furness 1989; Camphuysen and Garthe 1999) and are not further considered here.

METHODS

Historical material used in this paper regarding the population trends of the Herring Gull and the changes to landfill practices in Britain has been collected from many sources. In addition, studies with co-workers and personal observations on uniquely color-banded adult Herring Gulls marked between 1975 and 1995 have given an in-depth knowledge of the feeding behavior of this species both at landfills and elsewhere in the north of England and eastern Scotland. Information on the abundance of Herring Gulls in Britain prior to 1912 is sparse, while that relating to the situation between 1890 and 1912 was gathered over many years by searches of local literature, reports in newspapers, diaries and obscure sources such as unpublished and archived correspondence, but further material remains to be discovered. I have accumulated information for many years on culling of large gulls, including previously unreported information that has added to those I have personally observed.

Three nationwide censuses of the seabird populations of Great Britain, Northern Ireland and the Republic of Ireland included the Herring Gull: the first in 1969-1970 (Cramp *et al.* 1974), the second in 1985-1987 (Lloyd *et al.* 1991) and the third in 1998-2002 (Mitchell *et al.* 2004). For convenience, these are subsequently referred to as the 1970, 1985 and 2000 censuses, which are the years in which most of the counts were made. The Republic of Ireland and Northern Ireland have been excluded from this study because the historical information for both countries is less complete, and there is evidence in Mitchell *et al.* (2004) that the recent changes in status of the Herring Gulls there have been more extreme. All comments and figures hereafter relate to Great Britain (England, Scotland, Wales, Isle of Man and Channel Islands) and are presented throughout as the numbers of adult Herring Gulls, rather than as the number of breeding pairs given in the reports, as this facilitates the inclusion of immature and non-breeding individuals when required. In all censuses conducted, numbers of immature and non-breeding adult Herring Gulls were not recorded, but in late autumn these represent an additional 30% or more than just the numbers of breeding adults reported (J. C. Coulson, unpubl. data).

Censuses of colonies of large gulls during the breeding season are difficult for several reasons, including access, the wide spread of laying dates and the exclusion of non-breeding adults, which at times exceeds 15% (Drost *et al.* 1961; Kadlec and Drury 1968; J. C. Coulson, unpubl. data); so for these reasons counts tend to underestimate the adult population size. Reinterpretation of census data has also led to some minor changes in the numbers reported in each national census but, in general, these are small and have had no appreciable impacts on the recorded population trends considered here.

Relevant data on the history of refuse collection and transport to sites variously called dumps, refuse tips or landfills and the use of these sites by Herring Gulls have been traced by literature searches, journals, diaries and personal records. Information on the behavior of Herring Gulls was collected at many landfill sites, but mainly at Coxhoe, County Durham, northeastern Eng-

land (about 20 km from the sea), and at other landfill sites between Scarborough in Yorkshire, England, and in eastern Scotland between 1975 and 1999. Studies were made on town-nesting Herring Gulls at Newcastle, Sunderland and South Shields, (Tyne and Wear), Berwick-upon-Tweed and Ashington (Northumberland), Teesside (then Cleveland), and Whitby and Scarborough (Yorkshire), all in northeastern England.

This study used over 1,500 adult Herring Gulls, each marked with a unique combination of colored Darvic leg-bands (Coulson 1963), allowing individual recognition, and, in a few cases, temporary yellow dye was added to the tail to assist detection in the field. Observations on these marked Herring Gulls were made to detect both their breeding areas and their visits to landfill sites.

RESULTS

Herring Gull Population Changes Since 1900

Literature, diaries, reports and private correspondence obtained for the period from 1890 to 1912 indicated that Herring Gulls were few, with extensive lengths of coastline without nesting pairs, and produced an estimate of only some 200 adults breeding in England, Wales and the south of Scotland during this time. Adequate evidence of numbers in northern Scotland could not be found for that period, but the British population was probably less than 1,000 adults. Between 1900 and 1970, numbers increased by 13% per year (Coulson 1991) and by 1970 reached over half a million adults, producing more than twice as many surviving young than was believed to be needed to replace adult mortality (data based on Cramp *et al.* 1974). It is interesting to note that the term 'common' in relation to the status of Herring Gulls in Britain changed progressively in its meaning during the 20th century. In 1912, the Herring Gull was recorded as a common breeding bird on the Farne Islands, but in a letter at that time, the same person wrote that he had found six nests there. That colony recently contained over a thousand individuals and the species is still described as common.

Between the first and second censuses, in 1970 and 1985, respectively, the recorded numbers of breeding adult Herring Gulls in Britain showed a dramatic decrease from 563,000 to 293,000 birds, a decrease of 48% (Lloyd *et al.* 1991). These results suggest that the population expansion had ceased by 1970. Between 1985 and 2000, national censuses showed variable regional changes in numbers, but in Britain there had been only a 2-3% decrease (but a much larger one in Northern Ireland and the Republic of Ireland) and there were still about 286,000 adults. Although there has been no national census since, counts made at relatively few sites annually until 2014 (Joint Nature Conservation Committee 2014) suggested that this population decline may have continued at a low annual rate until about 2004 and then remained at about the same level since. Despite uncertainty about the representativeness of these samples (e.g., they contained no urban sites), data up to 2008 were used to place the Herring Gull in Britain on the U.K.'s Birds of Conservation Concern Red List (Eaton *et al.* 2009).

The change in the Herring Gull population in Britain is shown in Fig. 1 on a logarithmic scale so that the steepness of the slopes indicates the rates of change. The results of the next national census will be important in updating the recent population trend. While few Herring Gulls originating in Britain emigrate, the numbers present in winter are increased by the immigration of

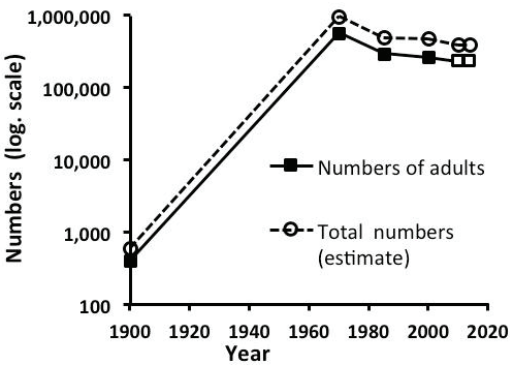

Figure 1. The numbers of all Herring Gulls and of adult Herring Gulls during the breeding season in Britain from 1900 to 2014 plotted on a logarithmic scale to indicate the rate of change in numbers. Open squares indicate estimates based on samples of a relatively small number of colonies counted annually and reported by the Joint Nature Conservation Committee (2014).

Herring Gulls from northern Scandinavia and Russia (Stanley *et al.* 1982; Coulson *et al.* 1984), which inflate the winter numbers nationally, but probably by less than 15%.

History of Refuse Management in Britain

The information presented below is a summary from a large number of sources, including the relevant Acts of Parliament and local government records. The Public Health Act of 1875 was concerned primarily with reducing the incidence of cholera by improving the quality of drinking water and the removal of human sewage from houses and manure from stables. A minor clause of the Act authorized local authorities to remove refuse from properties and, for the first time, empowered them to supply receptacles for the deposition of refuse as they thought fit. The Act included no instructions as to where or how this refuse was to be disposed, and the implementation was slow and variable. As a result, most household refuse produced by the human population in Britain at that time (about 21 million in 1851) was dumped locally and in small quantities.

It was not until 1912 that "controlled tipping" on land was introduced for the disposal of municipal solid waste and was organized by the local authorities, who used small "bin lorries," manned by "dustmen," to collect refuse from households. The name "dustmen" indicates that an appreciable amount of the refuse at that time was ash produced by burning coal to heat houses and probably contained little food waste. Refuse was collected at weekly intervals and taken to local hollows, ponds, old quarries or marshes where it was deposited. These sites were still small and were called dumps, refuse tips, or more recently by the more socially acceptable term landfills.

The 1936 Public Health Act allowed local authorities to provide sites and apparatus (e.g., lorries, compactors, and bulldozers) for the deposition and treatment of waste. In the first half of the 20th century, much waste material was burnt at landfill sites, and this persisted at many places until finally banned by the U.K. Clean Air Act of 1956. The combination of fire, smoke and associated human activity at these landfill sites would probably have deterred gulls.

Legislation controlling the methods of refuse disposal was not introduced until 1947, when new and larger regional authorities developed landfill sites that received greater amounts of refuse. For the following 50 years, waste was deposited in layers up to 3 m thick, leveled and compacted by heavy machinery. Refuse was to be covered by soil or other inert materials as soon as possible, but in practice this was applied at the end of each working day. As a result, much refuse was accessible to gulls only from when the first lorry arrived at the landfill site each day, which was often not before 09:30 hr and until about 16:00 hr, when most refuse had been covered and the site closed for the day.

The appreciable amount of ash in household waste was reduced during the 1950s, as oil or gas central heating replaced domestic coal fires. However, it was replaced by increasing amounts of waste of many other kinds, including industrial and building waste, plastics, paper, wood and plant material, all of which were unsuitable as food for gulls. From about 1970, much household refuse was placed in plastic bags before collection, and this made access to food more difficult for gulls. By 1994, there were 3,435 authorized landfill sites in Britain, and in 2000, about 23 million metric tons of refuse was sent there in a year, but only some 18% of this was putrescible material and only a modest proportion of that was potential food for gulls (Greig *et al.* 1983, 1985)

Within the last 40 years, further changes to the management of refuse have taken place. Industrial incinerators were introduced at a minority of areas, but subsequently abandoned due to the production of toxic dioxins. In the 1980s, active areas of some landfill sites were enclosed within netting in an attempt to exclude gulls, but these failed in most cases because the gulls found novel ways of accessing the refuse, such as by walking as a flock through the restricted but open entrance, rather than flying directly onto the refuse. In the 1990s, initial compacting and bailing of refuse into large cubes was

introduced and these were stacked, making the contents less available to gulls, while in some places the introduction of refuse management within closed buildings successfully excluded gulls.

A European Landfill Directive, brought into force as the Landfill (England and Wales) Regulations 2002, was introduced gradually and in stages. It required progressive reduction in the amounts of biodegradable municipal waste to 50% of the 1995 level by 2013 (which was achieved) and aims to further decrease this to 35% by 2020 by sorting refuse at the point of collection and increasing recycling of materials. As of 2014, there are still many landfill sites within Britain where Herring Gulls feed, but these are being reduced and this will be continued in the future.

When Did Herring Gulls Start Using Landfill Sites?

Many assumptions have been made when claiming that Herring Gulls fed at landfill sites in Britain during the whole of their population expansion during the 20th century, and sound evidence in support of these assumptions appears to be totally lacking. Until the end of the 1920s, Herring Gulls were entirely seabirds, restricted to a coastal distribution in Britain and only rarely moving inland during severe winter weather. For example, they were not recorded in the extensive surveys of flight lines of other gulls in the London area in the 1920s (Nicholson 1995). This restricted distribution alone put many landfill sites beyond the feeding range of Herring Gulls. Collinge (1924-1927) examined the stomach contents of 539 Herring Gulls collected in England and failed to find food items that could have been collected from landfills. I have located only one record of gulls feeding in numbers at landfill sites in Britain before the 1940s. Furness and Monaghan (1987) mention that by 1922 complaints about gulls feeding at landfills were already being made, but it had not been possible to rediscover the origins of this claim and it is more likely that complaints were related to Black-headed Gulls (*Chroicocephalus ridibundus*). It is unlikely that Herring Gulls in Britain fed regularly at landfills before the 1940s.

Food shortages and rationing in Britain during and beyond the 1939-1945 World War II must have reduced waste food being sent to landfills. In many places, waste food was specifically collected as "swill" to help support the increased pig production, and rationed food continued into the early 1950s. The only contemporary reports discovered of Herring Gulls at landfills relate to the winter period of 1943 in northwestern England (Blezard *et al.* 1943) and of a few individuals in 1949 present at a coastal landfill site near Brighton in southern England (W. R. P. Bourne, pers. commun.) and at another landfill in northeastern England (J. C. Coulson, unpubl. data). In the winter of 1952-1953, small numbers of Herring Gulls were recorded for the first time roosting at night on inland reservoirs (Hickling 1954) and so were presumably feeding inland. The numbers roosting inland increased appreciably in the following decades.

That no mention of numbers of Herring Gulls frequently feeding at landfill sites were made by the many authors writing in the 1940s to early 1960s is of considerable importance, since the expectation is that they would have commented had it existed. These, among others, include Witherby *et al.* (1940), Gibson-Hill (1947), Nicholson (1951), Lack (1953), Fisher and Lockley (1954), Bannerman (1962) and Wynne-Edwards (1962). More significantly, the ethologist and able field naturalist Niko Tinbergen (1953) considered at length several unusual feeding methods used by Herring Gulls in his monograph on the species, but made no mention of their presence at landfills or even of dense feeding flocks anywhere.

Vine (1951), in an extensive account of gulls in the Breckland of southeastern England, made no mention of gulls at landfill sites. The surveys of wintering Lesser Black-backed Gulls (*Larus fuscus*) organized by Barnes (1952, 1956) reported the first records of this species at a landfill site, but did not mention Herring Gulls being present. The revised edition of *The Birds of the Lon-*

don Area (Committee of the London Natural History Society 1964) also mentioned the occasional Lesser Black-backed Gull at rubbish dumps but made no mention of Herring Gulls there, although they did report them being observed at sewage farms and roosting on the London reservoirs. On 20 February 1953, the Onlooker section of the *Carlisle Journal* newspaper reported unspecified numbers of Herring Gulls regularly visiting the local landfill site at Carlisle in northwestern England; in the same newspaper on 24 January 1956, R. Graham reported some 500 Herring Gulls in January 1956 at a large landfill site also near Carlisle. Crook (1953) recorded only Black-headed Gulls feeding at Council landfills in the south of England and considered it sufficiently unusual to write that "Spencer writing from Lancashire informed him that the larger gulls there were found feeding at 'offal tips' near towns." Records were still infrequent in the early 1960s, but it is evident that the habit of using landfills among Herring Gulls had become widespread by the mid-1960s (Parslow 1967). The habit of feeding at landfills seems to have developed rapidly, and several research studies made in the late 1960s and early 1970s in Scotland, Wales and England all recorded appreciable numbers of Herring Gulls feeding at landfill sites in winter and summer (Brown 1967; MacRoberts and MacRoberts 1972; Mudge 1978). Subsequently, records of several thousand Herring Gulls at a time feeding at landfill sites have been recorded, although most report only hundreds of individuals present at a time. In The Netherlands, Herring Gulls were first reported visiting landfill sites in the 1930s (Camphuysen 2013).

The evidence obtained to date indicates that frequent feeding by Herring Gulls at landfill sites in Britain probably did not start before the early 1940s and then it was only local, coastal and seasonal. This developed rapidly, becoming widespread in England, Wales and Scotland during the 1960s and persists to the present time, despite recent changes in refuse management. If this interpretation is correct, landfills in Britain could not have played a part in the rapid increase of Herring Gulls between 1900 and 1950, and leaves only 20 years or less for the exploitation of landfills until their numbers started to decline.

How Do Gulls Feed at Landfills?

Herring Gulls feeding at most landfill sites are predominantly adults. The less numerous immature birds tend to arrive earlier and leave later during the day (Fig. 2) and usually feed more peripherally than the adults or patrol at low density, sometimes with a few adult females on areas compacted and covered long ago and distant from the working faces (Monaghan 1980). The diurnal pattern of feeding by Herring Gulls varies considerably between individual landfill sites, but it tends to be consistent at the same site on successive days. These differences are illustrated in Fig. 3, where the numbers present and feeding are shown at three sites. At those sites that closed for 30 min at midday (most landfill sites in northeastern England), feeding by Herring Gulls took place most consistently at this time, but only infrequently and unpredictably at other times, with gulls apparently inhibited by the frequent arrival of vehicles (which often

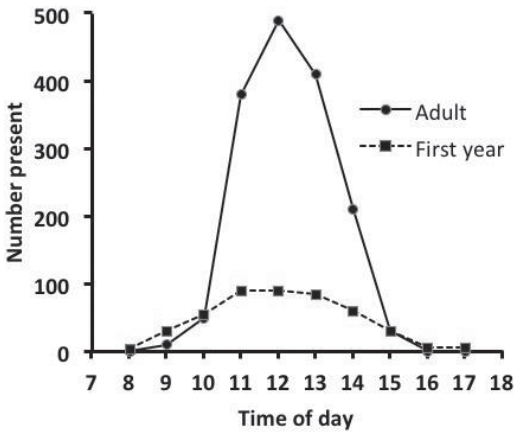

Figure 2. The average number of Herring Gulls counted during each hour of the working day at Coxhoe landfill, County Durham, northeastern England. The few first-year birds tended to arrive earlier and leave later, while adults dominated during the middle of the day, when most of the feeding took place. Numbers shown are the average of counts made on 4 days between October 1995 and early February 1996.

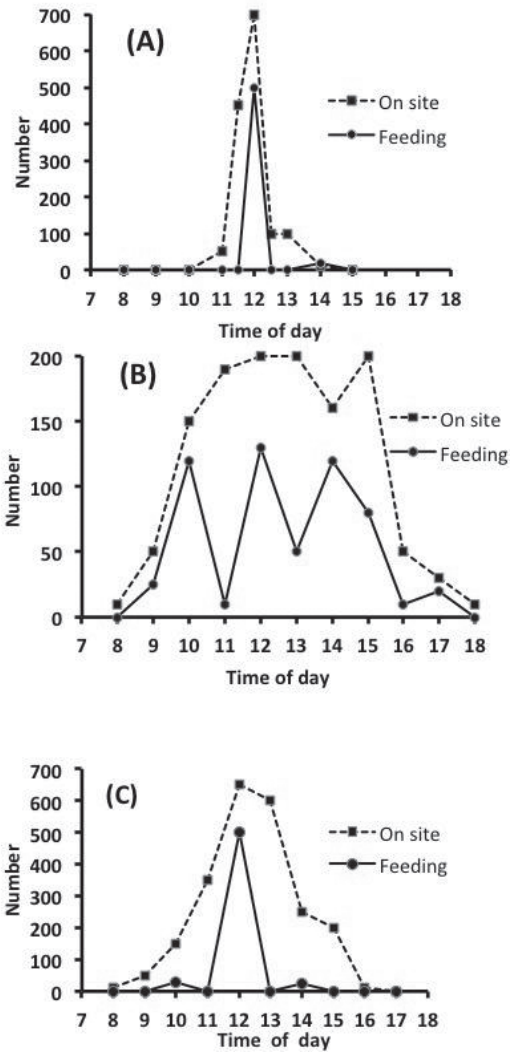

Figure 3. The maximum number of Herring Gulls present and feeding in the first 30 min of each hour of the working day at: (A) Scarborough landfill, Yorkshire, in April; (B) Aberdeen landfill, Scotland, in April; and (C) Coxhoe landfill, County Durham, in January, illustrating variations in the patterns of gull presence and feeding at different landfill sites.

queued up before unloading) and humans moving around the vehicles. As a result, most Herring Gulls at many of the landfill sites did not feed or only infrequently fed before noon, and their arrival at or near some sites was delayed until late morning and so several hours after sunrise. An exception to this pattern was observed at the busy Aberdeen landfill site in Scotland, where gulls fed frequently and close to vehicles for much of the day, even remaining within a few meters of persons when they left the lorries. Between April and June, adult Herring Gulls regularly fed at landfill sites only within their normal feeding range from the breeding areas, while other landfills, particularly those far inland, were not visited at this time of year, even by immature gulls. The feeding patterns of gulls at landfill sites during the breeding season resembled those used in the winter, but there were more hours of daylight and often gulls only fed during the opening hours.

Frenzy Feeding

At many landfill sites in northern England and elsewhere, Herring Gulls fed for only a small proportion of the time that uncovered refuse was available. When they did feed at the active working face with recently deposited refuse, it was typically in a large, dense flock, best described as a feeding frenzy. This behavior, shared only with Black-headed and Lesser Black-backed Gulls at landfills, arises from the considerable hesitancy shown by individuals to initiate feeding. Typically, numbers of gulls gradually built up at a day roost near the active landfill site after 09:30 hr or later in the morning. Commonly, no feeding by gulls occurred at the active working face of the landfill for some time or, when they did, it was infrequent and of short duration when unloading vehicles were absent from the working face. When incoming vehicles were prevented from entering the landfill at midday, sometimes the gulls responded almost immediately to the absence of vehicles and compactors and moved onto the landfill in a dense flock to feed. However, on many occasions there were delays of 5-10 min and even up to 20 min before feeding commenced. There was no obvious reason for these delays. Eventually, one or two gulls would leave the nearby roost, fly back and forth over the active landfill area and eventually land on the refuse, giving characteristic wheezy feeding calls. Within seconds, most gulls moved from the roost to the landfill and a feeding frenzy would begin immediately, with hundreds of gulls searching for

Table 1. The estimated number of adult Herring Gulls and the percentage change in abundance in Britain as reported from three national censuses between 1970 and 2000; numbers reported shown to the nearest 500 birds. Note that the census in some years was restricted to coastal colonies. There are minor differences between the numbers of adult Herring Gulls reported for the 1985 census by Lloyd *et al.* (1991) and Mitchell *et al.* (2004) for specific administrative areas, but these have only marginal impact on the changes shown. Note: Coulson and Coulson (2015) consider that the numbers of Herring Gulls breeding on urban sites in Britain were underestimated in 2000 and corrections for this shortfall would produce a 2% national increase between 1985 and 2000 and not the declines shown in this Table and in Fig. 1.

Census 1970	Census 1985	Census 2000	Census 1985	Census 2000	Change 1970-1985	Change 1985-2000	Change 1985-2000	
Coastal	Coastal	Coastal	Total	Total	Coastal	Coastal	Total	Source
563,000	—	—	—	—	—	—	—	Cramp *et al.* (1974)
568,000	292,000	—	322,000	—	-48%	—	—	Lloyd *et al.* (1991)
568,000	288,500	282,000	—	286,000	-49%	-2 to -3%	-11%	Mitchell *et al.* (2004)

food over a small area and considerable aggressive interactions occurring (Greig *et al.* 1983, 1985). Between 10-20% of the Herring Gulls made no attempt to feed during the feeding frenzy event and remained on the nearby roost.

Eventually, those feeding left the work area together, either spontaneously or when the site reopened to vehicles. Typically, the flock feeding frenzy continued for less than 15 min and was on many occasions interrupted by a synchronous panic departure, despite no external stimulus being evident. Only on some occasions did the gulls immediately return after a panic departure and continue to feed, but invariably many returned to the nearby roost site. Following the site reopening to refuse vehicles at 12:30 hr, feeding was infrequent as in the morning. As a result of this social behavior, the gulls lost much potential feeding time due to their reluctance to start feeding as soon as food became available.

This hesitancy to feed at landfills and the need to form a flock before starting to feed does not occur elsewhere in the feeding behavior of Herring Gulls. While flocks often gather behind fishing boats, the first individual to arrive starts to feed as soon as food is jettisoned overboard or the nets are hauled; otherwise, the potential food is lost. Herring Gulls accumulate in flocks over surface shoaling fish, but the first birds arrive singly or in small groups and do not wait for a flock to form before feeding. On agricultural land, they show little hesitancy before following a plowing tractor, and they are spread out widely when searching for grain or invertebrates in fields or when feeding on intertidal areas. The frequent delays in gull initiation of feeding at landfills leave the impression that the gulls are cautious about approaching the active working face and require the stimulus of a bold individual before they will start to feed.

The hesitancy to feed at landfills was well illustrated when a long line of diced bread was dropped from a vehicle driven slowly through the center of a day roost of Herring Gulls on the edge of a landfill site. Individual gulls in front of the vehicle walked a few meters aside as the vehicle approached, but immediately returned as it passed, with many then standing within a meter of bread. However, the food remained untouched for 15 min until one immature gull moved a few paces, then picked up and swallowed one piece of bread. Within 30 sec, the other gulls had consumed all of the bread.

Time of Arrival at Landfill Sites

It takes time for refuse lorries to collect and deliver their first loads to the landfill site, so it was 09:30 hr to 10:00 hr (long after sunrise) before the lorries arrived and the first potential food was dumped and exposed. Typically, most Herring Gulls arrived near the landfill during the late morning (Figs. 2 and 3) after the first refuse was deposited. At one coastal site, the gulls did not arrive until after 11:00 hr and rapidly aggregated in numbers before they fed for the first time at noon (Fig. 3B). After the noon

feeding frenzy, numbers of gulls declined as many adult gulls drifted away to drink, preen and possibly to feed elsewhere. Numbers continued to decline and few gulls were present when the landfill closed each day (between 16:00 hr and 17:00 hr).

Marked Herring Gulls, which would later visit inland landfill sites on the same day, left the overnight coastal roost just after dawn and flew in the direction of landfills, but frequently stopped and fed on farmland along the way, consuming grain or invertebrates on grassland or feeding behind a plowing tractor. Typically, they arrived at landfills after having spent some hours feeding elsewhere, which may explain why up to 20% of the Herring Gulls present at the landfills did not join in the midday feeding frenzies at the landfills.

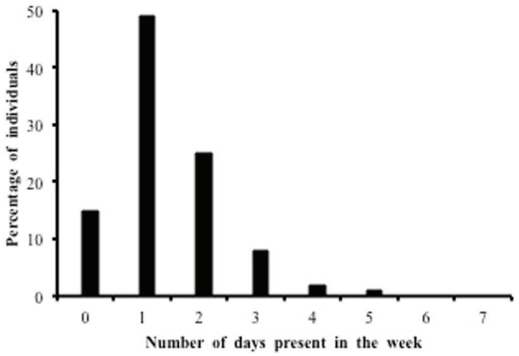

Figure 4. The proportion of individually marked Herring Gulls that visited Coxhoe landfill, County Durham, on 0 to 7 days and based on 279 marked individuals and combining data for four different weeks in October, November and December, spread over 2 years. Individual gulls that did not visit during the week had all been seen there within the previous 14 days and were seen again in the 14 days following the study week, thus excluding individuals that had left the area.

Frequency of Visits to Landfills

The assumption has frequently been made that the large number of gulls seen daily at landfills returned there day after day, but this did not apply to Herring Gulls at landfill sites in northeastern England studied between July and February. Numbers present were indeed similar on successive days, but records of individually marked gulls indicated that less than a third of the individuals present on a particular day had been there on the previous day, and similarly only a minority would be present on the following day (Coulson *et al.* 1987). An additional example of this type of observation is shown in Fig. 4.

Where are the Gulls on Days They Were Not at Landfills?

Individually marked adult Herring Gulls were recorded visiting several landfill sites in an area, usually on different days, and obviously many had knowledge of several alternative sites, although they usually showed a preference for one. Movement to other landfill sites explained less than 10% of the birds not seen at the study landfill on consecutive days. When frequently absent from landfill sites, marked gulls were found feeding along the shore, along rivers, in agricultural fields and behind plowing tractors and over a large area in excess of 400 ha, where they often occurred spread out and at low densities. There were also records of them frequently feeding at sea behind local fishing boats.

Do Some Herring Gulls Avoid Landfill Sites?

Table 2 shows the proportion of individually marked adult Herring Gulls for which their nesting areas were located and which were found at landfill sites within northeastern England. Herring Gulls that were

Table 2. The proportions of adult Herring Gulls with known breeding areas which were uniquely marked in northeastern England and then subsequently seen at landfill sites in that area.

Breeding Area	Number of Individuals	Percentage Observed at Landfills
Local, mainly urban nesting	75	7%
East coast Scotland, rural	470	47%
Northern Scandinavia, rural	101	66%

breeding locally at urban sites rarely visited landfills at any time of the year, while those visiting from eastern Scotland, northern Scandinavia and Russia were much more frequently identified at landfills. Herring Gulls breeding at urban sites in South Shields and Sunderland, northeastern England, fed predominantly at sea, along the shore and in fields, and only rarely visited nearby landfill sites at any time of the year and not at all during the breeding season. Over 200 adult Herring Gulls were captured and marked while visiting landfills within 3 km of Scarborough, which had over 600 adults nesting in the town at that time; 36 were subsequently recorded at nests on rural coastal cliffs up to 30 km away, but only two were found among those nesting within that town. In northeastern England, but not necessarily everywhere, many local and urban nesting gulls did not visiting landfills. In contrast, marked individuals of the larger and darker Herring Gulls of the subspecies *L. a. argentatus* breeding in northern Scandinavia and northwestern Russia and wintering in northeastern England were the most persistent in returning frequently to landfill sites (Table 2), and even more so at inland landfill sites in southeastern England (Stanley *et al.* 1982).

What Happens When Landfills Are Closed on Saturday at 12:00 Hr and All Day on Sunday?

Herring Gulls arrived at landfills in the morning on Saturdays as on the weekdays. Fewer vehicles brought refuse and gulls sometimes fed between 10:30 hr and 12:00 hr, but only when vehicles were absent from the site. The active dumping area was covered with soil by 12:00 hr and no midday feeding frenzies occurred, and gulls left the landfill earlier than on a normal working day. There was no exposed refuse or vehicle and compactor activity on Sundays. Gulls still arrived at the landfill during the morning but most moved on, often without landing. This "Sunday" pattern was repeated when the landfill was closed on weekdays, such as Christmas Day and on public holidays.

Effects of Culling

There was apparently no extensive or organized culling of adult Herring Gulls in Britain before 1970, but between 1960 and 1980 8% of recovered Herring Gulls banded in Britain had been shot, including individuals killed in colonies on grouse moors. Between 1970 and 1985, extensive culling of Herring Gulls was carried out to address problems, including noise, nuisance, pollution, damage to property, risk to aircraft, public health risks and impacts on other avian species. As an experiment in conservation, culling was carried out to evaluate the feasibility of controlling numbers breeding on the Isle of May. Coulson (1991) estimated that nearly 100,000 adult Herring and Lesser Black-backed gulls were killed in Britain between 1972 and 1987 (including 45,500 gulls, of which some 41,000 were Herring Gulls, on the Isle of May, a National Nature Reserve, alone). No permission other than from the landowner was needed at this time to cull Herring Gulls, as it was covered by a general license. There were no requirements or facilities to report culls and the numbers killed. Since making the estimate of 100,000 gulls culled by 1991, more information has been obtained. I now consider this figure to be an appreciable underestimate, as the existence of many additional areas have been identified where culling went unreported, presumably to avoid adverse public responses, although details are not available. These include dockyards at Rosyth in southeastern Scotland and military airfields in northeastern Scotland. In northwestern England, colonies of Herring Gulls have been culled at Haverigg prison complex, Sellafield nuclear reprocessing plant, Royal Air Force Carlisle and in large numbers on at least two grouse moor colonies. In northeastern England, culls have taken place on buildings of Austin and Pickersgill Ltd. in Sunderland, where in 1976 alone approximately 600 were shot (Monaghan 1977), and more at the nearby Cole's Cranes. Herring Gulls have been culled in five towns in northeastern England and also killed at landfill sites in several parts of England, all with the approval of their lo-

cal councils in several parts of the England, with the approval of their local councils. Culling on nature reserves has taken place on the Isle of May (Nature Conservancy Council, now Scottish Natural Heritage), at a series of nature reserves in England and Scotland (Royal Society for the Protection of Birds) and on the Farne Islands in northeast England (National Trust).

As a result of this additional information, my revised estimate is that almost 150,000 adult Herring Gulls were culled in England and Scotland between 1970 and 1985 (i.e., about 10,000 adults each year, which suggests that about 5% of the then adult population in Britain was being culled each year). These culls could have increased the reported annual mortality rate of the Herring Gull from 8.3% (Coulson and Butterfield 1986) to about 13.3% and would have reduced the average lifespan of an adult from about 11.5 to 7.0 years, appreciably reducing the lifetime reproductive productivity. Since the population expansion of the Herring Gull had probably ceased by 1970, culling alone is enough to account for the recorded 48% decline (-4.3% per year) in Herring Gull numbers between 1970 and 1985.

Culling of Herring Gulls has continued in recent years, but at a lower intensity, and numbers killed remained unknown at many sites, including at landfill sites in Yorkshire and Lancashire (Cook 2008; Cook *et al.* 2008). In 2010 and for the first time, culling of Herring Gulls in England required a specific license. As part of their application, applicants for licenses in England in 2010 reported that they had killed 3,256 Herring Gulls in the previous year (2009), so the annual total culled in Britain in 2009 must have been higher than this. In 2010, over 100 licenses were issued to cull a total of 4,304 Herring Gulls in England alone (Carter 2011), but only 1,263 were reported as killed, but even so, this represents over 1% of the adult population in England. Between 2010 and 2012, nearly 5,000 adult Herring Gulls were culled under licenses issued in England and they continue to be culled under license (Natural England 2014). For example, in 2013 and despite considerable opposition, a license was granted to cull 475 Herring Gulls to protect aircraft at a single coastal Site of Special Scientific Interest on the Ribble Estuary, Lancashire (Natural England, pers. commun.).

Impact of Botulism

Botulism in Herring Gulls is usually fatal and in Britain is caused by a toxin produced by the type C strain of the bacterium *Clostridium botulinum*. Initially, the symptoms are a characteristic flaccid paralysis that results in dehydration and then eventual death. There have been an increasing number of reports of botulism in Herring Gulls throughout Britain and in Northern Ireland and the Republic of Ireland in recent years (e.g., Macdonald and Standring 1978; Sutcliffe 1986: Lloyd *et al.* 1991; Mitchell *et al.* 2004), and confirmed deaths have been reported in every month of the year. Certain diagnosis of botulism in gulls found dead is difficult, because it requires a blood sample taken from the individual while still alive (Macdonald and Standring 1978), but death from botulism is often attributed to birds that show paralysis or are found dead with partially extended wings. On some occasions, large numbers of gulls die at the same time, but reports of small numbers of fresh deaths become appreciable when considered over many weeks and months.

In 1993, Ortiz and Smith (1994) sampled 19 landfill sites throughout Britain and found exceptionally high frequencies and abundance of spores of *C. botulinum* type C in soil and mud at 63% of these sites. They report that the bacterium required anaerobic conditions in areas with accumulations of organic material such as animal carcasses and a microclimate where temperatures are raised during winter conditions. They justifiably concluded that landfills were probably the main source of botulism infection in gulls.

The extent to which botulism has been and is still killing Herring Gulls is unknown in quantitative terms, but its frequency has clearly increased during the past 45 years and is occurring at an appreciable level elsewhere in northern Europe (Neimanis *et al.* 2007). The increase of cases of botulism and

its occurrence throughout the year suggests that it has played a part in the cessation of the population growth of the Herring Gull population in Britain and subsequently its recent decline.

Nesting on Urban Buildings

Herring Gulls were first reported nesting on buildings in Britain in the 1920s, but the habit spread slowly until about 1960, after which time it increased markedly (Monaghan and Coulson 1977). Despite the national decline in the Herring Gull population since about 1970, Herring Gulls nesting on buildings in urban areas continued to increase during the next 40 years (Raven and Coulson 1997; Mitchell *et al.* 2004) and continue to increase to this day. Many marked individuals hatched and reared on natural, coastal sites are known to have recruited as adults into urban areas (Duncan and Monaghan 1977; Monaghan and Coulson 1977), but insufficient nestlings have been marked in towns to determine whether the reverse movement has also occurred.

As a result of the increase in urban areas, over a quarter of Herring Gulls currently nesting in England now do so on buildings (Mitchell *et al.* 2004). This has become problematic for several reasons, mainly due to their proximity to human habitation and unacceptable aggressive behavior (while protecting nestlings), soiling of buildings and people with feces and the snatching of food from humans.

Animal protection groups and many Town Councils have attributed the spread of Herring Gull urban nesting to food discarded or fed to them in towns and to their learning to find food by breaking into plastic sacks and rubbish containers in streets. While keeping urban areas cleaner and free of consumable rubbish is highly desirable, it has not prevented gull numbers from increasing in towns and likely never will. Studies in towns in northeastern England during the late 1960s and early 1970s found that the Herring Gull's habit of finding food there did not begin until several years after breeding first started (J. C. Coulson, unpubl. data). Studies on marked individuals and analyses of regurgitated pellets and food from Herring Gulls nesting on buildings in northeastern England suggest that much less than 10% of their food was obtained from within the town limits during both winter and the breeding season (J. C. Coulson, unpubl. data, using same methods as for Lesser Black-backed Gulls (Coulson and Coulson 2008)). Urban nesting Herring Gulls still obtain most of their food beyond town limits, frequently consuming fish obtained at sea and grain, earthworms and other invertebrates collected from farmland. Marked individuals are known to travel up to 25 km from urban areas to feed during the breeding season. That most gulls obtain their food elsewhere has become self-evident, as many urban colonies have increased to well over a thousand adults, requiring orders of magnitude more food than can be found within towns.

Surprisingly, town-nesting Herring Gulls in northeastern England rarely visited nearby landfill sites at any time of the year (Table 2). It is evident that in some areas, but not all, town-nesting Herring Gulls have not depended on local urban sources of waste to maintain the high reproductive rate reported there by Monaghan (1977). However, in some other urban areas, (e.g., Aberdeen), nearby landfills probably did provide a larger portion of food obtained by some Herring Gulls breeding there in the 1980-2000 period.

DISCUSSION

The role played by landfills in the population explosion of Herring Gulls in Britain has been greatly exaggerated, and no support has been found for the assumption that they were a key source of food for Herring Gulls in the first 50 years (1900-1950) of their rapid population expansion in Britain. It would seem that many have repeated this assumption without critically researching the historic use of landfills by gulls.

Many well-known authors writing in the 1930-1962 period who might have been ex-

pected to comment on flocks of gulls feeding at landfills all failed to mention this feeding behavior. Until the 1950s, Herring Gulls seldom moved inland, and, as a consequence, many landfill sites were beyond their feeding range. For the first half of the 20th century, most landfill sites were small and unattractive to large gulls, while the regular burning of refuse there would likely have been a deterrent to gulls exploring the sites.

In Britain (and elsewhere), seabirds were heavily and increasingly hunted and persecuted during the 19th century, aided by improved transport and firearms that were developed during the industrial revolution. The first Sea Bird Protection Act was passed by the British parliament in 1869, but its implementation was slow and ineffective for many years, as were later Bird Protection Acts passed during that century.

By about 1900, protection in Britain was at last becoming effective, but many accounts from that time clearly indicated that numbers of several seabird species had then reached all-time low levels, and these included the Herring Gull, Black-legged Kittiwake (*Rissa tridactyla*), Northern Gannet (*Morus bassanus*), Great Skua (*Stercorarius skua*), Common Eider (*Somateria mollissima*), Atlantic Puffin (*Fratercula arctica*) and Common Murre (*Uria aalge*). At about this time, numbers of all these species in Britain simultaneously began to recover toward former (but unknown) numbers and the increases continued for much of the 20th century, while the Northern Fulmar (*Fulmarus glacialis*) bred for the first time on the British mainland in 1903 and then increased and spread dramatically (Fisher 1952). The coincidence of the increase of these species, despite different food requirements and feeding methods, adds further support to the view that protection was the underlying cause of the initial increase. Protection became progressively more effective during the 20th century. The initial expansion of the Herring Gull population, as with other species, was unlikely to be limited by food shortages as it and other species were recovering toward former levels.

When Herring Gulls eventually started to use landfills around the 1950s, there were only 20 years or less when that additional food could have supported the population expansion. At best, the contribution of landfills to the increase of the Herring Gull was brief. While landfills have been used extensively by Herring Gulls during the past 40 years and still are, this did not stimulate an increase in the gull's population over this period.

In recent decades, observers have commented on the hundreds of gulls at landfill sites engaging in feeding frenzies, yet incorrect assumptions have been made about the ease with which gulls find food there. The time available for Herring Gulls to feed at landfills varies considerably between sites, but Coulson *et al.* (1987) estimated that in northeastern England, those present on a particular day spent less than 30 min feeding there. Studies by Greig *et al.* (1983, 1985) have shown that abundant food in not always readily available at landfill sites, resulting in intense competitive feeding during frenzies, and with immature and female gulls gaining less benefit by feeding there than adult males. Finding food among landfill refuse is difficult because it is often hidden among the large amounts of non-consumable material, and immature individuals take several years to become efficient at this method of feeding.

The impression that individual Herring Gulls regularly return to landfills day after day, despite similar numbers appearing on consecutive days, is not supported by studies on marked individuals, and the average individual visited on only 1.36 days per week and some rarely visit landfills at all (Coulson *et al.* 1987). On some days, Herring Gulls did not obtain any food at landfills, while some individuals visiting a landfill had already fed elsewhere before arriving. As many gulls left early in the day, there was a possibility of feeding elsewhere.

Surprisingly, attention has not been drawn to the unusual behavior of Herring Gulls feeding at landfills in dense groups, which results in a feeding frenzy. Typically, the gulls slowly aggregate into a loafing flock near a landfill and wait one or more hours before feeding is initiated, apparently as a

result of a marked hesitancy to be the first individual to attempt to feed. This behavior, which appears to be unique to a few gull species, greatly reduces the time spent feeding, and Herring Gulls are clearly not usually maximizing feeding opportunities during the time spent at or near landfill sites.

These detailed studies on Herring Gulls suggest that landfills are not necessarily the easy source of food that many believe them to be, and the species does not appear to be well adapted to taking full advantage of feeding opportunities at these sites. Perhaps, this is because feeding at landfills is only a recent development. The widespread idea that Herring Gulls obtain their total daily food requirements in 20-30 min at landfills is probably a misrepresentation of the situation, as it does not take into account that the gulls on that day were also feeding elsewhere.

The decline in numbers of Herring Gulls since 1970 has been variously attributed to declines in marine fish discards and offal, increased cover of material at landfills and deaths from botulism. Previously, culling has been regarded as of little consequence. For example, Brown and Grice (2005), with the resources of Natural England, concluded that culling was "unlikely to have been responsible for the decline in the overall population in the 1970s and 1980s." However, the extent and impact of culling has been greatly underestimated, mainly because statistics were not collected before 2010, and the existence and extent of many culls in the past have not been recorded or made available. Culling by shooting and the use of alphachloralose to kill Herring Gulls increased rapidly after 1970, and enough gulls were probably killed to have had an appreciable influence on the rate of decline between 1970 and 1985 and to prevent a recovery up to the present time.

It is obvious that populations of animals cannot continue to increase indefinitely, even if the species manages to exploit new habitats and food sources. There are many examples frequently quoted in standard ecological textbooks of animal populations recovering from exploitation, rapidly increasing in numbers, temporarily exceeding their resources and declining to a lower level. This pattern of population growth and decline could apply to the Herring Gull in Britain since 1900. There has been a rapid recovery, then an overshoot followed by a decline, and finally a stable or slightly declining population in recent years. Reduced exploitation, increased protection and an underexploited food supply for many years have been involved in the case of the Herring Gull, but, in addition, several factors such as disease, culling and changing food supplies and feeding areas have also contributed to the observed population changes.

A final thought: is it possible that the move to feeding at landfills by Herring Gulls was not actually beneficial to the Herring Gull population in the long run, and could this change in behavior have brought about the end of the population expansion in Britain? The change to using landfills as a food source brought the gulls into areas where they were much more likely to be infected and killed by botulism. This possibility has even greater interest because in some areas of Britain, urban nesting gulls rarely visit landfill sites. Could this difference explain the paradox of why the numbers of Herring Gulls breeding on natural sites have been declining for the past 45 years, while the numbers of some of those using urban nesting sites have continued to increase since 1970?

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