Aspects of the ecology of gulls in the urban environment

Susan Jane Raven

Aspects of the ecology of gulls in the urban environment

Susan Jane Raven

Presented in candidature for the degree of Doctor of Philosophy.
University of Durham, Department of Biological Sciences, 1997.

Acknowledgements

The work presented in this thesis was made possible by the assistance and co-operation of a great many people. The British Trust for Ornithology and the Seabird Group endorsed the survey of roof-nesting gulls and by doing so greatly increased the number of volunteers who became involved. Dr. Richard Gregory and the Regional Representatives of the British Trust for Ornithology were of particular help in the organisation of the survey. Paul Walsh and Mark Tasker of the Joint Nature Conservation Committee provided roof-nesting gull data from the Seabird Colony Register as well as much useful advice. The many people who actually carried out counts of roof-nesting gulls in their local areas are too numerous to mention here but their work was greatly appreciated.

Ken Smith and Bob Walters, Ecology Officers at ICI Wilton, worked hard to enable me to have access to the roof of the warehouse on the Wilton site and the Teesside Ringing Group, particularly Eric Woods and Geoff Myers, worked with me while ringing chicks on this roof. Dr. David Thompson of Glasgow University assisted with the identification of fish otoliths. The Port of Tyne Authority kindly allowed me to accompany their patrols along the River Tyne and I am grateful for the help given and interest shown by Captain Andrew Nelson and all the patrol crews. Northumbrian Water and the Environment Agency made available information concerning the input of treated and untreated sewage to the River Tyne.

In the Department of Biological Sciences I would like to thank Dr. John Coulson and Dr. Keith Hamer for their constructive advice while supervising the work in this thesis. Also in the department thanks must go to Eric Henderson, Dr. Mark O'Connell and Robin Ward for answering countless questions, and John Carter, Justin Maude and Katherine Webb for their assistance with fieldwork.

Finally, I must thank the following people for their constant support and help during the last four years; my mother, Michael Ioannou, Louise Revell, Karen Haysom, Michelle Nickerson and Takebumi Itagaki.

Contents

Abstract 1

Chapter 1: General Introduction 2

Chapter 2: The distribution and abundance of *Larus* gulls nesting on buildings in Britain and Ireland 8

2.1 Introduction 9

2.2 Review of roof-nesting by *Larus* gulls 10

2.2.1 Britain and Ireland 10
2.2.2 Europe 16
2.2.3 North America 17
2.2.4 Other continents 18

2.3 Methods 19

2.4 Results 20

2.4.1 Herring Gulls and Lesser Black-backed Gulls 20
2.4.1.1 Abundance and distribution 20
2.4.1.2 Changes since 1976 24
2.4.1.3 Regional variation 27
2.4.1.4 Coastal and inland nesting 32
2.4.1.5 Effect of colony size on rate of increase 33
2.4.1.6 Loss of colonies 33
2.4.1.7 Nest site types 35
2.4.2 Common Gulls and Great Black-backed Gulls 36
2.4.3 Responses of local authorities 38

2.5 Discussion 39

Chapter 3: Breeding success of Herring Gulls and Lesser Black -backed Gulls on a large warehouse 43

3.1 Introduction 44

3.2 Study Site 46

3.3 Methods 47

3.4 Results 50

3.4.1 Use of the roof 50
3.4.1.1 Number of breeding pairs 50
3.4.1.2 Distribution over the roof 50
3.4.1.3 Types of nest sites 52
3.4.1.4 Nest density 56
3.4.2 Breeding success 57
3.4.2.1 Initiation of laying 57
3.4.2.2 Clutch size 57
3.4.2.3 Egg volumes 59
3.4.2.4 Hatching success 59
3.4.2.5 Survival to fledging 62
3.4.3 Adult mortality due to botulism 66
3.4.4 Factors potentially influencing breeding success 67
3.4.4.1 Nest density 67
3.4.4.2 Nest site type 69
3.4.4.3 Elevation 70
3.4.4.4 Grouped and dispersed nesting 70

3.5 Discussion 70

Chapter 4: The diet of Herring Gulls nesting on a large warehouse 81

4.1 Introduction 82

4.2 Methods 83

4.3 Results 86

4.3.1 Adults 86
4.3.1.1 Diet 86
4.3.1.2 Changes through the season 92
4.3.2 Chicks 92
4.3.2.1 Diet 92
4.3.2.2 Changes through the season 95
4.3.3 Review of dietary studies of roof-nesting gulls 98

4.4 Discussion 98

Chapter 5: The effect of improvements to sewage treatment on the numbers and distribution of gulls on the River Tyne 108

5.1 Introduction 109

5.2 Study Area 111

5.2.1 The River Tyne 111

5.2.2 Use of the polluted river 112
5.2.3 Improvements to sewage treatment 115

5.3 Methods 115

5.4 Results 117

5.4.1 Changes in sewage input since 1969/70 117
5.4.2 Other changes on the river since 1969/70 117
5.4.3 Use of the river by gulls in 1993/94 119
5.4.3.1 Black-headed Gull 120
5.4.3.2 Common Gull 120
5.4.3.3 Lesser Black-backed Gull 120
5.4.3.4 Herring Gull 123
5.4.3.5 Great Black-backed Gull 123
5.4.3.6 Kittiwake 123
5.4.4 Comparing abundance - 1969/70 and 1993/94 124
5.4.5 Sections 10 - 14 128
5.4.6 Comparing distribution - 1969/70 and 1993/94 129
5.4.7 Factors affecting the distribution of gulls in 1993/94 132

5.5 Discussion 135

Chapter 6: General Discussion **142**

Summary **151**

References **158**

Appendices **172**

Appendix 1 Herring Gulls and Lesser Black-backed Gulls nesting on buildings in Britain and Ireland in 1994 173

Appendix 2 Common Gulls nesting on buildings in Britain and Ireland in 1994 183

Appendix 3 Great Black-backed Gulls nesting on buildings in Britain and Ireland in 1994 184

Appendix 4 Towns where roof-nesting gulls definitely absent in 1994 185

Appendix 5 Counties where no records of roof-nesting gulls had been received by 1994 186

Abstract

A survey in 1994 recorded nearly 14,000 pairs of *Larus* gulls of four species nesting on buildings in Britain and Ireland. The majority of these records involved Herring Gulls, although large numbers of Lesser Black-backed Gulls were also observed. Since the last such survey in 1976, Lesser Black-backed Gulls had shown the highest rate of increase. Despite the sharp decline in the numbers of Herring Gulls breeding in Britain and Ireland since the mid-1970s, numbers nesting on roofs had continued increasing, albeit at a lower rate than before. New developments since 1976 included increasing numbers nesting inland and on the roofs of large industrial buildings.

The study of a colony of Herring Gulls and Lesser Black-backed Gulls nesting on one such industrial building showed that the breeding success of these birds, although lower than that found for roof-nesting birds at more dispersed colonies, was higher than that at many traditional colonies. Low nest density, shelter for chicks and safety from predators were thought to be important contributors to this success. In addition, the colony was situated very close to the sources of food, agricultural land and urban areas, found to be most important in the diet of Herring Gulls nesting there. A review of dietary studies of roof-nesting Herring Gulls found that, despite the location of such colonies in urban areas, urban sites were not always an important source of food.

The reduction in availability of one urban source of food, untreated sewage, was found to have little effect upon the gulls using an urban stretch of river. In particular, neither of the species causing most problems in urban areas, the Herring Gull and Lesser Black-backed Gull, decreased in number; in fact, numbers of these species nesting on buildings in the area increased considerably.

Chapter 1

General Introduction

During the 20th century, great increases have been seen in the numbers of gulls of many species throughout their range (Blokpoel & Spaans 1991). In Britain and Ireland, the numbers of the six most commonly occurring gull species, Black-headed Gull *Larus ridibundus*, Common Gull *L. canus*, Lesser Black-backed Gull *L. fuscus*, Herring Gull *L. argentatus*, Great Black-backed Gull *L. marinus* and Kittiwake *Rissa tridactyla*, have all risen, both during the breeding season (all species: Parslow 1967, Cramp *et al.* 1974, Lloyd *et al.* 1991, Gibbons *et al.* 1993; Black-headed Gull: Gribble 1962, 1976; Herring Gull: Chabrzyk & Coulson 1976; Great Black-backed Gull: Davis 1958; Kittiwake: Coulson 1963, 1974, 1983) and over the winter (Hickling 1954, 1967, 1977, Bowes *et al.* 1984, Waters 1994).

Two main reasons have been put forward to explain these increases, both of which could account for the increased reproductive success and reduced mortality of adults and juveniles necessary for such a rise in numbers. Firstly, increasing amounts of food have become available to gulls due to human activities, and, secondly, laws preventing the persecution of seabirds have been implemented (Lloyd *et al.* 1991).

Many studies have noted the use by gulls of anthropogenic sources of food, for example, rubbish tips (Horton *et al.* 1983, Pons 1992), waste fish from trawlers and fish docks (Harris 1970, Davis 1974, Furness *et al.* 1992) and untreated sewage from outfalls (Fitzgerald & Coulson 1973). These food sources are thought to be more important for the larger gull species (Mudge & Ferns 1982a, Götmark 1984).

Several authors have suggested that such food enhances reproductive success. Davis (1974) found that pairs of Herring Gulls where at least one parent fed on waste food from the fish docks or tips had higher reproductive success than pairs that fed solely on naturally occurring food. He also felt it was possible that such food may have enhanced the survival of both juvenile and adult birds. Hunt (1972) found that the survival of Herring Gull chicks at colonies nearer a source of waste food, again fish or refuse, was higher than those at colonies further from these food sources. This was felt to be due to the proximity of food which meant that parent birds were not away from the nest for as long and so were better able to protect their chicks.

Sibly & McCleery (1983b) found that Herring Gulls could obtain food more rapidly at tips than at other sources of food and that if deprived of this source of food, the birds at the site they studied would have been unable to breed successfully. Spaans (1971) found that chicks which were fed waste from tips grew faster than those which were not fed such food, suggesting that rubbish had a higher energy content. More support for the importance of artificial food in the increase in gull numbers comes from studies where such food has decreased in availability. Pons (1992) found that the breeding success of a colony of Herring Gulls decreased significantly when the availability of food at a frequently used tip declined and Fordham (1970) found a similar occurrence at colonies of Dominican Gulls *Larus dominicanus* when the availability of waste offal and refuse was reduced.

There is, however, evidence to suggest that feeding on waste from tips may not always be beneficial to gulls. Pierotti & Annett (1987) found domestic waste to be less rich in fat and protein then other sources of chick food and it may also be hard for young chicks to handle (Hillström *et al.* 1994). Such factors may explain the findings of Pierotti & Annett (1987) that Herring Gulls which specialised in feeding on garbage raised fewer chicks. Rubbish tips also have frequently been suggested as a possible source of the disease botulism (Sutcliffe 1986, Worrall 1987, Ortiz & Smith 1994).

In some studies it was felt that the rise in food availability was unlikely to be the sole reason for the increases in gull numbers that were observed. In order to explain the fact that the increase in the numbers of gulls occurred some time after large amounts of artificial food became available, Harris (1970) suggested that there was a time lag before birds adapted their behaviour to exploit this source of food. Davis (1974), working on the same colonies, suggested that in fact the reason for this time lag was that initially, despite the increased availability of food, the number of gulls was unable to increase due to the extensive egg collection that was taking place. Until the end of the 19th century gulls were subject to intense pressure from humans in the form of egg collecting and the shooting of adult and juvenile birds for their feathers and for sport. The cessation of these practices after the introduction of protective legislation may have allowed the numbers of these species to increase. The reduction of persecution is felt to be the main reason for the increase in the numbers of the Kittiwake (Coulson 1963).

In addition to these two main reasons, other factors have been suggested as potentially contributing to the increase in numbers of certain gull species. The rise in the numbers of reservoirs and gravel pits which provide safe roosting sites may enhance survival and is felt to be important for Black-headed Gulls and Lesser Black-backed Gulls (Lloyd *et al.* 1991). In the case of the Great Black-backed Gull, which feeds on other seabird species, the rise in the numbers of these prey species during the present century may have increased the amount of food available to them (Lloyd *et al.* 1991). In neither of these cases have detailed studies been carried out to establish the importance of these factors.

Despite the overall increases seen in the numbers of all six species of gull during the present century, in some cases declines have been seen. Mostly these have been on the scale of a colony or region but, in the case of the Herring Gull, breeding numbers have declined by almost 50% since the 1970s (Lloyd *et al.* 1991). Reasons suggested for this decline include botulism, culling, increased Fox *Vulpes vulpes* predation and a decline in food availability (Gibbons *et al.* 1993). In other species, only local declines have been observed during this period. These are felt to be the result of local factors such as breeding season food shortages (Coulson 1983), egg collection, destruction of nests due to high tides, human disturbance or habitat disappearance (Gibbons *et al.* 1993).

The importance to gulls of food from urban areas has led to an increase in their contact with humans. As well as frequenting sources of food such as rubbish tips, fish docks, urban rivers and town streets, gulls also, in increasing numbers, nest on the roofs of buildings (Cramp 1971, Monaghan & Coulson 1977), loaf on playing fields and airfields (Rochard & Horton 1980) and roost on reservoirs (Benton *et al.* 1983). These habits have led to a variety of problems.

Gulls are known to be carriers of Salmonellae, organisms which cause food poisoning in humans, which it is felt they ingest while feeding at rubbish tips (Monaghan *et al.* 1985) and sewage outfalls (Butterfield *et al.* 1983). There is concern that these pathogens are then dispersed by the gulls to other sites they frequent, however, although it is possible for Salmonellae to be transmitted from gull faeces to cattle, there is no evidence for transmission to humans (Butterfield *et al.* 1983). The main threat to humans comes from the large numbers of gulls roosting on reservoirs that can lead to the pollution of drinking water (Benton *et al.* 1983). Other pathogens thought to be carried by gulls include *Campylobacter* species and the larval form of the beef tapeworm *Taenia saginata* (Furness & Monaghan 1987). In towns in France, Herring Gulls and Yellow-legged Gulls *Larus cachinnans* have been observed killing and eating domestic pigeons *Columba livia*, so it is therefore possible that they may pick up pathogens carried by this species (Vincent & Guiguen 1989).

Several problems arise from the habit of nesting on roofs. There are many reports of gulls disturbing the inhabitants of the buildings on which they are nesting due to the noise they make (Blokpoel *et al.* 1990, Vincent 1994) and they will also swoop at people on or around the building on which they are nesting (Blokpoel & Smith 1988, Stewart 1988, Thorne 1991). This can prove dangerous for workmen on such buildings (Blokpoel *et al.* 1990).

In addition, complaints have been made about gulls fouling cars, equipment and buildings (Vermeer *et al.* 1988, Blokpoel *et al.* 1990). In some cases such fouling, due to its corrosive nature, can actually be detrimental to metal structures on roofs (Blokpoel & Smith 1988, Vermeer *et al.* 1988, Vincent 1994). Nest material, feathers and regurgitated food remains may collect on a roof, blocking gutters and drains so that rain water cannot drain away. The resulting standing water may damage the roof (Paynter 1963, Blokpoel & Smith 1988, Vermeer *et al.* 1988, Vincent 1994). Gulls can transfer soil and seeds to a roof with their nest material and the resulting vegetation growth can lead to cracks in the roof lining (Blokpoel & Smith 1988). This can also be damaged by the gulls pecking it (Blokpoel & Smith 1988, Blokpoel *et al.* 1990). Nests on buildings can also be a fire hazard (Blokpoel *et al.* 1990).

The presence of gulls feeding and loafing on airfields is also a cause for concern. Rochard & Horton (1980) found that 42% of the collisions between birds and aircraft in the United Kingdom in one year were caused by gulls. This problem is exacerbated if habitats frequently used by gulls such as a rubbish tip or a reservoir are situated near an airport (Horton *et al.* 1983).

As the numbers of gulls frequenting urban areas rises, the demand for effective measures for controlling their numbers increases. Successful procedures have been developed for solving some local problems, for example, the contamination of a reservoir by roosting gulls (Benton *et al.* 1983) but, in many cases, particularly when trying to reduce large numbers of roof-nesting gulls, the results have been less successful. In order to develop successful measures for countering the problems caused by gulls in urban areas, it is necessary to understand in more detail their ecology in this environment.

This thesis concerns the ecology of gulls in urban areas, in particular, the trait of nesting on buildings. In Chapter 1, the status of roof-nesting *Larus* gulls in Britain and Ireland in 1994 is considered. The results are compared with those of the two previous surveys of gulls nesting on buildings (Cramp 1971, Monaghan & Coulson 1977) to establish the changes that have taken place in the intervening period. Chapter 2 considers the breeding success of Herring Gulls and Lesser Black-backed Gulls nesting on one large roof. This type of site has increasingly been reported to be used by roof-nesting gulls in the years since the previous surveys. The success of this colony is contrasted with that found in the more dispersed rooftop colonies which are the only roof-nesting colonies to have previously been studied in Britain.

In Chapter 3, the diet of the Herring Gulls nesting at this colony, both adults and chicks, is described. The extent to which gulls at this rooftop colony utilise urban sources of food is assessed and compared with a review of other studies concerning the diet of roof-nesting Herring Gulls. Chapter 4 describes a study into the effects of a reduction in the availability of one urban food source upon gulls in an urban area. A comparison is made between the numbers and distribution of six species of gulls using an urban stretch of river before and after improvements to sewage treatment were made.

Chapter 2

The distribution and abundance of *Larus* gulls nesting on buildings in Britain and Ireland

Much of the work in this chapter has been published in the following paper -

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

2.1. Introduction

Gulls nesting on buildings and other man-made structures are now a common sight in coastal and, more recently, inland areas of Britain and Ireland, a development which is also occurring in other countries (Section 2.2). Other structures utilised for nesting include bridges, jetties, pipelines and, in 1993, an oil platform in the Irish Sea (North Sea Bird Club 1994). Nesting gulls can cause disturbance to the inhabitants of a building due to noise, fouling and the aggression of adult gulls in defence of their young (Monaghan & Coulson 1977), and can also damage the fabric of the building (Vermeer *et al.* 1988). The spread of gulls into urban areas is therefore a matter of growing concern.

In Britain and Ireland, the Herring Gull was the first gull species to nest on buildings. Since the first reports early this century, the habit has spread considerably. A more recent, but similar, increase has been seen in the Lesser Black-backed Gull since roof-nesting was first recorded in this species in the 1940s. To a much lesser extent, this behaviour has also been recorded in Great Black-backed Gulls and Common Gulls. These changes have been well-documented by two surveys of roof-nesting gulls in Britain and Ireland, carried out in 1969 (Cramp 1971) and 1976 (Monaghan & Coulson 1977), which are described in more detail, together with the situation abroad, in Section 2.2.

The period from the beginning of the century to the mid-1970s saw a large increase in the number of gulls breeding in Britain and Ireland (Harris 1970) and many other parts of the world (Blokpoel & Spaans 1991). Chabrzyk & Coulson (1976) estimated that the Herring Gull in Britain had increased at a rate of 12-13% per annum during most of this century. The results of the 1976 survey indicated that the numbers of Herring Gulls and Lesser Black-backed Gulls breeding on rooftops were increasing even faster (Monaghan & Coulson 1977). This high rate of increase was thought to be mainly due to extensive immigration from saturated traditional colonies (Monaghan & Coulson 1977), supported by the high fledging success found in urban colonies (Monaghan 1979). The increase was not confined to existing sites however, and many records were received from previously uncolonised towns indicating a progressive spread of both species (Monaghan & Coulson 1977).

Since the mid 1970s, the total number of breeding Lesser Black-backed Gulls in Britain and Ireland has continued to increase but, in contrast, there has been a dramatic decline in the number of Herring Gulls. Between the surveys of coastal colonies of 1969-70 and 1985-87, the numbers of this species fell by 43% from 335,100 to 190,900 pairs (Lloyd *et al.* 1991). The reasons for this decline, which showed large regional variations, have not been established but factors such as culling, botulism, increased Fox predation and changes in food availability may be involved (Gibbons *et al.* 1993). As many rooftop colonies, particularly inland ones, were not included in these surveys, the changes in numbers of roof-nesting gulls during this period are not known. Lloyd *et al.* (1991) suggested that whilst the numbers of gulls nesting on buildings were still increasing, the rate of increase, especially for Herring Gulls, had probably slowed since 1976. Published records from this period suggest that roof-nesting has become established and more frequent in Common Gulls and Great Black-backed Gulls (Sullivan 1985, Stewart 1988, Duncan 1994). The 1994 survey was organised with the aim of estimating the current numbers and distribution of *Larus* gulls nesting on buildings in Britain and Ireland in 1994.

2.2 Review of roof-nesting by *Larus* gulls

2.2.1 Britain and Ireland

During the first thirty years of this century, several records of Herring Gulls nesting on buildings were received from Devon and Cornwall and, in the 1930s, the phenomenon was observed in Dover, Kent (Took 1955). During the 1940s, roof-nesting Herring Gulls spread to coastal towns in the north-east of England (Chislett 1954) and were first observed in Ireland, in Dunmore East on the south-east coast (O'Meara 1975). At this time Lesser Black-backed Gulls also started nesting on roofs; a small colony was found on a factory in South Wales (Morrey Salmon 1958). By the 1950s, roof-nesting Herring Gulls were present in Peterhead on the north-east coast of Scotland (Bourne 1979).

At the time of the first roof-nesting gull survey in 1969/70, over 1,250 pairs of Herring Gulls and about 60 pairs of Lesser Black-backed Gulls were found nesting on buildings in Britain and Ireland, at 55 and 5 sites respectively (Cramp 1971) (Figures 2.1 a & b). Lesser Black-backed Gulls were mainly confined to south Wales, however, Herring Gulls were found in many coastal towns and a few inland ones. It was reported that in 1971 a

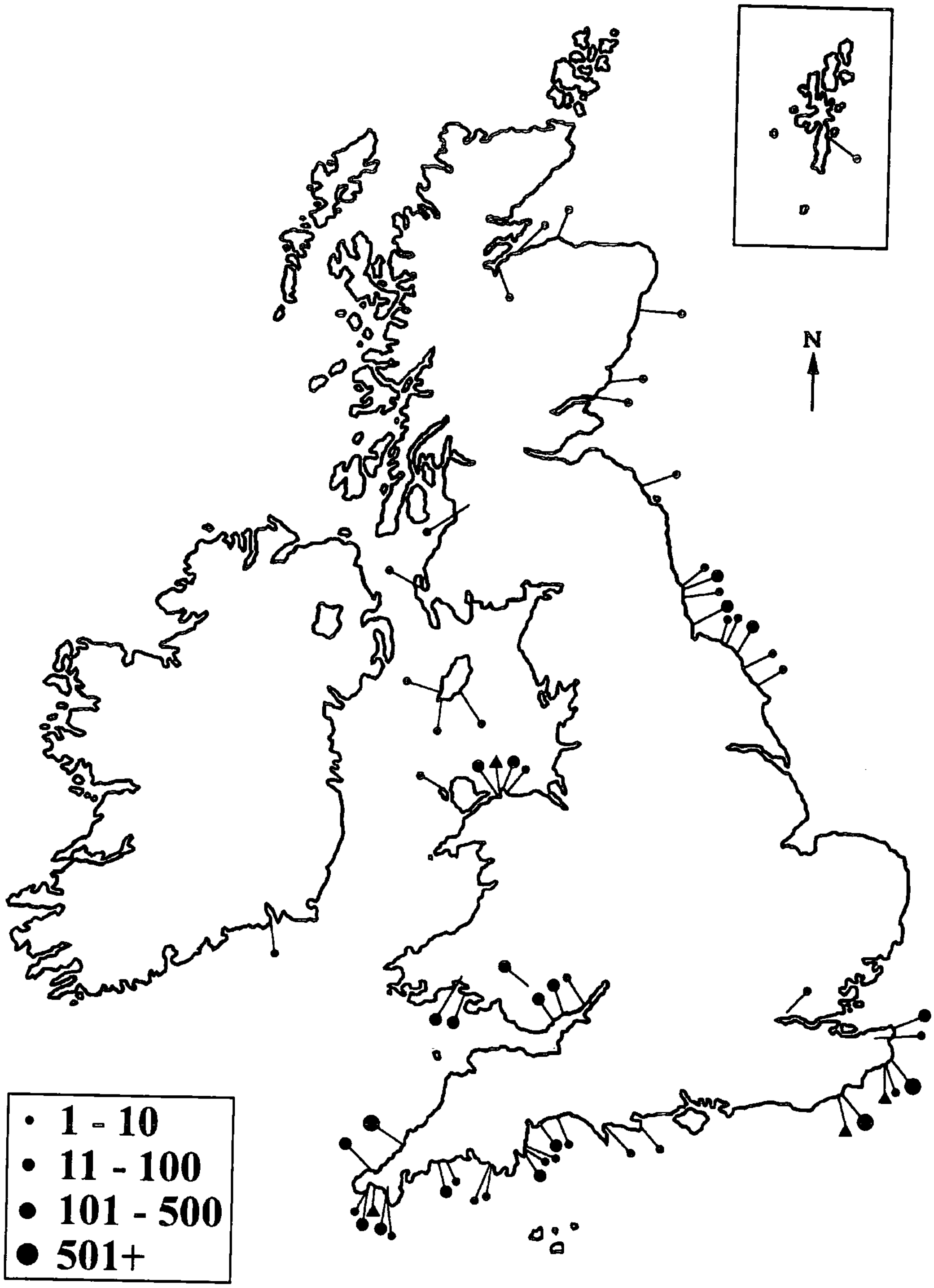


Figure 2.1a: Distribution and size of colonies of Herring Gulls nesting on buildings in 1969 (redrawn from Cramp 1971). Filled circles indicate the number of breeding pairs at the site. A triangle indicates that breeding was recorded but no count was carried out.

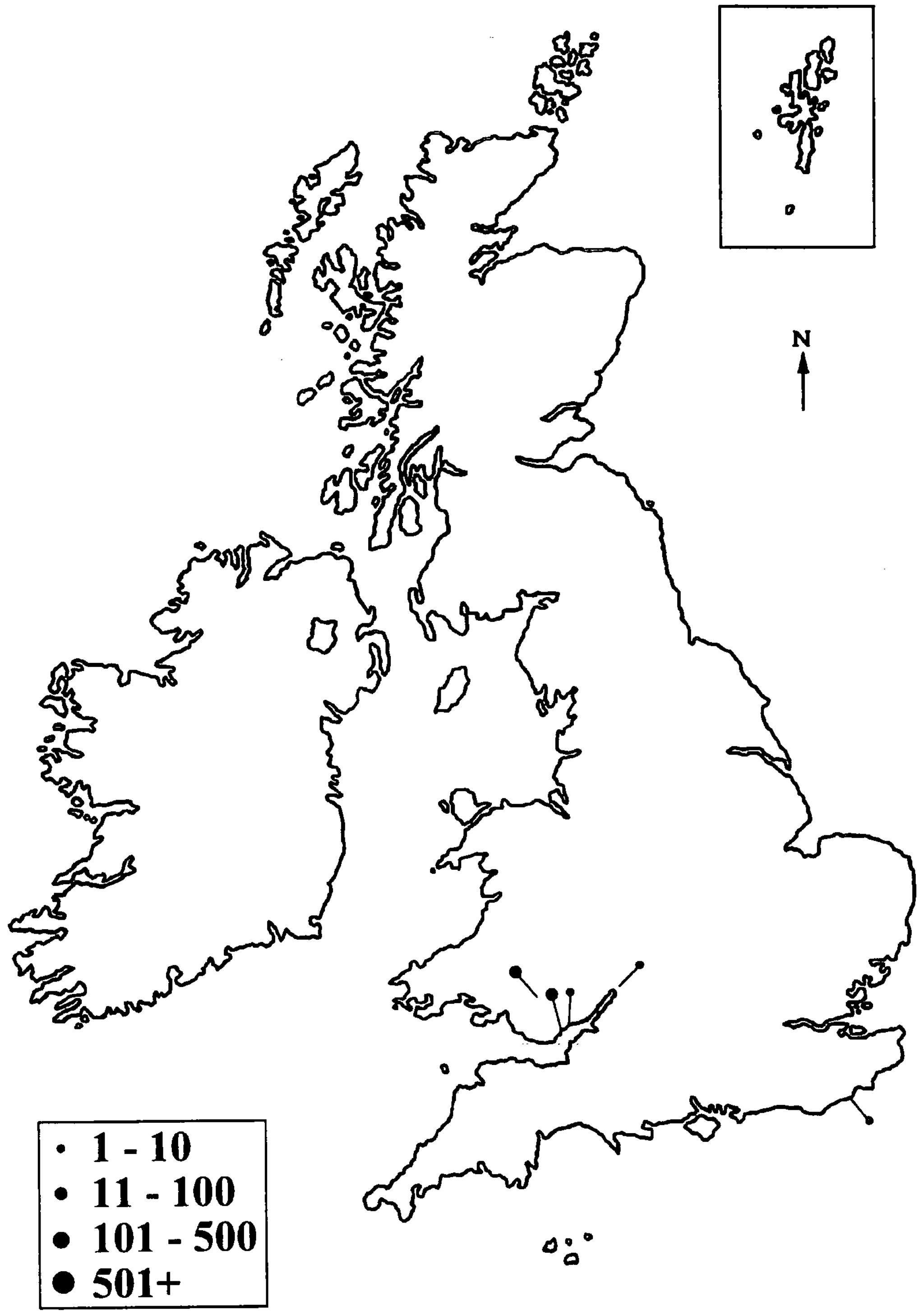


Figure 2.1b: Distribution and size of colonies of Lesser Black-backed Gulls nesting on buildings in 1969 (redrawn from Cramp 1971). Legend as for Figure 2.1a.

pair of Common Gulls nested on a shed at Inverness Airport and that a pair of Great Black-backed Gulls had been reported nesting on buildings in Newlyn in Cornwall in 1970 (Cramp 1971).

By 1976, when a second survey was carried out, the numbers of both species nesting on buildings had increased to 2,968 pairs of Herring Gulls at 92 sites and 323 pairs of Lesser Black-backed Gulls at 12 sites (Figures 2.2 a & b). This represented an increase in the numbers of these species of 17% and 28% per annum respectively. The number of sites colonised by Herring Gulls was found to have increased at a constant rate of 9.3% per annum since at least 1940. In the case of the Herring Gull, this increase was mostly due to the colonisation of new towns within the area already used, however, Lesser Black-backed Gulls, as well as colonising new towns in south Wales, were found nesting on buildings in towns in a new area, the north-east of England. No new records of Common Gulls nesting on buildings were received, but it was reported that seven pairs of Great Black-backed Gulls were nesting on buildings in Cornwall in 1974 (Monaghan & Coulson 1977, King 1979).

Despite the lack of a comprehensive survey since 1976, several reports have discussed the situation in certain areas. Along the coast of Cleveland and Yorkshire, a survey of breeding Herring Gulls in 1978-79 found that the gulls nesting on buildings were increasing in number faster than those nesting on natural sites, and that the proportion of the area's gulls nesting on buildings had increased from 3% to 12% in the previous ten years (Mericas Leach *et al.* 1980). In the inner Bristol Channel region, from 1975 to 1980, numbers of Lesser Black-backed Gulls nesting on buildings increased while, according to the area, the numbers of roof-nesting Herring Gulls either remained the same or decreased (Mudge & Ferns 1982b, Harford 1985). A large increase in roof-nesting Lesser Black-backed Gulls has also been seen in the Forth-Clyde region of Scotland since the late 1980s; Herring Gulls have also shown a small increase in this region (Clyde Bird Reports 1987-1993, Bourne 1988, Holling 1991, Dott 1994). In addition records of isolated incidents involving these species have been noted in many county bird reports.

Since 1976, records of Common and Great Black-backed Gulls have become more frequent. Common Gulls were observed nesting on a roof in Aberdeen in 1984 (Sullivan

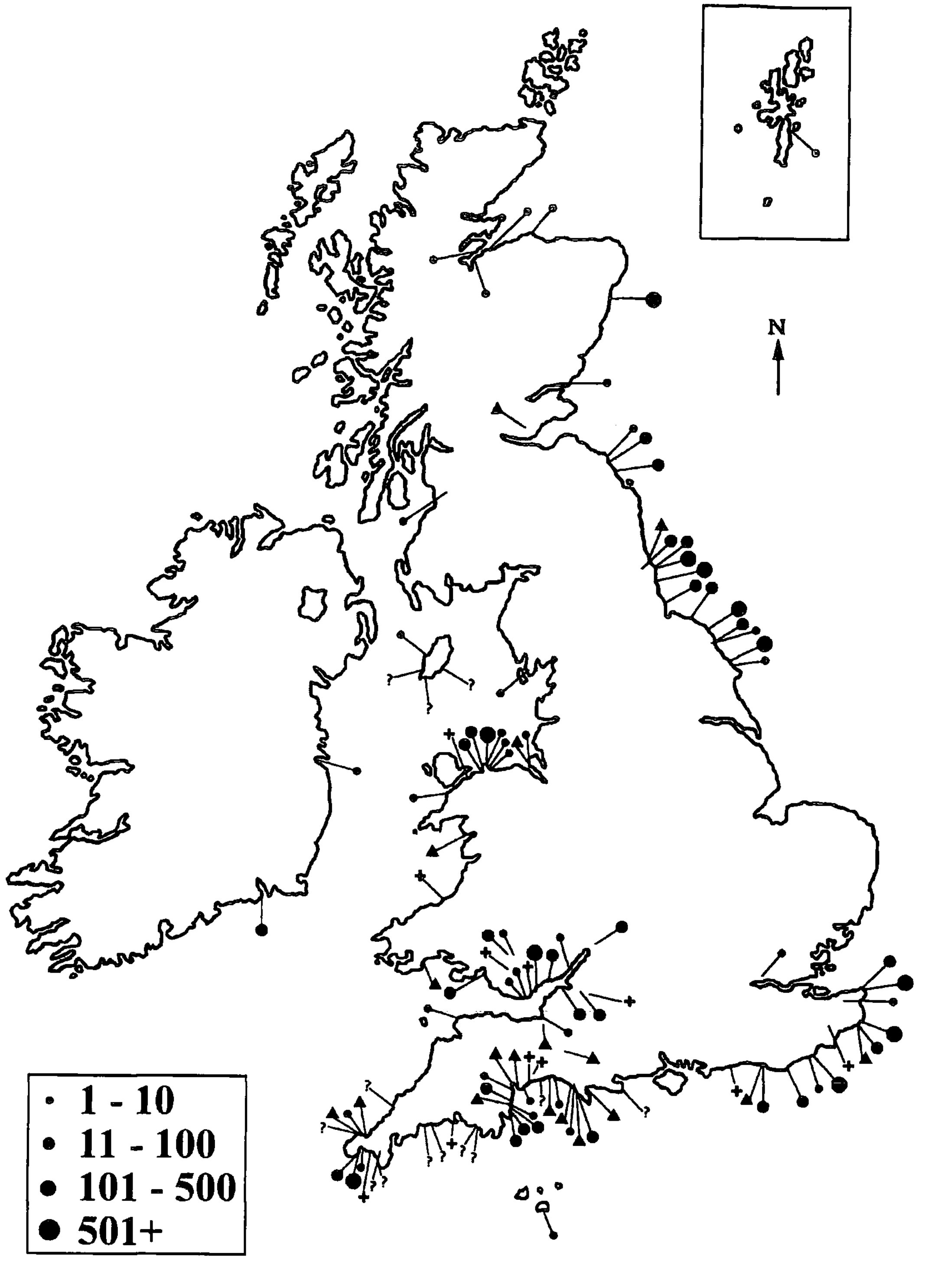


Figure 2.2a Distribution and size of colonies of Herring Gulls nesting on buildings in 1976 (redrawn from Monaghan & Coulson 1977). Filled circles indicate the number of breeding pairs at the site. A triangle indicates that breeding was recorded but no count was carried out. A cross indicates that birds were observed prospecting but breeding was not proven. '?' indicates that breeding had been recorded previously but the site was not checked in 1994.

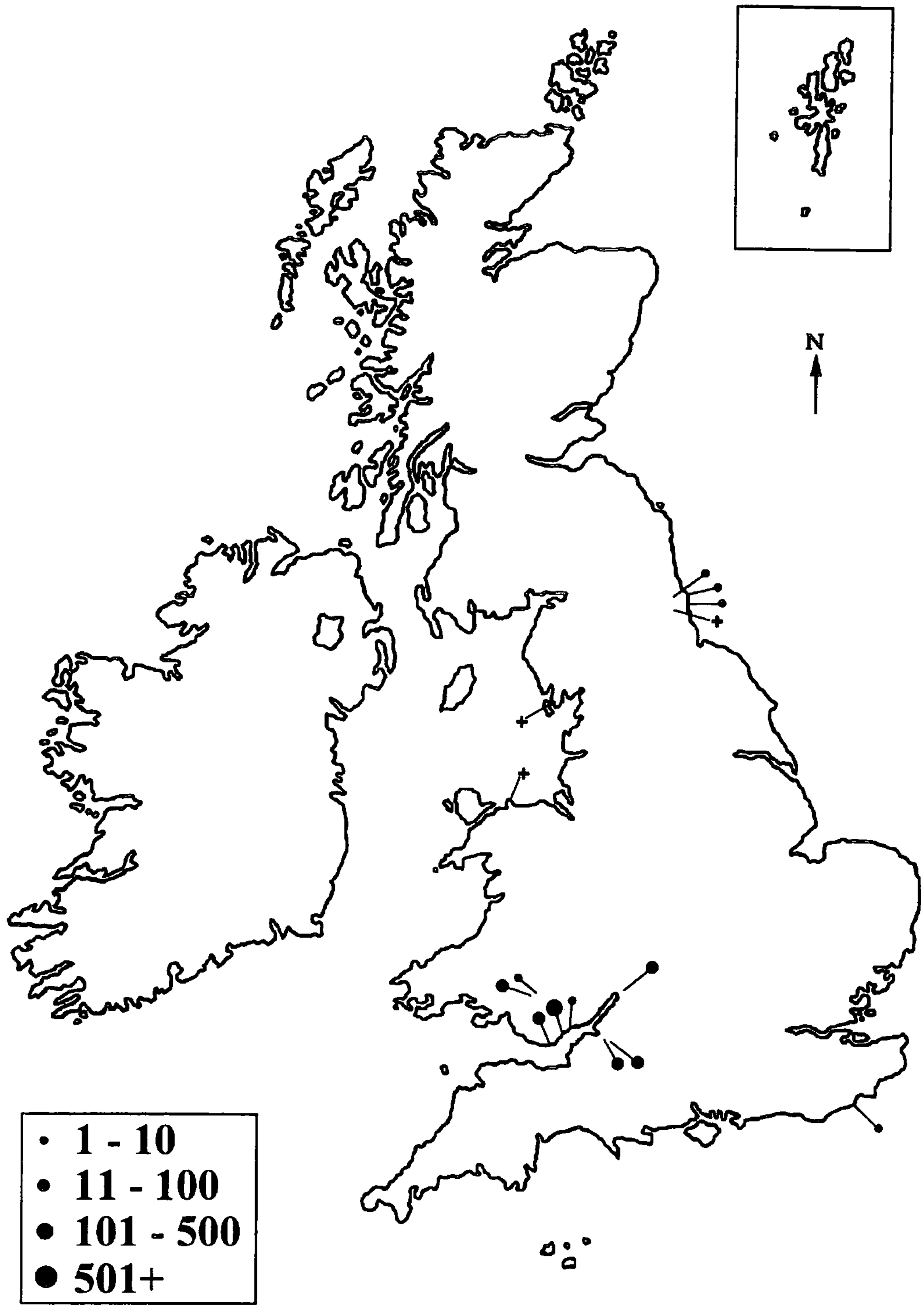


Figure 2.2b Distribution and size of colonies of Lesser Black-backed Gulls nesting on buildings in 1976 (redrawn from Monaghan & Coulson 1977). Legend as for Figure 2.2a.

1985) and, by 1988, numbers had increased to about 30 pairs (Stewart 1988). Records have also been received from Dalcross Airport, Inverness (Stewart 1988), Camphill Waterworks, Ayrshire (Ayrshire Bird Club 1992), a former armament stores near Wick Airport in 1986 (H. Clark, in litt.), and a church near Oban (J.C.A. Craik, in litt.). In the case of the Great Black-backed Gull, records also suggest a possible increase in the numbers nesting on roofs. In the late 1980s and early 1990s, groups of 10-15 pairs were found nesting at a chemical complex near Whitehaven, Cumbria and HM Dockyard, Rosyth in Scotland (unpublished data, Seabird Colony Register). In 1993, two pairs were recorded nesting in Aberdeen's docklands (Duncan 1994).

2.2.2 Europe

It was in Europe that the first ever record of gulls nesting on buildings was made when, in the 1890s, Yellow-legged Gulls were observed nesting on the roofs of Black Sea towns in Bulgaria (Reiser 1894). Mountfort & Ferguson-Lees (1961) saw several hundred pairs in these towns in 1960. By 1992, 63% (2705 pairs) of the Yellow-legged Gulls breeding in Bulgaria nested on buildings, with about 5% of the population in towns and villages in the interior of the country (Nankinov 1992).

It was not until the 1970s that records were found of this species nesting on buildings in other countries and in none other has the habit become so common. In Italy in 1971 a pair nested on a roof in the zoological gardens in Rome, and a few pairs have nested regularly in the city since then (Cignini & Zapparoli 1985). In the early 1980s, a pair nested on a mooring buoy in the harbour of San Remo (Balletto & Spanò 1982) and, in 1986, a pair was reported nesting on a church in Genoa (Spanò 1986). In 1975, the first nest was found on a building in Spain, in the zoological gardens in Barcelona and, by 1984, 25 pairs were known to breed in the city (Petit *et al.* 1986).

In the early 1980s, Yellow-legged Gulls were observed nesting on buildings along the south coast of France and, by 1984, had colonised four towns there (Thomas 1984). By 1995/96, it was considered that there were at least 50 pairs nesting in the south of France, including a few on the island of Corsica (Cadiou, in press). Since the late 1980s the species has nested in increasing numbers on roofs on Gibraltar (J. Cortes, in litt.) and, in 1996, a pair of Yellow-legged Gulls were observed nesting on a building in Versoix on the shores of Lac Léman in Switzerland (Albrecht 1996). Apparently nesting had been occurring for 8 years previous to this with a maximum of four nests present in any one year. In 1996, a Yellow-legged Gull paired with a Lesser Black-backed Gull nested on a roof at IJmuiden in The Netherlands (Cottaar 1996).

The first records of Herring Gulls nesting on buildings in continental Europe were in the late 1950s and early 1960s from Bremerhaven and Wilhelmshaven on the northern coast of Germany (Cramp 1971). The first report from France was from Morlaix, a village on the northern coast of Brittany, and, by 1984, eight towns in Brittany had roof-nesting Herring Gulls (Thomas 1984). In 1985, a pair of Great Black-backed Gulls was found nesting on a building in Cherbourg (Lefeivre 1985) and in the next few years small numbers of Lesser and Great Black-backed Gulls began to nest on buildings in Le Havre (Vincent 1989). By 1995/6 it was considered that a minimum of 6,500 pairs of Herring Gulls, 500 pairs of Lesser Black-backed Gulls and 20 pairs of Great Black-backed Gulls, were nesting in north-west France, the vast majority along the coast, but a few nesting inland (Cadiou, in press).

In Scandinavia, Herring Gulls have been recorded nesting on buildings in Finland. At least one pair nested successfully in the city of Tampere from 1975 to 1977 (Kosonen & Mäkinen 1978) and then, in 1980, a few pairs were observed in Helsinki (Bergman 1982). In the Netherlands, very occasional records of roof-nesting Herring Gulls had been reported since the 1950s, but it was not until 1987 that a large colony of Herring Gulls nesting on buildings was found in IJmuiden harbour. A few pairs of Lesser Black-backed Gulls were also nesting there, the first record of this species nesting on buildings in that country (Vegelin 1989). In addition to these two species, Common Gulls also nest on buildings in northern Holland, with records since 1975 (Kooistra 1985, Woutersen & Roobeek 1992). This species has also been recorded nesting on buildings in both Norway and Sweden (Cramp 1971).

2.2.3 North America

On the west coast of North America, it is the Glaucous-winged Gull *Larus glaucescens* which nests on buildings. Observations since 1946 by Eddy (1982) describe the growth of this phenomenon along the waterfront in Seattle, USA, up to an estimated minimum of 300 pairs in 1981. In 1962, the species was observed nesting on the gravel roof of a building in Vancouver, Canada (Oldaker 1963) and, by 1986, the population nesting on buildings in the city was estimated to be about 500 pairs and the habit had been reported in Victoria, on Vancouver Island (Vermeer *et al.* 1988). Between 1986 and 1989, the number of gulls nesting on buildings in Vancouver increased at a rate of 9% per annum (Vermeer 1992).

The first record for roof-nesting on the east coast came from Boston, when a colony of 150 pairs of Herring Gulls were found breeding on a roof. The colony was found in 1961, but was said to have formed a few years earlier (Paynter 1963). Subsequently, the numbers of roof-nesting gulls grew until they numbered in the thousands (Fisk 1978). Reports have also been received of roof-nesting Herring Gulls in cities in New York and New Hampshire (Blokpoel & Smith 1988). The first records of roof-nesting gulls in the Great Lakes region were made in Canada in the mid 1980s, however it is thought that the habit actually began in the early 1970s (Blokpoel & Smith 1988, Blokpoel *et al.* 1990). Both Herring Gulls and Ring-billed Gulls *Larus delawarensis* were involved, nesting on lakeside buildings around Lakes Ontario and Erie. In the mid 1980s the first reports were received from the American part of the region and a survey carried out in 1994 reported 7,992 pairs of gulls (71% Ring-billed Gulls, 24% Herring Gulls, 5% unknown species) nesting on buildings at 30 colonies, 2% and 4% respectively of the breeding populations of these species in the region (Dwyer *et al.* 1996).

Two other species have been recorded nesting on man-made structures in North America. The Western Gull *Larus occidentalis* was recorded nesting on a pier in San Francisco from 1922 until at least 1977 (Fisk 1978) and, in 1985 the Mew Gull *Larus canus brachyrhynchus* was found nesting on a gravel roof in Alaska (Burger & Gochfeld 1988).

2.2.4 Other continents

Only a few records have been found from other countries. In New Zealand, the Dominican Gull was first reported nesting in the city of Auckland in the late 1960s (Turbott 1969) and also, more recently, a few nests have been reported on buildings in Wellington and Lower Hutt (Robertson 1992). The only known record from Africa comes from Cape Town, South Africa where, in 1974, at least 18 nests of Hartlaub's Gull *Larus hartlaubii* were found on the roof of a hospital (Broekhuysen & Elliott 1974).

2.3 Methods

Prior to the 1994 breeding season, information concerning past records of roof-nesting gulls was extracted from the literature, the Seabird Colony Register, county recorders, local authorities and gull study groups, to identify sites for survey. The enquiry to local authorities formed part of a questionnaire also concerning public reaction to roof-nesting gulls and their response to the problem. Requests for information and assistance were placed in appropriate newsletters.

The sites considered were those where gulls nested on buildings or other man-made structures. These included towns, cities and villages, as well as isolated industrial establishments and farms. For convenience hereafter they are all referred to as sites. As in the 1976 survey, each town or city has been considered as a single site thus avoiding the difficulty of defining and recognising new colonies within them. With the assistance of the British Trust for Ornithology's network of Regional Representatives and volunteers from the organisations initially contacted, an attempt was made to survey as many of these sites as possible, ideally during the last two weeks of May.

At each site, volunteers were asked to record the number of breeding pairs of each gull species (using an apparently occupied nest site as indicative of one breeding pair), and, if possible, details of nest site type and fledging success. Details of other sites where gulls were seen prospecting or were definitely absent were also requested.

There are difficulties associated with counting gulls nesting on buildings which mean that numbers are frequently underestimated. In many cases the roofs of buildings where nesting is suspected are inaccessible and, if there is no vantage point from which they can be overlooked, it is impossible to prove that nesting is taking place. Even if newly fledged young are seen, the actual number of nests cannot be counted. In addition, by removing nests, eggs or adult birds, control measures may further confuse a count of roof-nesting gulls. When only one or two nests are present in a town, they are often missed. In the case of the 1994 survey, the large number of sites colonised by then meant that it was not possible to find volunteers to survey them all.

For some sites not surveyed in 1994, counts were carried out in 1995, or if 1993 data were available, these were used. Overall, 77% (190/246) of all sites where nesting or prospecting gulls had been recorded previously were checked. In addition, nesting was recorded at 38 new sites, identified either by searches for this survey in areas where roof-nesting had not been reported previously or because problems had been reported to the local authorities. All known sites in Ireland were checked and there was no significant difference between the regions of Britain (see Figure 2.6) in the proportion of known sites covered ($\chi^2 = 7.84$, d.f. = 5, $P > 0.05$).

Summaries of the results for each species are given in Appendices 1, 2 and 3; these include the results of the 1994 survey, and other data from the sources mentioned above. Appendices 4 and 5 give details of towns and counties from which roof-nesting gulls were absent in 1994. In all 2 by 2 χ^2 tests in this and subsequent chapters Yates' correction has been used.

2.4 Results

2.4.1 Herring Gulls and Lesser Black-backed Gulls

2.4.1.1 Abundance and distribution

In 1994, records were received of 11, 047 pairs of Herring Gulls nesting on buildings at 188 sites and 2, 544 pairs of Lesser Black-backed Gulls at 84 sites in Britain and Ireland (Figures 2.3 a & b). Prospecting gulls were observed at a further 8 and 13 sites respectively. By obtaining a mean colony size for each region and using this value for those sites which have past records of roof-nesting gulls but were not counted in 1994, the total numbers of roof-nesting gulls were estimated at 16, 900 pairs of Herring Gulls and 3, 200 pairs of Lesser Black-backed Gulls. The numbers of gulls present at a site varied considerably (Figure 2.4), from a single pair (in 18 cases) to several hundred pairs of gulls and, in one extreme case, Aberdeen, over 2, 000 pairs. However, the majority of sites for which numbers were counted (66%) supported less than 50 pairs.

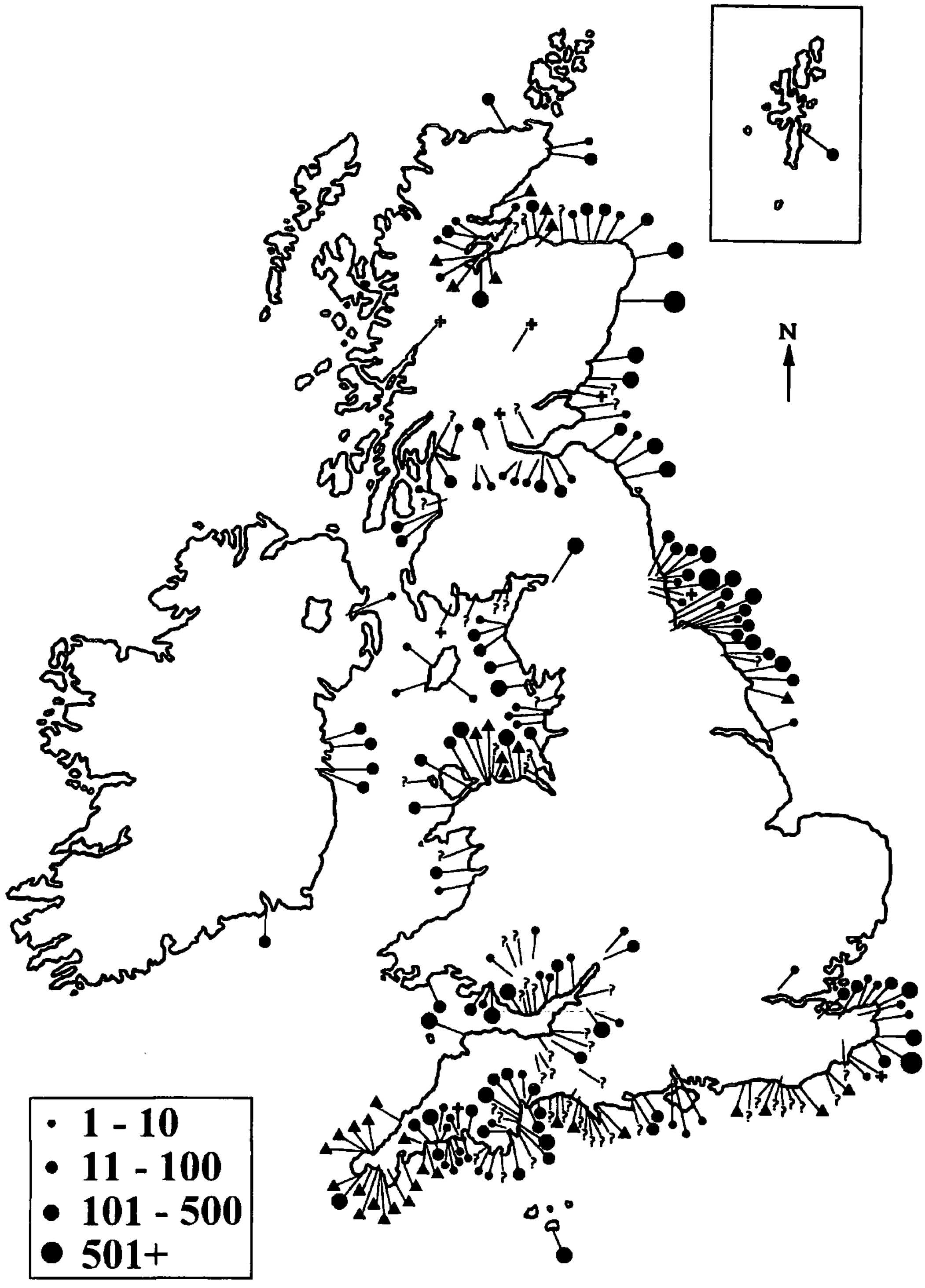


Figure 2.3a Distribution and size of colonies of Herring Gulls nesting on buildings in 1994. Filled circles indicate the number of breeding pairs at the site. A triangle indicates that breeding was recorded but no count carried out. A cross indicates that birds were observed prospecting but breeding was not proven. '?' indicates that breeding had been recorded previously but the site was not checked in 1994.

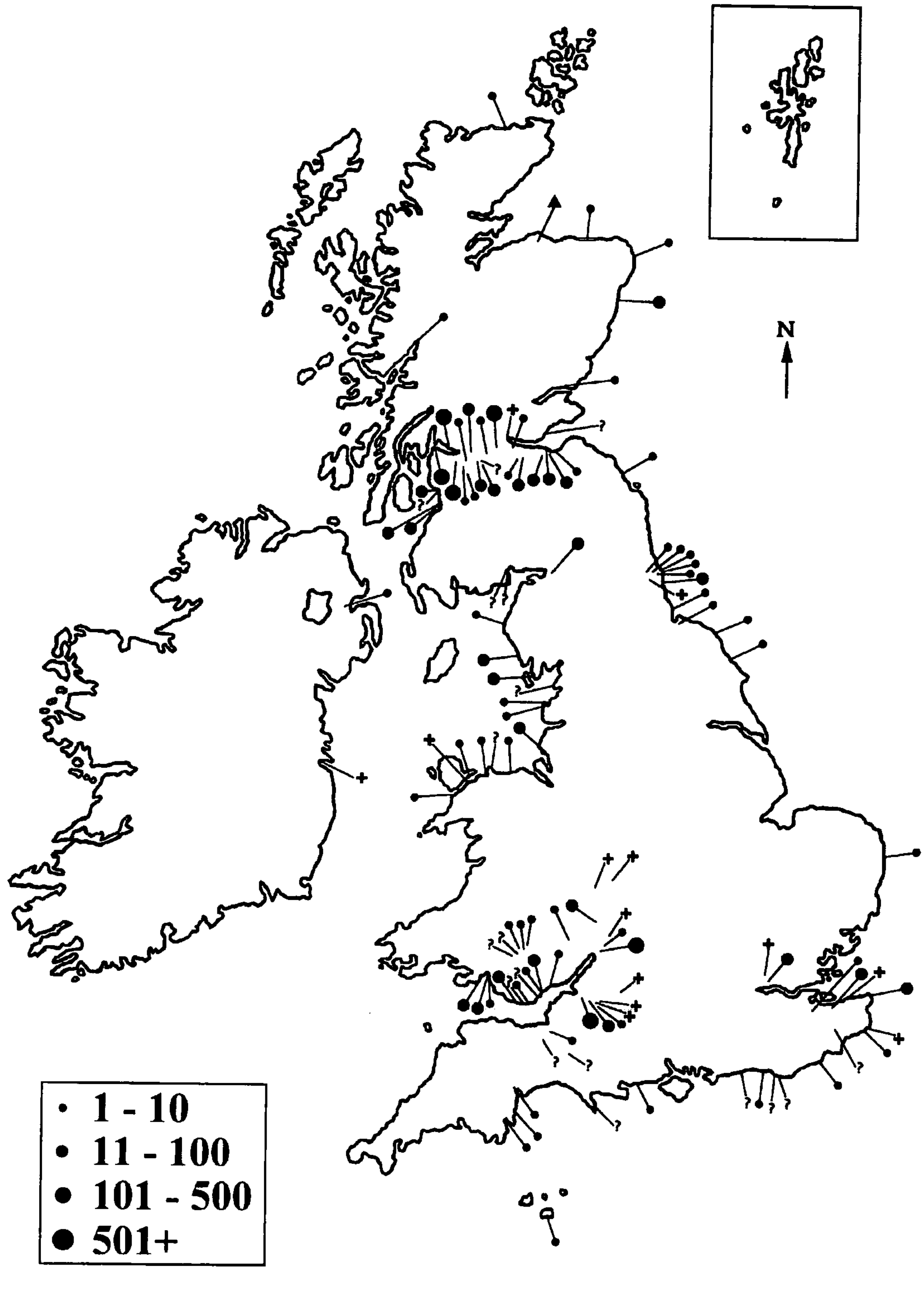


Figure 2.3b: Distribution and size of colonies of Lesser Black-backed Gulls nesting on buildings in 1994. Legend as for Figure 2.3a.

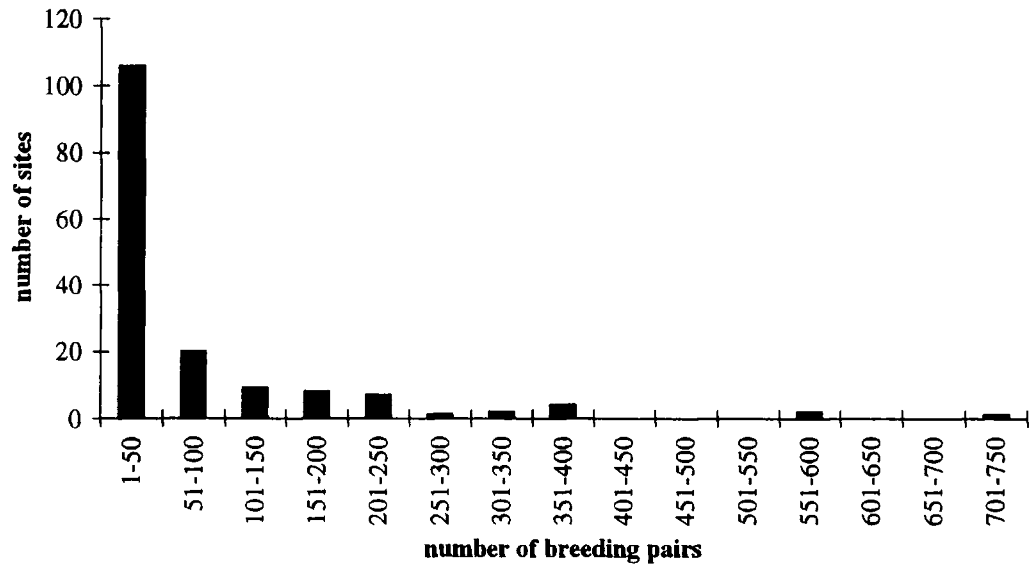


Figure 2.4: Histogram showing the frequency distribution of the number of pairs of roof-nesting Herring Gulls and Lesser Black-backed Gulls per site counted in 1994. Aberdeen, where there were over 2,000 pairs of gulls, has been omitted from this figure.

2.4.1.2 Changes since 1976

The results from sites counted both in 1976 and 1994, and sites colonised since 1976, show that there has been a 5-fold increase in the numbers of Herring Gulls and an 18-fold increase in the numbers of Lesser Black-backed Gulls nesting on buildings over this 18 year period (Table 2.1). The proportional increase of Lesser Black-backed Gulls is significantly greater than that of Herring Gulls ($\chi^2 = 208$, d.f. = 1, $P < 0.001$). Between 1976 and 1994, the average annual increase in the number of breeding pairs at sites in existence in 1976 and surveyed again in 1994 was 8% for Herring Gulls and 10% for Lesser Black-backed Gulls. However, if sites colonised since 1976 are included, these annual rates rise to 10% and 17% respectively (Table 2.1).

In the Herring Gull, adding in the newly colonised sites did little to raise the rate of increase of nesting pairs, indicating that the increase in this species had mainly occurred by the expansion of existing colonies. This is in contrast to the Lesser Black-backed Gull where the newly colonised sites contributed greatly to the overall rate of increase. Using the results of the 1994 survey, together with data on past nesting records, it has been possible to determine the total number of sites at which roof-nesting has been recorded since 1976. When compared to Herring Gulls, a significantly greater proportion of the sites where Lesser Black-backed Gulls have been recorded nesting on buildings to date have been colonised since 1976 (Table 2.1; $\chi^2 = 34.4$, d.f. = 1, $P < 0.001$). From 1976-1994, the number of towns colonised by roof-nesting gulls increased at an average rate of 13% per annum for Lesser Black-backed Gulls, but only at 4.7% per annum for Herring Gulls. Considering both species together, the average annual rate of increase in the number of sites colonised by large gulls, 5.1%, is only marginally greater than that of Herring Gulls. This is because many of the new Lesser Black-backed Gull colonies have been formed at sites already colonised by Herring Gulls. Sites with both species present form 82% of sites colonised by Lesser Black-backed Gulls, but constitute only 34% of Herring Gull sites.

A comparison between the periods 1969-1976 and 1976-1994 suggests that for both species the mean annual rate of increase in the number of breeding pairs has declined (HG: 17%/year to 10%/year, LBBG: 28%/year to 17%/year). Whilst the rate at which new sites have been colonised has remained unchanged for Lesser Black-backed Gulls at

Table 2.1: Details of rates of increase of roof-nesting Herring Gulls and Lesser Black-backed Gulls, 1976 - 1994, by region. Regions are defined in Figure 2.6. Sites in existence in 1976 but not checked in 1994 were excluded. P indicates the results of χ^2 tests comparing the proportional increase in the number of breeding pairs, or the proportion of sites colonised since 1976 in a region with that in the rest of the survey area.

Region	No. of breeding pairs				No. of sites colonised			
	1976	1994	P	% annual average increase 1976-1994	by 1976	by 1994	P	% annual average increase 1976-1994
Herring Gull								
East Britain	974	2,629	< 0.001	5.7	19	43	n.s.	4.6
SE England	306	1,518	n.s.	9.3	13	32	n.s.	5.1
SW England	106	762	< 0.01	11.6	36	67	n.s.	3.5
Bristol Channel	225	869	< 0.001	7.8	17	30	n.s.	3.2
West Britain	108	1,078	< 0.001	13.6	19	48	n.s.	5.3
NE Scotland	210	3,182	< 0.001	16.3	7	31	< 0.05	8.6
Ireland	14	146	< 0.05	13.9	2	8		8.0
Total	1,943	10,184		9.6	113	259		4.7

Table 2.1: (continued)

Region	No. of breeding pairs				No. of sites colonised			
	1976	1994	P	% annual average increase 1976-1994	by 1976	by 1994	P	% annual average increase 1976-1994
Lesser Black-backed Gull								
East Britain	6	197		21.4	3	21		11.4
SE England	1	65		26.1	1	13		15.3
SW England	0	8		-	0	7		-
Bristol Channel	132	875		11.1	8	26		6.8
West Britain	0	1,301		-	0	31		-
NE Scotland	0	57		-	0	6		-
Ireland	0	8		-	0	2		-
Total	139	2,513[a]		17.4	12	108[a]		13.0

a - total includes two sites at which a single pair nested which are not within the above regions

13% per annum, the comparable figures for Herring Gulls have declined from 9% per annum to 5% per annum (Figure 2.5).

2.4.1.3 Regional variation

From the 1976 survey, Monaghan & Coulson (1977) defined five main regions of Britain where Herring Gulls nested on buildings; east Britain, south-east England, south-west England, the Bristol Channel region and west Britain (Figure 2.6). Roof-nesting gulls were absent from the English coastline between the Rivers Humber and Thames and the western coasts of both Scotland and Ireland. Rates of increase in the number of breeding pairs of Herring Gulls between 1976 and 1994 have been calculated for these five regions. A comparison of these rates with those from 1969-1976 (Table 2.2), shows that a decline in the rate of increase has occurred in all of the five original regions except for south-east England, where a slight increase has taken place. In eastern Britain, which supported the highest rate of increase in roof-nesting gulls between 1969 and 1976, the rate has dropped appreciably to the lowest rate in the five regions.

Table 2.2: Regional rates of increase in the number of breeding pairs of Herring Gulls, 1969-76 and 1976-94. Using regional boundaries and data from Monaghan & Coulson (1977).

	Annual increase in number of breeding pairs of Herring Gulls	
Region	1969-1976	1976-1994
SE England	6%	9%
SW England	19%	11%
Bristol Channel	16%	8%
West Britain	20%	9%
East Britain	29%	6%

Since 1976, the geographical range of roof-nesting gulls has expanded (Figures 2.2 & 2.3). Two additional regions have therefore been defined; north-east Scotland and Ireland, and the limits of three of the original regions have been extended (Figure 2.6).

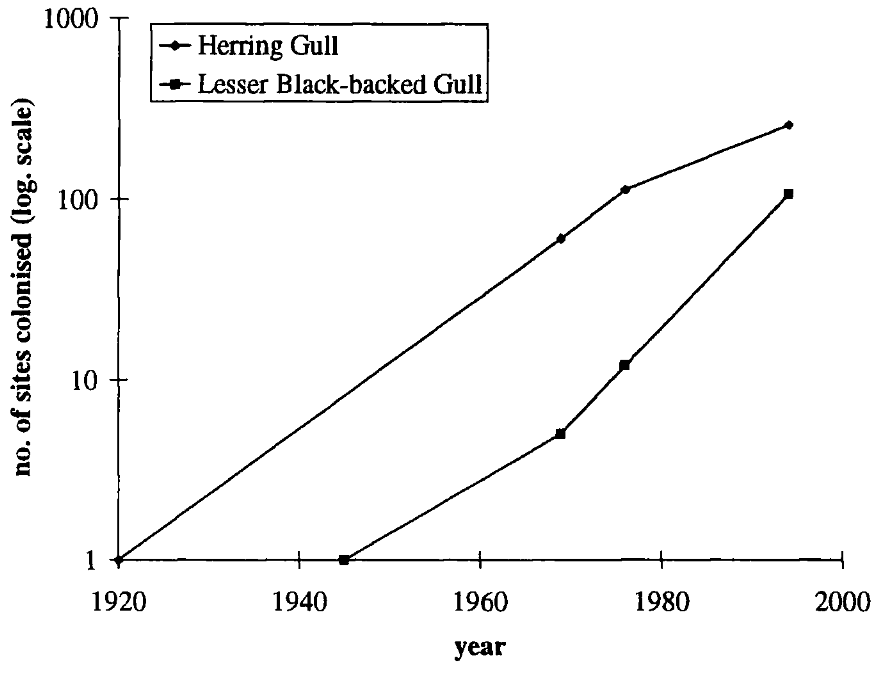


Figure 2.5: Increases in the number of sites colonised by roof-nesting Herring Gulls and Lesser Black-backed Gulls in Britain and Ireland.

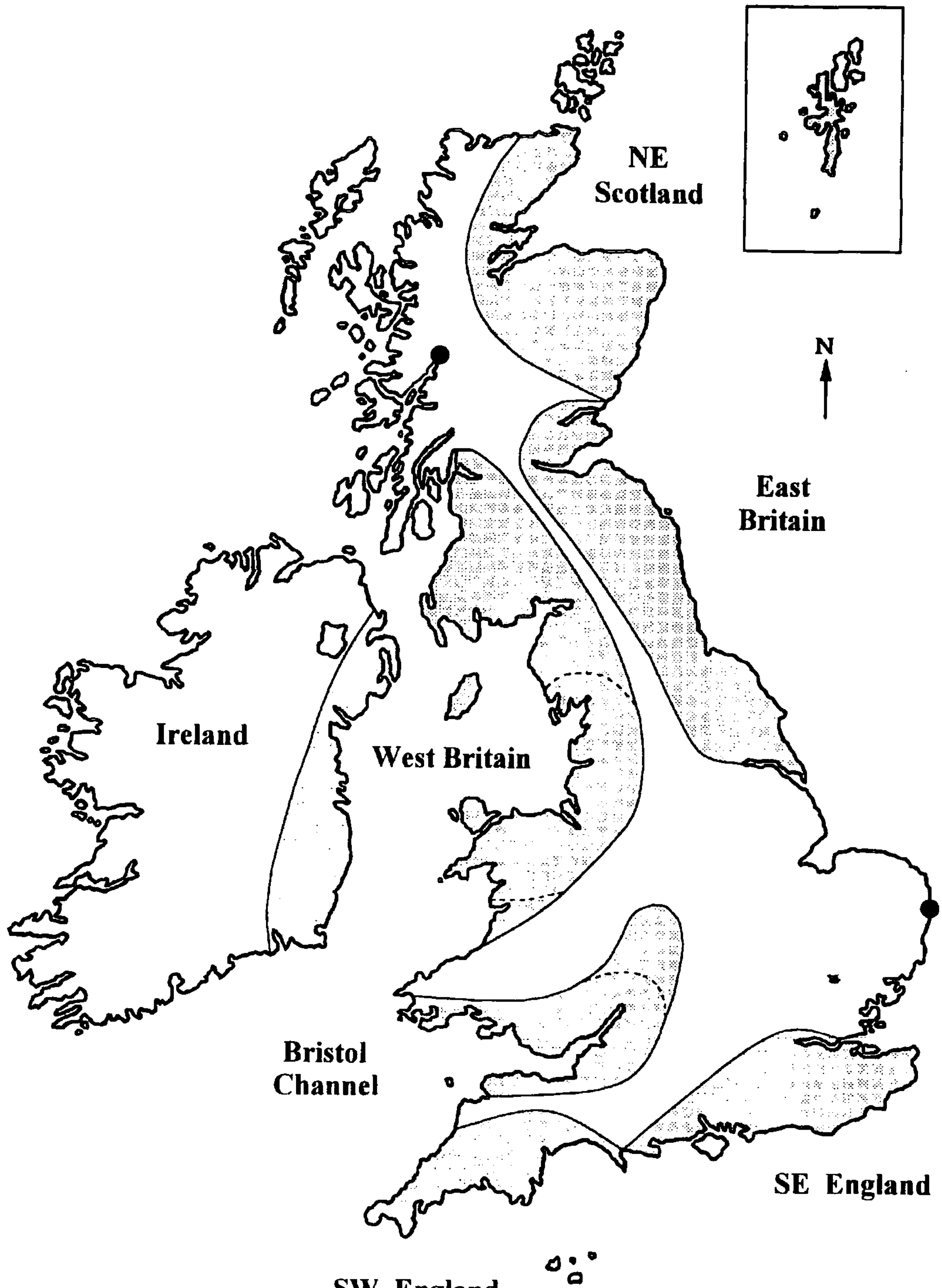
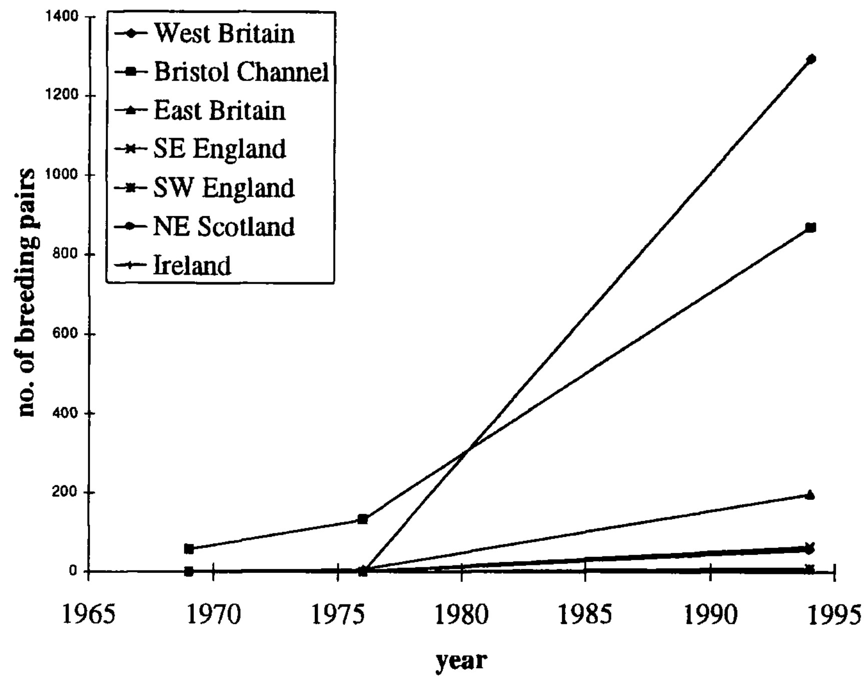


Figure 2.6: Boundaries of the seven main regions in which gulls nested on buildings in Britain and Ireland in 1994. Shetland is included in north-east Scotland, the Isle of Man in west Britain and Jersey in south-west England. The dotted lines indicate the original boundaries of two of the regions as defined in 1976. Jersey was not included in south-west England in 1976. The filled circles indicate the locations of two single pairs of Lesser Black-backed Gulls nesting outside the defined areas in 1994.

These new regional boundaries are used throughout this chapter unless stated otherwise. When the proportional increases in the numbers of Herring Gulls in these seven regions are compared (Table 2.1), the increases in north-east Scotland, west Britain, south-west England and Ireland are significantly higher than the overall rate, whereas the increases in east Britain and the Bristol Channel area are significantly lower. There is little regional variation in the increases in the number of sites colonised by Herring Gulls, with the exception of north-east Scotland where the proportion of sites colonised since 1976 is significantly greater than that overall (Table 2.1).

In 1976, Lesser Black-backed Gulls nesting on buildings were almost entirely restricted to the Bristol Channel area, with only a few pairs elsewhere. Since then, they have spread considerably and, in 1994, were nesting on buildings in all seven regions as well as single pairs at two other isolated sites (Figure 2.6). Details of these increases are given in Table 2.1 and, as it is not possible to calculate realistic percentage annual increases for several regions because few or no birds were nesting there in 1976, these data are shown graphically in Figure 2.7. These indicate that, although roof-nesting by Lesser Black-backed Gulls is still increasing progressively in the Bristol Channel area, it is increasing most rapidly in western Britain.

Roof-nesting Herring Gulls and Lesser Black-backed Gulls now share a similar geographical range in Britain and Ireland, but there are still regional differences in their abundance. This is shown by the ratios of the numbers of each species in each region and is shown in Table 2.3. In most regions, Herring Gulls greatly outnumber Lesser Black-backed Gulls, particularly in southern England and north-east Scotland, but numbers of the two species are almost equal in the Bristol Channel region and the Lesser Black-backed Gull actually predominates in western Britain, most noticeably in the Forth-Clyde region.



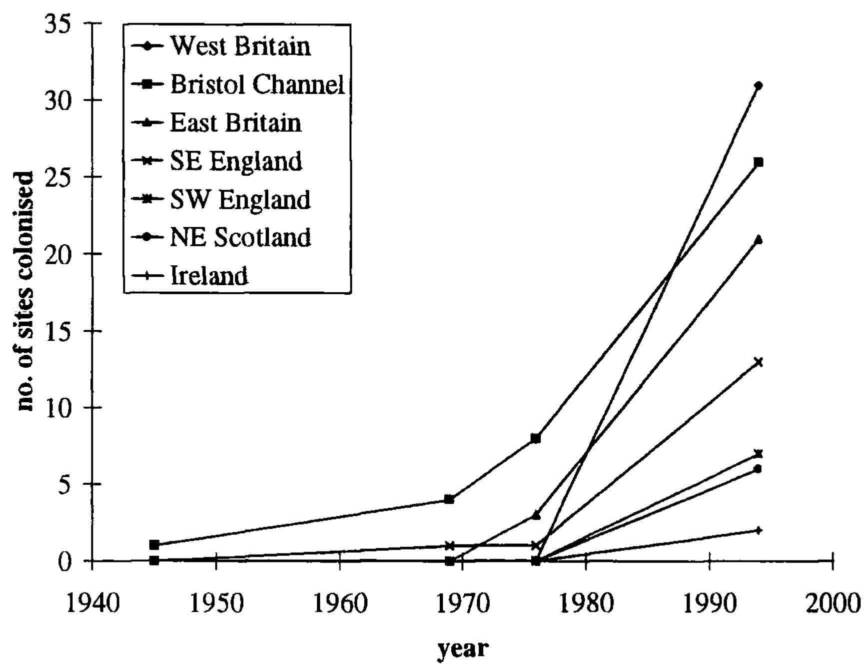


Figure 2.7: Regional increases in the number of breeding pairs of Lesser Black-backed Gulls and the number of sites colonised by this species.

Table 2.3: Regional variation in the ratio of Herring Gulls to Lesser Black-backed Gulls.

Region	No. of breeding pairs: Herring Gull	No. of breeding pairs: Lesser Black-backed Gull	No. of pairs of Lesser Black-backed Gulls per 100 pairs of Herring Gulls
East Britain	2,628	197	7.5
SE England	1,563	57	3.7
SW England	1,492	8	0.5
Bristol Channel	913	867	95
West Britain	1,059	1,283	121
NE Scotland	3,177	56	1.8
Ireland	146	8	5.5

2.4.1.4 Coastal and inland nesting

In general, Herring Gulls nest mainly near the coast, whilst Lesser Black-backed Gulls utilise both coastal and inland sites (Gibbons *et al.* 1993). In this study, coastal sites have been defined as those situated on the coast or shores of an estuary, and the above trend is reflected by gulls nesting on buildings (Table 2.4).

Table 2.4: The number of coastal and inland sites colonised by roof-nesting Herring Gulls and Lesser Black-backed Gulls by 1994. The numbers in parentheses are the numbers of these sites that were colonised in, or before, 1976.

Site location	No. of colonised sites: Herring Gull	No. of colonised sites: Lesser Black-backed Gull	Rate of annual increase of breeding pairs, 1976-1994: Herring Gull	Rate of annual increase of breeding pairs, 1976-1994: Lesser Black-backed Gull
Coastal	188 (92)	61 (6)	9.59	23.09
Inland	71 (22)	47 (6)	10.17	15.81

A greater proportion of Lesser Black-backed Gull sites in 1994 were inland ($\chi^2 = 8.35$, d.f. = 1, $P < 0.01$), especially in areas such as the Forth-Clyde region and around the Bristol Channel. However, if the proportions of gulls nesting coastally or inland are compared for sites formed in or before 1976 and those formed since, the proportion of coastal to inland Lesser Black-backed Gull sites has remained the same ($\chi^2 = 0.03$, d.f. = 1, $P > 0.05$), but the proportion of Herring Gull sites inland has increased significantly since 1976 ($\chi^2 = 6.03$, d.f. = 1, $P < 0.01$). The rate of increase in the number of pairs of breeding Herring Gulls between 1976 and 1994 does not differ between coastal and inland sites ($\chi^2 = 0.96$, d.f. = 1, $P > 0.05$), whereas in Lesser Black-backed Gulls it is significantly higher at coastal sites ($\chi^2 = 21.0$, d.f. = 1, $P > 0.001$) (Table 2.4).

2.4.1.5 Effect of colony size on rate of increase

Between 1976 and 1994, initially smaller colonies of Herring Gulls nesting on buildings increased proportionally faster than larger colonies (Figure 2.8a) implying that as a colony grows its rate of increase progressively slows. This relationship is shown on an arithmetic plot in Figure 2.8b which demonstrates that a colony of 2-3 pairs increases at twice the rate of one of 10 pairs and three times the rate of a colony of 100 pairs. The average size of a roof-nesting Herring Gull colony in 1976 was 46 pairs, by 1994, the average size of the same colonies was 180 pairs. However, new colonies have been formed and if these are included the average size in 1994 is reduced to 75 pairs. This size-related increase in colony size could possibly explain the lower rate of increase in the numbers of Herring Gulls nesting on buildings that has occurred between 1976 and 1994, however, the average colony sizes for 1976 and 1994 given above would be expected to lead to annual rates of increase of 6.14% and 5.25% respectively. The difference of barely 1% between these rates of increase is clearly not sufficient to account for the observed drop in the overall rate of increase of Herring Gulls, to which other factors must also have contributed.

2.4.1.6 Loss of colonies

During the survey, a confirmed absence of gulls was reported from twelve sites where roof-nesting had been recorded in, or since, 1976. Nine of these cases involved sites where only one or two pairs of Herring Gulls had nested on buildings previously and one involved a pair of Lesser Black-backed Gulls within a much larger colony of Herring

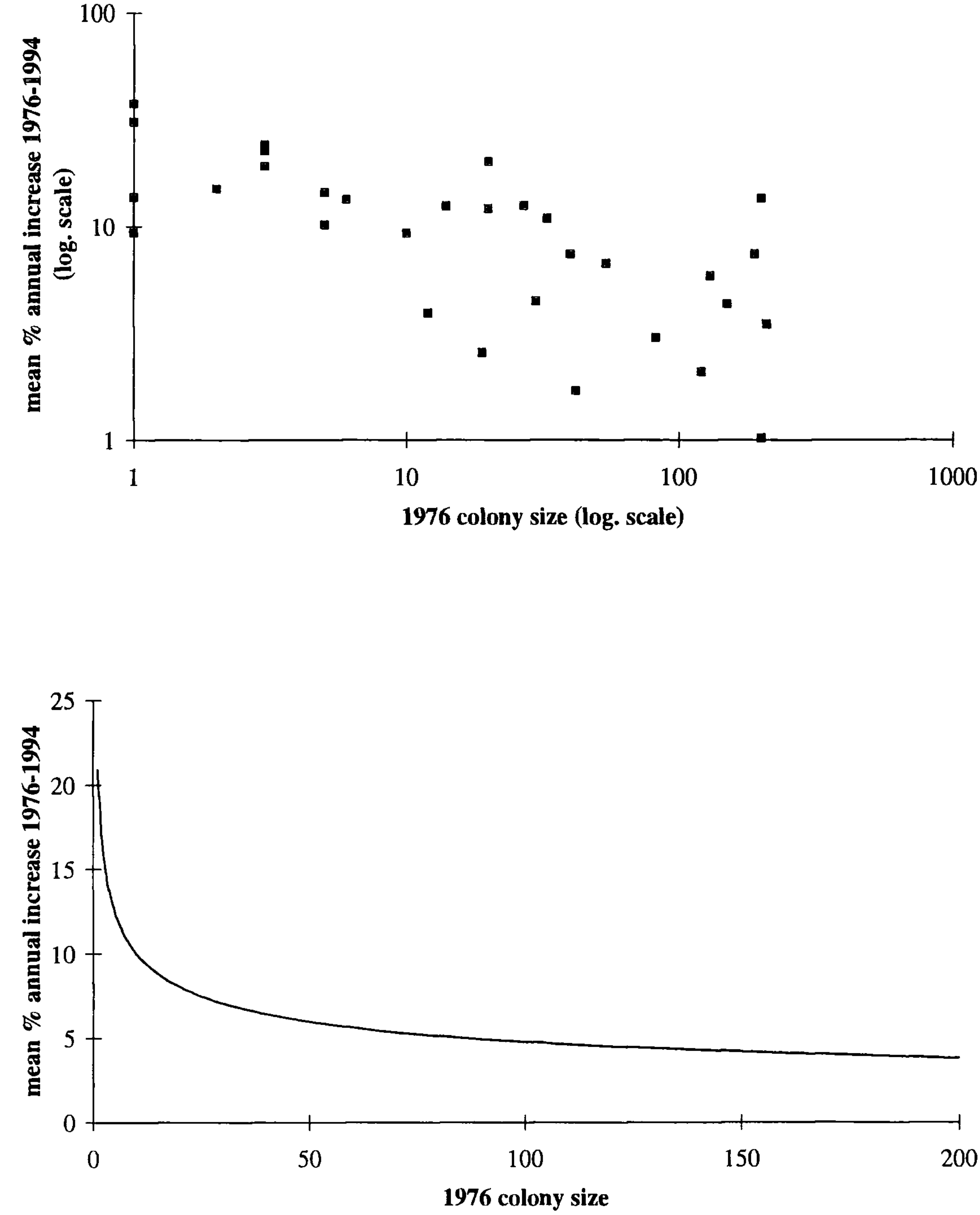


Figure 2.8: Relationship between Herring Gull colony size in 1976 and the rate of increase in the size of the colony between 1976 and 1994. The upper figure shows a log-log plot, log.y = 1.32-0.32log.x ($r = 0.68$, d.f. = 30, $P < 0.01$). The lower figure shows the above regression on an arithmetic plot.

Gulls. Only two of these involved large and well-established colonies and in each case human intervention had caused the desertion. At Herbrandston, Dyfed, the roof of the building was removed (G. Rees, in litt.) and at Portishead, Avon the entire building was demolished (R. Bland, in litt.). Two sites which had been deserted in 1976 now have roof-nesting gulls again; both of these sites had only a few nesting pairs prior to desertion. It appears that in some cases roof-nesting may be sporadic in the early years when only one or two pairs are present, but once numbers rise above this level, colonies are very unlikely to disappear without concerted action by the human population.

2.4.1.7 Nest site types

The 1976 survey found that gulls tended to nest mainly on residential and commercial buildings, often initially in the centre of towns. Industrial properties were used in only four towns (Monaghan & Coulson 1977). By 1994, the number of sites where gulls were known to be nesting on factories and other industrial buildings had risen to at least 74. This increase is only partly due to the expansion of colonies from the centre of towns to industrial estates on the outskirts, as in some areas industrial buildings were colonised initially. This was particularly so with Lesser Black-backed Gulls in the Forth-Clyde area of southern Scotland. Such industrial buildings offer large numbers of nest sites and encourage the formation of much denser colonies than on residential buildings where nest sites are limited to widely-spaced chimney stacks or dormer windows.

Details of the type of nest sites used by Herring Gulls are available for two towns in Tyne & Wear for both 1976 and 1994 (Table 2.5). There has been no significant change in the proportion of different nest sites used in Sunderland ($\chi^2 = 7.41$, d.f. = 3, $P > 0.05$), but in South Shields, the distribution has changed significantly ($\chi^2 = 14.0$, d.f. = 3, $P < 0.01$) with proportionally fewer birds now using flat roofs (shops and offices) and more on sloping roofs. The reduction in birds using flat roofs here is probably because these sites have been more accessible for control measures. The increase in the use of sloping roofs is mainly due to the colonisation of shallow sloping warehouse and factory roofs on the outskirts of the town. This phenomenon has been reported from several sites and the lack of significant change in Sunderland is probably because it was one of the few towns where many industrial properties were already used by 1976.

Table 2.5: Details of distribution of Herring Gull nests in South Shields and Sunderland, Tyne & Wear, in 1976 and 1994 (data from Monaghan & Coulson (1977), and J. Maude & K. Webb, unpublished BSc dissertations, University of Durham).

	Percentage of nesting pairs			
	South Shields		Sunderland	
Nest site type	1976	1994	1976	1994
Chimney stacks	36	36	18	14
Sloping roofs	10	21	43	37
Flat roofs	40	30	30	33
Ledges	14	13	9	16
Total numbers	209	388	189	634

2.4.2 Common Gulls and Great Black-backed Gulls

In 1994, records were received of 236 pairs of Common Gulls nesting on buildings at 10 sites (Figure 2.9) but they were no longer nesting at the site previously used in Wick (section 2.2.1), which, in 1994, was solely occupied by Herring Gulls. The largest numbers were present in Aberdeen, which supported nearly 150 pairs, but all other records were of 25 or fewer pairs. The types of nest sites most frequently used were buildings with large, flat or gently sloping roofs, such as schools, warehouses and farm buildings. At six of these sites other gull species were nesting nearby.

The 1994 survey reported 11 pairs of Great Black-backed Gulls nesting on buildings at ten sites, including one pair nesting on a jetty (Figure 2.9). In 1995 a pair was recorded nesting on a bus station in Edinburgh for the first time. The Cornwall and Cumbrian sites were not checked, so the survey results are likely to underestimate the true figures. It is thought that Great Black-backed Gulls no longer nest at HM Dockyard, Rosyth. The records provide evidence of a spread of the area where this species nests on buildings. All records from the survey were of single pairs except for one case of two pairs, and at all sites other gull species were nesting on buildings nearby.

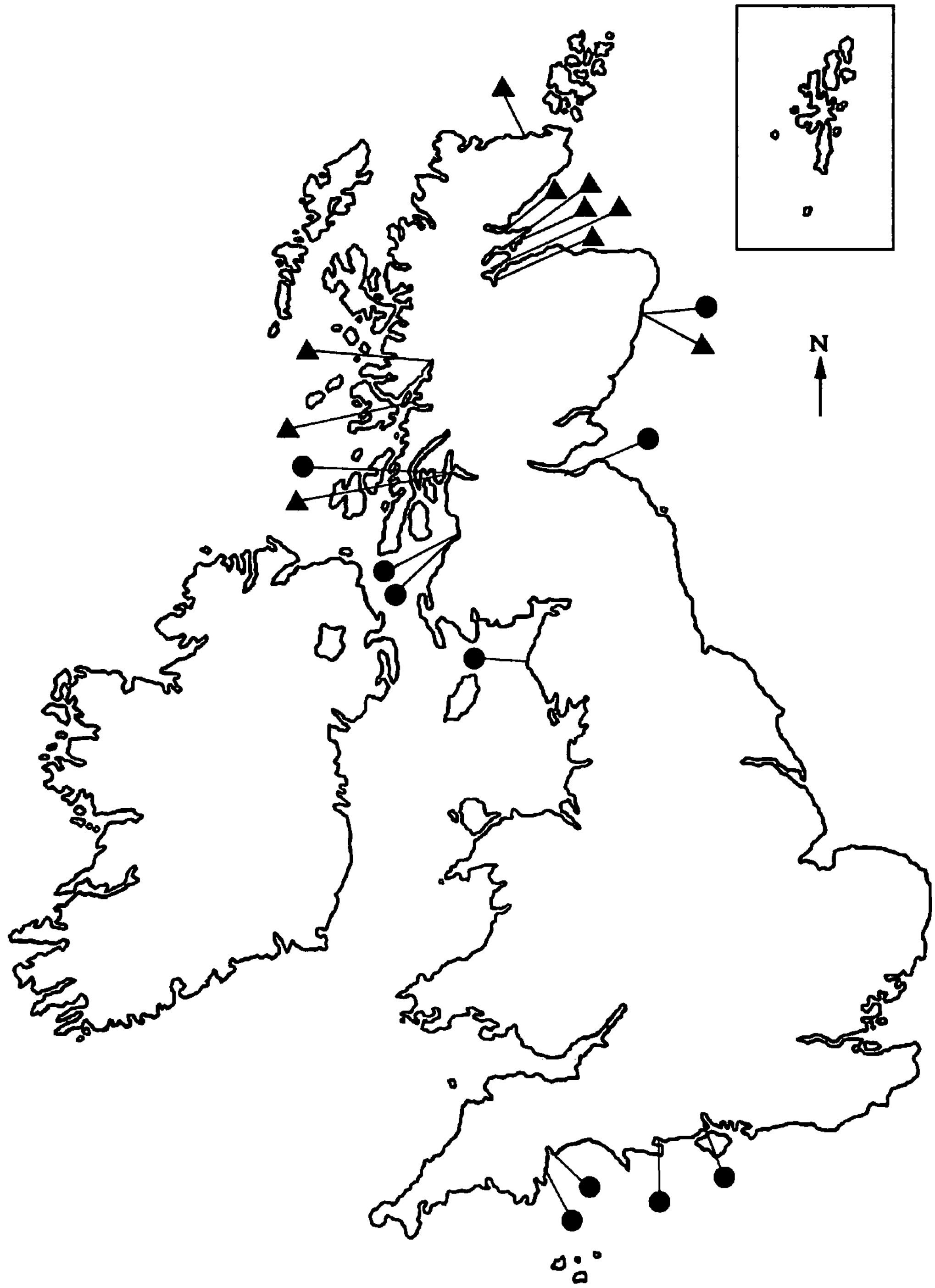


Figure 2.9: Distribution of colonies of Common Gull (filled triangles) and Great Black-backed Gull (filled circles) nesting on buildings in Britain and Ireland in 1994.

2.4.3 Responses of local authorities

In late 1993, questionnaires concerning gulls nesting on buildings were sent to the Environmental Health departments of 197 local authorities in Britain. These included all coastal authorities and also those inland in areas where gulls had been recorded nesting on buildings in the past. 186 (94%) of these questionnaires were completed and returned, and of these, 74 local authorities reported that they were aware of gulls nesting on buildings in their administrative area. The results of the questionnaire are summarised in Table 2.6.

Table 2.6: Responses to questionnaire of local authorities with gulls nesting on buildings in their administrative area (n = 74).

Question	Yes	No
have you received any complaints from the public concerning these gulls ?	58 (78%)	16 (22%)
do you have a control policy for these gulls ?	12 (16%)	62 (84%)

Complaints from the public about gulls nesting on buildings were received by 78% of these local authorities. The complaints concerned noise, fouling of cars and property, damage to buildings and the aggression of adult birds towards roof maintenance workers and residents of buildings. However, only 12 of these authorities carried out measures to attempt to control the number of gulls. The majority of these 12 merely responded to individual cases by either removing the eggs and nest or by culling the adult birds at a particular site where a complaint had been made. In only four cases were large scale control operations carried out on the scale of an entire town; three involved removal of eggs and nests from every accessible nest site, while the fourth involved the culling of as many adult birds as possible using the narcotic drug α-chloralose. It was this last authority which was the only one to have any success in reducing the numbers of gulls nesting on buildings. Three other authorities reported success in keeping numbers stable;

one by large scale egg and nest removal and two by the removal of eggs and nests in response to requests by residents.

Comparing the results of the 1994 survey with these questionnaires it could be seen that at least 25 local authorities reported that they were not aware of gulls nesting on buildings when, in fact, there were such gulls in their area. In most of these cases, the gulls were either present in very small numbers or were nesting on areas with restricted access such as industrial properties and military bases. Local authorities have to deal mainly with residents or commercial dwellings.

2.5 Discussion

Since 1976, the number of gulls nesting on buildings has continued to increase in Britain and Ireland. Two species are mainly involved, the Herring Gull and the Lesser Black-backed Gull, but records of Common and Great Black-backed Gulls nesting on man-made structures have also become more frequent. The increase in the numbers of Herring Gulls nesting on buildings is of particular interest due to the decline in their overall numbers which has taken place during this period (Lloyd *et al.* 1991). In the period 1988-1991 it is thought that 205,700 pairs of Herring Gulls and 88 700 pairs of Lesser Black-backed Gulls nested in Britain and Ireland (Gibbons *et al.* 1993). The estimated numbers of gulls nesting on buildings in 1994 constitute 8.2% and 3.6% of these populations respectively. In 1976, only 0.6% of the Herring Gull population of Britain and Ireland nested on buildings (Monaghan & Coulson 1977). Thus there has been a rapid redistribution of the nesting habitat of both species which, presumably, will continue.

The reason for this difference in the population trends of Herring Gulls nesting on natural and man-made sites is not known. Emigration of young birds between the two types of nesting areas occurs; for example, many young gulls reared on the Isle of May in the Firth of Forth have been found breeding on buildings in north-east England (Monaghan & Coulson 1977), so they are not distinct populations. Therefore man-made sites are either more attractive to recruits or the survival rates of adults nesting on buildings are higher than those breeding on cliffs or islands along the coast. It is probable that the same factor, food, contributes to both possibilities. Towns offer additional sources of food, namely waste which is left by human activities, such as scraps from 'fast food' shops, waste from fish docks and food put out specifically for the gulls by local people. In some areas, Herring Gulls now pull material from waste bins in streets and rip open plastic sacks left for refuse collection. These habits appear to be spreading rapidly and are adding further to the problems gulls cause in towns.

The increase of Herring Gulls and Lesser Black-backed Gulls has taken place in two ways, firstly by the expansion of existing colonies, and secondly by the progressive colonisation of towns previously without nesting gulls. Many towns have the capacity to support large numbers of gulls; for example, Aberdeen now has over 2,000 pairs of gulls of four different species nesting in the city and many other towns and cities have potential nesting sites for similar numbers. In particular, the trend towards colonisation of industrial sites means that large numbers of gulls can nest on a relatively small number of roofs. In many coastal areas, virtually all towns now have nesting gulls and nationally the number of colonised towns is approaching the asymptotic level. However, in recent years inland sites have started to be colonised, particularly by the Lesser Black-backed Gull which has now been recorded nesting as far inland as Birmingham. Although relatively small numbers of gulls are involved in nesting inland at present, this development opens up many more sites to colonisation by roof-nesting gulls.

The spread of roof-nesting Lesser Black-backed Gulls between 1976 and 1994 has been considerably greater than that of the Herring Gull. In many cases this species has joined existing Herring Gull colonies in coastal towns, but it appears that in some inland areas, for example the Forth-Clyde region of Scotland, it has been the initial coloniser, with Herring Gulls following later. Consideration has to be given to the possibility that the spread of the Lesser Black-backed Gull in southern Scotland and northern England has been caused by the extensive culling and consequent disturbance to this species on the Farne Islands, Northumberland, Abbeystead, Lancashire and several islands in the Firth of Forth, including the Isle of May, over the period under review. Further, the Lesser Black-backed Gull colony on Flanders Moss, an inland site near Stirling, also disappeared during this time, again probably caused by human activity. An association between disturbance at colonies elsewhere and the spread into towns may exist.

The size of Herring Gull colonies influences the rate of colony increase with small colonies increasing at proportionately higher rates than large ones, an effect previously shown for the Kittiwake (Coulson 1983). This may explain why between 1976 and 1994, the rate of increase in the numbers of roof-nesting gulls was highest in those areas which were newly colonised and where many colonies were still small, rather than those regions where roof-nesting is well-established and most towns now support large numbers of gulls (e.g. east Britain). The natural disappearance of roof-nesting gulls from a site has been observed only in colonies of a few pairs. The rapidity with which small colonies increase in size means that they very quickly pass this vulnerable stage and reach a size at which a reduction in numbers is likely only with considerable human effort. Low initial numbers of nesting gulls often pass unnoticed in urban areas and therefore the stage at which they may most easily be dissuaded is missed.

Whilst town nesting gulls are regarded by most local councils as a minor problem, complaints about such gulls from residents, visitors and industry are increasing with the number of roof-nesting gulls, and several authorities have had to employ control measures. Although success may be achieved on a small scale, dissuading birds from nesting on an individual roof, this usually results in the birds moving to another roof nearby. A variety of methods are used such as preventing nesting by blocking the nest site with wire netting, spikes or wires, or by removing either the eggs and nest, repeatedly if the gulls attempt to renest. Shooting adult birds on rooftops is not permitted by most police forces and permission is known to have been granted in only two towns.

On the larger scale of an entire town, attempts to tackle the problem have been less successful. The pricking of eggs and nest removal to reduce breeding success have not been successful management policies for several reasons. As adult Herring Gulls live on average 10-15 years, reduction of their reproductive output is not likely to cause a rapid decrease in the numbers nesting in a town. As most Herring Gulls do not breed until they are about five years old, whatever effectiveness arises from preventing breeding by egg and nest destruction is delayed. Also, appreciable numbers of the recruits to a breeding group are hatched in other breeding areas up to 100 km away (Coulson 1991). Herring Gull distress calls have been used to try to deter gulls from nesting, however, the result was birds merely moving to previously unused areas of the town and it is likely that the extensive use of these calls would result in habituation by the gulls and disturbance to residents. The use of narcotic drugs such as α-chloralose to remove adults has moderated the problem in some places but access to, and permission to cull at, many nesting sites is a problem.

In 1976, ten towns were reported to be carrying out extensive gull control measures (Monaghan & Coulson 1977). In 1994, all of these towns still had roof-nesting gulls and, in all cases, the numbers present were greater than in 1976. Of the local authorities questioned in this study, only one felt that they had been successful in reducing the number of gulls nesting in their area, and this was by carrying out an extensive culling program. Conflict exists between human residents as to whether or not local authorities should try to reduce gull numbers by culling. Effective, non-lethal management methods remain to be developed and need to be based on detailed research.

Chapter 3

Breeding success of Herring Gulls and Lesser Black-backed Gulls on a large warehouse

3.1 Introduction

The number of gulls nesting on buildings in many parts of the world has been increasing since the early part of the 20th century (Chapter 2). Such an increase can be explained in part by the recruitment of large numbers of young gulls to such colonies, and suggests that buildings provide suitable nesting habitat. The breeding biology of gulls nesting on buildings has been the subject of several studies. The results of these studies have, however, differed as to the reproductive success of roof-nesting gulls when compared to those nesting at more traditional sites.

In most of the studies carried out, no difference was found between the clutch size or hatching success of gulls nesting on roofs and those at more traditional sites (Monaghan 1979, Vermeer *et al.* 1988, Belant 1993, Chaussabel 1995). The only exception was the study by Mudge (1978) in which both of these parameters were found to be low due to human disturbance, especially egg collection, on roofs. Monaghan (1979) and Chaussabel (1995) found fledging success of Herring Gulls to be greater in roof-nesting colonies than elsewhere. Mudge (1978) observed that chicks from rooftop nests grew faster and fledged in better condition than those from a nearby island, however, the initial losses of eggs in this colony led to the overall fledging success being no different to that at traditional colonies. Vermeer *et al.* (1988) found that fledging success of roof-nesting Glaucous-winged Gulls was lower than that found on a well-studied island colony of this species.

In many studies, it was found that the nesting density in towns was significantly lower than that found in traditional colonies (Monaghan 1979, Vermeer *et al.* 1988, Belant 1993, Chaussabel 1995). It has been suggested that this may contribute to the high reproductive success observed in some roof-nesting colonies (Monaghan 1979, Chaussabel 1995). Many nest sites in towns are isolated or distant from other nests and so the chicks are subject to little aggression from neighbouring birds, so increasing their survival.

Differences in reproductive success between roof types support this suggestion. Monaghan (1979) found that fledging success was higher for nests at isolated sites, such as chimney stacks, when compared to nests on flat roofs where several pairs could nest.

Vermeer *et al.* (1988) also found that breeding success was lower on a roof supporting a large number of nests when compared with dispersed pairs nesting at lower density over several roofs. Despite the nest density at the large roof colony they studied being lower than that found at an island colony, birds nesting on this roof had lower reproductive success, a finding that was attributed to the lack of shelter for chicks on the roof.

In addition to differences in nesting density, Chaussabel (1995) found that in towns adult birds were present at the nest for a higher proportion of the time and that they defended and fed their chicks more frequently. He felt that the proximity of food to these nests meant that adult birds did not have to spend as much time away from the nest in order to feed their brood and so the chicks were not left vulnerable for as long in towns. In addition to these potential advantages of roof-nesting, the safety of such nests from some of the predators which take eggs and young from nests on the ground (Vermeer *et al.* 1988) may also be important.

In several studies it was found that roof-nesting birds laid later than those at nearby traditional colonies (Mudge 1978, Vermeer *et al.* 1988, Belant 1993, Chaussabel 1995). There are two potential explanations for this finding. Firstly, it is known that young, inexperienced gulls breed later than those with more experience (Coulson & White 1960, Davis 1975) and it has been suggested that the birds nesting on roofs include a higher proportion of inexperienced birds (Mudge 1978, Vermeer *et al.* 1988). Secondly, because rooftop colonies tend to be more dispersed than traditional ones, there may be less of the social stimulation thought to encourage the initiation of breeding (Mudge 1978, Chaussabel 1995).

In the only study in which the age of adult gulls nesting on buildings has been investigated, no differences were found in the age of birds breeding on roofs and those breeding on a nearby island (Belant 1993). However, in the studies by Mudge (1978) and Vermeer *et al.* (1988), some aspects of the breeding biology of the roof-nesting gulls suggested that they may be younger and less experienced than birds nesting at more traditional sites. In addition to their late breeding, circumstantial evidence of inexperience included two three year old birds attempting to breed, all of the chicks being raised by less than 50% of the breeders (Mudge 1978), a bimodal distribution of clutch initiation dates and a significant difference in the volumes of eggs of early and late nesters (Vermeer *et al.* 1988).

The above studies mostly involved relatively dispersed urban colonies (Mudge 1978, Monaghan 1979, Chaussabel 1995), however, increasingly in Britain and Ireland Herring Gulls and Lesser Black-backed Gulls are being found nesting on large industrial buildings (Chapter 2). Many such sites have the potential to support several hundreds of breeding pairs of gulls. Although they still have the advantages of being close to food and safe from ground predators, it is possible that colonies on large buildings may reach densities higher than those found so far for roof-nesting gulls. If low nesting density is an important factor in ensuring high breeding success at roof-nesting colonies, as suggested by some of the above studies, then on such buildings this advantage may be lost and reproductive success lowered.

Among the Glaucous-winged Gulls nesting in Vancouver studied by Vermeer *et al.* (1988), was a group of 80 pairs nesting on two adjacent roofs of a large warehouse and Belant (1993) studied a colony of 176 pairs of Herring Gulls nesting on two adjacent roofs in Ohio, USA but did not follow the chicks to fledging. No study has been carried out on Herring Gulls or Lesser Black-backed Gulls nesting in large numbers on one roof in Britain or Ireland. The aim of the present study was to investigate the breeding biology of a mixed colony of these species nesting on the large roof of a warehouse in order to determine whether such a colony is indeed less successful than those in which birds nest in a dispersed fashion on the rooftops of a town.

3.2 Study Site

The site chosen for this study was a large building on the industrial site owned by ICI at Wilton on Teesside, north-east England (NZ 577217). The ICI Wilton site covers an area of several square kilometres to the south of the River Tees, and is involved in the production of various chemical products. Numerous pairs of Herring Gulls and Lesser Black-backed Gulls were known to nest on the roof of this building.

The building supporting the gull colony, known as the Melinar stores, is situated in the middle of the plant and has two main parts (Figure 3.1). The taller, brick section is a derelict polypropylene production unit, while the lower is a warehouse and is actively used throughout the day. The entire building complex covers an area of approximately 4 hectares. The roof of the warehouse is flat with substantial ridges, occasionally traversed by walkways. Many of these ridges support large, raised glass or plastic skylights, together with air vents. One wing of the derelict unit stretches over part of the warehouse roof, forming an upper section, partly ridged in the same way as the main roof below and partly flat. Unprotected 6-inch diameter drainage holes are found at regular intervals in the channels between the ridges. Lack of maintenance has meant that in some parts of the roof vegetation has become established and has blocked drains, causing temporary pools of water to form in wet weather.

Access was possible, by ladder, to the level of the main roof and the upper section but not the top of the derelict building. It was possible to enter the latter due to broken windows and doors level with the main warehouse roof. A long, narrow low passage ran out from the derelict building, cutting through several ridges.

3.3 Methods

The study was carried out during the breeding season of 1995. Several visits were made to the warehouse during the early months of the year in order to construct a map of the colony site. Regular visits began on 27 April, continuing until mid-August.

During the laying period, visits were made every other day and on each visit the entire roof was searched for new nests and eggs. The positions of all nests were marked on a map of the roof and given a number, both on the map and on the roof itself. On each visit, new eggs were labelled with their nest number and their position in the laying sequence (a,b or c). The date of the visit was noted and the length and breadth of the egg were measured to the nearest 1 mm with Vernier callipers. Egg volumes were calculated using the following formula described by Harris (1964b) -

$$\text{volume} = 0.000476 \times \text{length} \times \text{breadth}^2$$

Figure 3.1: The roof of the Melinar Stores, ICI Wilton, Teesside. Upper photograph looks south-west and shows the main level of the roof with the derelict polypropylene production unit in the background. Lower photograph looks north-east, was taken from the polypropylene unit and shows the main level of the roof.

The loss of any egg during incubation was also noted, together with the reason for this loss, if known. During this period, the species breeding at each nest site was determined by observation of incubating birds. For the few nests for which this was not possible, the species was determined later by examining the plumage of the chicks. By the time the chicks are fully feathered, the inner primary feathers of Lesser Black-backed Gull chicks are significantly darker than those of Herring Gull chicks (Baker 1993).

For a five-day period at the peak of hatching the site was visited every day in order to establish the nest of hatching for as many chicks as possible. For the rest of the hatching period the frequency of visits decreased to every three days until the end of June after which visits were made once every week. When each chick was found it was 'ringed' with a ring made of masking tape, carrying the nest number, and, if known, which egg it was from. At the age of 10 days or above, with the assistance of the Teesside Ringing Group, chicks were ringed with monel rings, the masking tape removed and their details noted against the new, permanent ring number.

In order to investigate the reproductive success of the birds nesting on this roof, a thorough search was made of the whole site on each visit and the identities of all chicks found were recorded. From mid-July onwards, after which the majority of chicks should have fledged, counts of the total number of chicks on the roof were carried out from a vantage point on every visit. When dead adults or chicks were found, notes were made of any signs which might explain the reason for their death. In the case of ringed chicks, the identity of the dead bird was recorded. After fledging, the nearest neighbour distance was measured to the nearest 0.5m for every nest and details were noted of the type of nest site.

In the colony a number of birds, both adults and chicks, were found dead exhibiting symptoms characteristic of the paralytic disease botulism; such birds were typically found lying on their ventral side with the wings partly extended away from the body. A green staining was often visible around the vent resulting from diarrhoea. This disease is caused by the ingestion of the toxin produced by the anaerobic soil bacteria *Chlostridium botulinum* which acts by inhibiting the release of a neurotransmitter, acetylcholine, so causing progressive paralysis of the voluntary muscles. In birds this causes a characteristic loss of the use of the wings, then legs , then neck. Death can result for several proximate reasons such as respiratory failure, drowning, lack of water or exposure (Rosen 1971).

If blood samples are taken from moribund gulls it is possible, with laboratory tests, to test for botulism, however, it was not possible to do this in the present study. Several studies have proven the presence of botulinum Type C toxin in dead gulls exhibiting such symptoms in Britain and Ireland (Lloyd *et al.* 1976, Macdonald & Standring 1978, Quinn & Crinion 1984, Worrall 1987) and therefore it has been assumed that botulism was the most probable cause of death of the birds with such symptoms in the present study. The one adult bird found dead which did not exhibit the symptoms of botulism was an adult Herring Gull which showed signs of bleeding from the vent and was not found in the characteristic position associated with botulism.

3.4 Results

3.4.1 Use of the roof

3.4.1.1 Number of breeding pairs

During the breeding season of 1995, 247 pairs of Herring Gulls and 21 pairs of Lesser Black-backed Gulls nested on the roof of the Melinar Stores at ICI Wilton. These figures indicate the number of nests in which clutches were laid. 20 nests were built in which no eggs were apparently laid. Only one repeat clutch, that of a Lesser Black-backed Gull, was found in a nest which had previously held eggs, and this clutch was excluded from the analysis. Two eggs laid without a nest in a loafing area, and two laid beside a nest which had contained a full clutch for some time, were also excluded.

3.4.1.2 Distribution over the roof

Figure 3.2 illustrates the distribution over the roof of nests in which eggs were laid. 86% (18/21) of the Lesser Black-backed Gull nests and 81% (201/247) of the Herring Gull nests were on the lower surface of the roof. Although access to the uppermost surface of the roof was not possible, no gulls were observed to frequent it regularly and it is unlikely that any birds nested there. The majority of Lesser Black-backed Gulls nested

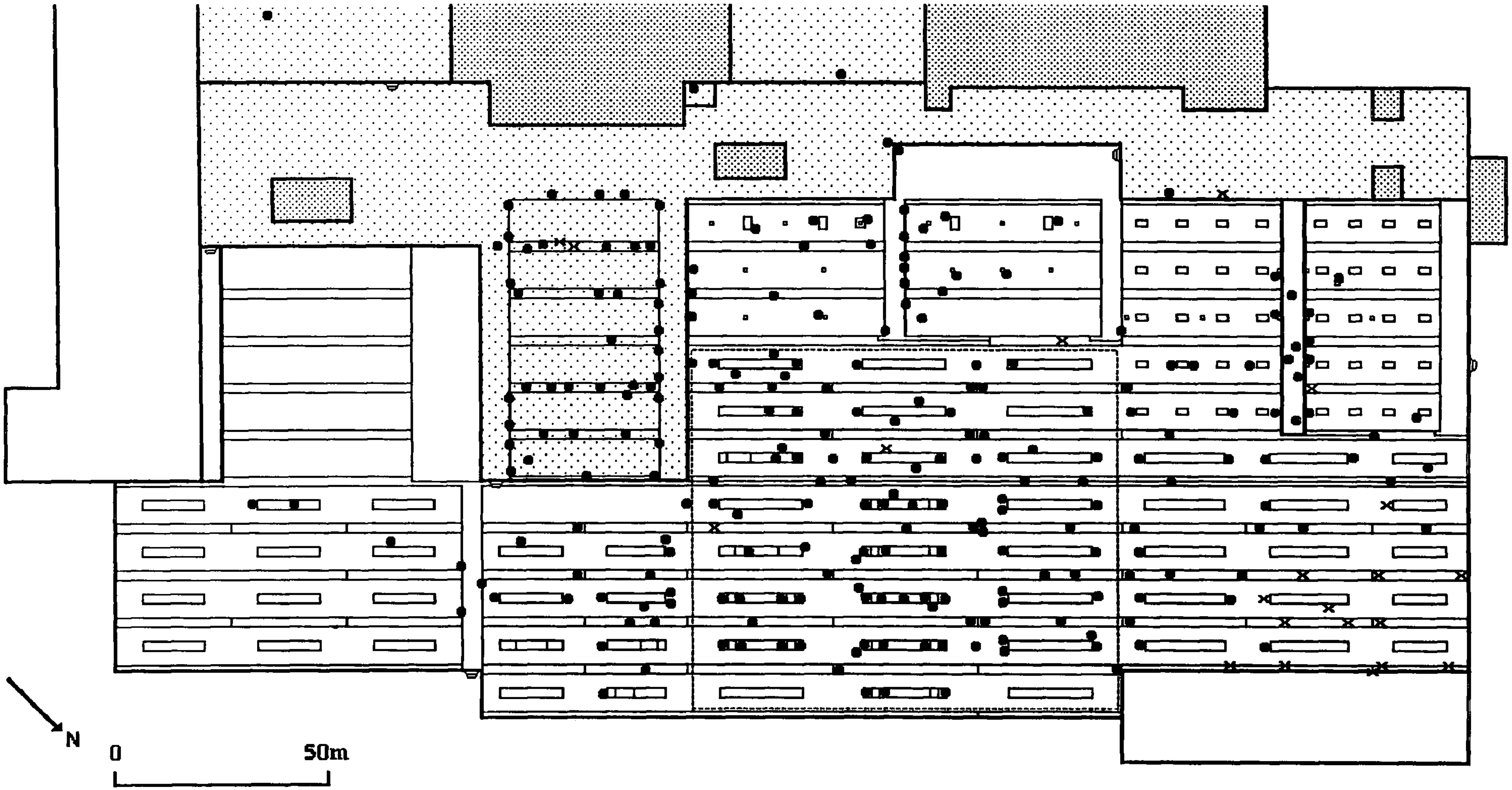


Figure 3.2: Diagram of the study area on the roof of the Melinar Stores, ICI Wilton. Nests of Herring Gulls are indicated by filled circles and nests of Lesser Black-backed Gulls are indicated by crosses. Upper levels of the roof are indicated by increasingly dark shading. Area bounded by dotted line indicates main body of the colony.

together in a group in the north eastern corner of the roof, but 33% (7/21) were scattered throughout the colony, some distance from any other members of their species. The nearest neighbour of 97% (240/247) of Herring Gulls was a conspecific.

Of the 247 nests of Herring Gulls, 241 (98%) were built on the ridged areas of the roof, with only 6 (2%) nests found on the flat areas. In the case of the Lesser Black-backed Gull, 20 (95%) of the 21 nests were found on the ridged areas. Although the exact dimensions of the roof were not known, the areas of the ridged and flat areas of the roof were estimated using measurements of a small section and found to comprise 78% and 22% respectively of the area of the roof which was studied. It was found that the proportion of Herring Gull nests on the ridged area of the roof was higher than the proportion of the roof area it comprised ($\chi^2 = 53.47$, d.f. = 1, $P < 0.001$) suggesting that this species nested preferentially on the ridged areas of the roof. The proportions of Lesser Black-backed Gull nests on the two types of area were not significantly different from the relative areas of these two roof types ($\chi^2 = 3.22$, d.f. = 1, $P > 0.05$), suggesting that this species had no preference for either part of the roof.

It was found that of the 247 Herring Gull nests, 235 (95%) were next to a structure of some sort, as were all of the Lesser Black-backed Gull nests. In some cases these structures were as minor as the slope of one of the ridges on the roof, but very few nests were found completely in the open. The presence of many structures, such as skylights or air vents, on the ridged areas of the roof may account for the apparent preference of Herring Gulls for this area for nesting.

3.4.1.3 Types of nest sites

The types of sites used can be grouped into five main categories (Table 3.1), which are illustrated in Figure 3.3.

Nest Site Type 1

Nest Site Type 2

Figure 3.3: The five main types of nest site used on the roof of the Melinar Stores.

Nest Site Type 3

Nest Site Type 4

Figure 3.3: (continued)

Nest Site Type 5

Figure 3.3: (continued)

Table 3.1: Details of the five main categories of nest site in the study area.

Nest Type	Description	No. of nests Herring Gull	Lesser Black-backed Gull
1	in open or against slope of ridge	45 (18.2%)	9 (42.9%)
2	against divider in dips or against small clump of vegetation	30 (12.2%)	5 (23.8%)
3	on skylight	42 (17.0%)	0 (0.0%)
4	against skylight, vent, wall or large clump of vegetation	82 (33.2%)	5 (23.8%)
5	in corner of ridge ends	48 (19.4%)	2 (9.5%)

Only 18 nest sites did not fit these descriptions exactly, most of these being nests surrounded by vegetation between the ridges of the upper surface. Others included a nest 6m inside the passage on the lower surface of the roof, a nest on the roof of a shed on the upper surface, a nest tucked under the edge of a section of roof and a nest in a corner between high walls. These nests were put into the above category that was most appropriate in terms of the environment of the nest. Due to the low number of pairs of Lesser Black-backed Gull nests in several cases, it was not meaningful to test statistically whether the distributions of the nests of the two species between the above types of nest site were similar. It is noticeable, however, that a much higher proportion of Lesser Black-backed Gulls nested at relatively open sites while none nested on skylights and few in the corner of ridge ends.

3.4.1.4 Nest density

The distance between nests varied from as little as 1m to one nest which was 34m from its nearest neighbour. The median distance (± IQR) between the nest of a Herring Gull and its nearest neighbour of either species was 5.00 m ± 2.75 (n = 247), whilst that for a Lesser Black-backed Gull nest was 6.50 m ± 2.75 (n = 21). These distances did not differ between species (Mann Whitney U test, U = 2019, P > 0.05). If, however, the median distance between a nest and its nearest neighbour of the same species is considered, the distance was significantly greater for Lesser Black-backed Gulls (10.00m ± 8.00) than for Herring Gulls (5.00m ± 2.50; U = 1402.5 P < 0.001), which is to be expected because a third of the nests of Lesser Black-backed Gulls were surrounded by Herring Gull nests. The density of the nests of both species within the whole of the studied area of the roof was 79 nests per ha, however, if only the main body of the colony was considered, the density was 116 nests per ha.

3.4.2 Breeding success

3.4.2.1 Initiation of laying

During the laying period, visits to the roof were made every 2 days; therefore eggs found on any particular visit could have been laid at any time in the previous 48 hours. The first Herring Gull eggs were found on 27 April and, because two eggs were already present in two clutches, it was estimated that these clutches could have been initiated as early as 24 April. The first Lesser Black-backed Gull eggs were observed on 9 May, and may have been laid that day or the day before, 8 May. The distributions of dates on which the first egg was found in nests of both species are shown in Figure 3.4 (HG: n = 237, LBBG: n = 19). The median date (± IQR) of clutch initiation was 11 May ± 4 days for Herring Gulls, whilst that of Lesser Black-backed Gulls (19 May ± 9 days) was significantly later (Mann Whitney U test, U = 850, P < 0.001).

3.4.2.2 Clutch Size

Clutch size was known for 245 pairs of Herring Gulls and 21 pairs of Lesser Black-backed Gulls. Clutches of 1,2,3 and 4 eggs were laid by Herring Gulls. In both cases where a fourth egg was laid the first egg was lost very soon after laying, in one case by falling from the nest which was on a slope and in the other by the parents continuing to build their nest after the start of laying so that the first egg became buried. The mean clutch size (± sd) for Herring Gulls was 2.81 ± 0.48. Only clutches of 2 or 3 eggs were laid by Lesser Black-backed Gulls, and the mean clutch size (± sd) was 2.71 ± 0.46 eggs. Due to the low numbers of Lesser Black-backed Gull clutches it was not meaningful to compare the clutch sizes of the two species statistically.

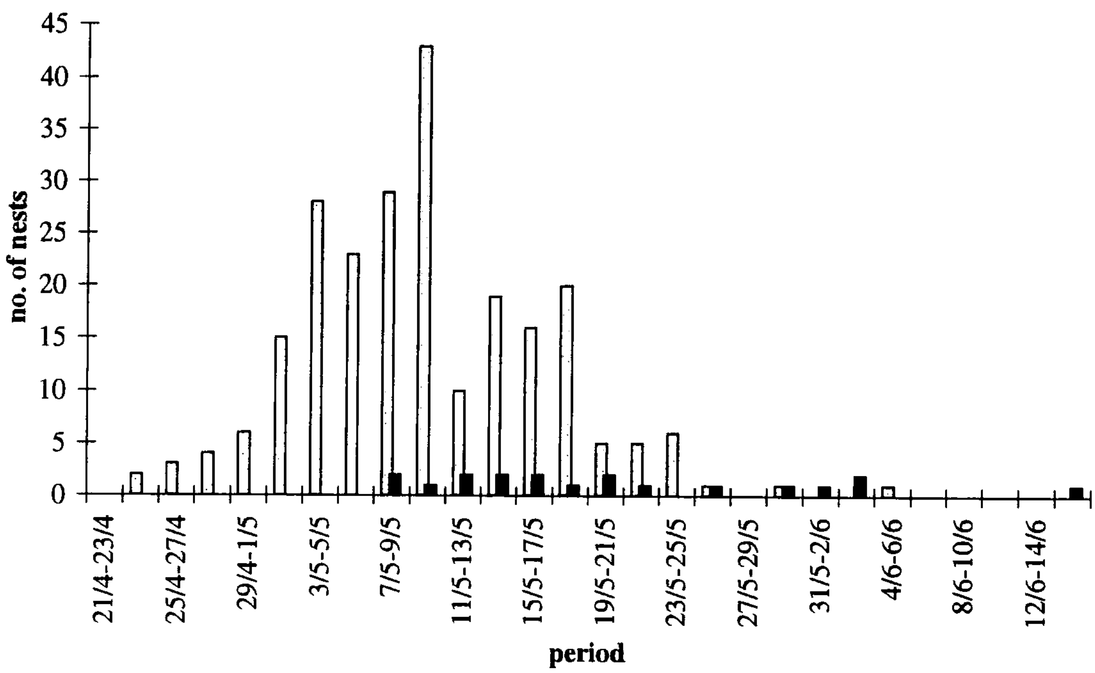


Figure 3.4: Distribution of dates of clutch initiation for Herring Gulls (light bars) and Lesser Black-backed Gulls (dark bars).

3.4.2.3 Egg volumes

Details of the volumes of the eggs of Herring Gulls and Lesser Black-backed Gulls are given in Table 3.2. A two-way ANOVA showed that for three egg clutches, egg volume varied significantly with respect to the position in the clutch and the species, with the eggs of Herring Gulls being larger than those of Lesser Black-backed Gulls (species, $F_{1,605} = 36.31$, $P < 0.001$, position, $F_{2,605} = 17.83$, $P < 0.001$). There were no interactions between these factors ($F_{2,605} = 0.30$, $P > 0.05$). In the case of two-egg clutches there was no effect of either species or position in the clutch on egg volume (species, $F_{1,67} = 0.66$, $P > 0.05$, position, $F_{1,67} = 1.40$, $P > 0.05$). There were no interactions between these factors ($F_{1,67} = 0.17$, $P > 0.05$).

One-way repeated measure ANOVAs, with univariate tests, were used to investigate further the variation in egg volume with position in the laying sequence of three egg clutches of both species. It was found that in the case of the Herring Gull, eggs from each position were significantly different in volume, whilst for Lesser Black-backed Gulls, c-eggs were found to be significantly smaller than either a- or b-eggs. Details of these differences are given in Table 3.3.

3.4.2.4 Hatching success

The fate of all eggs in a clutch was known for 236 Herring Gull nests, in which a total of 663 eggs was laid. Of these eggs, 496 (74.8%) hatched successfully. This was significantly higher than the proportion for Lesser Black-backed Gulls where only 45.6% (26/57) of the eggs in the 21 nests hatched successfully ($\chi^2 = 20.58$, d.f. = 1, $P < 0.001$). The mean number of eggs hatched per nest for these nests (± sd) was 2.10 ± 1.07 for Herring Gulls and 1.24 ± 1.26 for Lesser Black-backed Gulls. The fates of eggs from these nests are shown in Table 3.4. The lower hatching success of Lesser Black-backed Gull eggs is explained by the higher proportion of these eggs which were stolen or were addled (due to embryo death or a lack of fertilisation).

Table 3.2: Details of the volumes of eggs laid by Herring Gulls and Lesser Black-backed Gulls.

Species	Clutch Size	N	Order in laying sequence	Egg volume (mm^3 ± sd)
Herring Gull	c-1	8	a	74.05 ± 7.52
	c-2	29	a	74.86 ± 5.71
			b	71.49 ± 5.74
	c-3	189	a	79.03 ± 6.51
			b	77.59 ± 5.87
			c	70.66 ± 5.53
	c-4	2	a	76.36 ± 0.61
			b	75.25 ± 4.11
			c	74.16 ± 6.40
			d	67.10 ± 2.31
Lesser Black-backed Gull	c-2	5	a	72.27 ± 9.13
			b	70.63 ± 8.31
	c-3	13	a	71.44 ± 2.88
			b	71.40 ± 3.97
			c	66.76 ± 6.08

Table 3.3: Details of within-clutch differences in egg volumes for Herring Gulls and Lesser Black-backed Gulls.

Species	Clutch size	N	Egg comparison	Percentage difference in egg volume	Significance
Herring Gull	c-2	29	a-b	4.50%	
	c-3	189	a-b	1.82%*	$F_{2,187} = 460.3, P < 0.001$
			a-c	10.59%*	
			b-c	8.93%*	
Lesser Black-backed Gull	c-2	5	a-b	2.27%	
	c-3	13	a-b	0.06%	$F_{2,11} = 7.58, P < 0.01$
			a-c	6.55%*	
			b-c	6.50%*	

* = comparisons which are significantly different, results of univariate tests

Table 3.4: Fate of the eggs of Herring Gulls (n = 663) and Lesser Black-backed Gulls (n = 57).

	Herring Gull		Lesser Black-backed Gull	
Fate of egg	No. of eggs	% of eggs	No. of eggs	% of eggs
hatched successfully	496	74.8	26	45.6
stolen	39	5.9	11	19.3
did not hatch -				
addled	114	17.2	19	33.3
chick died hatching	7	1.1	1	1.8
cracked as laid	4	0.6	0	-
buried in nest	2	0.3	0	-
fell from nest	1	0.2	0	-

3.4.2.5 Survival to fledging

The maximum possible number of chicks fledged from the roof can be calculated as the number of chicks hatched in the 229 nests for which chicks were followed minus the number of these chicks which were found dead on the roof. 69 Herring Gull chicks and 3 Lesser Black-backed Gull chicks from these nests were found dead, resulting in estimates of 85.6% (410/479) and 88.5% (23/26) respectively of the chicks which hatched surviving to fledge. However, these are likely not to be good estimates for several reasons. Firstly, as the chicks grew older they were increasingly difficult to locate, meaning that on any visit many of the older chicks that were in fact alive were not caught and identified. This problem has been encountered in several studies (Paynter 1949, Paludan 1951, Brown 1967). Secondly, the presence of drainage holes in the roof into which small chicks could fall, or into which the bodies of small chicks which had died for another reason could be washed, provided an unmeasurable source of mortality. Thirdly, it is possible that chicks were eaten by adult gulls.

The causes of the deaths of these chicks are given in Table 3.5. Symptoms of botulism were exhibited by 25% of the Herring Gull chicks found dead (4% of those hatched) and this disease may also have been the cause of the death of some of the younger chicks in which the symptoms would not be so evident (see section 3.4.3). No Lesser Black-backed Gull chicks showed symptoms of botulism. The ages of Herring Gull chicks found dead exhibiting symptoms of botulism are illustrated in Figure 3.5. It is apparent that these symptoms were not found in very young chicks.

Table 3.5: Causes of death of chicks found dead in study area from 229 Herring Gull nests and 21 Lesser Black-backed Gull nests.

	Herring Gull		Lesser Black-backed Gull	
Cause of death	No. of chicks	% of those found dead	No. of chicks	% of those found dead
Unknown	31	44.9	2	66.7
Botulism	17	24.6	0	-
Adults	15	21.7	1	33.3
Shut in shed	2	2.9	0	-
Observers	2	2.9	0	-
Drowned	1	1.5	0	-
Stuck in crack	1	1.5	0	-
Total	69		3	

The other main identifiable reason for chick mortality was as a result of attacks by adult gulls: 22% of Herring Gull chicks (3% of those hatched) and one of the three Lesser Black-backed Gull chicks (4% of those hatched) were found with head injuries characteristic of this behaviour. In most cases, the cause of death was unclear, with the chicks found dead either in or near their nest. Potential reasons for these deaths include illness, starvation, exposure to rain or sun, or attacks from adults not resulting in visible injuries.

If it is assumed that above the age of 20 days it is not possible for chicks to fall, or their bodies to be washed, down the drainage holes or be eaten whole by adult gulls, then all chicks dying above this age should have been found. Parsons (1971b) found that the mean age of chicks taken by cannibals was 6.7 days so it is unlikely that chicks that had reached the age of 20 days were taken by such birds. Therefore all chicks surviving to

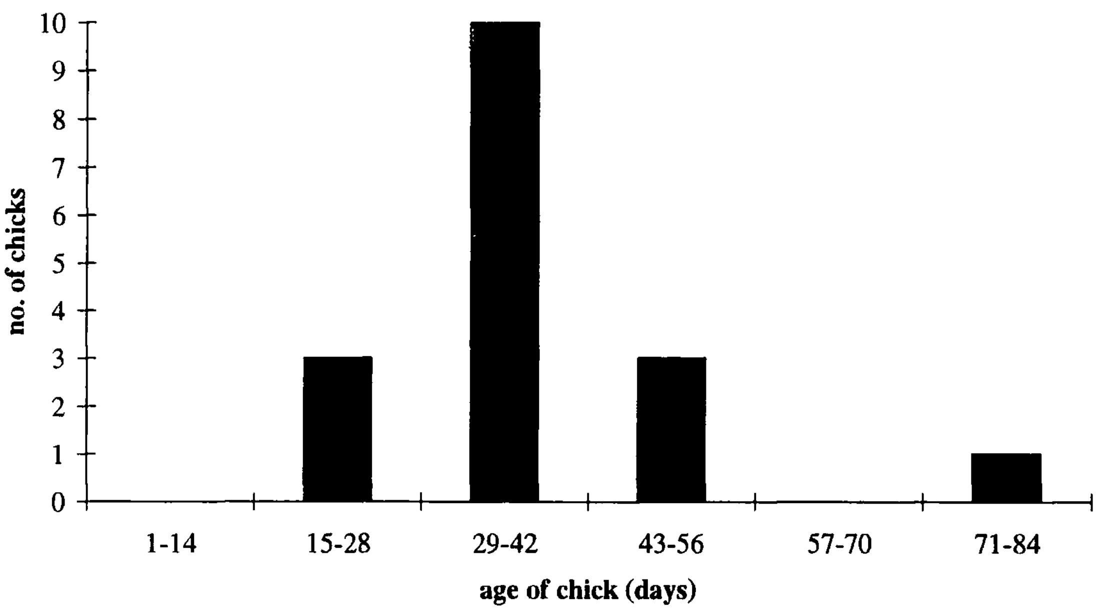


Figure 3.5: Ages of chicks found dead exhibiting symptoms of botulism.

the age of 20 days, and not found dead after this age, can be presumed to have fledged successfully. Of the chicks that hatched in the 229 nests studied, 353 Herring Gulls and 13 Lesser Black-backed Gulls survived to 20 days. After this age, 22 Herring Gull chicks but no Lesser Black-backed Gulls were found dead. These figures suggest that 69.1% (331/479) of Herring Gull chicks and 50.0% (13/26) of Lesser Black-backed Gull chicks survived to fledge. These proportions for the two species are not significantly different ($\chi^2 = 3.31$, d.f. = 1, $P > 0.05$). These figures represent mean fledging successes (± sd) of 1.45 ± 1.06 chicks per nest for Herring Gulls and 0.62 ± 0.92 chicks per nest for Lesser Black-backed Gulls. The value for Lesser Black-backed Gulls is significantly lower than that for Herring Gulls ($\chi^2 = 14.88$, d.f. = 3, $P < 0.01$).

In order to provide an independent estimate of fledging success, the results of counts carried out of the total number of chicks in the colony were used (Table 3.6). It can be seen that from 31 July, the number of chicks seen in the colony declined. In addition, young birds began to be seen in increasing numbers away from the colony, loafing by a nearby pool. For this reason, only the counts from 18 July and 24 July were used to estimate fledging success. Extrapolating from the distribution of the dates of clutch initiation, using values of 30 days for the incubation period and 35 days for the fledging period (Cramp & Simmons 1983), by the dates of these two counts, 69% and 92% of Herring Gull and Lesser Black-backed Gull chicks should have fledged.

Table 3.6: Details of counts of chicks (Herring and Lesser Black-backed Gull) seen in the study area late in the breeding season of 1995.

Date of count	No. of chicks counted
18 July	333
24 July	326
31 July	275
5 August	163
11 August	129
17 August	9

In order to use these data to estimate the fledging success of Herring Gulls, the number of birds which died after each count date and the number of chicks that were probably Lesser Black-backed Gulls were deducted. This led to similar estimates of 315 and 309 chicks for the number of Herring Gull chicks which survived to fledge from the roof. If the lower estimate is used, 60.7% of the 509 Herring Gull chicks which hatched on the roof survived to fledge. This proportion represents an estimate of 1.25 chicks fledged per nest from the 247 Herring Gull nests present on the roof. During each count some chicks would have been hidden from view behind skylights and also undoubtedly some chicks had left the roof by the time of these counts; this value is therefore an underestimate. This suggests that the figure of 1.45 Herring Gull chicks fledged per nest is probably an acceptable estimate of the fledging success.

3.4.3 Adult mortality due to botulism

In total, 26 adult birds and 3 sub-adults were found dead in the study area, although it is not known whether or not these adults were breeding there. The symptoms of the paralytic disease botulism were shown by 28 of these birds (Table 3.7).

Table 3.7: Details of the species and age of birds found dead in the study area exhibiting symptoms of botulism.

Species	Age	No. of dead birds showing symptoms of botulism
Herring Gull	2nd summer	2
	3rd summer	1
	adult	23
Lesser Black-backed Gull	adult	2

Assuming that all the dead adult birds found in the colony were breeding there, botulism was responsible for the deaths of 5% of both the Herring Gulls and the Lesser Black-backed Gulls nesting at this site. These proportions are minimum values because birds may have died away from the colony. The period in which individuals died is known for

22 of the 28 adult birds and for all of the 20 chicks; this is illustrated in Figure 3.6. It can be seen that the peak in the number of both chicks and adult birds dying from botulism was during July.

3.4.4 Factors potentially influencing breeding success

The effects of several aspects of the roof environment of the colony on breeding success were investigated for the Herring Gull. In most cases the number of nests of Lesser Black-backed Gulls was too low to investigate further, however, the relative success of birds nesting in the group of conspecifics was compared with those nesting amongst the Herring Gulls.

3.4.4.1 Nest density

The effect of nesting density on breeding success was compared by classifying nests into five groups, according to the distance to the nearest neighbouring nest (0-2.0m, 2.5-4.5m, 5.0-7.0m. 7.5-9.5m, 10m+), and comparing the fledging success of these groups of nests (Table 3.8). It was found that there were no significant differences in the fledging success of nests at differing distances from their nearest neighbour of either species or of the same species (any sp. - $\chi^2 = 16.98$, d.f. = 12, $P > 0.05$, same sp. - $\chi^2 = 18.45$, d.f. = 12, $P > 0.05$).

Table 3.8: Details of fledging success of Herring Gulls at nests at varying distances from the nearest nest of either or the same species.

	Nest of either species		Nest of the same species	
Distance to nearest nest (m)	No. of chicks per nest	N	No. of chicks per nest	N
0 - 2.0	1.44 ± 0.94	55	1.46 ± 0.93	54
2.5 - 4.5	1.44 ± 1.19	54	1.42 ± 1.20	55
5.0 - 7.0	1.55 ± 1.00	62	1.57 ± 1.00	60
7.5 - 9.5	1.22 ± 1.11	41	1.25 ± 1.10	40
10+	1.65 ± 1.06	17	1.50 ± 1.10	20

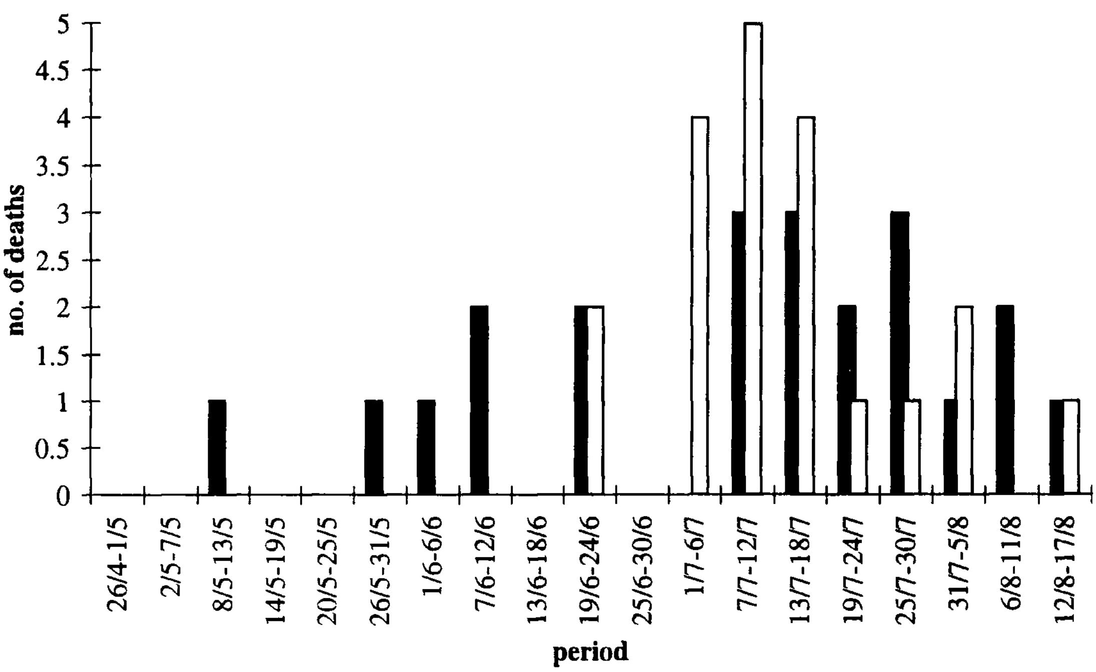


Figure 3.6: Distribution of the dates of deaths thought to be due to botulism during the breeding season. Dark bars indicate adult birds (both Herring Gulls and Lesser Black-backed Gulls), light bars indicate chicks.

3.4.4.2 Nest site type

In order to investigate whether or not nest site type influences breeding success, the nest site types described in section 3.4.1.3 were grouped into two main categories according to the degree of protection provided for chicks. Group 1 consisted of types 4 and 5, both of which had a high degree of shelter from the corners of ridges, vegetation and the covers of skylights. The nests in group 2 (types 1, 2 and 3) had less protection for chicks around them. Group 3 was included in this category because, despite frequently having the shelter of an air vent on the skylight, such nests were above the level of the main surface of the roof and there was very limited space around the nest which was often built on sloping corrugated iron or perspex. When the fledging success of Herring Gulls nesting at these two groups of nests was compared (using the proportion of nests where no chicks, one chick or two or three chicks fledged) it was found to be higher at group 1 nests (1.72 ± 1.06 chicks per nest, n = 104) than at group 2 nests (1.12 ± 0.96 chicks per nest, n = 125; $\chi^2 = 20.14$, d.f. = 2, $P < 0.001$).

Breeding success at these two groups of nests (group 1 - n = 104; group 2 - n = 125) was investigated further to determine the possible cause of the variation in fledging success with nest site type. There was no difference in the median nearest neighbour distance of nests at the two types of site, either to the nearest neighbour of any species (Mann Whitney U = 6668, $P > 0.05$) or of the same species (U = 6724.4, $P > 0.05$). There was also no difference in the median laydate of birds nesting at the two types of site (U = 6961, $P > 0.05$), or in the clutch sizes ($\chi^2 = 0.07$, d.f. = 1, $P > 0.05$). When egg volumes from the two types of nest site were investigated it was found that while the position of the egg in the clutch influenced egg volume, nest site type had no effect (2-way ANOVAs, c-3, nest type, $F_{1,566} = 0.11$, $P > 0.05$, position in clutch, $F_{2,566} = 105.11$, $P < 0.01$; c-2, nest type, $F_{1,57} = 0.27$, $P > 0.05$, position in clutch, $F_{1,57} = 4.83$, $P < 0.05$). There were no interactions between either of these factors in either case (c-3, $F_{2,566} = 0.04$, $P > 0.05$; c-2, $F_{1,57} = 9.96$, $P > 0.05$).

Differences were found, however, in hatching success at the different nest site types. The proportion of eggs hatching successfully was significantly higher for birds nesting at sheltered group 1 sites than the more exposed group 2 sites ($\chi^2 = 12.47$, d.f. = 1, $P < 0.001$). There was also a significant difference in the proportion of chicks which survived to fledge ($\chi^2 = 13.5$, d.f. = 1, $P < 0.001$), with success being greater at group 1 nest sites. Therefore, increased hatching success and chick survival probably led to the greater fledging success found at the more sheltered group 1 nest site types.

3.4.4.3 Elevation

In order to investigate whether there was a difference between the fledging success of birds nesting on the two levels of the roof, a sample of nests from each level containing equal proportions of the two main nest site types was compared (lower - n = 117, upper - n = 39). No significant difference in fledging success was found between the two levels of the roof ($\chi^2 = 6.11$, d.f. = 3, $P > 0.05$).

3.4.4.4 Grouped and dispersed nesting

In the case of the Lesser Black-backed Gull, the importance of position in the colony was investigated by comparing the breeding success of birds breeding in the group of this species in the north-eastern corner of the roof with those dispersed amongst the Herring Gulls. No significant difference was found between these two groups in the proportion of nests at which no chick survived to fledge and those where one or more chick did so (Fisher's Exact test, P = 0.25).

3.5 Discussion

During the breeding season of 1995, 247 pairs of Herring Gulls and 21 pairs of Lesser Black-backed Gulls nested on the roof of the Melinar Stores at ICI Wilton in north-east England. The birds nested predominantly on the ridged area of the roof where many structures such as skylights and air vents were present. The majority of nests of both species were placed against a structure of some kind, behaviour which has also been seen in other roof-nesting gull studies (Vermeer *et al.* 1988, Belant 1993, Vincent 1994) as well as studies of more traditionally situated colonies (Haycock & Threlfall 1975). Most of the Lesser Black-backed Gull nests were grouped in one corner of the roof, however, about one third built nests among the Herring Gulls. MacRoberts & MacRoberts (1972) found that by the time Lesser Black-backed Gulls arrived at their study colony, Herring Gulls had already established territories. Most of the Lesser Black-backed Gulls then built nests in areas without Herring Gulls, but some nested amongst them, as seen in this study.

Five main types of nest sites were utilised by the gulls nesting on the roof of the Melinar Stores. It appeared that the proportions of nests at the different types of site may have differed for the two species, with Herring Gulls tending to nest more on the ridges and skylights while Lesser Black-backed Gulls nested more in the dips of the roof. A tendency for Lesser Black-backed Gulls to nest on flatter sites than Herring Gulls was also noticed by Mudge (1978) in his study of roof-nesting gulls and has been seen at traditional colonies (Harris 1964b, Brouwer & Spaans 1994).

In the present study, the median distance to the nearest nest of either species was similar for both species (5m and 6.5m), corresponding to a density in the main body of the colony of 116 nests per ha. This compares with values ranging from 2.08m to 5.5m at more traditional colonies (Burger & Shisler 1980, Belant 1993, Chaussabel 1995). At the colony where internest distance was 2.08m, nesting density was found to be 710 pairs per ha (Belant 1993). Spaans *et al.* (1987) found a nesting density of 30.5 nests per ha at the colony they studied, which rose to 96.7 nests per ha some years later after a large increase in breeding numbers. Parsons (1971a) and Worrall (1987) recorded extremely high nest densities of 600-1,100 nests per ha and 15,000 nests per ha respectively.

Nearest neighbour distances recorded in rooftop colonies vary from 5.1m to 16m (Belant 1993, Chaussabel 1995), the former corresponding to a density of 135 nests per ha (Belant 1993). In both of these cases, and also in a study of roof-nesting Glaucous-winged Gulls (Vermeer *et al.* 1988), these values were lower than that found at nearby traditional colonies. Monaghan (1979) found that in the urban colonies she studied nest density was generally 1 - 2 nests in a 4.6m radius, lower than the density found by Parsons (1971a) on the Isle of May. Densities higher than this were found only on flat roofs which supported several nest sites (Monaghan 1979). The nesting density found at ICI Wilton appears to be lower than that found at many traditional colonies. When compared to other large roof-nesting colonies, nest density appears to be similar to that found on a large roof by Belant (1993) but less than that found by Monaghan (1979), whose results corresponded to a nest density of 200-300 nests per ha. It was, however, higher than that found by Chaussabel (1995) for a dispersed urban colony.

As found in other studies of colonies where both Herring Gulls and Lesser Black-backed Gulls nest (Paludan 1951, Harris 1964b, MacRoberts & MacRoberts 1972, Mudge 1978), on the roof of the Melinar Stores Lesser Black-backed Gulls began laying eggs later than Herring Gulls. The median dates of clutch initiation for the two species were 18/19 May and 10/11 May respectively. In comparison to the dates found in studies of more traditional British Herring Gull colonies, the onset of laying at Wilton in 1995 was a little later than that found in other years for colonies in Wales (29 April - 6 May; Harris 1964b, Mudge 1978, Chaussabel 1995) but slightly earlier than that found for colonies in Scotland (16 May - 18 May; Parsons 1971a). The onset of laying of Lesser Black-backed Gulls at Wilton was during the same period as that recorded in studies carried out in Wales (16 May - 23 May; Harris 1964b, Davis & Dunn 1976). When British roof-top colonies are considered, it is found that the Wilton Herring and Lesser Black-backed Gulls began nesting a little later than roof-nesting birds in Wales (Herring Gulls - 4 May-7 May; Mudge 1978, Chaussabel 1995; Lesser Black-backed Gulls - 15 May; Mudge 1978).

Several studies of roof-nesting gulls comparing their clutch initiation dates with those of nearby local colonies of the same species have found that rooftop nesting gulls laid later (Mudge 1978, Belant 1993, Chaussabel 1995), although Vermeer *et al.* (1988) found no difference. It appears that the laying dates of the gulls nesting on the roof of the Melinar Stores fit in to the regional pattern of laying in Britain, initiating laying after colonies to the south but before a colony to the north. As there was no traditional colony near the ICI Wilton site, it was not possible to establish whether birds at a such a colony would lay earlier than roof-nesting birds. No detailed studies of breeding biology at traditional colonies in north-east England are available in the literature for comparison.

The clutch sizes of the two species nesting on the roof of the Melinar Stores appeared not to differ greatly; 2.81 eggs per nest for Herring Gulls and 2.71 eggs per nest for Lesser Black-backed Gulls. The clutch size of Herring Gulls nesting at traditional colonies has been found to range from 2.30 to 2.95 eggs per nest (Paludan 1951, Harris 1964b, Brown 1967, Kadlec & Drury 1968, Parsons 1971a, Hunt 1972, Haycock & Threlfall 1975, Burger & Shisler 1980, Coulson *et al.* 1982, Spaans *et al.* 1987, Pons 1992, Belant 1993, Vincent 1994, Chaussabel 1995). Clutch sizes recorded in studies of roof-nesting Herring Gulls, including the present study, fit into this range (2.39 - 2.89;

Mudge 1978, Belant 1993, Vincent 1994, Chaussabel 1995).

In the case of Lesser Black-backed Gulls, clutch sizes at traditional colonies range from 2.44 to 2.80 (Paludan 1951, Harris 1964b, Brown 1967, Davis & Dunn 1976). The clutch size of the birds nesting at ICI Wilton was within this range although the only other study of roof-nesting Lesser Black-backed Gulls in Britain found the clutch size to be rather lower, at 2.32 eggs per nest (Mudge 1978). Clutches in that colony, however, were subjected to egg collection. Most studies have found similar clutch sizes in rooftop and traditional colonies (Vermeer *et al.* 1988, Belant 1993, Chaussabel 1995) and the results of the present study support this.

It is difficult to compare egg volumes in this study with those in the literature because of possible variation in the measurements made by different observers. Two of the three studies which have compared egg volumes between rooftop colonies and nearby traditionally situated colonies found that eggs from rooftop colonies were significantly larger (Belant 1993, Vincent 1994). However, Chaussabel (1995) found there to be no difference in volume between the two types of colony. Belant (1993) suggested that the larger egg volume of rooftop birds was due to later initiation of laying, with the consequence that females had more time to build up reserves and could therefore lay larger eggs.

In the present study, there was significant variation in the volumes of eggs within clutches of both Herring Gulls and Lesser Black-backed Gulls. This variation was more extreme in the case of the Herring Gulls with c-eggs being 11% smaller than a-eggs and 9% smaller than b-eggs. B-eggs were 2% smaller than a-eggs. In two egg clutches, b-eggs were 5% smaller than a-eggs. In the case of Lesser Black-backed Gulls, within-clutch variation in egg volume was seen only in three egg clutches where although a-eggs and b-eggs had similar volumes, c-eggs were 7% smaller than both.

Such variation has been observed to differing extents in many studies of large gulls, although it has not been investigated in other studies of rooftop colonies. The usual finding is that c-eggs are significantly smaller in volume than a- or b-eggs, which are similar in volume (Paludan 1951, Harris 1964b, Parsons 1971a, Davis 1975, Haycock & Threlfall 1975, Spaans & Spaans 1975, Kilpi 1996). The scale of the difference between c-eggs and a-eggs has been found to range from 4.5% (Kilpi 1996) to 10 - 12% (Paludan

1951, Harris 1964b, Parsons 1971a, Davis 1975). In the case of the Lesser Black-backed Gull the c-egg has been found to be 6 - 9% smaller than the a- and b-eggs (Paludan 1951, Harris 1964b). The results from the present study suggest that the within clutch variation in egg size was high for both species, but similar to that found in several studies of traditional colonies.

In the present study, the hatching success of Herring Gull eggs (75%) was considerably higher than that of Lesser Black-backed Gull eggs (46%). A higher proportion of the eggs of the latter species were either stolen or addled. The hatching success of Herring Gulls in this study was similar to the figures found in most studies of Herring Gulls at traditional colonies, which range from 62% to 80% (Paynter 1949, Harris 1964b, Brown 1967, Parsons 1971a, Haycock & Threlfall 1975, Burger & Shisler 1980, Spaans *et al.* 1987, Pons 1992, Belant 1993, Chaussabel 1995). Paludan (1951), in two years of his study, found hatching success to be 56% and 90%, the low success in one year being due to heavy gales washing away many nests. Most of the values for hatching success of roof-nesting Herring Gulls, including the present study, also fit into this range (66% - 76%; Belant 1993, Vincent 1994, Chaussabel 1995), and both of the studies which have compared a roof-nesting site with a nearby traditional site have found the hatching success at each to be similar (Belant 1993, Chaussabel 1995). The only exception was the study by Mudge (1978) which found hatching success to be only 49% due to extensive egg-collecting on the roofs of Cardiff.

In the case of Lesser Black-backed Gulls, hatching success at traditional colonies has been found to range from 59% to 72% (Paludan 1951, Harris 1964b, Brown 1967, Davis & Dunn 1976), higher than that found in the present study. The only other study of roof-nesting Lesser Black-backed Gulls also found low hatching success (40%) due, as in the case of Herring Gulls at that site, to egg collecting (Mudge 1978).

Several other studies of mixed Herring Gull and Lesser Black-backed Gull colonies have been carried out. Both Harris (1964b) and Mudge (1978) found that the hatching successes of the two species were similar. The main reason for egg loss in colonies of both species is the stealing of eggs by other gulls (Harris 1964b, Brown 1967, Davis & Dunn 1976). Paludan (1951) found Herring Gulls to have higher hatching success than Lesser Black-backed Gulls, the reason suggested being that they stole large numbers of the eggs of the latter species. Brown (1967) however, found that as a higher proportion of Herring Gull eggs failed to hatch, Lesser Black-backed Gulls had higher hatching success. It is likely that in the present study the greater numbers of Herring Gulls present in the colony stole a large proportion of the eggs of Lesser Black-backed Gulls. The reason for the higher proportion of Lesser Black-backed Gull eggs which were addled is not known. Hatching success can be influenced by human disturbance (Hunt 1972), but in this study the level of disturbance was the same for both species.

The proportion of chicks which survived to fledge in this study was similar for both species; 69% for Herring Gulls and 50% for Lesser Black-backed Gulls. However, the difference in hatching success led to the fledging success of the former species (1.45 chicks per nest) being significantly higher than the latter (0.62 chicks per nest). In most traditional colonies studied, fledging success has been found to vary from 0.7 - 1.44 chicks per nest (Kadlec & Drury 1968, Parsons 1971a, Haycock & Threlfall 1975, Burger & Shisler 1980, Pons 1992). Figures lower than this include 0.5 chicks per pair (Pons 1992) after a large drop in the availability of a food source used by many breeding birds. A drop in fledging success (1.35 chicks per pair to 0.39 chicks per pair) was also observed by Spaans *et al.* (1987) after a large increase in the number of breeding birds and consequently the density of the colony; increased predation by conspecifics was believed to be the reason for this change.

The proportion of Herring Gull chicks hatched which survived to fledge in several traditional colonies ranged from 52% to 67% (Paynter 1949, Brown 1967, Spaans *et al.* 1987). After the increase in breeding numbers and nest density described above, this proportion dropped to 23% in the study by Spaans *et al.* (1987). Chaussabel (1995) found that an estimated 64% of chicks hatched survived to the age of 2 weeks.

If studies of roof-nesting gulls are considered, fledging success has been found to vary from as high as 1.2 - 1.6 chicks per nest (Monaghan 1979) or even two chicks per nest (Chaussabel 1995), to only 0.55 chicks per nest (Mudge 1978). The proportion of chicks which fledged successfully varied from 47% (Mudge 1978) to an estimate by Chaussabel (1995) that on roofs 95% of the chicks hatched survived to the age of 2 weeks. Monaghan (1979) found that fledging success was lowered if there was human disturbance to a roof or if several pairs nested together on a flat roof. Both Monaghan (1979) and Chaussabel (1995) found that fledging success was higher for rooftop Herring Gull colonies when compared to traditional colonies, but Mudge (1978) found that the two types of colony had similar low reproductive success.

In the case of traditional Lesser Black-backed Gull colonies, the proportion of chicks which fledged successfully was 50% in the study by Harris (1964b) and 43% and 69% in two years of a study by Davis & Dunn (1976). Brown (1967) found that 56% of chicks hatched survived to the age of 10 days. Between 1989 and 1995, fledging success of this species varied between 0.02 and 0.45 chicks per pair on the island of Skomer and 0.54 and 0.81 chicks per pair on the Isle of May (Walsh *et al.* 1993, Walsh *et al.* 1995, Thompson *et al.* 1996). At a moorland colony at Abbeystead, Lancashire, fledging success was found to be 1.5 chicks per pair (O'Connell *et al.* 1997). Only one other study has been carried out on roof-nesting Lesser Black-backed Gulls to date. Mudge (1978) found that 62% of the chicks hatched fledged successfully, but fledging success was still low (0.58 chicks per pair) due to low clutch size and hatching success.

It appears that the fledging success of the Herring Gulls nesting on the roof of the Melinar Stores was as high as the most successful colonies at traditional sites. However, it was a little lower than at colonies in which the gulls nested on dispersed roofs. The Lesser Black-backed Gull was less successful, mainly due to lower hatching success, but its fledging success was similar to that at many traditional colonies and also to that in the other study carried out on roof-nesting birds of this species. Such a situation, with Herring Gulls being more successful than Lesser Black-backed Gulls at a mixed colony has also been seen on Isle of May, probably the nearest studied colony to Wilton, from 1989 to at least 1995 (Walsh *et al.* 1995, Thompson *et al.* 1996). The reason for this difference is unknown.

These results suggest that, at least for Herring Gulls, the roof of the Melinar Stores at ICI Wilton is a successful site for nesting. There are several potential explanations for this. An important cause of chick mortality in many colonies is the killing of chicks by adult gulls (Harris 1964b, Brown 1967, Davis & Dunn 1976). This is either the result of territorial aggression when chicks wander into the territories of other gulls, in which case the chicks are rarely eaten, or cannibalism, deliberate predation by adults which specialise in feeding on gull chicks (Parsons 1971b). In the present study there was no evidence for cannibalism occurring within the colony, although it is possible that gulls from nearby colonies may have taken chicks. Chicks were, however, found dead with injuries characteristic of territorial attacks by adults. In his study on the Isle of May, Parsons

(1971b) found that, on average, there was one cannibal for every 250 pairs of gulls. In a colony of about 250 pairs, such as that at Wilton, there may not be enough chicks available to support such a feeding specialisation.

It has been suggested that the low nest density often found in roof-nesting gull colonies reduces the loss of chicks due to aggressive attacks from neighbouring birds (Monaghan 1979, Chaussabel 1995). High nesting density can be associated with high levels of both egg predation (Brouwer & Spaans 1994) and chick mortality (Parsons 1971a, Hunt & Hunt 1975). As nesting density in the present study was low when compared with some traditional colonies it is possible that this contributed to the low chick mortality observed.

The degree of shelter around a nest can affect the survival of chicks. Several studies have found that birds nesting in open areas have lower reproductive success than those nesting at a site with some shelter (Brown 1967, Burger & Shisler 1980, Parsons & Chao 1983, Belant 1993). This shelter can reduce predation on eggs and chicks and also protect them from heavy rain or strong heat. Too much cover around the nest appears to be disadvantageous, possibly providing cover for predators and impeding the escape of adult birds from the nest (Davis & Dunn 1976, Brouwer & Spaans 1994).

In several studies of roof-nesting gulls a high proportion of nests have been found next to structures (Vermeer *et al.* 1988, Belant 1993) and this was also noted in the present study. It was also found that Herring Gulls nesting at sites with more shelter had higher fledging success than those at more open sites due to higher hatching success and chick survival. At the site studied there were a large number of structures on the roof and so many nests were located near shelter. This may have benefited chick survival.

Hunt & McLoon (1975) found that chicks wander further from their nest when they are hungry, so making them more vulnerable to neighbouring adults. It has been found, in both traditional colonies (Hunt 1972) and rooftop colonies (Chaussabel 1995) that chick survival is higher in colonies nearer sources of food. The present study colony is located near many potential sources of food (Chapter 4) and this may also increase the breeding success of the gulls nesting there.

Several types of predator have been recorded as taking the chicks of large gulls (Harris 1964b, Brown 1967). Those potentially present in the vicinity of the study colony include Carrion Crow *Corvus corone*, Grey Heron *Ardea cinerea*, Fox, Hedgehog *Erinaceus europaeus* and Brown Rat *Rattus norvegicus*. Of the above ground predators, the only one which could have possibly gained access to the colonies was the Brown Rat. Feral cats *Felis domestica* were seen frequenting the buildings, however, neither of these species were observed in the colony and no evidence was found that chicks might have been killed by them. It is possible that such predators were responsible for the deaths of chicks that disappeared when young. However, none of the chicks nearest the derelict building, through which such predators would have to come to reach the roof, disappeared which suggests that ground predators were not an important cause of mortality. Predatory birds were never seen at the colony and it is also unlikely that they caused significant chick mortality.

There were, however, detrimental factors associated with the study colony. The paralytic disease botulism was the probable explanation for many of the deaths of both chicks and adults. Although in several cases it has been proven to be the cause of adult mortality during the breeding season (Lloyd *et al.* 1976, Mudge & Ferns 1982b, Sutcliffe 1986, Worrall 1987), mortality of chicks due to botulism has not been described in detail before although Worrall (1987) noted that it did occur in chicks. The disease was probably responsible for the deaths of 5% of the breeding adults of both species on the roof of the Melinar Stores, less than the mortality described by Worrall (1987) for Flat Holm where in the years 1983-85 between 14% and 28% of breeding adult Herring Gulls and between 6% and 10% of breeding adult Lesser Black-backed Gulls died of botulism. In his study, most deaths were found, as in this study, in the months of July and August. A positive correlation was found between mean monthly maximum temperature and number of corpses found.

It is possible that young chicks were not fed food which contained the botulinum toxin, although the most obvious symptoms of the disease (for example, the outstretched wings) may not be evident in a very young chick. It is also possible that chicks becoming increasingly paralysed could have fallen down drainage holes, their deaths therefore going unrecorded. It is therefore probable that the proportion of chicks estimated to have died from botulism is an underestimate and it may be that chicks also died indirectly due to the disease if one or both of their parents died. Several chicks which had reached the age at which they would normally be considered to have fledged were found dead in the colony, exhibiting the symptoms of botulism.

The source of the botulism intoxication is not known. Feeding at tips has often been implicated as a source (Quinn & Crinion 1984, Sutcliffe 1986, Worrall 1987, Lloyd *et al.* 1991) and is the most likely source of the intoxication described in the present study because Herring Gulls at this colony were found to feed extensively at these sites (Chapter 4). Ortiz & Smith (1994) found Type C botulism spores in a high proportion of the tips they studied but none in rubbish prior to tipping. They suggested that the gulls themselves and other scavenging species transferred the bacteria between feeding sites. Botulism can be transferred when a bird feeds on the corpse of another bird which has died from botulism (Rosen 1971). In the present study this is unlikely to have occurred because, at least within the study area, birds were never observed to eat the bodies of adults or chicks which had died from botulism, an observation also noted by Worrall (1987).

Human disturbance can be an important factor in determining breeding success at gull colonies (Kadlec & Drury 1968). In the present study no visits to the roof of the building were allowed without a permit. In addition to my visits, repair work was carried out along one edge of the roof in August and on two occasions during the incubation period people were observed walking through the colony. These visits were not observed to have a detrimental effect upon the gulls, although my frequent presence in the colony may have led to a slight increase in egg and chick predation. However, due to the high ridges and skylights throughout the colony, my presence usually disturbed only the gulls in my immediate vicinity and the disturbance was always short-lasting.

In conclusion, the roof of the Melinar Stores at ICI Wilton, Teesside appears to have many features advantageous to nesting gulls; reasonably low nest density, shelter for chicks and few predators. The proximity to urban sources of food, especially rubbish tips, may allow parents to spend more time at their nest but also is probably the source of intoxication with botulism that caused the death of both adults and chicks.

Although the breeding success of the gulls nesting at this site was a little lower than that recorded for birds nesting at more dispersed rooftop sites, such as those provided by residential and commercial buildings, it still compared favourably with many traditional colonies. It is possible, however, that if in the future the number of gulls nesting at this site rises, increased nest density and competition for nest sites may have a detrimental effect upon breeding success. In the present study there were areas of the roof on which there were no nesting birds so it seems likely that numbers will have to increase considerably before these factors become a problem.

Chapter 4

The diet of Herring Gulls nesting on a large warehouse

4.1 Introduction

During the 20th century, increasing quantities of food originating from the activities of humans have become available to gulls (Furness & Monaghan 1987). Such food includes domestic waste, from rubbish tips and the streets of urban areas, and fish waste. The latter results from the discarding of bycatch, fish of unmarketable species or of too small a size, and offal from fishing vessels (Camphuysen *et al.* 1995) and the loss and discarding of material at fish docks. The increasing availability of such food is one of the factors to which the large rise in the numbers of the Herring Gull and other *Larus* gulls this century has been attributed (Lloyd *et al.* 1991). As an adaptable feeder on a wide range of foods, the Herring Gull is well-suited to exploiting new and diverse potential food sources. During the breeding season, an increased availability of waste foods has been suggested to raise reproductive success (Spaans 1971, Hunt 1972, Davis 1974) and may also, outside the breeding season, increase the survival of juveniles and adult birds (Harris 1970, Davis 1974, Mudge & Ferns 1982a, Pierotti & Annett 1987).

Studies have shown that the diet of the Herring Gull during the breeding season is diverse and varies from colony to colony. Marine invertebrates from the shoreline dominated the diet of adult birds on the Dutch Wadden Sea islands (Spaans 1971, Noordhuis & Spaans 1992) and the Clyde area, Rhum and the Shetland Islands of Scotland (Furness *et al.* 1992). They were also important in the diet of birds nesting in Denmark (Spärck 1951), on Walney Island, England (Sibly & McCleery 1983a), in Le Havre, France (Vincent 1994) and in Bangor, Wales (Chaussabel 1995).

Herring Gulls nesting by an inland lake in southern Sweden were found to feed primarily on freshwater fish (Andersson 1970), as were those breeding by the Great Lakes of North America (Mendall 1939, Fox *et al.* 1990, Belant *et al.* 1993). Marine fish are also caught by Herring Gulls, although in many cases they are obtained by scavenging for discards behind trawlers or at fish docks (Harris 1965, Davis 1974, Löhmer & Vauk 1970, Parsons 1971a, Furness *et al.* 1992, Vincent 1994, Camphuysen *et al.* 1995).

In many colonies human waste, often from tips, is important in the diet of Herring Gulls (Spärck 1951, Harris 1965, Davis 1974, Mudge & Ferns 1982a, Sibly & McCleery 1983a, Chaussabel 1995). At the colony on the island of Trébéron in France, waste was the most important source of food for nesting birds and when its availability was reduced, breeding success decreased significantly (Pons 1992). The other main source of food for Herring Gulls is agricultural land. Terrestrial invertebrates, such as earthworms (Lumbricidae), have been found to be important in the diet of this species in several studies (Harris 1965, Threlfall 1968, Melville 1974, Sibly & McCleery 1983a, Pons 1992, Chaussabel 1995).

As already seen in Chapter 2, the numbers of Herring Gulls nesting on buildings in Britain and Ireland have continued to increase since the mid-1970s, despite an overall drop in the breeding numbers of this species in these countries. The buildings where gulls nest are often in close proximity to sources of food originating from human activities, such as refuse tips and fish docks. Given the probable role of such food in leading to an increase in gull numbers, a possible reason for the success of roof-nesting gulls may be that such food contributes more to their diet than that of gulls nesting at more traditional sites.

The aim of this study is to review information on the diet of Herring Gulls at urban colonies and to conduct a detailed investigation into the diet of both adults and chicks of this species nesting at one urban site, the roof of the Melinar Stores building at ICI Wilton, Teesside, north-east England.

4.2 Methods

Several methods are available for studying the diet of Herring Gulls, each with its associated limitations (Spaans 1971, Furness & Monaghan 1987). The diet of adult birds can be determined directly by examining the stomach contents of dead individuals, although digestion may make identification of food items difficult and indigestible items may accumulate in the gut over a period of time, so appearing more important than they really are. One of the most commonly used methods, with the benefit of being non-lethal, is the analysis of regurgitated material. Gulls regurgitate indigestible material as pellets and large numbers of pellets can be collected quite simply. However, there are considerable limitations to data obtained in this way. Different food items contain varying proportions of indigestible materials and so the quantities present in pellets bear no relation to the actual importance in the diet. This type of analysis is most useful for examining seasonal changes in diet at a colony and, although it gives an indication of what types of food are taken by the birds studied, it provides no accurate indication of the relative importance of these food items in the diet.

The diet of chicks can be studied by observing the food regurgitated on to the ground for the chicks by the parent birds. However, this food is eaten very quickly and so may be difficult to identify, leading to a bias towards easily identifiable foods. Aspects of the environment of the colony, such as vegetation, may restrict such observations. If the food regurgitated by chicks can be examined, a more accurate picture of their diet can be collected, although some items may have already been digested and it has been suggested that soft foods may be regurgitated more easily than hard foods (Hunt 1972, Spaans 1971). However, Spaans (1971) found no significant differences between data collected in this manner and the stomach contents of a sample of chicks taken during the same study. Nevertheless, the cautions outlined for the interpretation of pellet data must also be borne in mind when studying chick regurgitations.

In this study, the diet of adult Herring Gulls nesting on the roof of the Melinar Stores (see Chapter 3 for site description) building at ICI Wilton was investigated during the breeding season of 1995 by the analysis of regurgitated pellets. These were collected in two areas of the roof, chosen because they contained solely Herring Gull nests (Figure 4.1). In the area on the lower surface of the roof (area A) there were 29 nests, and in the area on the upper surface (area B), 41 nests. These areas were totally cleared of all pellets on 11 and 13 May and then collections for analysis were carried out every two days from 15 May until 8 June. Collection then occurred every three days until the beginning of July and from then every six days until 17 August. The bare surface of the roof enabled all pellets to be collected with confidence. Pellets from each area were kept separate and were taken back to the laboratory where the contents of each were established. For those pellets which were fragile, the contents were noted on site. Species of fish eaten by the gulls were identified from sagittal otoliths found in pellets using Härkönen (1986) and by comparison with reference material. Mammalian jaw bones were identified using Yalden & Morris (1990).

The diet of chicks was studied by examining chick regurgitations obtained during routine handling of chicks for measurement or ringing. Regurgitations were recorded from

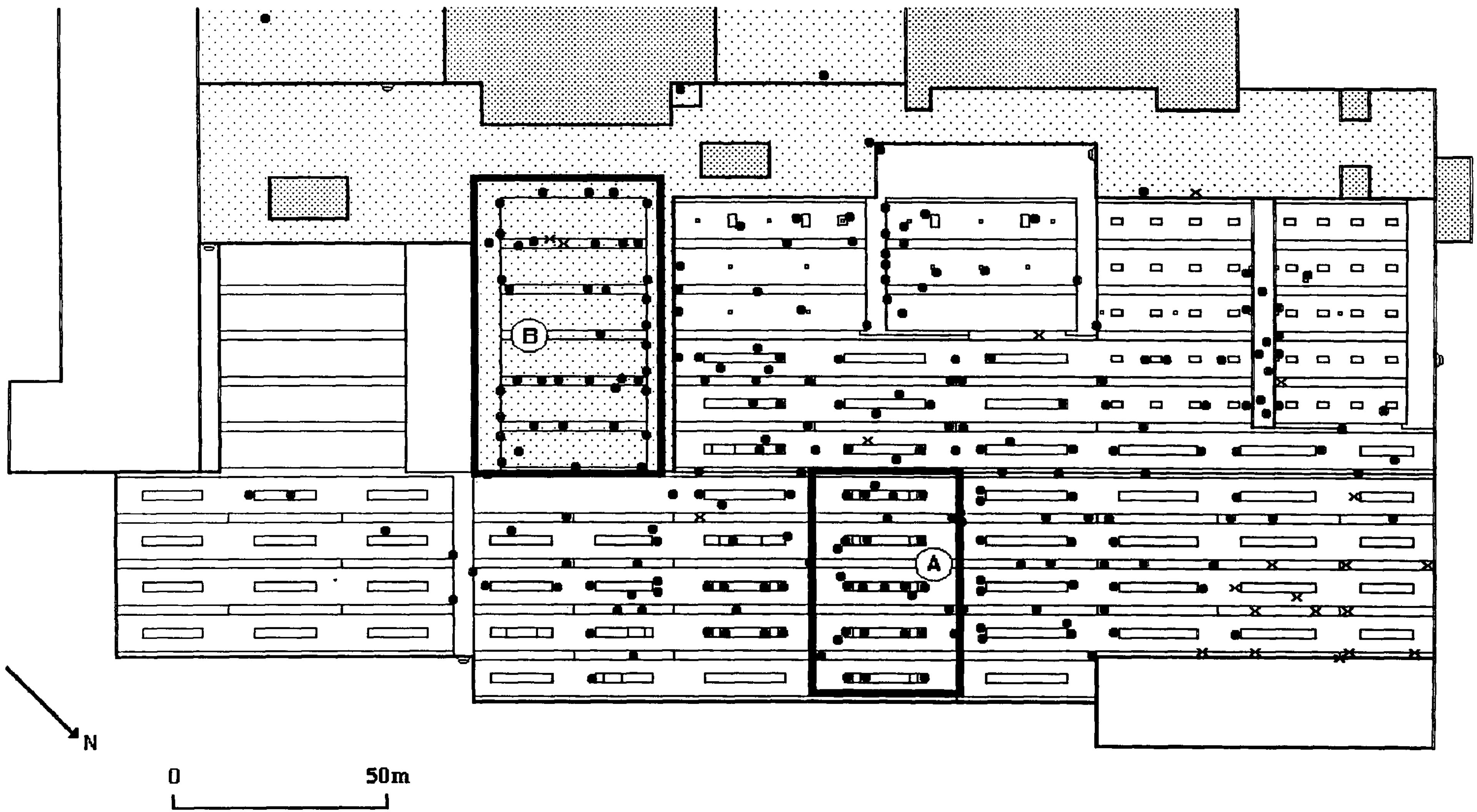


Figure 4.1: Plan of the study areas on the roof of the Melinar Stores, ICI Wilton.

chicks on all areas of the roof. The contents of the regurgitations were noted on site. The identity of each chick was noted from its ring number. If regurgitations were obtained from more than one chick from the same nest, only one of the samples was used in the analysis in order to avoid bias due to the dietary specializations of individual adults.

Data were expressed as the number of pellets or regurgitations in which each food item was found. This is a convenient way of summarising the data although it does tend to overestimate the importance of small, but regularly occurring items (Mudge 1978). However, Spaans (1971) found that there was good agreement between the frequency of occurrence and the weight of each food item in chick regurgitations, despite a slight over-representation of marine invertebrates and rubbish in the former.

The food items recorded in pellets were grouped according to their likely area of origin (urban areas - waste; agricultural land - terrestrial invertebrates, mammals and plant material; marine/littoral areas - fish, crabs and other marine invertebrates). Birds were not included in these categories as it is likely that all food of this type was obtained opportunistically at the colony. As each of these groups included at least one item which was fairly indigestible, and therefore well-represented in pellets, it may be possible, with caution, to compare the importance of these categories.

4.3 Results

4.3.1 Adults

4.3.1.1 Diet

In total, 3,483 pellets were collected from the study areas during the period 15 May to 17 August 1995. It is likely that the majority of these pellets were produced by the gulls breeding within the study areas, although non-breeding birds visiting the colony may have accounted for a small proportion. Allowing for the variation in the length of time between collections, the number of pellets collected on each occasion decreased throughout this period (Figure 4.2). There are two possible reasons for this; firstly towards the end of the study the intervals between collections of pellets were longer and

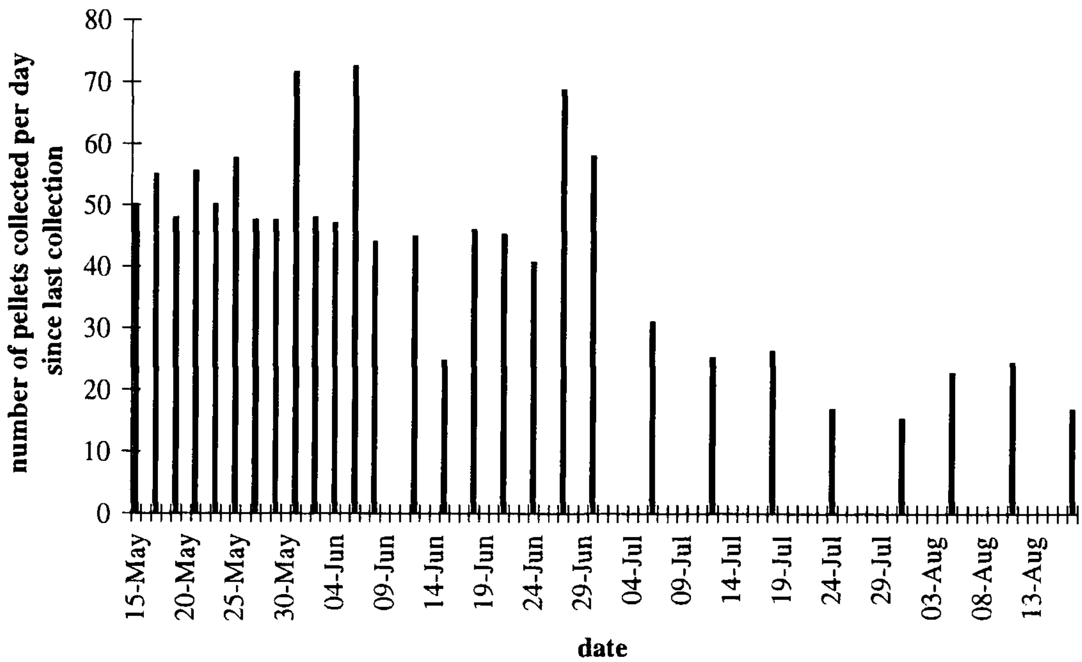


Figure 4.2: Changes in the number of pellets collected per visit during the breeding season.

so a proportion of the pellets produced may have disintegrated before they could be collected. Secondly, it may be that by the end of the study period the chicks of many birds had fledged and so many adults had ceased to frequent the roof.

After the study areas had been chosen and the collection of pellets had begun, two pairs of Lesser Black-backed Gulls built nests within the upper study area (Area B). Pellets of Herring Gulls and Lesser Black-backed Gulls are indistinguishable (Löhmer & Vauk 1969) and so as two of the 43 nests in Area B were of the latter species, the sample taken from this area will have contained some Lesser Black-backed Gull pellets. The results given in Table 4.1 show that there were differences in the proportion of pellets containing the main types of food in the two study areas ($\chi^2 = 36.9$, d.f. = 7, $P < 0.001$).

From Table 4.1, it can be seen that a wide variety of items was found in the pellets from the study site. Plant material was the item most commonly found, being present in over 70% of pellets in both study areas. In most cases this material was grass (Gramineae), all other forms of plant material such as seeds, grain, straw and seaweed being found in less than 5% of pellets.

Items associated with domestic waste, whether from tips or from scavenging around towns, were found in about 60% of pellets. Inedible items, mainly polythene, paper and glass, were found most frequently. Edible food waste found consisted mostly of the bones of domestic animals although meat, bread, vegetable matter and egg shells were occasionally found.

Fish remains, such as sagittal otoliths and other skeletal elements, were found in 14% of pellets. Many of the otoliths were worn and broken, but some permitted identification of the fish that had been eaten. Otoliths were found from the following species; Haddock *Melanogrammus aeglefinus*, Whiting *Merlangius merlangus*, Scad *Trachurus trachurus*, Bib *Trisopterus luscus*, Poor Cod *T. minutus*, and Norway Pout *T. esmarkii*.

The remains of crabs were found in 14-18% of pellets, however, the extent to which their exoskeletons had been broken down meant that it was not possible to identify the species involved. It is likely that pellets consisting solely of crab remains would disintegrate quickly, like fish pellets. Other marine invertebrates were present in about

Table 4.1: Details of the items found in pellets regurgitated by adult Herring Gulls during the breeding season.

Food Item	Percentage frequency of occurrence in pellets	
	Area A	Area B
Fish sp.	**13.2**	**13.9**
Crab sp.	**18.0**	**13.7**
Other marine invertebrates	**5.1**	**4.5**
shell pieces	4.4	3.1
Mytilus edulis	0.6	1.0
Littorina saxatilis	-	0.1
Patina pellucida	-	0.1
Patella sp.	-	0.1
Chlamys sp.	-	0.1
whelk sp.	0.1	0.1
barnacle sp.	0.1	0.1
echinoderm sp.	-	0.1
Terrestrial invertebrates	**3.3**	**3.9**
Coleoptera	3.2	3.4
other	0.1	0.5
Mammals	**0.5**	**2.5**
Talpa europaea	-	0.1
Sorex araneus	-	0.1
Arvicola terristris	-	0.1
Oryctolagus cuniculus	-	0.2
Rattus sp.	-	0.1
unidentified sp.	0.5	2.0
Birds	**1.0**	**0.9**
egg shell (gull)	0.6	0.6
feather (gull chick)	-	0.1
feather (non-gull)	0.3	0.2
juvenile *Sturnus vulgaris*	-	0.1

Table 4.1: (continued)

Food Item	Percentage frequency of occurrence in pellets	
	Area A	Area B
Plants	**75.9**	**72.4**
plant fibres	73.3	70.4
grain	1.7	1.4
straw	1.3	1.3
seaweed	0.4	0.2
algae	-	0.1
seeds	3.7	2.6
other	0.2	0.1
Waste	**59.3**	**60.9**
bones	19.0	22.6
meat	2.7	2.9
bread	1.3	1.6
vegetable	0.4	0.5
egg shell (hen)	0.3	0.3
polythene	27.1	27.3
paper	21.1	21.2
glass	16.4	19.7
foil	6.4	6.9
plastic	4.2	5.2
wood	3.2	2.9
string	2.6	2.2
fabric	1.2	0.7
metal	0.5	0.9
polystyrene	0.3	0.1
other	1.7	1.2
Grit	**33.0**	**38.5**
Sand/soil	**43.5**	**36.9**
Feather (adult gull)	**10.7**	**12.4**
Total pellets examined	**1563**	**1920**

5% of pellets, the species most commonly found being *Mytilus edulis*. The remains of terrestrial invertebrates were found in only 3-4% of pellets, most of these remains being the hard elytra of Coleoptera. The pellets were not examined microscopically and so the presence or absence of earthworm chaetae was not established.

The remains of mammals were found in very few pellets including, on two occasions, the skulls of Water Voles *Arvicola terrestris*. To my knowledge, this species has never been recorded in the diet of the Herring Gull (Harris 1965, Cramp & Simmons 1983). However, as this record was from Area B where two pairs of Lesser Black-backed Gulls also nested, it is not possible to state for certain that the Water Voles were eaten by Herring Gulls.

Food of an avian origin was also rarely found in pellets and most appeared to have come from the colony itself, for example, pieces of egg shell from Herring Gull eggs and newly fledged Starlings *Sturnus vulgaris* from a nest present on the roof. In one pellet feathers, probably from a Herring Gull chick, were found, but no other evidence was found of conspecific chicks being eaten and no bird was observed to eat any of the corpses on the roof of chicks or adults that died. Some feathers of bird species other than gulls were found in a few pellets but it was not possible to identify the species concerned.

Sand, soil and grit were found in many pellets and were probably ingested together with other types of food. The gull feathers found were probably taken in accidentally during preening.

Grouping the food items according to their most probable area of origin, it can be seen that food from agricultural land was found in 77% of pellets from Area A and 74% from Area B. these values for items from urban areas were 59% and 61% respectively, while food of a marine or littoral origin was found in 33% and 29% of pellets from Areas A and B respectively. It appears that agricultural land and the urban environment, probably mostly tips, may be the most important sources of food for the Herring Gulls at the study site, with food originating from the sea and shore being used less frequently.

4.3.1.2 Changes through the season

Figure 4.3 illustrates how the proportions of pellets containing food from the three main sources, urban areas, agricultural land and marine or littoral areas changed with time. When the results are considered in four-week periods, the proportion of pellets containing food from all three sources changed significantly in both study areas (agricultural land - Area A, $\chi^2 = 47.31$, d.f. = 3, $P < 0.001$, Area B, $\chi^2 = 116.58$, d.f. = 3, $P < 0.001$; urban areas - Area A, $\chi^2 = 10.61$, d.f. = 3, $P < 0.05$, Area B, $\chi^2 = 17.88$, d.f. = 3, $P < 0.001$; marine/littoral areas - Area A, $\chi^2 = 7.84$, d.f. = 3, $P < 0.05$, Area B, $\chi^2 = 22.80$, d.f. = 3, $P < 0.001$).

The proportion of pellets containing food from agricultural land declined as the season progressed. One constituent of this category, grain, although found in only a small proportion of pellets overall, was important during the month of August when it was found in 8% - 26% of pellets. In the case of food from urban areas, the proportion of pellets in which it was found appeared to rise towards the end of the study period. The proportion of pellets in which items from marine and littoral areas were found peaked in the third period of the study.

The changes observed could be due to changes in the availability of these food items or they could be the result of changes in the food selected by the gulls. Selective changes may be connected with the stage in the breeding season, however, in order to investigate this it would be necessary to study individual nests to see whether changes in diet coincided with different stages in the breeding season.

4.3.2 Chicks

4.3.2.1 Diet

A total of 62 regurgitations was obtained from chicks between 31 May and 10 July 1995 and their contents are given in Table 4.2. Due to the difficulty of catching older chicks, these are under-represented in this analysis. Of the 61 regurgitates for which the age of the chick was known, only six (10%) were from chicks more than three weeks old.

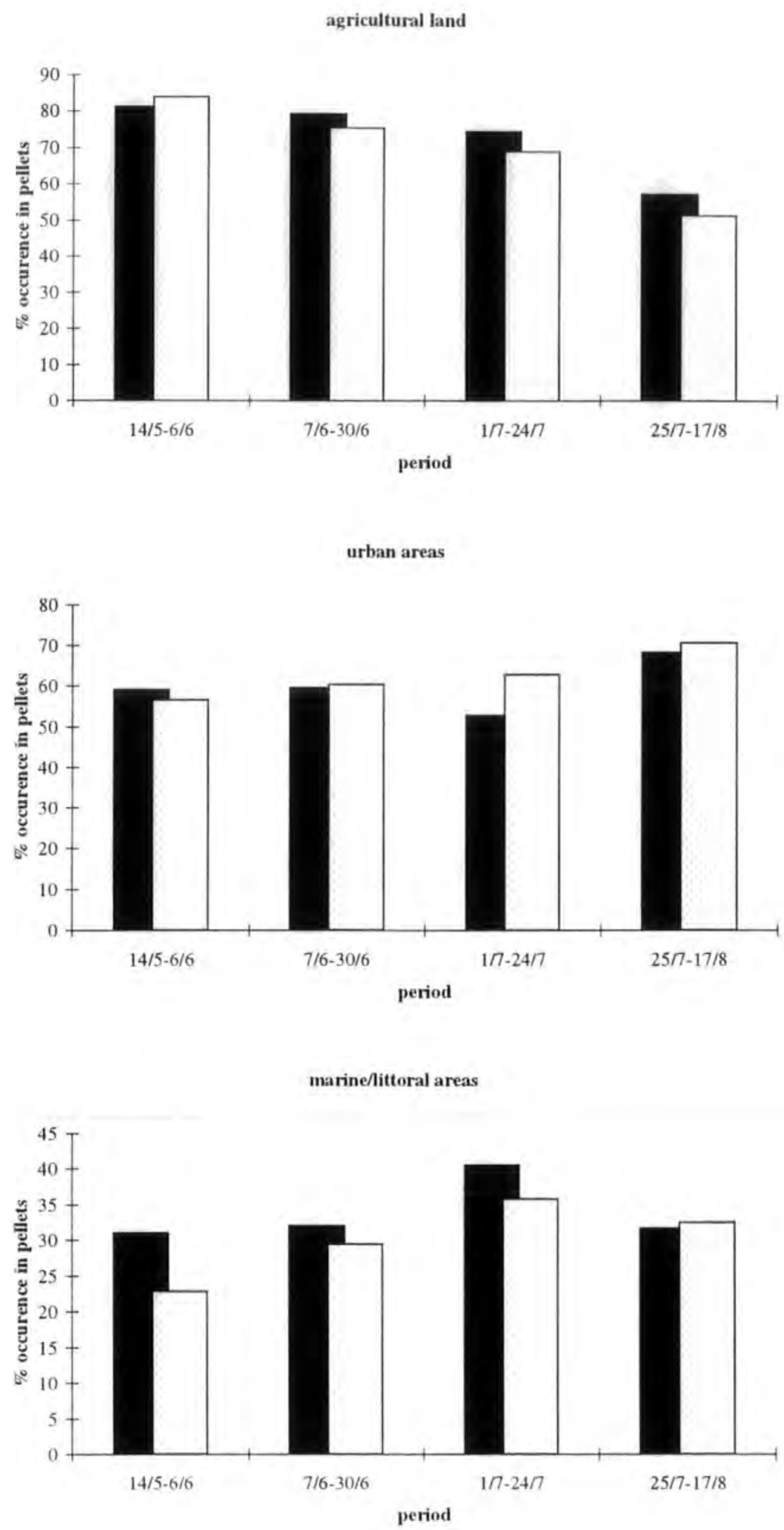


Figure 4.3: Changes in the proportion of pellets containing food items from the three main sources of food, agricultural land, urban areas and marine/littoral areas. Dark bars represent data from Area A and light bars represent data from Area B.

Table 4.2: Details of the items found in regurgitations from Herring Gull chicks during the breeding season.

Food Item	Percentage frequency of occurrence in regurgitations
Fish sp.	**37.1**
Crab sp.	**3.2**
Other marine invertebrates	**-**
Terrestrial invertebrates	**29.0**
earthworm	27.4
Lepidoptera larva	1.6
Tipulid larva	1.6
Tipulid adult	1.6
Mammals	**1.6**
Sorex araneus	1.6
Birds	**-**
Plant material	**6.5**
Waste	**41.9**
potato	1.6
onion	1.6
bread	8.1
egg shell (hen)	3.2
pasta	1.6
meat (inc. fat, offal)	6.5
chicken (inc. skin, meat, offal)	12.9
bacon	9.7
polythene	3.2
polypropylene grit	1.6
Grit	**-**
Sand/soil	**9.7**
Feather (adult gull)	**-**
Total regurgitations examined	**62**

Three types of food were recorded most frequently; fish, waste and terrestrial invertebrates, mainly earthworms. Both whitefish and non-whitefish were found in regurgitates. The edible waste found consisted predominantly of meat, such as chicken and bacon, with bread and pieces of egg shell from domestic hens also present. Plant material and pieces of crab shell were observed in few regurgitations. No grit, gull feathers, birds or marine invertebrates other than crabs were found at all, and only one regurgitation contained any remains of mammals (an entire Common Shrew *Sorex araneus*).

4.3.2.2 Changes through the season

Changes in the proportions of regurgitations containing the three main types of food (fish, terrestrial invertebrates and waste) during the study period are illustrated in Figure 4.4. As the number of samples from the first and last periods were small, the proportion of regurgitations containing these items from 25 May to 18 June (n = 42) was compared with that from 19 June to 12 July (n = 20). The proportion of pellets containing terrestrial invertebrates decreased significantly between these two periods ($\chi^2 = 4.31$, d.f. = 1, $P < 0.05$), however, there was no significant change in the proportion of regurgitations containing fish ($\chi^2 = 1.44$, d.f. = 1, $P > 0.05$) or waste ($\chi^2 = 0.10$, d.f. = 1, $P > 0.05$).

When the diet was investigated according to the age of the chicks (Figure 4.5), no significant differences were found between the proportions of these three food types in regurgitations from chicks that were one, two or three or more weeks old (terrestrial invertebrates - $\chi^2 = 2.39$, d.f. = 2, $P > 0.05$, fish - $\chi^2 = 2.07$, d.f. = 2, P > 0,05, waste - $\chi^2 = 1.91$, d.f. = 2, $P > 0.05$). However, it was found that the proportions of whitefish and non-white fish in the fish regurgitated changed as the chicks grew (Figure 4.6). The regurgitates of chicks up to one week old comprised mostly non-white fish, but as the chicks grew, this proportion dropped and that of white fish increased (1 wk vs 2+ wks ; Fisher's exact test $P = 0.01$). The plant material and crab remains that were found in chick regurgitations were all found in chicks that were more than one week old.

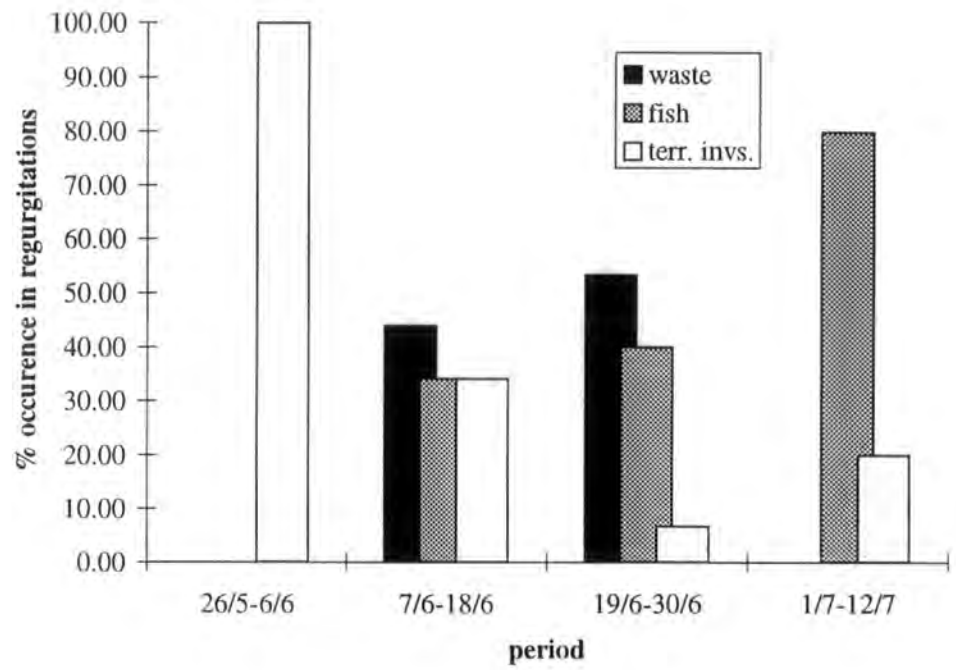


Figure 4.4: Changes in the percentage frequency of occurrence of the three main types of food in chick regurgitations during the breeding season.

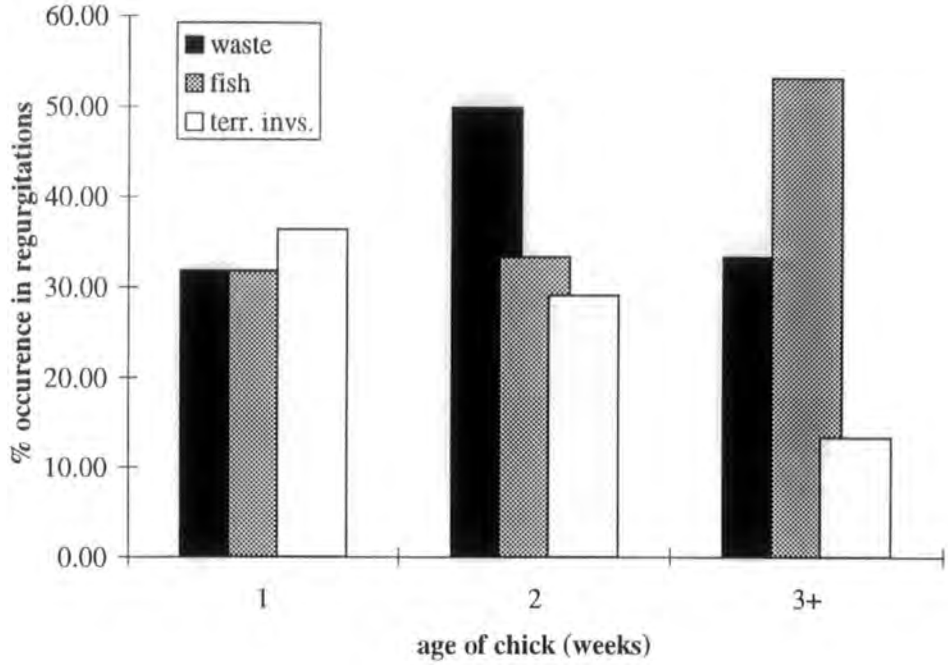


Figure 4.5: Changes in the percentage frequency of occurrence of the three main types of food in regurgitations from chicks aged up to one week, one to two weeks and up to and over three weeks old

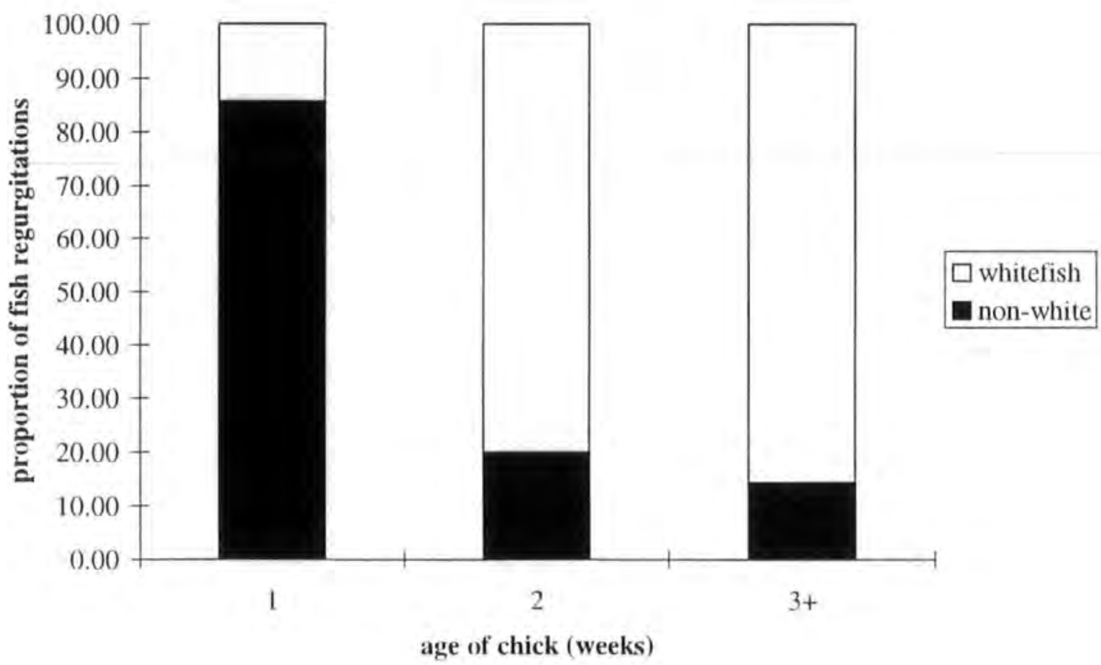


Figure 4.6: Changes in the relative proportions of regurgitations containing whitefish and non-whitefish from chicks aged up to one week, one to two weeks and up to and over three weeks old.

4.3.3 Review of dietary studies of roof-nesting gulls

The results of the present study and four others which have considered the diets of roof-nesting Herring Gulls are summarised in Table 4.3. Although it is difficult to compare these results closely due to the different methods of data collection used, it can be seen that the foods most important to gulls vary between these studies. Domestic waste from tips was found to be an important part of the diet of Herring Gulls nesting on the roofs of Cardiff and Teesside but much less important in that of birds nesting on roofs in Sandusky and Le Havre where freshwater fish and marine fish waste respectively were found to play an important dietary role. In Bangor, marine invertebrates made a major contribution to the diet of roof-nesting Herring Gulls.

4.4 Discussion

The results of this study show that Herring Gulls nesting on the roof of the Melinar Stores at ICI Wilton fed mainly on agricultural land and in urban areas, with food of marine or littoral origin playing a lesser role. The food taken from urban areas is available as a direct result of man's activities, as is a proportion of the food from marine and littoral areas as it is likely that much of the fish eaten by the gulls was scavenged from fishing vessels or fish docks.

Herring Gulls have been recorded to fly distances of 25 - 60km in search of food (Spaans 1971, Götmark 1984) and within this distance of the study colony there are many potential feeding areas. Herring Gulls are known to feed at Hartlepool Fish Quay, Guisborough tip and in fields on the Wilton estate, although few are seen in the Tees estuary during the breeding season. It was not possible to accurately determine the flight paths of the birds leaving the colony due to high buildings and equipment blocking the view in several directions but many birds did appear to leave in a southerly direction, which would support the idea that the agricultural land of the Wilton estate and the tip at Guisborough may be the most important sources of food for birds at this colony.

As the diets of adult Herring Gulls and their chicks were investigated using different methods, it is difficult to compare the results. Due to the lack of easily digested foods, pellet analysis is likely to give a less complete picture of the diet than the analysis of chick regurgitations, however, even with this limitation the diet of the adults appears to

Table 4.3: Review of studies of the diet of Herring Gulls at rooftop colonies in the breeding season.

Reference	Location of colony	Date of study	Method of study	Results of study
Mudge & Ferns (1982a)	Cardiff, Wales, U.K.	1973-1976	chick regurgitations (n = 133)	tip - 68%, fields - 15%, freshwater - 11%, littoral areas - 6%
Belant *et al.* (1993)	Sandusky, Ohio, U.S.A.	1992	food remains (n = 106)	freshwater fish - 72%, garbage - 17%, birds - 14%
			adult pellets (n = ?)	freshwater fish - 98%, vegetation - 8%
Vincent (1994)	Le Havre, France	1981-1987	adult stomach analysis (n = 76)	marine food - 54%, terrestrial food- 23%, waste - 6%
			chick regurgitations - first meal (n = 38)	marine vertebrates - 58%, terrestrial invertebrates - 30%, marine invertebrates - 7%, vegetation - 0%, waste - 0%
			chicks over 2 weeks old (n = 26)	marine vertebrates - 40%, terrestrial invertebrates - 20%, marine invertebrates - 24%, vegetation - 15%, waste - <3%

Table 4.3: (continued)

Reference	Location of colony	Date of study	Method of study	Results of study
Chaussabel (1995)	Bangor, Wales, U.K.	1994	adult pellets (n = 14)	human origin - 18%, marine invertebrates - 43%, terrestrial invertebrates - 25%
			chick regurgitations (n = 35)	human origin - 45%, marine invertebrates - 38%, terrestrial invertebrates - 17%
Present study	Teesside, U.K.	1995	adult pellets (n = 3483)	agricultural land - 77%/74%, urban areas - 59%/61%, marine/littoral areas - 33%/29%
			chick regurgitations (n = 62)	domestic waste - 42%, fish sp. - 37%, terrestrial invertebrates - 29%, plant material - 7%, crab sp. - 3%

be more diverse than that of the chicks, the latter being fed mainly on terrestrial invertebrates, waste food and fish. It is unlikely that the longer length of the period in which adult diet was studied meant that more seasonal variation was incorporated in this sample as those food items not found in the chick diet were found in adult pellets during the chick-rearing period. It is possible, however, that the lower diversity of chick diets may be explained to a small extent by the lower sample size.

The item most commonly found in the diet of adults was grass, being present in over 70% of pellets. Most studies of the diet of Herring Gulls have found some grass in pellets, albeit infrequently, but three studies have found a high proportion, similar to that observed in this study. Grass was found in 70% of pellets on Ailsa Craig, Scotland by Nogales *et al.* (1995) and in 94% of pellets from the Skerries Islands, Northern Ireland by Melville (1974). In the latter study this grass occupied 75% of stomachs by volume. On Anglesey and in North Caernarvonshire, Threlfall (1968) found grass in 81% of adult stomachs analysed.

Several suggestions have been put forward to explain the presence of grass, with its very low nutritional value, in pellets. The most frequent of these is that it is ingested accidentally whilst feeding on terrestrial invertebrates such as earthworms or Tipulids (Harris 1965, Mudge 1978, Fox *et al.* 1990, Noordhuis & Spaans 1992). This explanation was also put forward by Melville (1974) and Nogales *et al.* (1995) and, in addition they suggested that the grass may have been eaten deliberately to aid pellet formation.

In the present study, remains of terrestrial invertebrates were found in only 3% - 4% of pellets, the majority being the hard elytra of Coleoptera. Many terrestrial invertebrates are easily digested and leave little or no trace in pellets, such that their importance in the diet can be underestimated. An observational study by Sibly & McCleery (1983a) showed that terrestrial invertebrates were an important source of food for gulls nesting on the island of Walney, a source of food missed by previous studies based on pellet analysis. The presence of terrestrial invertebrates, mostly earthworms, in 29% of chick regurgitations indicates that these species are definitely eaten by the gulls at ICI Wilton. It is therefore possible that the high frequency of occurrence of grass in pellets indicates a much greater importance for terrestrial invertebrates than their remains would suggest.

In the present study the proportion of pellets containing food from agricultural land decreased during the breeding season. However, other studies have found differing results. Nogales *et al.* (1995) found no change in the proportion of pellets containing grass, while that containing Coleoptera remains increased. Noordhuis & Spaans (1992) found that the proportion of grass pellets found around nests increased as the chicks were hatching. In the present study, grain was found to be eaten when available during harvesting at the end of the breeding season in August as noted by Harris (1965), Threlfall (1968), Andersson (1970), Parsons (1971a) and Vincent (1994).

It has been found that the availability of earthworms to gulls depends on the presence of worms near the surface of the ground which, in turn, is determined by the humidity of the soil (Sibly & McCleery 1983a). During dry weather few worms are available and consequently few are eaten by gulls (Kirkham & Morris 1979, Noordhuis & Spaans 1992, Pons 1992). Noordhuis & Spaans (1992) found that grass pellets were almost absent in dry months, supporting the idea that grass ingestion is linked to the consumption of terrestrial invertebrates. It may therefore be possible that changes in the proportion of food from agricultural areas in pellets seen in this study were linked to climatic conditions.

In the case of the chicks, the proportion of regurgitations containing terrestrial invertebrates in the period until the end of June was significantly higher than that from July onwards. Other studies have found that terrestrial invertebrates such as earthworms are important for young chicks, but become less so as they grow older (Pons 1992, Nogales *et al.* 1995). This has also been found in the Ring-billed Gull (Kirkham & Morris 1979) and is thought to be because these species are easy for small chicks to handle and digest.

Domestic waste was found in 60% of pellets in the present study. Most was probably obtained by the gulls from tips although some may have been scavenged from town streets. In most studies on the diet of Herring Gulls such waste has been found to some extent. In many cases, it was found in less than 40% of pellets (Spärck 1951, Andersson 1970, Davis 1974, Noordhuis & Spaans 1992, Belant *et al.* 1993, Chaussabel 1995), but it was present in 43% of pellets from Herring Gulls nesting on Ailsa Craig, Scotland

(Nogales *et al.* 1995) and, over a five year period, in 61% to 85% of pellets from the island of Trébéron, France (Pons 1992).

In the present study, waste was found in 42% of chick regurgitations, mostly consisting of various types of meat. In three other studies, the proportion of waste in the diet of chicks was higher than this. Mudge & Ferns (1982a) found that 70% of food fed to older chicks came from rubbish tips while Chaussabel (1995) found the proportion of pellets containing waste to be 59% for chicks on the island of Bardsey and 45% for chicks on the roofs of Bangor. The waste found in the diet of chicks on Ailsa Craig was predominantly meat which was present in 42% of regurgitations (Nogales *et al.* 1995). Other studies have found proportions of 25% or less (Spaans 1971, Belant *et al.* 1993, Hillström *et al.* 1994).

The proportion of adult pellets containing waste appeared to increase towards the end of the study period. A similar result was found by Belant *et al.* (1993) who established that although there was no significant difference between the proportion of rubbish in adult pellets during the incubation and chick rearing periods, a significant rise was seen in the post-fledging period. In contrast, Nogales *et al.* (1995) found no change in the proportion of waste in pellets during the study period. Pierotti & Annett (1987) found that the proportion of waste in the diet of adults specializing in feeding on waste decreased significantly with the hatching of the chicks, a result also found in Western Gulls in California (Annett & Pierotti 1989). In the latter study, if the eggs failed to hatch, the proportion of waste in the diet of the parent birds did not change. In the present study no significant changes were found in the proportion of waste in the diet of chicks with time or chick age. However, other studies have shown that this proportion is greater in the diet of older chicks (Pons 1992, Belant *et al.* 1993, Hillström *et al.* 1994). It is possible that waste may be difficult for young chicks to handle.

Several authors have suggested that the increased availability of waste food has increased the reproductive success of gulls (Spaans 1971, Hunt 1972, Davis 1974) and also reduced juvenile and adult mortality (Harris 1970, Davis 1974, Mudge & Ferns 1982a). Davis (1974) included both rubbish from tips and also waste fish in this category and found that pairs where at least one parent fed on such food fledged more young than those which did not feed on artificial sources. Using the same definition of waste, Hunt

(1972) found that birds breeding in colonies nearer sources of waste food had higher breeding success than those breeding further away. Fordham (1970) found that after a reduction in the amount of waste offal and refuse available, significantly larger losses of young Dominican Gulls in New Zealand were reported in the breeding season.

The evidence as to whether feeding on waste from tips benefits the gulls is varied. It has been suggested by several authors that such food may increase reproductive success and also decrease adult and juvenile mortality. Sibly & McCleery (1983b) found that feeding at tips had higher energy returns than did feeding elsewhere. Spaans (1971) found a positive correlation between brood size and the occurrence of garbage in the diet and it was felt that in order for birds with large broods to provide enough energy for their chicks they had to feed them with waste. Pons (1992) carried out a study of the diet and breeding biology of a colony of gulls before and after a large reduction in the availability of the waste that made up a large part of their diet. He found that the reduction in the availability of waste led to a reduction in the proportion of waste in the diet of adults and also a reduction in all breeding parameters, resulting in a 61% decrease in the number of chicks fledged from the colony.

There are, however, some disadvantages to eating waste. Pierotti & Annett (1987) found that garbage (in this case chicken) was less profitable than small fish for protein, fat and calories per gram and that adults that specialised on garbage fledged fewer chicks than those that specialised on other foods. In addition to potentially being less profitable, it may also be difficult for young chicks to handle (Hillström *et al.* 1994). In addition, it has been suggested that it is at rubbish tips that Herring Gulls become contaminated with botulism (Sutcliffe 1986, Worrall 1987, Ortiz & Smith 1994).

Fish appeared to play a lesser role in the diet of the Herring Gulls nesting at ICI Wilton, despite the presence of the fish dock at Hartlepool and the nearby Tees estuary and coastline. It was found in 14% of adult pellets, but was more important to chicks, being present in 37% of regurgitations, an observation noted in several other studies (Threlfall 1968, Furness *et al.* 1992, Noordhuis & Spaans 1992, Nogales *et al.* 1995).

It is possible that the presence of fish in the diet of adult birds was underestimated. During a study of the diet of the Great Skua *Catharacta skua*, Furness & Hislop (1981) found that pellets of whitefish began to degrade after 48 hours and had almost totally disintegrated after six days. For most of this study, pellets were left only two or three days before collection, however, from the beginning of July (about 3 weeks after the peak of hatching), pellets were collected at intervals of six days. It is possible that in this time some pellets may have disintegrated to a point where they were not recorded. Therefore the number of pellets containing fish, and indeed the number of pellets, may have been underestimated during the last weeks of the study.

The sagittal otoliths of a number of species of fish were found in the pellets during this study. All of these species are the subject of commercial fisheries in the North Sea (Camphuysen *et al.* 1995) and so may have been obtained from behind trawlers or at fish docks. The list of species found cannot be considered to be complete as the otoliths of several species are rarely found in pellets as they are small and easily broken up in the gizzard of gulls, for example, Mackerel *Scomber scombrus* (Löhmer & Vauk 1969). The numbers of otoliths found of each species cannot be considered as representative of the importance of these species in the diet of the gulls as the proportion of otoliths recovered from pellets is influenced by the size and species of the fish (Jobling & Breiby 1986, Johnstone *et al.* 1990).

The remains of crabs formed the bulk of the traces of marine invertebrates found in pellets, being observed in 13-18% of pellets but only 3% of chick regurgitations. Other species of marine invertebrate were found in only 5% of adult pellets and were not present in chick regurgitations. Marine invertebrates have been found to be more important in several other studies (Spaans 1971, Furness *et al.* 1992, Noordhuis & Spaans 1992, Chaussabel 1995).

In the present study, the proportion of food from marine and littoral areas appeared to peak in the first half of July. In several cases, the proportion of fish in the diet of gulls has been seen to increase immediately after the hatching of the chicks (Andersson 1970, Haycock & Threlfall 1975, Pierotti & Annett 1987, Noordhuis & Spaans 1992 and, for the Western Gull, Annett & Pierotti 1989). A drop in the importance of marine invertebrates in the diet of adults after the hatching of chicks has been observed by Spaans (1971) and Noordhuis & Spaans (1992). In the case of many such species, the presence of a shell or carapace makes them difficult for chicks to handle.

In this study, no significant change was observed in the proportion of fish in the diet of chicks with time or with the age of the chick, but increases with chick age have been observed in other studies (Hillström *et al.* 1994) and also decreases (Nogales *et al.* 1995). In the present study, and also that by Furness *et al.* (1992) a change in the composition of the fish fed to chicks was observed, with non-whitefish predominating in the diet of young chicks, but being replaced by whitefish as the chicks grew older.

In the present study, birds and mammals constituted only a small part of the diet of the Herring Gulls. It is probable that they were eaten opportunistically when available to the gulls, for example when the Starlings from the nest on the roof fledged. This has been seen in other studies where there is a peak in the consumption of birds when the chicks of conspecifics (Parsons 1971b) or other species nesting nearby, such as Eiders *Somateria mollissima*, begin to hatch (Spaans 1971, Hillström *et al.* 1994) or when passerine birds are migrating (Löhmer & Vauk 1969, Fox *et al.* 1990). Also Herring Gulls have been observed to kill and eat domestic pigeons (Vincent & Guigen 1989).

From the results of this study and others involving Herring Gulls nesting on buildings it can be seen that, despite their proximity to man's waste, these birds do not necessarily utilise it more than those nesting at more traditional sites. Belant *et al.* (1993) found that birds nesting on the roofs of Sandusky, Ohio had a very similar diet to those nesting on a nearby island, the only significant difference being an increased importance of birds in the diet of the roof-nesting birds. Birds nesting on the rooftops of Cardiff, Wales were compared with those nesting on the island of Steep Holm 10 miles away by Mudge & Ferns (1982a). Again differences in diet were small; birds on the rooftops took more freshwater food and fewer birds. Chaussabel (1995) found that the birds he studied nesting on the rooftops of Bangor, Wales and those on Bardsey island had significantly different diets, with the former taking more marine invertebrates and the latter taking more waste and terrestrial invertebrates. These differences can be attributed to the fact that these two colonies are 40 miles apart and so birds nesting at each had different foraging opportunities.

It appears that birds nesting on rooftops do not necessarily take more waste food than those at traditional sites, despite their proximity to man and sources of waste. However, from the results of the present study and those outlined above, it does appear that conspecific chicks are less frequently found in the diet of adults nesting on rooftops, possibly a result of the reduced aggression from neighbouring birds associated with rooftop colonies which is thought to be one explanation for the higher reproductive success found at such colonies (Monaghan 1979, Chaussabel 1995).

Chapter 5

The effect of improvements to sewage treatment on the numbers and distribution of gulls on the River Tyne

5.1 Introduction

It is well-documented that untreated sewage is used as a source of food by many gull species (Vernon 1970, Fitzgerald & Coulson 1973, O'Connor 1974, Mudge 1978, Cramp & Simmons 1983). For this reason, it might be expected that the improvements in the treatment of sewage introduced in the last 30-40 years have had an effect on gulls using areas such as urbanised rivers and estuaries, where previously the enormous quantities of untreated sewage discharged had provided a constant and easily available source of food. Several studies have identified responses in bird numbers thought to be due to changes in the quantity of untreated sewage entering a river or estuary, despite the difficulties inherent in determining the causes of long term population changes (Bryant 1987). Such changes can affect birds directly, if the discharged matter is utilised as food, or indirectly, if the birds' food supply is affected (Green *et al.* 1993).

An example of the direct usage of untreated sewage by birds is the close association that was found between sewage outfalls and flocks of Goldeneye *Bucephela clangula* and Scaup *Aythya marila* wintering off the Scottish east coast (Milne & Campbell 1973, Pounder 1974, 1976 a&b, Campbell 1978). Outfalls discharging domestic and distillery waste were particularly favoured and it is thought that the birds fed directly on items from the effluent, such as grain. After improvements to the treatment of sewage entering the Firth of Forth, numbers of these species in the Firth declined and the distribution of the remaining birds changed, to feed predominantly near the one remaining outfall discharging untreated sewage (Campbell 1984). Mute Swans *Cygnus olor* have also been found to feed directly on discharged matter, particularly vegetable waste. In the Tay estuary large flocks gathered to feed at the outfall of a vegetable processing factory and dispersed when the factory ceased operating (Pounder 1974).

Generally, organic pollution such as the discharge of untreated sewage into a sea, estuary or river, leads locally to a decrease in invertebrate species diversity, but an increase in numbers and biomass, unless the level of pollution is so high that no invertebrates can survive (Gray 1979). For birds which feed on intertidal invertebrates, such an increase in food availability means that larger numbers of individuals can feed in a given area. This indirect effect of the input of untreated sewage was felt to be the reason for the increasing numbers of waders feeding on the Scheldt estuary in Belgium after it became more polluted (Van Impe 1985) and, conversely, has been used to explain a decrease in numbers of certain overwintering wader species on the Clyde estuary, Scotland after improvements to sewage treatment (Furness *et al.* 1986).

Fish are also affected by the input of untreated sewage because the low concentrations of dissolved oxygen associated with such pollution prevent them surviving in, or migrating through, highly polluted waters (Topping 1978). Furness *et al.* (1986) suggested that because reduced water pollution in the Clyde estuary also led to increased numbers of fish which preyed on the same invertebrates as the birds, the waders' food supply was possibly even further depleted.

Gulls may be influenced by the input of untreated sewage both directly and indirectly because, not only do they feed on items from sewage outfalls, but invertebrates and also fish play a role in their diet (Cramp & Simmons 1983). The use of sewage by gulls was examined in some detail by Fitzgerald & Coulson (1973), a study which will be described in detail later in this chapter, and Mudge (1978). The latter study took place at outfalls along the Welsh coast of the inner Bristol channel where it was found that most of the gulls feeding were Black-headed Gulls. Other species were only found in small numbers and it was concluded that, for gulls in this area, sewage outfalls were of little importance during the summer months and, although frequented more in winter, such outfalls were still not used by a large proportion of any species. The high proportion of Herring Gulls feeding at outfalls that were immature suggested that adult birds preferred to feed elsewhere. His analysis of the stomach contents of Black-headed Gulls which had been feeding at outfalls showed that they selected small pieces of sewage, usually plant and vegetable material, and larger items were not taken.

Two studies have considered the effect of changes in the input of untreated sewage upon gull species. In his study on the Scheldt estuary, Van Impe (1985) reported higher numbers of Black-headed Gulls breeding near the estuary after it became polluted: however, this increase could not be definitely attributed to any increase in food. In Wellington Harbour, New Zealand, improvements to sewage treatment, and the closure of two abattoirs which had previously discharged their waste straight into the harbour, were thought to explain a decrease in the number of Dominican Gulls feeding in the harbour, together with a redistribution of birds of this species, and also Red-billed Gulls

Larus novaehollandiae, towards the remaining sewer discharging untreated waste (Robertson 1992).

In view of recent concerns over the large numbers of gulls present in urban areas, and the known use of sewage by these birds, this study attempts to investigate the effect that improvements to the treatment of sewage discharged into the river Tyne, in north-east England, have had on the numbers and distribution of gulls regularly using the river. Prior to these improvements, a study was carried out on the usage of the river by (Fitzgerald & Coulson 1973), with a further study planned for after the completion of the improvements. The present study involved the carrying out of the second part of this investigation to establish the effect of these changes.

5.2 Study Area

5.2.1 The River Tyne

In its final stages before flowing into the North Sea, the River Tyne runs through the centre of urban and industrial Tyneside in north-east England and, by the late 1960s, almost 40 million gallons of untreated sewage, both domestic and industrial, were discharged daily into its tidal reaches, through over 100 outfalls (Fitzgerald & Coulson 1973). The river was highly polluted and Salmon *Salmo salar* were no longer able to migrate through its waters to spawn upstream (Fitzgerald & Coulson 1973).

The first studies of gulls on Tyneside were made by Rollin (1928, 1931a) who noted that the tidal mudflat known as Jarrow Slake was an important roost for Black-headed, Herring, Lesser and Great Black-backed Gulls, whilst Common Gulls feeding on the river roosted at sea. Black-headed, Herring and Great Black-backed Gulls were observed to feed at the sewer outfalls at Newcastle; however, few Common Gulls were observed there as they fed mainly in fields (Rollin 1931 a&b).

In the 1940s, Kittiwakes began to nest on a warehouse at North Shields (Coulson & White 1958) and nesting birds subsequently spread to other buildings upriver. Coulson & MacDonald (1962) noted that the Kittiwakes were not only flying out to sea to feed but were also feeding along the river, taking items of sewage, handouts of bread and freshwater fish. In the 1960s, Herring Gulls began to nest on buildings in North and

South Shields (Cramp 1971, Monaghan 1979) and by the 1970s had spread to Newcastle (Northumberland Bird Reports). The most thorough study carried out on the use of the River Tyne by gulls is that carried out by Fitzgerald & Coulson (1973) which is considered below.

5.2.2 Use of the polluted river

The study by Fitzgerald & Coulson was carried out from October 1969 to September 1970, when the river was still highly polluted. The study area was a 24-km stretch of the tidal reaches of the river, from the ferry landing at North Shields to the power stations at Stella (Figure 5.1). The species involved were Black-headed, Common, Lesser Black-backed, Herring and Great Black-backed Gulls and Kittiwakes. Details of the survey given below are taken from Fitzgerald & Coulson (1973) unless otherwise stated.

The area was surveyed from the Port of Tyne Authority's patrol boat every two or three weeks during the study period. Each survey trip began at 0900h from the North Shields ferry landing and observations were made on the journey upstream, which lasted approximately 1.5 hours (Fitzgerald 1970). The study area was divided into 14 sections (Figure 5.1), of arbitrary length, their boundaries being obvious, and hopefully permanent, landmarks which would be possible to use again in the planned future survey. On each trip the numbers of gulls of each species on or over the river, the waterfront buildings and the river banks was noted in each section. The proportion of immature birds was also recorded (Fitzgerald 1970). Gulls flying upstream were not counted on the assumption that they would be encountered again further upriver.

The survey method was felt to provide a good indication of the number of gulls using the river on a particular day as it was observed that major movements of gulls along the river only occurred immediately after sunrise and before sunset, numbers remaining relatively stable during the rest of the day. In addition, the short duration of the trip helped to limit the effect that gull movements may have had on the numbers seen (Fitzgerald 1970).

During this study, it was observed that sewage was utilised by all six species of gulls, although to differing extents. Stepwise multiple regression was used to analyse the factors influencing the distribution of each species among the sections of the study area. The factors considered were the physical characteristics of each section and its sewage

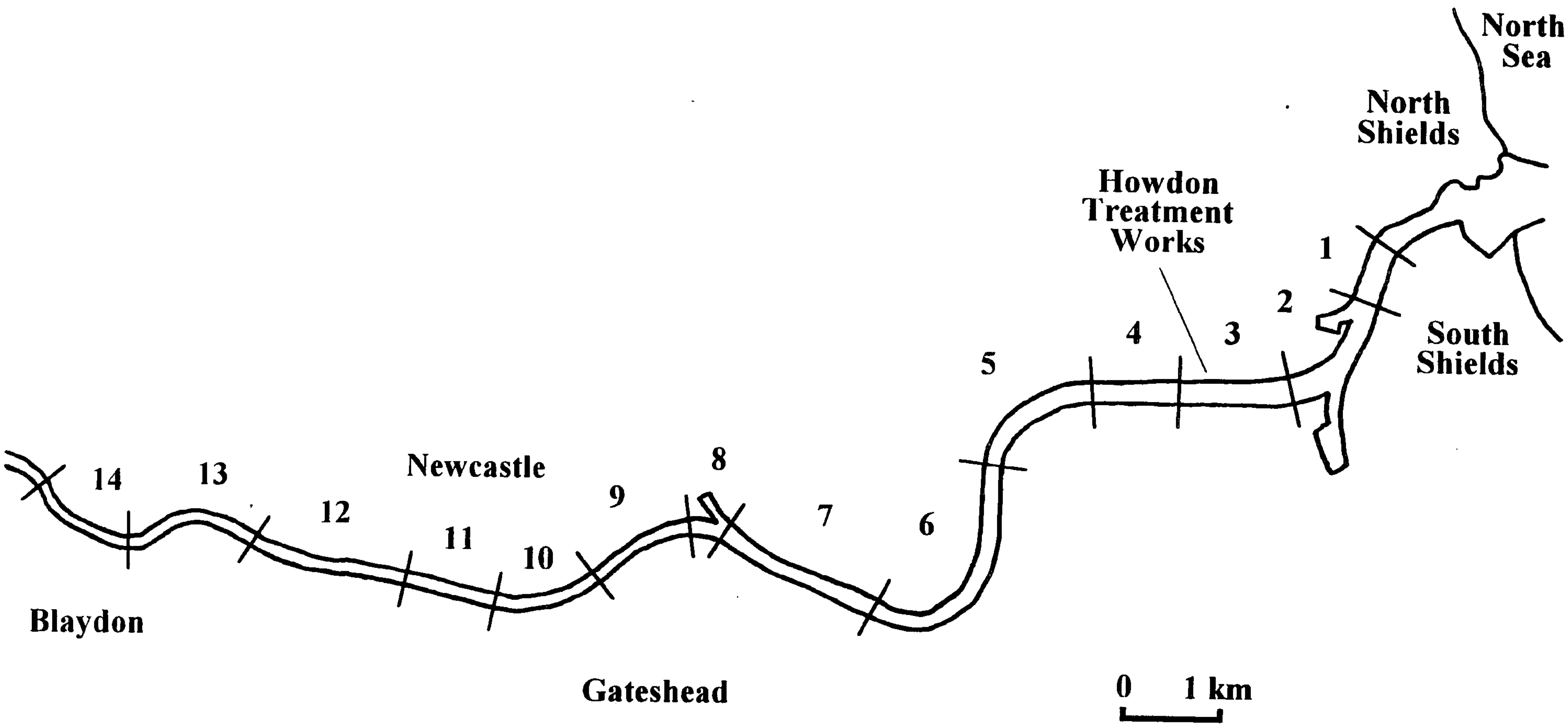


Figure 5.1: Plan of the study area on the River Tyne used in 1969/70 and 1993/94.

input. The equations generated by the multiple regressions were used to predict the changes in the numbers of gulls using the river which might be expected if the sewage input was reduced to zero. The findings of these analyses are summarised in Table 5.1. They suggested that the effect of such an event would lead to a decline in the numbers of all species using the river except the Kittiwake.

Table 5.1: Results of the 1969/70 survey of the distribution and abundance of gulls on the polluted River Tyne (from Fitzgerald 1970, Fitzgerald & Coulson 1973).

Species	Factors having significant* effect on distribution	Predicted change in numbers if sewage input reduced to zero
Black-headed Gull	none identified	-23%
Common Gull	none identified	-29%
Lesser Black-backed Gull	no. of sewage outfalls (+ve)	-100%
Herring Gull	no. of sewage outfalls (+ve) degree of urbanisation (-ve)	-61%
Great Black-backed Gull	width of river (+ve) no. of sewage outfalls (+ve) degree of urbanisation (+ve)	-100%
Kittiwake	distance from nearest breeding colony (-ve)	+85%

* $P < 0.05$

In this study Fitzgerald & Coulson (1973) found that the majority of Black-headed and Herring Gulls feeding on the wing along the river fed at sewage outfalls. Although all other species were observed feeding at such sites, more individuals fed elsewhere. Kittiwakes fed rarely on the river, occasionally dipping for small items of food near the outfall at the Fish Quay through which fish waste was discharged. Herring Gulls fed mainly on spilled fish and offal and 70% of the birds of this species seen feeding at outfalls were at the Fish Quay outfall. Herring Gulls also scavenged on refuse, carrion and offal along the tideline and fed at outfalls upriver. Great Black-backed Gulls took on large pieces of offal from outfalls and the Fish Quay and also fed on carrion stranded on the tideline. Lesser Black-backed Gulls were never seen feeding along the tideline, taking mainly offal from the Fish Quay and sewage outfalls. Fewer Black-headed and Common Gulls fed at the Fish Quay outfall due to competition from the larger species, preferring to feed at other outfalls upstream and exposed mud and rocks along the tideline.

5.2.3 Improvements to sewage treatment

Construction of the new Tyneside sewage system started in 1973. An interceptor sewer was built along each bank of the river, and along the coast north of the river, to take sewage from the old system to a treatment works at Howdon which was opened in 1980. Here sewage undergoes preliminary and primary treatment, reducing the organic load by 60%, before the treated water is discharged into the river and the sludge resulting from the treatment process is dumped at sea, 10-13km from the coast (S. Clark, pers. comm.). The result of these improvements was to significantly decrease the pollution of the river, to the extent that Salmon now pass through the estuary on their way upstream (S. Clark, pers. comm.).

5.3 Methods

The present study was carried out from October 1993 to September 1994 and, in order to ensure that a comparison between the data from the two studies could be made, the procedure of the 1969/70 survey was repeated as precisely as possible. With the co-operation of the Port of Tyne Authority the survey was again carried out by boat. The same study area and section boundaries were used, and the trips carried out at the same time of day, but trips were made more frequently, usually once a week.

The only major difference arose due to the fact that the Swing Bridge at Newcastle (the boundary between sections 9 and 10) no longer opened to allow the passage of large boats further upriver. This meant that the patrol boat used for the survey could pass through to the upper reaches of the study area only at low tide. In addition to this, mechanical problems with this boat meant that for a four-month period, and other occasional trips, a larger boat had to be used which could not pass under the Swing

Bridge, even at low tide. Therefore the majority of trips covered only sections 1 to 9 of the study area.

In order to investigate the factors influencing the distribution of gulls along the stretch of the river under study, stepwise multiple regression was again employed. As far as possible, the same variables were used as in the 1969/70 survey (Fitzgerald 1970), however, some changes were made to ensure all data were appropriate for use in multiple regression. Each species was considered separately and the dependent variable was the mean number of gulls seen per km in a section during the months that the species was present on the river. The independent variables investigated for their possible influence on the distribution of gulls were; the average width of the river, the area of mud exposed at low tide, the degree of urbanisation of the banks, the distance upstream, the volume of untreated and treated sewage discharged, the number of outfalls and, for those species for which it was appropriate, the number of breeding pairs in a strip 0.5km wide along each bank of the river. The last variable was used in place of the distance to the nearest breeding colony used in the 1969/70 analysis because, by 1993/94, it was difficult to define separate colonies of nesting Herring Gulls and Lesser Black-backed Gulls along the banks of the river. In 1993/94, the number of outfalls was omitted from the analysis due to its extremely high correlation with the input of untreated sewage ($r = 0.96$, $n = 9$, $P < 0.001$).

The area of mud exposed at low tide was estimated from Ordnance Survey maps. The degree of urbanisation of the banks was estimated, from observations, as the proportion of the banks that were developed and actively used. The data concerning sewage input were obtained from Northumbrian Water and the Environment Agency. Only major outfalls, those discharging more than $300m^3$ per day, were included. The figures for the number of breeding pairs were obtained from surveys carried out for the roof-nesting gull survey described in Chapter 2 and additional observations of the ground nesting gulls in this area.

5.4 Results

5.4.1 Changes in sewage input since 1969/70

By 1993/94, 97% of Tyneside's domestic and industrial waste was treated at Howdon (Northumbrian Water) instead of being discharged straight into the river or sea. The remaining 3%, from sites between the river and the interceptor sewer which had not yet received pumping stations to transport their sewage up to the main sewer, was still discharged untreated. In most cases the amount discharged was small and only 12 outfalls along the entire tidal reaches had discharges considered significant (> 300 m^3/day) (Northumbrian Water).

In the study area itself, the input of untreated sewage decreased by 91% from 150,227 m^3/day in 1969/70 to 13,659 m^3/day in 1993/94. Figure 5.2 shows that in all sections a reduction in the discharge of untreated sewage has occurred. This reduction has been greater in sections 10-14, upstream of the Swing Bridge at Newcastle (97%), than in sections 1-9 downstream of the bridge (86%). By 1993/94, half of the study sections received no significant input of untreated sewage, including section 8 into which the largest volume, 26,000 m^3/day of domestic sewage and waste meat from an abbatoir, was discharged in 1969/70 from the Ouseburn outfall.

5.4.2 Other changes on the river since 1969/70

In addition to the improvements to sewage treatment, there have been other changes on the River Tyne since 1969/70. The decline of heavy industries has led to the closure of many shipyards and industries along the banks; the Quayside at Newcastle is no longer used for berths and many buildings are now derelict, whilst others have been demolished and the banks left as open space or redeveloped for new industry or housing. The tidal mudflats of Jarrow Slake, previously the major gull roost on the river (Rollin 1928, 1931a, Fitzgerald & Coulson 1973), have been reclaimed and developed as the Port of Tyne's coal and car terminal. River traffic has decreased. In 1970, 6,500 vessels entered the river, however, by 1993 this figure had approximately halved (Captain A. Nelson, pers. comm.).

In 1969/70 only two species of gull, the Herring Gull and the Kittiwake, bred on Tyneside. In 1976, Lesser Black-backed Gulls were recorded nesting for the first time,

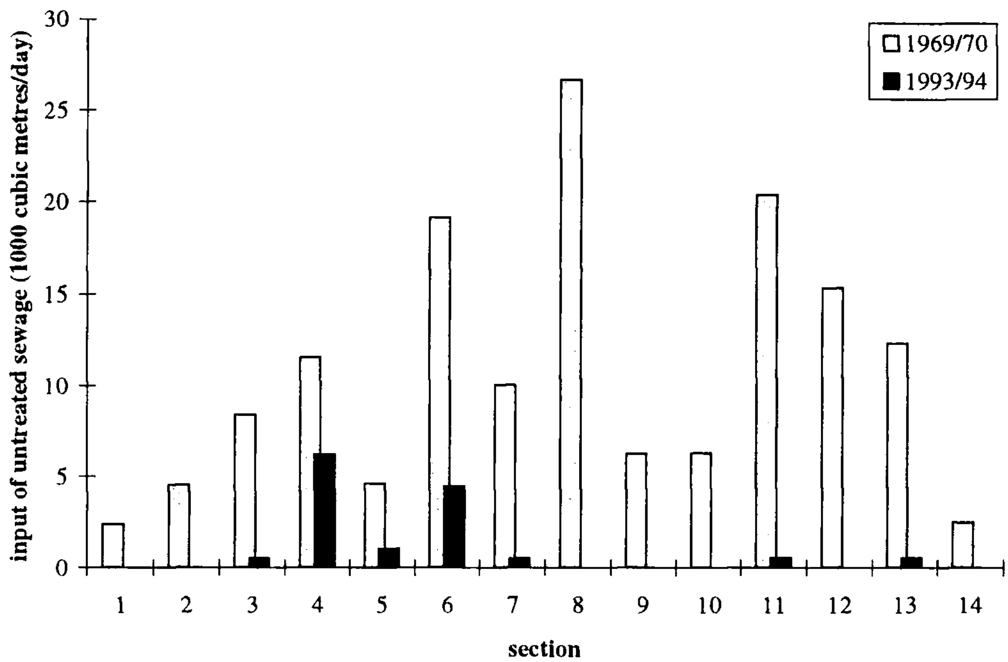


Figure 5.2: The input of untreated sewage to the study sections of the River Tyne before and after improvements to sewage treatment.

on buildings in South Shields and Newcastle (Monaghan & Coulson 1977), and by 1994, there was a minimum of 25 pairs of this species nesting on Tyneside, all on buildings, frequently with Herring Gulls (Chapter 2). Some nested in the centres of Newcastle and South Shields, but most were found on the roofs of large buildings along the river banks.

In the summer of 1969, prior to the start of the 1969/70 survey, a total of 27 pairs of Herring Gulls were recorded nesting on Tyneside, on buildings in North and South Shields (Monaghan & Coulson 1977). In the intervening years, numbers have risen steadily, new areas have been colonised and, in 1994, 551 pairs were found nesting on Tyneside, the majority on buildings (Chapter 2). The average annual rate of increase in this period has been 12.3%. The main concentrations were in South Shields, Newcastle and North Shields but large numbers of birds also nested on riverside buildings.

During the breeding season of 1970 there were three Kittiwake colonies (North Shields warehouse, Baltic Flour Mill - Gateshead, Newcastle Quayside warehouse) along the River Tyne study area (Fitzgerald 1970), supporting a total of 199 pairs (Cramp 1971, Galloway *et al.* 1971). Since then the warehouse in Newcastle has been demolished but three extra buildings have been colonised; a loading structure at the Port of Tyne Ferry Terminal, the International Paints factory at Felling and a building next to the Tyne Bridge, Newcastle. In 1994, the number of pairs nesting in the study area was estimated at 423 (pers. obs.), an average annual rate of increase of 3.1% since 1970. While in 1970 the majority of Kittiwakes on the River Tyne were nesting on the warehouse at North Shields, by 1993/94, the Baltic Flour Mill in Gateshead, the colony furthest inland, was by far the largest, with 49% of the pairs nesting along the river.

5.4.3 Use of the river by gulls in 1993/94

Of the 50 survey trips made during the 1993/94 survey period, only eleven (22%) covered the full study area. These eleven were not equally distributed throughout the year, as no full trips could be made between mid-January and mid-May. The following analysis therefore considered only the data for sections 1 to 9 (14km), which are available for 49 trips.

The six species of gull observed in the 1969/70 study were still found to be feeding on the River Tyne in 1993/94. The seasonal pattern of usage varied between these species, with Black-headed, Common and Great Black-backed Gulls present mainly outside the breeding season, Lesser Black-backed Gulls and Kittiwakes found only during the breeding season and Herring Gulls present all year round (Figure 5.3).

5.4.3.1 Black-headed Gull

The Black-headed Gull was the commonest gull in the study area during the winter months. Numbers peaked during January (monthly mean ± sd = 806.0 ± 206.4), then declined as birds left for their breeding grounds. This species does not breed in the vicinity of the study area so except for a few individuals, mostly immatures, it was not seen from April to June. Birds began to return in late June, including a few juvenile birds, and numbers rose steadily through the autumn months. The number of immature birds recorded during the winter months of this survey was underestimated due to the difficulty of identifying them in large flocks, therefore, 21 counts were carried out on land at the Fish Quay. From October 1993 to the end of March 1994, on average 18% of the Black-headed Gulls here were immature. 15 counts carried out on the return journey of the survey trip in this period suggested that the proportion of immatures was less here at 10%.

5.4.3.2 Common Gull

This species was also a winter visitor to the study area, but in far lower numbers than the Black-headed Gull. The largest numbers were found during trips in February (monthly mean ± sd = 105.0 ± 89.3) during a period of cold weather and heavy snow. Common Gulls do not breed in this area and in May and June only one bird, in each case an immature, was seen per trip. Few birds were seen in the rest of the study period, with no sign of the large flocks on passage that are seen on the coast at this time (Durham Bird Reports).

5.4.3.3 Lesser Black-backed Gull

The Lesser Black-backed Gull was absent from the river during the winter months. Although many British breeders now overwinter in the south-west of Britain instead of migrating to the Iberian peninsula and north Africa (Lack 1986), few do so in north-east England and the first bird was seen on the River Tyne on 3 March. Numbers increased during this month and from April to August remained fairly constant: the mean number

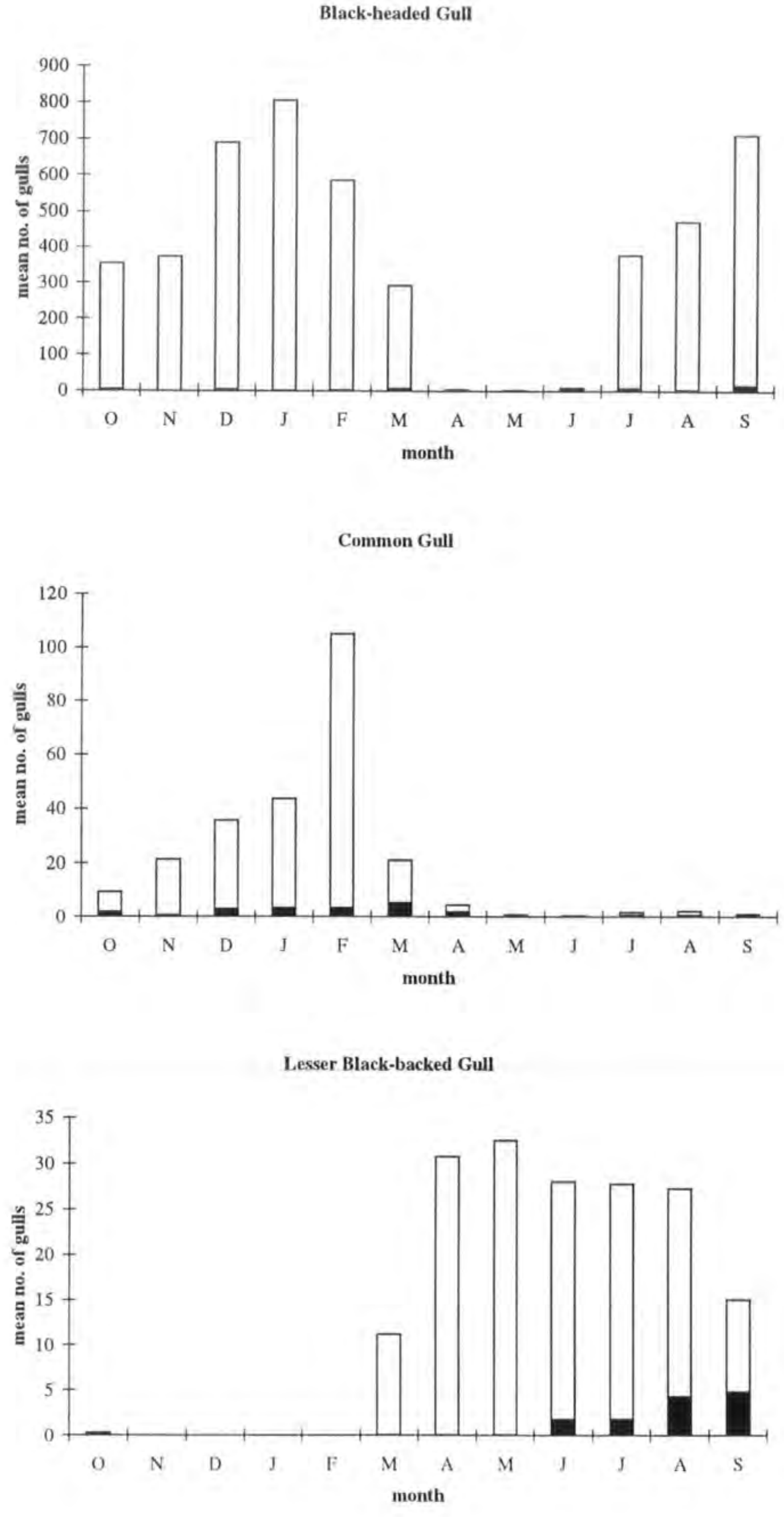


Figure 5.3: Mean numbers of gulls seen per trip in sections 1 to 9 of the River Tyne study area in each month of the 1993/94 survey. Solid shading indicates immature individuals.

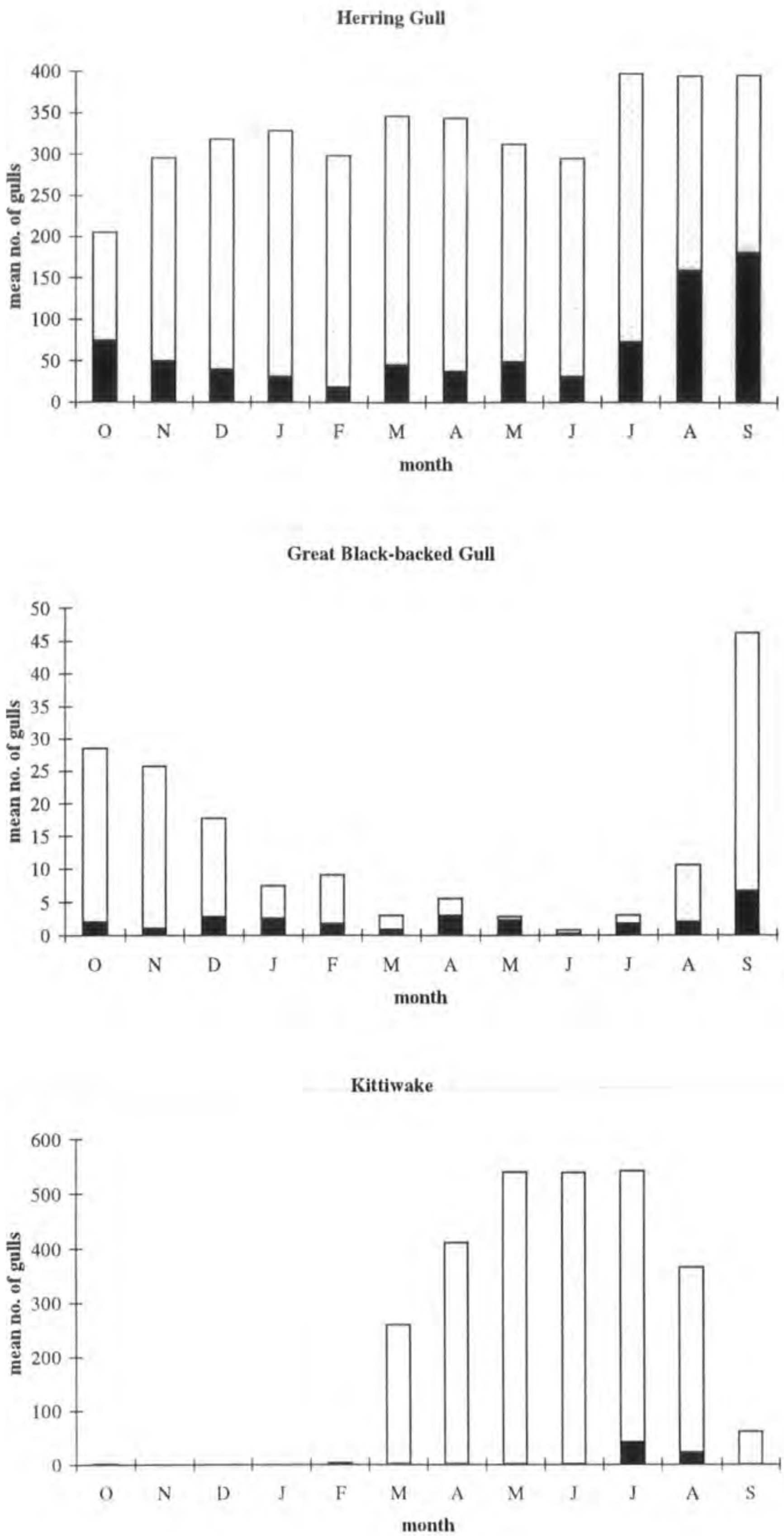


Figure 5.3: (continued)

seen per trip (± sd) was 29.4 ± 7.8 birds. By September numbers had dropped as birds left for their wintering areas. From June to September small numbers of third summer birds were seen in the study area. It was impossible to distinguish between newly fledged Herring and Lesser Black-backed Gulls during the survey, and so, due to the far greater numbers of nesting Herring Gulls present, all juveniles were recorded as this species. The number of immature Lesser Black-backed Gulls recorded in August and September was thus likely to be an underestimate.

5.4.3.4 Herring Gull

Herring Gulls were present in large numbers throughout the study period, with immature individuals constituting an average of 20% of these birds over the year. The lowest numbers were observed in October, but from November until the end of June numbers remained fairly constant (mean ± sd = 317.8 ± 69.2), then increased in July to remain high (396.7 ± 78.5) until the end of the study period. The increases from July onwards were due to the large numbers of juvenile birds present, newly fledged from nests along the river.

5.4.3.5 Great Black-backed Gull

Of the four species using the river during the winter months, the Great Black-backed Gull was the least common in the study area, however, larger numbers frequented the Fish Quay at North Shields (pers. obs.). Numbers declined from October over the winter and through the spring. During the breeding season, as this species does not breed in this area, only a few individuals were seen, mainly immature birds. From July, numbers began to rise again and the highest numbers of the study period were observed in September (monthly mean ± sd = 46.3 ± 43.9).

5.4.3.6 Kittiwake

During the winter months no Kittiwakes were seen in the study area, although individuals were present at the North Shields Fish Quay in every month of the year (pers. obs.). The first birds were seen upriver on 3 February, numbers then increasing until May from when numbers remained approximately constant until July and the mean number of birds seen per trip was 540.2 ± 66.7 (sd). During the breeding season the Kittiwake was the commonest gull in the study area. From August onwards the number of birds declined as they left the area. The immatures present in July and August were newly fledged juveniles, presumably from the river colonies, however, from the end of February, a first summer bird was seen in the study area on several occasions.

5.4.4 Comparing abundance - 1969/70 and 1993/94

During the 1969/70 study period, 18 survey trips were made. In five of these trips (28%) section 1, nearest the river mouth, was not surveyed and in one of these five trips, no data were collected for section 3. In order to use as many data as possible in the comparison between surveys, the trip with data missing for two sections was excluded and the analysis was carried out using the data for sections 2-9 from the remaining 17 trips. The number of gulls seen in this stretch of the river per survey trip in 1969/70 and 1993/94 are shown for each species in Figure 5.4.

In order to evaluate the changes in the abundance of each gull species between 1969/70 and 1993/94, the periods of the year when a species was totally, or virtually, absent from the river were excluded from the analysis. The periods analysed involved the non-breeding season, July to March, for Black-headed, Common and Great Black-backed Gulls and the breeding season, April to August for Lesser Black-backed Gulls and Kittiwakes. Herring Gulls were present throughout the study period.

The mean number of gulls seen per trip during these periods was calculated for 1969/70 and 1993/94 (Table 5.2). The mean number of gulls of all species using sections 2-9 of the study area has not changed significantly between the two surveys (t test for unequal variances, $t_{17.5} = -0.27$, $P > 0.05$). If individual species are considered however, appreciable changes have taken place. The most pronounced changes have occurred in the mean numbers of Lesser Black-backed Gulls and Kittiwakes, which have both shown large increases, especially the latter. These changes meant that the frequency distribution of the survey data was radically different in the two surveys and so a robust rank-order test (Siegel & Castellan 1988) was used to test the significance of these changes. Both were found to be highly significant (LBBG; $U = -10.45$, $P < 0.001$: KW; $U = -8.65$, $P < 0.001$). Both Common and Great Black-backed Gulls showed a decrease in mean numbers of about 90%, changes which were highly significant (t tests for unequal variances, CG; $t_{32.98} = 8.31$, $P < 0.001$: GBBG; $t_{18.99} = 2.51$, $P < 0.001$). These decreases were particularly marked at certain times of year (Figure 5.4), especially late

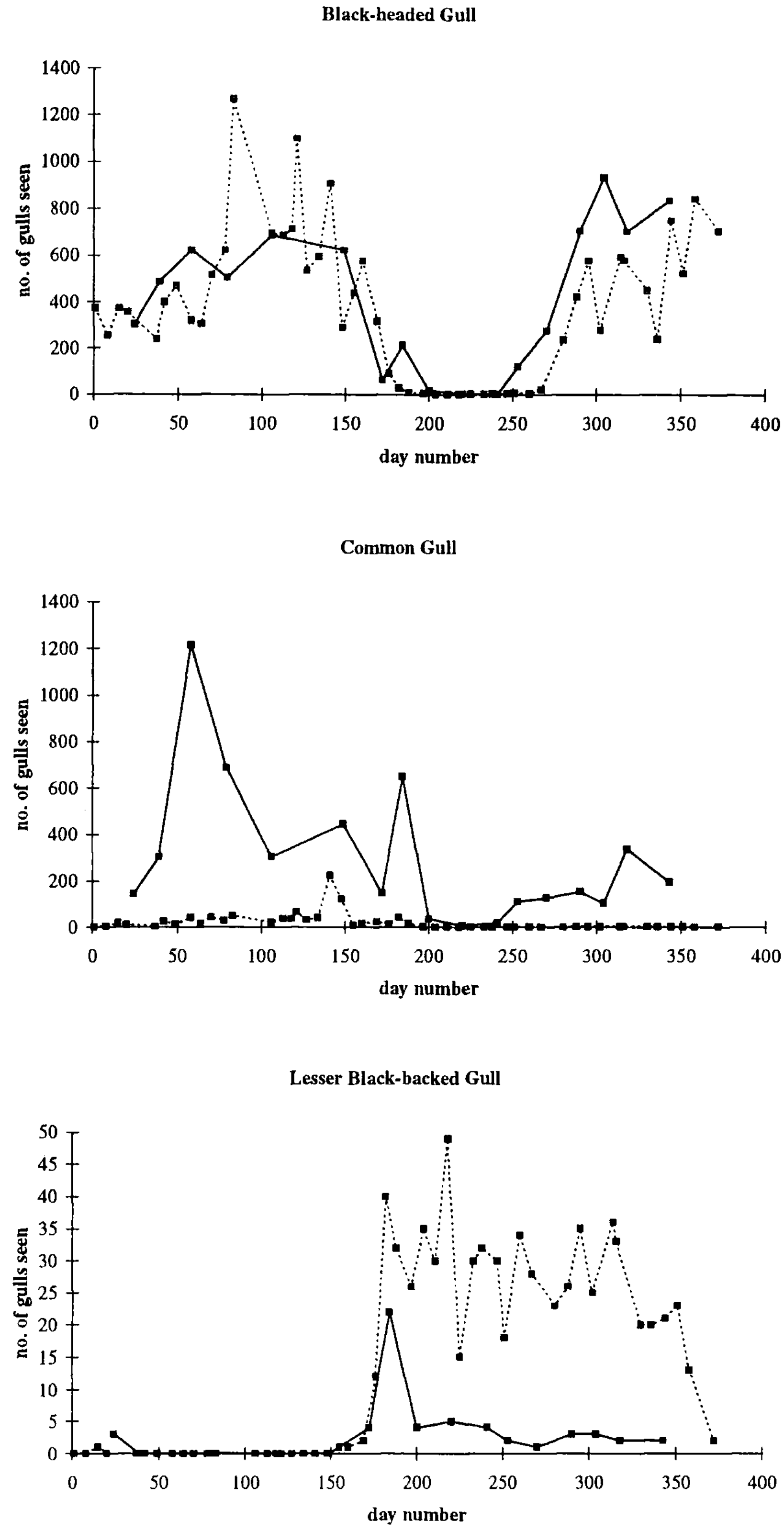


Figure 5.4: Numbers of gulls seen in sections 2 to 9 of the River Tyne study area on each trip in 1969/70 (solid line) and 1993/94 (dotted line). Day 1 is 1 October.

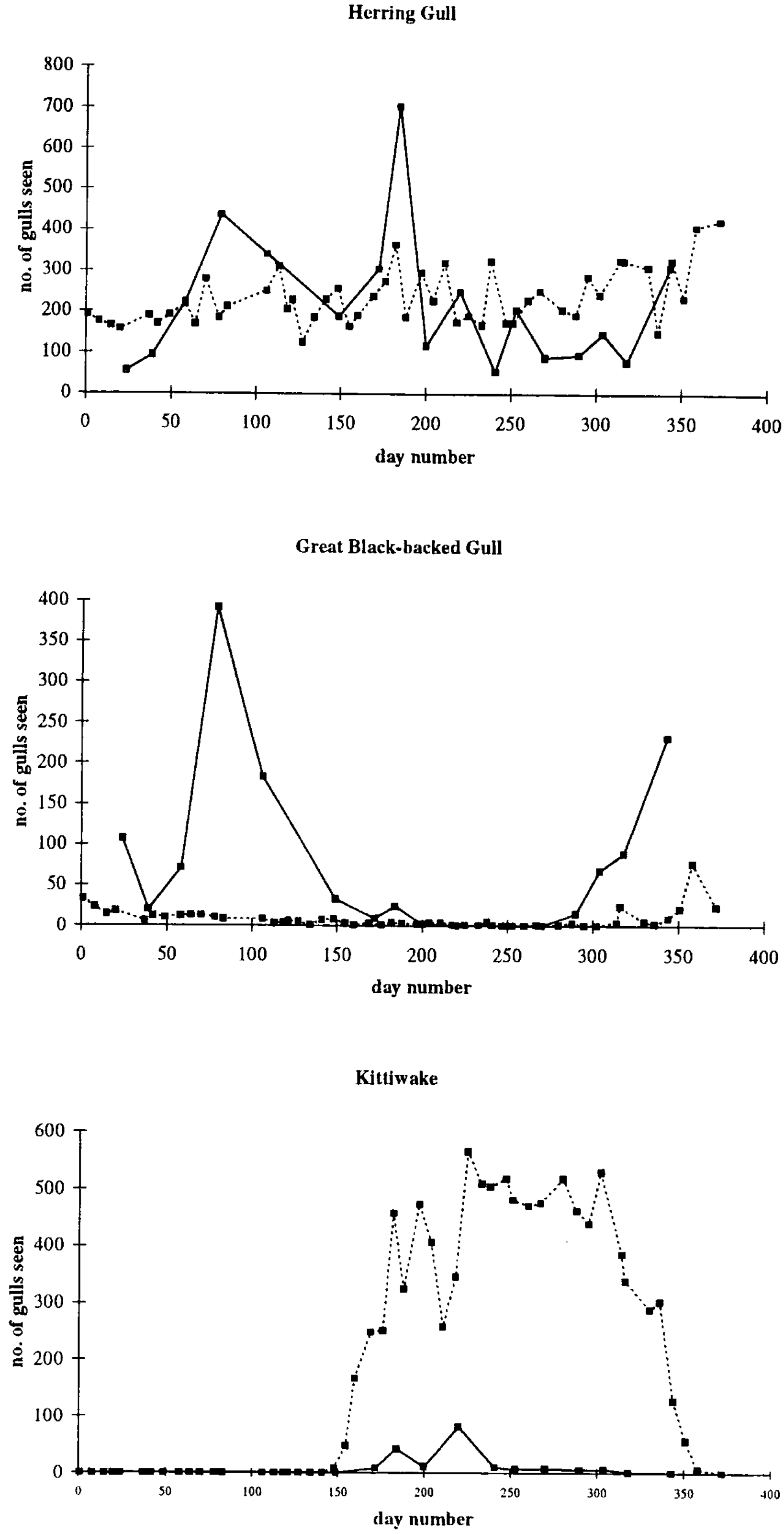


Figure 5.4: (continued)

November/early December. In 1993/94, numbers of Common Gulls did not increase after the end of the breeding season as happened in 1969/70. The mean number of Herring Gulls using the study area did not change significantly between the surveys (t test for unequal variances, $t_{17.64} = -1.57$, $P > 0.05$), nor did the mean number of Black-headed Gulls (t test for equal variances, $t_{64} = 0.41$, $P > 0.05$).

Table 5.2: Changes in the mean number of gulls seen per trip in sections 2-9 of the River Tyne between the surveys of 1969/70 and 1993/94. These figures are for the period of the year when the species is present on the river (see text). The figure for total gulls is for the entire year.

	Mean no. of gulls seen per trip			
Species	1969/70	1993/94	Percentage change	P
Black-headed Gull	588.64	504.43	-14.31	n.s.
Common Gull	367.45	25.65	-93.02	***
Lesser Black-backed Gull	4.80	26.50	+452.08	***
Herring Gull	216.71	233.49	+7.74	n.s.
Great Black-backed Gull	110.82	10.68	-90.36	*
Kittiwake	17.30	366.67	+2019.48	***
Total gulls	1015.47	861.53	-15.16	n.s.

n.s. = P > 0.05, * = P < 0.05, ** = P < 0.01, *** = P < 0.001

The predictions in Table 5.1, made by Fitzgerald & Coulson (1973) considered the situation which would arise if the input of untreated sewage to the river was reduced to zero. These predictions should be treated with caution as equations generated by regression should only be confidently used for prediction within the range of the sample data. In this case, a value of zero sewage is far below any of the samples used in the analysis. In addition, the predictions were generated using data from the whole study area whilst data from only part of this area were available to calculate the changes in numbers.

In fact, by 1993/94, the input of untreated sewage to the area for which comparative data were available for the two surveys (sections 2-9) had been reduced only by 86%, so it was not possible to compare the observed changes with those predicted. However, it is evident that the decreases in the numbers of Common Gulls and the increases in the numbers of Kittiwakes were more extreme than predicted. The numbers of Herring Gulls and Lesser Black-backed Gulls did not decrease as predicted; numbers of the former did not change while numbers of the latter increased considerably. The decreases observed in the numbers of Black-headed Gulls and Great Black-backed Gulls are slightly less than predicted, as might be expected by a smaller reduction in untreated sewage input than that used by Fitzgerald & Coulson (1973) to generate the predictions in Table 5.1.

5.4.5 Sections 10-14

In order to determine whether the changes in numbers observed in sections 2-9 of the study area could be taken as representative of the whole original study area, those trips in 1993/94 when the full length of the survey area was counted were compared to those carried out at a similar time in 1969/70. The changes in numbers in sections 10-14 were compared with those for sections 2-9 (Table 5.3).

Table 5.3: Details of changes in numbers of gulls seen in sections 2-9 and sections 10-14 of the study area between 1969/70 and 1993/94.

Section	Reduction in untreated sewage input	Change in numbers of gulls seen per trip					
		BHG	CG	LBBG	HG	GBBG	KW
2-9	86.1%	-35.3%	-98.9%	+585.7%	-28.8%	-90.1%	+925.3%
10-14	98.2%	+43.7%	-91.1%	+233.3%	-51.1%	-74.7%	-100%

In the case of those species present in the winter months, counts from the period October to December were compared. In the summer of 1993/94, only two counts including sections 10-14 were made and so, for those species present only in the summer, these were compared with the two counts in 1969/70 carried out nearest these dates.

Except for the Common Gull, for which the decrease in numbers was similar in both sections of the river, in all cases the changes observed in the downstream sections were not the same as further upstream. The increases seen in Kittiwakes and Lesser Black-backed Gulls in sections 2-9 were not matched by the increases further upstream and, in the case of the Kittiwake, none were observed further upstream than the Swing Bridge at Newcastle in 1993/94. The numbers of Herring Gulls decreased more in the upriver sections, while the numbers of Great Black-backed Gulls decreased more downstream. Black-headed Gulls showed an increase in numbers in the sections of the river downstream, but a decrease further upstream.

The use of fewer survey trips means that these values for sections 2-9 vary from those in Table 5.2. For most species this is minimal, but for the Herring Gull, the change is in the opposite direction. This variation along the study area is considered further below in section 5.4.6.

5.4.6 Comparing distribution - 1969/70 and 1993/94

In order to compare the spatial distribution of gulls along the study area in the two surveys, the mean number of gulls seen per trip was calculated for each of the sections 2 -9 in each year (Figure 5.5).

The decrease in the number of Common Gulls occurred, to a varying degree, in all sections of the river. However, that observed in Great Black-backed Gulls occurred predominantly in section 3. The Lesser Black-backed Gull was most commonly seen in sections 4 and 5, part of the river where it was seen least in 1969/70. The increase in Kittiwake numbers was localised, occurring in only a few sections of the river (2,6 and 9). Even in those species where no significant difference was found in the overall numbers of gulls using the river in 1969/70 and 1993/94, it appears that changes in distribution have occurred. During this period there was a pronounced decline in the

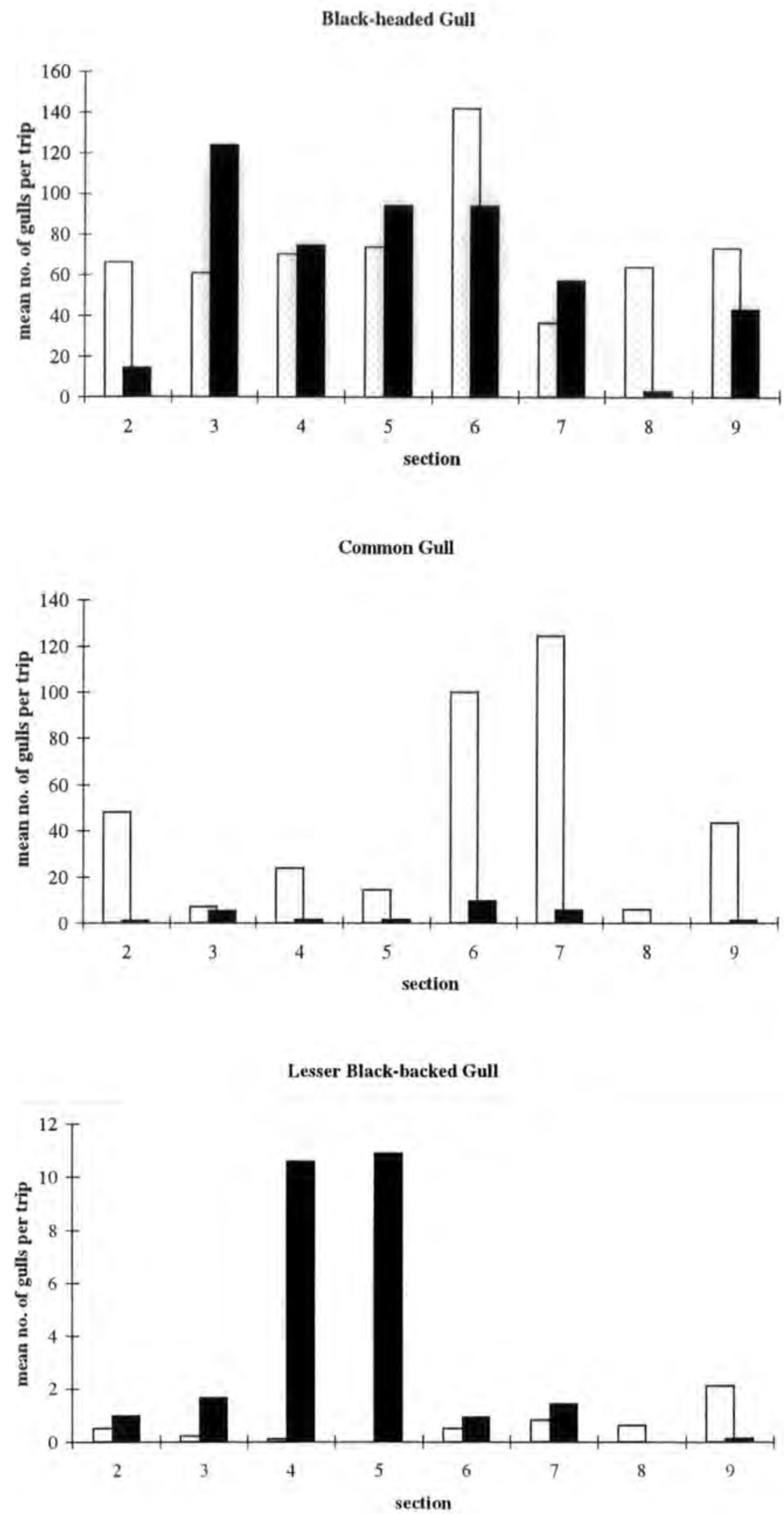


Figure 5.5: Changes in the mean number of gulls seen per km in each of the River Tyne study sections 2 to 9 between 1969/70 (light bars) and 1993/94 (dark bars).

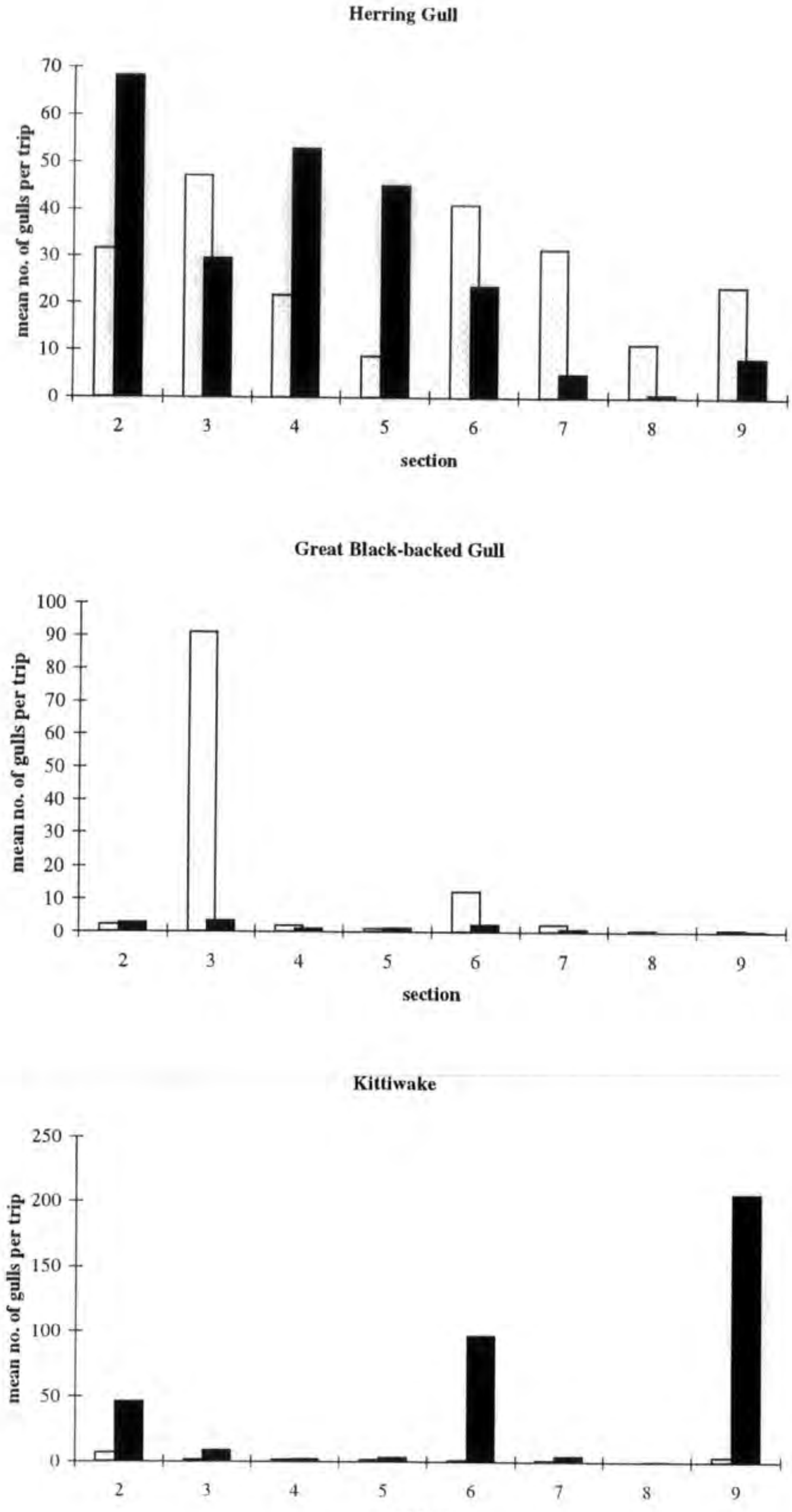


Figure 5.5: (continued)

numbers of Black-headed Gulls found in section 8. This was also found for Herring Gulls as part of a general trend of numbers dropping upstream and increasing nearer the river mouth.

5.4.7 Factors affecting the distribution of gulls in 1993/94

Details of the data used in stepwise multiple regressions to investigate the possible factors influencing the distribution of the six gull species are given in Table 5.4. It was not possible to ascertain the effect of the input of treated sewage on gull distribution as the data proved unsuitable for this type of analysis. Treated sewage enters the river only from the Howdon treatment works in section 3, where 250,000 m^3 is discharged per day. When considering the following analysis it must be borne in mind that significant correlations were found between some of the variables. The distance upstream was negatively correlated to the width of the section ($r = -0.93$, $n = 9$, $P < 0.001$) and also, in the case of the Herring Gull, to the number of breeding pairs ($r = -0.81$, $n = 9$, $P < 0.01$). There was a positive correlation between the number of pairs of breeding Lesser Black-backed Gulls in a section and the amount of untreated sewage entering a section ($r = 0.73$, $n = 9$, $P < 0.05$).

The results of these analyses are given in Table 5.5. The distributions of both Black-headed Gulls and Common Gulls are significantly, and positively, affected by the area of mud exposed at low tide. In the case of the Common Gull, the degree of urbanisation of the banks also plays a significant role, with numbers of this species being higher in the less developed parts of the river. The distributions of both Herring and Great Black-backed Gulls are significantly influenced by the distance upstream. In each case this is a negative relationship, with numbers decreasing further upstream. No other factors were found to be significant in explaining the distributions of these species. In the case of the Lesser Black-backed Gull and the Kittiwake, the distribution of breeding birds was found to have a significant and positive relationship with the distribution of birds along the river. A secondary factor influencing the number of Kittiwakes was the distance upstream, this variable having a negative effect on the numbers of birds.

The adjusted R^2 values produced by the multiple regressions for each species except one indicate that the majority of the variation in numbers was explained by variation in the factors investigated. The value from the analysis of Black-headed Gull numbers was

Table 5.4: Details of characteristics of sections 1 to 9 of the River Tyne study area in 1993/94.

	Mean no. of gulls per km											Number of breeding pairs		
Section	BHG	CG	LBBG	HG	GBBG	KW	Mean width (km)	Area of exposed mud (m^2)	Degree of urbani-sation	Distance upstream (km)	Input of untreated sewage (m^3/day)	LBBG	HG	KW
1	11.28	1.22	0.55	136.8	8.35	61.42	0.36	600	0.60	1.15	0	3	128	45
2	8.73	0.63	0.59	42.09	1.58	28.40	0.35	2,400	0.75	2.30	0	1	68	42
3	90.47	3.93	1.19	21.53	2.33	6.17	0.42	103,400	0.65	3.80	492	0	22	0
4	44.09	0.91	6.23	31.22	0.54	1.15	0.25	12,100	0.70	5.33	6,191	7	40	0
5	77.95	1.18	8.99	37.38	0.87	2.89	0.31	25,300	0.70	6.79	1,013	4	16	0
6	25.94	2.62	0.25	6.48	0.59	26.56	0.21	49,000	0.40	9.21	4,450	2	9	90
7	23.50	2.28	0.58	2.05	0.27	1.65	0.15	22,100	0.33	12.25	490	0	0	0
8	16.04	0.18	0.00	3.67	0.18	0.83	0.14	1,275	1.00	13.54	0	0	0	0
9	35.38	0.95	0.10	6.89	0.09	168.82	0.13	7,225	1.00	14.22	0	0	1	246

Table 5.5: Results of stepwise multiple regression analyses of factors influencing the distribution of gulls on the River Tyne in 1993/94.

Species	Step number	Variable	β	F	d.f.	P	adjusted R^2
Black-headed Gull	1	area of exposed mud	6.39×10^{-4}	8.04	1,7	< 0.05	0.47
Common Gull	1	area of exposed mud	3.27×10^{-5}	41.71	1,7	< 0.001	0.84
	2	degree of urbanisation	-1.69	58.28	2,6	< 0.001	0.93
Lesser Black-backed Gull	1	breeding numbers	0.32	10.88	1,7	< 0.05	0.55
Herring Gull	1	distance upstream	-0.10	28.73	1,7	< 0.01	0.78
Great Black-backed Gull	1	distance upstream	-0.05	15.92	1,7	< 0.01	0.65
Kittiwake	1	breeding numbers	0.01	14.52	1,7	< 0.01	0.63
	2	distance upstream	-0.08	30.13	2,6	< 0.001	0.88

slightly less than the others and so it is possible that at least one other factor, not used in this analysis, has an important effect upon the distribution of this species, for example grassland.

5.5 Discussion

The results of this study show that in the period between these two surveys, significant changes have taken place in the abundance and distribution of the gull species using the study area on the River Tyne. During this period the amount of untreated sewage entering this stretch of the river was reduced by about 91%, however, other changes have taken place which may have affected gull numbers and distribution.

It is thought that the Black-headed Gulls breeding in Britain remain in this country over winter but that the population is augmented at this time by birds from northern Europe (Flegg & Cox 1972). 47% of the recoveries of this species from north-east England were of continental breeding birds (MacKinnon & Coulson 1987). No significant change was found between the numbers of Black-headed Gulls using sections 2-9 of the study area in 1969/70 and in 1993/94. In the initial study, none of the factors investigated were found to significantly influence the distribution of this species. However, the majority of birds observed feeding in the study area were doing so at outfalls, predominantly the outfall at Ouseburn, suggesting that untreated sewage was an important source of food for Black-headed Gulls (Fitzgerald 1970). Therefore the lack of a response to the decline in the availability of untreated sewage is perhaps surprising.

However, in 1969/70, Black-headed Gulls were also seen feeding at other sources, such as mudflats. The 1993/94 study provided evidence suggesting that, in response to the decline in untreated sewage, Black-headed Gulls have switched to these other sources. Further evidence for this comes from the fact that in 1969/70, the distribution of this species was concentrated in section 8, around the Ouseburn outfall, the largest on the river. In 1993/94, however, nothing was discharged from this outfall and such a concentration was no longer found, the birds being distributed more evenly between the sections of the river.

In 1993/94, the amount of mud exposed at low tide was shown to significantly and positively influence the distribution of Black-headed Gulls. Elsewhere, this species is known to feed in large numbers on estuarine mudflats (Crook 1953, Vernon 1970, 1972, Mudge & Ferns 1982a, Curtis *et al.* 1985) on intertidal invertebrates such as *Nereis diversicolor*. However, this relationship was complicated by the fact that section 3, which had the largest expanse of exposed mud, was also the site where the treated sewage from the Howdon works was discharged. Black-headed Gulls fed in large numbers at this outfall and therefore this cannot be eliminated as a cause of the attraction of this part of the river. In all probability, the two factors are inextricably linked at this site as, on an ebbing tide, particles from the outfall would be left stranded on the mud, available to the gulls in addition to the invertebrates naturally there.

As the Common Gulls breeding in Britain tend to move south and west to overwinter (Radford 1960), it is probable those wintering on the River Tyne are some of the large numbers of birds from Scandinavia, Denmark and Germany which overwinter in Britain (Vernon 1969). Between 1969/70 and 1993/94, the numbers of Common Gulls observed on the River Tyne decreased by 93%. In 1969/70, no factor investigated was found to affect the distribution of this species (Fitzgerald 1970) however, they were observed to feed at outfalls, as well as on mudflats (Fitzgerald & Coulson 1973). The observed decrease is far higher than that predicted by Fitzgerald & Coulson (1973) for a cessation in the input of untreated sewage, suggesting that another factor may be responsible.

This drop in numbers is unlikely to be explained by a large decline in the numbers of Common Gulls wintering in Britain as, during this period, the numbers wintering inland have increased, and although a small decrease in the numbers wintering around the coast was seen between 1983 and 1993 (Waters 1994), this could hardly account for the drop in numbers observed. Common Gulls tend to winter inland, moving to estuaries and the coast only in periods of severe weather (Cramp & Teagle 1955, Vernon 1970) and therefore it may be the case that the higher numbers observed in the winter of 1969/70 were due to it being colder in that year. The fact that the decline in numbers occurred over the whole length of the study area suggests a large scale factor such as climate may be responsible rather than a local factor which varies along the length of the study area.

In 1993/94 it was found that the distribution of the few Common Gulls present was correlated positively with the amount of exposed mud at low tide and negatively by the degree of urbanisation of the banks. For the reasons described in section 4.5.1, treated sewage may also be important in determining the distribution of this species and indeed, individuals were seen to feed at the Howdon outfall. The attraction of the less urbanised area of the study area may be due to the areas of grassland there which Common Gulls are known to prefer (Rollin 1931b, Crook 1953, Vernon & Walsh 1966, Vernon 1970, Mudge & Ferns 1982a, Jones 1985).

In 1969/70, the distribution of the few Lesser Black-backed Gulls observed in the study area was found to be positively influenced by the number of sewage outfalls; sites at which they were observed to feed. However, between the two surveys, numbers did not decrease as might be expected in response to a reduction in food availability, but increased by over 400%. Clearly the reduction in the input of untreated sewage had little effect on this species.

During the study period, the numbers of Lesser Black-backed Gulls breeding in Britain and Ireland have increased a great deal (Lloyd *et al.* 1991), as have the numbers nesting on buildings, and the number of towns where this occurs (Monaghan & Coulson 1977, Chapter 2). Nesting on buildings by this species did not occur on Tyneside in 1969/70 as the first such report was in the 1970s. In 1993/94, as Lesser Black-backed Gulls were usually seen on the riverside buildings on which they nested, it is probable that the increase in numbers observed on Tyneside was a result of the expansion of this species seen on a national scale (Chapter 2). Those birds seen in 1969/70 must have been birds on passage or non-breeders, which took advantage of the sewage as a food source. It appears that this source of food, and indeed others available along the river, were not essential as no Lesser Black-backed Gulls were observed feeding on the river in 1993/94, despite the presence of breeding pairs along the banks.

In 1969/70, it was found that the distribution of Herring Gulls along the River Tyne study area was influenced positively by the number of sewage outfalls and negatively by the degree of urbanisation. The majority of Herring Gulls seen feeding in the study area were at outfalls. However, between 1969/70 and 1993/94, despite the large reduction in the amount of untreated sewage available as food, the numbers of this species did not change significantly.

Between 1969-70 and 1985-87, the number of Herring Gulls nesting on the coasts of Britain and Ireland declined by almost 50% (Lloyd *et al.* 1991). It is thought that the birds wintering in north-east England include birds breeding locally (Coulson & Butterfield 1986), birds breeding on the east coast of Scotland (Coulson & Butterfield 1985) together with birds of the subspecies *L. argentatus argentatus* which breed in northern Norway and make up almost 25% of the wintering population in north-east England (Coulson *et al.* 1984b). Breeding numbers in Norway have also declined between the two surveys (Lloyd *et al.* 1991).

With the decline in overall breeding numbers in Britain and the reduction in the availability of sewage as a food source on the River Tyne, the fact that the numbers of Herring Gulls observed in the study area did not decline between 1969/70 and 1993/94 is therefore of interest. However, the number of Herring Gulls nesting on buildings in Britain has continued to increase in recent years (Chapter 2). Between the two surveys, the numbers of this species nesting on buildings on Tyneside has increased by an average of 12.3% annually.

The distribution of Herring Gulls along the study area had changed by 1993/94, with birds moving away from the upper sections, in particular section 8 into which no untreated sewage was now discharged, towards the river mouth. This new distribution was confirmed by the negative relationship found between the distance upstream and the numbers of this species observed. There are several potential explanations for the attraction of the river mouth. The majority of breeding birds were found in North and South Shields, the towns at the mouth of the river and many feed at the Fish Quay in North Shields. In addition, the nearby coastline and sea provide many feeding opportunities. Herring Gulls have been observed feeding where sewage sludge from the Howdon treatment works is dumped out at sea (S. Clark, pers. comm.).

At 12.3%, the annual increase in the number of pairs of Herring Gulls breeding on Tyneside is in line with that seen nationally (Chapter 2) and it is this which is likely to be the reason for the increase in the numbers observed in the study area. The large numbers now present suggest that alternative local food sources more than make up for the reduction in untreated sewage.

In 1969/70, the distribution of Great Black-backed Gulls was positively influenced by the width of the river, the number of sewage outfalls and the degree of urbanisation. From this seeming reliance on sewage, it was predicted that the species would disappear from the river after improvements to sewage treatment (Fitzgerald & Coulson 1973). By 1993/94, the numbers in the study area had dropped by 90%.

The Great Black-backed Gulls wintering on the north-east coast of England breed in Norway (Coulson *et al.* 1984a). The number of Great Black-backed Gulls wintering inland in Britain increased between 1963 and 1993, however, for the period 1983-1993, for which coastal sites were counted, a decrease of 40% was found in north-east Britain (Waters 1994). It is unlikely that these changes are responsible for such a large decrease in numbers as observed on the River Tyne. Given the importance of sewage in 1969/70, it is probable that the decrease in numbers along the river may be explained by the reduction in available food caused by the improvements to sewage treatment.

The decline in numbers has taken place predominantly in section 3, a possible explanation being the loss of much of Jarrow Slake, an important roost for the species, to a reclamation scheme. The distribution of Great Black-backed Gulls in 1993/94 was significantly influenced only by the distance upstream. As with Herring Gulls, this species was found more commonly near the mouth of the river, the reasons for this being similar to those given for the Herring Gull. An additional attraction of this area for the Great Black-backed Gull may have been the presence of a disused dock which was used as a loafing area in section 1. It is likely that these attractions, particularly the fish waste provided by the Fish Quay, are the only reasons for the continued presence of the species on the River Tyne.

The huge increase in the number of Kittiwakes between 1969/70 and 1993/94 indicates that the decrease in the input of untreated sewage has not had a detrimental effect on this species. Fitzgerald & Coulson (1973) predicted that numbers would increase with decreased pollution suggesting that it would permit fish populations to expand, so providing more food for Kittiwakes. Coulson & MacDonald (1962) observed

Kittiwakes fishing in the fresh water of the River Derwent just before it enters the River Tyne, however, in 1993/94, the species was never observed to take fish from the river. In 1993/94, Kittiwakes were only occasionally seen feeding on the river, taking particles from the surface of the water near outfalls, but never observed feeding at outfalls on the wing as observed in other gull species and in Kittiwakes feeding at an outfall in Ireland outside the chick rearing period (O'Connor 1974).

In 1969/70, the distribution of Kittiwakes was negatively influenced by the distance from the nearest breeding colony and the situation was similar in 1993/94 as the number of breeding pairs had a positive effect on the numbers of Kittiwakes observed. Also significant in 1993/94 was the distance upstream, stressing the importance of the sea for feeding. It appears that the nesting sites along the river are its only attraction for Kittiwakes as they feed almost exclusively out at sea, therefore, changes in food availability on the river are not responsible for the increase in numbers observed.

In Figure 5.5 it can be seen that the sections showing the largest increases in Kittiwake density between the two surveys (2,6 and 9) were those containing Kittiwake breeding colonies. From the beginning of the century until 1969, Kittiwake numbers in Britain and Ireland increased at a rate of 3-4% per annum. This increase declined slightly thereafter, with reductions in numbers in some areas (Coulson 1983), however, the increase has been maintained on the east coast of England (Lloyd *et al.* 1991). Between 1970 and 1994, the average annual increase in numbers nesting along the River Tyne was 3.1%, suggesting that the increase in the number of individuals seen in the study area was merely a reflection of the ongoing expansion of Kittiwake numbers in Britain.

It can be seen that the reduction in the input of untreated sewage to the River Tyne has had different effects on the six species studied. The river is unimportant to the Kittiwake as a feeding area and therefore the changes seen in its numbers have been as a result of national population trends. The other species, which all utilised untreated sewage to some extent, have been affected by the reduction of this food source. Most, however, have found alternative sources of food so that numbers have remained stable or increased.

In the case of Black-headed Gulls, intertidal invertebrates and treated sewage have become important sources of food and numbers have remained stable. The Common Gull was observed far less frequently than before, however, it was felt that this was the result of the latter survey being carried out in a milder year. In the case of the Lesser Black-backed Gull, the river was no longer used for feeding but food must presumably have been available locally as birds were nesting on riverside buildings, colonised as part of the national expansion of this species. The number of Herring Gulls observed in the study area did not change although the number nesting on buildings along the river increased. Like the Lesser Black-backed Gulls, they may have exploited food sources away from the river, such as rubbish tips, to compensate for the loss of untreated sewage, although many were observed feeding on the tideline and at the Fish Quay. The drop in numbers shown by Great Black-backed Gulls is likely to be due to the loss of sewage. Mainly a feeder on large items of carrion or offal, the improvements to sewage treatment have removed their main local source of food apart from the Fish Quay.

In the context of the problems caused by gulls in urban areas, this study has shown that despite a significant reduction in the availability of an important food source, the overall numbers of gulls utilising the river has not changed. The presence of other food sources has proved enough to support similar, or larger, numbers of all species except the Great Black-backed Gull and, in the case of Herring and Lesser Black-backed Gulls, high breeding numbers. It is these last two species that are perceived to cause most problems in urban areas and therefore, in a long term plan to reduce numbers in urban areas it will be necessary to reduce all the main food sources, not just one. However, as it is thought that gulls pick up *Salmonella* species and other pathogens by feeding on sewage (Monaghan *et al.* 1985), the switch to other sources of food may have reduced the numbers of gulls carrying bacteria which are harmful to man.

Chapter 6

General Discussion

In recent years, increasing numbers of gulls have begun to frequent urban areas both in Britain and Ireland and abroad. One of the most noticeable and problematic aspects of this behaviour is the use of the roofs of buildings for nesting. In addition to disturbance to the inhabitants of these buildings, considerable structural damage can be caused to roofs. In Chapter 2 of this thesis, the results of a survey of roof-nesting gulls in Britain and Ireland in 1994 were described. A total of nearly 14,000 pairs of *Larus* gulls were recorded in this survey; 11,047 pairs of Herring Gulls, 2,544 pairs of Lesser Black-backed Gulls, 236 pairs of Common Gulls and 11 pairs of Great Black-backed Gulls. In each case, the number of pairs recorded had increased since the last such survey in 1976.

In 1976, it was found that numbers of both Herring Gulls and Lesser Black-backed Gulls nesting on buildings were increasing at rates faster than those nesting at more traditional colonies. By 1994, the numbers of Lesser Black-backed Gulls were still increasing at a high rate, but the rate of increase in Herring Gull numbers had declined. In the case of the Herring Gulls, this increase was mainly the result of the expansion of existing colonies, while much of the increase seen in the numbers of roof-nesting Lesser Black-backed Gulls was due to the formation of new colonies. These increases suggest that buildings provide good nest sites for gulls. This is seen most strongly in the case of the Herring Gull where the increase in numbers of roof-nesting birds has occurred despite the overall decline in the breeding numbers of this species in Britain and Ireland that has been observed since the mid-1970s. This finding, illustrating that individuals of a species, differing only in nesting habitat, can exhibit different population trends has important implications for the validity of making assumptions about the population dynamics of a species based on a limited number of studies.

As noted in Chapter 2, there are two potential explanations for the increase in the number of gulls nesting on buildings. It may be that the survival of adult birds nesting on buildings is higher than that of birds nesting at traditional colonies or recruitment to rooftop colonies may be greater than to those that are more traditionally sited. At present there are no data available to allow the relative importance of these two explanations to be determined. It is not known whether adults nesting at rooftop colonies have a higher chance of survival. It is known that for large gulls the highest mortality occurs at the end of the breeding season (Harris 1964a, Coulson & Butterfield 1986). This may be due to the stresses imposed by the raising of chicks and also due to the fact that birds are concentrated at breeding colonies so increasing competition for food in the area. It is possible that the situation of rooftop colonies near many potential sources of food means that adult birds are placed under less stress during the breeding season and so have lower mortality. However, it seems unlikely that the rates of increase in the numbers of roof-nesting gulls have been caused by increased adult survival alone.

From what little work has been done on the recruitment of first-time breeders to gull colonies, it is thought that young birds visit several colonies during the breeding season before they begin to breed. The selection of a colony in which to breed has been suggested to be influenced by the density of the colony and its apparent success, in terms of the presence of fledged young (Chabrzyk & Coulson 1976). If rooftop colonies prove to be suitable sites for breeding and birds nesting at such sites have high fledging success then it is likely that recruitment to these colonies would be high. In some studies of roof-nesting gull colonies it has been suggested that there are many young birds nesting in such colonies (Mudge 1978, Vermeer *et al.* 1988). Such a finding would support the idea that there is high recruitment to gull colonies on roofs although there is little direct evidence for it (Belant 1993).

Previous studies of roof-nesting gulls have suggested that at colonies where nests are dispersed, often on isolated sites such as chimney stacks, fledging success is higher than that found in colonies at more traditional sites (Monaghan 1979, Chaussabel 1995). However, where there is a large number of pairs nesting on a single roof or where the nests are on roofs where egg collection or control measures are carried out, fledging success can be lower (Mudge 1978, Monaghan 1979, Vermeer *et al.* 1988).

Several reasons have been suggested to explain the high breeding success found at some roof-nesting gull colonies. The most frequently invoked is that the low nesting density often found at such colonies, associated especially with dispersed rooftop colonies, means that chicks are subject to less aggression from neighbouring birds. This factor is frequently an important cause of mortality in large gull colonies (Paynter 1949, Harris 1964b, Brown 1967, Davis & Dunn 1976), and so chicks at low density colonies, such as those on rooftops, may have a higher chance of surviving to fledge than those at traditional colonies (Monaghan 1979).

In addition, it has been suggested that because rooftop colonies are almost always situated in urban areas, they are near, and have easy access to, many sources of food (Monaghan 1979, Chaussabel 1995). The fact that nests built on roofs are inaccessible to many ground predators has also been suggested as a potential advantage of roof-nesting colonies (Monaghan 1979, Vermeer *et al.* 1988). In one study it was suggested that no gulls specialising in cannibalism were nesting in the colonies. It was thought that the small size of these colonies meant that it was not possible for birds to specialise on eating conspecific chicks because there were not enough chicks available (Monaghan 1979).

An interesting finding from Chapter 2 was that in the 1994 survey many more colonies were recorded from the roofs of large industrial buildings such as warehouses than in the 1976 survey. Such colonies have the potential of supporting large numbers of nesting gulls and it is possible that high nesting densities, similar to those found in many traditional colonies may develop. If low nesting density is indeed an important factor in the success of rooftop colonies, this advantage may be lost in such colonies.

In Chapter 3, a study of the breeding biology of such a colony is described. In this mixed colony on the roof of one large building, 247 pairs of Herring Gulls and 21 pairs of Lesser Black-backed Gulls nested in 1995. It was found that the fledging success of Herring Gulls at this colony was 1.45 chicks per nest. Although less than that found in towns where most nests were more widely dispersed this success was higher or at least similar to most traditional colonies. In contrast, the fledging success of the Lesser Black-backed Gulls, 0.62 chicks per nest, was significantly lower than Herring Gulls, the difference being mainly due to the lower hatching success of Lesser Black-backed Gull eggs and the fact that more of the eggs of this species were stolen, most probably by Herring Gulls.

The nesting density of this colony was found, as expected, to be greater than those at rooftop colonies where nests were spread out over many buildings (Monaghan 1979, Chaussabel 1995) but was similar to that found in another study of a large roof colony (Belant 1993). It was lower than that found at many traditional colonies. The only factor investigated which was found to affect the fledging success of Herring Gulls was the type of nest site. Fledging success was greater at nests with a higher degree of shelter and it is possible that the disadvantages of higher density nesting are not as pronounced on roofs with a large amount of shelter for the chicks such as air vents and skylights, as suggested by Vermeer *et al.* (1988).

It appears from this study that the nesting densities reached on the roof studied were not high enough to have a serious detrimental effect on breeding success. It may also suggest that the other factors mentioned above may also be important for the success of roof-nesting gulls. At the study site, no evidence was found of predators taking eggs or chicks, although at other sites the taking of a Lesser Black-backed Gull chick from a rooftop nest by a Sparrowhawk *Accipiter nisus* has been observed (T. Hextell, in litt.) and Buzzards *Buteo buteo* have been seen attempting to take Herring Gull chicks from rooftop nests (Dr J.W. Woodhead, in litt.). In most studies of large gull colonies predation by other species has been found to be a less important cause of mortality than that by other gulls. However, in the Common Gull extensive predation on eggs and chicks has been observed by American Mink *Mustela vison* and Fox (Craik 1995, Costers 1992, Woutersen 1992). In the case of this species in The Netherlands, it is thought the colonisation of dune areas by Foxes is the reason for the declining numbers of nesting birds in colonies here, and the initiation of colonies elsewhere, including on buildings (Costers 1992, Woutersen 1992). Also in The Netherlands, Foxes were thought to be responsible for a mixed Yellow-legged Gull x Lesser Black-backed Gull pair changing from nesting on the ground to nesting on the roof of a nearby shed (Cottaar 1996).

The third main potential reason for the success of roof-nesting gulls is the proximity of many such colonies to sources of food. In urban areas there are rubbish tips, fish docks, sewage outfalls and rubbish lying in the streets. Chaussabel (1995) found that this was important, because adult birds were absent from the colony for less time than those at a local traditional colony further from food sources and so were better able to defend their chicks. The relative proximity to sources of waste food was also found to be important, for the same reason, in determining the survival of chicks at island colonies in a study by Hunt (1972).

In Chapter 4 a study of the diet of the Herring Gulls breeding at a rooftop colony was described. It was found that the most important sources of food appeared to be human waste, probably from rubbish tips, and food from agricultural land. Marine food and food from the shore appeared to be of less importance, although fish appeared to be a major component of the food fed to chicks. Other studies have also suggested that food from urban areas is not always the most important component of the diet of gulls nesting on buildings (Belant 1993, Chaussabel 1995), although this is the case in some colonies (Mudge & Ferns, 1982a). It appears that, as in traditional colonies, the food taken by gulls varies according to what is locally available. Food is frequently considered to be an important factor in determining the population dynamics of seabirds and, while Pons & Migot (1995) found evidence that food originating from human activities is a limiting factor for the reproductive success of Herring Gulls, it does not appear that the higher success of gulls nesting on buildings when compared to those nesting at more traditional sites, is simply due to a higher proportion of such foods in their diet.

The paralytic disease botulism was suspected to be the cause of death of a number of adults and chicks at the study colony. Botulism has been proven or suspected to be the cause of death of gulls at several other large gull colonies in Britain and Ireland (Sutcliffe 1986, Worrall 1987) and it is thought that gulls become intoxicated with the botulinum toxin while feeding at tips (Sutcliffe 1986, Ortiz & Smith 1994). Chicks become intoxicated if they are given food containing the toxin by their parents. The number of adults which died from botulism in this study was less than that at the traditional colony studied by Worrall (1987). It is likely that the incidence of botulism at a colony depends on the feeding habits of the birds nesting there and so is not necessarily a more serious problem at rooftop colonies.

In the light of the above discussion it appears that roofs can provide suitable nest sites for gulls at which they can breed successfully. The proximity to food is likely to be important in many rooftop colonies, although those on isolated buildings outside urban areas may have no special advantage over traditional colonies in this respect. The high chick survival associated with low nesting density is likely to play the most important role where nests are dispersed rather than in colonies where many pairs nest on one large roof. Most roof-nesting colonies prove inaccessible to ground predators such as foxes although species such as rats may be able to gain access to the roof of a building, as will aerial predators such as birds of prey. In this case, birds nesting in larger numbers may be less vulnerable than isolated nests, due to the numbers of adults present to deter predators.

From the findings of this thesis it appears probable that the numbers of gulls nesting on buildings in Britain and Ireland will continue to increase in the foreseeable future. Although in some regions the rate of increase appears to be declining, there are many areas as yet uncolonised with many buildings suitable for nesting gulls, for example, inland towns and cities. Many problems are associated with roof-nesting gulls (Vermeer *et al.* 1988, Blokpoel *et al.* 1990, Belant 1993) and their increase is viewed with some concern by local authorities and the occupants of buildings on which they nest. The results of Chapter 2 illustrate that despite attempts in many areas to control numbers of roof-nesting gulls, little progress has been made. Methods have been found for dissuading gulls from nesting on individual buildings, but no success has been achieved in removing them from a town altogether.

As mentioned in the introduction to this thesis, two main reasons have been put forward to explain the rises in numbers of gulls during the course of the 20th century; the relaxation of the persecution of these species and an increase in the availability of food, particularly that originating from man's activities. Most of the control methods attempted so far have involved local reversals of the relaxation of persecution; for example, the removal of eggs and nests and the culling of adults. The fact that as many as 70% of young birds breed in a different colony to the one they were reared in (Coulson 1991) means that local control efforts have little impact as there are always recruits from other colonies ready to take over empty nest sites. As the attractiveness of towns for nesting is unlikely to change there will always be a source of recruits ready to move in. In order to have an impact, control would have to be carried out on a massive scale and the difficulties involved with culling gulls in towns and the public dislike of such operations make such an event extremely unlikely to happen. Other control methods have concentrated on reducing the attractiveness of the rooftop habitat with the use of wires and cages to deter nesting gulls. However, such methods are feasible only on a small scale.

As an alternative to control methods, a reversal in the increase in the availability of waste foods may, in the long term. have the effect of reducing gull numbers. In Chapter 5, the effect of a reduction in the availability of food from sewage outfalls on the gulls using a stretch of urban river was considered. In the study area the volume of untreated sewage discharged into the river decreased by 91% from 1969/70, when an initial survey was done (Fitzgerald & Coulson 1973), to 1993/94 when a second survey was carried out. Fitzgerald & Coulson (1973) found that untreated sewage was utilised by all six species of gull that used the river and they predicted that a reduction in its availability would lead to a drop in the numbers of all species using the river except the Kittiwake. In fact, numbers of Black-headed Gulls and Herring Gulls did not change and the numbers of Lesser Black-backed Gulls increased greatly. It is thought that as the availability of untreated sewage declined these species switched to other sources of food, for example, the mudflats exposed at low tide, treated sewage, the Fish Quay at North Shields and also sites away from the river. The numbers of Kittiwakes using the study area increased far more than expected in line with the national rate of increase of this species. Significant decreases were seen in the numbers of Great Black-backed Gulls and Common Gulls frequenting the study area. This was expected in the case of the former species due to its reliance on untreated sewage in 1969/70, however, the reason for the decline in the numbers of Common Gulls is less clear and may have been due to milder weather conditions during the second study.

One of the most important findings of this study was that the reduction in the availability of untreated sewage had little effect upon those species most considered as pests in towns, the Herring Gull and the Lesser Black-backed Gull. In both cases it seems that there were sufficient alternative sources of food to make up for the reduction in the availability of untreated sewage. In fact during the period between the two studies the numbers of these species breeding on the roofs of Tyneside rose steadily.

A study by Pons (1992) investigated the effect of an 80% reduction in the availability of waste at a rubbish tip upon a nearby breeding colony of Herring Gulls. In the year after this reduction he found a considerable drop in breeding success at the colony suggesting that the tip was an extremely important source of food for birds at this colony. However, during the next breeding season breeding success had improved slightly, although it was not as high as before the reduction in food availability. It seems as though possibly by the second year after the reduction in this food source birds were beginning to be more successful at finding food from other sources. The findings of this study and those of Pons (1992) suggest that a reduction in the availability of one artificial source of food would not be enough to lead to a decline in the numbers of gulls frequenting urban areas.

It seems that in order to have any effect on the numbers of gulls frequenting urban areas it would be necessary to remove all sources of food from such areas. It is probable that decreases in such food may well occur in the future as in many places improvements to sewage treatment and waste disposal methods are being implemented. However, it is probable that such reductions would affect not only gulls breeding in towns but also those breeding at traditional colonies, as well as wintering gulls. Given the other potential advantages of breeding on buildings, it may even be that gulls nesting at traditional colonies would be more affected by such changes.

In conclusion, it seems that in the future gulls nesting on buildings will continue to be a common sight in Britain and Ireland, with the potential for numbers to increase still further in many areas.

Summary

1. During the present century the number of gulls breeding and wintering in Britain and Ireland has increased considerably, a fact which has been attributed mainly to an increasing availability of potential food and a reduction in persecution. The presence of many sources of food in urban areas has led to such sites being increasingly frequented by gulls in both summer and winter.

2. In 1994 a survey of *Larus* gulls nesting on buildings was carried out in Britain and Ireland. Records were received of 11,047 pairs of Herring Gulls, 2,544 pairs of Lesser Black-backed Gulls, 236 pairs of Common Gulls and 11 pairs of Great Black-backed Gulls nesting on buildings. These values were minimum estimates and it is possible that the true population size of the two most frequently found roof-nesting species could have been as high as 16,900 pairs of Herring Gulls and 3,200 pairs of Lesser Black-backed Gulls; 8% and 4% respectively of the total breeding numbers in Britain and Ireland.

3. Since 1976, the number of Herring Gulls nesting on buildings has increased five-fold, an annual average rate of increase of 10%, lower than that for the period 1969 - 1976. During a similar period the total breeding numbers in Britain and Ireland declined by almost 50%. The increase observed in the number of roof-nesting Herring Gulls occurred mainly due to the expansion in size of existing colonies. Numbers of Lesser Black-backed Gulls nesting on buildings increased 18-fold since 1976, an annual average rate of increase in numbers of 17%, considerably higher than that of Herring Gulls. A large part of this increase involved the colonisation of new areas.

4. Throughout most of Britain and Ireland, the Herring Gull was the commonest gull found nesting on buildings, however, numbers of the two species were about equal in the Bristol Channel region and in western Britain the Lesser Black-backed Gull predominated. Rates of increase were highest for the Herring Gull in north-east Scotland, Ireland and west Britain and for the Lesser Black-backed Gull in west Britain and the Bristol Channel. A higher proportion of Lesser Black-backed Gull colonies were found inland.

5. During the period 1976 - 1994, small colonies were found to increase in number at a higher rate than larger ones. This drop in the rate of increase with an increase in colony size was not sufficient to explain the reduction in the rate of increase of Herring Gull numbers. It was found that the only roof-nesting colonies which had disappeared naturally since 1976 were those where only a few pairs had nested. There were no records of success in removing colonies larger than a few pairs from towns.

6. In comparison to the 1976 survey, a large number of large industrial buildings were recorded as being used by roof-nesting gulls in 1994. Such sites have the potential to support large numbers of pairs at high nest densities. During the breeding season of 1995 a study was carried out on the breeding success of a mixed colony of 247 pairs of Herring Gulls and 21 pairs of Lesser Black-backed Gulls nesting on a large warehouse roof on the ICI Wilton site, Teesside.

7. Both species showed a tendency to nest against structures on the roof such as skylights and air vents. The distance to the nearest neighbour of either species was similar for both species (Herring Gull - 5m, Lesser Black-backed Gull - 6.5m), but the distance to the nearest neighbour of the same species was greater for the Lesser Black-backed Gull (Herring Gull - 5m, Lesser Black-backed Gull - 10m). Nest density was 116 nests per ha in the main body of colony. Although this nest density was higher than that found in some roof-nesting colonies dispersed over many roofs, it was lower than that found in many traditional colonies.

8. Initiation of clutches was earlier for Herring Gulls (11 May) then Lesser Black-backed Gulls (19 May). Clutch sizes were 2.81 eggs per pair for Herring Gulls and 2.71 eggs per pair for Lesser Black-backed Gulls. Egg volumes varied within the clutch. For Herring Gulls eggs from each position in the laying sequence were different in volume, a-eggs were 2% larger than b-eggs and 11% larger than c-eggs. B-eggs were 9% larger than c-eggs. In the case of Lesser Black-backed Gulls, c-eggs were smaller than both a- or b-eggs, by 7% and 6% respectively.

9. Hatching success was higher for the eggs of Herring Gulls (75%) than for those of Lesser Black-backed Gulls (46%). A higher proportion of Lesser Black-backed

Gull eggs were stolen and addled. It is possible that the large numbers of Herring Gulls in the colony were responsible for the stolen eggs but the reason for the higher proportion of addled eggs is unknown.

10. The proportion of chicks surviving to fledge was similar for the two species, 69% for Herring Gulls and 50% for Lesser Black-backed Gulls, however, the difference in hatching success led to the final fledging success being higher for Herring Gulls (1.45 chicks per nest) than for Lesser Black-backed Gulls (0.62 chicks per nest). The proximate reason for most chick mortality was unknown but attacks by adults were important, as was botulism in the case of Herring Gull chicks. Nest site type was found to affect breeding success with both hatching success and chick survival being higher at nests with a high degree of shelter.

11. Botulism was thought to be responsible for the deaths of 5% of the adults of each species at the study colony. Although intoxication with botulism was not proven, the symptoms displayed by the majority of dead adults and chicks strongly suggested that it was the cause of death. It was thought that the toxin was ingested while feeding at rubbish tips.

12. A study of the feeding biology of the Herring Gulls nesting at ICI Wilton was carried out during the breeding season of 1995. The diets of adults and chicks were assessed by the analysis of pellets and regurgitations respectively.

13. Food from agricultural land was found in over 70% of adult pellets, food from urban areas, most probably tips, was found in 60% of pellets, while food from littoral and marine areas was found in about 30% of pellets. Species of fish eaten were identified using sagittal otoliths. All were found to be commercially fished species and so were most probably obtained as bycatch or waste from trawlers or fish docks. The diet of chicks was found to have three main components. Edible waste such as meat and bread was found in 42% of regurgitations, fish in 37% and terrestrial invertebrates, mainly earthworms, in 29%.

14. During the breeding season the proportion of pellets produced by adults which contained food from agricultural areas declined steadily, that containing food from

urban areas was relatively constant through most of the study but increased at the end of July, and that containing food from littoral and marine areas appeared to peak during July. In the case of chicks, no change was found in the proportion of regurgitations containing edible waste or fish, but that containing terrestrial invertebrates declined with time. As chicks grew, no changes in the proportion of pellets containing the three main food types were found, although the type of fish regurgitated changed from non-whitefish to whitefish.

15. A review of other studies concerning the diet of roof-nesting gulls showed that despite the location of such colonies in close proximity to sources of food in urban areas, these foods are not always the most important to birds nesting at these colonies.

16. A survey of the numbers and distribution of six species of gulls along the tidal reaches of the River Tyne, north-east England, was carried out from October 1993 to September 1994. The results of this study were compared with a similar study carried out in 1969/70, when 40 million gallons of untreated sewage were discharged into the study area daily. By the time of the 1993/94 study, the quantity of untreated sewage discharged into the study area had been reduced by 91%.

17. The number of Black-headed Gulls observed in the study area did not change between the two surveys, although changes were seen in the distribution of the species. It appears that in response to the reduction in the availability of untreated sewage, this species switched to feed at other food sources along the river, for example, mud flats and the outfall through which treated sewage is discharged from the treatment works.

18. Between the two surveys the number of Common Gulls observed in the study area dropped by 93%. This species frequents coastal areas mostly during periods of cold weather and it was felt that as the decline was seen throughout the study area, rather than in those areas where the reduction in untreated sewage discharged was greatest, that the drop in numbers may have been due to 1993/94 being a milder year.

19. The number of Lesser Black-backed Gulls observed in the study area increased by over 400% between the two surveys. Most of the birds seen in 1993/94 were at nests on riverside buildings and the species was never observed feeding in the study area. It is likely that the increase in numbers was due to the overall rise in the numbers of Lesser Black-backed Gulls nesting on buildings and that there were sufficient other food sources in the area to provide food for these roof-nesting birds.

20. Herring Gull numbers seen in the study area did not change between the two surveys although the distribution of the species changed, moving away from outfalls and towards the mouth of the river. The attractions of the river mouth include the North Shields Fish Quay and the coastline. During this period the numbers of this species nesting on buildings along the River Tyne increased in line with that seen throughout Britain and Ireland.

21. A 90% drop was seen in the number of Great Black-backed Gulls frequenting the study area between the surveys. This was thought to be due to the reduction in the availability of untreated sewage. It was surmised that the only reasons that some individuals frequented the study area in 1993/94 were the attractions of the North Shields Fish Quay and a roosting site.

22. The number of Kittiwakes seen in the study area increased by over 2000% between the two surveys. Most of the individuals observed were either at breeding colonies or in flight; they were rarely seen feeding in the study area. The reduction in sewage treatment clearly had no detrimental impact on the numbers of this species using the study area and the increase observed is consistent with the rise in breeding numbers observed regionally.

23. It appeared that in fact the numbers of only one species of gull, the Great Black-backed Gull, were affected negatively by the reduction in the availability of untreated sewage. In the case of the Black-headed Gull and the Herring Gull, the distribution of the species along the study area changed as new sources of food were exploited. The two species which cause most problems in towns, the Herring Gull and the Lesser Black-backed Gull, showed either no change or an increase in numbers in the study area, while the numbers nesting on buildings in the general area increased.

24. Roof-nesting by gulls has continued to increase since 1976, even in the Herring Gull where the total breeding numbers in Britain and Ireland have declined in this period. Colonies on large industrial roofs have become more frequent since 1976 and breeding success on such a roof was found to be higher than at many traditional colonies, although slightly lower than at dispersed roof-nesting colonies. The advantages of this site included its inaccessibility to ground predators, its proximity to food sources and the provision of shelter for chicks by structures such as skylights and air vents. Nest density had not yet reached high levels although this may become a problem in the future. It is likely that the number of roof-nesting gulls will continue to increase in the near future. Control methods have not proved successful on a large scale and it is probable that only a reduction in several major sources of food will have an effect on gull numbers, although this will not be restricted to those nesting on buildings.

References

Albrecht, P. (1996) Première nidification en Suisse du Goéland leucophée *(Larus cachinnans*) sur un bâtiment. Nos Oiseaux 43: 302.

Andersson, A. (1970) Food habits and predation of an inland-breeding population of the Herring Gull *Larus argentatus* in southern Sweden. Ornis Scand. 1: 75-81.

Annett, C. & Pierotti, R. (1989) Chick hatching as a trigger for dietary switching in the Western Gull. Colonial Waterbirds 12: 4-11.

Ayrshire Bird Club (1992) Ayrshire Bird Report 1991: 38.

Baker, K. (1993) An Identification Guide to European Non-Passerines. BTO Field Guide No. 24, British Trust for Ornithology.

Balletto, E. & Spanò, S. (1982) Nidificazione ripetuta di Gabbiano reale *(Larus argentatus michahellis*) nel porto di Sanremo (Imperia). Riv. ital. Orn., Milano 52: 191-194.

Belant, J.L. (1993) Nest-site selection and reproductive biology of roof- and island-nesting Herring Gulls. Trans. N. A. Wildl. & Natur. Resour. Conf. 58: 78-86.

Belant, J.L., Seamans, T.W., Gabrey, S.W. & Ickes, S.K. (1993) Importance of landfills to nesting Herring Gulls. The Condor 95: 817-830.

Benton, C., Khan, F., Monaghan, P., Richards, W.N. & Shedden, C.B. (1983) The contamination of a major water supply by gulls (*Larus* sp.). A study of the problem and remedial action taken. Water Research 17: 789-798.

Bergman, G. (1982) Population dynamics, colony formation and competition in *Larus argentatus*, *fuscus* and *marinus* in the archipelago of Finland. Ann. Zool. Fennici 19: 143-164.

Blokpoel, H. & Smith, B. (1988) First records of roof-nesting by Ring-billed Gulls and Herring Gulls in Ontario. Ontario Birds 6: 15-18.

Blokpoel, H. & Spaans, A.L. (1991) Superabundance in gulls: causes, problems and solutions. Acta XX Congressus Internationalis Ornithologici, Volume IV: 2359-2398.

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

Bourne, W.R.P. (1979) Herring Gulls nesting on buildings in Eastern Scotland. North East Scotland Bird Report 1978: 45-46.

Bourne, W.R.P. (1988) Herring and Lesser Black-backed Gulls nesting in Rosyth Dockyard. Sea Swallow 37: 65.

Bowes, A., Lack, P.C. & Fletcher, M.R. (1984) Wintering gulls in Britain, January 1983. Bird Study 31: 161-170.

Broekhuysen, G.J. & Elliott, C.C.H. (1974) Hartlaub's Gulls breeding on the roof of a building. Bokmakierie 26: 66-67.

Brouwer, A. & Spaans, A.L. (1994) Egg predation in the Herring Gull *Larus argentatus*: why does it vary so much between nests ? Ardea 82: 223-231.

Brown, R.G.B. (1967) Breeding success and population growth in a colony of Herring and Lesser Black-backed Gulls *Larus argentatus* and *L. fuscus*. Ibis 109: 502-515.

Bryant, D.M. (1987) Wading birds and wildfowl of the estuary and Firth of Forth, Scotland. Proceedings of the Royal Society of Edinburgh 93B: 509-520.

Burger, J. & Shisler, J. (1980) The process of colony formation among Herring Gulls *Larus argentatus* nesting in New Jersey. Ibis 122: 15-26.

Burger, J. & Gochfeld, M. (1988) Habitat selection in Mew Gulls: small colonies and site plasticity. Wilson Bulletin 100: 395-410.

Butterfield, J., Coulson, J.C., Kearsey, S.V., Monaghan, P., McCoy, J.H. & Spain, G.E. (1983) The herring gull *Larus argentatus* as a carrier of salmonella. Journal of Hygiene, Cambridge 91: 429-436.

Cadiou, B. (in press) La reproduction des Goélands en milieu urbain: historique et situation actuelle en France. Alauda 65.

Campbell, L.H. (1978) Patterns of distribution and behaviour of flocks of seaducks wintering at Leith and Musselburgh, Scotland. Biological Conservation 14: 111-124.

Campbell, L.H. (1984) The impact of changes in sewage treatment on seaducks wintering in the Firth of Forth, Scotland. Biological Conservation 28: 173-180.

Camphuysen, C.J., Calvo, B., Durinck, J., Ensor, K., Follestad, A., Furness, R.W., Garthe, S., Leaper, G., Skov, H., Tasker, M.L. & Winter, C.J.N. (1995) Consumption of discards by seabirds in the North Sea. NIOZ Rapport 1995 - 5, Netherlands Institute for Sea Research, Texel.

Chabrzyk, G. & Coulson, J.C. (1976) Survival and recruitment in the Herring Gull *Larus argentatus*. Journal of Animal Ecology 45: 187-203.

Chaussabel, D. (1995) Reproduction du Goéland argenté (*Larus argentatus*) en milieu urbain, une approche comparée au milieu insulaire. Licencié en Sciences Zoologiques, Université Libre de Bruxelles.

Chislett, R. (1954) Yorkshire Birds. A. Brown & Sons Ltd, Hull.

Cignini, B. & Zapparoli, M. (1985) Nidificazione del Gabbiano reale *Larus cachinnans michahellis* nella città di Roma. Atti Conv. ital. Orn. III: 255-256.

Costers, R. (1992) Hoe vergaat het de Stormmeeuw *Larus canus* bij Petten? Sula 6: 93-99.

Cottaar, F. (1996) Broedende Geelpootmeeuwen *L. cachinnans michahellis* te IJmuiden. Sula 10: 151-152.

Coulson, J.C. (1963) The status of the Kittiwake in the British Isles. Bird Study 10: 147-179.

Coulson, J.C. (1974) Kittiwake *Rissa tridactyla.* Pp 134-141 in 'The Seabirds of Britain and Ireland' (eds.) S. Cramp, W.R.P. Bourne & D. Saunders. Collins, London.

Coulson, J.C. (1983) The changing status of the Kittiwake *Rissa tridactyla* in the British Isles, 1969-1979. Bird Study 30: 9-16.

Coulson, J.C. (1991) The population dynamics of culling Herring Gulls and Lesser Black-backed Gulls. Pp 479-497 in 'Bird Population studies: Relevance to conservation and management' (eds.) C.M. Perrins, J-D Lebreton & G.J.M. Hirons. Oxford University Press, Oxford.

Coulson, J.C. & White, E. (1958) Observations on the breeding of the Kittiwake. Bird Study 5: 74-83

Coulson, J.C. & White, E. (1960) The effect of age and density of breeding birds on the time of breeding of the Kittiwake *Rissa tridactyla.* Ibis 102: 71-84.

Coulson, J.C. & MacDonald, A. (1962) Recent changes in the habits of the Kittiwake. British Birds 55: 171-177.

Coulson, J.C. & Butterfield, J. (1985) Movements of British Herring Gulls. Bird Study 32: 91-103.

Coulson, J.C. & Butterfield, J. (1986) Studies on a colony of colour-ringed Herring Gulls *Larus argentatus*: II. Colony occupation and feeding outside the breeding season. Bird Study 33: 55-59.

Coulson, J.C., Duncan, N. & Thomas, C. (1982) Changes in the breeding biology of the Herring Gull (*Larus argentatus*) induced by reduction in the size and density of the colony. Journal of Animal Ecology 51: 739-756.

Coulson, J.C., Butterfield, J., Duncan, N., Kearsey, S., Monaghan, P. & Thomas, C. (1984a) Origin and behaviour of Great Black-backed Gulls wintering in northeast England. British Birds 77: 1-11.

Coulson, J.C., Monaghan, P., Butterfield, J.E.L., Duncan, N., Ensor, K., Shedden, C. & Thomas, C. (1984b) Scandinavian Herring Gulls wintering in Britain. Ornis Scand. 15: 79-88.

Craik, J.C.A. (1995) Effects of North American Mink on the breeding success of terns and smaller gulls in west Scotland. Seabird 17: 3-11.

Cramp, S. (1971) Gulls nesting on buildings in Britain and Ireland. British Birds 64: 476-487.

Cramp, S. & Simmons, K.E.L. (eds.) (1983) The Birds of the Western Palearctic, Vol. III. Oxford University Press, Oxford.

Cramp, S. & Teagle, W.G. (1955) A comparative study of the birds of two stretches of the Thames in inner London, 1951-1953. London Bird Report 18: 42-57.

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

Crook, J.H. (1953) An observational study of the gulls of Southampton Water. British Birds 46: 385-397.

Curtis, D.J., Galbraith, C.G., Smyth, J.C. & Thompson, D.B.A. (1985) Seasonal variations in prey selection by estuarine Black-headed Gulls (*Larus ridibundus*). Estuarine, Coastal and Shelf Science 21: 75-89.

Davis, J.W.F. (1974) Herring Gull populations and man. Nature in Wales 8: 85-89.

Davis, J.W.F. (1975) Age, egg-size and breeding success in the Herring Gull *Larus argentatus*. Ibis 117: 460-473.

Davis, J.W.F. & Dunn, E. K. (1976) Intraspecific predation and colonial breeding in Lesser Black-backed Gulls *Larus fuscus*. Ibis 118: 65-77.

Davis, T.A.W. (1958) The breeding distribution of the Great Black-backed Gull in England and Wales in 1956. Bird Study 5: 191-215.

Dott, H.E.M. (1994) The spread of roof-nesting by gulls in the Lothian region to 1993. Lothian Bird Report 1993: 110-114.

Duncan, R. (1994) Roof nesting Great Black-backed Gulls in Aberdeen. Scottish Bird News 33: 5.

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

Eddy, G. (1982) Glaucous-winged Gulls nesting on buildings in Seattle, Washington. The Murrelet 63: 27-29.

Fisk, E.J. (1978) The growing use of roofs by nesting birds. Bird-Banding 49: 134-141.

Fitzgerald, G.R. (1970) The distribution and feeding ecology of gulls on the tidal reaches of polluted rivers in northeast England. Unpublished MSc thesis, University of Durham.

Fitzgerald, G.R. & Coulson, J.C. (1973) The distribution and feeding ecology of gulls on the tidal reaches of the Rivers Tyne and Wear. The Vasculum 58: 29-47.

Flegg, J.J.M. & Cox, C.J. (1972) Movement of Black-headed Gulls from colonies in England and Wales. Bird Study 19: 228-240.

Fordham, R.A. (1970) Mortality and population change of Dominican Gulls in Wellington, New Zealand. Journal of Animal Ecology 39: 13-27.

Fox, G.A., Allan, L.J., Weseloh, D.V. & Mineau, P. (1990) The diet of herring gulls during the nesting period in Canadian waters of the Great Lakes. Can. J. Zool. 195: 68: 1075-1085.

Furness, R.W. & Hislop, J.R.G. (1981) Diets and feeding ecology of Great Skuas *Catharacta skua* during the breeding season in Shetland. J. Zool., Lond. 195: 1-23.

Furness, R.W. & Monaghan, P. (1987) Seabird Ecology. Blackie, Glasgow.

Furness, R.W., Galbraith, H., Gibson, I.P. & Metcalfe, N.B. (1986) Recent changes in numbers of waders on the Clyde Estuary, and their significance for conservation. Proceedings of the Royal Society of Edinburgh 90B: 171-184.

Furness, R.W., Ensor, K. & Hudson, A.V. (1992) The use of fishery waste by gull populations around the British Isles. Ardea 80: 105-113.

Galloway, B., Meek, E.R. & Yeoman, P. (1971) Birds in Northumbria 1970. Report of the Tyneside Bird Club.

Gibbons, D.W., Reid, J.B. & Chapman, R.A. (1993) The new atlas of breeding birds in Britain and Ireland: 1988-1991. T & AD Poyser.

Götmark, F. (1984) Food and foraging in five European *Larus* gulls in the breeding season: a comparative review. Ornis Fennica 61: 9-18.

Gray, J.S. (1979) Pollution-induced changes in populations. Phil. Trans. Roy. Soc. Lond. 286B: 545-561

Green, P.T., Hill, D.A. & Clark, N.A. (1993) The effects of organic inputs to estuaries on overwintering bird populations and communities. British Trust for Ornithology. Contract ETSU TID 4086, Department of Trade and Industry.

Gribble, F.C. (1962) Census of Black-headed Gull colonies in England and Wales, 1958. Bird Study 9: 56-71.

Gribble, F.C. (1976) A census of Black-headed Gull colonies. Bird Study 23: 135-145.

Harford, C. (1985) Gull Trends in Glamorgan 1970-84. Cardiff Nat. Soc., Orn. Section, Cardiff.

Härkönen, T. (1986) Guide to the otoliths of the bony fishes of the northeast Atlantic. Danbiu ApS.

Harris, M.P. (1964a) Recoveries of ringed Herring Gulls. Bird Study 11: 183-191.

Harris, M.P. (1964b) Aspects of the breeding biology of the gulls *Larus argentatus, L. fuscus* and *L. marinus*. Ibis 106: 432-456.

Harris, M.P. (1965) The food of some *Larus* gulls. Ibis 107: 43-53.

Harris, M.P. (1970) Rates and causes of increases of some British gull populations. Bird Study 17: 325-335.

Haycock, K.A. & Threlfall, W. (1975) The breeding biology of the Herring Gull in Newfoundland. The Auk 92: 678-697.

Hickling, R.A.O. (1954) The wintering gulls in Britain. Bird Study 1: 129-148.

Hickling, R.A.O. (1967) The inland wintering of gulls in England, 1963. Bird Study 14: 104-113.

Hickling, R.A.O. (1977) Inland wintering of gulls in England and Wales, 1973. Bird Study 24: 79-88.

Hillström, L., Kilpi, M. & Lindström, K. (1994) Diet of Herring Gulls *Larus argentatus* during chick rearing in the Gulf of Finland. Ornis Fennica 71: 95-101.

Holling, M. (1991) Roof nesting gulls in Lothian. Lothian Bird Report 1990: 99-100.

Horton, N., Brough, T. & Rochard, J.B.A. (1983) The importance of refuse tips to gulls wintering in an inland area of south-east England. J. Appl. Ecology 20: 751-765.

Hunt, G.L. (1972) Influence of food distribution and human disturbance on the reproductive success of Herring Gulls. Ecology 53: 1051-1061.

Hunt, G.L. & Hunt, M.W. (1975) Reproductive biology of the Western Gull: the importance of nest spacing. The Auk 92: 270-279.

Hunt, G.L. & McLoon, S.C. (1975) Activity patterns of gull chicks in relation to feeding by parents: their potential significance for density-dependent mortality. The Auk 92: 523-527.

Jobling, M. & Breiby, A. (1986) The use and abuse of fish otoliths in studies of feeding habits of marine piscivores. Sarsia 71: 265-274.

Johnstone, I.G., Harris, M.P., Wanless, S. & Graves, J.A. (1990) The usefulness of pellets for assessing the diet of adult Shags *Phalacrocorax aristotelis*. Bird Study 37: 5-11.

Jones, M.J. (1985) Distribution and activity of Common Gulls and Black-headed Gulls on grassland in Manchester. Bird Study 32: 104-112.

Kadlec, J.A. & Drury, W.H. (1968) Structure of the New England Herring Gull population. Ecology 49: 644-676.

Kilpi, M., Hillström, L. & Lindström, K. (1996) Egg-size variation and reproductive success in the Herring Gull *Larus argentatus*: adaptive or constrained size of the last egg? Ibis 138: 212-217.

King, B. (1979) Roof-nesting by Great Black-backed Gulls. British Birds 72: 340-343.

Kirkham, I.R. & Morris, R.D. (1979) Feeding ecology of ring-billed gull (*Larus delawarensis*) chicks. Can. J. Zool. 57: 1086-1090.

Kooistra, H. (1985) Stormmeeuwen *Larus canus* broedend op en tegen gebouwen. Limosa 58: 73-74.

Kosonen, L. & Mäkinen, R. (1978) Harmaalokin pesintä rakennuksessa. Ornis Fennica 55: 87.

Lack, P. (1986) The Atlas of Wintering Birds in Britain and Ireland. Poyser.

Lefeivre, B. (1985) Goélands urbains nicheurs de Cherbourg. Caen. I.U.T. de Tours. Biologie appliquée. Génie de l'Environment. (quoted in Vincent, 1989)

Lloyd, C.S., Thomas, G.J., Macdonald, J.W., Borland, E.D., Standring, K. & Smart, J.L. (1976) Wild bird mortality caused by botulism in Britain, 1975. Biological Conservation 10: 119-129.

Lloyd, C., Tasker, M.L. & Partridge, K. (1991) The Status of Seabirds in Britain and Ireland. T. & A.D. Poyser, London.

Löhmer, K. & Vauk, G. (1969) Nahrungsökologische Untersuchungen an übersommernden Silbermöwen (*Larus argentatus*) auf Helgoland im August/September 1967. Bonn. zool. Beitr. 20: 110-124.

Löhmer, K. & Vauk, G. (1970) Ein weiterer Beitrag zur Ernährung Helgoländer Silbermöwen (*Larus argentatus*). Die Vogelwarte 25: 242-245.

Macdonald, J.W. & Standring, K.T. (1978) An outbreak of botulism in gulls on the Firth of Forth, Scotland. Biological Conservation 14: 149-155.

MacKinnon, G.E. & Coulson, J.C. (1987) The temporal and geographical distribution of continental Black-headed Gulls *Larus ridibundus* in the British Isles. Bird Study 34: 1-9.

MacRoberts, B.R. & MacRoberts, M.H. (1972) Social stimulation of reproduction in Herring and Lesser Black-backed Gulls. Ibis 114: 495-506.

Madden, B. (1994) Roof Nesting by Herring Gulls in Dublin City. Irish East Coast Bird Report 1993: 69-72.

Melville, D. (1974) Analysis of Herring Gull pellets collected in Co. Antrim. Seabird Report 4: 40-46.

Mendall, H.L. (1939) Food habits of the Herring Gull in relation to fresh-water game fishes in Maine. The Wilson Bulletin 51: 223-226.

Mericas Leach, M.C., Kearsey, S.V. & Wells, C. (1980) The 1978-79 survey of Herring Gull (*Larus argentatus*) colonies on the Yorkshire and Cleveland coast. Naturalist 105: 107-114.

Milne, H. & Campbell, L.H. (1973) Wintering seaducks off the east coast of Scotland. Bird Study 20: 153-172.

Monaghan, P. (1979) Aspects of the breeding biology of Herring Gulls *Larus argentatus* in urban colonies. Ibis 121: 475-481.

Monaghan, P. & Coulson, J.C. (1977) Status of large gulls nesting on buildings. Bird Study 24: 89-104.

Monaghan, P., Shedden, C.B., Ensor, K., Fricker, C.R. & Girdwood, R.W.A. (1985) Salmonella carriage by Herring Gulls in the Clyde area of Scotland in relation to their feeding ecology. J. Appl. Ecology 22: 669-680.

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

Mountfort, G. & Ferguson-Lees, I.J. (1961) Observations on the birds of Bulgaria. Ibis 103a: 443-471.

Mudge, G.P. (1978) Ecological studies of Herring Gulls (*Larus argentatus* Pont.) and other Larini, in an urban environment. Unpublished PhD thesis, University College, Cardiff.

Mudge, G.P. & Ferns, P.N. (1982a) The feeding ecology of five species of gulls (Aves: Larini) in the inner Bristol Channel. J. Zool., Lond. 197: 497-510.

Mudge, G.P. & Ferns, P.N. (1982b) Breeding populations of gulls in the inner Bristol Channel, 1980. Seabird Report 1977-81: 48-49.

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

Nogales, M., Zonfrillo, B. & Monaghan, P. (1995) Diets of adult and chick Herring Gulls *Larus argentatus argenteus* on Ailsa Craig, south-west Scotland. Seabird 17: 56-63.

Noordhuis, R. & Spaans, A.L. (1992) Interspecific competition for food between Herring *Larus argentatus* and Lesser Black-backed Gulls *L. fuscus* in the Dutch Wadden Sea area. Ardea 80: 115-132.

North Sea Bird Club (1994) Fulmar 76. (quoted in The Seabird Group Newsletter 70: 4).

O'Connell, M.J., Coulson, J.C., Raven, S. & Joyce, S. (1997) Nonbreeding and nests without eggs in the Lesser Black-backed Gull *Larus fuscus*. Ibis 139: 252-258.

O'Connor, R.J. (1974) Feeding behaviour of the Kittiwake. Bird Study 21: 185-192.

Oldaker, F. (1963) Unusual nest site of the Glaucous-winged Gull. Can. Field. Nat. 77: 65-66.

O'Meara, M. (1975) Building-nesting Herring Gulls (*Larus argentatus*. Pontoppidan) in Co. Waterford. Irish Nats. Journal 18: 152-153.

Ortiz, N.E. & Smith, G.R. (1994) Landfill sites, botulism and gulls. Epidemiol. Infect. 112: 385-391.

Paludan, K. (1951) Contributions to the breeding biology of *Larus argentatus* and *Larus fuscus*. Vidensk. Meddr dansk naturh. Foren. 114: 1-128.

Parslow, J.L.F. (1967) Changes in status among breeding birds in Britain and Ireland. British Birds 60: 177-202.

Parsons, J. (1971a) The breeding biology of the Herring Gull (*Larus argentatus*). Unpublished PhD thesis, University of Durham.

Parsons, J. (1971b) Cannibalism in Herring Gulls. British Birds 64: 528-537.

Parsons, K.C. & Chao, J. (1983) Nest cover and chick survival in Herring Gulls (*Larus argentatus*). Colonial Waterbirds 6: 154-159.

Paynter, R.A. (1949) Clutch size and the egg and chick mortality of Kent Island Herring Gulls. Ecology 30: 146-166.

Paynter, R.A. (1963) North American Herring Gulls nesting on a building. The Wilson Bulletin 75: 88.

Petit, J.G., Gabernet, M.E.M., Gimeno, F.J.T. & Gallisà, E.C. (1986) Urban nesting of Yellow-legged Gulls in Barcelona (Spain). In NATO ASI Series, Vol. G 12, 'Mediterranean Marine Avifauna' (eds.) MEDMARAVIS and X. Monbailliu. Springer-Verlag, Berlin.

Pierotti, R. & Annett, C.A. (1987) Reproductive consequences of dietary specialization and switching in an ecological generalist. Pp 417-442 in 'Foraging Behavior' (eds.) A.C. Kamil, J. Krebs & H.R. Pulliam. Plenum, New York.

Pons, J.-M. (1992) Effects of changes in the availability of human refuse on breeding parameters in a Herring Gull *Larus argentatus* population in Brittany, France. Ardea 80: 143-150.

Pons, J.-M. & Migot, P. (1995) Life-history strategy of the herring gull: changes in survival and fecundity in a population subjected to various feeding conditions. J. Anim. Ecol. 64: 592-599.

Pounder, B. (1974) Wildfowl and pollution in the Tay estuary. Mar. Poll. Bull. 5: 35-38.

Pounder, B. (1976a) Waterfowl at effluent discharges in Scottish coastal waters. Scottish Birds 9: 5-36.

Pounder, B. (1976b) Wintering flocks of Goldeneyes at sewage outfalls in the Tay Estuary. Bird Study 23: 121-131.

Quinn, P.J. & Crinion, R.A.P. (1984) A two year study of botulism in gulls in the vicinity of Dublin Bay. Irish Veterinary Journal 38: 214-219.

Radford, M.C. (1960) Common Gull movements shown by ringing returns. Bird Study 7: 81-93.

Reiser, D. (1894) Materialien zu einer Ornis balcanica. II Bulgarien. Wien 1-204. (quoted in Nankinov, 1992).

Robertson, H.A. (1992) Trends in the numbers and distribution of coastal birds in Wellington Harbour. Notornis 39: 263-289.

Rochard, J.B.A. & Horton, N. (1980) Birds killed by aircraft in the United Kingdom, 1966-76. Bird Study 27: 227-234.

Rollin, C.N. (1928) The birds of Jarrow Slake. The Vasculum 14: 144-147.

Rollin, N. (1931a) A preliminary survey of the habits and movements of gulls about Tyneside, I. The Vasculum 17: 17-23.

Rollin, N. (1931b) A preliminary survey of the habits and movements of gulls about Tyneside, II. The Vasculum 17: 51-58.

Rosen, M.N. (1971) Botulism. Pp 100-117 in 'Infectious and parasitic diseases of wild birds'. J.W. Davis, R.C. Anderson, L. Karstad & D.O. Trainer. The Iowa State University Press.

Sibly, R.M. & McCleery, R.H. (1983a) Increase in weight of Herring Gulls while feeding. Journal of Animal Ecology 52: 35-50.

Sibly, R.M. & McCleery, R.H. (1983b) The distribution between feeding sites of Herring Gulls breeding at Walney Island, U.K.. Journal of Animal Ecology 52: 51-68.

Siegel, S. & Castellan, N.J. (1988) Non-parametric Statistics for the Behavioral Sciences. McGraw-Hill.

Spaans, A.L. (1971) On the feeding ecology of the Herring Gull *Larus argentatus* Pont. in the northern part of The Netherlands. Ardea 59: 73-188.

Spaans, M.J. & Spaans, A.L. (1975) Enkele gegevens over de broedbiologie van de Zilvermeeuw (*Larus argentatus*) op Terschelling. Limosa 48: 1-39.

Spaans, A.L., De Wit, A.A.N. & Van Vlaardingen, M.A. (1987) Effects of increased population size in Herring Gulls on breeding success and other parameters. Studies in Avian Biology 10: 57-65.

Spanò, S. (1986) Nidificazione di Gabbiano reale, *Larus cachinnans*, nella città di Genova. Riv. ital. Orn., Milano 56: 269-270.

Spärck, R. (1951) The food of the North-European gulls. Proc. X Int. Ornith. Congress, Uppsala, 588-591.

Stewart, B.J. (1988) Roof- and ground-nesting Common Gulls in Aberdeen, 1988. North East Scotland Bird Report 1988: 54-57.

Sullivan, M.A. (1985) Common Gulls successfully nesting on a roof in Aberdeen. Scottish Birds 13: 227.

Sutcliffe, S.J. (1986) Changes in the gull populations of SW Wales. Bird Study 33: 91-97.

Thomas, A. (1984) Les goélands sont dans la ville. Penn ar Bed 116: 33-34.

Thompson, K.R., Brindley, E. & Heubeck, M. (1996) Seabird numbers and breeding success in Britain and Ireland, 1995. Peterborough, Joint Nature Conservation Committee. (UK Nature Conservation, no. 20).

Thorne, G.T. (1991) A roof-top gull colony in Newport. Gwent Bird Report 26: 20.

Threlfall, W. (1968) The food of Herring Gulls in Anglesey and Caernarvonshire. Nature in Wales 11: 2-8.

Took, G.E. (1955) Nesting of Herring Gulls on roof-tops in Dover. British Birds 48: 88-89.

Topping, G. (1978) Sewage and the sea. Pp 303-351 in 'Marine Pollution' (ed.) R. Johnston.

Turbott, E.G. (1969) Roof-nesting Black-backed Gulls. Notornis 16: 187-189.

Van Impe, J. (1985) Estuarine pollution as a probable cause of increase of estuarine birds. Mar. Poll. Bull. 16: 271-276.

Vegelin, J.C.G. (1989) Zilvermeeuwen *Larus argentatus* en Kleine Mantelmeeuwen *L. fuscus* als broedvogel op daken in IJmuiden. Limosa 62: 154-155.

Vermeer, K. (1992) Population growth of the Glaucous-winged Gull *Larus glaucescens* in the Strait of Georgia, British Columbia, Canada. Ardea 80: 181-185.

Vermeer, K., Power, D. & Smith, G.E.J. (1988) Habitat selection and nesting biology of roof-nesting Glaucous-winged Gulls. Colonial Waterbirds 11: 189-201.

Vernon, J.D.R. (1969) Spring migration of the Common Gull in Britain and Ireland. Bird Study 16: 101-107.

Vernon, J.D.R. (1970) Feeding habitats and food of the Black-headed and Common Gulls. Part I - Feeding Habitats. Bird Study 17: 287-296.

Vernon, J.D.R. (1972) Feeding habitats and food of the Black-headed and Common Gulls. Part II - Food. Bird Study 19: 173-186.

Vernon, J.D.R. & Walsh, T.P. (1966) The Common Gull in the Severn estuary in relation to feeding areas, roost sites and behaviour. Proc. Bristol Nat. Soc. 31:173-184

Vincent, T. (1989) Présence de Goélands bruns (*Larus fuscus graellsii*) et marins (*Larus marinus*) nicheurs dans une colonie urbaine de Goélands argentés (*Larus argentatus argenteus*). Le Gerfaut 79: 153-158.

Vincent, T. (1994) Ecologie et comportements des populations de Goélands argentés (*Larus argentatus argenteus* Brehm, 1822) en milieu urbain: l'exemple de la ville du Havre (Seine-Maritime, France). Thèse de Diplôme d'Université d'Etudes Doctorales, Université de Rouen. Bull. trim. Soc. géol. Normandie et Amis du Muséum du Havre, supplément au tome 81, Le Havre.

Vincent, T. & Guiguen, C. (1989) Prédation sur des Pigeons domestiques *Columba livia*, par les Goélands, *Larus argentatus* et *Larus cachinnans*, et conséquences éventuelles pour la pathologie humaine. Nos Oiseaux 40: 129-140.

Walsh, P.M., Sim, I. & Heubeck, M. (1993) Seabird numbers and breeding success in Britain and Ireland, 1992. Peterborough, Joint Conservation Nature Committee. (UK Nature Conservation, No. 10).

Walsh, P.M., Brindley, E. & Heubeck, M. (1995) Seabird numbers and breeding success in Britain and Ireland, 1994. Peterborough, Joint Nature Conservation Committee. (UK Nature Conservation, No. 18).

Waters, R. (1994) Wintering gulls 1953-1993. BTO News 190: 9-10.

Worrall, D.H. (1987) The effect of botulism on a breeding colony of gulls. Erkrankungen der Zootiere Symposium, Cardiff. Akademie-Verlag, Berlin: 25-31.

Woutersen, K. (1992) De Stormmeeuw *Larus canus* als broedvogel in de Schoorlse Duinen. Sula 6: 81-92.

Woutersen, K. & Roobeek, K. (1992) Broedgevallen van de Stormmeeuw *Larus canus* in het binnenland in Noord-Holland. Sula 6: 51-55.

Yalden, D.W. & Morris, P.A. (1990) The analysis of owl pellets. Occasional publication of The Mammal Society No. 13.

Appendices

Appendix 1: Details of the numbers of pairs of Herring Gulls and Lesser Black-backed Gulls nesting on buildings in Britain and Ireland, 1994.

P = prospecting birds seen, breeding suspected but not proven
P(N) = as above, but breeding proven in previous years
0 = breeding in previous years but none found in 1994
? = breeding in previous years but site not checked in 1994
* = Herring Gull x Lesser Black-backed Gull pair
+ = thought to be an underestimate
++ = known to be an underestimate as thorough survey not carried out

	Herring Gull		Lesser Black-backed Gull	
Site	colonised in or prior to 1976	colonised since 1976	colonised in or prior to 1976	colonised since 1976
Northumberland				
Berwick-upon-Tweed	216 ('95)			4 ('95)
Blyth	0			
Tyne & Wear				
North Shields & Tynemouth	57			2
Wallsend		46+		8+
Newcastle	30+		4+	
Gateshead		1		
Hebburn & Jarrow		19		5
South Shields	388		6	
Sunderland	695		21	
Washington		P		P
Durham				
Durham City		1		
Cleveland				
Hartlepool	229			7
ICI North Tees		15		
Middlesborough Dock		4		
ICI Wilton		138+		2+
Skinningrove Steelworks		36		
Cowbar		1		
North Yorkshire				
Staithes	24			
Runswick	22			
Whitby	240			3
Robin Hoods Bay	66			
Fylingthorpe	?			
Scarborough	174			1

Appendix 1: (continued)

Site	Herring Gull		Lesser Black-backed Gull	
	colonised in or prior to 1976	colonised since 1976	colonised in or prior to 1976	colonised since 1976
Filey	29			
Humberside				
Bridlington		nesting		
Withernsea		1		
Suffolk				
Lowestoft				1
Greater London				
London	5+			11+
Wood Green				P
Kent				
Maidstone		25		4
Faversham		80		20
Canterbury	5+			
Whitstable		10		P
Herne Bay		1		
Birchington & Westgate		79		
Margate, Kingsgate, Broadstairs & Ramsgate	365			20
Sandwich (Pfizer's complex)		6		
Dover	323			P
Folkstone & Cheriton	550			1*
Hythe	46			
Ashford		?		?
St Marys Bay		P		
New Romney		1		
East Sussex				
Hastings & St Leonards	nesting		6	
Bexhill	?			
Eastbourne	nesting			
Seaford		?		
Newhaven		?		?
Peacehaven		?		?
Lewes		?		
Brighton	nesting			2+ ('95)
Hove	?			
West Sussex				
Shoreham-by-Sea		?		

Appendix 1: (continued)

Site	Herring Gull		Lesser Black-backed Gull	
	colonised in or prior to 1976	colonised since 1976	colonised in or prior to 1976	colonised since 1976
Worthing		nesting		?
Hampshire				
Southampton		5+		
Hythe Naval Base		9		
Fawley Refinery		6		
Dorset				
Christchurch		30		1
Poole		17		
Swanage	?			
Wyke Regis & Weymouth	nesting			
Portland		?		?
West Bexington		?		
Burton Bradstock	?			
West Bay	?			
Bothenhampton	?			
Bridport	nesting			
Beaminster		?		
Charmouth	?			
Lyme Regis	nesting			
Devon				
Beer	?			
Sidmouth		24		
Budleigh Salterton	50			
Exmouth	80			
Woodbury		2		
Exeter	43			3
Dawlish	58			
Teignmouth	158			
Teignbridge	?			
Shaldon	?			
Babbacombe	?			
Torquay	145			1
Paignton	13			
Brixham	?			
Totnes		21		2
Dartington		1		
Dartmouth		72		

Appendix 1: (continued)

Site	Herring Gull		Lesser Black-backed Gull	
	colonised in or prior to 1976	colonised since 1976	colonised in or prior to 1976	colonised since 1976
Kingsbridge		?		
Salcombe		5		
Thurlestone	10			
Bigbury-on-Sea	?			
Plymouth		34+		
Ilfracombe	324			
Cornwall				
Saltash		0		
Sheviock		P		
Torpoint		1		
HMS Raleigh, nr Torpoint		10		
Crafthole		1		
Portwrinkle		3		
Downderry		5		
Seaton		1		
Plaidy		5		
Liskeard		1		
Looe	200			
Polperro		15		
Polruan	35			
Par		nesting		
St Austell		nesting		
Mevagissey		nesting		
Truro		nesting		
Mullion	nesting			
Poldhu		nesting		
Porthleven		nesting		
Helston	nesting			
Perranuthno		nesting		
Goldsithney		nesting		
Marazion	nesting			
Penzance & Newlyn	370			
Mousehole	nesting			
St Ives	nesting			
Carbis Bay	nesting			
Lelant	nesting			
Hayle	nesting			

Appendix 1: (continued)

Site	Herring Gull		Lesser Black-backed Gull	
	colonised in or prior to 1976	colonised since 1976	colonised in or prior to 1976	colonised since 1976
Newquay	nesting			
Somerset				
Hinkley Power Station		?		
Wellington		?		
Taunton		?		?
Burnham-on-Sea	?			
Highbridge		?		
Bridgwater	19			6
Yeovil	?			?
Avon				
Portishead	0			0
Bristol	175		400	
Avonmouth		?		
Bath		8	20	
Wiltshire				
Bradford-upon-Avon				P
Trowbridge				5
Melksham				P
Swindon				P
Gloucestershire				
Gloucester	45		255	
Ashchurch		1		6
Hereford & Worcester				
Evesham				P
Worcester				20
Kidderminster				P
Hereford				8
West Midlands				
Birmingham				P(N)
Gwent				
Chepstow	1			
Newport	12++		4++	
Brynmawr		<6		3+
Ebbw Vale				6+
Dukestwon, Tredegar				1 ('93)
South Glamorgan				
Cardiff	1++		27++	

Appendix 1: (continued)

Site	Herring Gull		Lesser Black-backed Gull	
	colonised in or prior to 1976	colonised since 1976	colonised in or prior to 1976	colonised since 1976
Tremorfa		3		5
Penarth				?
Barry	?		8	
Porthkerry		?		
Rhoose	?			?
Aberthaw		144		61
Mid Glamorgan				
Llwynypia		1		
Merthyr Tydfil	?		?	
Hirwaun	?		?	
West Glamorgan				
Port Talbot	140+			7
BP Baglan Bay		6		24
Swansea		15		40
Dyfed				
Pembry	0			
Carmarthen	0			
Tenby	25			
Herbrandston		0		0
Aberystwyth		6		
Gwynedd				
Aberdyfi		60+		
Barmouth	?			
Caernarfon	71			1
Holyhead	?			
Beaumaris		12		3
Bangor		43		P
Conwy	103			5
Deganwy	nesting			
Llandudno	nesting			?
Rhos-on-Sea	?			
Clwyd				
Colwyn Bay	nesting			
Old Colwyn	nesting			
Rhyl		123		6
Prestatyn		nesting		
Merseyside				

Appendix 1: (continued)

Site	Herring Gull		Lesser Black-backed Gull	
	colonised in or prior to 1976	colonised since 1976	colonised in or prior to 1976	colonised since 1976
Heswall	?			
West Kirby	?			
Liverpool		20++		18++
Southport	0[a]			
Lancashire				
Blackpool		1		
Fleetwood		6		1
Thornton Cleveleys		4+		6+
Heysham		?		?
Cumbria				
Barrow-in-Furness	120			15
Sellafield		70		12
Whitehaven		65+		2+
Workington		60		
Siddick		7		
RAF Carlisle		100+		75
Isle of Man				
Douglas	2+			
Port St Mary	0			
Port Erin	1			
Peel	10			
Dumfries & Galloway				
Dumfries		?		?
ICI Dumfries		?		?
Kirkcudbright		?		
Whithorn		P		
Stranraer	0			
Strathclyde[d]				
Ayr		93+		64+
Prestwick		40		56
Irvine				?
ICI Ardeer		3		20
Kilmarnock	?			
Greenock		35		141
Linwood				200
Paisley				8
Braehead				2+ ('93)

Appendix 1: (continued)

Site	Herring Gull		Lesser Black-backed Gull	
	colonised in or prior to 1976	colonised since 1976	colonised in or prior to 1976	colonised since 1976
Barrhead				1+
Glasgow		4 ('93)		40 ('93)
Springburn		2 ('93)		18+ ('93)
Possilpark North				?
Cumbernauld		13		350
Kirkintilloch				2+
Drumchapel				80 ('93)
Dumbarton		<5		175+
Rosneath		?		
Highland				
Fort William		P		1
Dounreay		58		1*
Wick Stores		7		
Wick		66		
Brora		nesting ('95)		
Portmahomack		6		
Dalmore Distillery		3		
Alness Academy		15		
Dingwall		1		
Cromarty		nesting		
Rosemarkie		nesting		
Fortrose	10			
Avoch		nesting		
Inverness	150			
Nairn	?			
Shetland				
Lerwick	59			
Grampian				
Burghead		?		
RAF Lossiemouth		32		
Lossiemouth	nesting			
Elgin		nesting		nesting
Buckie		?		
Portsoy		4 ('95)		
Banff		40 ('95)		1 ('95)
Macduff		36 ('95)		

Appendix 1: (continued)

Site	Herring Gull		Lesser Black-backed Gull	
	colonised in or prior to 1976	colonised since 1976	colonised in or prior to 1976	colonised since 1976
Pennan		1 ('95)		
Fraserburgh		26 ('95)		
Peterhead		215 ('95)		4 ('95)
Aberdeen	2000[b]			50
Tayside				
Killiecrankie		P(N)		
Montrose		240		
Arbroath	208			0
Carnoustie		?		
Dundee	P			7
Fife				
St Andrews		?		
Crail		1		
Kirkcaldy				?
Dunfermline	?			
Rosyth		0[c]		0[c]
Central				
Alloa		P		P
Grangemouth				4
Lothian				
Bathgate		4		4
Livingston		1		11
Ratho Station		3		19
Edinburgh		27		58
Granton Harbour		12		30
Leith Docks	0[a]			
Musselburgh		10		1
Cockenzie & Port Seton		0		
Longniddry		0		
Gullane		0		
Dunbar		13+		
Borders				
St Abbs	7			
Eyemouth	118			
IRELAND				
Belfast		1		8
Balbriggan		43		

Appendix 1: (continued)

Site	Herring Gull		Lesser Black-backed Gull	
	colonised in or prior to 1976	colonised since 1976	colonised in or prior to 1976	colonised since 1976
Skerries		18+		
Howth		35		
Coolock		0		
Dublin City[e]	25+			P(N)
Dunmore East	24			
Galway City		0		
CHANNEL ISLANDS				
Jersey	129			2

a nesting recorded in 1974, not included in Monaghan & Coulson (1977)
b numbers recorded in 1976 survey corrected to 200 pairs (M. Tasker, pers. comm.)
c absence not definitely confirmed
d data for Greenock - Rosneath from Clyde Bird Reports '93 - '94
e data from Madden (1994)

Appendix 2: Details of the number of pairs of Common Gulls nesting on buildings in Britain and Ireland, 1994. See Appendix 1 for legend.

Site	Number of breeding pairs
Strathclyde	
Ayr	?
Greenock	2
Highland	
Barcaldine	1
Fort William	25
Dounreay	12
Dalmore	8
Alness	15
Balnagall	1
Tore	10
Inverness	20
Grampian	
Aberdeen	142 ('93)[a]

a data from North-East Scotland Bird Report 1993

Appendix 3: Details of the number of pairs of Great Black-backed Gulls nesting on buildings in Britain and Ireland, 1994. See Appendix 1 for legend.

Site	Number of breeding pairs
Hampshire	
Fawley Refinery	1
Dorset	
Poole	1
Devon	
Exmouth	1
Torquay	1
Cornwall	
Looe	?
Penzance & Newlyn	P
Mousehole	?
Cumbria	
Whitehaven	1
Whitehaven Chemical Works	?
Strathclyde	
Ayr	1
ICI Ardeer	1
Greenock	1
Grampian	
Aberdeen	2
Fife	
Rosyth	0
Lothian	
Edinburgh	1 ('95)

Appendix 4: Details of towns checked thoroughly in 1994 where no roof-nesting gulls were found.

County	Definite absence	Probable absence
Tyne & Wear		Birtley
Durham		Seaham, Hawthorn, Easington Colliery, Easington, Blackhall Colliery, Blackhall Rocks
Cleveland	Stockton	Redcar, Marske, Saltburn
North Yorkshire	Malton, York, Selby	
Essex	Southend-on Sea	
Kent	Sandwich*, Deal*, Tenterden	
Devon	Honiton, Torcross, Beesands, Hallsands, East Prawle, East Postlemouth, Bideford	Westward Ho, Appledore
Cornwall	Cawsand, Millendreath	
Avon	Clevedon	
Gwynedd	Rhoscolyn, Treaddur Bay, Amlwch	
Cheshire		Warrington
Highland	Ullapool, Lochinver	Tain, Balintore, Invergordon, Evanton
Western Isles	Stornoway	
Grampian	Whitehills*, Gardenstown*, Crovie*	Rosehearty*, Sandhaven*

* = checked in 1995

Appendix 5: Details of counties in which no records of roof-nesting by gulls had been received by 1994. Information was obtained from county bird recorders and regional representatives of the British Trust for Ornithology.

Areas with no records of roof-nesting gulls
England
Bedfordshire
Berkshire
Buckinghamshire
Cambridgeshire
Cheshire
Derbyshire
Greater Manchester
Hertfordshire
Humberside (except coastal towns north of R. Humber)
Isle of Wight
Leicestershire
Lincolnshire
Norfolk
Northamptonshire
North Yorkshire (except coastal towns)
Nottinghamshire
Oxfordshire
South Yorkshire
Shropshire
Staffordshire
Surrey
Warwickshire
West Yorkshire
Wales
Powys
Scotland
Lewis/Harris
Islay, Jura, Colonsay
Rhum, Eigg, Canna & Muck
Shetland (excluding Lerwick)
Channel Islands
Guernsey
Alderney