

THE DISPERSION OF GULLS
IN THE LOTHIANS

BY

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P R E F A C E

Were some ornithologist resident in the vicinity of a thorough-going aerodrome to set himself the task of observing, for say a year, the effects of the establishment on the habits of the birds of the locality, material for a highly interesting and valuable chapter on bird-life would, it is safe to say, reward him for his trouble.

William Evans (1916)

It is unlikely that Evans, when he wrote the above words, could have seen the far-reaching effects which birds now have on the aviation industry but there is no doubt that the observations made for this study have been both interesting and rewarding from a personal point of view. Whether or not the material is valuable is for others to judge.

This dissertation examines the dispersion of one group of birds, gulls, in the Lothians and especially takes into account their effect on one airport - Turnhouse. The work is divided into three parts. The first deals with the history of birds and the problems they pose to aircraft operations, the second shows how gulls are dispersed in the Forth and Lothians, giving an indication of the way in which this concerns Turnhouse, while the third part seeks to show what can be done to modify the birds' habits so as to alleviate the hazard they present to aircraft.

Data tables, scientific names of birds mentioned, a list of birds recorded at Turnhouse and a glossary of terms are given as appendices following the main text. Figures and other tables are included in the text, facing the appropriate page where possible, but for the sake of clarity all Plates have been placed together at the end, after the appendices but in front of the bibliography.

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PART I

INTRODUCTION TO THE PROBLEMS OF BIRDS AND AIRCRAFT

The problems posed by birds to the aviation industry are of recent origin, having become serious only with the advent of high-speed aircraft. Prior to the Second World War man's intrusion into the air did not result in any great conflict with birds because aeroplanes flew relatively slowly and frequently operated from grass airfields, without requiring the extensive facilities - runways and terminal buildings - so necessary today.

Now, with fast turbine aircraft in use by both civil and military organisations throughout the world, plus a great increase in the actual numbers of aircraft flying, there has been a rapid rise in the number of birds struck by aircraft. The higher speed of flight has left less time for pilots and birds to react to avoid collisions and damage from such collisions is more serious as a consequence of the increased impact velocities and because of the relatively fragile nature of the turbine engine compared to the piston engine.

The mounting frequency of such incidents has attracted attention from all quarters of the aviation industry because of its costly and potentially fatal nature. It is the purpose of this Introduction to show in some detail what the problems are with regard to both aeroplanes and airfields and to describe ways in which these problems have been approached in the past and how they might be tackled in future.

As will be shown, an understanding of the ecological principles involved might in the first place have prevented some of these problems from arising and recourse to these principles may now be the best way to achieve successful

mitigation of them.

Aircraft collisions with birds: some examples

The collision of an aircraft with a bird or birds is universally termed a "bird-strike". Because any damage to an aircraft constitutes an accident, bird-strikes and the damage they cause have been well-documented by the appropriate authorities in a variety of countries. One of the fortunate aspects of the bird hazard to aircraft is that to date there have been only two major disasters and one near disaster:

In 1960 at Boston, U.S.A., an Electra four-engined turbo-prop aircraft took off with seventy-two people on board, and soon after take-off flew into a flock of starlings. One engine failed immediately and the power of another two was substantially reduced for a short time, causing the aircraft to yaw, stall, and spin into the ground from 150 feet. Sixty-two persons on board were killed.

In 1962 over the state of Maryland, U.S.A., a Viscount aircraft collided with a flock of whistling swans at an altitude of 6000 feet. Strikes on the tailplane caused the port side of it to break off and the aircraft to dive vertically to the ground. All seventeen people on board were killed.

Also in 1962, at Turnhouse Airport, Edinburgh, a Vanguard aircraft flew into a large flock of gulls immediately after take-off, at night and in poor weather. This was in spite of the fact that the airfield

had been inspected and declared free of birds 15 minutes before take-off. Number 4 engine failed at once and there was a loss of power on the remaining three. Number 2 engine was feathered by the pilot after 15 minutes, leaving the aircraft to fly on numbers 1 and 3 engines only. Number 3 engine became critical and the pilot kept it running beyond its limitations and just managed to maintain height, circle and make a successful landing, having been airborne for 25 minutes with 76 people on board.

About 125 dead gulls were picked up from the runway, among which 40 Common gulls, 30 Black-headed gulls and 1 Herring gull were identified.

Examples of less serious but nevertheless potentially dangerous incidents are much more numerous. The following occurrences will serve to illustrate the type of aircraft involved and damage to them which has resulted from hitting birds:

In 1954 a Viking twin-engined piston-driven aircraft was approaching to land at Renfrew Airport, Glasgow, at night. About 100 feet from the runway the aircraft passed through a massive flock of gulls suffering severe damage to external fittings and control surfaces. Over 400 dead gulls were picked up from the runway.

In 1962 at Lahore, Pakistan, a vulture struck the windscreen of a twin piston-engined Dakota when on late final approach, killing the second pilot. The first pilot was able to maintain control and effect a normal landing.

In 1962 at Prestwick Airport a D.C.8 four-engined jet aircraft ingested a bird into one engine, which had to be shut down. The aircraft dumped 12,000 gallons of fuel and diverted to land at London Airport. One dead gull was found on the runway, no birds having been seen prior to take-off. The cost in dumped fuel, delay and inconvenience to passengers and engine repairs totalled £47,500.

The instances of bird-strike damage quoted here show what can happen and are perhaps the most salutary way of introducing the problem of bird hazard to aircraft, before considering various aspects of it in some detail.

The time and place of strikes

There are geographical, seasonal and diurnal variations which affect the time and place at which an aircraft may encounter birds. These factors depend on the country and species concerned and can be properly assessed only by making a series of observations at specified places. Other factors are fairly constant and found in virtually all situations.

From the point of view of an aircraft, the greatest risk of a bird-strike occurs within 500 feet of the ground, which usually means at or near an airfield, either when taking off or landing. Trans-Canada Airlines (now Air Canada) found that over the five-year period from 1959 to 1963, 70% of their 486 strikes took place on take-off, landing or during climb from or descent to an airfield. The remaining 30% of strikes occurred at unspecified places but probably included a proportion near airfields as well as en route strikes, so that the original total of 70% is probably nearer 80% or 90%

(Bird, 1965). Detailed figures are not available from other sources but there is general concurrence with this data by others.

There are two reasons why strikes mostly happen below 500 feet. The first is that, excluding migratory movements and some soaring flights, the majority of bird movements take place below this altitude. Mitchell (1955) considered that even 200 feet may be above the majority of birds' usual daily movement. Migratory flight heights have been studied in considerable detail and Dorst (1961) quoting Meinertzhagen (1920 and 1955) lists a range of observed heights varying from 70 feet to 15,000 feet from thirteen different countries. More recent observations using radar have demonstrated that in Europe migration flights can occur at altitudes in excess of 7,000 feet but the majority take place between 1,000 and 2,000 feet (Eastwood, 1967). Most of these radar observations unfortunately excluded all movement at heights below 500 feet for technical reasons. Nevertheless on the evidence available 500 feet appears to be the upper limit for most bird movements and this is borne out by the experience and information acquired from the incidence of bird-strikes.

The second reason is the operational height of most aircraft. Almost all civil aircraft and many military ones cruise at altitudes above 5,000 feet and often much greater, thus the period spent at heights where birds are liable to be a hazard is confined to departure from and arrival at airfields. The exceptions to this are those military aircraft which have a low-level operational role, and it is significant that in their case the percentage of strikes occurring en route is approximately 70%, with only 30% near airfields.

In other words the reverse of the situation found with aircraft which cruise at height.

Frequency of strikes

Bird-strikes did not become a really serious problem until the wide-scale introduction of turbine-powered aircraft in the mid-1950s. There are a number of recorded instances of strikes concerning piston-engined aircraft during the Second World War (Paynter, 1947; "S.K." 1957 and Bourne, 1968) and as early as 1946 there was concern by the United Kingdom authorities about the incidents which had already occurred (Cooke-Smith, 1965a). In the same year field trials using falcons to scare away birds from airfields were begun in Britain and efforts were made to collect more information about the species and numbers of birds frequenting airfields (Wright, 1965). However the lack of documentation for this period suggests that the problem had not yet reached serious proportions.

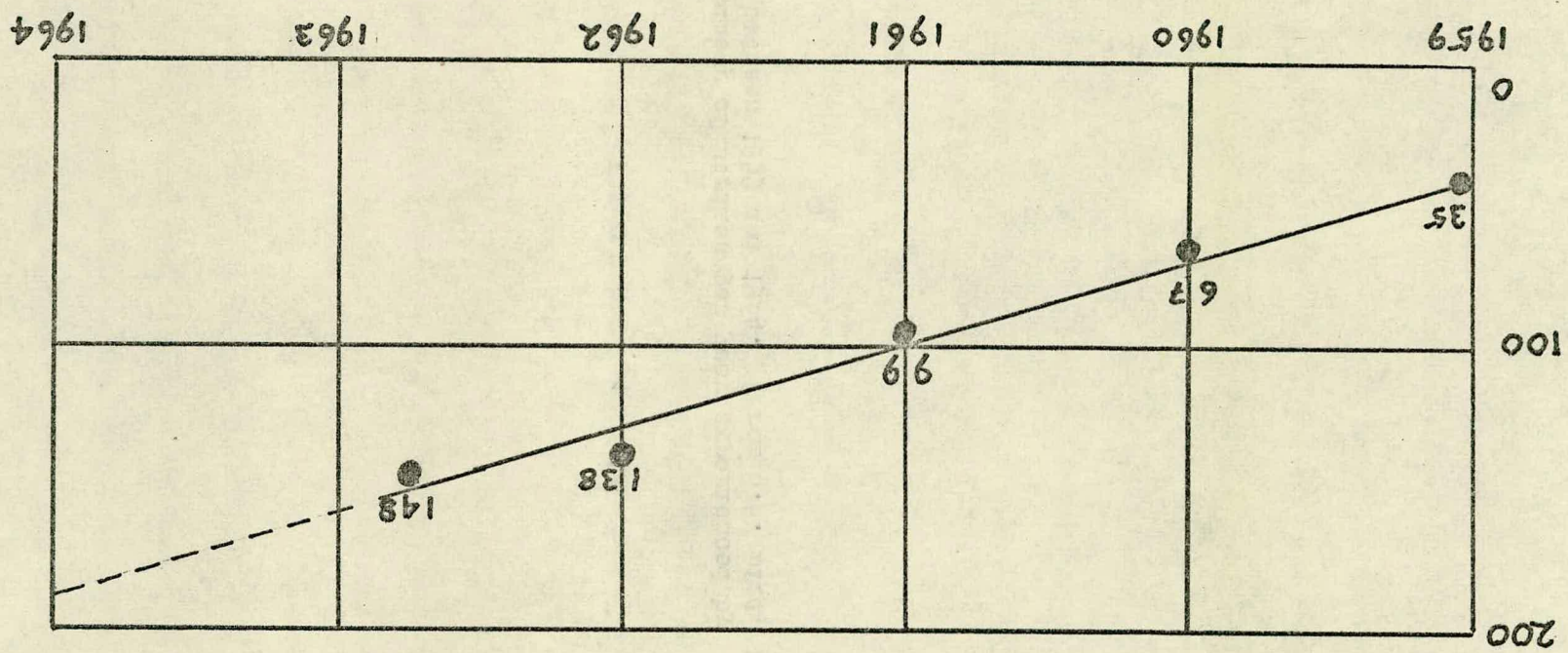
One of the earliest studies in depth was carried out by Robbins from 1956 to 1963 on the Midway Islands, where the United States Navy maintains an air base in the midst of a colony of Laysan and Black-footed albatrosses. He found that aircraft collisions with these birds reached an annual total of between 300 and 400 and that one out of every five aircraft which hit an albatross had either to abandon its take-off or jettison fuel and return to base for an appraisal of damage (Robbins, 1966).

The situation at Midway has become the classic example of the bird problem to aircraft but it is rather a special case. However at about the

same time as investigations were beginning there, other studies were begun, including one in the United Kingdom by Beer (1960).

FIGURE 1

The number of strikes per year experienced by
Air Canada between 1959 and 1964. (From W.H. Bird, 1965)



The high speed of aircraft, both civil and military, entering service in the 1950s and subsequently was undoubtedly one of the reasons for the increased number of strikes which caused damage to aircraft, as a consequence of the greater energy having to be absorbed by the aircraft on impact. Although the increase in the number of aircraft flying and the number of hours flown were probably contributory causes, there is evidence that the number of strikes was on the increase anyway. Trans-Canada Airlines statistics show that the number of strikes per thousand (revenue) flying hours rose from 0.159 in 1959 to 1.06 in 1963 or, putting it another way, there was one strike per 6,602 flying hours in 1959 but by 1963 a strike was recorded for every 945 hours flown. Figure 1 is further proof of the rise in strikes, which appears to be happening at an almost constant rate. The above information and Figure 1 is from W.H. Bird (1965).

The following are some further examples demonstrating the upward trend in numbers of bird-strikes in recent years:

From 1946 to September 1963, 145 notified bird-strikes took place at civil aerodromes in Britain. 105 of these involved aircraft belonging to British European Airways which reports an increase as faster and larger aircraft came into service (J.G.W. Brown, 1965).

Between 1958 and 1963 the British Overseas Airways Corporation has had to make 260 unscheduled engine changes, of which 81 (31%) were due to birds being ingested by jet and turbo-prop aircraft (Cooke-Smith, 1965).

Canadian Pacific Airlines experienced five strikes in 1961, nine in 1962 and 16 in 1963 and of the total 50% occurred to their D.C.8 jet aircraft.

Between January 1957 and October 1963 the Royal Canadian Air Force had a total of 181 reported bird-strikes. In 1957-58 there were 42 strikes, compared with 70 in 1962-63, in spite of a decrease of 35% in hours flown. Jet and turbo-prop aircraft flew 27% fewer hours than reciprocating engine types, yet experienced 62% more strikes.

The increase in bird strikes continues to give cause for concern to aviation authorities, but as will be shown in the section dealing with prevention and reduction of strikes, some progress has been made towards lessening both their frequency and their potential danger to life.

Cost of strikes

If it is accepted that cost in cash terms is secondary to cost in lives lost, then the cost of bird-strikes has been mercifully little. However the expense in money is often very considerable when it is remembered that a damaged aircraft not only has to be repaired but is not earning revenue during the time taken to effect the repair. There is also the inconvenience to passengers to be taken into account, with consequent loss of custom which may result from this, plus the expense of providing accommodation or alternative transport in some cases.

It is not possible to put a price on the total sums involved in the problem, which would have to include the cost of research and scaring equipment as well as the direct price of replacement parts for damaged aircraft. A few specific examples of direct costs will serve to indicate the nature of the expenses which can arise:

The average cost of one bird-strike to the Royal Navy comes to £6,500 (E.M. Brown, 1965).

Stables and New (1968) quote an estimated annual cost to the Royal Air Force of £1m.

Trans-Canada Airlines total costs arising from 489 strikes over a five-year period amounted to \$1,200,000 or approximately \$2,450 per strike.

The Vanguard aircraft involved in the near-disaster at Turnhouse in 1962 reportedly cost BEA £100,000, with four engine changes and including loss of operating returns.

These examples, show the scale of costs which may be involved. Every bird-strike is potentially dangerous although the vast majority - Trans-Canada Airlines quote 88% - cause little or no damage.

The effect of a strike on an aircraft

Whether a bird-strike damages an aircraft or not depends on four main factors, all more or less interrelated. These are: the part of the aircraft

struck, the size of bird concerned, the number of birds and the speed of the aircraft.

The engines are the most vulnerable part of an aeroplane, in particular the modern turbine engine. Unlike the sturdy propeller, turbine engines contain many small blades, rotating at high speed, which are relatively fragile. They also have to take in large quantities of air through a big frontal orifice, making the ingestion of birds easier and thus a real problem. Small birds can be ingested and passed through without damage, but larger ones and dense flocks can cause serious damage or so clog up the air-intake as to result in partial or total loss of power. Most of the cases of serious damage and certainly most of the expense arising from strikes, have been caused by hits on engines.

The airframe is less prone to suffer damage critical enough to cripple an aircraft, although expensive repairs may still be necessary. The wind-screen and nose of the aircraft and the leading-edges of the wings, tail and tailplane are the areas which are exposed to the greatest risk because they are frontal areas. Fortunately, apart from the risk of injury or death to the crew from cabin penetration, there are not usually any vital control surfaces, other than the aircraft's radar, situated in the front of the nose, wings or tail. The danger of decompression from cabin penetration in high-flying aircraft does exist, but at heights where this would be serious there is virtually no likelihood of encountering any birds - that is, above about 12,000 feet.

Energy varies as the square of velocity, therefore other things being

equal the damage caused by birds greatly increases as speed increases. Stables and New (1968) give an illustration of the disruptive effect of impact at high speed to show why an aircraft weighing, say, 100 tons cannot withstand safely colliding with birds weighing a few ounces or a few pounds:

The energy which has to be absorbed by an aircraft travelling at 600 m.p.h. which strikes a 4 lb bird is the same as that having to be absorbed by the ground when a 2 ft 6 in. cube of concrete weighing 1 ton is dropped from a height of 22 feet.

Plates 1 and 2 show the damage inflicted on the engines of the Vanguard involved in the near-disaster at Turnhouse in 1962.

The size of birds is related to their weight and weight is important because the heavier the bird the greater the damage it can inflict. Similarly dense flocks can block engine air-intakes whereas one or two birds may simply be minced up in the engine, and perhaps never even noticed by the pilot.

Reduction and prevention of bird-strikes

Methods employed to reduce the incidence of bird strikes fall into three categories:

1. Strengthening aircraft physically to enable them to withstand strikes.
2. Scaring off birds from airfields and warning aircraft of their presence there or, in the air, by means of radar.
3. Ecological control, either through habitat changes or reduction of food supplies or bird populations.

Research upon all these aspects has been taking place for some years now, with varying degrees of efficacy, and as a prelude to the consideration of the study made at Turnhouse the third category will be examined more closely than the other two. However it is also necessary to look into the reasons why strengthening aircraft and various means of scaring birds cannot provide the answer to the problem and these will be appraised first.

1. PHYSICAL PROTECTION OF AIRCRAFT

The difficulty with trying to provide an aircraft with adequate protection against birds is that, even with the new lightweight materials in use today, provision of increased strength invariably results in a heavier aeroplane with consequent loss of speed and operating efficiency. In practice, a compromise has been reached and regulations formulated by the Air Registration Board specify that engines and windscreens on civil airliners must be able to withstand impacts from birds up to 4 lb weight at maximum aircraft speeds up to 8,000 feet altitude. The reason for the choice of 4 lb is that when numbers of bird-strikes are plotted on a graph against the weight of birds involved, the resulting curve shows a marked change of slope at that weight. Most strikes concern birds weighing less than 1 lb, decreasing gradually towards 4 lb then dropping sharply to almost nil for birds from 6 lb to 20 lb (National Research Council, Canada, 1967). This is fortuitous in that to protect an aircraft from birds above this weight would place severe limitations on their usefulness.

Screening engines to prevent ingestion of birds leads to an increase in fuel consumption and icing problems and is impractical. However it has proved

TABLE 1

TABLE 1

Date	Description	Amount	Balance	Total
1945	Jan 1	100.00	100.00	100.00
1945	Feb 1	50.00	50.00	150.00
1945	Mar 1	25.00	25.00	175.00
1945	Apr 1	12.50	12.50	187.50
1945	May 1	6.25	6.25	193.75
1945	Jun 1	3.12	3.12	196.87
1945	Jul 1	1.56	1.56	198.43
1945	Aug 1	0.78	0.78	199.21
1945	Sep 1	0.39	0.39	199.60

TABLE 1

BSA

BOY SCOUTS OF AMERICA



Scaring Devices Used at Airfields

TABLE 1

<u>Acoustic</u>	<u>Pyrotechnic</u>	<u>Physical</u>	<u>Chemical</u>	<u>Animal</u>
Bird dis- tress calls	Shell crackers	Shooting	Tactile, Gustatory and olfac- tory rep- onents	Balcony Dogs
Carbide gun	Very flares	Vehicles	Maidin	
Ultrasonics	Signal rockets	Stuffed or wooden models of predators	Chloroform	
	Coloured smoke	Radio-cont- rolled model aeroplane	Malic hydrazide	
		Wire strung over the ground		
		Stakes in the ground		



BOSTON GUY

possible to strengthen windscreens enough to provide pilots with a reasonable degree of safety from head-on collisions with birds at speed.

Aircraft designers are well aware of the problem and endeavour to ensure that no essential services or controls are located in the fore parts of the wings or fuselage. The thin wings of jet aircraft provide less frontal area to be struck anyway, and the fact that they are swept back means that head-on strikes are less likely to occur and damage is reduced proportionally. Military aircraft, because they may have to operate at low-level, sustain an increased risk but to offset this the pilot has an ejector seat so that in the last resort he can abandon his aircraft.

Although investigations to find new and improved ways to give aircraft more protection are still going on, their application will always be limited by the factors mentioned above. They are a help towards lessening the cost of damage, but provide no solution for reducing the number of strikes.

2. BIRD SCARING AND BIRD WARNINGS

It is not necessary to describe in detail all the various and often ingenious ways which have been thought up to scare away birds from airfields. Wright (1965) and Brough (1968) have reviewed these at length. However to give an impression of the diversity of means which have been tried these methods are listed in Table 1 under five classifications.

The degree of success attained by using any one of these schemes or devices naturally varies to a certain extent depending on when and where it is used and against what species of bird or birds it is directed. In the

United Kingdom, as in the majority of other countries, gulls are the chief hazard. Starlings, corvids, lapwings and wood pigeons are amongst the other leading offenders in Britain. Elsewhere different species may be involved.

The most universally adopted scaring method is a combination of tape-recorded bird distress-calls (of the appropriate species) played through loud-speakers and reinforced by firing shellcrackers or sometimes with actual shooting of a few birds. The so-called distress call is only emitted by a bird under conditions of distress such as when struggling with a bird of prey. As such it differs from the alarm call which is in fact a warning call. Research into the behavioural effects of distress calls involves technical acoustical work on the reactions of birds to a variety of auditory stimuli. Papers by Brough (1965; 1968), Busnel (1965), Giban (1965) and Busnel and Giban (1968) give very full descriptions of this type of study but need not be dwelt on here. In essence, playing a recorded distress call to other birds of the same species elicits a fugitive response. In practice this causes them to leave the vicinity where the distressed "bird" is and when reinforced by firing shellcrackers birds can be removed from an airfield for considerable periods of time. Because this method has been adopted in Britain as well as by a number of other nations, it warrants fuller description.

Static loud-speakers having been shown to have serious disadvantages, a vehicle-mounted system was developed. Plate 3 shows this so-called bio-acoustic system mounted on a Board of Trade van at Turnhouse. Continuous loop cassettes of the distress-calls of the species causing trouble at the airfield are provided and the operator selects the one required and fits it to

a tape deck fitted inside the vehicle. Approximately $1\frac{1}{2}$ minutes of play is on the loop and this is broadcast through the speakers on the van roof. The effect of the distress calls is reinforced by firing shellcrackers, which are modified 12-bore cartridges containing a firework which explodes at the end of its 100 yard trajectory. The combined result does deter birds from returning provided that the equipment is properly used. Brough (1968) reports good results in over 90% of cases during controlled tests at five airfields for gulls, corvids, lapwings and starlings. Results using one or other of the devices by themselves were considerably poorer. Unfortunately the tendency is for enthusiasm for bird-scaring to wane and all too often the personnel responsible for doing the job have not been trained in the relevant aspects of bird recognition and behaviour. Inevitably this greatly reduces the effectiveness of the equipment.

Notwithstanding the human element, the bio-acoustical scaring method is unquestionably the most efficacious way yet found for reducing the bird-strike hazard by scaring. The realisation of this has led to its official adoption by the Ministry of Aviation, who also issue a pamphlet, "Bird Dispersal from Aerodromes", (Ministry of Aviation, 1965) embodying the basic requirements for its successful operation.

Of the other methods listed, falconry is probably the best but the requirement of trained falconers and falcons precludes its use in all but a few cases. Falcons are also at their least effective in conditions of poor weather with low cloud and rain or fog, the very time when bird hazards are usually greatest.

The failure of other schemes lies mainly in the ability of birds to become habituated to the noise or object involved, though other difficulties, such as the man-hours needed to string wires over an airfield, costs, or, in the case of chemical trials, poor results, have prevented their adoption for general use.

It is fair to conclude that scaring alone is an unsatisfactory way of approaching the bird problem at airfields because even with trained operatives carrying out the task the solutions it provides are at best temporary and at worst ineffectual. Realisation of this has led to concerted action being taken in other directions, among which has been the implementations of "bird forecasts", obtained by using radar, on the same lines as weather forecasts.

Radar has been used for some years to trace the movements of migratory birds and has now reached a stage of sophistication, inasmuch as it is possible to recognise genera and even species from their wingbeat pattern on a radar screen (Eastwood, 1967) and Schaeffer, (1968). This has rather obvious implications where birds and aircraft are concerned and there are two aspects of the problem where radar can be of assistance. The biggest danger comes from birds on migration, while local movements may also present a hazard. Both long-distance migration and local movements tend to follow patterns in time and space, often inter-related to the current meteorological situation. It should therefore be possible to initiate a warning system using radar, whereby aircraft and airports may be advised of approaching concentrations of birds. The question of local movement warnings has not yet been fully

investigated, but some progress has been made with migration warnings. In a recent paper Gunn and Solman (1968) reviewed the attempts to provide bird forecasts which had already been made using radar observations, and concluded that initial trials were encouraging but modifications would be required if an international scheme were to be feasible. In fact a bird-warning system is now in operation in Western Europe and further experiments are proceeding in Canada. As an example of a bird-warning emanating from the operation of the European scheme, the following signal was received at Turnhouse (and other airports) on 8th March, 1968:

Bird Migration Warning

Migration of storks from Portugal. NE direction about 3,000 feet. Speed approximately 15 kt. Duration 12 hours approximately.

Note that although this information is imprecise as to exact locality some biological knowledge is implicit in the fact that an estimated duration of the migration is given. Gunn and Solman envisage a roster of biologists preparing these bird forecasts in much the same way as meteorologists do now for weather, at every airport. While the chief application of bird-warnings is to aircraft en route, it should become possible, in the light of accumulated information, to predict the likelihood of concentrations of birds arriving at or near airfields as well.

However accurate bird forecasts may become, they are basically an avoidance measure which, while contributing to the reduction in strikes sustained, do nothing towards preventing the problem from arising. The next section

shows how some fairly elementary environmental changes can help do this on a short-term basis and considers ways of implementing long-term planning of habitat change using fundamental principles of ecology.

3. ECOLOGICAL METHODS

It is probably a truism to say that whenever man has been confronted with problems arising from an apparent superabundance of an animal population his first reaction has been to reach for his gun. In former times it may have been his bow and now it is often a chemical spray but the implication is the same: kill off the pest and the problem is solved. It is only very recently that it has become increasingly apparent to the general public that this is not so. Awareness of the danger and sometimes futility of placing too much reliance on slaughter did not really crystallise in the public mind until the publication of Rachel Carson's book "Silent Spring" in 1962. Although ecologists had already become alarmed at the rapidity with which modern technological methods of pest control could upset and contaminate the environment there was little they could do without having popular support on their side. "Silent Spring" focussed peoples' attention on what hitherto had been a matter concerning only chemical companies, their customers and scientists. It is fair to claim that only since its publication has public attention also been focussed on other aspects of pest control. Elton (1958), preceding Carson by four years with his book on "The Ecology of Invasions by Animals and Plants", had already shown how deliberate and accidental introductions of species foreign to an area could have unpredictable and often disastrous consequences. Other writers before him have indicated other dangers, often

arising from the wrong use of land or ignorance of the complexity which comprises the balanced network of species forming a stable community.

Chemicals have been used mainly against insect pests, although their use against mammals is not unusual - examples being "Warfarin" rat-poison, "1080" rabbit poison used in Australia and alpha-chloralose used for gulls in New Zealand - but they are only one means of control. Biological control has met with considerable success in a number of instances. Perhaps the best known is the introduction of myxomatosis into the Australian rabbit population, the outcome of which was to reduce their numbers to proportions where gassing, shooting and trapping were sufficient to prevent any further increase and, almost literally, saved the sheep-farmers' livelihood.

Two other examples, both taken from Elton, are the completely successful control of the fluted scale insect Icerya purchasi, introduced from Australia to California about 1868, by another Australian species, the lady-bird Norius cardinalis and the equally effective grafting of European vines on to American root-stocks to make them resistant to the American vine aphid Phylloxera vitifolii which had accidentally reached France and threatened to ruin the vineyards. Other examples could be quoted where biological control has proved not only the best but the most economical way of combating a pest species. However the purpose of the foregoing paragraphs has been to introduce the concept of applying ecological principles to what are basically ecological problems and not to survey them in detail. The many examples of habitat management used to encourage game on American farms have not been mentioned, nor have other less successful attempts to implement control by

means other than the long-established ones of gun, poison and trap. Suffice it to point out that there is a growing public awareness now of the desirability as well as the need to use ecological methods.

In seeking to find a solution to the problem of bird hazards to aircraft killing and scaring birds have featured prominently amongst the means employed. However attempts to carry out ecological changes to achieve a reduction of bird numbers at airfields have also been made and an early account of these is given by Cook-Smith (1965b). More recently Wright (1968) has summarised the work done in Britain, Canada, France, New Zealand and the U.S.A. in this direction.

Theoretically the hazard presented by birds to aircraft would be almost eliminated if every airfield and its surrounding area was made so unattractive to birds that they ceased to frequent it. In practice this is not possible for a multiplicity of reasons; even if it were, the lesser problem of en route bird-strikes and birds overflying airfields on seasonal or diurnal migrations would remain.

It is nevertheless possible to do a number of things which will lower the number of birds utilising an airfield and thus lessen the chances of a bird-strike occurring on it. Accomplishing this depends on what species are attracted to the airfield and what it is that attracts them. In general, birds which find security in open spaces for roosting and resting will be drawn to airfields whereas those preferring dense cover will avoid them. For instance, open rubbish tips attract gulls; bad drainage and consequent waterlogging may create ideal conditions for waders; geese and ducks like

ponds; long grass may harbour mice and voles and bring in birds of prey; starlings and the corvidae like seeds and small invertebrates and there may be a problem caused by birds nesting in suitable nearby cover such as bushes, aircraft hangers or even in aircraft (Bridgman, 1962). Moreover many less busy airfields provide a refuge relatively free from human interference, which is in itself an attraction.

At first glance the solutions to these problems seem obvious: close down garbage tips, put in adequate drainage systems, fill in ponds, mow the grass, poison insects and cut down trees and hedges. However procuring these remedies, even assuming that the need for them is always realised by airport managers, is often far from simple. Rubbish tips may be outwith the control of the airport authorities, ponds may be on land belonging to an adjoining farm, drainage is costly, and there is considerable controversy as to whether mown grass or long grass is the more successful bird deterrent. To illustrate the difference of opinions in different situations, the following will serve. Van Tets (unpublished CSIRO Report) maintains that in Australia paving an airport with abiotic plastic or bituminous soil-fixing compounds will eventually prove more practical than other methods and at the same time will solve dust and drainage problems. Conversely, Solman (1966) in discussing his paper considered that from a Canadian point of view the cost of laying and maintaining paving would be prohibitive and would adversely affect drainage, leaving pools of standing water which could attract birds.

This lack of unity is due not so much to scientific conflict as to the variable nature of the problem and conditions in which it is encountered.

The answer for Australia might just as easily aggravate the situation if applied in Canada and proposals to deal with bird problems must always make allowance for this. Even so some general principles for use in ecological and environmental control can still be formulated.

First, proposed siting of new airports should take bird hazards into account. Both Wright (1968) and Bourne (1969) have indicated the potential danger to be expected from gulls and waterfowl if the Foulness site is used for London's third airport. Similarly the now-abandoned plan to establish a Royal Air Force staging-post on the island of Aldabra in the Indian Ocean would have encountered serious difficulties from infestation of the airfield by frigate birds similar to the situation with albatrosses at Midway Atoll.

Secondly, at existing airfields, there is a limit to the habitat modification which can be carried out, conditional with normal operations. It may be possible merely to deter birds from using them or in some cases to provide a more attractive alternative, so inducing them to go elsewhere. To do either of these things requires certain essential knowledge which has to be acquired on the basis of the following questions for each individual airfield.

1. What species are involved?
2. What attracts them?

Having determined the answers to these, it is then possible to move on to a consideration of the behaviour and movements of each individual "problem species" and to carry out a survey of practical methods which can be adopted

to reduce their numbers by the most efficacious means. It is also important to keep in mind the predictable effects of any changes proposed as a result of the survey, lest the solution of one problem creates others equally serious.

To give an idea of what it is possible to do by these methods the results obtained from their application in three different countries are briefly reviewed below, and mention of research being conducted in the U.S.A. and Britain are referred to as background to the next part of this thesis.

On Midway Atoll, Robbins and his co-workers achieved a significant overall reduction of 27% in the mean number of albatrosses flying and nesting alongside the runways there once they had discovered that two thirds of the birds which presented a hazard in this way originated from areas within 750 feet of the runways. The remedy was to eliminate the relevant nesting population and then bulldoze the nesting area flat, which also had the effect of removing the source of upcurrents used by the birds for soaring. The mean reduction in birds along the main runway was a satisfactory 61%. A further experiment to translocate some of the Laysan albatross population by providing artificially increased nesting space at nearby Kure Atoll is still being evaluated but appears to have met with some success (Robbins, 1966).

In Australia, at Sydney Airport, a roosting population of 8,000 gulls has been cleared by filling or draining shallow ponds on the airfield and stringing wires over the tidal banks in nearby Cook's River. Daytime gull

numbers at both Sydney and Adelaide Airports have been reduced by about 90% by using adjacent garbage tips only at night and leaving them covered during the day (Van Tets, 1966). Further reductions in numbers of birds are being achieved at Sydney, Adelaide and Townsville Airports by improving the drainage to remove waterfowl.

The construction of a new airport at Auckland, New Zealand, posed major problems because of failure to take into account the tidally-linked movements and roosting requirements of vast numbers of waders. The sea-front location of the airport also led to problems with gulls and waterfowl. Saul (1967) in a very comprehensive paper, details how the provision of an artificial roost for the waders combined with improved drainage, removal of shelter, bare areas and pools, closing a rubbish tip and banning fishing operations within some distance of the airfield, together with an active programme of scaring, has already led to a 60% drop in the number of birds causing a hazard. A target of 90% is believed to be attainable with continued effort and the implementation of a system of growing grass long.

In the U.S.A., research by Drury (1955) and Kadlec and Drury (1968) into Herring gull populations and movements in New England points the way to the fuller understanding of birds necessary if long-term solutions to bird-strike dangers are to be found. Drury's work in fact formed only one aspect of a research programme initiated subsequent to the Electra crash at Boston and paid for by the Federal Aviation Agency. In Canada also work has been progressing into ecological aspects of the problem and similar studies continue in France and Holland.

In the United Kingdom, Bridgman (1965) has made a study of the seasonal variations in numbers of birds at three RAF airfields as part of the work being carried out by the Infestation Control Laboratory of the Ministry of Agriculture, Fisheries and Food, but so far this country has lagged behind others in tackling the problem from an ecological standpoint. The present economic climate may be partly responsible for this but there still appears to be a reluctance to accept that the bird hazard is on a par with such dangers as thunderstorms, metal fatigue or failure to carry out the proper maintenance of aircraft. These other risks have been minimised by efficient meteorological reporting, research and legislation respectively. That there has not yet been a major accident involving loss of life from a bird-strike in Britain is fortuitous and not the result of action taken to deal with the problem. The widespread nature of the hazard requires that the opinion of ornithologists be taken seriously and a national programme of research instituted towards effectively reducing the incidence of bird-strikes before they do cause a catastrophe. The ensuing work examines the problems found at one British airport - Turnhouse - and suggests possible ways in which they may be overcome.

P A R T II

THE DISPERSION OF GULLS IN THE LOTHIANS AND FORTH
IN RELATION TO TURNHOUSE AIRPORT



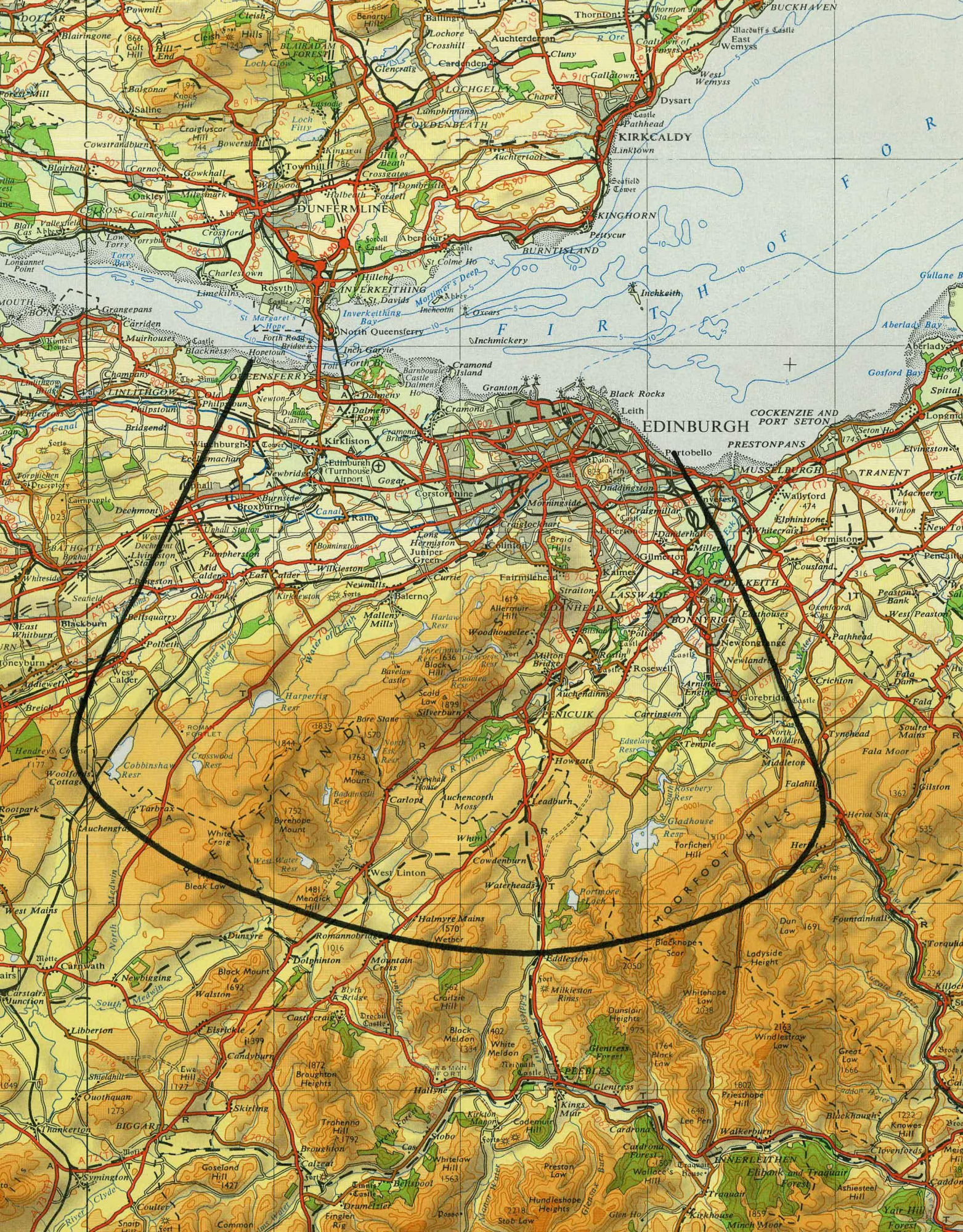
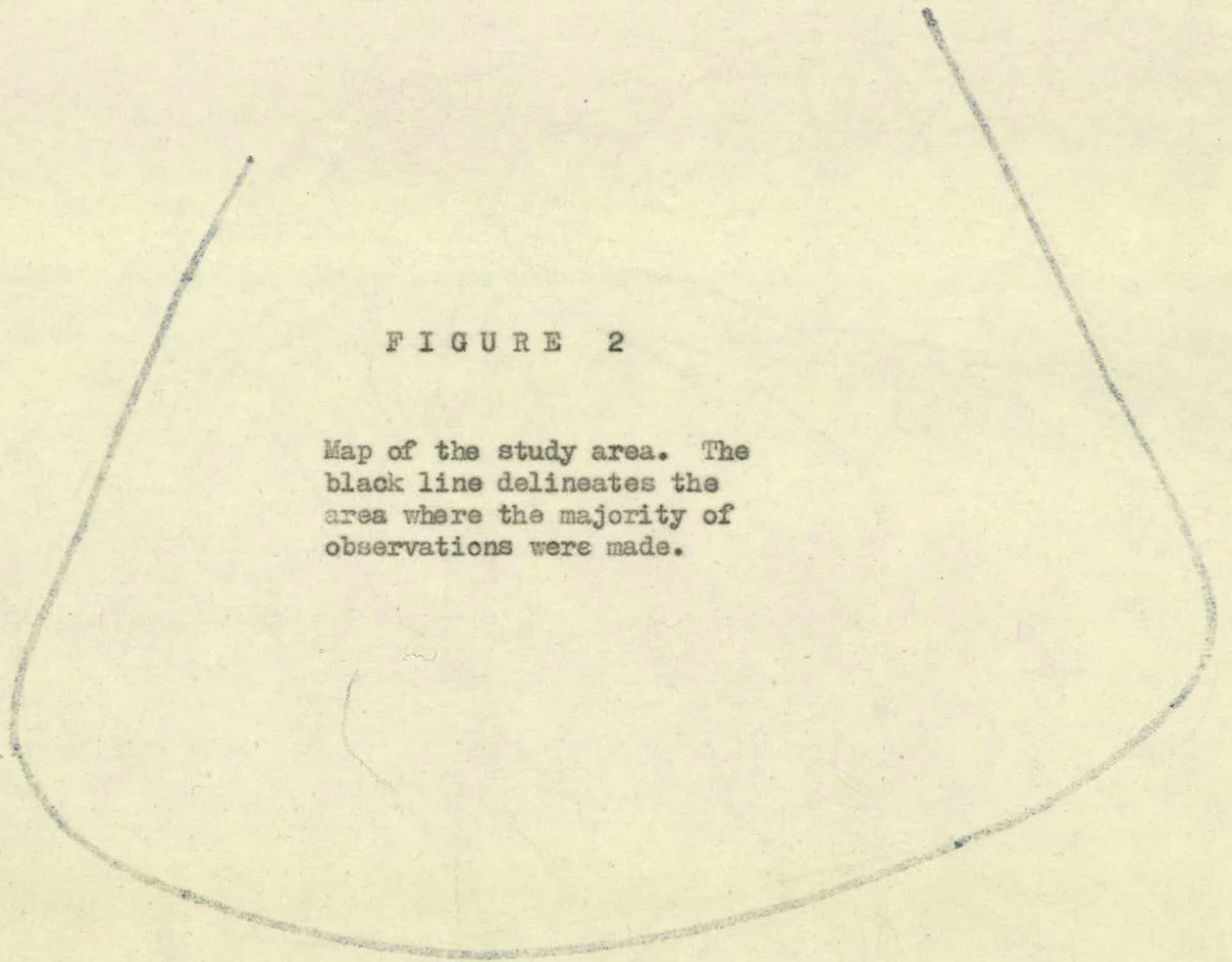


FIGURE 2

Map of the study area. The black line delineates the area where the majority of observations were made.



Introduction to Turnhouse Airport, its bird problems and how they were approached

Turnhouse Airport lies just to the west of the Edinburgh City boundary and some $2\frac{1}{2}$ miles from the south shore of the Firth of Forth, (see Figure 2). Situated between two main roads, the A.8 and A.9, access to the terminal buildings and control tower, which lie on its northern side, is gained from the A.9.

The airfield is 135 feet above sea-level and is approximately 350 acres in extent with a perimeter of just over $3\frac{1}{2}$ miles. The south and west edges are bounded by the Gogar Burn, the A.9 road runs along the north side and the eastern edge is delineated by the Edinburgh to Perth railway line. Most of the field is covered by mown grass, with the exception of the runways and perimeter track. There are two runways in current use, the main 13-31 runway which is 1,829 meters in length, and the short 08-26 runway. There is also a disused runway, 04-22. The airfield is at present administered by the Board of Trade but is due to be handed over to the British Airports Authority in the near future.

The surrounding country is largely agricultural, but there is a wood half a mile south of the airfield and a golf course to the northeast of it. Further away, there is higher ground to the north and north-east. To the west and east it is fairly open but 7 miles to the south are the Pentland Hills which comprise much ground over 1,500 feet in height.

The bird problem at Turnhouse is almost entirely caused by the daily flighting of gulls inland from the Forth in the morning and back to the sea

again at night. The intensity of this movement varies seasonally and may also be affected by tidal and weather factors. On occasion, in certain weather conditions, mass infestation of the airfield by gulls can occur while at other times smaller numbers may settle on the airfield and pose a problem by their attachment to the area in spite of persistent efforts to scare them away.

Other species which could sometimes prove hazardous but are not generally so at this airfield are rooks, jackdaws and woodpigeons. The two corvids are often seen in winter flying to and from roosts but are normally well outside the airport boundaries, while woodpigeons overfly the airfield in numbers sporadically and infrequently. Lapwings, Golden plover and oystercatchers have all been recorded settling on the airfield in quantity at migration time and could endanger aircraft but the infrequency and irregularity of their appearance precludes any means of control other than scaring. Starlings are not a hazard at present but any increase in the flock of 30-40 which frequent the airport would be dangerous. A complete list of species recorded at Turnhouse throughout the period of study, with notes on their status a propos of aircraft operations is given in Appendix IV.

The period covered by this study lasted just over twelve months, from 1st February, 1968 to mid-March, 1969. After an initial week's observations carried out at Turnhouse, to provide an indication of the problems to be faced, a programme was drawn up which formed the basis of the study. This was as follows:

1. Observations of daily gull movements.

These were made at Turnhouse, supplemented by other observations from along the south Forth coast and at a variety of inland places, with the aim of discovering the following facts:

- (a) the species of gulls involved
- (b) the numbers involved and factors influencing these
- (c) the flight-lines used and whether they formed an established pattern
- (d) where the birds were going and what they were doing once they arrived there and
- (e) the nature of the movements, whether directed or opportunist or a combination of both.

2. Survey of the history of gull populations in the Lothians and South Forth area.

This involved considering, first, the summer - or breeding - population, composed of resident birds and secondly the winter population, which is much greater, being augmented by immigrants from elsewhere. A literature search, combined with visits to existing colonies, enabled a fairly good interpretation of the history of the breeding population to be made. This, plus information available from ringing returns, was used to try and assess trends in the winter population.

3. The annual gull cycle.

Using the knowledge gained from the implementation of the first two parts of the programme, the annual cycle of gulls in the Lothians and South Forth was established as far as possible, with particular reference to its effect on the problem at Turnhouse.

Although conditions demanded that the work programme be undertaken in the sequence outlined above, its presentation here is made in the more logical order of progression from the general to the particular. Accordingly the first section covers the history of gull populations in the Lothians, leading on to a consideration of the annual cycle and thence to a detailed examination of daily movements. The results obtained are used in Part III to show how it may be possible to bring about a mitigation of the bird hazard at Turnhouse by their application to environmental and ecological modifications.

SECTION 1. THE HISTORY OF GULL POPULATIONS IN THE LOTHIAN AND FORTH

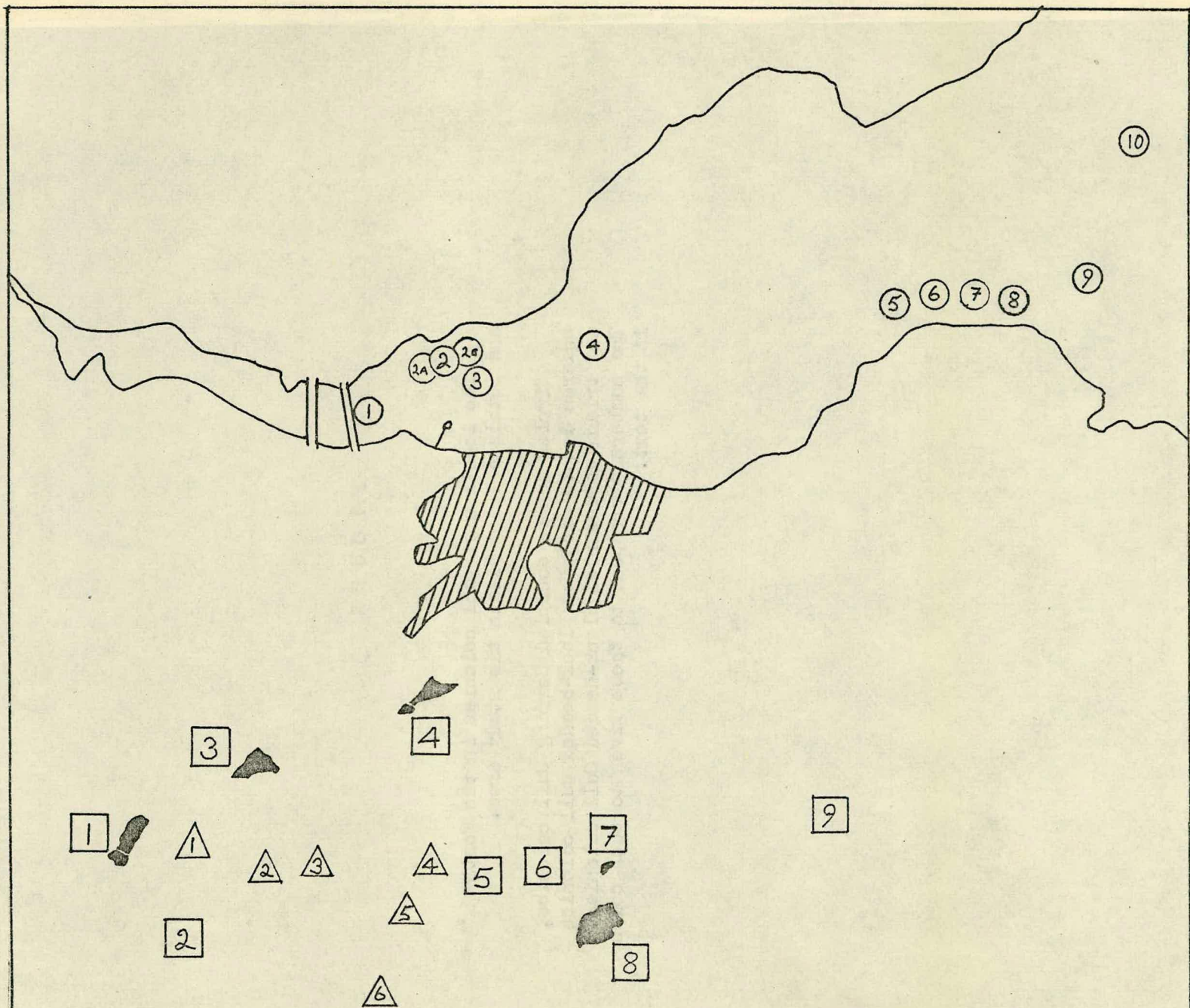
1.1. Composition of the breeding population

There are five species of gull which breed in Britain: the Great Black-backed gull, the Lesser Black-backed gull, the Herring gull, the Common gull and the Black-headed gull. Of these the Herring and Black-headed gulls combined form by far the largest section of the breeding population in the Lothians and Forth area, exceeding 92% of all the gulls breeding there. The remaining 8% or thereabouts is composed almost entirely of Lesser Black-backed gulls. There are several records of a pair of Common gulls nesting

FIGURE 3

The location of gull colonies in the Forth and Lothians lying within the study area.

Circles denote occupied Herring Gull colonies, squares denote occupied Black-headed Gull colonies and triangles deserted Black-headed Gull colonies. The numbers correspond to those given to each colony in the text.



at the Crane Loch and some old records exist of Great Black-backed gulls breeding on the Bass Rock but these two species are of little further concern as part of the summer population although Common gulls form a considerable proportion of the total winter population.

1.2. Survey of the breeding colonies: 1. Their past and present status

HERRING AND LESSER BLACK-BACKED GULL COLONIES

Herring gulls breed or have bred on ten of the eleven islands in the Forth and on the Haystack and Carr Craig, which are outliers of Inchcolm. No records have been found for Cramond Island but it is probably too disturbed for them to breed there except perhaps for a few pairs. They are known to have bred at St. Abbs Head since at least 1871 but this colony has not been included in the survey, although a large gullery still exists there. Lesser Black-backed gulls have not been accorded the same scrutiny as Herring gulls but are mentioned where appropriate under colony headings. The locations of all colonies of these species and of Black-headed gulls are shown in Figure 3.

A number of Herring gull colonies were not visited in 1968. This was in all cases due either to adverse weather preventing the boat from leaving harbour or to a boat not being available for the trip to that particular colony.

1. INCHGARVIE. Visited on 28th June, 1968. 120 pairs of breeding adult Herring gulls estimated present. 25 nests still contained eggs and 90 chicks were counted including ten swimming offshore. This was an accurate

count.

History: Date of colonisation not known but there are negative records up to 1954. Prior to this the island supported a tern colony at least in some years, but in 1954 rats much reduced the tern population.

2. INCHCOLM. Not visited.

History: The first mention of breeding is in 1950, when Herring gulls were noted breeding on the skerry by the jetty. They are recorded as being present in 1955 as well but no figures are available.

2a and 2b. THE HAYSTACK and CARR CRAIG. Not visited.

History: No figures are available for the Haystack but Herring gulls were recorded breeding in 1957 and 1962. Two Herring gull chicks were seen on 31st July, 1948 on Carr Craig and in 1951 there were 15-20 pairs and 20 well-grown young were seen. 100-200 pairs were noted in 1955.

3. INCHMICKERY. Visited on 18th June, 1968. 20-30 pairs of Herring gulls and 14 young observed and also a pair of Lesser Black-backed gulls which were apparently holding territory though no nest or young was found.

History: There are negative records up to 1958. In 1959 a single Herring gull's nest was found, containing three eggs. A pair and two fledged young were seen in 1960; in 1963 one nest was found and in 1966 50 nests were reported.

4. INCHKEITH. Visited on 27th June and 7th July, 1968. Size of the

colony estimated at 3,000 pairs of Herring gulls and about 100 pairs of Lesser Black-backs but this may well be too low. No count of nests or chicks was made.

History: In 1940 one pair of Herring gulls nested. By 1948 they were "occupying a whole cliff face" (Rintoul and Baxter, 1935). Lesser Black-backed gulls were not breeding prior to 1951 and the first definite record is of two pairs in 1956.

5. EYEBROUGHTY. Not visited.

History: Apparently negative records for 1950, 1951 and 1952. About 200 Herring gulls' nests found in 1967.

6. FIDRA. Not visited.

History: Up to 100 pairs of Herring gulls used to breed but this number has been reduced by rats.

7. THE LAMB. Not visited.

History: The current population is believed to be about 1,000 pairs of Herring gulls. R.W.J. Smith (pers. comm.). In 1951 there were 100-200 pairs of Herring gulls and about 12 pairs of Lesser Black-backed gulls.

8. CRAIGLEITH. Visited on 12th July, 1968. Size of colony upwards of 3,000 to 4,000 pairs of Herring gulls and 300-400 pairs of Lesser Black-backs. No estimate of numbers of nests or chicks made.

History: "Numbers" of Lesser Black-backed gulls were present in 1930 (H.J. Patten, in Rintoul and Baxter, 1935) and there were about 100 pairs in 1951. No figures available for Herring gulls. It is perhaps worth noting that gulls have nested since the 1840s "on the islands off North Berwick".

9. THE BASS ROCK. Not visited.

History: 515 Herring gulls (birds not pairs) were present in 1963 along with 18-20 pairs of Lesser Black-backed gulls (Nelson, 1963). The latter species was present in 1882 when two eggs were obtained and was a regular breeder at least till 1916 and sporadically thereafter till 1927. 8-10 pairs were present in 1893 and 20-30 pairs in 1896 and 1897. The Herring gull is mentioned in records from the beginning of the 19th century as a breeding bird and again in 1839 but records since then are intermittent and vague; "occurs in limited numbers" in 1847, "numerous" in 1867, "a few pairs" in 1871, "breeds in limited numbers" in 1872, "none" in 1886, one or two pairs in 1888, five nests in 1889, two or three nests in 1893, "many" in 1900, "a few pairs" from 1907 to 1912, 24 pairs at most in 1928, "present" as a breeding bird in 1955, 1957 and 1959 (Rintoul and Baxter, op. cit.)

10. THE ISLE OF MAY. Visited from 7th to 9th August, 1968. The Herring and Lesser Black-backed gull colony is very big and currently estimated at about 12,000 pairs altogether of which over 11,000 are Herring gulls (Jasper Parsons pers. comm.)

History: The first pair of Herring gulls nested in 1907. They have since steadily increased as follows: in 1914 about 12 pairs, 35 pairs in 1921, 58 pairs in 1924, 455 pairs in 1936, about 760 pairs in 1947, 1,000-1,250 pairs in 1951, 1,750 pairs in 1952, about 3,000 pairs between 1953 and 1958 (when control measures were being taken), no estimate in 1959, 2,700 pairs in 1957, 8,000 in 1965, 7,000 in 1966 and 11,000 in 1967. (The 1965 and 1966 estimates may have been too high and too low respectively.)

The Lesser Black-backed gull has followed a similar pattern since the first nesting pair was found in 1931. 2-3 pairs in 1933 and 1935, 7 pairs in 1936, 8 pairs in 1937, 15 pairs in 1938, 73 pairs in 1946, about 100 pairs in 1948, about 115 in 1951, 160-170 in 1952, 175 in 1953, 200 in 1954 and 200-250 between 1955 and 1958, 350 pairs in 1963, 450 in 1964 and 900 in 1966. Their present population is about 1,000 pairs. (Most records from Eggeling, 1960).

BLACK-HEADED GULL COLONIES

Black-headed gulls are known to nest annually at at least eight colonies within fifteen miles of the Edinburgh city boundary and when conditions are suitable sometimes at a ninth. There are also six sites on which breeding has been recorded in the past but which have not been used recently.

1. COBBINSHAW RESERVOIR. Visited on 20th June and 17th July, 1968. Most nests were situated on floating vegetation at the south-west corner of the reservoir. 200 adult pairs were estimated on the first visit and most nests were still occupied. By the second visit only ten nests were still occupied

and 130 adult pairs present. Of the 75 chicks counted, 15 were on the wing.

History: 500 pairs were noted in 1884 and gulls were "abundant" till 1905 and then decreased. 200-250 pairs in 1919, 200-300 pairs in 1933, 500-750 pairs in 1938, 300 pairs in 1952 and 300 pairs in 1958.

2. CRANE LOCH. Visited on 19th June and 11th July, 1968. The loch is a small moorland one and all the gulls' nests are located round the edge and close to the water. About 400 pairs of adults were present on both visits. On 19th June, 383 nests were counted of which one contained four eggs, 162 three eggs, 133 two eggs and 74 one egg. Three had two eggs and a chick, six one egg and a chick and eight one chick only. Five chicks were swimming on the loch and there were about seven unoccupied nests. On the second visit, 120 chicks were on the water, about 20 had reached the flying stage and 80-100 were found dead, most of these having injuries to the base of the skull.

An adult Common gull and a dead half-grown chick of the same species were seen on 11th July. This species also bred or attempted to breed in 1948 and 1952 (two pairs) and possibly in other years. This is the only place among the fifteen localities included here where Common gulls are found breeding.

History: 12-15 pairs in 1938, five pairs in 1947, 60 in 1948, 150 in 1950, 450 in 1951, 200 in 1952 and c. 450 in 1958. Hamilton (1962) states that this colony was classified under "Carnwath" by Hollom (1940) but this seems doubtful as Hollom also mentions the Crane Loch. I have used Hollom's figure here.

3. HARPERRIG RESERVOIR. Visited on 19th June, 4th and 17th July, 1968. The colony consisted of 25 pairs of adults and 24 occupied nests on the first visit and was entirely confined to the islet at the western end of the water, although one pair appeared to have attempted to nest on the shore opposite. There is a great deal of disturbance to this colony from small boys and fishermen and it was remarkable that about 14 chicks actually reached the swimming stage, despite this.

History: The reservoir was built in 1855-56 and enlarged in 1890. The gullery was established at least by 1880. 100-150 pairs were present from 1882 to 1905. 250 pairs in 1915 were reduced to 30 pairs by 1919 due to suspension of protection during the First World War. 20 nests in 1920, 50-60 pairs in 1934, 150-200 pairs in 1938, five or six birds seen in June, 1947 when the reservoir was very full, six birds seen on 28th May, 1950. Given reasonable protection this colony could probably recover to a certain extent.

4. THREIPMUIR RESERVOIR. Visited on 24th May, 19th June, 4th and 12th July, 1968. Few gulls sitting on nests on the first visit; the water level was very high and the Bavelaw Estate gamekeeper stated that the birds had been flooded off. 400-500 pairs were present on 19th June, most with nests. About the same number were there on 4th July but few nests were found; 50 chicks were seen of which only one was not at the flying stage. Only 100 pairs and ten nests were noted on the final visit, plus 12 fledged young. The colony apparently had a very poor season mainly due to the fluctuating water level.

History: Reservoir extension built in 1890. Eggs first noted in 1905 and 1906 and the colony remained small "for some years". 250-300 pairs in 1919 and 1920, six pairs in 1938, 200-250 pairs in 1947, 50 birds in May, 1950 and none in 1952. About 200 pairs in 1958.

5. AUCHENCORTH MOSS. Visited on 14th June, 1968. The colony consisted of thirteen adult pairs, three nests with eggs and several unoccupied nests situated round the small lochan in the middle of the Moss. The colony has been frequently harried in recent years. (Baxter Cooper, pers. comm.).

History: The area is recorded as "Law Moss" on a plan dated 1796. Less than 12 nests found in 1866, 400-500 pairs in 1885, 20-30 pairs in 1887 (but 150 pairs on nearby Coalyburn Moor), 50 nests in 1889, 13 nests in 1894, about 50 pairs in 1897 and 1898. A decline for a decade was followed by a short good period and then severe harrying during the First World War. 250 pairs in 1919 and 1920, ten nests in 1933, 50 pairs in 1938, 100 pairs in 1950, two separate colonies of 200-300 pairs each in 1952, about 100 pairs in 1953 and 75 pairs in 1958 (but heavy collecting of eggs).

6. MOUNT LOTHIAN FARM. Visited on 18th June, 5th and 12th July, 1968. This colony is of recent origin and is situated on a small area of march created by a choked stream which runs through grass pastures. 50-60 pairs of adults were seen on the first visit, ten occupied nests found and 30 chicks noted. By the second visit this was reduced to 40 pairs, two occupied nests and one non-flying chick. Only 12 adult birds were seen on the final visit but a mixed group of adults and young were observed sitting in a nearby field.

History: Colony established in 1951 when 60 pairs were present. They did not breed again until 1963 when 25 birds and 5 nests were noted. In 1964 there were 50 pairs. 20 pairs nested unsuccessfully in 1965 and there were none in 1966 and 1967 (pool dry in 1966).

7. ROSEBERRY POOL. Visited on 28th June, 1968. About 100 pairs seen and some occupied nests found. Approximately 60 chicks were on the water and a further 30-40 flying round. The count of adults was probably lower than the maximum for the season (see below).

History: "Occasionally used" about 1920, "Scarcely room for any more" in 1925, 15-20 pairs and 10 nests in 1933, 80 pairs in 1938, 30 birds in July 1950, one pair in 1953, c. 100 pairs in 1959, c. 60 in April, 1960 (but reduced to 10 in May), 50 pairs in 1961 and 1962, 100 in 1963, 150 in 1964, 200 in 1965, 250 in 1966, 1967 and 1968.

8. GLADHOUSE RESERVOIR. Not visited.

History: A sporadically-used breeding place, utilised only when the water level is such as to produce suitable nesting areas. Successful nesting seems to be the exception as history shows: 40-50 pairs in 1946, possible breeding in 1947, none in 1948 and 1949, three pairs attempted to breed in 1950, none in 1951 and 1952, 12 pairs with eggs in 1953 - failed, no breeding from 1954 to 1957, two or three pairs in 1958 and at least one fledged young, c. 20 pairs in 1959 but poor results, none in 1960, ten pairs in 1961, 300 pairs in 1962, unproven attempt in 1963, five pairs attempted nesting in

1964, seven attempted nesting in 1965, four pairs in 1966, none in 1967 and six abandoned nests in 1968.

9. FALA FLOW. Not visited.

History: The colony was occupied before 1885, when it was fairly large but was deserted for some years from 1897. There were 200-300 pairs in 1915, "Very few" in 1919, 10-15 in 1933, 6-10 in 1938, none in 1947, two pairs in 1950. The colony is reportedly still in existence and occupied in 1968, but is very small.

THE DESERTED COLONY SITES

The moss between Cobbinshaw and Crosswood reservoirs (1) held c. 150 pairs in 1933 and 12-15 pairs in 1938. It is now a forestry plantation and untenable as a Black-headed Gullery. Bawdy Moss (2), which was by far the largest of these now-deserted colonies was colonised in 1916 or 1917, deserted for a time, then reoccupied. In 1933 there were 750-1,000 pairs, c. 100 pairs in 1938, 15-16 pairs in late July, 1948, 350 pairs in 1949, 600-750 pairs in 1950, 450-500 pairs in 1951. In May, 1952 there were 350 pairs but the colony was deserted by July and the birds were thought to have transferred to Auchencorth. The reason for desertion was almost certainly the implementation of a drainage scheme on the moor. There was no sign of any birds in June, 1968 and the moor is still well-drained. The colony at Craigengar Hill (3) was probably occupied after the desertion of White Moss (6) in 1919 but little information about it is available. It was not visited but is not thought to have been recently used. Marsfield Loch (4) had three nests

in 1894, ten nests in 1925 when "none had nested for years" and one nest in 1933. In 1955, 50-100 pairs were recorded at South Mains (5) near Carlops and a few pairs were noted there in 1959 but none returned in 1960. The already mentioned colony at White Moss (6) near West Linton was occupied in 1878 and had c. 1,000 pairs in 1902. Desertion began in 1915 and was complete by 1919 when the birds had moved to Craigengar Hill.

Rosebery Reservoir is mentioned by Hollom (1940) but it is virtually certain that he meant Rosebery Pool. Two pairs did in fact attempt to breed at Rosebery Reservoir in 1968 and this is believed to be the first record of nesting there. (D.G. Andrew, pers. comm.).

TABLE 2

TABLE 2

Forth Gull Populations

Colony	Herring Gull		Lesser Black-Backed Gull		Year of Most Recent Estimate
	Maximum	Minimum	Maximum	Minimum	
Inchgarvie	120	120	0	0	1968
Inchcolm	Present	Present	0	0	1955
Haystack	Present	Present	0	0	1962
Carr Craig	200	100	0	0	1955
Inchmickery	30	25	1	0	1968
Inchkeith	3,000+	3,000	100+	100	1968
Eyebroughty	200	200	0	0	1967
Fidra	100	100-	0	0	1968
The Lamb	1,000	1,000	12+	12	1968
Craigleith	4,000+	3,000	400+	300	1968
Bass Rock	250+	250	20	18	1963
Isle of May	12,000	12,000	900	900	1968
Total	20,900+	19,795-	1,433+	1,330	

Herring and Lesser Black-backed gull populations in the Forth, showing most recent maximum and minimum estimates for each colony with the year in which the estimate was obtained.

1.3. Survey of the breeding colonies: 2. Population changes

It is unfortunate that the nature of the available data on both Herring and Lesser Black-backed gull colonies and Black-headed gull colonies is such that determination of changes in their population is difficult to assess. However it is possible to gain a fairly accurate impression of trends if allowance is made for various sources of error. Because of their similarity, Herring and Lesser Black-backed gull populations will be treated simultaneously but separately from the Black-headed gull population to which they bear little resemblance.

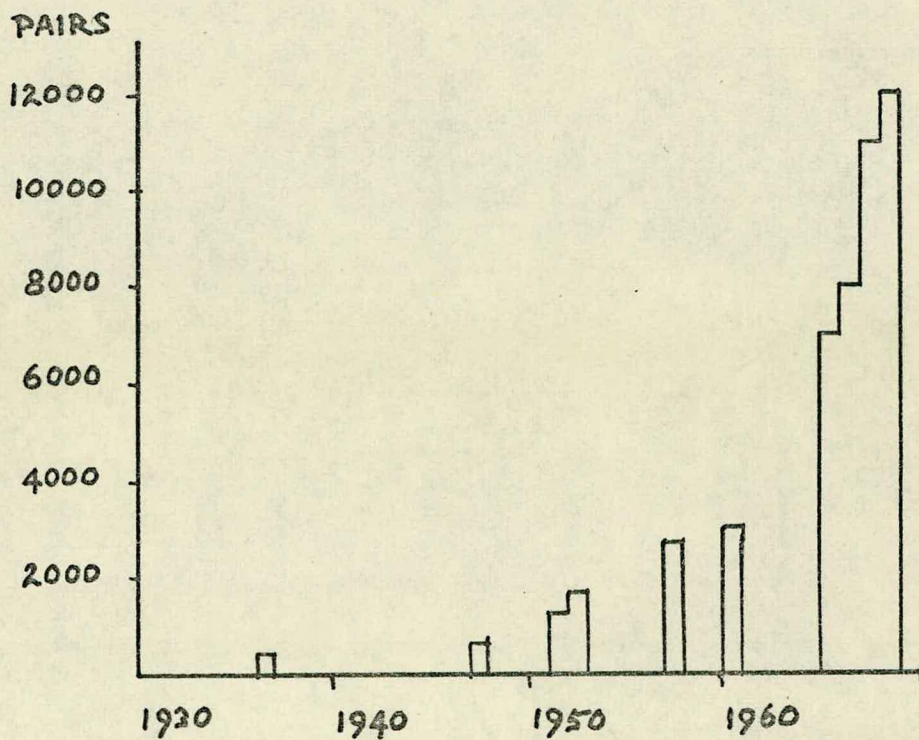
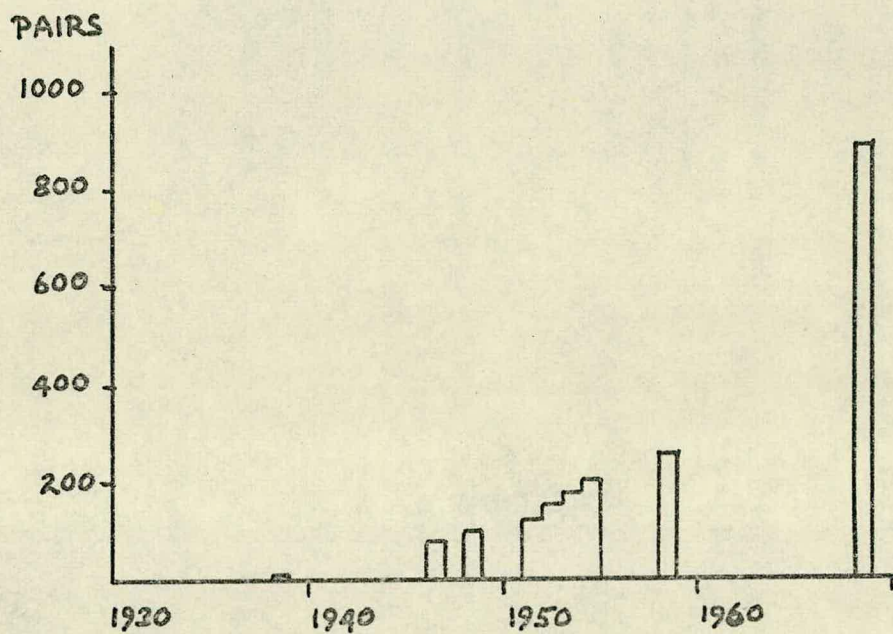
THE HERRING AND LESSER BLACK-BACKED GULL POPULATIONS

The total breeding population of the ten colonies listed in 1.2., taking the most recent figure available for each, comes to between 19,700 and 20,900 pairs for Herring gulls and between 1,330 and 1,430 pairs for Lesser Black-backed gulls (see Table 2). Bearing in mind that some of the figures are fourteen years old, that the St. Abbs Head colony has been excluded and that there has been an increase at all colonies for which past data is available except Fidra, then it seems probable that there are now about 25,000 pairs of breeding Herring gulls in the Forth as well as about 1,500 Lesser Black-backs.

The population of Herring gulls on the Isle of May represents over 50% of the total breeding population in the Forth. Calculation shows, presuming population estimates are correct, that its rate of increase is approximately 20% per annum or a little less. This has been so since its inception in 1907, except during the second World War when military installations may have caused

Isle of May Lesser Black-backed Gull (top)
and Herring Gull (bottom) populations from
1930 to 1968.

FIGURE 4



disturbance and from 1953 to 1960 when control of the numbers of gulls was attempted.

The explanation for this very high rate of increase is not yet known. Reference to mortality rates based on ringing returns for Herring gulls by Paynter (1947), Faludan (1951), Hickey (1952) and Olsson (1958) serve only to show that productivity per adult pair, combined with the immature and adult mortality rates, is insufficient to provide the annual recruitment necessary if a 20% growth-rate is to be achieved.

Kadlec and Drury (1968) however, have demonstrated that mortality rates based on ringing returns are too high to be consistent with the observed rate of population growth, productivity and age structure of the New England Herring gull population. They found that since 1900 the Herring gull population there has doubled every 12 to 15 years and that this increase involved founding new colonies and expanding the breeding range, as has happened in the Forth. Productivity was in the range 0.8 to 1.4 young per breeding pair per year, but 15 to 30% of the adults do not breed in any given year. Mortality for birds of two years of age and older was 4 to 9%, much lower than the 25 to 30% computed from ringing returns. The calculated rate of increase using the lowest of these figures is just under 14% per annum, which agrees with the observed doubling of the population every 12 years, though a 10% annual increase would be sufficient to double it every 15 years. Drury (1965) showed that a recently-founded and rapidly expanding population relied on immigration of part of the production of older colonies for its expansion. It may well be that this is the reason for the discrepancy between the total population growth-rate

in New England and that of the Isle of May population. The Isle of May is a rapidly expanding colony and it can be inferred that, as in some recent New England colonies, immigration has taken place.

Supporting this view is the similarity between the general pattern of events in New England and those in the Forth. However factors not yet known, such as geographical differences, availability of food and differing rates of productivity and mortality may exist, which would further account for the discrepancy in growth rates between the two populations. All that is certain is that there has been very rapid growth of Herring and Lesser Black-backed gull populations during the past seventy years in the Forth area, involving both increase in colony size and the founding of new colonies.

THE BLACK-HEADED GULL POPULATION

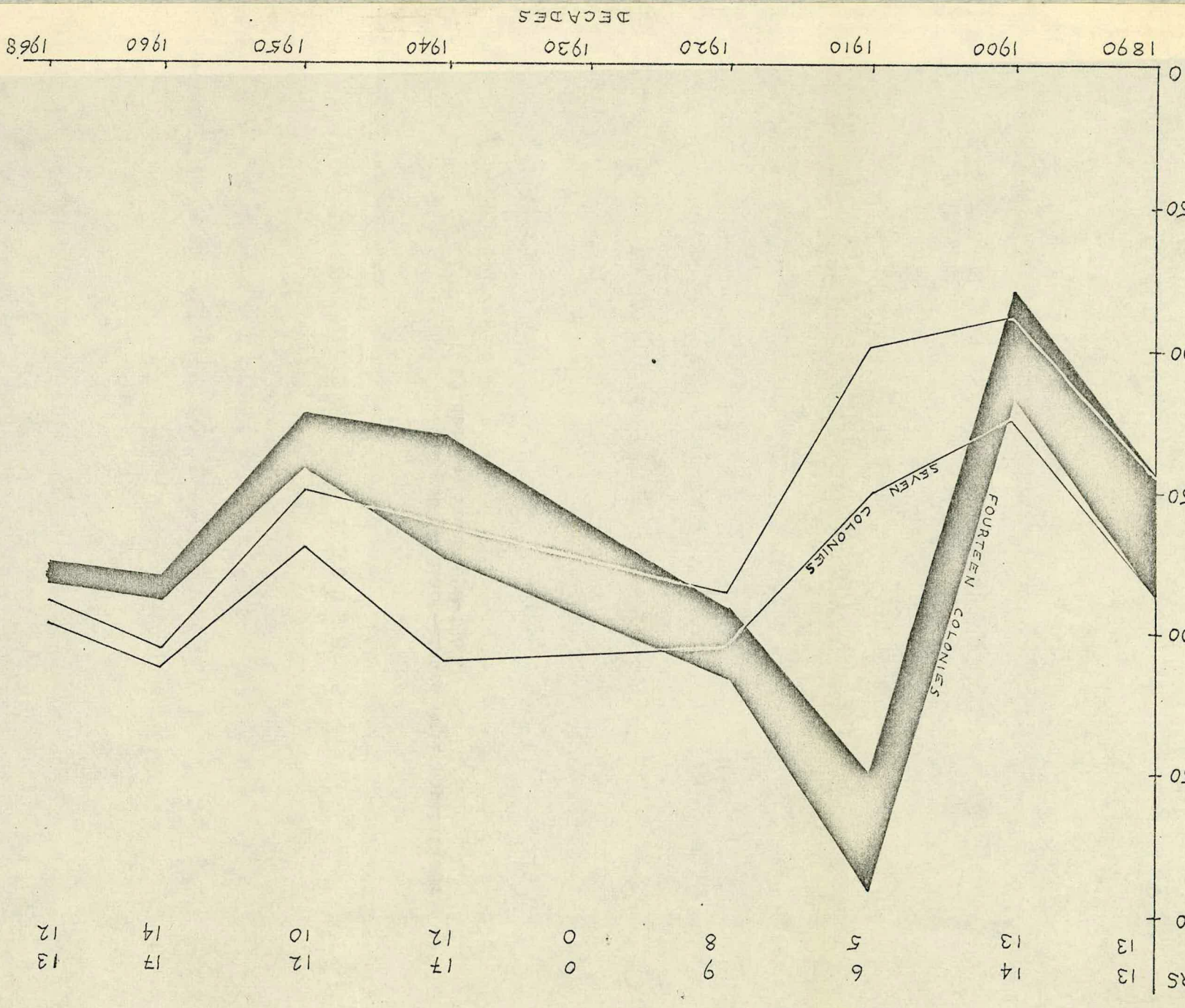
Contrasted with the Herring gull population, Black-headed gulls appear to have remained remarkably stable in numbers since the turn of the century.

Reasons which may be postulated for this are first, an overall constancy in suitable habitats available for breeding and secondly a similar constancy in the food supply available during breeding seasons. Given lack of new areas for colonisation and an unvarying food supply, a stable situation is perhaps to be expected. It is thus interesting to note that when it has become possible to colonise new areas, such as Mount Lothian and Gladhouse in dry years, gulls have nested or tried to nest there, suggesting that it is only the absence of more breeding ground which is preventing expansion.

FIGURE 5

Changes in Black-headed Gull populations
by decades from 1890-1968.





Stability of population can only be claimed on a long-term basis, because in any particular year there can be enormous fluctuations within individual colonies and to a lesser extent, of total population. The lack of continuity in observations from the various colonies made extraction of a population graph from the existing data difficult. Eventually it was decided to sum all the existing observations for each of fourteen colonies per decade, dividing this by the number of observations to obtain the mean number of pairs breeding in that decade. Observations often consisted of estimates such as "400 to 500 pairs", therefore the maximum and minimum pairs per decade was calculated to give the resulting possible range of pairs per decade from 1882 to 1968. Because the number of observations available from colonies in any one year or any one decade varied greatly, information from the seven best-documented colonies was treated in the same way as that for the total population for comparison. Data from Mount Lothian and Gladhouse colonies was not included as they are only occupied sporadically in dry years and are not typical.

The results of both these calculations are shown in Figure 5, and can be seen to follow a similar pattern with the exception of the period from 1900 to 1920 where the mean number of pairs breeding in all fourteen colonies differs markedly from the mean number for the seven best-documented ones. There were only six records in the decade up to 1910; five all from one colony, which was one of the seven (Harperrig) and one from another which was not. It is the latter record of 1,000 pairs, incidentally the only quantitative record from that colony (White Moss), which has produced this wide divergence.

It would be wrong to pretend that Figure 5 does more than illustrate a general trend in Black-headed gull population fluctuations. Especially in the years up to 1930, observations were either few in number or all from a few colonies, or both, and therefore possibly not a very accurate measure of total population trends. Notwithstanding its limitations however, the data does give the best possible indication of the situation over the past eighty years and it can be concluded with a reasonable degree of certainty that there has not been any great change in the total Black-headed gull population, at least in this century. Although six colonies are listed as disused, some of these were only occupied irregularly and in fact an equivalent number of new colonies has been founded. Some of these are also irregularly occupied, and this can be adduced as additional evidence for believing that the population has a long-term stability.

1.4. The non-breeding summer population

This consists largely of immature Herring gulls, with some adults, mostly found in the areas surrounding sewer outlets, docks and rubbish dumps. Immature Great and Lesser Black-backed gulls and Common gulls are also present but very few Black-headed gulls were noted.

No past records dealing quantitatively with summerring non-breeding gulls were found and because it was evident from the scarcity of their presence at Turnhouse that they are unlikely to prove a hazard to aircraft during the summer months they formed a very minor aspect of this study. In the context of research into the population dynamics of Forth gull populations they would of course require closer investigation.

1.5. The winter population: previous records

The almost total absence of previous records specifically concerning the winter population of gulls in the Forth made a quantitative comparison between the present situation and that of former years impossible. However it was reasonably supposed that the increase in breeding population must have led to a similar increase in the winter population and the scanty evidence available supports this.

Rintoul and Baxter (1935) mention that Gray (1871) thought Herring gulls were at their commonest in winter when he saw them "in companies numbering 30 to 40 birds" on Leven Sands, while they themselves, as a measure of increase, "think it nothing surprising to see a flock of three or four hundred there, but the greatest assemblage [we] have ever seen was on the Forth below Leith, on 2nd January, 1934, when there must have been thousands".

The same authors (1953) state about the Black-headed gull: "Great numbers spend the winter along our coasts. In December, 1909, thousands were recorded on the Bass [Rock], in frost" and again on 1st January, 1913 "about 300 were feeding on fry off the Bass". Baxter and Rintoul also refer to the immigration of thousands of Common gulls but give no details concerning their winter habits.

More recently, a paper by Hickling (1954) on the wintering of gulls in Britain mentions "large numbers roosting in the Forth" and gives figures for five reservoirs within the study area which are used as roosts; these will be referred to later. Hickling (1967) has also produced evidence for an increase

TABLE 3

The Autumn and Winter Populations of the Three
Common Gull Species of the South Forth Basin

		<u>Coastal</u>		<u>Inland</u>		<u>Total</u>	
		% popn.	% imm.	% popn.	% imm.	% popn.	% imm.
Herring Gull	Aug-Oct	23.5	49.0	3.6	34.0	19.4	48.5
	Nov-Feb	34.1	29.1	11.9	26.9	27.5	28.6
Common Gull	Aug-Oct	11.6	15.5	34.2	5.7	16.3	11.3
	Nov-Feb	11.9	29.9	72.9	8.9	30.0	14.8
Black-Headed Gull	Aug-Oct	62.8	3.1	61.1	1.7	62.4	2.8
	Nov-Feb	54.0	2.2	15.2	12.5	42.5	3.3

The autumn and winter populations of the three common gull species of the south Forth basin. Great and Lesser Black-backed gulls are omitted from this table: their total percentage of the population was 1.5 and 0.4 respectively.

TABLE 4

Gladhouse Gull Roost

	<u>Gladhouse</u>		<u>Gladhouse</u>		<u>Inland:</u>
	1-10 Jan 1953		14 Jan 1969		Winter 1969
G.BB. Gull	100	0.2%	5	0.3%	- %
Herring Gull	4,000	8.1%	255	16.5%	11.9%
Common Gull	40,000	81.5%	1,050	67.7%	72.9%
Blk-hd. Gull	5,000	10.2%	240	15.5%	15.2%
Total	49,000	100.0%	1,550	100.0%	100.0%

Comparison between Hickling's (1954) data for Gladhouse, a count made in January 1969 and the total inland population for 1968/69. The 1969 figure for Gladhouse was a single observation of 10,015 birds observed flighting to roost that evening.

of about 50% in the number of gulls wintering inland during the period 1953 to 1963. Unfortunately the paper was confined to English roosts, which limits the amount which can be inferred from it with regard to the south Forth area.

1.6. Composition of the winter population

The winter population consists of birds both from the local colonies and from elsewhere in Britain and Europe. This section describes the composition of the population quantitatively by species, leaving the questions of its origins, dispersal and migration to be covered in Section 2, The Annual Cycle.

Table 3 shows the results obtained from 140 observations made at the coast and inland in the south Forth region during this study, 70 during the autumn and 70 during the winter of 1968/69. The two species of Black-backed gulls have been omitted because of insufficient data, but in any case they do not form more than about 2% of the population as a whole. It has not been possible to test the accuracy of the figures given here; small flocks of gulls were counted accurately but an arbitrary observational error of $\pm 10\%$ was allowed for when estimating large flocks or aggregations. The high percentage of immatures in the autumn figures reflects the presence of young birds which had not at that time dispersed from the area and will be referred to again when considering dispersal and immigration.

It can also be seen from Table 3 that Herring and Black-headed gulls together make up 88% of the coastal population, while Common gulls form 73% of the inland population. There is considerable overlap, however, because Black-headed gulls frequently fly inland to feed behind ploughs and Herring gulls fly

inland to feed at rubbish tips while Common gulls do sometimes feed on the coast although short grass fields seem to be their preferred habitat.

1.7. Winter roosting

In the study area, gulls are known to roost inland at Cobbinshaw, Gladhouse, Harperrig and Threipmuir Reservoirs and at Portmore Loch. Of these, Gladhouse and Portmore between them contain the bulk of the inland roosting population. Table 4 gives some idea of the composition of the Gladhouse roost, which appears to have changed remarkably little in the past 16 years and agrees well with the composition of the inland population as a whole for 1968/69, though it should be noted that the first two columns of the table are results from single observations and not series.

Coastal roosts are established at Leith and off Cramond Island and both of these areas have assemblies of thousands of gulls. It is not known whether the birds remain all night on the water at Cramond but it is thought that they probably do, at least in fine weather. It is possible however, that they sit on the Forth islands as well. Some of the ones at Leith are known to use Inchkeith Island for roosting.

Weather affects roosting inasmuch as extreme frost results in the freezing over of reservoirs, with the result that gulls which normally roost there are forced to fly to the coast. Conversely, during stormy weather heavy seas may cause coastal-roosting gulls to seek shelter inland.

Numbers at any one roosting place fluctuate considerably. Weather undoubtedly contributes to this, both because it may cause the roost itself to

become temporarily untenable and because it may bring about a reduction in available food-supply, for instance flooded fields or hard frozen ground. There is evidence from Radford (1962) that Black-headed gulls have a strong attachment to their wintering area and analyses of ringing returns suggest this is true of other gulls also (Harris, 1962a; 1962b; 1964 and Radford, 1960). It thus seems unlikely that the fluctuations in numbers of birds at particular roosts are more than the effects of circulation within the wintering area. It was beyond the scope of this study to carry out the census work needed to show this, but it is known to be generally true for geese in south-east Scotland (W. Brotherston, pers. comm.). While geese cannot be directly compared with gulls, both show similar behaviour in winter as far as roosting is concerned and indeed are often found utilising the same places.

1.8. Winter feeding

In 1.5. the inference was made that an increase in the winter gull population of the Forth had taken place, despite lack of quantitative proof of this. Circumstantial subjective evidence indicates that there has been a similar increase in many other places too and Hickling (1967) considers that there has been a population explosion among the commoner species of gull. He suggests that improved feeding and roosting opportunities may have led to better winter survival and this is a reasonable hypothesis. As already mentioned, there is good evidence of a big (50%) rise in the number of gulls wintering inland over the ten years from 1953 to 1963 in England (Hickling, 1967) and there is nothing to show that this has occurred because of a reduction in numbers roosting at the coast. It is therefore very probable that

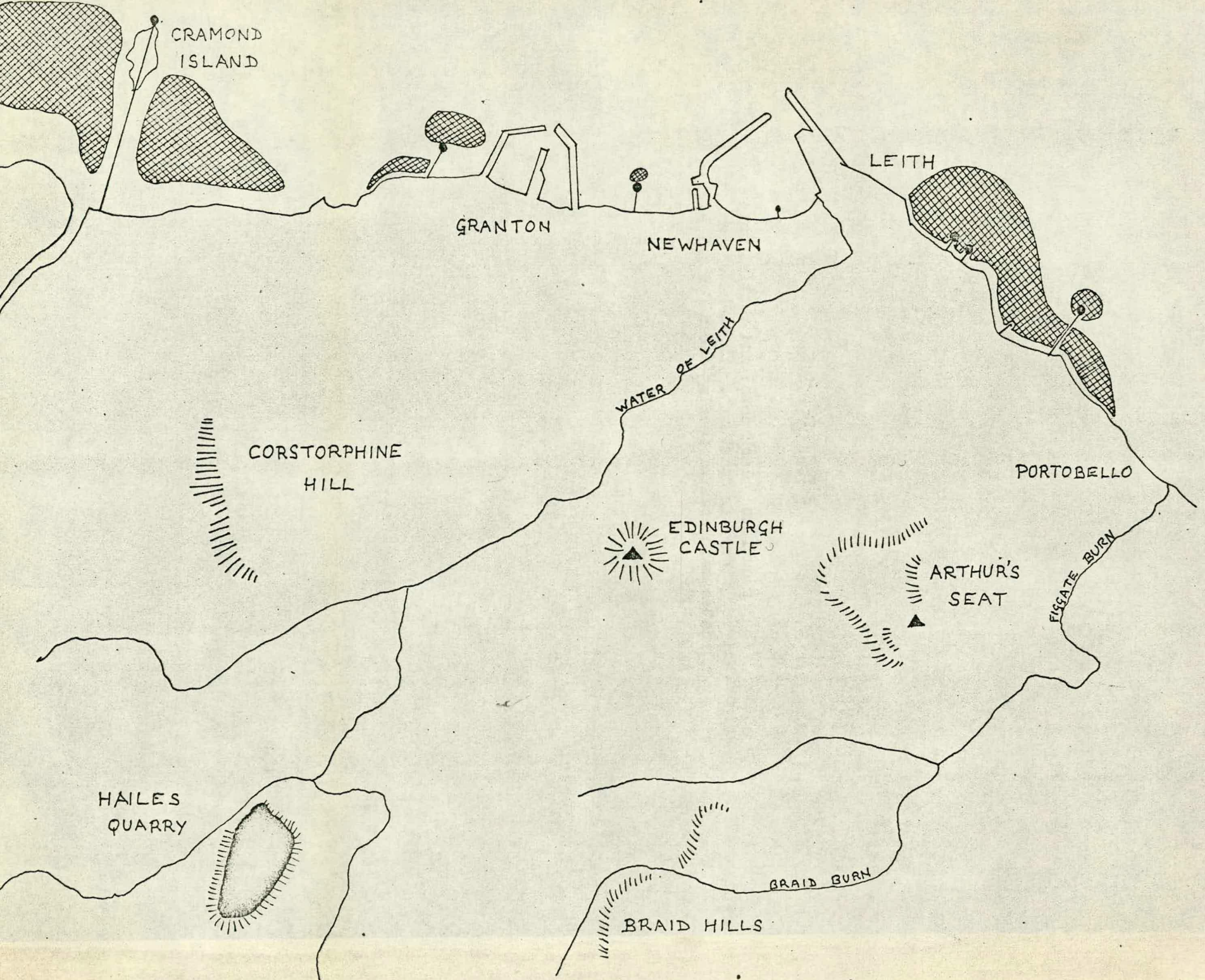
there must have been a widespread increase in population and that inland roosting is a result of gulls exploiting previously unused - or unavailable - sources of food.

The situation in the south Forth and Lothians regarding winter feeding falls naturally into two categories, inland feeding and coastal feeding. Birds feeding inland derive a great deal of their food supply from agricultural operations, particularly ploughing, although harrowing, disking and even hay-turning in autumn attract large flocks of gulls. Because of the shifting nature of this supply of food, the gulls also move round, but it was noticed that they return in the morning to the area where they were feeding the previous day. They only leave for another area if they discover that ploughing is not taking place in the first area that morning, and hence their food supply is not available. This method of feeding is especially applicable to Black-headed gulls because unlike Common gulls they do not seem able to obtain food so easily from short grass fields. However Common gulls are also found following ploughing operations when possible. The reason for the difference in preference for short grass fields between Black-headed and Common gulls is simply explained: Common gulls catch earthworms by foot-paddling whereas Black-headed gulls do not, possibly because they are not heavy enough (Tinbergen, 1962). Therefore the Black-headed gulls are unable to utilise short grass and must depend to a greater extent upon the easily available worm supply thrown up by the plough.

The above methods of feeding have been in use for years and have probably not altered greatly, so cannot be said to account for the increase in

FIGURE 6

Sewer outlets (black dots) and rubbish dump (Hailes Quarry) in Edinburgh. Cross-hatching indicates main coastal feeding-areas for gulls.



CRAMOND
ISLAND

GRANTON

NEWHAVEN

LEITH

WATER OF LEITH

CORSTORPHINE
HILL

PORTOBELLO

EDINBURGH
CASTLE

ARTHUR'S
SEAT

FISCATE BURN

HAILES
QUARRY

BRAID BURN

BRAID HILLS

food-supply which was suggested as the reason for better winter survival. Coastal feeding on the other hand does appear to hold at least part of the answer.

Figure 6 shows the location of sewer outlets and rubbish dumps along the southern side of the Forth within the study area. The sewers serve the City of Edinburgh and discharge approximately half of the sewage which flows into the whole of the Firth. Unfortunately records are not kept of the amount which is discharged, but measurements were made in 1967 during the costing stage of planning new sewage plant. These showed that 38.033 million gallons per day are released untreated into the Forth and this contains 246,440 lb (approximately 100 tons) of solid matter in suspension. What percentage of this solid waste is edible to gulls is not known.

The rubbish tip at Hailes Quarry contains all the crude refuse from Edinburgh and records dating back to its beginning and beyond are in existence but because the method of recording has altered, the crude refuse of former years bears no relation to that of today, making it impossible to compare the past and present figures. However, using the available figures for total refuse - which includes trade refuse and plant residues - the refuse per head of population was calculated. This is given in Table 5 and can be seen to be remarkably constant, although possibly increasing slightly during the past six or seven years. This is probably due to the introduction of "smokeless zones" to the city, which has prevented people from burning much of their rubbish. The fall in the population of Edinburgh during the last five years is misleading because the population of the Forth area as a whole has increased slightly.

TABLE 5

Galuses per Head of Population in Birmingham

Year	Birmingham's Population	Total Galuses (Tons)	Total Galuses/Population
1958	400,404	528,135	0.13
1957	407,986	491,471	0.12
1956	400,187	468,287	0.12
1955	418,282	480,653	0.11
1954	413,270	450,288	0.11
1953	428,228	440,041	0.10
1952	422,222	412,212	0.09
1951	400,201	360,222	0.09
1950	390,201	360,222	0.09
1949	380,201	360,222	0.09
1948	370,201	360,222	0.09
1947	360,201	360,222	0.09
1946	350,201	360,222	0.09
1945	340,201	360,222	0.09
1944	330,201	360,222	0.09
1943	320,201	360,222	0.09
1942	310,201	360,222	0.09
1941	300,201	360,222	0.09
1940	290,201	360,222	0.09
1939	280,201	360,222	0.09
1938	270,201	360,222	0.09
1937	260,201	360,222	0.09
1936	250,201	360,222	0.09
1935	240,201	360,222	0.09
1934	230,201	360,222	0.09
1933	220,201	360,222	0.09
1932	210,201	360,222	0.09
1931	200,201	360,222	0.09
1930	190,201	360,222	0.09
1929	180,201	360,222	0.09
1928	170,201	360,222	0.09
1927	160,201	360,222	0.09
1926	150,201	360,222	0.09
1925	140,201	360,222	0.09
1924	130,201	360,222	0.09
1923	120,201	360,222	0.09
1922	110,201	360,222	0.09
1921	100,201	360,222	0.09
1920	90,201	360,222	0.09
1919	80,201	360,222	0.09
1918	70,201	360,222	0.09
1917	60,201	360,222	0.09
1916	50,201	360,222	0.09
1915	40,201	360,222	0.09
1914	30,201	360,222	0.09
1913	20,201	360,222	0.09
1912	10,201	360,222	0.09
1911	0,201	360,222	0.09
1910	0,201	360,222	0.09
1909	0,201	360,222	0.09
1908	0,201	360,222	0.09
1907	0,201	360,222	0.09
1906	0,201	360,222	0.09
1905	0,201	360,222	0.09
1904	0,201	360,222	0.09
1903	0,201	360,222	0.09
1902	0,201	360,222	0.09
1901	0,201	360,222	0.09
1900	0,201	360,222	0.09

TABLE 5

the population of the City of Birmingham and the annual
 quantity of refuse produced in the City, showing the
 comparatively constant production of refuse per capita
 per annum. (Population figures supplied by the
 Registrar General's Office.)

TABLE 5

Refuse per Head of Population in Edinburgh

Date	Edinburgh's Population	Total Refuse (tons)	<u>Total Refuse</u> <u>Population</u>
1856	161,000	-	-
1901	316,837	101,574	0.32
1911	320,318	169,086	0.53
1921	420,264	100,713	0.24
1931	439,010	154,244	0.35
1941	No census	-	-
1951	466,761	120,644	0.26
1961	468,361	140,339	0.30
1962	475,338	133,915	0.28
1963	476,228	144,041	0.30
1964	473,270	150,228	0.32
1965	472,352	150,653	0.32
1966	468,765	146,287	0.31
1967	467,986	181,414	0.39
1968	466,464	226,135	0.48

The population of the City of Edinburgh and the annual tonnage of refuse produced in the city, showing the comparatively constant production of refuse per capita per annum. (Population figures supplied by the Registrar General's Office.)

The fall in Edinburgh is due to industries moving outside the city boundary, inducing a shift in population and not to a decline in birth-rate.

Direct comparison between refuse and sewage produced and Forth gull population figures is not possible, but because the ratio of refuse per capita of the human (Edinburgh) population has remained relatively constant it can be assumed that the amount of refuse available to gulls must have increased as the human population increased. While the same cannot be shown for sewage, it is as certain as can be that it must have followed suit. This being so, there undoubtedly must have been an increase in food available to gulls in winter. The summer supply will also have increased, but the distance from colonies to Edinburgh, where the largest supply is, is frequently too great to enable the breeding birds to take advantage of it, so lessening considerably the importance of sewage and refuse as a summer food source.

It will be extremely interesting to observe whether the installation of an incinerator, which will burn all crude refuse and result in the closing of Hailes Quarry tip, will materially affect the gull population after it becomes operational in 1971. As the Edinburgh sewage system is to have primary treatment plant installed by about 1975-77, which will reduce the solid sewage by half, and Kirkcaldy sewage system is to be similarly modified, there will be a further reduction in food available after this date.

Meanwhile, no definite pronouncement can be made on the precise relationship between waste products from Edinburgh and other towns and the winter gull population in the Forth. The indications are that the amount of sewage and

refuse available for gulls to feed on has increased, noticeably within the past six or seven years, and that this may probably lead to better winter survival, which in turn leads to an increase in breeding population. Because the figures for refuse are not comparable and those for sewage not available it would be unwise to place too great a reliance on results which would be obtained by direct comparison between them and gull population figures.

SECTION 2. THE ANNUAL GULL CYCLE, DISPERSAL AND MIGRATION

The annual cycle corresponds in broad terms to the calendar year. Summer corresponds to breeding, autumn and spring to arrival and departure and winter to communal gathering. Because the summer and winter periods of the year have already been comprehensively described in Sect.1, attention will be concentrated initially on autumn and spring. The whole yearly pattern will then be brought together and its implications regarding the bird problem at Turnhouse discussed.

Because they form a very small (2%) proportion of the total gull population, the two species of Black-backed gulls are omitted from this section.

2.1. Definition of migration and dispersal

To avoid confusion, the usage of these terms as applied here will follow Landsborough Thomson (1964):

Migration. The regular movement of birds between alternate areas inhabited by them at different times of year.

TABLE 6

Forth Herring Gull Ringing Recoveries

	Distance Miles	Age in Years				Total	
		0-1	1-2	2-3	3-4		over 4
Winter Nov-Mar	0-49	23	2	2	1	1	29
	50-100	16	2	1			19
	101-200	8	3	1			12
	201-300	2	2	1			5
	Over 300	5	2			1	8
	Foreign	1	1				2
Total	55	12	5	1	2	75	

	Distance Miles	Age in Years				Total	
		0-1	1-2	2-3	3-4		over 4
Summer Apr-Jul	0-49	25	7			3	35
	50-100	5	3				8
	101-200		5				5
	201-300	3					3
	Over 300						0
	Foreign	2				1	3
Total	35	15	0	0	4	54	

	Distance Miles	Age in Years				Total	
		0-1	1-2	2-3	3-4		over 4
Autumn Aug-Oct	0-49	42	8	4	4	5	63
	50-100	16	2				18
	101-200	8	1				9
	201-300		1				1
	Over 300	1					1
	Foreign		1				1
Total	67	13	4	4	5	93	

Forth Herring Gull ringing recoveries. The winter and summer returns show the distance from the Forth at which birds were found during the sedentary periods of their year, while the autumn returns show mainly the dispersal of young from the breeding grounds.

of having them, the proposed system.

Members of said Board will be highly interested in the distance from the camp of which letters were sent and which are contained in the records of the proposed system. The dates and number of letters from

Letter	0-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	Total
Letter 1		1									1
Over 300	1										1
501-700		1									1
101-500	4	1									5
20-100	10	5									15
0-10	45	2	0	0	1	1	1	2			52
Letter Distance	0-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	Letter

Letter	0-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	Total
Letter 1		1									1
Over 300	1										1
501-700		1									1
101-500	2	1									3
20-100	2	1									3
0-10	52	1						2			55
Letter Distance	0-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	Letter

9 STATE

Letter	0-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	Total
Letter 1		1									1
Over 300	2	1									3
501-700	5	5									10
101-500	0	1									1
20-100	48	5	1								54
0-10	52	5	5	1	1	1	1	1			62
Letter Distance	0-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	Letter

Length of the letter and number of letters

State 9

Dispersal. Outward spread from a point or area of origin. A movement away from the breeding locality in the off-season, not amounting to true migration. (This term is applied here to birds which may eventually return to breed in the area of origin on reaching maturity.)

2.2. Migration and dispersal of the Herring gull

It is doubtful whether more than a very few, if any, of the Herring gulls breeding in the Forth migrate. Ringing returns for the years 1950 to 1967 are shown in Table 6. It will be seen that there are no adult recoveries from distances over 50 miles from the breeding colony in autumn and only one each in winter and summer. The summer recovery, from Norway, was of a bird ringed in October, presumably as an adult. The winter one, from south England, could have been a migrant or might have been breeding at a colony other than its natal one, with the consequence that its wintering area would also be different. A greater number of recoveries are required however, before it can be said with certainty whether or not Forth adults do migrate.

A further look at Table 6 shows that the recovery of immature birds is not confined to the Forth area. In autumn and summer just more than half, and in winter just under half, of the first year birds are found within 50 miles of their home colony. In their second year more than half in all three periods are found at distances greater than 50 miles from their colony of origin.

There are insufficient records to make any definite conclusions possible, but the suggestion is that the young birds disperse from their colonies in

late summer, spending the first weeks thereafter quite nearby. This accounts for the high proportion recovered close to home in autumn. Some then move away, usually southerly, to spend the winter in different areas. They remain there in the following summer but during the course of their second winter and summer they gradually drift back towards their home colony. They eventually reach their area of origin at the onset of maturity, to join the breeding birds there, although some may mate with birds from other areas altogether and go there to breed. The reducing mortality rate found in older birds would partly account for the reduction in recoveries in the second and subsequent years.

Obviously it would be stretching the evidence to conclude that this is what does happen, especially as ring losses from wear may have prevented the true situation regarding adult birds from becoming apparent (Hickey, 1952; Kadlec and Drury, 1968; Olsson, 1958). However Olsson (1958) found that 41.9% of Fenno-Scandian Herring gulls summered at distances in excess of 200 km from their home colonies in their first year, 28.6% did so in their second year and only 13.8% were doing so in their third year. He does not give figures for birds wintering away from their home area. There is a degree of similarity between the events Olsson describes and those in the Forth, although far more Forth birds remain near their point of origin than did those in Fenno-Scandia. Harris (1964) claims that there is little evidence to show that young birds move further afield than adults, but he was mainly concerned with populations in England, which may well follow different patterns of movement. It is noteworthy that the one Scottish colony he considered (in Ross) showed

FIGURE 7

Map showing recoveries of Herring Gulls ringed in the Forth. Recoveries from less than 50 miles from the place of ringing are not shown.

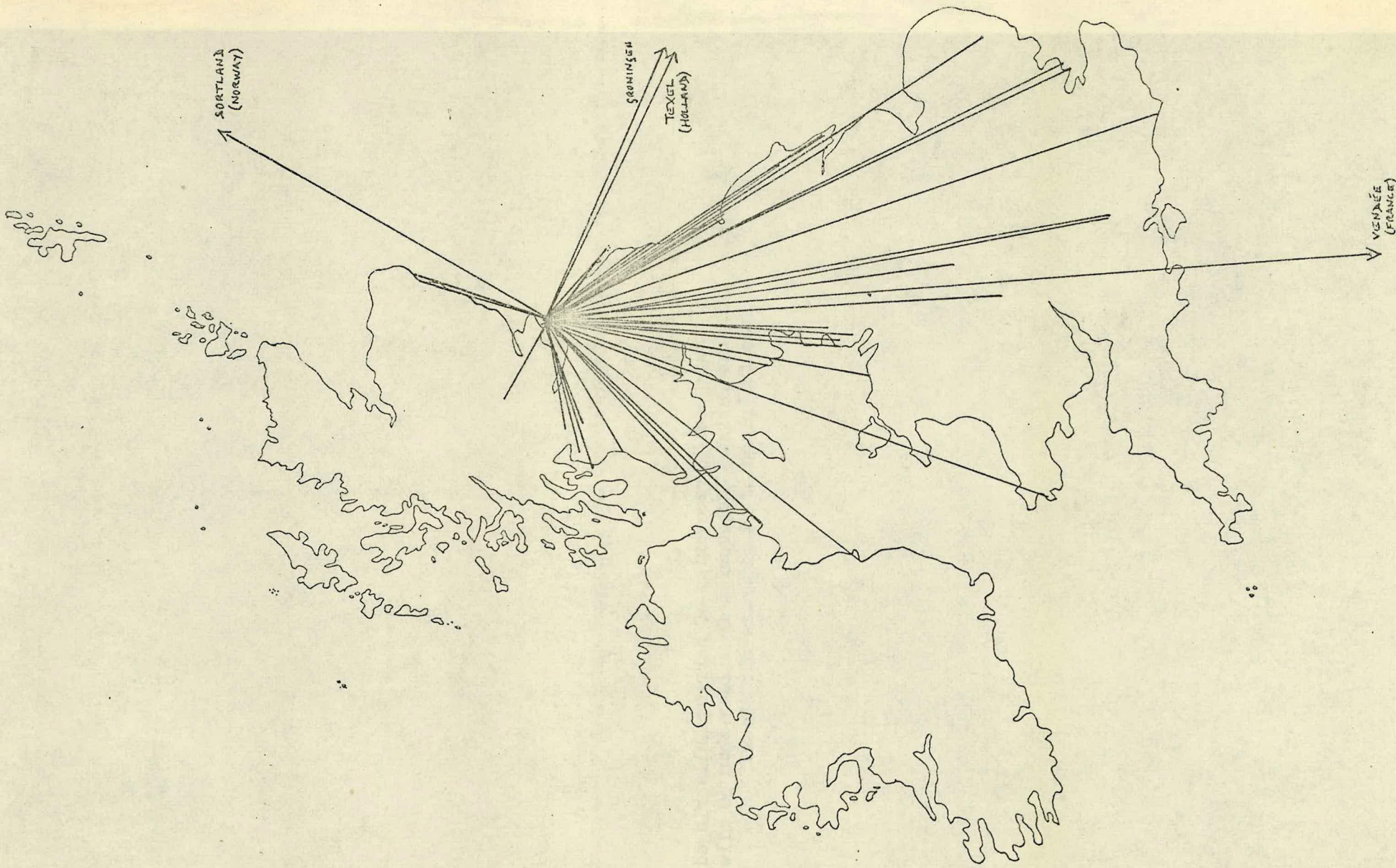
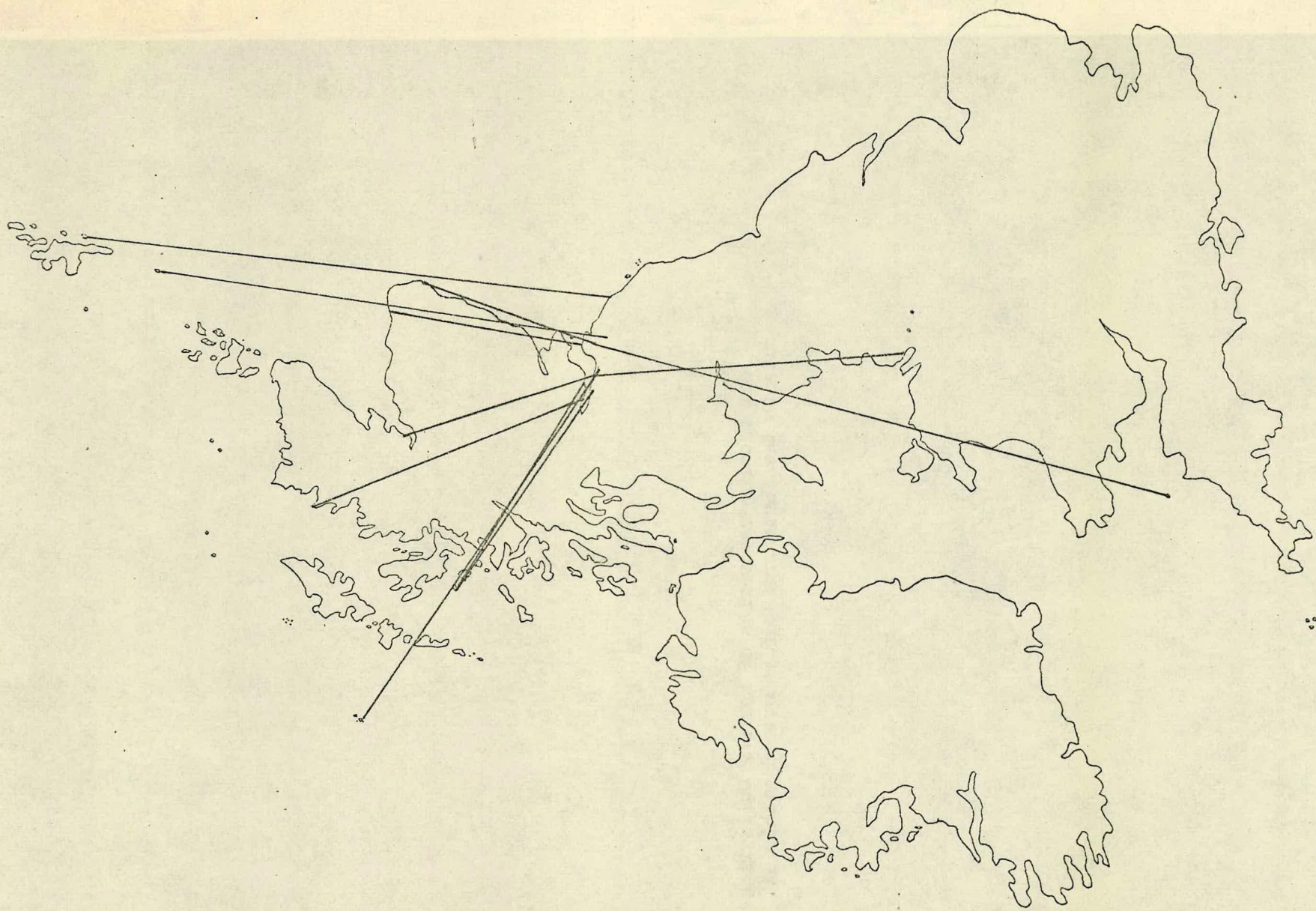


FIGURE 8

Map showing recoveries of Herring Gulls ringed
outwith the Forth area but recovered within it.



first-year birds were recovered much further from the colony of their birth than were first-year birds from English colonies, similar to those from the Forth. It is unfortunate that he did not give full details of the recoveries for other age-classes from the colony. One further point against Harris's view is that of eleven Herring gulls ringed outwith the Forth area and recovered from it, all were immatures, although without knowing the proportion of adults also ringed outwith the Forth, this does not necessarily show very much - especially as not many Herring gulls are ringed as adults in most places, because of difficulty in catching them.

Figure 7 shows the direction, distance and number of recoveries from each direction and distance of Herring gulls ringed in the Forth. Figure 8 gives the same information for birds from other areas which were recovered in the Forth region. There is no evidence of large scale autumn immigration of Herring gulls from abroad to the Forth area.

2.3. Migration and dispersal of the Black-headed gull

Data about the movements of Black-headed gulls from the Lothians area is rather sparse, there being only 69 ringing recoveries for the period from 1950 to 1958. These are given in Table 7 and suggest that about 40% of the adults migrate, one recovery being from as far away as Spain, while the remainder probably disperse to nearby coastal or inland roosts for the winter. Conversely, after an initially high local recovery rate in autumn (75%), 83% of the winter recoveries of immatures are from distances greater than 50 miles from the natal colony. The four summer recoveries of adults at places other

Number of persons in each age group and distance from home

Total	Age in Years			Distance Miles
	over 5	2-5	0-1	
1	0		1	0-50
2	1		1	51-100
2	2		0	101-200
1			1	201-300
1			1	Over 300
2	1		1	Foreign
10	10		0	Total

Total	Age in Years			Distance Miles
	over 5	2-5	0-1	
10	10		0	0-50
2	2		0	51-100
1	1		0	101-200
1	1		0	201-300
0			0	Over 300
0			0	Foreign
14	14		0	Total

TABLE 7

Total	Age in Years			Distance Miles
	over 5	2-5	0-1	
18	18		0	0-50
3			3	51-100
1	1		0	101-200
1	1		0	201-300
0			0	Over 300
0			0	Foreign
23	23		3	Total

TABLE 7

South Forth Basin Black-Headed Gull Ringing Recoveries

	Distance Miles	Age in Years			Total	
		0-1	1-2	2-3		over 3
Winter Nov-Mar	0-50	1			6	7
	51-100	1			1	2
	101-200	2	1		2	5
	201-300	1				1
	Over 300		1			1
	Foreign	1			1	2
	Total	6	2	0	10	18
Summer Apr-Jul	0-50	10	1	1	10	22
	51-100			1	2	3
	101-200	1			1	2
	201-300				1	1
	Over 300					0
	Foreign					0
	Total	11	1	2	14	28
Autumn Aug-Oct	0-50	9	1	1	7	18
	51-100	3				3
	101-200				1	1
	201-300				1	1
	Over 300					0
	Foreign					0
	Total	12	1	1	9	23

than their home colony probably indicate birds which have paired with birds from other areas and have gone to breed elsewhere.

The direction, distance and number of recoveries from each direction and distance of Lothians Black-headed gulls are shown in Figure 9. It will be noted that several - all immature birds - are from Ireland. Figure 10 gives the points of origin of the 19 birds ringed elsewhere and recovered in the Lothians. Only three were in summer and all three were less than two years old.

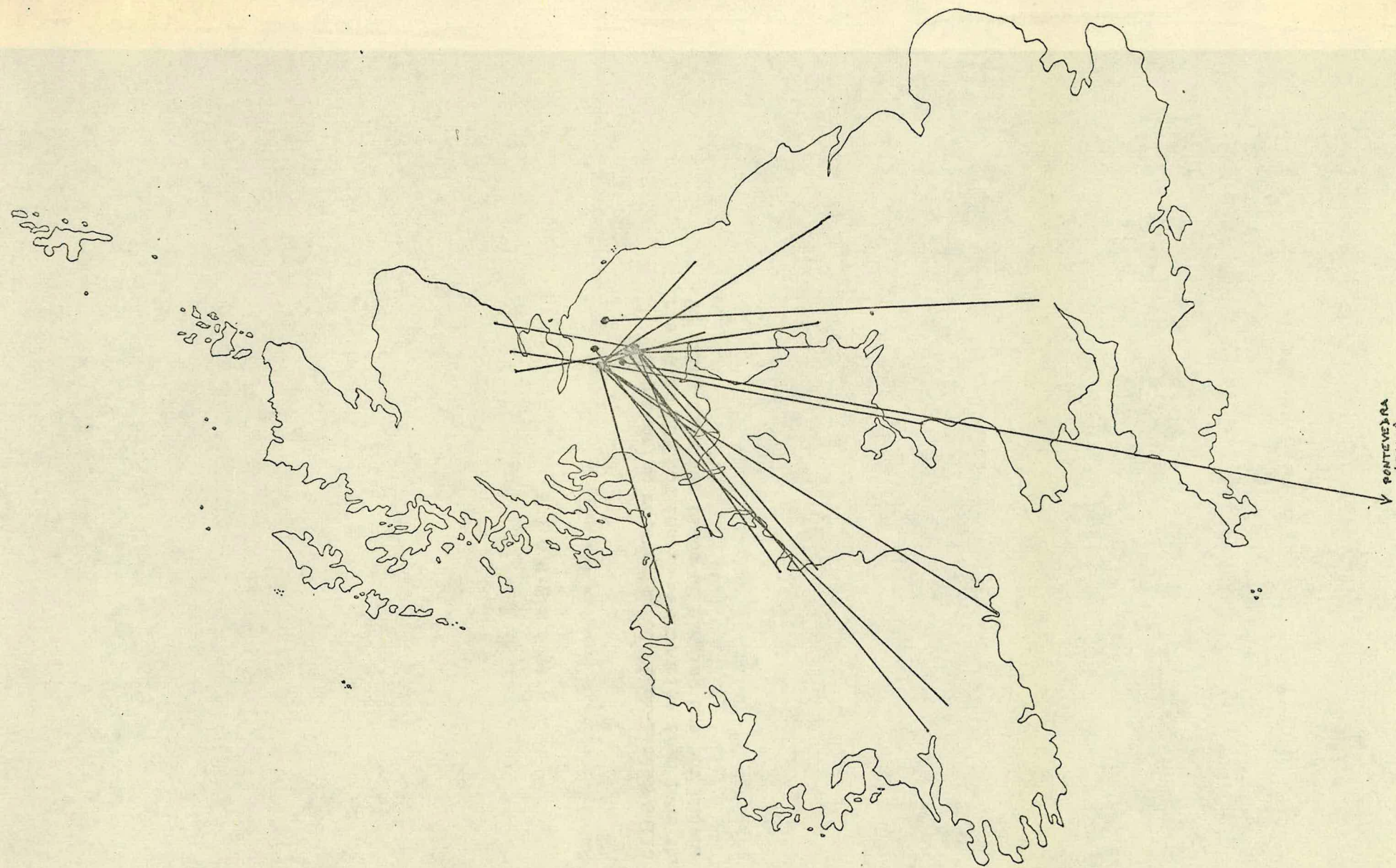
Despite the limited amount of data the deductions which can be made from it agree well with the analysis of all British Black-headed gull movements made by Radford (1962) from ringing recoveries.

In the same paper Radford also analysed the recoveries of foreign-ringed birds recovered in Britain. This showed that most of the immigrants to south Scotland come from Norway and Sweden. Birds from Denmark, Finland, Germany, Holland, Poland and Czechoslovakia were mainly recovered in southern England, while those from Iceland were found in Shetland, Orkney, Inverness and Ireland.

There can be little doubt that birds from these countries are true migrants and make their journey annually, especially when it is remembered that the percentage of immatures in the autumn and winter in the Forth and Lothians was found to be only 2.8 and 3.3% respectively. That fact shows that the immigrants are not dispersing immatures which are spending their first winter away from their home area, as appears to be the case with at least a proportion of British birds.

FIGURE 9

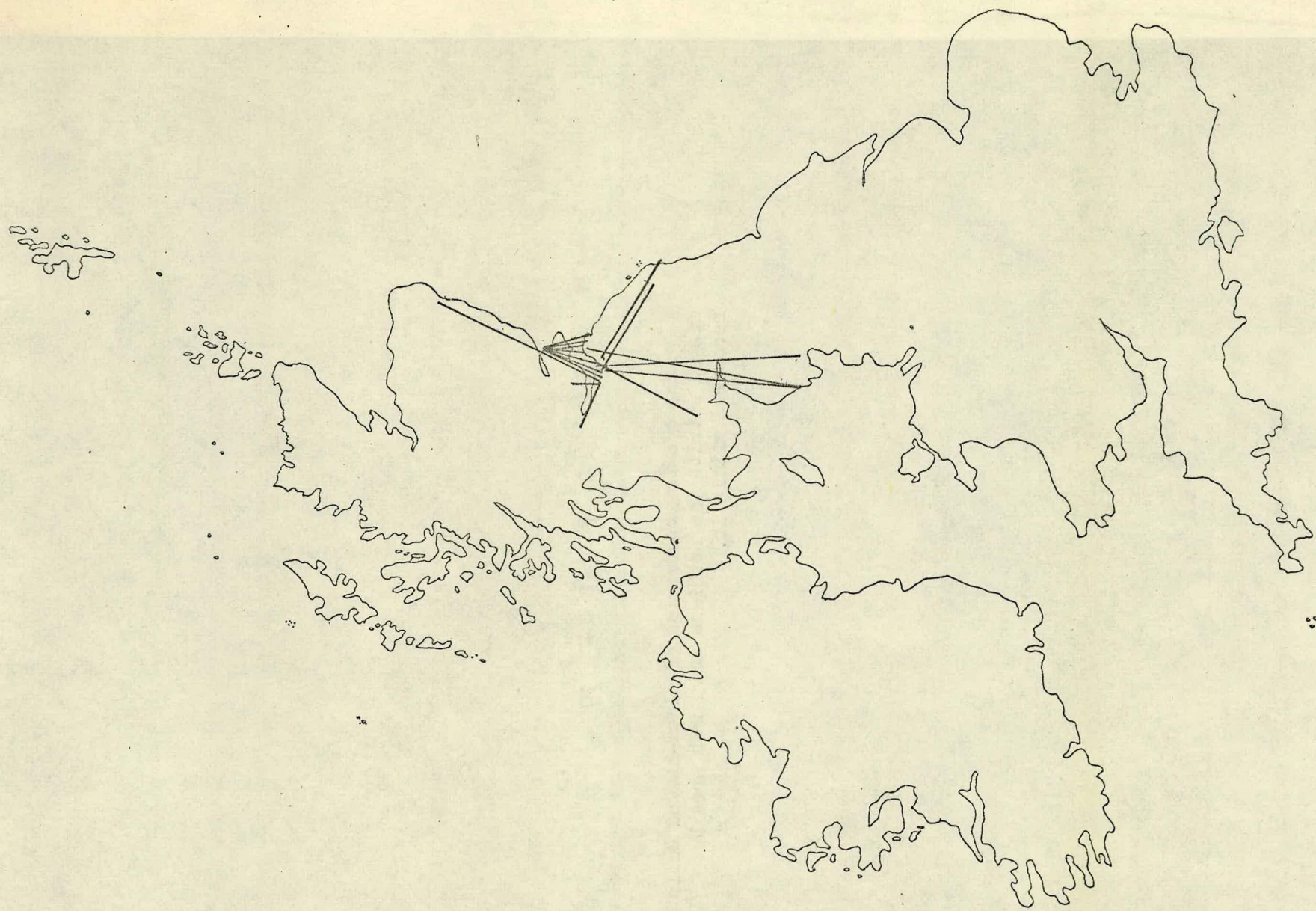
Map showing recoveries of Black-headed Gulls
ringed in the Lothians. Recoveries from less than
50 miles from the place of ringing are not shown.



PONTEVEDRA

FIGURE 10

Map showing recoveries of Black-headed Gulls
ringed outwith the Lothians and Forth area but
recovered within it.



2.4. Migration and dispersal of the Common gull

Unlike the Herring and Black-headed gulls, the Common gull does not breed in the study area, excepting the few attempts to do so by one or two pairs at Crane Loch in Lanarkshire.

Radford (1960) has analysed the ringing returns for the species both from Britain and from abroad. These show that most of the distant recoveries of juveniles ringed in Scotland were made south or south-west of their colonies, only two having been recovered on the east coast, at Edinburgh and South Shields. The majority of recoveries were local, many being of young found dead or dying within a short time of ringing, thus perhaps reflecting juvenile mortality rather than a tendency to be sedentary. Of nine birds ringed as adults in Scotland in summer, all were recovered locally, one of them one and two of them two summers later.

Recoveries in Britain of birds ringed abroad show that immigrants to Scotland come mainly from Norway, north of Bergen, but there were two recoveries each from North Sweden and Germany and one each from Denmark, Finland, Estonia and Russia. Radford suggest that there is direct passage of birds breeding in Norway to the British Isles, especially of those from mid- and North Norway, citing the high proportion of August recoveries of young birds as evidence. This is supported by observations from the Forth made during the autumn and winter of 1968/69, there being a much higher number of Common gulls present during August than during other autumn and winter months. The ratio of immatures to adults is also greater at this period than at any other. Additional evidence of the Norwegian origin of Common gulls

wintering in Scotland is supplied by Bourne and Patterson (1962) who describe the spring departure from Scotland in a north-north-east direction as watched by them on radar.

Thus the Common gulls found in the Forth and Lothians throughout the winter are true migrants. Scottish-bred birds on the other hand may well not exhibit migratory behaviour to the same extent, there being evidence that a portion of the population are apparently more or less attached to their breeding area all year. This seems to be especially true of West Coast birds.

2.5. Summary of the annual cycle

Within the study area, the annual cycle of the three numerically most important species of gulls may be summarised as follows:

- (a) Summer. Breeding of Herring and Black-headed gulls on islands in the Forth and at inland colonies to the south of Edinburgh respectively.

Some non-breeders of both species, as well as some immature Common gulls, summer on the coast and may make flights inland to feed.

- (b) Autumn. Dispersal of young and adult Herring and Black-headed gulls from their colonies. Emigration of some Black-headed gulls.

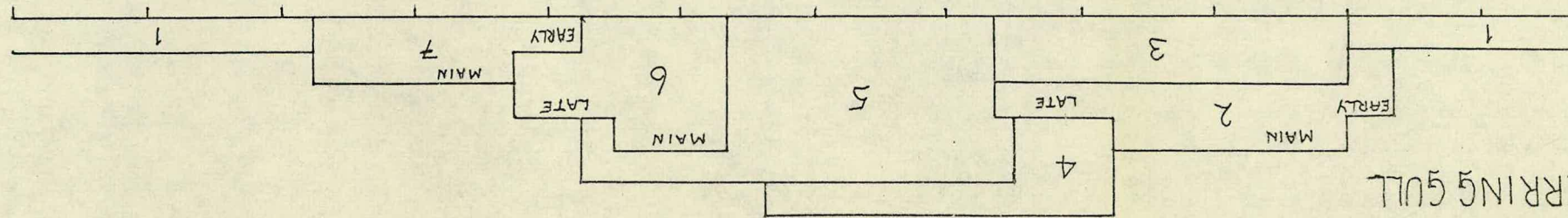
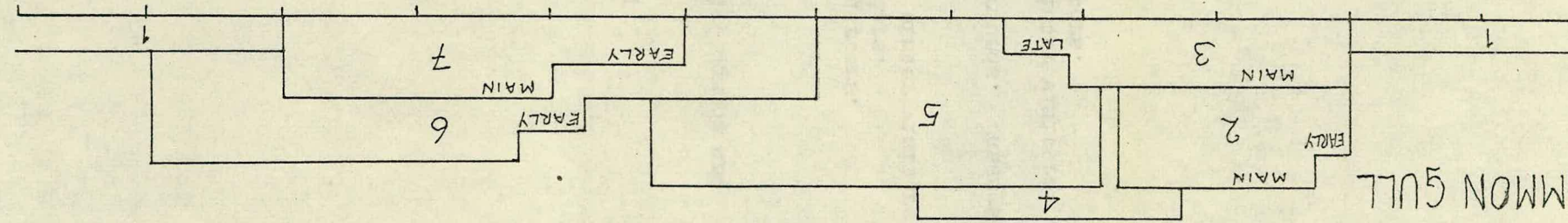
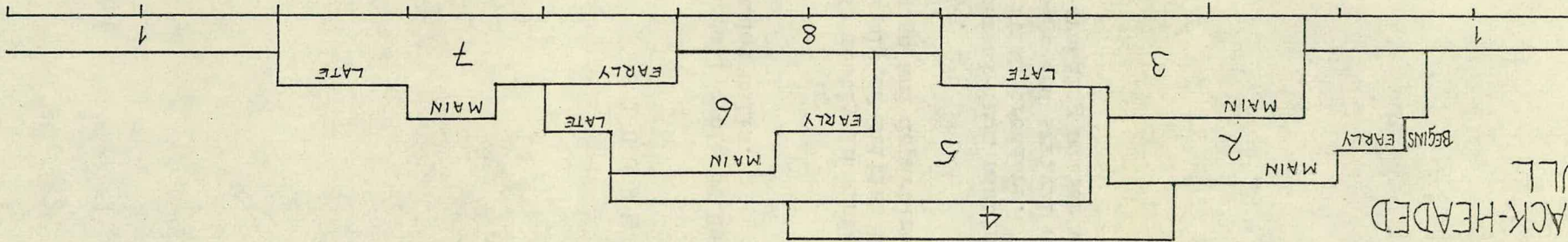
Arrival of early immigrant Common and Black-headed gulls, especially passage birds, from Scandinavia.

FIGURE 11

The annual cycle of Herring, Common and Black-headed Gulls.

1. Birds mostly in winter quarters.
2. Assembly of British breeders.
3. Passage and departure of winter visitors.
4. Eggs.
5. Young.
6. Dispersal from nesting grounds. Passage of British breeders.
7. Passage and arrival of winter visitors.
8. Non-breeding summer visitors.

JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC



- (c) Winter. Locally-bred Herring and Black-headed gulls remain on winter range in local area.

Immigration of Common and Black-headed gulls from abroad ends in November. Large numbers overwinter in the area.

Roosting by resident and immigrant birds is either coastal or inland at reservoirs. Diurnal flights take place from roosts at dawn and back to them at dusk.

- (d) Spring. Immigrant Common and Black-headed gulls depart, the former in a concentrated period in suitable weather in early April.

Breeding birds return to their colonies.

The timing and overlap of the cycles for each species are shown in Figure 11. (Adapted from Fisher, 1954).

2.6. The annual cycle and Turnhouse Airport

This examination of the annual cycle in relation to Turnhouse is made in general terms. Detailed consideration and presentation of quantitative material will be given in Section 3.

During the summer, from mid-April to early July, there is virtually no bird problem at Turnhouse. The numbers of gulls frequenting the airfield are low and few birds overfly the airfield. Exceptionally, usually on wet days, twenty or thirty gulls may congregate on the airfield and be reluctant to leave but otherwise such numbers may not be seen in the course of a whole

day, or even several days. Nearly all these birds are immatures.

In May there is a slight increase in the number of birds to be seen, almost certainly due to birds whose nests have failed leaving their colonies. Most of them probably join the non-breeding birds at the coast.

From mid-July onwards, there is a rapid build-up in the numbers of fully fledged young birds which have just left their colonies. This is reflected in the higher numbers of both young and adults present at Turnhouse. In some years there have been mass infestations of the airfield by flocks of gulls in late summer and early autumn, completely swamping all efforts made to scare them off (E.N. Wright, pers. comm.), but this extreme was not reached in 1968. By August, passage birds from other parts of Britain and abroad are beginning to move through, and winter residents to arrive, thus increasing numbers still further.

Passage does not finally cease till late October or early November, but before then roosting behaviour has become established. Every morning at first light the vanguard of gulls leaving the roost at Cramond appears overhead at Turnhouse, flying south. They are followed by continuous streams of birds flying over and to either side of the airfield, for a period of about two hours. The movement then tails off, virtually ceasing for most of the day, before beginning again in reverse in the evening. The timing, duration and quantity of this movement and other factors affecting it will be treated in Section 3. Similar movements occur at each roosting area throughout the winter.

There is no sudden observable change in behaviour from winter to spring. The routine of flighting out from, and back to, roosts continues, gradually lessening in intensity as British-breeding birds leave for their colonies and winter residents depart on migration. There is no apparent increase in numbers due to passage-birds going through the area, probably because these coincide with the departure of British breeders to their nesting grounds. By mid-March flighting has greatly lessened and continues on a diminishing scale until by mid-April it has ceased almost entirely and the summer season has begun once more.

The bird hazard at Turnhouse is thus seasonal. The time of greatest risk is from late July until October, when there are a large number of immature birds present. These are particularly troublesome because, unlike adults, their reaction to the presence of aircraft is quite unpredictable. They may prove difficult to scare off and when they do fly up are as liable to head into the path of an approaching aircraft as away from it.

Throughout the winter there is a continuous daily risk from overflying gulls during the two hours immediately prior to darkness. The only exceptions to this are during very frosty weather or periods of snow, when the gulls remain on the coast. There is a lesser risk during the major part of the day, from gulls settled on or near the airfield; these can usually be scared off however. During and after rain, pools of standing water are often present on the airfield and these have the twofold effect of attracting more gulls and making them reluctant to go away when scared. This situation becomes acute if high winds accompany rain, as birds are particularly

reluctant to leave under these conditions.

The least hazard is encountered in the breeding season, during which few gulls frequent the airfield.

The above outline describes the essence of the bird hazard at Turnhouse. It is hoped that it will enable Section 3 to be appreciated in context, against the background of the seasonal changes in weather, gull numbers and movement described here.

SECTION 3. THE DAILY CYCLE

Introduction

Most of this section is based on observations made at Turnhouse, but data obtained from coastal observations and from elsewhere in the study area are included.

Presentation of the material is as follows: first, the results obtained from the Turnhouse observations, showing the hourly, daily and seasonal situation there, then an examination of these results in relation to factors bearing on them such as rainfall, temperature and tidal state.

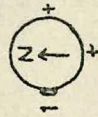
Throughout this section, unless otherwise stated, the data from Turnhouse has been split into three periods. Period A, from 15th March to 19th July, corresponds to the time of assembly at, and occupation of, gull colonies by British breeders. Period B, from 1st to 14th March and 20th July to 31st October, corresponds to the main passage of spring and autumn migrants and to the dispersal of young and adults from British breeding colonies. Period C,

FIGURE 12

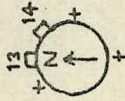
Seasonal direction of gull flight over Turnhouse.
Black lines = 0300-1000 hrs. GMT. Open lines = 1500-2200 hrs. GMT.
Periods A, B and C correspond to the definition in the text
(see p. 79). Figures are the rate/hour of gulls passing;
a + sign indicates less than one gull/hour.

1000 - 1500 HRS GMT.

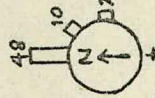
A.



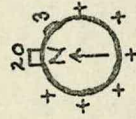
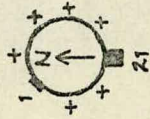
B.



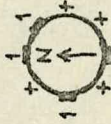
C.



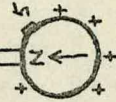
A.



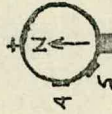
B.



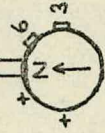
602



C.



953



403

1061

from 1st November to 28th February, corresponds to the time when gulls are occupying their wintering grounds. (See Figure 11).

Inevitably, these rather arbitrary divisions have resulted in a degree of overlap, especially in spring when the passage and departure of winter migrants continues well after British breeders have begun to nest. However the impossibility of distinguishing migrant gulls from resident ones necessitated their being lumped together and it was decided to follow the observed local gull cycle when splitting the year into periods. Thus Period A begins in mid-March by which time assembly is almost complete at Black-headed gull colonies and well under way at Herring gull colonies.

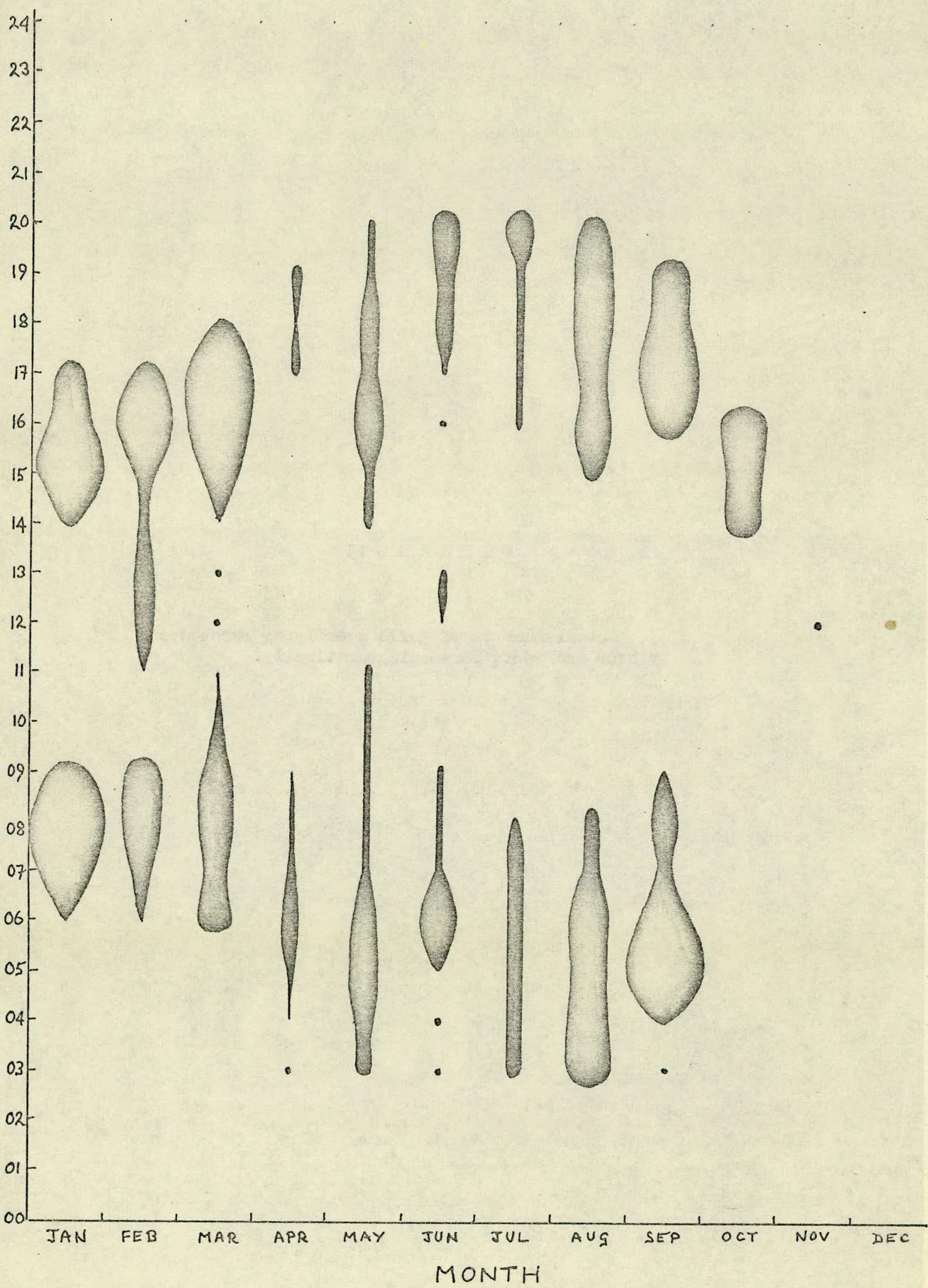
3.1. Direction and rate per hour of gulls overflying Turnhouse

It was mentioned in the Introduction to Part II that gulls flying out from roosts on the Forth in the morning and returning to them again at night formed the major part of the bird problem at Turnhouse. Figure 12 shows the direction of these movements, together with the mean rate per hour, for Periods A, B and C. Each period has been divided into Morning, from 0300 to 1000 hours, and Evening, from 1500 to 2200 hours. Middle Day, from 1000 to 1500 hours, is shown in the inset. The mean rate per hour - or gulls per hour - was obtained by dividing the total number of gulls observed during that hour by the number of observations made at that hour.

It can be seen, first, that the direction of movement was largely south in the morning and north in the evening, irrespective of Period. Secondly, the highest rate of movement was in winter (C) and the lowest in summer (A),

FIGURE 13

Actual numbers of gulls overflying Turnhouse
by hour and month shown diagrammatically.



with the migratory period (B) in between. Thirdly it is apparent that there was quite close agreement between the morning and evening rates within each Period. There is possibly less agreement than there should be because of the fact that most evening observations were made on Thursdays, while the morning ones were on Fridays. Thus the counts were not for the same day's movements out and back, with the result that tidal and weather conditions differed in some instances. Fourthly, the direction of movements during Periods A and B included a small proportion of birds going to all points of the compass (except west in B: Evening), whereas during Period C this was not so. Winter movements may thus be less random even than summer and migration-season ones.

The Middle Day movements were obtained from the relatively few observations made during these hours and are not therefore entirely reliable as indication of what actually happens. If they show anything, it is that during the short days of winter (C), northward movement begins earlier than 1500 hours. This is also true of Period B to a lesser extent, while during Period A there was virtually no movement at these times.

3.2. Numbers of gulls per hour per month overflying Turnhouse

Figure 13 is a diagrammatic representation of the actual numbers of gulls observed overflying Turnhouse. It can be seen that both the quantity and the timing varied according to season and daylength. Numbers were greater and took less time to pass in winter than in summer. Movements also took place later in the morning and earlier in the evening in winter than in summer.

FIGURE 14

Graph of the rate per hour at which gulls
overflow Turnhouse Airfield.

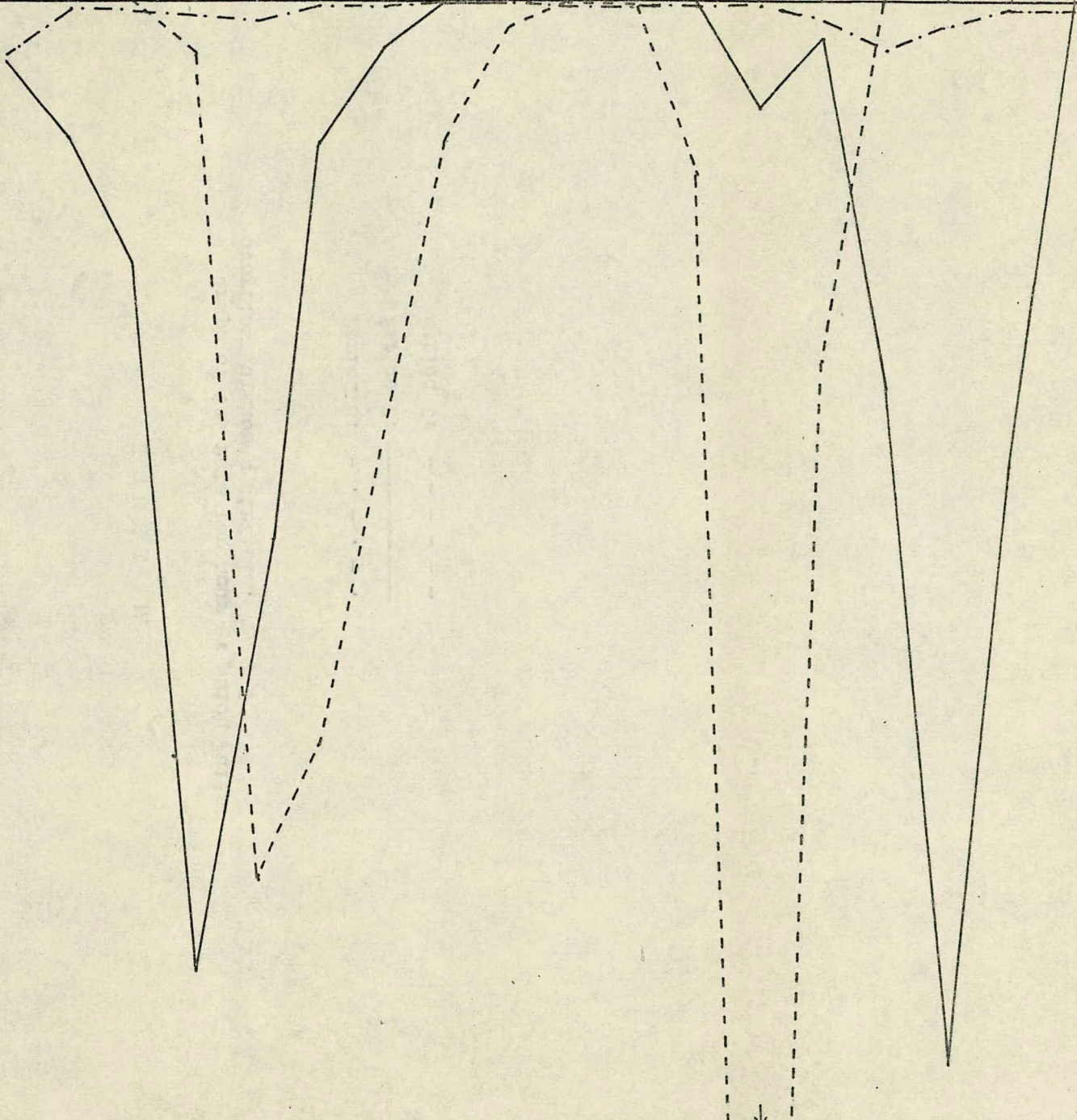
Period A: - . - . - .

Period B: —————

Period C: - - - - -

HOURS S.M.T.

21 20 19 18 17 16 15 14 13 12 11 10 09 08 07 06 05 04 03



Insufficient observations were made at Turnhouse in November and December to include here, but there is no reason to believe that the pattern for these months was much different from that for January and February.

3.3. The rate per hour of gulls overflying Turnhouse

Figure 13 gave a crude idea of the overall pattern of gull numbers at Turnhouse throughout the year. In Figure 14 the data has been divided into Periods and expressed as the rate per hour.

From this can be seen that in Period A, the rate at which gulls passed over Turnhouse never exceeded 70 per hour and was usually considerably lower. Small peaks in movement occurred between 0500 and 0700 hours in the morning and between 1500 and 1800 hours in the evening, with a second evening peak at 2000 hours, but activity was never very intense. The peak at 2000 hours was caused by a flock of immature Common gulls, which rested on many days in a young potato crop adjacent to the airfield, leaving as a flock about that time.

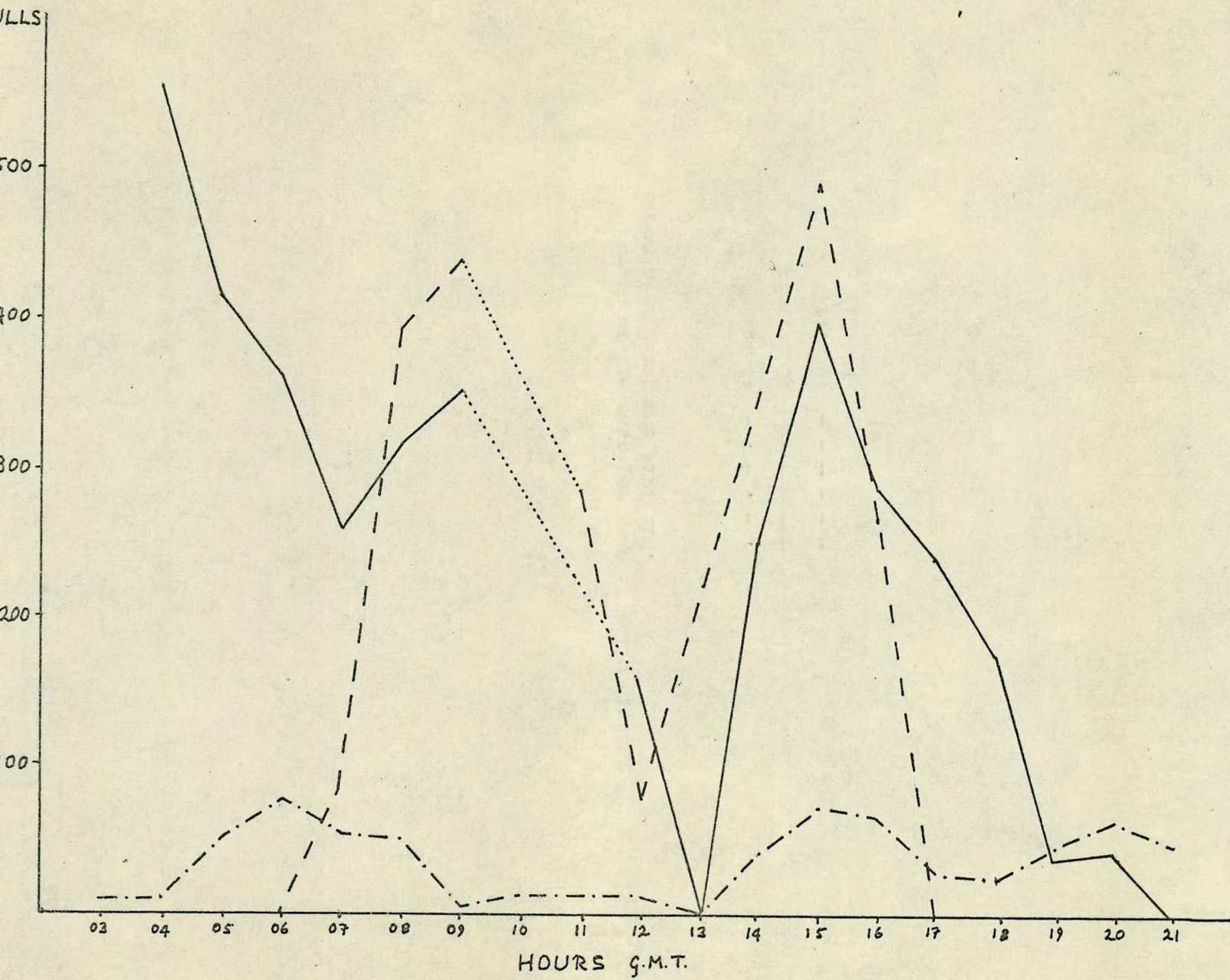
During Period B, the morning rate was over 1350 gulls per hour at its maximum, while the evening maximum was 1230 gulls per hour. Peak rates were found between 0400 and 0600 hours in the morning and between 1500 and 1800 hours in the evening. The longer duration of the evening movement would account for the maximum rate being rather less than that found in the morning.

The pattern of Period C was similar to that of Period B but with greater numbers involved. The maximum rate in the morning was 2,408 gulls per hour

FIGURE 15

Graph of the rate per hour of gulls sitting
on or near Turnhouse Airfield.

Period A: - . - . - .
Period B: _____
Period C: - - - - -



and in the evening 1,166 gulls per hour. The morning movement was at its greatest between 0700 and 0900 hours, while the greatest part of the evening movement was spread over an interval of nearly four hours, from 1300 to 1700 hours. If the maximum morning rate is multiplied by two (hours) and the maximum evening rate by four (hours), the products are 4,816 and 4,664 respectively. Thus the maximum rate in the evening was not quite half that of the morning but the duration of the movement was nearly twice as long.

3.4. The rate per hour of gulls sitting on the airfield

The data for this section includes gulls which were sitting in fields surrounding the airfield and close enough to be considered a potential hazard, as well as birds which were actually on the airfield itself. Figure 15 shows the data divided into periods and expressed as a rate in the same way as Figure 14. It gives an indication of the hours of day during which gulls sit on or near Turnhouse airfield during three different periods of the year.

From the graphs it is apparent that there are more gulls in the mornings and evenings than during the middle of the day. This is due to several factors. In the morning, gulls flying inland sometimes land on or near the airfield initially, only leaving when disturbed by people moving about. This is especially true of days with long hours of light, when inland movement begins long before most people are on the move. Gulls which have settled on the airfield itself are of course, usually scared off and often leave the vicinity altogether. Both these forms of disturbance result in a drop in numbers.

Agricultural activities have considerable influence on the number of gulls present. Ploughing, harrowing, disking and hay-turning operations all attract gulls. If ploughing is commenced at, say, 1400 hours, this will lead to gulls coming in to the area fairly quickly, even though very few may have been present prior to this. There are also weather, tidal and seasonal factors which may have a bearing on whether or not gulls are present throughout the day. (See 3.8.). All these factors or various combinations of them, lead to a tremendous variation in the number of gulls to be seen in the area at any one time.

The evening peaks are caused largely by gulls which are moving back towards the coast landing to feed for a short time. Very often the airfield and the surrounding fields are undisturbed in the evening.

In short, there is no one simple explanation for the fluctuations found in the numbers of sitting gulls. Many more observations would be required in order to give a complete answer. However Figure 15 does provide a guide to the times when flocks of sitting gulls are most likely to be present and this, taken together with the various reasons mentioned above, makes prediction of periods of gull concentration around the airfield possible.

3.5. Height of flight

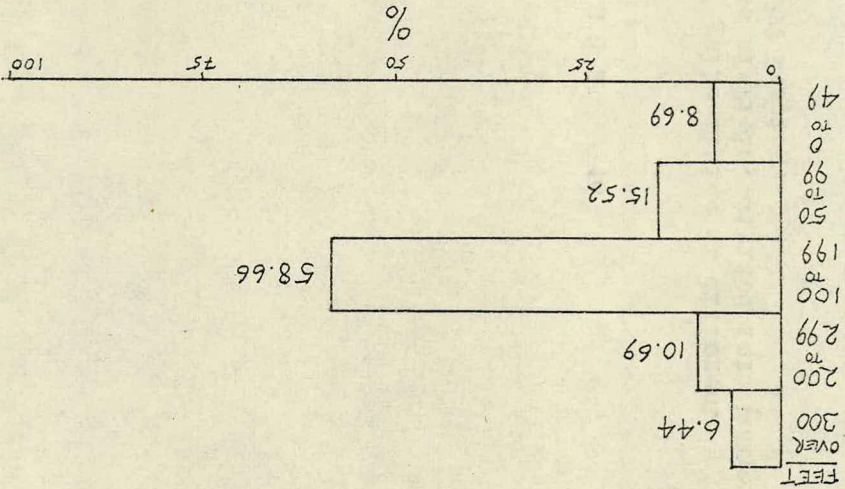
The heights at which gulls were flying over Turnhouse were noted when possible. Although it was often difficult to do this when counting large numbers, a total of 26 observations were made in the morning and 22 in the evening during the course of the year. These were split into Summer, from

FIGURE 16

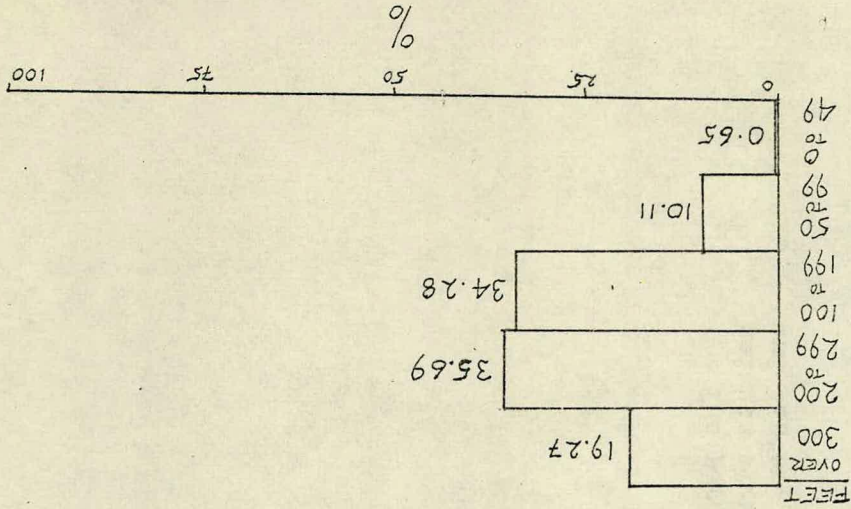
The percentage of gulls flying at different heights over Turnhouse Airfield, divided into Summer and Winter, Morning and Evening.

WINTER

MORNING

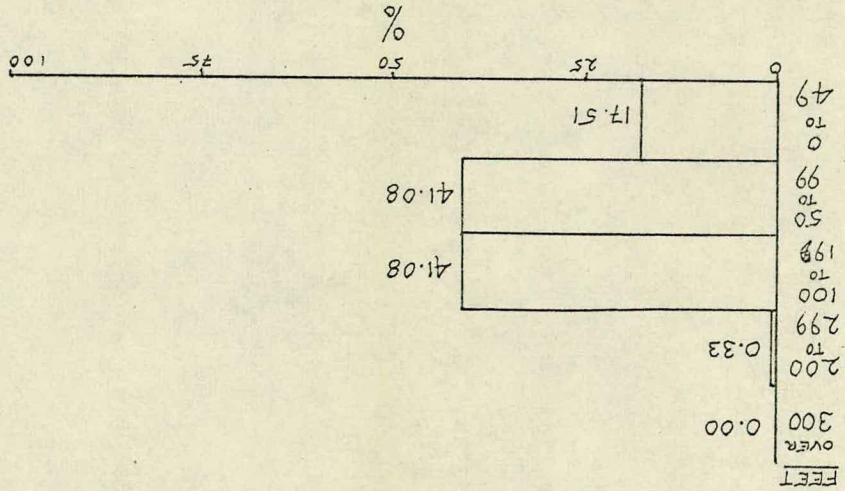


EVENING

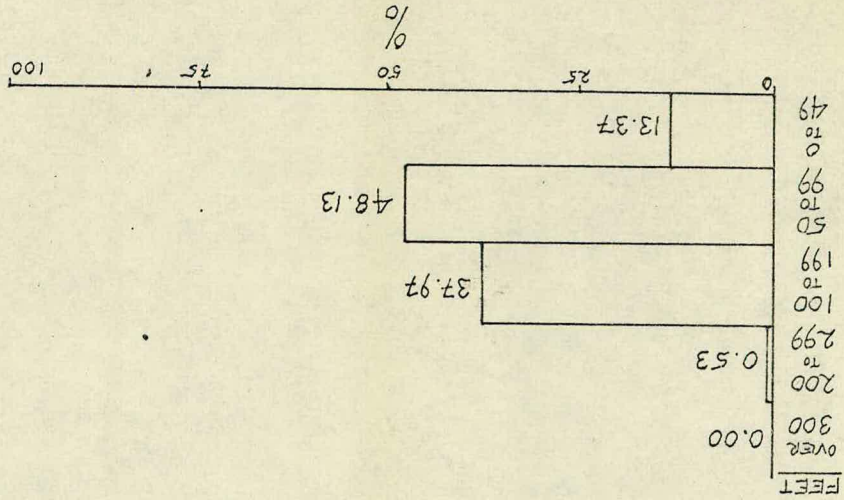


SUMMER

MORNING



EVENING



15th March to 19th July, and Winter, from 20th July to 14th March respectively. Figure 16 shows the percentages of gulls at different heights during morning and evening, summer and winter.

Chi-squared tests showed that there was a significant difference in flight height between morning and evening movements in winter at the 0.1% level ($P = 0.01$) with four degrees of freedom, the morning flight taking place at a lower altitude than the evening one. There was no significant differences between flight heights in summer.

The occurrence of differing heights of flight in winter only is not at first readily explicable. The most obvious reason for a higher mean height of flight in the evenings is the use made by gulls of warm up-currents of air (thermals), in which they soar. These only develop after the sun has warmed the land and are not therefore readily available to the birds in the mornings as an easy means of gaining height. That gulls do use them in the evenings has been observed at Turnhouse and elsewhere. However there seems no good reason for them not to soar in thermals in summer as well as in winter; indeed there are often more and stronger up-currents in summer. The answer would thus appear to be unconnected with the physical presence of thermals.

Turning to the social behaviour of gulls, it is possible to construct quite a convincing explanation of why winter and summer heights of flight should differ. In winter, gulls are flock animals with an intricate social structure and it would appear that soaring plays a part in the communal pre-roosting pattern. Thermal soaring involves gulls milling round and round

above their point of departure for their evening roost, steadily gaining height with the aid of the up-current of air. Suddenly one bird will break away and set course for the roost, to be followed immediately by others. Usually they arrange themselves in loose V-formation. Not all leave the thermal at once and there may be several minutes between the departure of each flock, the remainder continuing to wheel round until another bird breaks off. The process is repeated until all the gulls are on their way to roost.

The difference in heights of flight is thus due to utilisation of thermals for soaring, but the fact that gulls use them would seem to be brought about by the social behaviour of a type similar to that described by Wynne-Edwards (1962) in his chapter on communal roosting. The occurrence of this behaviour only in winter becomes quite logical if the above explanation is accepted, because in summer most birds are involved in colonial breeding, with its attendant displays and such pre-roosting-flight behaviour has no place or function at this time.

The comparatively few full-grown non-breeding birds which do continue to flight to and from the coast in summer do not apparently indulge in thermalling. This is probably because the intensity of the instinct to participate in flocking behaviour is subdued in summer, perhaps because the actual number of birds is also greatly reduced.

It is worth mentioning that on days of very strong winds, gulls fly extremely low. On January 30th, 1969, when the mean wind speed was 22 kt. and gusts of up to 53 kt. were recorded, the morning flight was made at heights of 10 to 20 feet above the ground. Previously, gulls returning to roost at

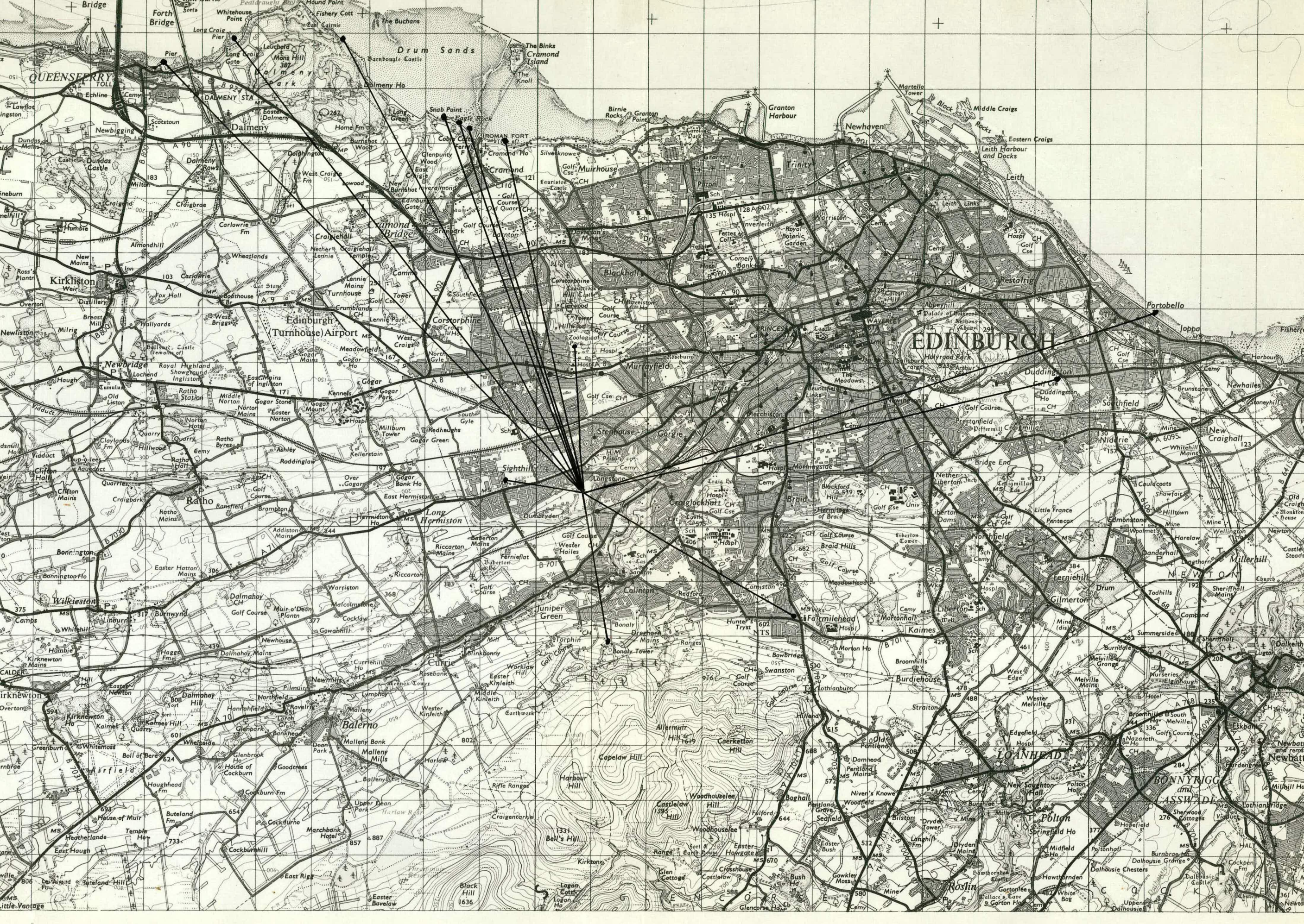


FIGURE 17

Map showing sighting and recovery points of
gulls seen or found after being caught and
colour-marked at Hailes Quarry.

Gladhouse Reservoir on a stormy evening had also been seen to fly very low. The reason for this is certainly because by flying low and following the lowest contours the birds have a lower wind strength to contend with. Observations of height of flight on days of very high wind speed were not included in the analyses.

3.6. Marked gulls

Tracing the movements of gulls in the study area presented a difficult problem. It was impossible to identify individuals, for one gull looks very much like another of its species. Consequently it was decided to try and mark a number of individuals with coloured dyes and plastic patagial tags, primarily to discover whether the same birds were using particular feeding areas and roosts every day.

Despite being equipped with a 90 ft x 45 ft cannon-net (See Appendix V for description), it proved remarkably difficult to catch gulls at all. This was partly due to there being only a limited number of places where it was safe to operate the net, but largely because of the wary nature of the gulls themselves. A total of only 104 gulls were caught, 103 of these being Herring gulls from Hailes Quarry rubbish dump and one a Black-headed gull from Gogar Mains Farm near Turnhouse.

The Herring gulls were fitted with brown patagial tags and had their heads dyed with Malachite Green. All were caught on the 24th July, 1968 and Figure 17 shows sightings and recoveries made at points outwith the catching area. Up to six marked Herring gulls at any one time were subsequently seen

back at Hailes Quarry in the following three weeks, out of a total of 2,500 to 3,500 present there daily - that is 5.77% of the birds caught. The last tagged bird to be seen was reported by the dump foreman on the 16th November.

The Black-headed gull was caught on 28th November, 1968. It was dyed with Gentian Violet, but no patagial tags were fitted. A "blue" gull was reported to be frequenting ploughed fields just north of Turnhouse for the following two weeks and was almost certainly this bird. On 14th January, 1969 a Black-head gull "dyed blue on neck" was noted by an Air Traffic Control Officer on the airfield. Allowing for the fact that the dye had probably faded considerably by this time, it is not improbable that this was the same bird.

None of these marked birds have been seen since then. The chances of seeing them again were always slender, and there was also the distinct possibility that the patagial tags had either come loose or been broken off by the birds themselves. The Malachite Green dye faded within three weeks of application and the Gentian Violet would be unlikely to have lasted more than a month or two.

Although not by any means as successful as was hoped, the marking scheme has shown that at least a proportion of gulls return to the same area to feed on successive days over a period of time. Observations made at Turnhouse and elsewhere support this; for example a Lesser Black-backed gull was seen every day in the same place at Turnhouse for a number of weeks throughout the winter of 1968-69, and an immature Glaucous gull frequented the Newhaven



FIGURE 18

Map showing major flight-lines used by gulls which roost on the south Forth coast. The morning lines only are shown for clarity; the evening ones are a reversal of these.

Harbour area for some weeks in 1968.

It is not justifiable to draw too many conclusions from the present rather scanty evidence, but it seems extremely probable that gulls continue to visit a particular area fairly regularly over periods of at least some weeks. However further marking experiments would be necessary to demonstrate this with certainty.

3.7. Flight lines

Observations of gulls flying to and from feeding areas and roosts was carried out regularly at Turnhouse and was supplemented by watches at the coast, at Gladhouse Reservoir and elsewhere.

On fine days with mean wind speeds below about 20 kt and a cloud base of 1,500 feet or more, flying took place on a broad front for which "flight routes" would be a more appropriate term than "flight lines". However, as already mentioned in 3.5., on days with very strong winds gulls fly low, following very definite flight lines. These coincide with valleys and dips in the ground and often involve the birds flying considerably greater distances to reach their destination than on fine days when they fly higher and more directly.

Figure 18 shows the flight lines observed from nine strategic points in Edinburgh on 30th January, 1969, a day of high winds, and later checked in part by subsequent observations. Note how in no case did the gulls fly over high points, invariably circumnavigating them. In better conditions, similar

routes are followed, but these are more direct, with birds spread out over hundreds of feet instead of in long chains as on this occasion.

As birds reached points along their route where feeding was available, some would land and start foraging. This was not usually a mass movement, with a hundred or two arriving at one time, but a gradual build-up as ones, twos and small groups left the main stream. This suggests that each bird may have been aiming for a particular destination, otherwise it would seem more logical for flocks to settle en masse at each feeding place. If however, gulls leave their roost in no particular order, each flock having lost its identity overnight, it would then explain the gradual accumulation in small numbers at the feeding areas as individuals returned to the place where they last fed on the previous day. An alternative explanation would be that birds leaving the roost first are either scouts or ones which are in some way leaders. These settle in places where food is available and by their presence on the ground attract others, flighting out later, to the food-supply. Both ideas are highly speculative at present, but there seems to be remarkably little known about this aspect of gull behaviour and it may be that someone will be prepared to pursue it, perhaps with a more widespread colour-marking experiment.

The above description is generally true of local gull-movement in the study area in winter. Crook (1953), in his paper on the gulls of Southampton Water, found that gulls there also used fixed flight lines.

In summer, flight lines are still used to a very limited extent by the small number of non-breeding gulls which continue diurnal inland flighting from and to the coast. Most birds are involved in breeding however and are

absent for up to four months. There are no fixed flight lines to and from colonies, birds presumably making use of the most direct route to and from the food available on a day to day basis.

3.8. Factors affecting local gull movements

From observations made and data collected at Turnhouse, it became apparent that a number of factors had to be influencing the numbers of gulls which were seen there. Accordingly an analysis of co-variation was carried out to test the effects of season, state of ground (wet or dry), temperature, wind speed and the interactions between them, on the number of gulls sitting on the airfield. A second analysis of co-variation was used to test the interaction between tidal state and time of day.

(a) Weather Factors

Because of the nature of the data, it was necessary to use arbitrary divisions in each category of the first analysis to obtain a layout approximating an experimental design. Season was divided into Summer, from 15th March to 14th August, and Winter, from 15th August to 14th March; State of Ground was taken from the code used by the Meteorological Office, but adapted to give simply wet and dry; Temperature was grouped into two categories, -5°C to 13°C and 13.5°C and over (there were only two minus readings); Wind Speed was also grouped into two, 0 to 9 kt and over 10 kt. All meteorological data used was the mean for the day on which an observation was made.

The result of analysing these four factors statistically showed that only season was significant, with $F = 3.83$ at the 5% level with 1 and 151 degrees

of freedom. Biologically, this means that diurnal local movements of gulls are not affected by weather, a not unexpected result from this analysis, given the rather crude data and arbitrary categories employed. Observation alone would lead to the conclusion that state of ground probably does have an effect, which may well have been masked in the present analysis. Collection of a considerably greater number of observations representative of all the different combinations of these four weather factors and allowing division into a greater number of categories would give scope for a more refined analysis, with consequently a better chance for interactions to be manifested.

(b) The Tidal Factor

Gulls which fly over Turnhouse on their way to and from inland feeding places mostly emanate from the extensive area of tidal mud-flats known as Drum Sands at the mouth of the River Almond near Cramond. The area is used as a roost at night but when the mud-flats are uncovered, large numbers of gulls feed there during the day.

It seemed reasonable to suppose that if, when gulls were due to leave the roost at first light, the mud-flats were uncovered, then a proportion at least would remain behind to feed on the flats rather than immediately flying inland. It might also be expected that this would hold good at other times of the day as well.

To test this hypothesis, an analysis of co-variation was made using observations of gulls flying over Turnhouse, made between 0300 and 0900 hours in the morning and 1400 and 2000 hours in the evening at times when the tide

was (i) between three quarters full and full, both ebbing and flowing and (ii) between one quarter full and ebb, both ebbing and flowing. Testing the interaction between time of day and tidal state gave a statistically significant result at the 5% level with $F = -8.01$ with 1 and 20 degrees of freedom.

The biological significance of this inverse answer - which, it must be remembered was derived from observations at Turnhouse, not the coast - is that low tides in the morning or evening do have an effect on the number of gulls which pass over Turnhouse. More gulls feed at the coast during low tide and therefore the concentrations at Turnhouse are less than at times of high tide, in the mornings and evenings at least.

Crook (1953) suggested "very tentatively" that such a situation might be true of gulls at Southampton Water. In the light of the above result, it would seem that he was probably right; indeed it is probable that this is a widespread feature of gull movement in all areas where similar tidal situations occur at roosting places.

3.9. The nature of local gull movements and feeding behaviour

This section, like the foregoing ones, is concerned primarily with local movements in winter.

From what has been stated so far, it is evident that local gull movement in the study area is remarkably regular within the limits imposed by seasonal, weather and tidal factors. However no consideration has yet been made of these movements with regard to their characteristics - whether they are

directed, opportunist or a combination of both these things. Movement during the winter, once autumn migration has ceased, is almost entirely connected with flighting between roosts and feeding areas, the exception being hard-weather movements, which result in a temporary sojourn on the coast for inland roosting birds while their usual roosts are frozen up. At such times inland feeding ceases almost entirely because of frozen ground making food inaccessible; virtually all gulls remain on the coast until a thaw comes. (See Plate 4).

Where a food source is permanent, such as a rubbish dump or sewer outlet, gulls are present throughout the day in winter (and in lesser quantities in summer too). At Hailes Quarry rubbish dump there are always between 2,500 and 3,500 Herring gulls present during the week. On Sundays when the dump is closed, the gulls arrive as usual, but disperse again once it is obvious to them that no food is forthcoming. In extremely frosty weather the number of gulls increases rapidly, Common and Black-headed gulls joining the Herring gulls until their more usual haunts unfreeze. Behaviour at sewer outlets is similar; although discharge may not be constant, there are nearly always Herring, Common and Black-headed gulls round them, together with a few Great and Lesser Black-backed gulls.

Feeding inland, gulls are less sure of a regularly-situated food-supply. In particular this applies to Black-headed gulls which, as was pointed out in 1.8., are dependent largely upon agricultural operations. To utilise the products of ploughing, harrowing and other farming methods which provide a plentiful supply of invertebrates, these birds have to be opportunist in as much as

they have to locate areas where these operations are taking place on a day to day basis. Once they have located such an area they will remain there, returning on subsequent days to the same place as long as the ploughing continues. Should ploughing be completed in one place after the gulls have gone to roost for the night, they will return to that place the following day and only move on once it has become established that no food is available there any more. In this way their feeding habits and flighting may be regarded also as directed. "True" opportunism is exhibited by the Black-headed gull only in such situations as may for instance be found when a hill-walker in the Highlands sits down to have lunch. In a remarkably short space of time one or two Black-headed gulls will appear, apparently from nowhere, and circle around waiting for scraps. This happens often, even in areas remote from roads, where such scavenging behaviour at lay-byes is well-known.

Common gulls, which also feed inland to a large extent, use short grass fields and waterlogged areas much more than Black-headed gulls. The reasons for this are mentioned in 1.8. They are in consequence less dependent on agricultural operations for their food, although they too follow the plough, often in close association with Black-headed gulls. They are also opportunist in a similar way to the Black-headed gull, swooping down to take scraps should they chance to see some available.

Herring gulls, being offal-feeders, show a reduced tendency towards opportunist feeding than the other two species mentioned. Their food-sources are unshifting for the most part and there is less need for them to forage over long distances. Nevertheless some do feed inland, almost invariably in

the company of Black-headed or Common gulls or both.

The habit of following ships for some distance from land, which Herring gulls and Black-backed gulls particularly are well-known for, might be thought of as opportunism, but in fact it is really the exploitation of a known food-source. A ship which does not soon discharge edible waste rapidly loses its retinue of gulls to one which is doing so; a parallel may be seen here between Herring gulls following ships and Black-headed gulls following a plough.

Feeding behaviour of gull flocks, whether inland or coastal, has one feature in common. There are always two groups of birds, one "active" and one "passive", the former feeding while the latter rests, usually some distance away. There is a constant interchange of birds between these two groups as those which are replete fly to join the resting group and others, their previous feed digested, return to the feeding group. Plate 5 shows this situation at Hailes Quarry with Herring gulls, while Plates 6 and 7 portray a resting group and a feeding group of Black-headed gulls.

Hickling (1957), in a comprehensive paper on the social behaviour of gulls wintering inland, considers that feeding and flighting are both social in character, a conclusion which is supported strongly by the observations made during this study. He also concludes that there are some permanent flocks always to be found in the same place during the day, in which individual membership is constantly changing, while Crook (1953) regards flock continuity from day to day as being unlikely. While this may be so, some form of

continuity would seem to be necessary - especially in the case of Black-headed gulls following the plough - otherwise it is difficult to see how the birds would know to return to the same place, which they will do even if ploughing has not begun before they arrive. It is reasonable to assume that at least a proportion of the same birds return to the same place on consecutive days; that they do so is indicated by the fact that some of the wing-tagged Herring gulls did return on succeeding days to Hailes Quarry.

Summarising, it can be said that the three species considered here are remarkably regular in their movements, but some doubt remains as to the composition of flocks from day to day. Movement is largely directed towards known food-sources, but gulls are also quick to exploit unexpected food-sources arising by chance. It is possible that opportunism plays a larger part at times of food scarcity than when food is abundant.

P A R T III

SOME POSSIBLE ANSWERS TO TURNHOUSE AIRPORT BIRD PROBLEMS

Tackling the Problem

In Parts I and II, the problem of birds and aircraft was reviewed and the situation as it affects Turnhouse considered in some detail. It is now necessary to see whether, in the light of what is already known, it is both possible and practical to do anything about reducing the bird hazard at Turnhouse.

In the Introduction to Part II (p. 30), it was suggested that the results obtained from the Turnhouse study would be considered in relation to their environmental and ecological applications and this must be the long-term aim. However because it is a long-term aim it is also necessary to look at short-term measures which might help to lessen hazards in the immediate future.

SECTION 1. SHORT-TERM IMPROVEMENTS

1.1. Scaring techniques

Scaring birds off the airfield was until very recently the job of the Air Traffic Control personnel at Turnhouse. The disadvantage of this arrangement was that their first priority had to be the controlling of air traffic. This meant that at busy times bird-scaring simply could not be properly carried out, despite an awareness of the need to do it. The advice of the Ministry of Agriculture, Fisheries and Food team engaged on research into the bird problem has been that bird-scaring should be carried out by airport Crash-Fire Sections, members of which would be trained in the effective use of bird distress-call replay equipment and shellcrackers. The transfer

of this duty to the Fire Section at Turnhouse has in fact just been completed. This in itself is an improvement as, except in emergencies, the firemen have the required time to do the work more thoroughly. Thus one of the recommendations which was to have been made here has been rendered unnecessary.

It is widely acknowledged that the combined use of distress-calls and shellcrackers is not entirely successful in removing birds from airfields, although properly operated for maximum effect the results achieved are very good. Unfortunately the times when this method is least effective are the times when the bird-strike hazard is most likely to occur, namely when birds - usually gulls - persist on the airfield despite efforts to scare them off.

It is realised that there are some very valid reasons to support objections to the use of firearms on an airfield - danger to personnel, to the public and to aircraft being the leading ones. However there is no doubt that were current scaring methods to be reinforced at times by the use of a 12-bore shotgun the result would be effective. It is unlikely that it would need to be used frequently. Saul's (1967) experience at Auckland Airport has proved that a minimum of actual killing is required because birds can be rapidly conditioned to associated various sights and sounds with danger; in this case, the van carrying the scaring equipment, the distress-calls and the shellcrackers being fired. Occasional use of a shotgun at times of particular hazard should be quite enough to ensure better results from everyday scaring operations.

Providing objections to the use of a gun can be overcome, and given adequate rules and safeguards this should not be difficult, then there is a

strong case for giving this system a trial. Public objections to killing a minimal number of birds can be expected, but a tactful explanation of the necessity for doing so should satisfy all but the lunatic fringe.

1.2. The airport environment

Turnhouse is fortunate in that it is situated in a relatively birdless area. The airport itself is not bounded by any features particularly attractive to birds (except during agricultural operations, but see p. 109). Purists might argue that because the Gogar Burn is frequented by a pair or two of Mallard and Moorhens that it should be covered over, diverted or filled in, but a sense of proportion must be kept. The hazard from waterfowl at Turnhouse is almost nil and it is not justifiable to expend vast sums of money insuring against negligible risks.

Points which should be carefully watched but which require no action at present are the Rookery just north of the A.9 road and the tendency for starlings to nest in airport buildings. The former is very small but could become potentially hazardous and the latter is a habit which should be discouraged. Any increase in the starling population on the airfield could be a liability, quite apart from the fact that these birds have been known to nest in aircraft (Bridgman, 1962). It is therefore advisable that any known nest sites should be blocked up or otherwise rendered inaccessible.

There is a commendable lack of refuse and edible litter on the airfield and round airport buildings. No possible improvement could be made here as long as the situation remains as favourable as at present.

Turning to the airfield itself, the greatest attractions there are on wet days when pools of water collect on the runways and eventually on the grass also. Countering this would involve costly improvements in the drainage scheme and it is questionable whether the results would be good enough to warrant the expense. However there is one measure which might help and which has not yet been tried at Turnhouse and that is allowing the grass to grow longer. Nine inches is the ideal height as this prevents gulls from obtaining clear all-round vision and deters them from settling.

Objections to long grass are threefold. One, it presents a fire hazard when it dries; two, it attracts flocks of small graminivorous birds and three, at Turnhouse it provides a source of revenue by being sold for making silage. It is, nevertheless, possible to overcome these.

The Turnhouse bird problem is primarily an autumn and winter one, so it is suggested that grass-cutting for silage can be continued as usual except that it should cease in sufficient time to allow the grass to reach the desired height of nine inches. In this way little revenue would be lost. The fire hazard is much less of a risk than it is said to be by opponents of the long-grass system, provided the grass is not allowed to grow long right up to the edge of the runway. The only likelihood of a grass fire occurring is through carelessness on the part of airport personnel or from an aircraft crashing and leaving the runway, in which case there could well be a fire anyway. Finally the problem of seeding grass attracting small birds may or may not arise but the possibility of doing so can be obviated by using a monoculture of an asexually reproducing grass. Long-grass trials at other British

airfields have not been in existence long enough to evaluate the results, but according to Wright (1968) the initial findings have been satisfactory. It would seem to be well worth attempting at Turnhouse.

Agricultural operations, which take place periodically in the fields bounding the airport, are a major attraction for a large number of gulls. Ploughing, which provides the most prolific food source, is the chief one. Because of this, they do unquestionably have a hazard potential. It would only require a large flock following a plough to be scared sufficiently badly to rise en masse into the air and fly into the path of an aircraft on final approach to cause a disaster. On the other hand this has never happened yet and by providing an alternative attraction outside the confines of the airfield the gulls are kept clear of the immediate vicinity of aircraft, though far more are present than would be the case were no ploughing being done.

It is not possible to say for certain whether the one situation is better than the other, but on balance the risk to aircraft from birds following tractors outwith the airfield seems, from observations made, to be very small. Thus the advantages accruing from having such a counter-attraction to the airfield probably outweigh the attendant risk of having more gulls in the neighbourhood.

SECTION 2. LONG-TERM MEASURES

The short-term improvements mentioned have all been aimed largely at gulls and other birds which sit on the airfield. This is because there is

no short-term measure to deal with over flying birds, with the possible exception of trying to condition them, by means of shooting, to fly round the airfield instead of over it. However this is not really desirable, even if it were possible to do, as it could result in more birds flying across the runway approach-paths, no less dangerous a situation than having them flying over the airfield.

2.1. The problems

The title of this section does not preface a lengthy recapitulation of all that has been written so far.. Turnhouse Airport is in what is probably a unique position, in that it is very shortly to acquire a radar installation and a new runway is planned for the not too distant future, together with new terminal buildings. Hence any consideration of possible long-term measures to counteract the bird-hazard must take these facts into account.

The acquisition of radar presents no problems. Rather the reverse, for as will be suggested later (p. 115) it may be possible to make use of it to forecast bird-movements or at least warn of their approach. The proposed new runway however, will lie in such a direction the the final approach path to it from the northern end will bring aircraft directly over Cramond Island and Drum Sands, straight up the flight-line used by gulls which roost there. This has obvious implications, and makes the finding of some way to mitigate the hazard from these birds all the more urgent.

Other factors which have a bearing on the gull problem are the future patterns of waste-disposal, for both sewage and refuse. These are dealt with

TABLE 8

Gull Numbers at Drum Sands, Cramond

Date	Time	Tide State	Number of Gulls
5 Jul. 1968	1015	Full	50
23 Aug. 1968	1300		625
2 Aug. 1969	0930	$\frac{3}{4}$	905
16 Aug. 1968	1010		750
4 Oct. 1968	1430		670
17 Jan. 1969	1100	$\frac{1}{2}$	225
24 Jan. 1969	1120		440
30 Jan. 1969	1000		165
22 Jul. 1968	1715	$\frac{1}{4}$	750
6 Sep. 1968	1000		4180
27 Sep. 1968	1045		1175
22 Nov. 1968	1125		1005
7 Feb. 1969	1000		3630
21 Feb. 1969	1020		4000
29 Oct. 1968	1600	Ebb	1500*

* This observation was made from the east side of Cramond breakwater, from which it was not possible to see how many gulls there were to the west. As the west side is the preferred roosting area this count is much lower than it would have been had all the birds been visible. Table 9 shows the rate per minute at which birds were arriving at the west side of the breakwater.

TABLE 9

Rate Gulls per Minute	Time Hours GMT
150	1545
250	1615
250	1630
360	1640
19	1655

These rates were obtained by taking the average number of gulls counted over a period of five minutes prior to the time given in the table.

in 2.4. on p. 117,

The problem, then, is mainly one of finding means of removing or otherwise controlling the large gull roost at Drum Sands. Other factors and measures for dealing with them are of secondary importance to this.

2.2. The Drum Sands roost

Observations at this roost showed that it is used not only by gulls which feed inland during the day but also to a lesser extent by others which flight in from feeding grounds further down the Forth. The tidal mud-flats, extending to approximately 7 sq km (2,430 acres) are used as a feeding area by large numbers of gulls during the day when they are uncovered, as well as by concentrations of waders (Oystercatchers, Curlew, Redshank, Knot, Dunlin and others) and duck (Mallard, Shelduck). Rosebery Estates maintain the area west of the River Almond as an unscheduled bird-sanctuary where shooting and disturbance is prevented as far as possible.

Table 8 shows the numbers of gulls present at Drum Sands at different states of the tide during the autumn and winter of 1968/69. In addition, observations made on the evening of the 29th October, 1968 showed gulls pouring into roost between 1530 and 1700 hours at the rates shown in Table 9.

Note that in July numbers are comparatively small. During quarter tide in September and again in February numbers are very high, while in mid-winter they are lower; this may be attributable to the presence of passage birds at these times on their way south and north again respectively.

Although no estimate for the total numbers roosting was made on 29th October, on 7th March, 1969 a total of 16,000+ was estimated to be roosting on the water west of Cramond Island by 1730 hours. While some of these birds may have flown in from further east, by far the greater number came from inland.

The size of this roost - both the area it covers and the number of gulls using it - make the task of finding suitable means to remove or reduce it a formidable one. The fact that the greater part of the birds are almost certainly winter immigrants and not locally-bred only adds to the difficulties: the percentage composition of the population using the Drum Sands area during the day is as follows:

<u>Greater Black-backed gull</u>	<u>Lesser Black-backed gull</u>	<u>Herring gull</u>	<u>Common gull</u>	<u>Black-headed gull</u>
1.2	0.5	29.8	6.4	62.1

These figures were obtained from eleven counts made during the day at different times and seasons and are thought to be reasonably representative.

This composition may or may not differ slightly at night but is nevertheless enough to show that Black-headed gulls make up nearly two-thirds of the gulls present. In a roost of 16,000 birds there would thus be 10,600 Black-headed gulls, or about 7,800 more than the total adult breeding population in the study area. This example demonstrates reasonably convincingly that many immigrants are present. The Great Black-backed and Common gulls are also immigrants, as these species breed sparsely or not at all in the Forth region. The majority of Herring gulls are, from what has been stated elsewhere (p. 64

et seq.) most likely to have been bred in the Forth. From all this, it is reasonable to deduce that a programme of controlled culling at colonies would not have a sufficiently far-reaching effect on the numbers of gulls at this roost, even if results could be guaranteed, which is unlikely (Thomas, 1969).

It is just conceivable that a more direct approach to the problem, a poisoning campaign similar to that tried at Southern Black-headed gull colonies in New Zealand (Caithness, 1968), might work. Even if it succeeded in greatly reducing the gull population however, there are high attendant risks of killing many birds of other species and probably also domestic pets, both of which are undesirable prospects. It is moreover questionable whether such wholesale slaughter is morally allowable, and the public outcry which would be raised would be entirely justifiable. Alteration of the habitat is thus the sole means left of accomplishing the task, short of the discovery of some altogether new way of repelling gulls.

Saul (1967) describes the provision of artificial roosts for gulls and waders to keep them away from Auckland Airport in New Zealand. The circumstances were somewhat different, but the results achieved were good and the principle of providing an artificial roost in place of a natural one - which was in fact on the new airfield - sound conservation practice. To carry through a similar undertaking at Drum Sands would be a much larger project, but in principle would be perfectly possible. In essence all that is required would be to reclaim Drum Sands from the sea, the land from which could undoubtedly be put to good use, and to provide an artificial alternative roost, attractive to gulls, at a place far enough up or down the coast to ensure the

flight-lines of gulls using it would be well clear of Turnhouse Airport.

The attractive sea-front at Cramond would be altered, but with skilful landscaping need not be changed for the worse. The only alternative would be to dredge the mud-flats to a depth whereby the feeding attraction of the area would be eliminated, but this might well be more costly and lacks the benefit of acquiring land as would be the case with reclamation. There is no certainty that the gulls would not continue to roost on the water either, with this second scheme.

There is little to be gained from going further into how these objectives could be reached at this stage. The proposal is entirely theoretical at present and a good deal of research into the roosting behaviour of the gulls is still required before any commitment could be made. The advice of engineers as to the feasibility of reclaiming the flats and constructing an artificial roost would also have to be sought before any firm decision could be taken. Nevertheless, it is believed that this or a similar scheme will be necessary if reasonable freedom from the bird-hazard is to be achieved at Turnhouse.

2.3. Radar and bird forecasts

The installation of radar facilities at Turnhouse, besides making the control of air traffic easier, will also provide an opportunity for more exact observation of gull movements. Dr. W.R.P. Bourne (pers. comm.) states that a certain amount of bird movement can be seen even on G.C.A. radar at Heathrow (London) Airport, so presumably this will be possible at Turnhouse.

Bird forecasting by using radar was mentioned on p. 19. This is a logical measure already adopted in Canada and in use for migration warnings in Europe too. It should be an easy step from this to forecasting local movements and perhaps even to fitting aircraft movements into the birds' "traffic patterns". Sufficient research has already been done on the use of radar in ornithology for advice to be available on how to use it to best effect.

It is possible that a radar of suitable type, located in the most advantageous place for viewing bird-movements and used to keep aircraft clear of them, would provide an adequate safeguard against bird-strikes. If this were so, it would certainly be more economic than altering the environment at Drum Sands. However specialist advice would be required about this as there may be severe limitations imposed by bad weather, such as low cloud and rain, which would render such a radar temporarily useless at times of mass bird movements.

Researches by Tanner (1966, 1967, 1968 and pers. comm.) into the effects of microwaves on birds were published in garbled form by the press in 1969, leading to speculation concerning the possibility of an airborne method of deflecting birds from the path of an aircraft, using an adapted version of the aircraft's own radar set. However the actual situation is far less advanced than this, and while it is to be hoped that Tanner's work may lead to the production of such a device, it is unlikely to do so in the immediate future.

2.4. Waste disposal

The effect of waste disposal practices on aircraft operating at Turnhouse is at present confined to the marginal danger sometimes occurring from Herring gulls soaring over Hailes Quarry rubbish dump. Two engine-changes necessary on a Lightning fighter aircraft from Leuchars (Fife), which struck "a large gull" while on approach to the main runway when carrying out a practice diversion to Turnhouse may have been caused by a gull from there. However the Quarry is three miles from the end of the runway and most aircraft are flying high enough at this point to avoid any possibility of collision with these birds.

A proposal by Edinburgh Corporation Cleansing Department to establish a new rubbish dump at Braehead Quarry, north-east of the airfield near Lennie Park, half-a-mile from the end of the 08/26 runway, would have been a major hazard. Soaring birds would have been directly in line with the final approach-path and others would probably have utilised the airfield as a resting area. Fortunately this proposal came to light during the course of investigations for this study and was pointed out to the Board of Trade. Discussions between these two authorities resulted in a decision not to dump refuse at this site. In fact by 1971 Edinburgh should have an incinerator in operation which will consume all the refuse collected in the city, Hailes Quarry having been filled and closed down. Thus there will soon be no open refuse tip close enough to Turnhouse to attract gulls and so constitute a hazard. The West Lothian County Council tip at South Queensferry is only used for non-edible rubbish and no gulls are found there.

The sewage treatment plant at Hallyards, approximately $1\frac{1}{2}$ miles west of Turnhouse, is of a type which does not attract gulls so presents no problem. The sewer outlet off the north end of Cramond Island may be an additional attraction to the Drum Sands area, but it is doubtful whether closing it would significantly reduce the number of gulls there. Other Edinburgh sewer outlets - which between them contribute about 50% of all sewage emptied into the Forth - are not connected with the bird hazard at Turnhouse, except possibly indirectly because they provide part of the food-source necessary to support a large winter gull population. This, as was postulated in Part II, may be part of the reason why gulls are increasing so rapidly at this time.

Plant for primary treatment of sewage is to be installed at Edinburgh about 1975. It will settle out about 50% of the solid matter in the city's sewage and this will then be shipped to the mouth of the Firth of Forth and dumped. A new liquid-sewage pipe will carry the remaining solids - in - suspension and liquid about a mile out to sea to the east of Leith Docks. Secondary treatment (activated sludge) is proposed for the 1980s.

The effect of the treatment of sewage and the closure of Hailes Quarry rubbish dump on the gull population could lead to a reduction in winter population or to a change in habits. The latter seems more probable, as it has already been noticed in Leicestershire by Hickling (1969), where closure of open tips has already occurred, but the true answer must await the event.

2.5. Gulls as pests: general trends

A recent discussion, organised by the Seabird Group and held in Durham in April this year, reviewed the problem of gulls as pests. The conclusions reached were not really in advance of anything which has been written or quoted here, underlining the fact that while it is easy to point out the problems involved, there is as yet no satisfactory solution to them.

It is known that all the common species of gulls are increasing with great rapidity. A considerable amount has been learned about them, but if effective means of controlling them are to be found then there is much more to be discovered. Besides being the major hazard-species where aircraft are concerned - half the reported bird-strikes in Britain involve gulls (Brough, 1969) - they are also possible vectors of salmonellosis, probably because of their predilection for refuse and offal. This is a matter of some concern to water-boards because of the danger of pollution of reservoirs with Salmonella types. Gulls also have other noisome habits; they carry away offal and muck from rubbish dumps, meat-works and glue-works and drop it in nearby streets and gardens, bringing complaints from residents in the district to sanitary and cleansing departments. There is also a disturbing tendency to nest on house roofs in some countries and this could become an unmitigated nuisance should the habit spread. There is too, strong evidence that they cause terns to desert their colonies (Crowell and Crowell, 1946).

Clearly a greater degree of organisation is required on the part of ornithologists if enough is to become known about gulls for some plan to be formulated on how to deal with them. At present knowledge is lagging behind,

while the demand for help from different quarters is increasing as gulls increase. Arguments as to whether gulls are "friend or foe" continue, on the one hand there are those who find them attractive and wish them to remain protected, on the other those who, while they may also appreciate their aesthetic appeal, realise that some species at least are a pest and wish to control them. Either way it would be progress if co-operative efforts to learn more about gulls were to be undertaken, otherwise there is a danger that the increasing pressure for "something to be done" about gulls which are pests will result in decisions on the course of action to be taken passing out of the hands of competent and conservation-minded people. This could well lead to needless slaughter, carried out in the wrong way for the wrong reasons and achieving little. If conservation - in the best sense - is to flourish, then its protagonists must show that they can and are willing to help solve wildlife management problems.

SECTION 3. CONCLUSION

The tenor of Part III has been kept fairly general, deliberately, because while it is possible to suggest means of alleviating the bird hazard at Turnhouse, based on the results obtained from this study, their implementation is entirely in the hands of the relevant authorities. Whether or not they wish to do so, or should do so, is not the concern of this work. If, however, it is proposed that some of them should be taken up, then it will be a prerequisite that further research should be done first, to ascertain more precisely than was possible here exactly what is required. Hence there was little sense at this

Plate 5a Halls Quarry refuse tip. The group of gulls to the left of the picture are resting while those on the right are feeding on recently-dumped rubbish. Some can be seen in transit between the two groups.



stage in trying to present a set of clear-cut plans. It is hoped that sufficient detail has been given to show the direction to be followed should this happen.

(01. 1 999) Revised and submitted to the President

Factor	1 factor	2 factors	3 factors	4 factors	5 factors
R	-	1	1	1	0000
R1	-	1	1	1	0010
R2	-	1	1	1	0020
R3	-	1	1	1	0030
R4	-	1	1	1	0040
R5	-	1	1	1	0050
R6	-	1	1	1	0060
R7	-	1	1	1	0070
R8	-	1	1	1	0080
R9	-	1	1	1	0090
R10	-	1	1	1	0100
R11	-	1	1	1	0110
R12	-	1	1	1	0120
R13	-	1	1	1	0130
R14	-	1	1	1	0140
R15	-	1	1	1	0150
R16	-	1	1	1	0160
R17	-	1	1	1	0170
R18	-	1	1	1	0180
R19	-	1	1	1	0190
R20	-	1	1	1	0200

APPENDIX I(1)

Let the following be the number of factors in the set of factors. Let the following be the number of factors in the set of factors. Let the following be the number of factors in the set of factors.

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APPENDIX I(i)

Observations at Turnhouse per Period (see p. 79)

Hour	Period A	Period B	Period C	Total
0300	4	1	-	5
0400	9	4	-	13
0500	10	5	-	15
0600	15	6	2	23
0700	13	6	7	26
0800	11	6	7	24
0900	5	1	3	9
1000	2	-	-	2
1100	2	-	-	2
1200	1	1	2	4
1300	1	-	4	5
1400	1	1	5	7
1500	2	2	8	12
1600	4	4	9	17
1700	8	7	4	19
1800	9	6	-	15
1900	9	5	-	14
2000	7	1	-	8
Total	113	56	51	220

The above table shows the number of hour's observations per hour per Period made at Turnhouse. The Grand Total hours watched is also given.

Each hour covers the hour following it, e.g. 0300 covers 0300 to 0359 G.M.T.

Annual Report of the Government of India for the year 1965-66

Year	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021																																											
0001	0001	0002	0003	0004	0005	0006	0007	0008	0009	0010	0011	0012	0013	0014	0015	0016	0017	0018	0019	0020	0021	0022	0023	0024	0025	0026	0027	0028	0029	0030	0031	0032	0033	0034	0035	0036	0037	0038	0039	0040	0041	0042	0043	0044	0045	0046	0047	0048	0049	0050	0051	0052	0053	0054	0055	0056	0057	0058	0059	0060	0061	0062	0063	0064	0065	0066	0067	0068	0069	0070	0071	0072	0073	0074	0075	0076	0077	0078	0079	0080	0081	0082	0083	0084	0085	0086	0087	0088	0089	0090	0091	0092	0093	0094	0095	0096	0097	0098	0099	0100
0001	0002	0003	0004	0005	0006	0007	0008	0009	0010	0011	0012	0013	0014	0015	0016	0017	0018	0019	0020	0021	0022	0023	0024	0025	0026	0027	0028	0029	0030	0031	0032	0033	0034	0035	0036	0037	0038	0039	0040	0041	0042	0043	0044	0045	0046	0047	0048	0049	0050	0051	0052	0053	0054	0055	0056	0057	0058	0059	0060	0061	0062	0063	0064	0065	0066	0067	0068	0069	0070	0071	0072	0073	0074	0075	0076	0077	0078	0079	0080	0081	0082	0083	0084	0085	0086	0087	0088	0089	0090	0091	0092	0093	0094	0095	0096	0097	0098	0099	0100	

APPENDIX I (A)

APPENDIX I(ii)

Observations of Gulls Flying over Turnhouse by Hour and Month

Hour	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
0300					0 22	0	12		0	
0400				0	0 10 40 0	0	5 25 2101	146 100	0	
0500				7 11	34 202 42 0	0	43 25	500 95 125	100 5950	
0600	0		652 25 103	37 3	65 5 51 0 12	200 93 151	39 16 55	81 183 764	400 839 1239	
0700	540 1556 96	68 11	151 16 56 85	14 3	4 13 9 1	0 4 2	89 2	26 77 34 7	8 22	
0800	5108 2531 3470	27 904	820 30 25 0	4 2	0 20	2 0 6	1 1	96 0 24 3	0 133	
0900	40 440	178	21	0	12 0	1			0	
1000			1		4					
1100		0			1					
1200		80 16	0			0				
1300	500	0 26	0		1					
1400	34 0	0 11	0		6					113

(cond.)

Hour	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
1500	3000 1440 184 4320	3 57	103 200		3 1			12		391
1600	1800 128 196	3670 780 35	1975 500 780		2 93	0	3	1 500	377	629
1700	96	66	3022 4000 40	5	11 77 20 1	0	6 0	0 0 293 24	209 3542	
1800			6	0	35 45 0 5	20	5 0	0 254 532 429	285 462	
1900				3	0 0 1	27 30 29	3 0	43 94 181 371	191	
2000					9 1	84 65 150	2 151	75		
Total	25479	5932	12711	89	857	865	2583	7121	13757	1133
No. of Observations	20	18	25	13	43	26	21	33	18	3
Mean	1274	330	508	7	20	33	123	216	653	378

The above data shows the actual numbers of gulls which were counted during watches carried out at Turnhouse. They refer only to gulls overflying the airfield. The mean given at the foot of each column is the mean number of gulls/hour/month, obtained by dividing the total number of gulls observed in each month by the total number of hours watched during that month. Each hour listed covers the hour from e.g. 0900 to 0959. Times are G.M.T.

APPENDIX I(111)

Observations of gulls sitting at Turnhouse by Hour and Month

Hour	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
0300					0 20	0	20		0	
0400				0	0 10 53 0	0	4 20	115 100 2000	0	
0500			250	110 0	9 182 100 0	0	37 25	250 71 142	100 1500	
0600	0		5 65	24 0	61 8 44 13	200 90 94	50 33	250 131 400	830	
0700	1 410 0	0 0	15 40	35 0	60 18 0 12	200 90 12	80 33	25 126 23 650	400 830	
0800	40 400 1050	20 0	0 10 10	20 60	4 140	200 90 6	10 33	121 580 36 430	400 950	
0900	500 720	100	5	0	12 2	0			350	
1000					12					
1100		285			12					75
1200		160 82	170		12					
1300	355	81 225	20	0						
1400	156 1435	46 175	20		45					500

(cond.)

Hour	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
1500	522	0	40 0		86 55			1050		500
1600	72 0	10 1000	200 10		1 110	138	3	50 586	1055	105
1700		0	7	0	0 30 0 0	140	45 42	150 360 299 450	555 405	
1800			0	0	0 20 0 0	138	17 41	85 355 300	203 150	
1900				0	20 0 0	111 30 7	80 170	97 75 20 180	0	
2000					0 0	20 95 125	83 170	57		
2100							83			

Numbers of gulls sitting on or near Turnhouse airfield during different hours of day throughout the year 1968-69.

Each hour covers a period of 60 minutes, thus 0700 includes all observations made between 0700 and 0759.

Special Provisions Applicable to Single to Multiple
Residences and Bed-rooms

Table 1

Room	Area	Volume	Notes	Area
BR	CS	8		BR
BR	TRC	2		BR
	TRT			BR

BR	OT	1		BR
	OT	2		BR
	OT	3		BR
	OT	4		BR
	OT	5		BR

APPENDIX I (IV)

BR	OT	1		BR
	OT	2		BR
	OT	3		BR
	OT	4		BR
	OT	5		BR

Room	Area	Volume	Notes	Area
BR	CS	8		BR
BR	TRC	2		BR
	TRT			BR
	OT	1		BR
	OT	2		BR
	OT	3		BR
	OT	4		BR
	OT	5		BR

Room	Area	Volume	Notes	Area
BR	CS	8		BR
BR	TRC	2		BR
	TRT			BR
	OT	1		BR
	OT	2		BR
	OT	3		BR
	OT	4		BR
	OT	5		BR

APPENDIX I(iv)

Heights of Flight of Gulls Flying over Turnhouse Airport,
with Dates and Percentages

1. MORNING

Date	0-49 ft	50-99 ft	100-199 ft	200-299 ft	Over 300 ft
3 Feb		8			
7	4	8	23		
6 Mar		3	317		250
8					18
14	4		131	4	

19			6		
19 Apr		1	10		
26	15	3	2		
3 May	4	74	5	1	
10	21	10	2		
16	2	11	80		
24		1			
14 Jun		1			
21	3	4			
28			5		
5 Jul	7	13	3		

19			9		
2 Aug		1	1		
16	6	14	38		
23	16	21	18		
30	1	69	2		
6 Sep		7			
27	4	17	3	1	
<u>1969</u>					
17 Jan		237	2185	474	32
24	370	338	8		
7 Feb			7	19	
=====					
Total	52	122	122	1	0
(Summer)					
%	17.51	41.08	41.08	0.33	0.00
=====					
Total	405	723	2733	498	300
(Winter)					
%	8.69	15.52	58.66	10.69	6.44

(cond.)

2. EVENING

Date	0-49 ft	50-99 ft	100-199 ft	200-299 ft	Over 300 ft
25 Apr	8				
2 May		5	31	1	
9	4	49	1		
15	4	9			
23	2	3	1		
6 Jun	1				
27		19	24		
4 Jul	3	3	1		
18	3	2	13		

1 Aug	15	4		1	1
15		1	48	2	
22	4	12	5		
29	5	242	68	1	
5 Sep	30	98	396		
26	1	19	209	1736	1124
4 Oct	4	382	138	30	68
11 Nov				87	4
<u>1969</u>					
16 Jan			676	816	604
23	2	24	235	33	
29	2		185		
6 Feb		146	719	660	63
7 Mar		50	636	86	

Total (Summer)	25	90	71	1	0
%	13.37	48.13	37.97	0.53	0.00

Total (Winter)	63	978	3315	3452	1864
%	0.65	10.11	34.28	35.69	19.27

Note The dotted lines indicate the arbitrary division of the year into summer and winter for the purpose of investigating whether there was a difference in flight heights according to season.

REPORT OF EXAMINATION OF THE RECORDS OF THE

OFFICE OF THE SECRETARY OF DEFENSE

Serial	Date	Time	Place	Subject	Remarks	Disposition			
51	7	57	Y	1	58	7	1	0	0010
52	5	02	ME	122	123.5	04	4	04	0020
53	5	50	PH	1	101	1007	0	101.4	0030
54	4	04	PH	2	575.1	012	1	101.5	0040
55	2	07:45	08	0	004	08	01	101	0050
56	1	00:15	001	0	0000	002	0	000.5	0060
57	1	00:15	002	0	000	002	0	000.5	0070
58	1	1	0	0	0	0	0	0	0080
59	1	0	08	0	002	0	0	0	0090
60	1	0	08	0	002	0	0	0	0100
61	1	0	08	0	002	0	0	0	0110
62	1	0	08	0	002	0	0	0	0120
63	1	0	08	0	002	0	0	0	0130
64	1	0	08	0	002	0	0	0	0140
65	1	0	08	0	002	0	0	0	0150
66	1	0	08	0	002	0	0	0	0160
67	1	0	08	0	002	0	0	0	0170
68	1	0	08	0	002	0	0	0	0180
69	1	0	08	0	002	0	0	0	0190
70	1	0	08	0	002	0	0	0	0200
71	1	0	08	0	002	0	0	0	0210
72	1	0	08	0	002	0	0	0	0220
73	1	0	08	0	002	0	0	0	0230
74	1	0	08	0	002	0	0	0	0240
75	1	0	08	0	002	0	0	0	0250
76	1	0	08	0	002	0	0	0	0260
77	1	0	08	0	002	0	0	0	0270
78	1	0	08	0	002	0	0	0	0280
79	1	0	08	0	002	0	0	0	0290
80	1	0	08	0	002	0	0	0	0300

APPENDIX IV

Serial	Date	Time	Place	Subject	Remarks	Disposition
81	1	0	08	0	002	0
82	1	0	08	0	002	0
83	1	0	08	0	002	0
84	1	0	08	0	002	0
85	1	0	08	0	002	0
86	1	0	08	0	002	0
87	1	0	08	0	002	0
88	1	0	08	0	002	0
89	1	0	08	0	002	0
90	1	0	08	0	002	0
91	1	0	08	0	002	0
92	1	0	08	0	002	0
93	1	0	08	0	002	0
94	1	0	08	0	002	0
95	1	0	08	0	002	0
96	1	0	08	0	002	0
97	1	0	08	0	002	0
98	1	0	08	0	002	0
99	1	0	08	0	002	0
100	1	0	08	0	002	0

Classification of records is to remain under original category unless + valid reason.

Approved by: [Signature]

Approved by: [Signature]

Approved by: [Signature]

APPENDIX I(v)

Numbers of Gulls Overflying Turnhouse in relation
to Different States of Tide

Hour	Tide $\frac{3}{4}$ -F	Obs.	Mean	Tide $\frac{1}{3}$ - $\frac{2}{3}$	Obs.	Mean	Tide $\frac{1}{4}$ -E	Obs.	Mean
0300	0	1	0	22	3	7	12	1	12
0400	40	4	10	2,357	6	393	30	2	15
0500	6,151	6	1,025	781	7	111	202	3	67
0600	2,037	7	379	1,572	9	175	98	4	25
0700	854	10	85	158	6	26	1,878	9	209
0800	2,636	8	329	4,560	6	760	6,009	7	858
0900				492	5	98	200	4	50
1000							4	1	4
1100				0	1	0	1	1	1
1200				96	4	24	0	1	0
1300	500	1	500	27	2	14	0	1	0
1400	113	2	57	40	3	13	11	2	6
1500	404	3	135	4,745	7	678	257	2	129
1600	4,955	6	826	5,231	8	654	503	2	252
1700	3,703	7	529	7,535	9	837	78	2	39
1800	1,206	8	151	817	5	163	50	2	25
1900	508	3	169	89	6	15	376	5	75
2000	228	3	76	309	5	62			
Total	23,335	69	//////	28,831	92	//////	9,709	49	////

Total Gulls + total observations gave means of 338, 313 and 198 respectively for the three states of tide.

Note Only the three-quarters to full and quarter to ebb states were used when calculating the effect of time and tide on the number of gulls at Turnhouse.

Year	1957	1958	1959	1960	1961	1962	1963	1964
Population	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000
Area	100	100	100	100	100	100	100	100
Income	100	100	100	100	100	100	100	100
Production	100	100	100	100	100	100	100	100
Consumption	100	100	100	100	100	100	100	100
Investment	100	100	100	100	100	100	100	100
Government	100	100	100	100	100	100	100	100
Private	100	100	100	100	100	100	100	100
Foreign	100	100	100	100	100	100	100	100

1. The first part of the report is devoted to a general survey of the economic situation in the country. It deals with the main trends of economic development, the role of the state, and the achievements of the people's economy.

2. The second part of the report is devoted to a detailed analysis of the economic situation in the country. It deals with the main trends of economic development, the role of the state, and the achievements of the people's economy.

3. The third part of the report is devoted to a detailed analysis of the economic situation in the country. It deals with the main trends of economic development, the role of the state, and the achievements of the people's economy.

4. The fourth part of the report is devoted to a detailed analysis of the economic situation in the country. It deals with the main trends of economic development, the role of the state, and the achievements of the people's economy.

5. The fifth part of the report is devoted to a detailed analysis of the economic situation in the country. It deals with the main trends of economic development, the role of the state, and the achievements of the people's economy.

6. The sixth part of the report is devoted to a detailed analysis of the economic situation in the country. It deals with the main trends of economic development, the role of the state, and the achievements of the people's economy.

7. The seventh part of the report is devoted to a detailed analysis of the economic situation in the country. It deals with the main trends of economic development, the role of the state, and the achievements of the people's economy.

8. The eighth part of the report is devoted to a detailed analysis of the economic situation in the country. It deals with the main trends of economic development, the role of the state, and the achievements of the people's economy.

APPENDIX I (VI)

The report is divided into two main parts. The first part is devoted to a general survey of the economic situation in the country. It deals with the main trends of economic development, the role of the state, and the achievements of the people's economy.

The second part of the report is devoted to a detailed analysis of the economic situation in the country. It deals with the main trends of economic development, the role of the state, and the achievements of the people's economy.

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APPENDIX I(vi)

Actual and Average Numbers of Gulls at Turnhouse throughout
the Period of Study, with Weather Data

All weather data is the mean for the day in question. An asterisk by the date indicates that that observation was made by the Air Traffic Control Officers at Turnhouse.

State of ground code

- 0 Surface of ground dry.
- 1 Surface of ground moist.
- 2 Surface of ground wet, standing water on surface.
- 3 Surface of ground frozen.
- 4 Glaze on ground but no snow or melting snow.
- 5 Ice, snow or melting snow covering less than one half of ground.
- 6 Ice, snow or melting snow covering more than one half of ground.
- 7 Ice, snow or melting snow covering ground completely.

Note Numbers 0 to 3 apply to representative bare ground, 4 to 7 an open representative area. The highest code figure applicable is used.

Date	Numbers of Gulls				Rainfall m.m.	State of Ground (see code)	Mean Temperature °C	Mean Wind kt.
	Overflying		Sitting					
	Actual	Average	Actual	Average				
'69 Jan 5			500	500*	1.0	5	.5	5
11			120*	120*	.2	1	.5	5
14			50*	50*	7.3	1	5.5	2
16	4800	2400	522	261	0.5	1	4.0	8
16*			98*	98*	0.5	1	4.0	8
17	5244	1748	500	167	2.9	3	.5	12

Date	Numbers of Gulls				Rainfall m.m.	State of Ground (see code)	Mean Temperature °C	Mean Wind kt.
	Overflying		Sitting					
	Actual	Average	Actual	Average				
'68 May 14*			-*	-*	8.5	1	11.0	6
15	129	18	110	16	4.1	2	9.5	10
15*			50*	50*	4.1	2	9.5	10
16	164	27	100	17	4.1	1	9.0	6
16*			56*	56*	4.1	1	9.0	6
17*			12*	12*	-	1	9.0	5
18*			50*	50*	-	1	10.0	5
19*			9*	9*	-	1	9.0	4
20*			5*	5*	-	1	11.0	6
21*			13*	13*	-	0	8.5	7
23	8	2	-	-	-	0	9.5	7
23*			50*	50*	-	0	9.5	7
24	1	-	12	3	-	0	12.5	12
26*			50*	50*	2.3	1	9.5	10
'68 Jun 7*			*	-*	-	1	13.0	12
9*			-*	-*	-	0	16.5	6
10*			-*	-*	-	0	18.5	8
12*			23*	23*	4.6	0	14.5	5
13	131	26	200	40	-	0	18.5	6
13*			4*	4*	-	0	18.5	6
14	202	34	202	34	-	0	16.0	5
14*			5*	5*	-	0	16.0	5
15*			50*	50*	-	0	13.5	11
17*			5*	5*	-	0	15.5	5
18*			-*	-*	-	0	18.0	7
20	95	48	95	48	5.2	1	14.0	9
21	97	24	90	22	.2	1	14.5	14
21*			50*	50*	.2	1	14.5	14
24*			20*	20*	2.9	1	14.0	13
25*			35*	35*	2.5	1	15.5	10

	27	179	90	125	63		1	15.0	5
	27*			-*	-*		1	15.0	5
	28	160	27	103	17		1	13.5	7
	28*			-*	-*		1	13.5	7
	30*			-*	-*		0	20.5	15
'68 Jul	1*			25*	25*	18.8	1	18.0	5
	2*			165*	165*	15.5	1	14.0	7
	4	10	3	80	27		1	13.5	17
	4*			50*	50*		1	13.5	17
	5	177	35	80	16		1	14.0	9
	5*			12*	12*		1	14.0	9
	6*			7*	7*		0	14.5	5
	8*			5*	5*	4.7	0	14.0	8
	10*	209	108	50*	50*	8.6	1	13.0	8
	11*	202	58	58*	58*	3.5	1	13.0	8
	13*			150*	150*	1.8	1	13.5	7
	14*			150*	150*	1.8	1	11.5	6
	15*	200	80	150*	150*	9.7	1	13.0	5
	16*			150*	150*	2.3	2	12.5	6
	17*	251	51	150*	150*		1	16.0	7
	18	160	32	170	35		0	15.0	6
	18*			170*	170*		0	15.0	6
	19	81	14	33	6	4.4	0	17.5	5
	19*			50*	50*	4.4	0	17.5	5
	21*	121	20	150*	150*		1	19.0	6
	25	-	-	42	42		1	16.5	5
	26*	201	154	75*	75*		1	15.0	5
	27*			70*	70*		1	17.0	5
	28*	278	140	150*	150*		0	15.5	9
	30*			50*	50*		0	16.5	4
'68 Aug	1	119	24	97	19		0	16.0	7
	1*			97*	97*		0	16.0	7
	2	122	61	95	48		0	17.5	5
	2*			5*	5*		0	17.5	5
	3*			50*	50*		0	17.0	6
	4*			500*	500*		0	16.5	5
	5*			50*	50*		0	16.0	6
	10*			25*	25*		0	18.0	5
	12*			50*	50*	1.3	0	16.5	5

'68 Sep	27	6944	1736	1500+	375	6.0	1	13.0	12
	27*			1500*	1500*	6.0	1	13.0	12
	29*			50*	50*	4.4	1	13.5	9
	30*			200*	200*	8.4	1	10.5	16
'68 Oct	5	1133	378	680	227	.9	1	13.0	3
	12*			50*	50*	1.2	1	13.0	23
	14*			50*	50*	.2	1	10.0	13
	15*			50*	50*	2.8	1	10.0	11
	17*			150*	150*	-	1	9.0	12
	20*			160*	160*	-	1	14.5	13
	23*			50*	50*	-	1	13.0	5
	26*			100*	100*	.4	1	12.0	3
	29*			150*	150*	3.4	1	11.5	14
'68 Nov	11	-		2760	2760	.1	1	9.0	6
	15*			500*	500*	-	1	5.0	11

APPENDIX IIGLOSSARY

AIRFIELD. The total area of Turnhouse Airport, or any other airport, excluding all buildings (but including runways).

AIRPORT. The total area of the airfield plus the terminal buildings.

APPROACH, FINAL APPROACH. The path followed by an aircraft intending to land after making the final turn aligning it with the runway on which it will land.

BIRD-STRIKE. The act of collision between a bird and an aircraft.

CIRCUIT. The procedural path to be followed by an aircraft circling an aerodrome preparatory to landing.

TRAFFIC PATTERN. The procedural pattern laid down for aircraft in flight to follow while under control from the ground.

VERY PISTOL. A pistol firing cartridges containing flares, usually red, white or green and normally used for signalling purposes. A modified version is used to fire shellcracker cartridges.

APPENDIX IIIScientific Names of Birds Mentioned in the Text

Laysan Albatross	<i>Diomedea immutabilis</i>
Black-footed Albatross	<i>Diomedea nigripes</i>
Frigate birds spp.	<i>Fregata</i> spp.
Storks spp.	<i>Ciconia</i> spp.
Whistling Swan	<i>Cygnus columbianus</i>
Mallard	<i>Anas platyrhynchos</i>
Gre geese spp.	<i>Anser</i> spp.
Moorhen	<i>Gallinula chloropus</i>
Oystercatcher	<i>Haematopus ostralegus</i>
Lapwing	<i>Vanellus vanellus</i>
Golden Plover	<i>Charadrius apricarius</i>
Great Black-backed Gull	<i>Larus marinus</i>
Lesser Black-backed Gull	<i>Larus fuscus</i>
Herring Gull	<i>Larus argentatus</i>
Common Gull	<i>Larus canus</i>
Glaucous Gull	<i>Larus hyperboreus</i>
Black-headed Gull	<i>Larus ridibundus</i>
Terns spp.	<i>Sterna</i> spp.
Woodpigeon	<i>Columba palumbus</i>
Carriion Crow	<i>Corvus corone</i>
Rook	<i>Corvus frugilegus</i>
Jackdaw	<i>Corvus monedula</i>
Crows spp. (corvids)	<i>Corvus</i> spp.
Starling	<i>Sturnus vulgaris</i>

APPENDIX IVList of Birds Seen at Turnhouse, their Status
and their Hazard Potential

The following list comprises observations made from the control-tower and elsewhere on the airfield during the period from 1st February, 1968 to 31st March, 1969. Because gulls were of prime interest, little time was spent in observing other species in detail. However the hazard potential is indicated approximately as shown:

A = High hazard potential; B = moderate hazard; C = low hazard and
D = negligible hazard.

Large birds were easier to spot and identify from the control-tower and there are therefore almost certainly some small passerines, omitted from this list, which do in fact frequent the airfield.

- FULMAR Fulmarus glacialis. One seen once, during a rainstorm when visibility was about 50 yards, on 15th May, 1968 at 1858 hours. D
- MALLARD Anas platyrhynchos. One or two pairs frequented the Gogar Burn and probably nested. Occasionally seen flying over. D
- TEAL Anas crecca. Single birds and pairs noted infrequently. D
- PINTAIL Anas acuta. A single duck flying past the control-tower on 28th June, may have been of this species. D
- GREY GEESE spp. Anser spp. Migrating flocks, usually flying above 1,500 feet, were seen in spring and autumn. C
- KESTREL Falco tinnunculus. One or two often seen hunting over and around the airfield. D
- PARTRIDGE Perdix perdix. Pairs seen occasionally in summer on the south side of the airfield. D
- PHEASANT Phasianus colchicus. Single birds and pairs sometimes seen on the periphery of the airfield. D
- MOORHEN Gallinula chloropus. One or two pairs usually to be found near the Gogar Burn. Probably nested there. D
- OYSTERCATCHER Haematopus ostralegus. Flocks of up to 100 sometimes present, but 20-40 more usual. Less in evidence in summer. B

- LAPWING Vanellus vanellus. Flocks of 200 and more were not unusual in spring and autumn, but they did not often remain long. B
- GOLDEN PLOVER Charadrius apricarius. Often associated with flocks of Lapwing in spring and autumn. B
- CURLEW Numenius arquata. Occasionally seen flying over. D
- REDSHANK Tringa totanus. Not often seen but sometimes a flock would arrive along with Oystercatchers. C
- DUNLIN Calidris alpina. Occasional flocks seen in the distance. D
- GREAT BLACK-BACKED GULL Larus marinus. Infrequently recorded. Never seen sitting on the airfield. C
- LESSER BLACK-BACKED GULL Larus fuscus. Usually one or two amongst flocks of other gulls which flew over. Sometimes seen near the airport buildings. C
- HERRING GULL Larus argentatus. See text. A
- COMMON GULL Larus canus. See text. A
- BLACK-HEADED GULL Larus ridibundus. See text. A
- WOODPIGEON Columba palumbus. Irregular, but flocks flying over on migration in spring and autumn were frequent and large enough (often over 100) to be hazardous. B
- TAWNY OWL Strix aluco. Regular, but probably only one or two pairs in the vicinity. D
- SWIFT Apus apus. Often seen in the distance and frequently in May round airport buildings, but never more than 20-30. D
- SKYLARK Alauda arvensis. Several most probably nested on or near the airfield. D
- SWALLOW Hirundo rustica. Often seen in summer. D
- HOUSE MARTIN Delichon urbica. Occasionally seen, especially in late summer. D
- CARRION CROW Corvus corone. Regularly between 5 and 20 on the airfield. C
- ROOK Corvus frugilegus. Combined flocks of Rooks and Jackdaws flighted north every morning and south every evening during the winter, passing to east and west of the airfield. At present they are no hazard but the western flight-line might be dangerous when the new runway is installed. C-B

- JACKDAW Corvus monedula. See Rook. C-B
- MAGPIE Pica pica. A pair frequently seen north of the airfield. D
- BLUE TIT Parus caeruleus. Sometimes seen. D
- SONG THRUSH Turdus philomelos. A few present on most days round airport buildings and on the grass near them. D
- REDWING Turdus iliacus. Flocks twice seen in spring, flying north-east, presumably on migration. D
- FIELDFARE Turdus pilaris. Three seen on 7th February, 1968. D
- BLACKBIRD Turdus merula. One or two usually present. D
- ROBIN Erithacus rubecula. One or two often seen. D
- DUNNOCK Prunella modularis. Regularly seen. D
- PIED WAGTAIL Motacilla alba. At least one pair present throughout the summer. D
- WAXWING Bombycilla garrulus. A flock of eight birds flying east over the airfield on 7th February, 1968 were probably this species. D
- STARLING Sturnus vulgaris. A flock of about 40 birds usually present and a few pairs nested in airport buildings. Flocks of up to 500 were seen fighting in an east-west direction in winter, to the north of the airfield. B
- GREENFINCH Carduelis chloris. Small flocks sometimes seen. D
- CHAFFINCH Fringilla coelebs. Usually some present in winter. Less frequent in summer. D
- HOUSE SPARROW Passer domesticus. Present throughout the year in small numbers. D

APPENDIX VTechnical description of the Cannon-net Trap

There are several versions of cannon-net traps in use but the same principles apply to them all. Basically the trap consists of a net, initially folded back on itself, which on firing is carried over the top of the birds it is hoped to catch by means of electrically fired projectiles attached to the leading edge of the net. Plate 8 shows the net at its fullest extent after firing before falling to the ground. Note the cannon barrels thrown into the air by the force of the explosion.

The net used was made of Ulstron 83P twine, dyed green and measuring 90 ft x 45 ft. Diagonal stretch mesh was $1\frac{1}{2}$ in. and the edging cord was $\frac{3}{4}$ in. circumference 4 lb spun nylon. Traces for attaching the four projectiles to the net were also made from this cord, there being sixteen of these. A 2 ft deep overlap of net was attached to the leading edge to prevent birds from crawling out after being caught.

The barrels of the four cannon were made from cold as drawn mild seamless steel, part number BSS 980.CDS2, obtained from Brown and Tawse Tubes Ltd., St. Leonards Street, Bromley-by-Bow, London, E.3. Their dimensions were $2\frac{1}{4}$ in. outside diameter x 10 gauge x 30 in. long. Breeches were made from bored steel block, 3 in. long, inserted into the barrels and welded. A bore of 1.1 in. diameter was required to take the Imperial Metal Industries No. I Mk.3 Electric Engine Starter Cartridges. The bore was bevelled at the end to accept the cartridge rim. Cartridges were loaded with 20 gm. of black punt-

gun powder, capped with cardboard wads and sealed with candle wax. Base-plates were made of $10\frac{1}{4}$ in. x $6\frac{1}{4}$ in. x $5/32$ in. steel with a reinforcing of steel bars for strength and to hold the sockets for the barrels. These sockets were 3 in. long drilled mild steel bars with a generous $2\frac{1}{2}$ in. inside diameter and $\frac{1}{4}$ in. thick walls. One inch thickness of steel was left at the bottom, drilled to take the $\frac{3}{4}$ in. deep Tufnol plugs through which ran the electrical contacts for firing the cartridges. The two contacts consisted of sprung brass pins as found in household light-bulb sockets, attached to wires which were led out through holes in the sides of the steel sockets and base plates.

The projectiles were 7 in. long and 1.910 in. in diameter. $7/32$ in. semicircular grooves were machined on these with centres $1\frac{5}{16}$ in. from either end, their depth being 0.3 in. at the centres. $\frac{3}{4}$ in. diameter rings were welded on to one end of each projectile to take the harness rope for attaching them to the traces on the net. GACO Angus O-rings (143 P90 Hard) were fitted to the grooves, the purpose of these being to take up clearance of up to 0.1 in. between the projectiles and the cannon barrels and so prevent jamming.

A current of 300 milli-amperes was required to fire the projectiles and this was obtained from two 90 volt batteries in series operating through a condenser, a charging switch being fitted to the firing-box for this purpose.

When attempting to catch gulls the net was placed on the ground, the base line pegged into the soil and the net furled back into a thin line. The cannons were dug into the ground behind the net at an angle of 30° - 35° to the horizontal, the two centre ones being at right-angles to the net and the other

two facing out at about 45° . The cartridges were then inserted into the breeches of the cannon and light camouflage of grass or other suitable material spread over the net.

The cannon were connected up to a specially made-up base-cable using two-way connectors, and the base cable was attached to the firing cable, which led away to the firing point. Finally the firing-box was joined to this cable and all was then ready for firing. If birds arrived in the catching area and firing appeared imminent, the charging switch was operated about 30 seconds prior to firing.

Catching gulls proved difficult because of the wary nature of the birds and the limited number of places where the equipment could be operated with safety and free from public interference. Some success was achieved however (see Plate 9). Experience showed that it would be quite possible to catch large numbers of gulls if a place could be found at either a roost or regularly used feeding area where the equipment (or dummy replica) could be left in position for several days to accustom the birds to its presence. This was unfortunately not possible within the area where this study took place.

PLATES 1 - 11

PLATE 1

PLATE 2

PLATE 3

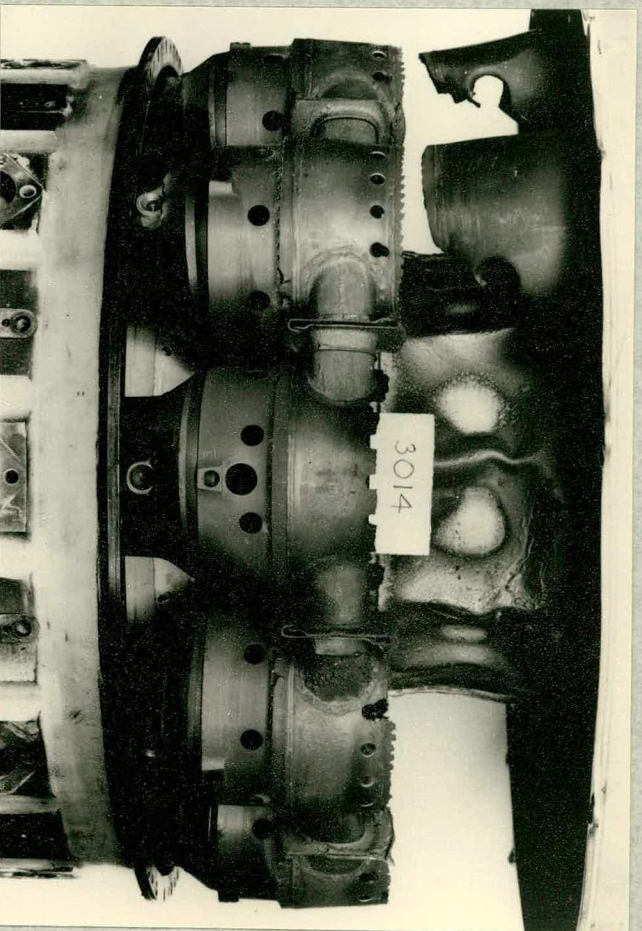


Plate 1a Flame Tubes showing overheating

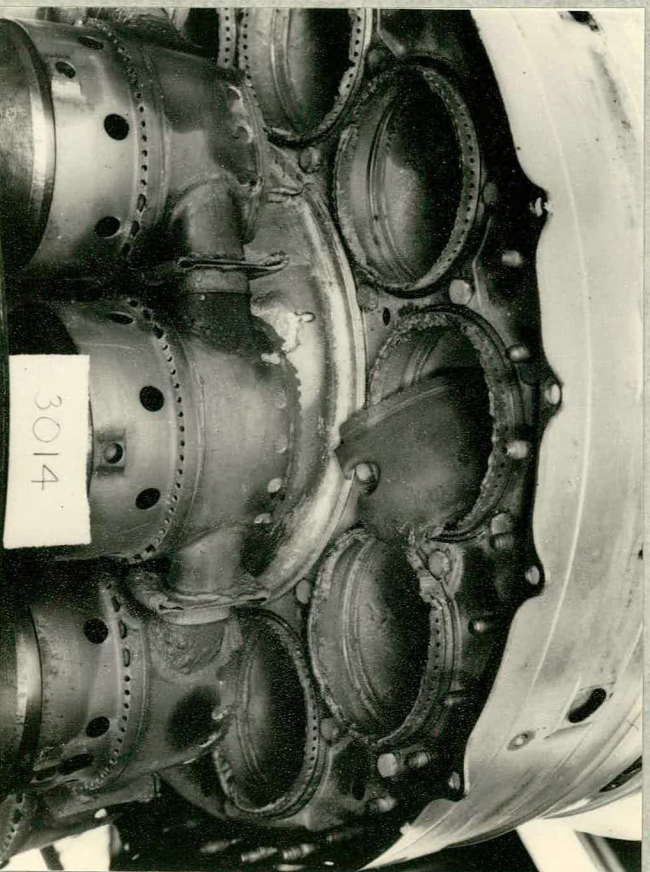
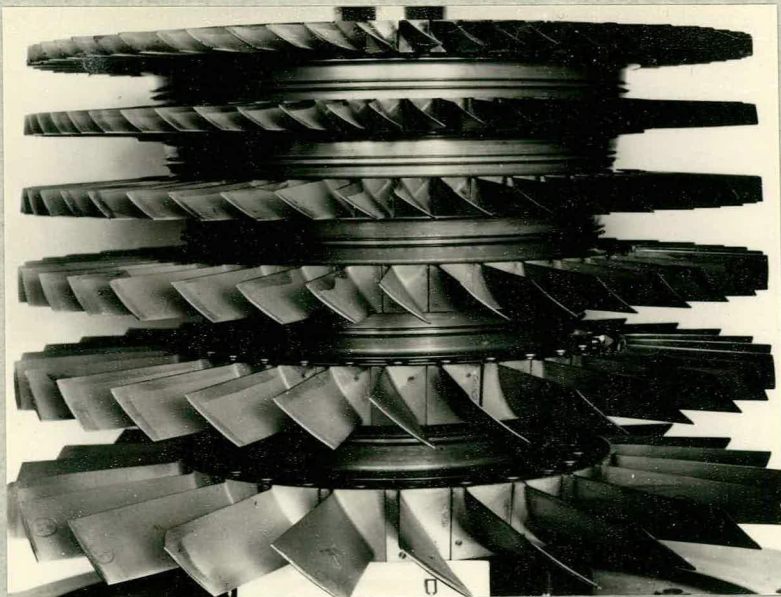


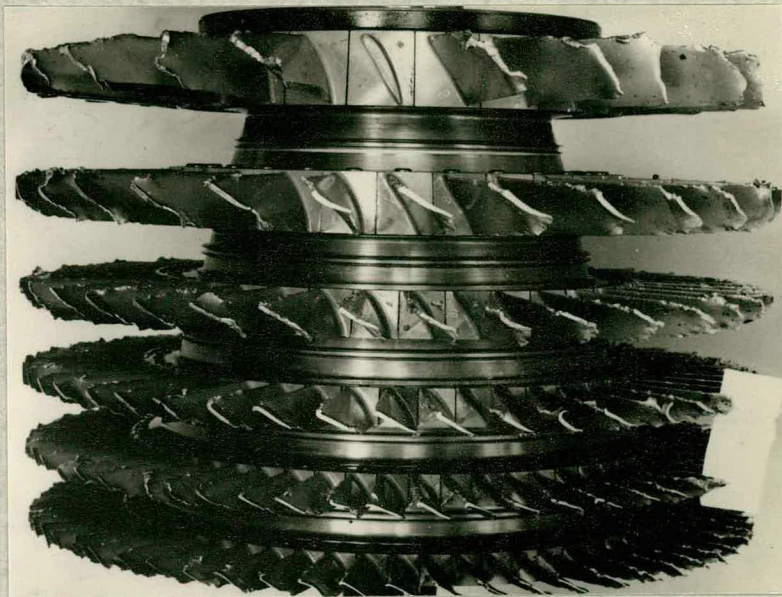
Plate 1b Flame Tubes and Discharge Nozzles

One of the four Vanguard engines, showing damage sustained after collision with a large flock of gulls.

2a



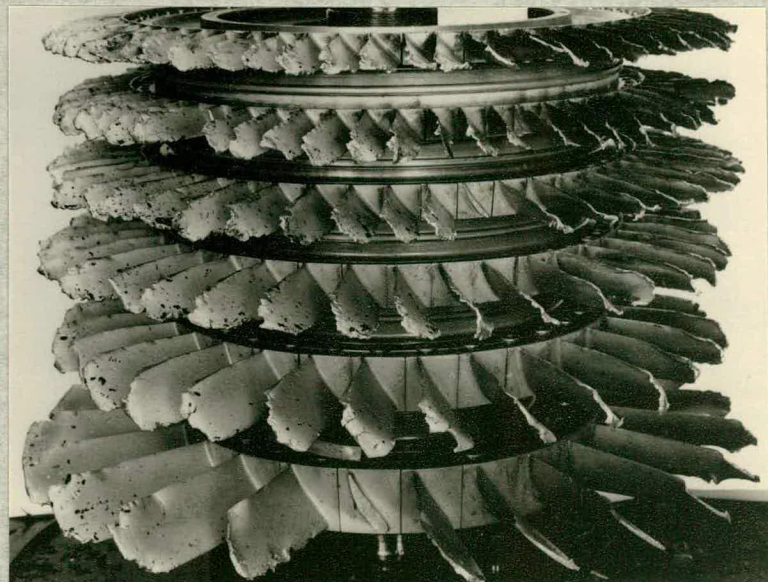
2b



2c



2d



Plates 2a, 2b, 2c and 2d The compressors from the four Vanguard engines.

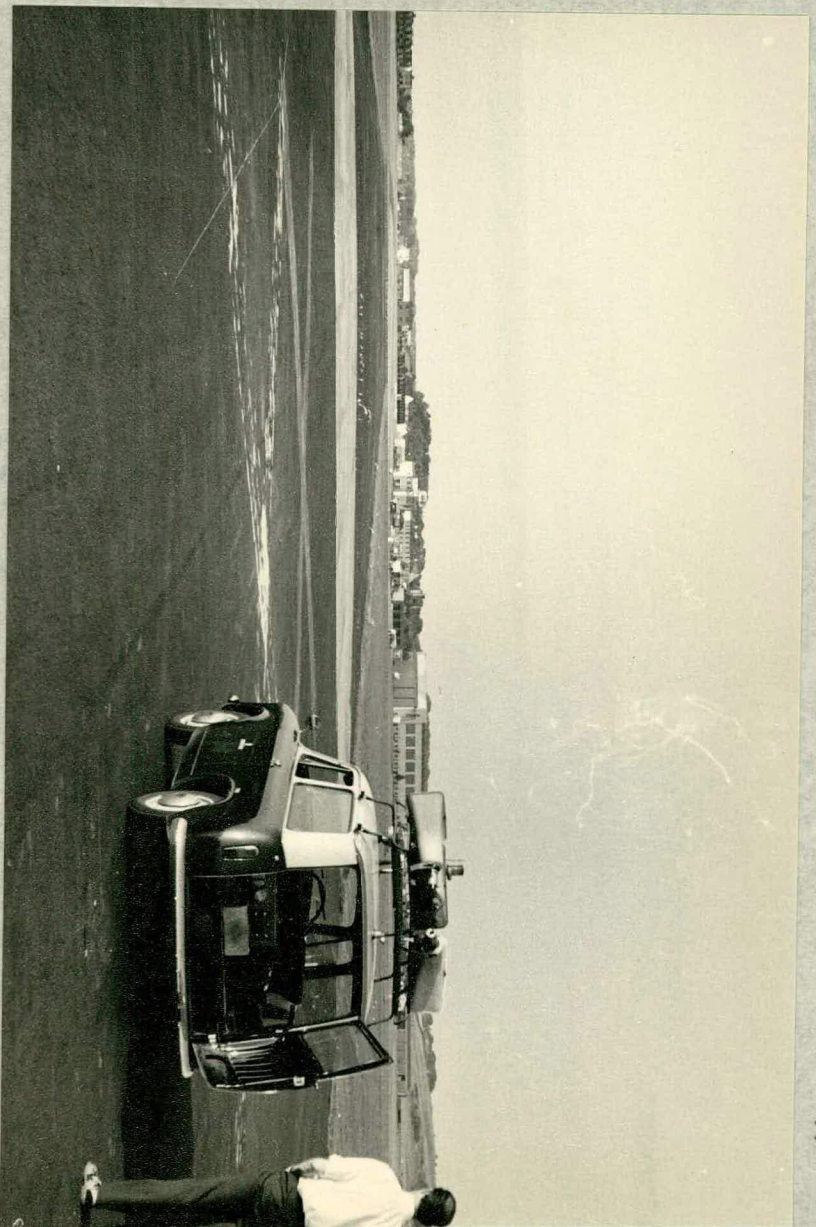


Plate 3a. Gulls on the runway

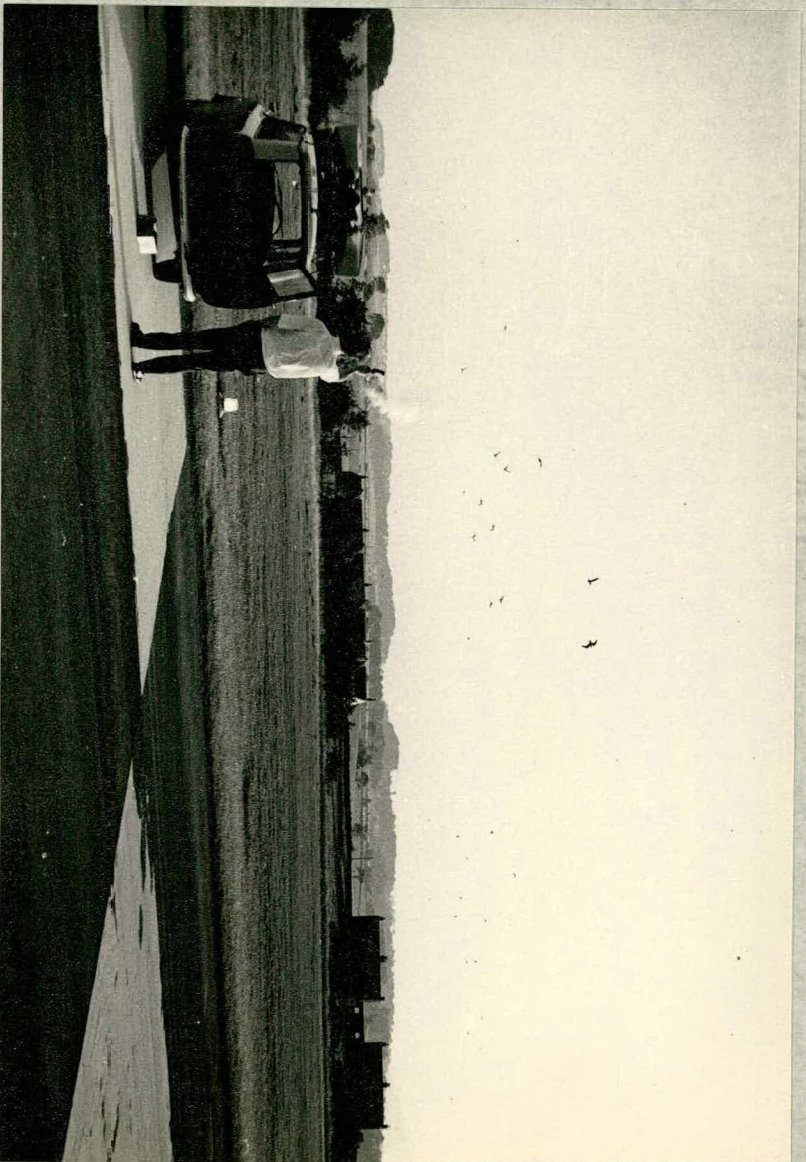


Plate 3b. Firing a shellcracker. Note that the gulls are being scared away towards the airfield boundary.



4b



Plates 4a and 4b Concentrations of gulls at Leith
during a spell of severe frost.



Plate 5b

Edinburgh refuse tip near Mid Calder in 1938.
The habit of feeding on refuse was obviously
common then too.



Plate 6 A resting flock of gulls in a field near Edinburgh.



Plate 7 Black-headed Gulls feeding behind a tractor.

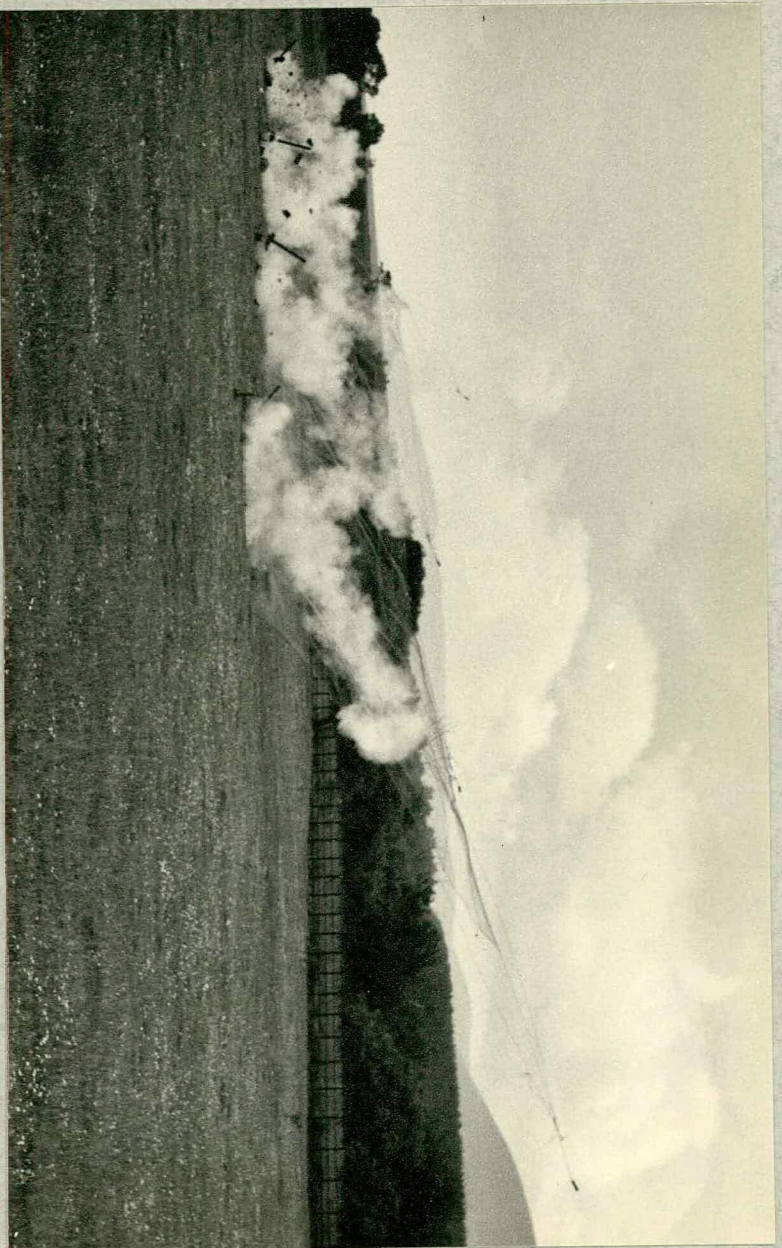


Plate 8 Firing the cannon-net



Plate 9 A large catch of Herring Gulls. Very rapid extrication of the birds was required on this occasion, the net having inadvertently been fired over large pools of rainwater.



Plate 10 A Herring Gull chick fitted with "Darwin"
petagial tags.



Plate 11

The remains of seventy-one gulls killed by a De Havilland Dove aircraft in January 1969 at Turnhouse. The aircraft sustained £400-worth of damage. The incident occurred on take-off just after first light and was caused by south-bound overflying gulls. A faster aircraft would have been much more severely damaged than the slow-flying Dove.

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