POPULATION STUDIES ON THE SOUTHERN BLACK-BACKED GULL

ROBIN ALEXANDER FORDHAM

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CONTENTS

ABSTRACT	1
ACKNOWLEDGEMENTS	3
I INTRODUCTION	6
II GENERAL STRUCTURE OF THE POPULATION	10
1. Contributing colonies	10
1.1 Breeding	10
1.2 Roosting	16
2. Historical notes	21
2.1 Extant colonies	21
2.2 Defunct colonies	30
2.3 Summary	31
3. Total population	34
3.1 Breeding season	34
3.2 Non-breeding season	35
3.3 Communal flocks	43
4. Summary	71
III COMPARATIVE BREEDING STUDY OF SOME COLONIES	78
1. Introduction	78
2. Nests	99
2.1 Nest sites	99
2.2 Nesting density	107
3. Egg stage	114
3.1 Laying	114
3.2 Clutch size	125
3.3 Egg mortality	128

4.	The chicks	134
4.1	Chick mortality	134
5.	Breeding success	139
5.1	Breeding synchrony	139
5.2	Overall success and contribution to the population	147
6.	Summary	158
IV	MORTALITY AND DISPERSAL OF BANDED GULLS	165
1.	Banding programme	165
2.	Mortality in the first year	168
2.1	Fledglings	168
2.2	Fledged young	172
2.3	Influence of some ecological factors	188
2.4	Comparison of the colonies	208
3.	Mortality of young on Somes Is. in relation to the food supply	212
3.1	Results	212
3.2	Interpretation of the results	223
4.	Mortality after the first year	237
4.1	The durability of bands	237
4.2	Mortality and survival	243
5.	Dispersal of gulls in the study area	255
5.1	First year	258
5.2	After the first year	275
5.3	Colour-band survey of Wellington Harbour and west coast	282
6.	Other dispersal movements	285
6.1	Dispersal to and from the study area	285
6.2	Range of dispersal	287

7.	Summary	291
V	GENERAL SUMMARY	303
VI	LITERATURE CITED	306
VII	APPENDICES	322
VIII	PLATES	349

ABSTRACT

An account is given of ecological studies on the Southern Black-backed Gull Larus dominicanus Licht. in which attention is directed to the structure and balance of the Wellington population. This population is large; in the 1963-64 season more than 5,600 pairs were breeding in the study area, and the peak non-breeding season population in 1964 exceeded 12,000 birds. Its growth has been closely associated with the increase of the human population, and the present distribution and dispersal of gulls is strongly influenced by the distribution of "artificial" feeding sites such as refuse tips and meatworks. The population is composed of breeding colonies, night roosting flocks and daily communal flocks which are inter-related by the social activities and dispersal of the birds. Thus the population is more or less integrated, rather than simply comprising discrete geographic units. Seasonal fluctuations in size and age composition of communal flocks are discussed.

Breeding success varies between colonies. It is affected by mammalian predation in some, and by drowning in others, while the largest colonies are comparatively safe for breeding birds. The rapid growth of the whole population in the last five to 10 years appears to have some influence on nesting density, clutch size, spread of laying and overall breeding success.

In recent years production of young has been twice that required to maintain the population which has grown at the rate of not less than 7.2% annually. Mortality of banded gulls

inside and outside the colony is described and the influence of several factors on chick mortality examined. The principal factor limiting the population appears to be the food supply in relation to the number of birds. When numbers increase and the food supply diminishes, major regulation of the population is apparently achieved in the colony by predation (but not cannibalism) of young by adults. Dispersal of banded gulls from the Wellington colonies is very restricted.

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I INTRODUCTION

For all its rich and varied seabird fauna New Zealand has very few gulls. Peters (1934) recognized 43 species of gulls, and placed 35 in the genus Larus,* but of this number only three species occur as breeding birds in New Zealand. They are the Red-billed Gull L. novaehollandiae scopulinus, Black-billed Gull L. bulleri and the Southern Black-backed Gull L. dominicanus. The closest relatives of all three species occur in the northern hemisphere. The first two are allied to the masked gulls (Moynihan, 1959) while the Southern Black-back is most similar to some of the other large white-headed Larus gulls, and has few features which especially distinguish it from its relatives. Indeed gulls as a whole display great uniformity which indicates, in the opinion of Tinbergen (1964) that the group is monophyletic. The point of origin of the group has recently been disputed however, thus although the oldest fossil Larinae known are from the Eocene of Europe and North America (Darlington, 1957, p.299), and most extant gulls are northern hemisphere forms (Thomson,

* Moynihan (1959) revised the classification of Laridae and included all gulls in Larus, tribe Larini, but in this study I have followed Peters (1934) in the use of the subfamilies Larinae and Sterninae.

1964), parasitological evidence led Szidat (1964) to suggest gulls originated in the southern hemisphere.

The Southern Black-back is confined to the southern hemisphere, but its latitudinal range is fairly wide, extending from about 6°S. (Lobos de Tierra Is., South America) to 68°S. in Graham Land, Antarctica (Murphy, 1936). West Wind Drift may have aided its dispersal (Falla, 1953, p.44; Fleming, 1962, p.97) and it now occurs on many islands in the southern oceans, as well as in Africa, South America, Antarctica and Australasia, although its status as a breeding bird in Australia is apparently recent (Gwynne and Gray, 1959). In New Zealand few species have, in recent times, spread so fast or become so common as the Southern Black-backed Gull. It is now widely known as a noisy scavenger in coastal towns, and viewed as a potential danger by some sheep farmers and aviation authorities. Populations in many parts of the country have increased markedly in living memory, and this has commonly been attributed to "better feeding conditions" because the numbers of birds have visibly increased in areas where refuse is available.

But although the species is familiar to many people, comparatively little is known of its ecology, in relation to overall population trends. No study has yet been made of a marked population either in New Zealand or overseas, and no experiments have been designed to examine possible limiting factors. Literature that is relevant to the population-ecology

of the Southern Black-back is limited, and comprises mainly general accounts of the bird's biology, or short discussions of specific topics. Thus general accounts have been prepared by various authors including Buller (1888), Guthrie-Smith (1914), Stead (1932), Murphy (1936), Oliver (1955); breeding and hostile behaviour has been described by Steinbacher (1938), Moynihan (1962), Fordham (1963 b), and some predatory behaviour by Robertson (1964); seasonal fluctuations in flock numbers have been noted by Wodzicki (1962); and aspects of the breeding cycle have been discussed by Bennett (1927), Falla (1937), Wilkinson & Wilkinson (1952), and Gillham (1963); the first detailed account of the breeding cycle was given by Fordham (1964 a & b). The remaining literature relating to population-ecology is very scattered, and composed of short notes in numerous publications.

In 1963 the Wellington area was chosen as the site for a population study. The area appeared suitable because the population was large, had apparently grown considerably since 1900, and was supplied by numerous breeding colonies, all of which experienced different ecological conditions. A number of birds had already been banded in several colonies, regular sample censuses had been started, and some knowledge of production obtained. The whole aim of the study therefore was to examine the population as a unit, determine its size, history, distribution, structure and behaviour, measure the

relative contributions made by the various breeding colonies, calculate the mortality and survival of gulls inside and outside breeding colonies, and attempt to deduce the factor or combination of factors responsible for its regulation.

The problem was approached from three aspects:

1. The general structure, dispersion and history of the population.
2. The comparative breeding success of a number of colonies.
3. The mortality and dispersal of the population.

Wherever possible these three aspects were related to each other in an attempt to achieve a co-ordinated picture of the population, and a better understanding of its balance.

II GENERAL STRUCTURE OF THE POPULATION

1. Contributing colonies

1.1 Breeding

The area chosen for this study extends from Kapiti Is. on the west coast North Island to Cape Palliser at its southern tip (Fig. 1). The whole area can be conveniently enclosed by a curved line between these two points so as to include the Lake Wairarapa region. Practical problems of transport and accessibility were important factors deciding the boundaries, however there is a gap of some 41 miles north of Kapiti Is. before the next major breeding colony is found - about two miles north of the Rangitikei River mouth - and for a considerable distance north of Cape Palliser on the east coast there are only a few small scattered breeding or roosting colonies. Thus the area does in fact include most, if not all, the colonies supplying the bulk of the Wellington population. For reasons of transport and distance it was not possible to consider colonies at the north end of the South Island, except in relation to the dispersal of some banded birds (section IV: 5).

The area contains a total of 31 breeding colonies; 21 on the mainland, and 10 on islands. These vary from a few scattered pairs to large colonies such as Mana Is. with ca. 2,000 pairs. The term "colony" is used in some cases purely

FIGURE 1

BREEDING COLONIES

1 North end Kapiti Is.	17 Leper Is.
2 Tokomapuna	18 Some Is.
3 Fisherman's Is.	19 Ward Is.
4 Brown's Is.	20 Northern colony Baring Hd.
5 Wharekohu Bay	21 Lighthouse colony Baring Hd.
6 Pukerua Bay	22 Lagoon colony Baring Hd.
7 Mana Is.	23 Mukamuka R. mouth
8 Pipinui Pt.	24 Palliser Spit
9 Opau Bay	25 Waiorongomai R.
10 Te Ikaamaru Bay	26 Ruamahanga R. mouth
11 Ohau Bay	27 Whangamoana cliffs
12 Ohau Pt.	28 Te Humenga Pt.
13 Cape Terawhiti	29 Otakaha R. mouth
14 Island Bay	30 Whale Pt.
15 Taputeranga Is.	31 Ngawihi Pt.
16 Moa Pt.	

for convenience. It is conjectural whether it can be applied to small dispersed groups of four or five pairs of gulls, however where a number of pairs are more or less concentrated (albeit scattered) in one area, it is practical to describe the group as a colony, with qualifying conditions noted, rather than to describe their existence as "scattered nesting" which has reference to a larger, illdefined region. The colonies are listed below in the order they appear in Fig. 1 with the actual or estimated (E) number of breeding pairs for each.

BREEDING COLONIES IN THE STUDY AREA (1963-64)

Wellington west coast

1 North end Kapiti Is.	600 E.
2 Tokomapuna (Aeroplane Is.)	35 E. (L.J. Paul, pers. comm.)
3 Fisherman's Is. (Motungarara)	5 E.
4 Brown's Is. (Tahoramaurea)	5 E.
5 Wharekohu Bay, Kapiti Is.	15 E. (Stidolph, 1948; J.A. Bartle, pers. comm.)
6 Pukerua Bay	4 E.
7 Mana Is.	2,000 E.
8 Pipinui Pt.	31 E. (J.A. Bartle, pers. comm.)
9 Opau Bay	5 E. (C. Summers, pers. comm.)
10 Te Ikaamaru Bay	20 E. (E.C. Hall, pers. comm.)
11 Ohau Bay	12 E. (E.C. Hall, pers. comm.)
12 Ohau Pt.	4 E. (E.C. Hall, pers. comm.)
13 Cape Terawhiti	40 E. (E.C. Hall, pers. comm.)

Wellington Harbour

14 Island Bay	6 E. (D. Stoops, pers. comm.)
15 Taputeranga Is.	135 E.
16 Moa Pt.	15 E.
17 Leper Is.	25 E. (No recent data; Secker, 1954)
18 Somes Is.	1,475 E.
19 Ward Is.	110 E.
20 Northern colony Baring Hd.	80 E.
21 Lighthouse " " "	250 E.
22 Lagoon " " "	310 E.

Lake Wairarapa - Palliser Bay

23 Mukamuka R. mouth	45
24 Palliser Spit	265 E.
25 Waiorongomai R.	73
26 Ruamahanga R. mouth	24
27 Whangamoana cliffs	12 E.
28 Te Humenga Pt.	58
29 Otakaha R. mouth	6
30 Whale Pt. (Waiwhero Stm.)	8
31 Ngawihi Pt.	4

Total counts of marked nests at the end of the season, or estimates based on nest counts during the season were obtained in the course of breeding studies made in 1963-64. Where counts were not possible information was collected from other persons. When making estimates allowance was made for

the time of season data were collected, and for the protracted laying shown by the gull (Fordham, 1964 a). In one colony where no recent data were to hand, the estimate was based on general observations, and on an aerial survey of the study area made on 23/11/64. In this survey the coastline was followed, all off-shore islands were visited, and a detour was made to the Lake Wairarapa region. The extent of known breeding colonies was noted, and special efforts made to locate unrecorded colonies. Aerial photography of the colonies, a technique which proved of immense value when applied to communal flocks in the non-breeding season (see section II: 3.2) was only partially successful. I found the dispersed incubating birds were sometimes disguised by vegetation or rocks at the nest site, and the steep or broken topography of a number of colonies concealed other birds from the camera. In communal flocks all birds stand together in a group so that even if the photograph makes the birds look like stones, the interpreter knows they are not! In the case of scattered nesting birds however, this does not apply, and so this survey did not provide complete results.

Apart from the colonies listed, solitary pairs are scattered all round the coast. Along Wellington west coast between Ohariu Bay and Pipinui Pt., and between Oteranga Bay and Island Bay there are scattered, isolated nests (C. Summers, P. Chandler, G. Jensen, pers. comm.); and at Tongue Pt., a mile north of Karori Stm., there are ca. four pairs (G. Jensen,

pers. comm.). On Kapiti Is. there are nests scattered along the north, north-west and east sides. In Wellington Harbour in 1963-64 there were two pairs on Miramar peninsula, and in Palliser Bay there was a pair on the east side.

To the best of my knowledge there are no other breeding grounds in the study area. The number of breeding pairs counted in the study area during 1963-64 therefore totals 5,684, with an estimated upper limit of ca. 6,000. Brief descriptions of the 11 colonies not included in the comparative breeding study (section III: 1) are given below.

Wellington west coast

Fisherman's Is. & Brown's Is. These small islands, each with an area of only a few acres, are mainly covered with taupata Coprosma repens and ngaio Myoporum laetum scrub, and nests are scattered round the rocky shores. Both are subject to human interference, and on Brown's Is. at least there are ship rats Rattus rattus.

Wharekohu Bay (S. end Kapiti Is.) I have few data on this colony except that it is possibly affected by either ship or Norwegian rats R. norvegicus since both are present on the island.

Pipinui Pt. The breeding area is ca. two miles north of Pipinui Pt. on an isolated stretch of rocky coast. It is spread over a very wide area, most nests being scattered along the cliffs rather than the beach (J.A. Bartle, pers. comm.), and D. Arthur, (pers. comm.), found nests in small groups, as

well as hundreds of yards apart). Wild cats (and probably mustelids) are present in the general area.

Opau Bay, Te Ikaamaru Bay, Ohau Bay, Ohau Pt. In these four coastal colonies nesting is scattered, and in the case of Te Ikaamaru Bay, nests occur on cliffs and rocky beach (E.C. Hall, pers. comm.).

Cape Terawhiti This is a beach colony on a small point about two miles north of Cape Terawhiti in which E.C. Hall (pers. comm.) reports nests are concentrated in one area.

Wellington Harbour

Leper Is. This small island has a partial cover mainly of taupata and boxthorn Lycium sp. amongst which the birds nest. Mammalian predators are absent, but there is some human interference.

Lake Wairarapa - Palliser Bay

Whangamoana cliffs About four miles S.E. of Lake Onoke some gulls nest on the cliff face. They are scattered round the mid regions of the cliffs, and spread for about a quarter of a mile. The birds are free from human interference, and possibly mammalian predators.

1.2 Roosting

Roosting flocks (i.e. night roosting flocks in the non-breeding season) are now considered as gatherings of birds distinct from breeding colonies in function, and sometimes location. This distinction follows usage by Lack (1954, p.255)

FIGURE 2

Roosting sites, and North Island colonies
adjacent to the study area.

ROOSTING SITES & ADJACENT COLONIES

and Thompson (1964) who define the term "flock" as an assemblage of birds, and "colony" as a group of birds breeding gregariously. There are at least 16 permanent roosting sites in the area, and unconfirmed evidence indicates the presence of 7 others. As with breeding gulls, isolated pairs or single birds roost around the coast, and the term "roosting flock" is a convenient one when a small number of birds are gathered together in the same area (e.g. the small islands off Kapiti). Roosting sites (or flocks) are listed below, and shown in Fig. 2.

ROOSTING FLOCKS IN THE STUDY AREA

Wellington west coast

Kapiti Is., north end	Large
Tokomapuna Is.	Probable
Fisherman's Is.	"
Brown's Is.	"
Mana Is.	Large
Pipinui Pt.	Possible
Te Ikaamaru Bay	(E.C. Hall, pers. comm.)
Cape Terawhiti	Possible
Karori Stm. mouth	"

Wellington Harbour

Taputeranga Is.	Large
Harbour mooring dolphins	
Leper Is.	
Somes Is.	Large
Ward Is.	"

Baring Hd., Northern flock

" " Lighthouse flock Large

" " Lagoon flock Large

Lake Wairarapa - Palliser Bay

Waiorongomai R.

Ruamahanga R. mouth

Palliser Spit Large

Whangamoana cliffs

Te Humenga Pt.

Otakaha R. mouth Probable

Eight of these flocks are notably larger than the others, in particular Kapiti Is., Mana Is., Somes Is. and Baring Hd., and between them provide roosting grounds for the bulk of the Wellington population. By observing flight movements of birds at dawn and dusk it was deduced that one or more roosting flocks must exist somewhere on the S.W. coast of Wellington, and it appears the most likely places are Cape Terawhiti area, and Karori Stm. mouth. Unfortunately local knowledge is lacking, although C. Summers told me a few gulls roost on rocky promontories between Island Bay and Cape Terawhiti. All the large, and a number of the smaller breeding colonies serve as roosting sites in both winter and summer, and on Somes Is. I found a marked site tenacity in some banded roosting birds (Fordham, 1964 a). Mrs. A. Weir who lived on the island between 1933 and 1959 recalls that the main roosting sites were the same as those used until recently, i.e. the

east and west beaches, lighthouse slopes, and east slopes.

There is insufficient evidence to indicate whether the remaining eight breeding colonies are also roosting sites, but it appears likely that very small colonies near large roosting sites may not serve as roosting sites themselves (e.g. Island Bay and Moa Pt.). However gulls often roost at sea immediately adjacent to a roosting site on land, so that evidence of their presence could be obtained only by visits at night.

In the larger flocks some birds roost on or near their summer nesting sites, but the majority are usually more or less concentrated into groups, not widely dispersed as when nesting. In coastal colonies these groups usually move out on to the beach around and below the high tide mark, away from the upper beach terraces where nests are built. The groups regularly form in the same general area each night. On Somes Is. one or two large groups roost in grazed paddocks on the E. and W. sides, 50 - 100 feet above the beach. Other comparable colonies in which there is evidence to suggest similar behaviour are Kapiti Is. (north end) in paddocks by the lake, and Mana Is. at about 300 feet on the north end.

Description of all the roosting flocks is unnecessary, since most have just been mentioned, or will be included in section III on comparative breeding studies, but note must be made of the following:

Wellington Harbour

Next to the floating dock in Wellington Harbour are four

large mooring dolphins on which gulls usually roost in varying numbers. They do not, of course, breed there; the dolphins are in regular use by shipping.

Lake Wairarapa - Palliser Bay

At the Waiorongomai R. roosting is not necessarily in the colony itself, but in paddocks about a quarter of a mile south. Across Lake Wairarapa at the Ruamahanga R. mouth some gulls roost on the islet where breeding occurs, and also on the water. On Palliser Spit the flock may shift up and down the spit away from the breeding grounds at the east end.

A number of breeding colonies and roosting flocks are adjacent to the study area. These are mentioned in appendix 2.

2. Historical notes

2.1 Extant colonies

There is, unfortunately, very little published information on the history of the many breeding colonies and roosting flocks in the area. In a search for records held by local people, information was sought about changes over the years in size or location of colonies, existence of predators or other natural hazards, and past events (e.g. earthquakes, floods etc.) which were known to have affected the colonies. This search was not very rewarding insofar as numerous persons who were contacted could give only general impressions from

memory. Sometimes too the data were conflicting. In a few cases however their information did provide clear evidence of changes in size or location of colonies over the years. No records could be found of some colonies, especially the smaller ones. Of these some at least are probably recent in origin (e.g. Island Bay and Moa Pt.) and are probably composed of birds which have spread from larger colonies nearby. One feature of great importance emerges however: that as a whole the gull population in the Wellington area has multiplied many times over in living memory.

Before passing to the colonies themselves it is interesting to pause and note how Heaphy (1879) described Wellington Harbour and its wildlife in 1839 . . . "Along the eastern shore, from the mouth of the Hutt R. to outside of Ward Island, the forest was uninterrupted, and the trees overhung the water, giving shelter to great numbers of wild fowl. The indigenous birds had been entirely unmolested, save when the Maori snared them in his furtive and noiseless manner. I remember, especially, the enormous number of waterfowl frequenting the shallows at the mouth of the Hutt River. Cormorants, ducks, teal, oyster-catchers, plovers, sand-pipers, curlew, and red-legged waders, were there in pairs, detachments, and masses, and so tame that it was slaughter rather than sport, to shoot them. At the beach at the head of Evans Bay, there were, beside ordinary waterfowl, flocks of Paradise ducks (Casarca variegata) As we descended the spur near the mouth of the Hutt

River, a whale and its calf were tumbling about between Lowry Bay and Some's Island."

It is of interest that no gulls are specifically mentioned as being present, (unless Heaphy included them under the general heading of "waterfowl") yet had gulls been numerically strong relative to other wading birds it is likely that he would have so recorded it, thus it seems fair to assume that at this early date in Wellington's history, gulls although present, were nowhere near as prominent amongst the sea birds as they are today. Nearly 50 years later however, Buller (1888) noted an increase in their numbers in Wellington Harbour.

Following are brief accounts of the history of the colonies; sources of reference are quoted for each.

Wellington west coast

Kapiti Is. Before the arrival of Europeans Kapiti Is. had long been occupied by Maoris who cultivated an area of ground at the north end close to the present site of the colony. Later (before 1844) whaling stations were set up, and during this period of time it is possible that gull colonies (if any existed) would have attracted egg collectors. Without mentioning years Mrs. S. Lovell (daughter of the caretaker from 1924-46) said the gulls "did not always nest in colonies, but in various places about the island", which suggests the colony at the north end formed after 1900. Stidolph (1948) recorded there had been a colony at the north end for many years, and in November 1941 and 1942 he found 129 and 120 nests

respectively. On the rest of the east side in November 1941 Stidolph found 25 nests. Since then the north end colony has increased to its present status of ca. 600 pairs.

Tokomapuna Is. Between 1924 and 1946 as many as 50 pairs of Black-backs nested with Red-billed Gulls L.novaehollandiae scopulinus and White-fronted Terns Sterna striata (Mrs. S. Lovell, pers. comm.) and in November 1941 Stidolph (1948) found 54 nests of which 44 were empty, and 10 contained eggs. In late October 1963 L. Paul (pers. comm.) found about 30 nests so that the colony has possibly remained fairly stable.

Wharekohu Bay (Kapiti Is.) In November 1941 Stidolph (1948) counted 16 nests in the area, and in October 1962 J.A. Bartle (pers. comm.) found 10-20 pairs present. This scattered colony appears then to be also fairly stable.

Mana Is. This colony has shown a most dramatic increase in numbers in the last 20 years till at present with ca. 2,000 pairs it is the largest in the area. Although I contacted members of the Vella family who had farmed the island from 1886-1952 I was unfortunately unable to obtain any useful data except that about 1908 a small colony (probably Southern Black-backs) formed at the S.W. end of the island. In 1944 W.R.B. Oliver and K. Wodzicki found Southern Black-backs nesting round the island, especially the northern and southern ends, and estimated 250 pairs were present (Wodzicki, 1944; Wodzicki & Oliver, 1944). Since 1953 when J. Gault began farming the island, the gulls have nested, (as at present) almost all round

the beaches and up the slopes.

Pukerua Bay I have little information about this colony, but local residents told me gulls had nested there "for a long time", and in January 1958 C.N. Challies found about seven young, and a few nests spread over the slopes.

Pipinui Pt. The first definite record of this colony is in December 1956 when D. Arthur (pers. comm.) noted gulls scattered along the coast, but not in great numbers, i.e. some 20-30 birds circling overhead. However E.C. Hall (pers. comm.) said gulls "were a nuisance to fishermen" in this area in 1947 so that the colony possibly existed then. In March 1959 W.H. Secker (pers. comm.) found remains of 29 nests and in January 1965 J.A. Bartle counted 31 pairs so the increase (if any) in recent years, has been slight. Between Pipinui Pt. and Opau Bay the number of nests scattered along the coast has, according to C. Summers and F. Hunt (pers. comm.) remained "about the same" since 1956.

Opau Bay In December 1943 H.L. Secker (1944) found ca. six nests, and F. Hunt (pers. comm.) stated that since 1947 there have been five to six pairs in the bay. In the 1962-63 season C. Summers (pers. comm.) saw ca. five nests, so this colony has apparently remained the same size for 20 years.

Te Ikaamaru Bay The 20 pairs which nest scattered in this area have all arrived since 1956 (E.C. Hall, pers. comm.).

Ohau Bay E.C. Hall reported the scattered colony of ca. 12 pairs has built up since 1956, while between Ohau Bay and Cape

Terawhiti in the same time C. Summers considers the number of gulls has increased.

Wellington Harbour

Taputeranga Is. This appears to be an old established colony, since locals used to collect eggs at the turn of the century, and J. Greco (pers. comm.) said "there seemed to be a lot of gulls about then". No other data are available, but it is likely that the presence of Norwegian rats exercises some control on breeding success, and consequently the number breeding, which at present is ca. 135 pairs.

Leper Is. The only record of this colony is that of Secker (1954) who found 26 nests in November 1954, but Mrs. A. Weir (who lived on Somes Is. from 1933-59) recalls the Leper Is. population "increased markedly" (as it did on Somes Is.) during that time.

Somes Is. This colony which is the largest in the harbour and the second largest in the study area has shown the same dramatic increase in numbers of gulls in the last 20 years, as occurred on Mana Is. Somes Is. has been occupied for well over a century and closed to the general public for 100 years. During this time it served first as a human quarantine station, then as a stock quarantine station. A lighthouse, manned until 1920 and thereafter automatic, was erected in 1866. In addition civilian internees were held there in both World Wars, so at times there has been great activity on the island, and parts of it have not always been available to nesting gulls.

From information given by P.D. Owen (ex-military guard) and Mrs. E. Wagstaff (wife of former Stock Quarantine Officer) there were penguins, but no gulls present during the war period 1914-18. After the war, about 1920, Miss R. Cleverly (lighthouse keeper's daughter) recalls the presence of "numerous Black-backs, and nests on top of rocks". In autumn 1938 when Miss Cleverly re-visited the island she found the south end "almost completely taken over by seagulls", an event probably due to there no longer being anyone living at that end of the island. Mrs. A. Weir lived on Somes Is. from 1933-59 and noted that in 1933 gulls nested only on the S.E. point, and that during the Second World War naval personnel used to collect eggs for baking. Up till 1953 most nesting was still on the S.E. point (S.S. Hunter, pers. comm.) and by 1959 Mrs. Weir recalls numbers had increased so that there were odd nests all round the island. Since then nesting has spread northwards along the E. and W. sides (Fordham, 1964 a) till most of the island, outside the farm area, is occupied by ca. 1,475 pairs. It appears therefore the most rapid increase in numbers has occurred in the last five to ten years.

Although I have only limited evidence relating to the period prior to 1914, it seems likely that a colony was on Somes Is. before that time.

Ward Is. This island is only about 200 yds. long and is much smaller than Somes Is., but R.A. Falla observed (pers. comm.) that it used to be the main harbour colony, though it

has now been superceded by Somes Is. In January 1949, Yaldwyn (1949) found 20+ nests, and in November 1950 (Oliver, 1953) found 45 nests. By 1963 the number of breeding pairs had increased to about 110.

Baring Hd. In February 1943 (the end of the breeding season) Secker (1943) found 50-60 nests. These were presumably in the Lagoon and Lighthouse colonies only, since it is likely the Northern colony is of recent origin. The present estimated sizes of these three colonies are respectively 310, 250 and 80 pairs so that there has been a big increase in the last 22 years.

Lake Wairarapa - Palliser Bay

Waiorongomai R. This colony which is subject to flooding comprised 73 pairs in 1963-64, but following successive floods there were only 26 birds and five used nests in mid December 1964. J. Luttrell and J. Matthews (pers. comm.) stated the colony formed after 1953.

Ruamahanga R. mouth This colony on the small islet in the river mouth is also subject to total flooding and in 1963-64 comprised 24 pairs. It formed from a few pairs between 1930 and 1940 at the present site (S. & R. Hall, pers. comm.).

Mukamuka R. mouth J. Luttrell reported (pers. comm.) that there were no birds present about 1950, and that the colony began with a few pairs soon after that time. In the 1963-64 season I recorded 45 breeding pairs, but in mid December 1964 there were only 25 nests in use and ca. 50 birds in the area.

Possibly stoat Mustela erminea activity is affecting the numbers breeding (section III: 4).

Palliser Spit This has been a firmly established colony for at least the last 40 years, and without doubt for a longer period. S. Hall (pers. comm.) recalls that about 1920 there were originally a "small number of birds" on a mound at the east end of the spit, and in 1942 when the outlet of Lake Onoke was shifted, the colony moved several hundred yards to the west. Cunningham (1949) found 137 nests in early December 1948, but in early December 1951 Oliver (1953) recorded only 33 nests. This apparent drop in numbers is so far unexplained. By November 1960 numbers had increased to 209 pairs, and in early November in both 1961 and 1962 there were ca. 220 nests (Challies, 1961, and pers. comm.). The present size of ca. 265 pairs indicates the colony has increased slowly for several years.

Whangamoana cliffs According to a local resident, gulls have been nesting in small numbers on these cliffs since about 1948. In the 1963-64 season about 12 pairs were present.

Te Humenga Pt. Gulls began nesting in this area about 1940, (N. Crew & F. McLeod, pers. comm.), and in early December 1954 J. Cunningham (pers. comm.) found 42 nests, 18 of which were empty. For two or three seasons about 1953, N. Crew found that wild pigs Sus scrofa rooted up parts of the colony and ate eggs, but in January 1961 Cunningham noted "well over 100 birds present, and more than 50 used nests". In 1963-64

I recorded 58 pairs, but the next season the colony was reduced to one successful pair, although up to 45 birds were known to be present. Observations by local residents suggest this reduction was at least partly due to people taking eggs.

Otakaha R. mouth This colony has been in existence since before 1952 when J. Cunningham (pers. comm.) banded seven chicks. In October 1954 Cunningham noted about 20 gulls present, while in 1963-64 and 1964-65 I recorded six and ca. ten pairs respectively.

Ngawihi Pt. In December 1952 J. Cunningham (pers. comm.) found four used nests, and it seems likely gulls were nesting there before that time. K. Clarke (pers. comm.) counted six pairs in 1962-63, and I recorded four and six pairs respectively in 1963-64 and 1964-65, so the colony has been stable in the last 13 years.

2.2 Defunct Colonies

While collecting data on existing colonies I obtained some information about four small colonies now defunct. Two of these were in Wellington Harbour, and two in Lake Wairarapa - Palliser Bay area. Dr. R.A. Falla told me there used to be a colony ca. two miles north of Pencarrow Hd., but it dispersed before 1960 following road works. About the 1960-61 season a pair began nesting on a roof in Eastbourne, Wellington, and by 1963 there were five pairs (Miss M. Wood, pers. comm.). This colony was then removed by the authorities.

In Palliser Bay, about one mile north of Turakirae Hd. there was a colony present from at least 1925 onwards, from which eggs were collected by a local bach owner (R.C. Nelson, pers. comm.). In late October 1963 J. Andrews and C. Christie (pers. comm.) found no trace of a colony, and during the aerial survey made in late November 1964 I saw no gulls in the area. It appears therefore this colony dispersed before 1963. In Hopai lagoon, at the north end of Lake Wairarapa, there used to be a small colony, which dispersed when the lake level rose some time after 1950 (J. Luttrell and E. Holmes, pers. comm.).

2.3 Summary

From the foregoing account it can be seen that the population in the study area has grown rapidly since 1900. Of the 21 colonies discussed up to the 1963-64 breeding season, 10 show a large or marked increase in numbers breeding, four show a slight or slow increase, six appear to be fairly stable (probably because there are insufficient records), and for one (Taputeranga Is.) no conclusion is possible.

<u>Large or marked Increase</u>	<u>Approximate Rate of Increase</u>	<u>Period Involved</u>
Kapiti Is. (north end)	x 5	Since 1941 (22 years)
Mana Is.	x 8	Since 1944 (19 years)
Te Ikaamaru Bay	-	Since 1956 (7 years)
Ohau Bay	-	Since 1956 (7 years)
Somes Is.	x 9	Since 1938 (25 years)

Ward Is.	x 5	Since 1949 (14 years)
Baring Hd.	x 11	Since 1943 (20 years)
Waiorongomai R.	-	Since 1953 (10 years)
Mukamuka R. mouth	-	Since 1950 (13 years)
Palliser Spit	x 2	Since 1948 (15 years)

Slight or slow IncreaseApparently fairly Stable

Pipinui Pt.

Tokomapuna Is.

Leper Is.

Wharekohu Bay, Kapiti Is.

Ruamahanga R. mouth

Opau Bay

Te Humenga Pt.

Whangamoana cliffs

Otakaha R. mouth

Ngawihi Pt.

The populations of Mana Is., Somes Is., and Baring Hd. have more or less "exploded" during the last 20-25 years, and at least seven of the ten colonies showing big increases are located close to Wellington City, or other centres of human population. The lowest rate of increase amongst the larger colonies is shown by Palliser Spit which is many miles from any prominent or important food source. The two meatworks on the edge of Wellington harbour began operations in 1883 and 1889 respectively, while the city council abattoir opened in 1909. Since 1905 at least 13 rubbish tips have opened in the Wellington area, 10 of these have been in the last 20 years, and seven of the nine still operating are now major tips. Four sewers have also been built this century but do not attract many birds. Thus one factor which has undoubtedly influenced

expansion of the gull population is the growth of important food sources such as meat works, rubbish tips, and to a lesser extent wharves, sewers and playing fields in and around the city.

Unlike the northern hemisphere, expansion of the fishing industry in New Zealand this century has not been such as to have affected gull populations significantly. Limited evidence obtained in the Lake Wairarapa - Palliser Bay area suggests future studies on the fluctuation of numbers in Wellington gull colonies may benefit from examination of local farming practice in the use of insecticides on pastures and ploughed land, and the effects on the local bird population.

Although there are few available references it is apparent the increase in numbers of Southern Black-backs in New Zealand has not been confined to the Wellington area, thus in a review of the natural history of Canterbury compiled by the Philosophical Institute of Canterbury, Stead (1927, p.218) described the gull as being on the increase, aided by development of the meat-freezing, agricultural and shipping industries.

Numerous authors have described fluctuations of gull populations in various parts of the world, but few have deduced a relationship between increase in numbers of birds, and food supply of human origin. Among those who have are included Sparck (1950), Herring Gull L. argentatus in Denmark; Fisher and Lockley (1954, p.105), several species; Gross (1955), Herring Gull in eastern North America; Vermeer (1963, p.90),

Glaucous-winged Gull L. glaucescens in British Columbia; and Murray and Carrick (1964, p.186), Silver Gull L. novaehollandiae in Australia.

3. Total population

3.1 Breeding season

In my description (section II: 1.1) of the breeding colonies and roosting flocks which compose the Wellington population I covered 31 breeding colonies in the study area, ranging from four to ca. 2,000 pairs. These birds totalled an estimated 5,684 pairs in the 1963-64 season, and an upper limit of ca. 6,000 pairs was set to include those gulls scattered outside the colonies, especially on Kapiti Is., and along the west coast between Island Bay and Pipinui Pt. To obtain a gross estimate of the total population of the study area during the breeding season it is necessary to include birds present in communal flocks at feeding sites and elsewhere, with those in the breeding colonies. Such an estimate has of course only limited significance because some breeding birds are occasionally present in communal flocks (for feeding, bathing etc.) and some non-breeding birds are to be found in the clubs of breeding colonies. Nevertheless, there is value in an attempted assessment.

Monthly counts of communal flocks in the harbour area from 1961-62 and 1963-65 have shown that the minimum number of

birds are present in December, which corresponds with peak breeding and occupation of breeding grounds, (see below in section II: 3.3). Although counts of all communal flocks in December have not been made, I will attempt an assessment of the population at this time based on the harbour counts, regular counts along Wellington west coast between Titahi Bay and Waikanae from 1961-62, observations made during field work in the 1963-64 and 1964-65 breeding seasons, and on the aerial survey of 23/11/64.

On 16/12/64 there were ca. 1,900 birds in communal harbour flocks, while on 17/12/61 there were ca. 450 on the west coast between Titahi Bay and Waikanae. For the rest of the study area, i.e. the remainder of the west coast, south coast, refuse tips, playing fields and sewer outlets etc., in or near the city, and the Lake Wairarapa - Palliser Bay region, I estimate ca. $1,550 \pm 500$ birds, making a total of ca. $3,900 \pm 500$ in communal flocks. With 5,684 breeding pairs counted (and an upper limit of ca. 6,000 pairs) this indicates a total population at the height of breeding of $15,300 - 15,900 \pm 500$ birds.

3.2 Non-breeding season

In late summer and autumn communal flocks begin to increase in size as the gulls return from their breeding colonies. This shift of population to the communal flocks

steadily throws an increasing pressure on food resources as thousands of gulls concentrate at or near feeding sites such as tips and meatworks. This pressure which was, during breeding, spread over several hundred square miles reaches a maximum from March - May. To a large extent the same feeding sites are frequented, but instead of a regular influx of breeding birds whose arrivals are distributed throughout the day, the bulk of the population feeds at about the same time.

In order to determine the pressure on feeding sites, locate communal flocks, and make a census of the population in the non-breeding season, I made two flights round the study area (30th July 1964, and 14th April 1965) and on 9th June 1965, a single flight from Cape Palliser up the east coast of the North Island. Flight paths followed the coastline, but in the study area I visited all main refuse tips, meatworks, sewers, playing fields or other known resting or feeding sites, and all breeding colonies except four small ones by Kapiti Island. These surveys came after three to four years' study of the distribution of gulls in the area, so that I was able to plan a route to include nearly all places frequented by gulls (Fig. 3). The purpose of the east coast survey was to contrast the city population with that of an area largely uninhabited by man.

Flights were made with the rear door of the plane removed, at a speed of 90-100 knots and monochrome photographs of all flocks were taken from an altitude of 800 feet with a 35 mm.

FIGURE 3

Route taken and area covered in aerial surveys.

single lens reflex camera and 135 mm. telephoto lens (Plate 1). Stray birds were counted individually. Later the flocks were counted directly from the negatives using a binocular microscope or photographic enlarger. I chose a weekday for the surveys so that tips and meatworks were operating, and also fine calm weather not immediately preceded by rain so that gulls were not widely scattered onto farm land or playing fields.

Regular counts have shown peak harbour population to be in autumn (March-May) so discussion will centre on the census made on 14/4/65. This census revealed 12,236 gulls in the study area, 10,288 (84.1%) being within 11 miles of Wellington Harbour (Fig. 3). Sub-regional totals were as follows:

Waikanae R. south to, but excluding Karehana Bay (also including Kapiti Island)	359	2.9%
Porirua Harbour (Karehana Bay to and including Titahi Bay)	1,981	16.2%
Titahi Bay south to, but excluding Ohiro Bay (also including Mana Island)	574	4.7%
Wellington Harbour (Ohiro Bay - Pencarrow Hd.) and environs, and Hutt Valley	8,324	68.0%
Pencarrow Hd. - Turakirae Hd.	814	6.7%
Palliser Bay and lower Wairarapa	184	1.5%
	<hr/> 12,236	<hr/> 100.0%

As expected, breeding grounds were deserted; all birds having abandoned their territories. Only 93 (0.76%) were in the immediate vicinity of breeding grounds and most of these were at Baring Hd. in a normal communal flock.

One hundred and fifty miles of coastline were traversed, along which 7,285 gulls were found (either on the sea-shore, or immediately adjacent to it) giving an average of 48.5 birds per mile of coast. Figures for sections of the coast were:

	<u>Miles of Coast</u>	<u>No. of Gulls</u>	<u>Gulls per Mile</u>
Waikanae R. south to, but excluding Karehana Bay (also including Kapiti Is.)	18.75	359	19.1
Porirua Harbour (Karehana Bay to, and including Titahi Bay)	17.25	1,231	71.4
Titahi Bay to, but excluding Ohiro Bay (also including Mana Is.)	33.75	574	17.0
Wellington Harbour (Ohiro Bay - Pencarrow Hd.)	38.25	4,169	108.9
Pencarrow Hd. - Turakirae Hd.	7.5	814	108.5
Turakirae Hd. - W. end Palliser Spit	11.25	5	0.4
Palliser Spit - Cape Palliser	23.25	133	5.7
	<u>150.0</u>	<u>7,285</u>	<u>av. 48.5</u>

The contrast between Wellington City area and other stretches of coast is strong, particularly in the case of uninhabited or thinly populated areas such as the west coast (Titahi Bay - Ohiro Bay) and Palliser Bay (Fig. 4) where there are only occasional farms, batches, or small settlements. In the area of Porirua Harbour there is also increased human activity, and the number of birds per mile of coast rose to 71.4. The importance of principal feeding sites was further emphasised by the fact that of the total 12,236 birds in the area, 5,977 (48.8%) were at or near refuse tips or meatworks,

while in the Wellington and Hutt Valley districts alone 5,267 (63.3%) of the 8,324 birds were at or near tips and meatworks (Plate 2).

The census made in winter 1964 (30/7/64) did not reveal the peak non-breeding season population because the number of gulls had already declined considerably after the autumn maximum. The same route as described above was followed with the exception that three tips in the Wellington and Hutt Valley area, and one at Porirua were not visited. The number of gulls counted in the study area was 7,221, 5,401 (74.8%) being within 11 miles of Wellington, and nearly 60% of the gulls in the Wellington and Hutt Valley districts were at or near tips and meatworks. It should be noted, however, that these data are less than the true values because some tips were not visited, but the counts of birds per mile of coastline were unaffected by this and were generally similar in relative proportion to those of the flight in April 1965. There were an average 37.1 gulls per mile of coast, and Wellington and Porirua Harbours were the most densely populated areas. Uninhabited stretches of coast had fewer gulls except that 855 birds were at, or in the vicinity of, 11 breeding colonies, thus modifying the distribution pattern. Colonies most affected by this early congregation prior to breeding were Mana, Somes and Ward Islands, Baring Hd. and Palliser Spit.

Further comparison between the two flights shows that on both occasions very few gulls were found on the farmland

of the lower Wairarapa: in July 1964 some were present at the Waiorongomai R. and Ruamahanga R. mouth colonies, but apart from a small group in a ploughed field none were seen in April 1965. In July 1964 a number of birds were at sea close to the coast, while in April 1965 very few were seen, and in July no gulls were seen in the Hutt River whereas in April nearly 370 were counted. Details of sub-regional totals, and numbers of birds per mile of coast for the July flight are given in appendix 3.

To place the Wellington population in proper perspective I wanted a comparison with a region outside the study area, and so in early June 1965 I made an aerial survey along the largely uninhabited coast between Cape Palliser and Castle Point (see Fig. 3). Here human habitation is limited to coastal farms and one small holiday settlement, while the shore-line itself is mainly rocky to the south, passing to shingle and sandy beaches in the north. Birds were scattered along the coast mostly in small groups numbering 10 or less. The groups were generally on the beach near farm buildings, or at stream mouths, showing the birds were still attracted to centres of human activity.

A total of 180 gulls were counted along just over 74 miles of coast, giving an average of 2.4 birds per mile. Sub-regional totals were as follows:

	<u>Miles of Coast</u>	<u>No. of Gulls</u>	<u>Gulls per Mile</u>
Cape Palliser - Honeycomb Rk. lighthouse	34.5	69 (38.3%)	2
Honeycomb Rk. lighthouse - Uruti Pt.	22.5	103 (57.2%)	4.6
Uruti Pt. - Castle Point lighthouse	18.25	8 (4.5%)	0.4
	<u>74.25</u>	<u>180 (100.0%)</u>	<u>2.4</u>

Although this survey was two months later than the one in the study area, it was made under similar conditions, i.e. on a weekday, in fine weather, and the distribution of birds (2.4 per mile) was very different to that in the study area as a whole (48.5 birds/mile) and Wellington Harbour in particular (108.9 birds/mile). The census thus provided the expected strong contrast with the population in the study area, particularly Wellington Harbour, and we are led to the inevitable conclusion that because the scavenging habit of the gull has enabled it to adapt to changes in human population, the distribution of the species is now influenced enormously by human habitation, and the study area has, on this account, an inflated population when compared with a region where human population is light.

3.3 Communal flocks

Outside breeding colonies most Southern Black-backs gather in communal* flocks, the activities of which are feeding, care of the body surface, sleeping, fighting etc. (Frontispiece, Plates 1 & 2). By the special nature of the activity involved, flocks of feeding birds are generally distinct from other flocks, where much of the time is spent in non-violent activities such as preening, standing, sitting or sleeping. Hence for the sake of convenience I shall divide communal flocks into either feeding or resting, in order to describe the major activity involved.

In a review of flocking behaviour Werth (1960, pp.744 & 747) considered that the range of gregariousness in birds (from solitary species to completely gregarious types) suggests flock formation evolved at an early period in bird evolution. Since then birds have evolved away from this basic gregariousness and Werth exemplifies rooks, gulls and geese as those types that have retained the more primitive gregariousness. Tinbergen (1951, p.112) suggested there is no separate social instinct, and that for a social animal (one which strives to be in the neighbourhood of fellow members of its species when performing some, or all of its instinctive activities) other members of the species form part of the adequate stimulus situation when

* "Communal" is a useful term for gatherings of gulls whose activities are not primarily nesting or roosting, and in a sense has been used already by Moynihan (1962) who referred to gulls and terns in "communal" areas away from breeding colonies.

these instincts (e.g. feeding, sleep) are active. Moynihan (1960, p.540) concluded that characters which seem adapted to promote gregariousness directly by increasing or facilitating the tendency of birds to join one another are conspicuous colouration (pied colouring in many gulls and terns); flash patterns on wings, rump, and/or tail; call notes; ritualized flying intention movements; and increased general mobility or restlessness.

Despite the readiness with which the majority of Southern Black-backs congregate, a small number do not join flocks but instead remain apart or in pairs, and together with birds flying between flocks, or apparently wandering, make up a "floating" itinerant section of the population. During the year there are marked fluctuations in the structure, size and number of flocks; both the latter showing an autumn peak and summer low. Communal flock sites are generally constant, but actual formation of flocks is not constant. The positions of regular and irregular communal flocks are shown in Fig. 4 where the relationship to centres of human population, and to major feeding sites is apparent. By contrast there are only a few flocks on uninhabited coasts, and most of these are at stream estuaries.

3.31 Fluctuation in numbers

In March 1963 monthly one-day counts of communal flocks round the harbour were recommenced, and continued until April

FIGURE 4

Communal flock sites in the study area, in relation
to built-up areas and major feeding sites.

Relative sizes of the flocks are not indicated. Diffuse
flocks (such as those along Wellington wharves) are not
shown, neither are some of the irregular flocks in the
Hutt Valley.

1965. These followed similar counts made between July 1961 and June 1962 and included some 33 miles of the harbour shores. Half the area (Oriental Bay to Ohiro Bay) was always covered in the morning, the other half (Muritai to Ngauranga) in the afternoon. Flock positions were mapped, each was counted (including itinerant birds) and in most cases the relative numbers of immature and adult birds noted. Flock totals and adult to first year ratios were calculated separately for the two portions of the count (the southern "city" end, and northern "Petone" end), then the overall total and ratio was taken.

Although four age classes may be recognized (first, second, third year and adult) first year and adult birds were chosen for special comparative attention because they share a relationship of considerable significance; they are the direct indicators of the future population. First year (and usually second year) birds could be identified at all times of year, but except for a few months following the moult near the end of the second year, it was impossible to identify third year birds with certainty. Thus any inaccuracy in an adult to first year ratio lay in the enforced inclusion of some third year birds with the adult group.

The counts did not, of course, include the whole population of the study area, but rather a representative sample, and covered populated and uninhabited coastal stretches, important feeding, and major resting sites, as well as numerous flocks

of no marked single character. The area of the counts and results are shown in Fig. 5. Details are given below in Table 1 in which census figures comprise estimates as well as accurate counts, and therefore are approximate.

TABLE 1 MONTHLY CENSUS AND ADULT : FIRST YEAR RATIO

	<u>1961</u>	<u>1962</u>	<u>1963</u>	<u>1964</u>	<u>1965</u>
<u>Jan.</u>		*1,151		1,747	2,346
<u>Feb.</u>		3,182 10.3		2,695 5.6	3,378 3.5
<u>Mar.</u>		4,338 6.6	5,302 6.5	4,900 7.0	*3,525 3.8
<u>Apr.</u>		4,336 6.1	*3,650 8.7	6,747 7.2	4,899 5.5
<u>May</u>		3,645 4.3	4,767 10.0	6,469 8.0	
<u>Jun.</u>		4,029 4.3	*3,502 3.8	*4,381 7.3	
<u>Jul.</u>	*1,717 3.2		3,384 4.2	3,750 3.9	
<u>Aug.</u>	2,583 2.4		*2,049 3.3	3,611 4.6	
<u>Sep.</u>	*1,862 1.5		*3,640 2.6	*2,150 1.5	
<u>Oct.</u>	2,574 1.3		2,844 1.9	2,234 1.2	
<u>Nov.</u>	1,518 0.6		2,644 1.7	1,645 1.0	
<u>Dec.</u>			1,799 0.7	1,918 0.6	

* Census apparently affected by weather, tides etc. (see below).

Counts were made about the 20th of each month, and mostly on the same day of the week. In this way tidal conditions and human activity remained about the same. It was found that gross fluctuations sometimes resulted from counts made during the weekend; this was because meatworks and refuse tips were usually not operating, and more people were present on beaches

FIGURE 5

A Fluctuations in adult to first year ratio, and the route taken during monthly counts.

B Fluctuations in the Wellington Harbour population.

A

B

than during the working week. In all cases where an extraordinary change was recorded in the population, it could be attributed to one or several factors: 1. the count was made at the weekend; 2. tidal movements were out of phase with those of other counts (this meant for instance that Petone beach was largely covered by water during the count, thus preventing gulls from standing there); 3. several days of heavy rain during or prior to the count, thus inducing birds to visit water-logged playing fields or pastures in search of food; 4. unusual human activity causing gulls to vacate a normally undisturbed locality.

Counts that were noticeably affected by one or more of these factors are marked with an asterisk in Table I and include the following: 1961: July (weekend, wet weather), September (tidal movements); 1962: January (weekend); 1963: April (weekend, wet weather), June (weekend, wet weather), August (weekend, wet weather), September (unusual activity on Somes Is. may have driven some breeding birds away to communal flocks); 1964: June (prior wet weather), September (cause uncertain); 1965: March (prior wet weather). In each case excepting September 1963, the effect was a lowering of the expected total.

As seen in Fig. 5 the communal flock population is minimum for the period November to January while breeding is at its peak, and the first marked influx of birds occurs in February. Gulls continue to arrive rapidly and flocks reach peak density

between March and May, then in June, with the onset of winter, numbers begin to decline steadily right through to the following breeding season. Although the minima for the three breeding seasons 1961-62, 1963-64, and 1964-65 were not greatly different, the autumn maxima showed an increase between 1962 and 1964 of the order of 2,400 birds (53%). This increase was almost certainly a reflection of the rapid population expansion which occurred in the area during the last five to ten years.

The relative numbers of adult and first year birds (Fig. 5a) are discussed below but it is worth noting here that the peak ratios dropped from 10.3:1 (1962) to 8.0:1 (1964), with indications of a further drop in 1965. This drop in the ratio, combined with the demonstrable increase in total numbers of birds up to 1964 (at least) implies an increase in the juvenile portion of the population and a subsequent rise in feeding pressure in the harbour area.

In 1964 the maximum count for any month was 6,747 birds (in April), and the mean number of birds present over the whole year (3,530) was 52.2% of the maximum counted. The percentage of birds present in the first (peak period) and second halves of 1964 are shown below:

	<u>Whole year</u>	<u>January-June</u>	<u>July-December</u>
Mean no. of birds	3,520	4,489	2,678
Percent of maximum count	52.2	66.5	39.7

Throughout the year an average of over half the maximum number of birds were present, which indicates that the Wellington

Harbour population is maintained at a fairly high level. In 1963 the mean number of birds present in the second half of the year (2,912) was 54.9% of the maximum count of 5,302 birds.* This value is considerably higher than the 37.9% recorded in 1964, and probably resulted from the late departure of breeding adults owing to the unfavourable weather in spring 1963-64 (Section III: 3.13). Mean numbers of birds present during parts of the year (from 1961-65) further illustrate the increase in population up to 1964.

MEAN NUMBERS COUNTED DURING THE YEAR (FROM TABLE 1)

	<u>1961</u>	<u>1962</u>	<u>1963</u>	<u>1964</u>	<u>1965</u>
<u>Whole year</u>				3,520	
<u>Jan. - Apr.</u> (annual build-up period)		3,251		4,022	3,537
<u>Jan. - Jun.</u>		3,446		4,489	
<u>Jul. - Nov.</u>	2,050		2,912	2,678	

Like the communal flock population, the number of itinerants varied through the year, and was minimum in January during the breeding season. In the non-breeding season wide fluctuations in numbers were recorded, and the pattern was different each year (Table 2).

* It is presumed the March count would have been the maximum for the year because numbers are still building up in January and February.

TABLE 2 NUMBER OF ITINERANTS AND PERCENTAGE OF TOTAL POPULATION

	<u>1961</u>	<u>1962</u>	<u>1963</u>	<u>1964</u>	<u>1965</u>
<u>Jan.</u>		127 11.0		176 10.0	159 6.7
<u>Feb.</u>		387 12.2		307 11.3	243 7.1
<u>Mar.</u>		379 8.7	317 5.9	334 6.8	
<u>Apr.</u>		470 10.8	278 7.6	450 6.6	
<u>May</u>		486 13.3	451 9.4	260 4.0	
<u>Jun.</u>		717 17.8	465 13.2	274 6.2	
<u>Jul.</u>	285 16.6		460 13.5	350 9.3	
<u>Aug.</u>	422 16.3		535 26.1	365 10.1	
<u>Sep.</u>	300 16.1		516 14.1	331 15.3	
<u>Oct.</u>	378 14.7		413 14.5	297 13.2	
<u>Nov.</u>	287 18.9		231 8.7	208 12.6	
<u>Dec.</u>	- -		156 8.6	165 8.6	

The average monthly percentage of itinerants in the total population was 9.4 (range 4.0 - 26.1%; based on the two years from March 1963 to February 1965) and in 1963 and 1964 the proportion was maximum in winter and early spring.

During the breeding season numbers of itinerants dropped rapidly, and this period was examined to see what changes in composition occurred. From August 1964 to March 1965 itinerants were counted in separate age groups (Fig. 6). These counts showed that the number of adults dropped steadily until January, then rose sharply when birds returned from the colonies. The number of first year birds was steady until December, then

FIGURE 6

Composition of itinerants during the breeding season.
Summer = December-February.

dropped, possibly as a result of increase in the supply of offal from meatworks in November. No young of the year were seen in January, but numbers increased after this. The number of second year birds dropped slowly till December, then rose in January as young of the previous season entered their second year.

The proportion of all juveniles in the itinerant population was greatest in November (21%), when many adults had already left for the breeding colonies, but the numbers of first and second year birds had not yet dropped very much.

3.32 Composition

As previously mentioned the changes in relative numbers of adult and first year birds were noted during the year, and expressed as a ratio. The counts revealed that very few first year birds (i.e. young of the year) join communal flocks in January so the adult to first year ratio is very high; in 1962 and 1964 there were no chicks present in January, and in 1965 there were relatively so few that an accurate calculation of the ratio was very difficult, being somewhere in excess of 50 : 1. From the results it appears the ratio increases until May, then drops, fairly rapidly at first till December (Fig. 5). The increase between February and March corresponds with the arrival of adults and young from the breeding colonies, and

from March to May with the mortality of some of the young; heaviest losses in the first year being prior to June (see Table 31).

From July to August onwards the drop is correlated with the departure of adults to the breeding colonies, whereas between May and July a variety of causes probably contribute to the drop. First of all heaviest killing at the meatworks is from November to June, with a peak in January and February (McIlwaine, 1964) so that until a month before the first adults begin to gather for breeding there is a considerable amount of offal available in the harbour. Presumably therefore it is not lack of food in autumn and early winter which causes adult dispersion (with resultant drop in the ratio). On the contrary the available offal and refuse appears to attract young birds to the city from adjacent flocks, and it may be their presence that lowers the ratio. Evidence in support of this hypothesis was found during six counts round the Pauatahanui Inlet (about nine miles north of Wellington Harbour) between mid July and early September. During this period some very large flocks were found in paddocks and on beaches, and they comprised a vast majority of adults (i.e. a very high ratio of adults to first year birds) suggesting that young birds were seeking food elsewhere. In addition sight and dead recoveries of birds banded in colonies outside Wellington Harbour indicate that a considerable proportion of gulls come to feed in the harbour

vicinity in autumn and early winter (Section IV: 5). Start of lambing in August and September was thought by Secker (1952) to initiate large scale movement of gulls away from the harbour, but there is sufficient evidence from the location of flocks outside the city, and from general behaviour of individual predatory gulls to make this appear, at best, of minor importance.

Finally, whaling at the Tory Channel Whaling Station extends from about July to October i.e. mid winter to mid spring (McIlwaine, 1964) and succeeds the heavy killing period at the city meatworks. However complete absence of recoveries of banded Wellington gulls from the whaling station suggests they are not attracted across Cook Strait for food. Further, the spring drop in the adult to first year ratio can be largely attributed to the departure of adults for breeding.

When numbers of second year birds were related to the numbers of adults (Table 3) it was found that from April onwards the ratio of adult to second year birds was higher than the ratio of adult to first year birds. This simply reflects the fact that by April, second year birds have already been exposed to mortality in the first year, as well as to a considerable proportion of the losses which occur in the second year (Section IV: 4.2). However between January and March young of the year are still joining communal flocks so that their numbers do not exceed those of second year birds, and for this short period the ratio of adults to second years is lower than

the ratio of adults to first years.

TABLE 3 SECOND YEAR BIRDS PRESENT IN 1964*

	<u>J</u>	<u>F</u>	<u>M</u>	<u>A</u>	<u>M</u>	<u>J</u>	<u>J</u>	<u>A</u>	<u>S</u>	<u>O</u>	<u>N</u>	<u>D</u>
<u>Adult</u>	348	991	2,355	2,078	2,788	1,578	867	1,482	521	490	500	186
<u>Second year</u>	213	353	359	281	252	147	213	212	178	227	183	152
<u>Adult:</u> <u>Second</u> <u>year</u>	1.6	2.8	6.6	7.4	11.0	10.7	4.1	7.0	2.9	2.2	2.7	1.2
<u>**Adult:</u> <u>First</u> <u>year</u>	-	5.6	7.0	7.2	8.0	7.3	3.9	4.6	1.5	1.2	1.0	0.6

* The adult to second year ratio was not always observed in the biggest flocks.

** From Table 1.

The Petone portion of the route followed each month (Fig. 5) included two large feeding sites and one very large resting site, with the result that in almost every month more gulls were counted there than at the city end. But the average adult to first year ratio at the Petone end was lower than that at the city end in 20 out of 34 counts, mostly in late summer and autumn (appendix 4). The imbalance of relative numbers of young birds at the Petone and city ends sometimes lasted for two to five months consecutively in one direction, and no doubt was caused by the concentration of young birds at meatworks during the period of heavy killing in summer and autumn.

When the adult to first year ratios of regular communal flocks were compared with monthly averages it was found that

some were nearly always below, while others were consistently above. This meant some flocks generally contained a fairly high proportion of young birds, while other flocks generally had more adults (Table 4).

TABLE 4 FLOCKS FROM WHICH REGULAR ADULT TO FIRST YEAR*
RATIOS WERE OBTAINED

<u>FLOCKS AT OR NEAR FEEDING SITES</u>			<u>FLOCKS AT RESTING SITES</u>		
	<u>Months</u> <u>Above</u> <u>Average</u>	<u>Months</u> <u>Below</u> <u>Average</u>		<u>Months</u> <u>Above</u> <u>Average</u>	<u>Months</u> <u>Below</u> <u>Average</u>
Oriental Bay	1	22	Kilburnie	16	1
Lyall Bay	6	14	Scorching Bay	13	4
Island Bay	3	13	Seatoun	16	4
Ohiro Bay	8	18	Fort Dorset	14	1
W. Petone	7	14	Breaker Bay	19	2
Korokoro Stm.	6	12	Airport S.	11	1
			Airport	14	2
			Days Bay	10	4
			Gracefield	13	2
			Hutt R. mouth	16	7

* Eleven other flocks were observed, but these either formed irregularly, or provided ratios above or below the average with approximately equal occurrence.

The flocks usually below the monthly average were either located at or adjacent to prominent feeding sites; those usually above were resting sites which did not regularly offer much food (e.g. reclaimed land, estuarine sand bars, playing fields, and some beaches not close to a feeding site); and

those above and below with approximately equal occurrence were located near an irregular food source. In other words resting flocks without ready access to food contained few juveniles, whereas feeding flocks contained a higher proportion of juveniles.

Feeding and resting flocks showed practically the same fluctuations in the adult to first year ratio, i.e. following the peak in autumn and winter the numbers of adults present in feeding flocks dwindled at about the same rate as those in resting flocks (Table 5).

TABLE 5 SEASONAL FLUCTUATIONS IN THE ADULT TO FIRST YEAR RATIO IN SOME FEEDING AND RESTING FLOCKS WHICH FORMED REGULARLY IN 1964.

MAINLY FEEDING FLOCKS

	<u>J*</u>	<u>F</u>	<u>M</u>	<u>A</u>	<u>M</u>	<u>J</u>	<u>J</u>	<u>A</u>	<u>S</u>	<u>O</u>	<u>N</u>	<u>D</u>
Oriental Bay	-	1.6	7.1	3.7	5.2	1.4	2.3	0.7	0.5	0.1	0.7	1.6
Ohiro Bay	-	8.0	6.8	9.0	10.5	4.5	2.0	1.8	0.8	0.7	0.8	0.3
Petone beach W.	-		2.9	5.8	3.1	2.9	1.0	2.0	0.7	0.5	0.5	0.8
Korokoro Stm.	-	4.0	2.8	3.5	3.1	2.8		4.0	4.0	0.5	0.2	

MAINLY RESTING FLOCKS

	<u>J*</u>	<u>F</u>	<u>M</u>	<u>A</u>	<u>M</u>	<u>J</u>	<u>J</u>	<u>A</u>	<u>S</u>	<u>O</u>	<u>N</u>	<u>D</u>
Breaker Bay	-	29.0	18.0	16.0	13.6	2.8	5.0	5.7	2.8	1.3	2.6	8.0
Fort Dorset	-	—*	43.0	25.0	33.0	9.5	45.0	3.0	5.3	6.0		
Hutt R. mouth	-	5.4	15.9	9.4	22.0	16.0	6.4	10.4	1.0	3.2	0.6	0.4

* Ratios too high to measure.

But peak attendance of all birds at feeding sites, especially those at or immediately adjacent to meatworks was in late summer and autumn (Table 6), whereas in resting flocks there was no clearly defined period of peak attendance, except that more birds appeared to be present in winter and early spring.

TABLE 6 ATTENDANCE AT SOME FEEDING AND RESTING FLOCKS WHICH FORMED REGULARLY IN 1964.

	<u>FEEDING FLOCKS</u>					<u>RESTING FLOCKS</u>		
	<u>1*</u>	<u>2*</u>	<u>3*</u>	<u>4</u>	<u>5</u>	<u>6</u>	<u>7</u>	<u>8</u>
<u>Jan.</u>	80	124	30	19	34	129	11	-
<u>Feb.</u>	200	80	67	53	85	263	59	26
<u>Mar.</u>	-	563	155	128	164	600	65	138
<u>Apr.</u>	600	724	114	126	139	550	56	110
<u>May</u>	1,040	575	222	60	150	350	44	141
<u>Jun.</u>	780	150	170	18	69	640	27	46
<u>Jul.</u>	533	98	5	140	110	1,000	82	51
<u>Aug.</u>	210	120	28	100	105	855	70	17
<u>Sep.</u>	36	45	11	41	64	700	48	50
<u>Oct.</u>	161	212	59	35	151	360	24	60
<u>Nov.</u>	250	27	68	32	165	236	14	-
<u>Dec.</u>	550	14	-	27	95	550	29	59

1. Ngauranga
2. Petone W.
3. Korokoro Stm.
4. Oriental Bay

5. Ohiro Bay
6. Gracefield
7. Breaker Bay
8. Fort Dorset

* Flocks at, or adjacent to meatworks.

This was consistent with seasonal availability of food from meatworks, and suggested that when the volume of discarded offal waned in autumn, more birds frequented resting sites. Also, after the breeding season adults increase in weight and first and second year birds show rapid growth which levels off in winter (Fordham, 1963 a). During this period therefore both young and old birds would be feeding actively, which probably explains peak attendance at feeding sites in late summer and autumn. Acting in association with this is a general tendency for birds to eat more food in cold weather (Kendeigh, 1949, p.115; Seibert, 1949, p.137; Davis, 1955, p.391). However attendance at all flocks was affected by their position relative to breeding colonies, roosting sites and, in the case of feeding flocks, to the type of food available. McIlwaine (1964) was also able to correlate the peak summer population of Giant Petrels Macronectes giganteus in the harbour with the amount of offal available from meatworks, but unlike the present study she was able to relate the following drop in winter with whaling activity at the Tory Channel Whaling Station.

Although flocks comprised mainly or entirely of one age class were sometimes found, their existence was explained by the breeding or feeding requirements of the absent age group(s) and there was apparently no socially imposed segregation into flocks of a single age. For instance resting flocks were

sometimes composed entirely of adults because the younger birds were away at feeding sites. And during the breeding season while most of the adults were absent, small flocks of first year or juvenile birds were occasionally found.

During summer breeding birds continue to visit communal flocks, but appear to frequent those close to their breeding colonies rather than ones that are further away. On seven counts out of eleven between September and December for the years 1961, 1963 and 1964, the average ratio of adults to first year birds in flocks close to breeding colonies was higher than that of flocks further away, indicating that the adults were not travelling far from their colonies. In the non-breeding season however there was no difference between the ratios of flocks close to, and far away from breeding colonies.

In the breeding season attendance of adults in communal flocks fluctuated during the day. Evidence of this was obtained in 1964-65 when notes were taken of the proportion of birds present in the breeding colony during the day, in an effort to deduce the periods of minimum attendance, and thus by implication the periods of peak attendance of breeding birds at communal flocks. The observations were made on Somes Is. where, in the course of behavioural studies a group of 15 pairs were observed for 17 hours over three days, and the numbers present counted at five minute intervals. The counts (presented in appendix 5) showed that an average of 24 (81%) of the 30 birds

were present, and that the range of attendance was 63% - 100%. When strangers were present attendance reached 103%. Thus in the periods of minimum attendance at the breeding colony up to 37% of the birds were absent, and it is known at least some of these would have joined communal flocks.

The periods of minimum attendance suggested by the counts were early morning (before about 8.30 a.m.), mid afternoon (between about 2 p.m. and 4 p.m.) and late afternoon (after 5 p.m.), so it may be expected that at these times more breeding birds were present in communal flocks than at other times. Similar counts made between 9 a.m. and 3 p.m. at the northern colony, Baring Hd. showed an average 79% of the birds were present, and a period of minimum attendance between 12 noon and 3 p.m. Observations in several communal flocks round the harbour (Table 7) suggested more adults were present from early to mid afternoon than during the morning, and showed a tendency for the number of **adults** to increase between 1 p.m. and at least 3 p.m. This coincided with a period of minimum attendance at the breeding colony, and implied the presence of more breeding birds.

TABLE 7 COMMUNAL FLOCKS DURING THE BREEDING SEASON

<u>LOCALITY</u>	<u>DATE</u>	<u>TIME</u>	<u>FIRST YEAR BIRDS</u>	<u>ADULTS</u>	<u>ADULTS : FIRST YEAR</u>
Lyall Bay	19/11/64	10 a.m.	10	7	0.7
		10.30	6	7	1.1
		11.	8	5	0.6
		11.30	10	4	0.4
<u>Houghton Bay</u>	19/11/64	12.30 p.m.	12	8	0.7
		1	11	8	0.7
		1.30	10	13	1.3
		2	10	13	1.3
		2.30	12	18	1.5
		3	14	13	0.9
<u>Lyall Bay</u>	2/12/64	9 a.m.	18	10	0.6
		10	13	8	0.7
		1.5 p.m.	9	9	1.0
		2	15	9	0.6
		2.30	19	11	0.6
		3	7	5	0.7
<u>Houghton Bay</u>	3/12/64	10.40 a.m.	18	-	0.0
		11.10	18	1	0.5
		12	16	3	0.2
		1.20 p.m.	13	2	0.2
		2	16	7	0.4

3.33 Integration

Repeat sightings of banded or recognizable individuals indicate that some birds have regular habits and visit the same area, flock, or feeding site frequently, in some cases daily. Some examples of these sightings are given below.

<u>Gull</u>	<u>Sightings</u>	<u>Location</u>	<u>Period</u>
S 6052	4	Wellington wharf	March-September 1962
S 9491	4	Wellington wharf	September-December 1962
S 3345	6	Oriental Bay	April 1961-April 1962

S 9527	6	Wellington wharf	April 1962-March 1963
S 9616	6	Oriental Bay	May 1962-August 1963
S 7077	7	Wellington wharf	July-November 1962
S 9422	12	Wellington wharf	May 1962-March 1963
S 13886	Every day	City building	Several months prior to May 1965
One-legged bird	16	Pukerua Bay	March-September 1964
Breeding* pair	Almost every day	Private residence in Stokes Valley	At least May 1963- April 1964

* For a few months each autumn this pair was accompanied by a chick.

Although some birds regularly visit certain areas, communal flocks do not comprise a regular unchanging complement of gulls. Observations made in many flocks between autumn and spring in 1964 showed that throughout the day individuals fly to and from flocks, and sightings of colour-banded or recognizable individuals indicated that gulls may join a flock for the period of a few days or less. For instance the apparently discrete flock at Pukerua Bay, about 14 miles north of Wellington Harbour, was observed for several hours on 25 occasions between 19/3/64 and 1/9/64. Pukerua Bay, the site of a small coastal flock usually numbering between 20-50 individuals, is several miles from any main feeding site and is about six miles from the nearest major roosting site - Mana Is. I presumed therefore that the local flock would comprise mainly regular birds, and would not often be joined by itinerants

from other areas. When observations began nearly all the birds in the flock were unbanded so their places of origin were unknown, but by noting the presence of colour-banded or recognizable individuals I found that representatives of several breeding colonies joined the Pukerua Bay flock for short periods, though some may not have been present for longer than a day.

The sightings were as follows:

<u>COLONY</u>	<u>AGE OF BIRD</u>	<u>NUMBER PRESENT</u>	<u>TIMES OBSERVED</u>
Mana Is.	1st yr.	1	6
" "	1st yr.	2	1
Kapiti Is.	1st yr.	1	2
" "	2nd yr.	1	3
" "	2nd yr.	2	1
Palliser Spit	2nd yr.	1	3
Somes Is.	1st yr.	1	1
" "	2nd yr.	1	1
" "	adult	1	1
Mukamuka R.	1st yr.	1	1

Similar observations made at other flocks also indicated a changing membership of gulls. New arrivals to the flock sometimes departed within minutes, while others (in this case colour-banded individuals) stayed for several hours before leaving, which indicated that a bird may join and leave several resting or feeding flocks during the day. These movements are probably influenced by the location of the roosting site from which the bird came relative to the site of regular communal flocks, its place in the social hierarchy, availability of food, and local disturbances.

From the evidence of repeat sightings of recognizable individuals in some areas, and of the irregular attendance of colour-banded birds in numerous flocks it appears therefore each communal flock is composed of a nucleus of birds which attend more or less regularly, and a varying number of birds which attend once or a few times only before moving on. In Britain, Hickling (1957, p.185) noted that individuals constantly left and joined mixed flocks of gulls, and in small flocks where all birds were watched, none stayed as long as half an hour.

Feeding flocks are, without question, composed of birds from many colonies, and even seemingly discrete flocks located some miles from any others (e.g. Pukerua Bay and Ohariu Bay) do not have a fixed and unchanging membership. For this reason communal flocks of gulls exist in a rather "fluid" state, and are partially integrated by the itinerant birds. As previously mentioned these birds, which may be seen any time between dawn and dusk flying singly or in small loose groups, represent throughout the year an average 9.4% of the population. During the day birds from several roosting sites may gather in feeding and resting flocks, and an individual from one particular roosting flock may eventually become a member of a group which at dusk flies to a different roost. In this way Kapiti Is. birds have been recovered on Mana Is.; Kapiti Is., Baring Hd. and Palliser Spit birds on Somes Is.; and Somes Is.

birds on Leper Is., Ward Is., Mana Is. and at Baring Hd. Most of the recoveries, which are summarised below, were made on Somes Is. where six birds from other colonies were captured while roosting.

<u>Banded</u>	<u>Recoveries (dead or recaptured)</u>
Somes Is.	Mana Is. 2 (+ several colour-band sightings), Leper Is. 3, Ward Is. 2, Wairau R. 1.
Palliser Spit	Somes Is. 4, Baring Hd. 1.
Baring Hd.	Somes Is. 3.
Kapiti Is.	Somes Is. 1, Mana Is. 1.

Although it is not uncommon for Southern Black-backs to roost away from their natal colonies during the immature years, or in the non-breeding season, I suspect, from the limited evidence available, that they return to their natal colonies to breed.

Demonstration of the integration of communal flocks was also found in autumn and winter observations of dawn and dusk flight-movements to and from roosting sites and some major feeding sites. These observations were made at the roosting sites themselves, and at various vantage points in and around the city. Other information was obtained during aerial surveys of the study area, and several people kindly brought their own observations to my attention. These included: D. Arthur, Mrs. J.V. Mainwaring, Mrs. J. Mason, K.H. Miers and L.J. Paul.

FIGURE 7

The integration of communal flocks: flight
movements to roosting sites at dusk.

sites. Individual communal flocks have not been marked on the figure, but are spread all round the coast as shown in Fig. 4. The observations of flight movements permitted a number of conclusions which show that during the day there is considerable mixing of the various elements of the population.

1. Flight paths of single birds or groups generally follow the topography of the country with movement concentrated along valleys and over saddles. Often gulls drift along on the lee side of a ridge just below the crest where presumably they ride the up-draughts which result from wind flowing over the ridge.*
2. Gulls roosting on Somes Is. dispersed widely during the day, showing a strong movement along the Hutt Valley, and to the city area, especially to major feeding sites. They also fed at Island Bay tip, although other large feeding sites were much closer.
3. Baring Hd. birds travelled into the city and to Wainuiomata to feed.
4. Taputeranga Is. birds dispersed at least as far as Wilton tip, and apparently some reached Ohariu Bay.
5. Mana Is. birds showed an amazing diurnal movement which reached Johnsonville tip, at least one of the meatworks beside Wellington Harbour, and almost certainly the two refuse tips in the upper Hutt Valley area. Passage of gulls between the west coast and the Hutt Valley has been recorded by Bull (1959).

* For discussion of this subject see Forster (1955).

Mana Is. birds also moved north along the coast towards Kapiti Is.

6. Kapiti Is. birds spread along the west coast, and reached at least as far as Pukerua Bay to the south.

7. At Johnsonville tip birds from Mana Is., Somes Is. and the Ohariu Bay region mingled, while at Wilton tip birds from Somes Is. and Ohariu Bay joined those from Taputeranga Is. and Karori Stm. At Island Bay tip some Baring Hd. birds probably joined those from Taputeranga Is. and Somes Is.

The overall result is that communal flocks are not discrete units, but instead display considerable integration which tends to knit the whole population together. This behaviour affects the social structure of the flocks because every new arrival means that a modification to the social hierarchy must eventually follow, and this results in a large number of disturbances during the day. For example, during periods of high activity, especially during the morning, such aggressive disturbances may occur at the rate of more than three per bird each half-hour (Fordham, unpublished observations).

4. Summary

1. In 1963 a population-ecology study of Southern Black-backed Gulls was started in Wellington. The study area chosen was south of a curved line between Kapiti Is. and Cape Palliser,

including the Lake Wairarapa region. Most (if not all) of the colonies supplying the bulk of the Wellington population were in the area.

2. Thirty-one breeding colonies have been described (21 on the mainland and 10 on islands), ranging in size from a few scattered pairs to about 2,000 pairs. Solitary pairs are scattered round the coast.
3. The number of pairs breeding in the area in 1963-64 was counted at 5,684, with an estimated upper limit of 6,000.
4. Brief descriptions of the 11 colonies not included in the comparative breeding study have been given.
5. There are at least 16 permanent roosting flocks in the area and seven others likely but unconfirmed.
6. An account of the history of the Wellington colonies has been given. In 1839 Southern Black-backs were not recorded in Wellington Harbour (although they were probably present) but by 1888 an increase in numbers was noted, and up to the time of writing (1965) the population as a whole has multiplied many times over. In recent years only four small colonies have become defunct.
7. Some colonies have grown very rapidly since 1900, and in the last 20 - 25 years the three largest have multiplied about eight, nine and eleven times respectively.
8. The correlation between the population "explosion" and food supply has been discussed, with the conclusion that growth

of important feeding sites such as meatworks, rubbish tips, wharves, sewers and playing fields near the city has enormously influenced the increase in numbers of gulls.

9. The total population in the study area during the breeding season was assessed at 15,300 - 15,900 $\pm$ 500 birds. This included 5,684 counted breeding pairs (with an estimated upper limit of 6,000 pairs) plus an estimated 3,900 $\pm$ 500 birds in communal flocks.

10. In autumn 1965, i.e. during the period of peak population in the non-breeding season, an aerial survey revealed 12,236 gulls in the study area, over 84% being within 11 miles of Wellington Harbour. There was an average of 48.5 birds per mile of coast, with extremes of almost 109 birds per mile in Wellington Harbour, and 0.4 birds per mile on uninhabited coast.

11. In the non-breeding season 48.8% of all gulls in the area were at or near refuse tips or meatworks, while in the Wellington and Hutt Valley districts alone 63.3% were at or near tips and meatworks.

12. A census of the non-breeding season population made in winter 1964 has been compared with that made in autumn 1965.

13. An aerial survey during the non-breeding season of a largely uninhabited stretch of coast adjacent to the study area revealed an average 2.4 birds per mile.

14. The distribution of the species is influenced enormously by human habitation.

15. In comparison with a region where the human population

is not dense the study area has an inflated population of gulls.

16. Away from breeding colonies gulls gather in communal flocks which are mainly located near centres of human population, or major feeding sites. On uninhabited coast only a few flocks form, mostly at stream estuaries.

17. Regular monthly counts have been made of communal flocks round Wellington Harbour. Low counts resulted when major feeding sites were not operating (i.e. tips and meatworks), when high tides covered resting sites, after very wet weather, and during unusual human activity.

18. The communal flock population was minimum between November and January (peak breeding time) and the first marked influx of birds was in February. Peak density was between March and May, after which numbers steadily declined to the following breeding season. Between 1962 and 1964 the autumn maxima increased by about 2,400 birds (53.3%), and the evidence indicates that this was largely composed of young gulls. The average number of birds per month over the whole year was 3,530, 52.2% of the maximum counted.

19. The number and percentage of itinerants in the total population was maximum in winter and early spring, and the average percentage per month was 9.4. During the breeding season the number of itinerants dropped rapidly, mainly because adults left for their colonies. The proportion of immature birds in the itinerant population was greatest in November (21%).

20. Very few young of the year joined communal flocks in January. The ratio of adult to first year birds increased until May, then dropped (fairly quickly at first) till December. The increase from February to March corresponded with the arrival of adults and young from the breeding colonies, and from March to May with the dispersal of some of the young. From July-August onwards the drop was correlated with departure of adults to the breeding colonies, but between May and July the causes of the drop were not certain. During this period there is a considerable amount of offal available in the harbour, so adults probably do not disperse, but this food probably attracts young birds from flocks adjacent to the city, and it is their presence that lowers the ratio.

21. Absence of recoveries of banded birds from the Tory Channel Whaling Station suggested gulls were not attracted across Cook Strait for food.

22. The spring drop in the ratio was largely the result of the departure of adults for breeding.

23. Resting flocks without ready access to food contained few juveniles, whereas feeding flocks contained a higher proportion of juveniles.

24. Breeding birds in feeding flocks left for their colonies at the same time and at about the same rate as those in resting flocks.

25. Peak attendance at feeding sites was in late summer and

autumn, while peak attendance at resting sites appeared to be in winter and early spring. This was consistent with seasonal availability of food from meatworks, and indicated that when the volume of discarded offal waned in autumn, more birds frequented resting sites. Active feeding by growing juveniles and by adults after breeding largely explained peak attendance at feeding sites in late summer and autumn.

26. There was apparently no socially imposed segregation into flocks of a single age group.

27. During summer breeding birds appeared to visit communal flocks close to their breeding colonies rather than ones further away. In the non-breeding season there was no difference between the ratios of flocks close to, and far away from breeding colonies.

28. Attendance of breeding birds at breeding colonies during the day ranged from 63% to 100%, thus during periods of minimum attendance 37% of the birds were absent. One of these periods was in the afternoon, which coincided with an increase in numbers of adults in communal flocks.

29. Each communal flock comprises a nucleus of birds which attend more or less regularly, and a varying number of birds which attend once or for a few days before moving on. Feeding flocks are composed of birds from many different roosting sites and apparently no flock is truly discrete.

30. Partial integration of communal flocks is achieved by the

itinerant birds. The movements of a bird during the day probably depend on the location of the roosting site from which it came, its place in the social hierarchy, availability of food, and local disturbances.

31. Dawn and dusk flight movements to and from roosting sites and some major feeding sites further demonstrated the diurnal integration of communal flocks which tends to unify the population.

32. Integration of communal flocks by itinerant birds is thought to have repercussions in the flock hierarchy.

III COMPARATIVE BREEDING STUDY OF SOME COLONIES

1. Introduction

The following is a record of a breeding study made during the two seasons 1963-64 and 1964-65. The bulk of the information was obtained from 20 breeding colonies in the 1963-64 season, during which time some 7,000 miles were travelled by car. One of these colonies, Some Is., was the subject of a detailed study of the breeding cycle during the 1961-62 season (Fordham, 1964 a & b), and provided a valuable comparison with the others. In the 1964-65 season return visits were made to 15 of the colonies to record start of laying, evidence of predation and other information, or to band chicks.

For the sake of convenience the colonies have been grouped in three sub-regions: Wellington west coast, Wellington Harbour, Lake Wairarapa - Palliser Bay (Fig. 1), and are listed below. The known or estimated (E) numbers of breeding pairs in each colony during the 1963-64 season are shown in parentheses. Estimations were made in all but one case (Mana Is.) from nest counts, allowance being made for the time of season and the known spread of laying for the Black-backed Gull.

<u>Wellington west coast</u>	<u>Wellington Harbour</u>	<u>Lake Wairarapa - Palliser Bay</u>	
Kapiti Is., N. end, 600 E	Island Bay 6 E	Waiorongomai R. 73	
Tokomapuna Is. 35 E	Taputeranga Is. 135 E	Ruamahanga R. mouth 24	

Pukerua Bay	4 E	Moa Pt.	15 E	Mukamuka R. mouth	45
Mana Is.	2,000 E	Somes Is.	1,475 E	Palliser Spit	265 E
		Ward Is.	110 E	Te Humenga Pt.	58
		Baring Hd.		Otakaha R. mouth	6
		Northern	80 E	"Whale Pt."	
		Lighthouse	250 E	(Waiwhero Stm.)	8
		Lagoon	310 E	Ngawihi Pt.	4

During the 1963-64 season eight of the 20 colonies were visited approximately once weekly (Somes Is. and seven in the Lake Wairarapa - Palliser Bay region: Waiorongomai R., Mukamuka R. mouth, Palliser Spit, Te Humenga Pt., Otakaha R. mouth, Whale Pt., and Ngawihi Pt.). In these a total of 436 nests were pegged, and records of eggs and chicks were kept. On Somes Is. and in the Palliser Spit colony samples of 134, and 85 nests respectively were taken, but in the remaining seven colonies every nest was marked. Eight colonies were visited at longer irregular intervals (Kapiti Is., Mana Is., Pukerua Bay, Moa Pt., Baring Hd. (three parts), and Ruamahanga R. mouth); two colonies (Ward Is. and Taputeranga Is.) were visited once, and limited data were obtained on two colonies (Tokomapuna Is. and Island Bay). In 1963-64 chicks were banded in seven colonies (Kapiti Is., Mana Is., Somes Is., Baring Hd., Palliser Spit, Mukamuka R. mouth, Te Humenga Pt.) and in the first four mentioned again in 1964-65. This programme was designed to test the significance of some ecological factors such as cover, nesting density etc. in relation to chick losses. Prior to the present study, banding had been

carried out by the author or other workers, for one or several seasons in the Kapiti Is., Somes Is., Baring Hd., and Palliser Spit colonies, so that the banding programme as a whole had a broad foundation.

Full meteorological records are not available for different parts of the area, but the annual summary for the Kelburn Meteorological Station, Wellington is given below.

	<u>Period</u>
Mean temperature 54.3 F.	1931-60
Mean monthly max. temperature 79.0 F.	1928-60
Mean monthly min. temperature 33.5 F.	" "
Bright sunshine hours 2012; Percentage of possible 45	1935-60
Rainfall 49.2"; Number of raindays 159	1921-50
Days of snow or hail 13.1	1928-60
Days of fog 12.4	1928-60
Percentage frequency of dominant winds N. 14.4, N.W. 32.2, S. 17.5, S.E. 11.3	1939-48
Days with gusts 40 mph. and over 180.6	1928-60

Thus the Wellington area has a mild, though rather windy climate, and is relatively free from fogs. Most wind comes from the N.W. and S. directions, and rain falls 7-8% of the time.

The colonies concerned in the study were subject to widely differing ecological conditions. Few had similar sets of factors operating, although some had certain features in common. Seven were on islands (one of these being in fresh water, at the Ruamahanga R. mouth), 11 were coastal, and two inland. Thirteen were mainly flat, while five were

on steep-sided islands, cliffs, or broken rock areas. Barren colonies, swampy and small colonies, colonies subject to human interference or predators contrasted with those showing the opposite condition. The variation in choice of breeding ground illustrated a remarkable adaptability, and further pointed to the fact that interpretation of the breeding results was best attempted without first defining that hypothetical set of factors likely to represent optimum breeding conditions. In some colonies critical factors influencing breeding success became apparent (e.g. flooding, mustelid predation) while in others no one ecological factor appeared to be of prime significance.* A brief description of each colony follows in which the numerical prefix refers to the colony's location in Fig. 1.

Wellington west coast

1 Kapiti Is. (Fig. 8 B) There are at least two colonies on Kapiti, one at the south end in Wharekohu Bay, and another much larger one at the north-east end. In this study interest is centred on the latter (Plate 3). Nesting is spread round three sides of a broad, flat, boulder spit projecting from the north-east corner of the island, and enclosing near its northern edge a shallow lake (once a lagoon). Fairly steep, short, boulder beaches rise to a scrub covered crest, behind which

* Before turning to the colonies themselves it should be noted that round almost the entire coastline of the study area (except the off-shore islands) hedgehogs Erinaceus europaeus and mustelids (especially stoats and ferrets Mustela putorius) may be found, and from Baring Hd. west to Pukerua Bay wild cats are present (pers. observation; P. Chandler, J. Bartle, B.M. Fitzgerald, pers. comm.).

FIGURE 8

BREEDING COLONIES

- A Mana Is.
- B Kapiti Is., north end
- C Baring Hd.
- D Somes Is.
- E Waiorongomai R.
- F Ruamahanga R. mouth
- G Ngawihi Pt.
- H Palliser Spit

is a depression of varying width, which in turn slopes up to a plateau containing the shallow lake. There is little or no soil cover in the colony. Nesting occurs from the tide mark below the beach crest to (and in parts beyond) the edge of the plateau, and the nesting ground is therefore mainly flat with surrounding low gentle slopes.

Nest counts were made on 3rd and 23rd November 1963, the second revealing 589 nests of which 455 contained eggs, 19 contained chicks, and 115 were empty. This count was as complete as time and the vegetative cover allowed and from it an estimate of 600 breeding pairs was made. Densest nesting was towards the western end of the north side of the spit. The colony is exposed to all weathers, although not all parts equally; nests in the depression being partly sheltered. In the main part of the colony (the north and east sides of the spit) the plant cover is scattered tauhinu Cassinia leptophylla up to six feet, and long grasses; nettle Urtica ferox and creeper Muehlenbeckia complexa also occur on the east side. On the south side of the spit (Webber's Bay) there is little vegetation, only scattered nettle, creeper, and Mariscus ustulatus. On the beach terrace of the east side there is a compact breeding colony of Red-billed Gulls, surrounded on three sides by scattered nests of Southern Black-backs. The closest nests to the Red-bills were respectively about 15, 27 and 69 feet distant.

The only known probable predators are Norwegian rats

which are fairly common on the east side, and especially so on the north where nesting is most dense (Plates 3 & 4). At low tide a rocky inter-tidal zone is revealed round much of the island, and although some rubbish is fed chicks (as with almost every other colony) the main food supply is probably natural foods from the island and nearby mainland. Human interference is restricted to a limited number of holiday picnickers having permission to land.

2 Tokomapuna Is. (Aeroplane Is.) Nesting on this small island occurs on the beach terraces which almost surround it. During one visit made by L.J. Paul (on 28/10/63) some 25 nests were found, including five with eggs, and the number of breeding pairs was estimated at 35. Tokomapuna is exposed to southerly storms, but partly protected from the north-west by Kapiti. Above the beaches there is a mixed taupata Coprosma repens and box-thorn Lycium sp. scrub in which many Starlings Sturnus vulgaris roost. Picnic parties pay occasional visits.

6 Pukerua Bay This very small coastal colony is about one and a half miles south of Pukerua Bay on an unsheltered beach terrace strewn with driftwood. During two visits in November, four scrapes were found in the colony, and a further three about a quarter of a mile northwards, so that it was thought some 10 pairs may be breeding in the area. However no eggs were found, and on a subsequent visit it was decided no birds had in fact bred successfully. Remains of two decayed fledglings showed breeding had occurred in previous years. Since

wildcats and mustelids have been caught or seen in the general region of the colony (B.M. Fitzgerald, pers. comm.), it is possible these animals have been responsible for the unsuccessful breeding.

7 Mana Is. (Fig. 8 A) The Mana Is. colony is the largest in the study area. The island itself is flat-topped with a high point of 398 feet in the north-west corner, and has very steep slopes on the north, south and west sides, and most of the east. Scree slides are common. Beach terraces are mostly wide, especially on the south side, and end in coarse boulder beaches with masses of driftwood (Plate 5). Gulls breed in driftwood, on beach terraces and the lower third of the slopes right round the island, excepting the north-west point (sheer cliffs) and part of the east side (in the vicinity of the jetty). Because of the island's size, terrain and scrub it was not practicable to count the nests, but an estimation of 2,000 pairs was made (based on comparison with the Baring Hd. colonies).

Mana is very exposed to all winds, but large rocks, driftwood and vegetation give some shelter for a number of nests. Plant cover in the nesting areas is provided by several dominant species: north side - creeper, Festuca sp. and box-thorn; east side - tauhinu, Hymenanthera crassifolia, Mariscus ustulatus and Scirpus nodosus; south side - creeper and spaniard grass Aciphylla sp.; west side - creeper, Hymenanthera crassifolia and Festuca sp. A colony of Red-

billed gulls is situated on a rock spur about halfway up the slopes at the north end, and a small number of Red-bills and White-fronted Terns nest on a large rock at the north end of the western beach. There are no mammalian predators on Mana, but sheep are farmed and have the run of the whole island. The nearby mainland, and the broad inter-tidal zone of the island itself are the probable sources of most food collected by breeding birds. Human interference is virtually limited to activities (e.g. mustering) of the farmer.

Wellington Harbour

- 14 Island Bay On the south-western edge of Island Bay about six pairs of gulls nest on bare rocks in the inter-tidal zone. Eggs and chicks were found in mid December by D. Stoops, so that despite the proximity of road and houses (less than 100 yds.) and the consequent human activity, there is some success in breeding. The south Wellington coast as a whole is unprotected from southerly storms but the colony is partly sheltered from the north-west by the mainland. Norwegian rats are present on the mainland and nearby Taputeranga Is., and possibly visit the close off-shore rocks.
- 15 Taputeranga Is. Nests are scattered over the island, which is more or less circular, but most are on the flat rocky ground surrounding the low central hill. This flattened ground is broken by jumbled rocks and sink holes, some containing stagnant pools. Densest nesting overall is to the west of a north-south tidal channel which divides the island

unequally, while on the larger (eastern) portion nesting is heaviest on the east and south sides. On the central hill there are only a few nests, scattered on the east and west slopes. During a brief visit on 30/11/64, 118 nests (either empty or with eggs or chicks) were found, and it was estimated that the colony comprised about 135 pairs. The island is exposed to north-westerly as well as southerly storms, although some shelter is given by large rocks and the scattered scrub. Low wind-shaped taupata (up to four feet) is the main scrub cover on the flat, with flax Phormium tenax and grass on the north and east sides; Salicornia australis on the south; and creeper, grass and Hymenanthera crassifolia west of the tidal channel. There is taller scrub comprising taupata, ngaio and karo Pittosporum crassifolium on the north slopes of the hill, but there is no nesting in this area, and the rest of the hill has mainly pasture grasses and spaniard grass.

Norwegian rats are, unfortunately, common, and can be seen during the day. They eat any chick or adult corpse, but I do not have positive evidence they attack live chicks, although this is possible. Fishing sheds in Island Bay, and a local city refuse tip provide a food supply for the birds, while being so close to the mainland means that people frequently visit the island, especially during weekends.

16 Moa Pt. The site of the colony is uneven, though mainly flat, barren ground on an exposed rocky point off the eastern end of Lyall Bay. At high tide the point is separated from

the mainland by very shallow water. During November and December 1963, 17 nests were found scattered amongst the rock outcrops; 12 containing eggs or chicks, and five empty, and the colony was estimated at 15 pairs. A cat was seen once on the colony edge, and with a sewer outlet little more than 100 yds. distant it is probable that rats are also present. The sewer attracts numbers of feeding gulls, and disturbances by people are fairly common, although it is likely the scattered nesting reduces the effect of any disturbance.

18 Somes Is. (Fig. 8 D) As already mentioned, a detailed study of this colony was made during the 1961-62 breeding season (Fordham, 1964 a & b). At that time seven areas were marked out so as to provide a thorough sample of the colony with respect to slope, aspect, exposure, cover etc. The areas were patrolled daily, and the records subsequently correlated. As a result of farm work, both completed and proposed on parts of the island during summer 1963-64, and because visits could only be made weekly, and were of necessity brief, it was not possible to repeat observations in all the marked areas. Three undisturbed beach areas (i.e. B, G & H) were chosen, the original boundaries and names being retained to facilitate comparison with the earlier work.

Towards the end of the 1961-62 season 1,419 used and unused nests were counted on the island, and a maximum estimate of 1,450 breeding pairs was made. During the present study it was noticed that nesting density had altered slightly in

some places, and it appeared that the total numbers breeding were higher than in 1961-62, but since no total nest count was made it was decided to raise the estimate to only 1,475 pairs. The numbers of nests marked in the three areas in 1963-64 were: area B - 60; area G - 38; area H - 36, and the main vegetative cover in each was as follows: area B - Scirpus nodosus and sand poppy Glaucium flavum; area G - flax, Scirpus and californian thistle Cirsium arvense; area H - flax, Scirpus, sand poppy and ice-plant Mesembryanthemum (Plate 8). Parts of areas G. and H are affected by southerly storms, but vegetation and rocks give some shelter in all areas. North-westerly weather affects all areas, but B least of the three. Although not often seen, there is a feral cat on the island, but there are no other mammalian predators. Most food is collected from the mainland, especially from rubbish tips and outfalls of two meatworks on the edge of the harbour. Because Somes Is. is a stock-quarantine station and landings have to be authorised, human interference is largely limited to farm workers. Plates 6-8 show parts of the colony.

19 Ward Is. The island is rectangular, approximately 200 yards long and 70 yards wide, with cliffs or steep slopes, and rocky shores on all sides except the north-western point and the eastern side where the slopes fall more gradually to a wide beach. The angle of the upper eastern slopes is gentle and there are several flat areas on top. Gulls nest mainly on the top and upper eastern slopes, and also scattered

along the beaches and slopes of the north-western, north and east sides. A visit was made on 5/12/63 when 77 nests were found, all with eggs or chicks. Of these, 52 were on top of the island and 25 round the beaches or lower slopes, and an estimate of 110 breeding pairs was made. Densest nesting was on the southern half of the top of the island. Ward Is. is exposed to all weathers, but much of the top is given good shelter by a thick plant cover up to 10 feet high composed of taupata, flax, karo, mallow plant Lavatera arborea and grass. Mallow plant, flax and taupata are the main plants scattered along the upper regions of the beaches.

A small number (ca. 15 pairs) of White-fronted Terns nest high on the north-west cliffs, while on the east beach at least one pair of North Island (variable) Oystercatchers Haematopus unicolor breed. No evidence of rats was found, and it is probable there are no mammalian predators present. Ward Is. is a popular picnic spot, so disturbances are common, especially at weekends.

20-22 Baring Hd. (Fig. 8 C) Strictly speaking this colony is composed of three distinct groups of birds which I have called the Northern colony (about half a mile north of the lighthouse), Lighthouse colony (west of, and beneath the lighthouse) and Lagoon colony (at the Wainuiomata Stream mouth). There are clear breaks between the colonies, in which there is no nesting, except for a few pairs between the Northern and Lighthouse colonies. All are flat beach colonies

but at the lagoon nests are also scattered over the lower slopes of the coastal cliffs. Three trips were made in November to record peak laying, and on 29/11/63 581 nests with eggs or chicks were found (Northern colony 71; Lighthouse colony 231; Lagoon colony 279). From the counts an overall estimate of 640 pairs for the three colonies was made. Baring Hd. is exposed to all weathers (including at times very strong winds) and there is little or no shelter for nesting birds. The Northern colony (Plate 10) is largely protected from high seas by the steep beach, but storm driven high tides invade small areas of the Lighthouse colony. Storms also affect the Lagoon colony, but indirectly; high seas block the lagoon outlet so that rising water drowns nests on low-lying ground to the landward side of the lagoon (Plate 11).

None of the colonies obtain much shelter from the scattered vegetation. In the Northern colony a little cover is given by thinly scattered sand poppy, creeper, tauhinu, spinifex Spinifex hirsutus and Scirpus nodosus. The main plants in the Lighthouse colony are sand poppy, creeper, spinifex, Hymenanthera crassifolia and, near the base of the cliffs, lupin Lupinus arboreus. Cover is scattered, especially in the southern half of the colony. At the Lagoon colony the main plants are lupin, gorse Ulex europaeus and Scirpus nodosus. Stoats have been seen in the general area of Baring Hd., and actually in the Lighthouse colony (W. Kemp, pers. comm.), and a few chicks killed and eaten by stoats

were found in the Lighthouse colony. No ferrets have been seen. Wildcats are also present, and one was shot near the Northern colony by Mr. Kemp.

Sheep are farmed in the area and occasionally moved along the beach, especially near the lagoon. Gulls obtain food from Wellington south coast, where there is a refuse tip and three sewers, and Wainuiomata township at the head of the Wainuiomata Stm. All three colonies are subject to some interference from people but warning notices have been posted and appear to have some influence.

Lake Wairarapa - Palliser Bay

25 Waiorongomai R. (Fig. 8 E) The colony of 73 pairs is on the mainly flat shingle bed of the Waiorongomai River, about 400 yards from Lake Wairarapa. The original course of the river was on the northern edge of the colony, while part of the present course (which is erratic) runs through it. Most of the time the river is dry, only carrying water after heavy rain, but at such times water flows over a considerable area of the nesting grounds (Plate 13). The fortunes of the colony vary from season to season; if heavy rain falls during breeding, it is likely many nests will be destroyed, but a dry summer may facilitate nesting. The colony is exposed to the prevailing north-westerly, and southerly weather, deriving little protection from the sparse vegetation. Low willow Salix sp. bushes, Mariscus ustulatus and Juncus spp. grow round the colony and

scattered through it, but most of the colony has a thin cover of pasture grasses, with a patch of rank growth on the lake side near a willow thicket.

Ferrets are common in the area, and during the 1963-64 season destroyed almost the entire colony while it was in the egg stage (Plate 12). Rabbits Oryctolagus cuniculus, hares Lepus europaeus, Wild Turkeys Meleagris galopavo and sometimes Pukekos Porphyrio porphyrio move about in the colony, while at times cattle and sheep are allowed into the area to graze. Some Pukekos nest close to the colony, while Black Swan Cygnus atratus and several species of duck nest nearer the shore of the lake. Most food is probably collected from surrounding farm land e.g. ploughed fields, and the mud flats and shallow water of Lake Wairarapa. This colony is almost undisturbed except when stock are being shifted.

26 Ruamahanga R. mouth (Fig. 8 F) Where the Ruamahanga River flows into Lake Wairarapa its course divides to pass either side of Willow Is. At the mouth of the southernmost channel is a very small unnamed, flat, low-lying island on which a colony of 24 pairs of gulls is established. The island is simply a mud bank with a fairly thick cover of grasses and sedges up to three feet high. Juncus spp. (esp. J. Maritimus), Scirpus spp., Mariscus ustulatus, Cyperus vegetus and pasture grasses are the main plants, and there are also several small willow trees (Plate 14). In early

November an inspection of Willow Is. was made by boat, but no breeding birds were seen either on the island or surrounding lake shore. The level of Lake Wairarapa is controlled by opening or closing the outlet of Lake Onoke into Palliser Bay (see Fig. 1), and this responsibility belongs to the Wairarapa Catchment Board. Often high seas prevent the outlet being opened, and if there is a coinciding period of heavy rain, the resulting rise of the lake waters drowns the island on which the colony stands. Strong north-westerly winds also raise the level of the lake considerably on the eastern side (sometimes more than one foot), so the island is liable to partial submersion from this cause alone (Plate 15).

Records kindly supplied by the Wairarapa Catchment Board (and summarised in appendix 6) show that between 1953 and 1965 the islet has been flooded for some time every spring and summer. The islet is at about the 101.5 ft. level (based on the High Water Ordinary Spring Tide level at Lake Onoke) so that at 102.5 ft. most nests would be invaded by water, and at 103.5 ft. all would be submerged.

The only other birds breeding on the island were two Pukekos. No evidence was found of mammalian predators, and the only animal visitors are stray cattle and sheep which can easily reach the island when the lake is very low. The food source for this colony is the same as for the Waiorongomai

R. colony, i.e. the lake itself, and surrounding farm land.

There is virtually no interference from humans.

23 Mukamuka R. mouth On a barren, flat, stony beach terrace immediately west of the Mukamuka River mouth is a compact colony of 45 pairs of gulls (Plate 16). The site is exposed to southerly and north-westerly winds (the latter funnels straight down the Mukamuka valley), but the steep beach and driftwood line suggests high seas rarely invade parts of the colony. The only plants over 10 inches high are Scirpus nodosus, pasture grasses and sand poppy, but these are thinly scattered, and the remaining plants are haretail Lagurus ovatus, and mat or prostrate species such as scabweed Raoulia australis and shore convolvulus Calystegia soldanella. A few Red-billed Gulls breed on a large off-shore rock. Stoats are present, and in 1963-64 killed many chicks (Plates 16 & 17). Other possible predators are wild pigs which dug up parts of the colony in May 1964, i.e. after breeding. Rabbits are also in the area, and farm cattle wander through the colony. Human interference is limited and may be of minor importance.

24 Palliser Spit (Fig. 8 H) This well known colony is on flat sandy ground near the east end of Palliser Spit. The spit is very exposed but nesting extends across from the storm-tide mark on the sea side, to almost the flood-tide mark on the edge of Lake Onoke. It appears from the driftwood lines

that storm driven seas rarely enter the colony. On 9/11/63 a census was made of all nests, revealing 210 with eggs or chicks, plus 43 without eggs. From this number an estimate of 265 breeding pairs was made. Most of the nests are located in the only patch of sand poppy on the spit (Plate 18). In fact there is no other area of the spit where any plants grow in such concentration. However the sand poppy itself is clumped and there are bare patches in the colony where few nests are found. Other dune plants in or around the colony include pingao Desmoschoenus spiralis, haretail and spinifex. About midway along the seaward edge of the colony, on bare sandy ground is a colony of about 40 pairs of Caspian Terns Hydroprogne caspia, the nearest nest being nine feet from a gull nest. Rabbits are present and sheep and cattle occasionally graze along the spit, but no signs were seen of rats or mustelids. When the outlet of Lake Onoke is closed, people (and sometimes dogs) have ready access to the spit, and unfortunately the colony receives numerous visitors.

28 Te Humenga Pt. The colony of 58 pairs is spread widely over a broad, flat, sandy point which is exposed to all weather. There is a moderately steep sand and shingle beach, and driftwood is scattered over most of the area but it appears the sea has not recently encroached inland. Similar to Palliser Spit a large number of nests are built in sand poppy, especially

in one big patch. Again this is the most abundant "tall" plant in the colony, growing to about two feet in height. At the top of the beach is a narrow belt of sand poppy, haretail, spinifex, Festuca littoralis and in places a succulent Cakile edentula. Inside this belt there is a scattered cover of sand poppy, haretail, scabweed, Festuca littoralis and Pimelea prostrata, but there is also a patch of sand poppy containing nearly half the nests. No evidence was found of mustelid activity, but stoats are present along this stretch of coast (pers. observation). Other possible predators are wild pigs which did no damage in 1963-64, but have destroyed nests and eggs in previous seasons (N. Crew, pers. comm.). Rabbits are also in the area. The colony is often disturbed by people (mainly at weekends) and on occasions in the past there has been considerable interference.

29 Otakaha River mouth A small colony of six pairs of gulls is scattered amongst sand dunes about 250 yards north of the Otakaha River mouth. All the nests are in a long, flat valley immediately behind the line of dunes at the top of the fairly steep beach. The valley is littered with old driftwood and parts of it are entered by the sea during storms. There is little vegetation to give protection from strong north-westerly or southerly winds, the main plants being pingao, haretail, spinifex and Festuca littoralis. No signs of any live predators were found, but a stoat skull was discovered close to

the colony suggesting some predation may have occurred in the past. Farm cattle sometimes wander in the area. Human interference is almost negligible.

30 "Whale Pt." (Waiwhero Stm.) On a flat, exposed, sand and shingle point about half a mile north of the Waiwhero Stm. mouth is a colony of eight pairs of gulls. The beach at this point is not steep, and high seas sometimes travel inland for a short distance. Plant cover is poor, including thinly scattered Festuca littoralis, Carex breviculmis and Mariscus ustulatus. No mustelid or other predators were noted in the colony, but stoats have been seen along this coast. Human interference is infrequent.

31 Ngawihi Pt. (Fig. 8 G) Four nests are scattered round the edge of the exposed rock and shingle point, at the top of steep shingle beaches. Plant cover comprises sparsely distributed sand poppy, haretail and Pimelea prostrata; also some scabweed and shore groundsel Senecio lautus. Near the end of the point is a hollow usually carrying brackish water. Immediately south of this hollow are contiguous colonies of Red-billed Gulls (ca. 200 pairs) and White-fronted Terns (ca. 400 pairs). One Black-backed Gull nest was 12 feet from the nearest tern nest. Stoats were seen in the colony attempting to catch adult Red-billed Gulls, but I have no direct evidence of predation on Black-backs. There is some human interference.

2. Nests

2.1 Nest sites

The Southern Black-back is very adaptable in its choice of nest site. It not only utilizes open sand or boulder beaches and river beds, but also steep hillsides, (sometimes cliffs) and areas thickly covered with high grass, shrubs or trees. Tradition appears to be a factor in certain colonies where nesting continues in the same place in successive years even though conditions (perhaps originally favourable) are repeatedly adverse to successful breeding. In this category parts or the whole area of a number of colonies can be placed, including Lagoon colony, Baring Hd.; Ruamahanga R. mouth; and Waiorongomai R. These three colonies are liable to be flooded once or several times during summer, at which time many nests are drowned. The first has been established for probably more than 30 years, while the other two are about 30 and 10 years old respectively, and all have grown over the years. Predators also affect some colonies: rats have been present for many years on Kapiti and Taputeranga Islands and cause losses in the egg stage, whereas stoats and ferrets respectively decimated the Mukamuka R. mouth and Waiorongomai R. colonies in 1963-64. Thus it seems that at least during a period of general population expansion, gulls have been reluctant to abandon established breeding grounds even when

conditions become unfavourable.

Natural growth of colonies also initiates occupation of unfavourable areas, and this has occurred at the Lagoon colony, Baring Hd. where birds have spread on to low ground which is quickly submerged in a flood. And on Somes Is. gulls have begun to occupy sites closer to the centre of human activity where, as a result, they receive more disturbances.

The amount of available vegetative or other cover in colonies differed widely. Extreme conditions occurred on the one hand at the Mukamuka R., and parts of the Baring Hd. colonies where thinly scattered low plants gave no cover; and on the other at Somes, Ward and parts of Kapiti Islands where there was a great deal of plant cover, so that some birds were nesting under trees and scrub. I have no precise data on the utilisation of cover in every colony but a salient feature is that nearly all nests are built beside some projection (plant, rock, wood etc.). Of 76 nests (the total number) in four colonies on the east side of Palliser Bay, 73 (96%) were beside plants or driftwood; the remainder were on bare sand or shingle. General observations in other colonies lend supporting evidence which implies a response by nest building gulls to a vertical component in the environment. Goethe (1960) described a similar type of response in some members of the L. argentatus - fuscus assemblage.

Evidence from Te Humenga Pt. and Palliser Spit suggests that when there is vegetation (such as broad-leaved herbaceous plants) on the breeding grounds, nests are built in and around it in preference to areas of bare ground. At Te Humenga Pt. the colony of 58 pairs was very scattered in an area thinly covered by coastal grasses, but there was a central area of sand poppy and a succulent (Cakile sp.) in which 46 (79%) of the nests were concentrated. These plants grow about two feet high, with irregular branches, and the former has fairly broad soft leaves, so that during summer they are prominent members of the coastal flora. On Palliser Spit there was one large patch of sand poppy in which the colony of 265 pairs was centred. It was the only plant on the sandy spit and had a "shrub" habit (other vegetation comprises mainly grasses) and could provide extra shelter or cover. Although virtually unlimited space was available for nesting the majority of the 265 pairs bred in the sand poppy, in which bare patches were avoided.

Besides orientation to a vertical component, other factors possibly contribute to stimulation of nest building in or near vegetation; plants provide material for nests, shelter for incubating birds and cover for chicks. Sand poppy and Cakile grow and flower between October and December so that the gulls exploit a seasonal plant cover which is present during peak nest building, laying and hatching. But

these annuals die off in late December, and do not provide cover for chicks from early-mid January onwards. Early nesting would be advantageous so as to make best use of the plant cover, and this occurred at Palliser Spit (where laying began in early October), but not at Te Humenga Pt., where peak laying did not occur until mid November. Here however the relative sizes and densities of the two colonies are significant, for Palliser Spit is larger and denser than Te Humenga Pt., and start of laying is directly related to nesting density. One final consideration is that concentrated numbers of gulls in an area enrich the ground and indirectly promote the growth of the plants in which they nest.

Since plant cover varied so much between colonies (and sometimes within colonies) I decided to test the influence of two factors on the choice of nest site. These were: existence of direct shelter for an incubating bird, and availability of protective cover for chicks. Somes Is. and Baring Hd. colonies were chosen for the test because they were large, subject to N.W. and S. gales, and showed extremes of plant cover (Plates 6-8 & 10-11). Six sample areas were taken on Somes Is., and each of three colonies at Baring Hd. were measured. The method was simple: each nest was assessed first for the amount of protection offered an incubating gull from the prevailing N.W. and S. winds using an arbitrary scale; and second the distance from the nest of available cover for

chicks using the divisions 0-3 feet, 3-10 feet, and greater than 10 feet. Adequate cover was defined (for this purpose) as that plant or other cover where a fledgling could hide with reasonable safety. The results are given below:

TABLE 8 DIRECT SHELTER FOR INCUBATING BIRD

	<u>SOMES IS.</u>		<u>BARING HD.</u>	
	<u>NESTS</u>	<u>%</u>	<u>NESTS</u>	<u>%</u>
None	116	43.8	181	80.5
Slight	70	26.4	36	16.0
Moderate	41	15.5	7	3.1
Good	38	14.3	1	0.4
	<u>265</u>	<u>100.0</u>	<u>225</u>	<u>100.0</u>

The relative amounts of shelter for nests in the two colonies were highly significantly different ($P < 0.005$, $v = 3$); a conclusion which could have been safely made by inspection, but although Somes Is. had much more vegetative cover than Baring Hd., 70.2% of the nests had no, or only slight shelter. At Baring Hd. 96.5% had no, or only slight shelter. On Somes Is. 29.8% of nests had moderate or good shelter, while the comparable figure at Baring Hd. was only 3.5%. It should be noted that although gulls in the Lighthouse and Lagoon colonies at Baring Hd. nested mainly on the beach or on open ground, there were contiguous areas of tree lupin Lupinus arboreus amongst which only a few birds chose to nest. At this stage then the conclusion appears to be that nest sites

are not necessarily chosen to provide shelter for the incubating bird. On Somes Is. in 1961-62 I found (Fordham, 1964 a) that of 95 nests, 67% were unsheltered (exposed), 24% had partial shelter, and only 8% were well sheltered. Measurements of available cover for chicks are summarised in Table 9.

TABLE 9 AVAILABLE PROTECTIVE COVER FOR CHICKS

<u>DIST. FROM NEST</u>	<u>SOMES IS.</u>		<u>BARING HD.</u>	
	<u>NESTS</u>	<u>%</u>	<u>NESTS</u>	<u>%</u>
0 - 3 feet	133	50.2	91	40.5
3 - 10	73	27.5	68	30.2
> 10	59	22.3	66	29.3
	<u>265</u>	<u>100.0</u>	<u>225</u>	<u>100.0</u>

The availability of cover in the two colonies was different, but the difference was just below the level of statistical significance ($.05 < P < .1$, $v = 2$). Such differences as there were lay in the fact that relatively more nests on Somes Is. had cover within 0-3 feet, while relatively fewer had cover greater than 10 feet distant. On Somes Is. 77.7% of nests had cover available within 10 feet, compared with 70.7% at Baring Hd., so that in both colonies a majority of nests were sited within reach of some cover even when (in the case of Baring Hd.) vegetation, driftwood or other types of protective cover were thinly distributed. On Meeuw Is. (S. Africa) Gillham (1963, p.280) noted L. dominicanus nested in "a belt of worn scrub and weed species which gave broken

cover up to 0.5m. high". Gillham also found (p.238) that by helping in the destruction of the original scrub and stimulating the spread of low growing cover plants, rabbits benefited ground nesting gulls and terns, but she concluded that too intense an opening out of the plant cover was not beneficial to these species. On Robben Is. gull nests were conspicuously absent from the closely nibbled swards of the scattered rabbit warrens. This evidence thus agrees with the data collected in the present study, which indicated a close association between cover and nests site.

The types of cover at Somes Is. and Baring Hd. were recorded as either plant, or non-plant (including rock, driftwood etc.), and as expected more use was made of plant cover in the former colony than at the latter; of 265 nests on Somes Is. 171 (64.5%) had plant cover available, while 129 (57.3%) of 225 nests at Baring Hd. had plant cover. But considering the general lack of vegetation in the latter colony the differences in choice of cover between the two places were not very great, which suggests that if nest building gulls respond to a vertical component in the habitat, then this component is more acceptable (or is more often presented) in the form of a plant, than in the form of a rock or piece of driftwood.

In Table 10 and Fig. 9 I have combined the measurements made at the two colonies for the purpose of underlining the

FIGURE 9

The relationship of shelter for incubating birds
and cover for chicks to choice of nest site.

SHELTER-COVER
RELATIONSHIP

relationship between shelter for the incubating bird and cover for chicks.

TABLE 10 SHELTER/COVER RELATIONSHIP;
SOMES IS. & BARING HD. COMBINED.

<u>SHELTER FOR INCUBATING PARENT</u>	<u>COVER FOR CHICKS</u>						
	<u>0 - 3'</u>		<u>3 - 10'</u>		<u>> 10'</u>		
None	71	24%	113	38%	113	38%	297
Slight	71	67%	23	21.7%	12	11.3%	106
Moderate	44	91.7%	3	6.3%	1	2%	48
Good	36	92.3%	2	5.1%	1	2.6%	39
							<u>490</u>

From the data in Fig. 9 it will be seen that with good or moderate shelter there is nearly always cover available at 0-3 feet; with slight shelter, 67% of nests still have cover available at 0-3 feet; and with no shelter most nests have cover at greater than 3 feet distant. However 24% still have cover available at 0-3 feet, further emphasising the relative importance of cover for chicks.

2.2 Nesting Density

Casual observation was sufficient to indicate the wide variation in nesting density in different colonies. To record nest distribution in a number of colonies I chose the technique of measuring to the nearest foot the distance between

any used nest and its closest neighbour. This was done in January, near the end of the season. If a barrier such as trees or rocks clearly prevented visual or physical contact between two pairs which otherwise would have been close together, the measurements were taken to other nests. All nests were measured in small colonies, but samples had to be taken in each of the large ones; in areas which displayed a range of densities or other conditions. Below (Tables 11 & 12) are listed the nesting distances recorded in 1963-64 and 1964-65.

TABLE 11 SHORTEST NESTING DISTANCES (1963-64)

<u>COLONY</u>	<u>NO. OF PAIRS</u>	<u>SAMPLE</u>	<u>RANGE</u>	<u>MEAN</u>
Ngawihi Pt.	4		14 - 267	140
Otakaha R. mouth	6		20 - 175	95
Whale Pt.	8		54 - 140	73
Ruamahanga R. mouth	24		20 - 56	34.4
" " "	21 (renest)		11 - 87	31.9
Mukamuka R. mouth	45		12 - 117	25.7
Te Humenga Pt.	58		7 - 347	58.5
Waiorongomai R.	114 (scrapes, no eggs)		7 - 113	21.4
" " "	73 ("renest")		6 - 213	22.7
Palliser Spit	ca.265	85	4 - 34	16.2
Somes Is.	ca.1,475	130	4 - 28	11

TABLE 12 SHORTEST NESTING DISTANCES (1964-65)

<u>COLONY</u>	<u>NO. OF PAIRS</u>	<u>SAMPLE</u>	<u>RANGE</u>	<u>MEAN</u>
Kapiti Is.	ca. 600	148	3 - 28	12.2
Baring Hd.	ca. 640	204	3 - 27	10.6
Somes Is.	ca.1,475	170	5 - 40	12.1
Mana Is.	ca.2,000	200	3 - 28	10.5

The first point to be made from these figures is that as colonies increase in size, mean shortest nesting distance * falls. Since distance is a function of nesting density, then an expression of density may be conveniently derived from the reciprocal measurement (because short distances between nests mean high density) thus in Fig. 10 B I have plotted the reciprocal of mean shortest nesting distance as a function of colony size, and this shows that nest density increases almost linearly with colony size, but at a slightly faster rate in the largest colonies. There is also some relationship to the age of the colony, probably because older colonies, through steady growth, are generally larger than younger ones.

The second point is that even in the larger colonies where mean distances appear approximately similar, the distribution patterns of the nests are different. For instance on Somes and Mana Islands (mean distances 12.1 and 10.5 feet), nest dispersal was significantly different at the 95%

* In succeeding discussion "shortest nesting distance" is abbreviated to "distance".

FIGURE 10

A Start of laying with respect to nest density.

B Relationship of nest density and numbers breeding.

level *; and similar differences were found between the dispersal of nests at Kapiti Is. and Baring Hd.

Highest densities were recorded on the west beach, Mana Is., and the Northern colony, Baring Hd., where mean distances were 9.5 and 9.2 feet respectively. In these two places however there is plenty of ground available for nesting, and in no colony does it appear that nesting space is truly restricted. On any island available ground is ultimately limited, but even on the small islet at the Ruamahanga R. mouth there is still plenty of room for nesting. Certain parts of Somes and Mana Islands are crowded, perhaps to the limit, but other areas offer room for expansion. For instance colonies such as Kapiti Is., Baring Hd., Mukamuka R. mouth, Palliser Spit etc., offer room for almost unlimited expansion.

Tradition is an important factor in the perpetuation of gull colonies, but as a result of favourable conditions in Wellington for most of this century, splinter colonies have formed readily in a number of areas, and one example is Baring Hd. (Fig. 8 c). Here three distinct groups of different sizes breed in the same general locality and each continues to grow outwards from the centre. Tradition does not confine

* Nest distribution patterns were compared using areas under the standard normal curve, and the formula

$$\frac{\bar{X}_1 - \bar{X}_2}{\sqrt{\frac{S_1^2}{N_1} + \frac{S_2^2}{N_2}}}$$

where $\bar{X}$ = the mean distance,
 S^2 = the variance,
 and N = the sample.

all the birds to one breeding area and because of this ability to exploit new ground, nesting space appears not to be a critical factor for nest distribution and growth of Wellington colonies.

Of the 12 colonies considered only Mana and Somes Islands have large areas of steeply sloping or broken ground, and the overall dispersal of nests in these two colonies was practically identical to that found at Baring Hd. and Kapiti Is. respectively, which are mainly flat. In addition all the colonies (except Somes Is.) that were measured in 1963-64 were on flat ground, and still showed wide differences in nesting density that were referable to the numbers of pairs breeding. It appears then that (apart from ground such as shear cliff or moving shingle, where nesting is clearly impossible) topography does not affect nest density.

Five of the colonies under discussion were subject to predation in 1963-64 and/or 1964-65: Kapiti Is., Norwegian rats; Baring Hd. (Lighthouse colony), stoats; Mukamuka R. mouth, stoats; Waiorongomai R., ferrets; Te Humenga Pt., man. Effects in nesting density however were noted only in three colonies, the conclusion being that in the other two (Mukamuka R. mouth, and Waiorongomai R.) predation, although severe, was of recent origin. Most marked effects were found at Te Humenga Pt., where the mean distance of 58.5 feet was far greater than that of comparable colonies (Table 11).

From information I was able to gather it appears local inhabitants have collected eggs at intervals over a number of years from this scattered colony. At Baring Hd. stoat predation was recorded only in part of the Lighthouse colony in which mean distance was 12.1 feet, as compared with 9.2 and 9.8 feet (av. 9.5) in the Northern and Lagoon colonies. And at Kapiti Is., samples in two areas gave mean distances of 11.2 and 13.3 feet (av. 12.2) which was higher than that of the Northern and Lagoon colonies Baring Hd., and unpredated Mana Is., (mean distance 10.5 feet). Thus in the light of Tinbergen's (1952, 1956, 1957) demonstration of dispersed nesting in gulls as a protection against predators, I conclude that predation has caused dispersed nesting in some of the Wellington colonies.

In 1963-64 the Ruamahanga R. mouth and Waiorongomai R. colonies renested following flooding and abandonment respectively. In the former colony nests and eggs were drowned, while at the latter early scrapes were abandoned (perhaps partly due to the influence of unfavourable weather) before any eggs were laid, but the birds returned to lay in phase with other colonies in Palliser Bay. In both cases renesting resulted in nest distribution patterns very similar to those before, and mean shortest nesting distances were not significantly different at the 95% level. This implies that despite the interruption to breeding activity, the intensity of territorial behaviour remained the same.

3. Egg Stage3.1 Laying

Eggs are laid between October and January. The start of laying was recorded in 1963-64 (11 colonies) and in 1964-65 (13 colonies) and the dates are listed below.

TABLE 13 START OF LAYING IN THE WELLINGTON COLONIES

	<u>NO. OF PAIRS</u> <u>1963-64</u>	<u>1963-64</u>	<u>1964-65</u>
Somes Is.	1,475	29/10	16/10
Baring Hd.: Northern	80		22/10
Lighthouse	250	640	16/10
Lagoon	310		20/10
Palliser Spit	265	11/10	13/10
Taputeranga Is.	135	26/10	19/10
Ward Is.	110	24/10	21/10
Waiorongomai R.	73	6/11	27/10
Te Humenga Pt.	58	29/10	ca. 9/11
Mukamuka R. mouth	45	6/11	28/10
Whale Pt.	8	9/11	15/11
Otakaha R. mouth	6	6/11	1/11
Ngawihi Pt.	4	14/11	11/11

3.11 Latitudinal effects

The data given in Table 13 represent a range of 35 days (11/10 - 14/11) for the start of laying in 1963-64, and 34 days (13/10 - 15/11) in 1964-65 for colonies which all fall within one degree of latitude (between $40^{\circ} 45'$ S., and $41^{\circ} 40'$ S.). Such a wide range provides striking comparison with the range of laying dates for colonies south of New Zealand. From eight colonies covering 18+ degrees of latitude (48° S. - 66° + S.) there was a range of only 20+ days (late October - 20/11) in start of laying. In Table 14 (from Fordham, 1964 a, with additional data) the sizes, latitudes and laying dates of colonies south of New Zealand are given.

TABLE 14 LAYING DATES FOR COLONIES SOUTH OF NEW ZEALAND

<u>LOCALITY</u>		<u>COLONY SIZE*</u>	<u>FIRST EGGS</u>	<u>AUTHOR</u>
(Somes Is.	41° S.	ca. 1,475 pairs		This study)
Kerguelen Is.	48° S.	Many colonies, some "numbering up to 100 birds".	16/11/1929	Falla (1937, p.238)
Falkland Is.	52° S	Breeding in "large rookeries". Numerous everywhere.	? No data	Murphy (1936, p.1067) Bennett (1926, p.319)
Heard Is.	53° S.	Plentiful at Atlas Cove.	ca. 4/11/1929	Falla (1937, p.239)
S. Georgia	54° S.	Very common (1925-27) Gulls usually congregate in colonies of several dozen pairs. (1912)	Late Oct.	Matthews (1929, p.581) Murphy (1936, p.1065)

<u>LOCALITY</u>		<u>COLONY SIZE*</u>	<u>FIRST EGGS</u>	<u>AUTHOR</u>
Macquarie Is.	55° S.	Numerous. Abundant round the coasts.	9/11/1912 & 1913	Falla (1937, p.239)
S. Orkney Is.	61° S.	ca. 300 birds	15/11/1902-1904	Clarke (1913, p.242)
S. Shetland Is.	63° S.	No data	Early Nov.	Bennett (1920, 1926)
S. of Antarctic circle	66°+S.	No data; small?	20/11/1908-1910	Gain (1914, p.102)

* This information is included because there are no nest density measurements available.

The affect of latitude on the onset of breeding has been noted by Lack (1950, p.295) who states that in Lapland all species start breeding one to two months later than in Britain, and the breeding season is much less extended. In broad terms this holds for the Southern Black-back, for in northern Peru "the nesting period of the species as a whole is continuous" (Murphy, 1936, p.1064) while in New Zealand egg laying occurs in only part of the year, between October and February (i.e. mid spring - summer), and south of New Zealand laying starts in late October or in November (i.e. late spring).

But from the laying dates of Wellington colonies lying in one degree of latitude it is clear the size of the colony reflects some factor which influences start of laying at least as much as latitude does. This factor is related to nest density which, as previously mentioned, increases positively with colony size. Most of the colonies mentioned in Table 14

are not small, i.e. they comprise probably more than 50 pairs; for instance on Kerguelen the population totals at least several hundreds of pairs. Even if Wellington colonies of less than 50 pairs are ignored, the range for start of laying on the 41st. parallel is 27 days (11/10 - 6/11) 1963-64, and 28 days (13/10 - 9/11) 1964-65, which is still greater than that of the group of southern colonies.

Meteorological effects cannot account satisfactorily for differences in laying dates between the Wellington and southern colonies, because weather conditions in the Wellington area must be considered constant, whereas the weather of the southern colonies varies from sub-antarctic to antarctic conditions (R.W. Balham, pers. comm.). It appears therefore that in this gull the effect of latitude per se can be obscured because of the great variation in start of laying which results from differences in numbers breeding and nesting density.

3.12 Effect of nesting density

The relationship of start of laying to nesting density is shown in Fig. 10 a, where there is a definite though not marked tendency for laying to start earlier in dense colonies. A strong correlation between nest density and start of laying was found in the Kittiwake Rissa tridactyla by Coulson and White (1960, p.76), and Vermeer (1963) noted a similar relationship in the Glaucous-winged Gull. In view of the clear

cut results described in the two latter studies, the sometimes conflicting data obtained from the Wellington colonies were not easy to interpret. For instance the laying dates in three marked areas on Somes Is. were:

Area	<u>1961-62</u>		<u>1963-64</u>		<u>1964-65</u>	
	<u>Density in*</u> <u>Nests/acre</u>	<u>First</u> <u>Eggs</u>	<u>Mean shortest</u> <u>Nest distance</u>	<u>First</u> <u>Eggs</u>	<u>Mean shortest</u> <u>Nest distance</u>	<u>First</u> <u>Eggs</u>
B	86	27/10	10.3	ca.7/11	12.1	28/10
G	88	23/10	11.5	ca.3/11	10.6	ca.20/10
H	75	21/10	11.5	29/10	13.1	19/10

* Distances between nests were not measured in this season.

In each of the three seasons the first eggs were laid in the area of lowest density (H), not highest density, and in 1964-65 only one day separated start of laying in areas G and H, in which the nest densities were significantly different at the 90% level. An important consideration is the age composition of the colonies concerned. I have no specific data of this kind, but as previously mentioned nesting density has a relationship to the age of the colony as a whole because, despite occasional formation of splinter colonies traditional breeding grounds become heavily populated and, although there is apparently no shortage of nesting space the gulls breed closer together. Thus older colonies, by steady growth, are larger than younger ones (see also Coulson and White, 1956).

Other evidence given in Fordham (1964 a, p.9) suggests that if established pairs do break up after breeding, many are

probably reformed before winter, and it seems probable that many pairs do not effectively part at all. Most breeding colonies in Wellington are also roosting colonies and these two factors give rise to social situations and to the opportunity of environmental stimuli which cannot occur in colonies where the gulls are absent all year except during breeding. Coulson and White (1960, p.72) found that although older Kittiwakes lay before younger ones, this factor alone could not account for earlier laying, except in the youngest colonies.* It may be that I encountered such an effect in Wellington for, as I have explained elsewhere, the Wellington population as a whole has expanded rapidly in recent years. This implies the existence of a larger proportion of young birds in breeding colonies than would occur in a more stable population, and in a sense some of the most rapidly growing colonies are "young". I conclude therefore that the influence of these young birds is superimposed on, and obscuring the effect of nesting density on start of laying in Wellington colonies.

The mechanism by which increased nest density causes earlier laying has yet to be explained, but mutual stimulation by more frequent contacts between individuals almost certainly

* Recently Coulson (1963) examined the age composition of two Kittiwake colonies by a technique which employed measurement of egg sizes and shapes. This technique may prove of considerable value in later studies.

plays a part. In 1964-65 I spent 45 hours observing the sequence of hostile postures in nesting gulls on Somes Is. Most of this time was spent in an area where the density was close to the average for the colony, but an isolated group of four to five more widely spaced pairs on a cliff were also observed. Observations included periods of high and low activity during the day. The behaviour of attacking birds was observed, in particular the frequency of actual attacks, in comparison with escape and threat postures (including re-directed attacks). Preliminary analysis of this information (Table 15) indicates that in the isolated, more widely spaced group of birds there was less hostile activity, and attacking birds carried out attacks with relatively less frequency than those in the area of higher density.

TABLE 15 FREQUENCY OF ATTACKS, AND OTHER HOSTILE
BEHAVIOUR BY ATTACKING BIRDS*

<u>AREA</u> ¹	<u>PERIOD</u> ²	<u>ATTACKS</u> ³	<u>OTHER HOSTILE</u> ⁴ <u>SEQUENCES</u>	<u>RATIO</u>
Higher density	13hrs. 8 mins.	474	322	1.5 : 1 (av.)
Lower density	6hrs. 16 mins.	8	15	0.5 : 1

* Hostile behaviour includes all intra-specific behaviour produced by attacks and/or escape motivation. Postures mentioned are described in Fordham (1963 b).

1. The mean shortest nest distance in the higher density area was 12.9 feet. The average distance separating nests in the lower density area was unmeasured, but was greater than 12.9 feet.
2. Observations in the higher density area were made on 12/11/64 and 20/11/64, and in the low density area on 8/12/64, 11/12/64 and 18/1/65.

3. Attacks include only charging, pecking and actual fighting, or any hostile sequence including one of these.
4. All other escape and/or threat sequences, including re-directed attacks such as grass-pulling. In the case of repetitive postures such as choking and grass-pulling, individual movements have not been counted separately, but grouped for each occasion. Long-calls were not counted.

Allowing that some of the observations in the lower density area were made later in the season when territorial disputes had lessened in frequency and intensity, the ratio of attacks to other hostile sequences was three times greater in the higher density area (no fights occurred in the lower density area, and only one peck was seen). Although it is not possible to compare the results on the basis of the number of birds involved, it is obvious the instance of attacking is greater in the higher density area.

If hostile disturbances do have a stimulating effect on breeding then here is a mechanism capable of advancing breeding activity in a high density area, but more work is needed to reveal the importance of courtship behaviour in the same role. In Kittiwakes Coulson and White (1960, p.75) have found that the percentage reaction to alighting birds in dense colonies is significantly greater than that occurring in less dense colonies, and in Lesser Black-back L. fuscus colonies Brown (1965) states that copulation by one pair seems to stimulate others to do the same.

The spread of laying on Somes Is. compared with that in

six small colonies of less than 100 pairs did not indicate synchronised laying relative to nesting density. The greatest spread in laying was on Somes Is. where there was highest nest density, which does not support one aspect of the "Darling effect" (Darling, 1938) whereby denser nesting was thought to induce synchronisation of breeding activities in the colony as a whole. But records from six areas on Somes Is. in 1961-62 (Table 16) again suggest the obscuring influence of numbers of young breeding birds in the colony.

TABLE 16 SPREAD OF LAYING OF FIRST 90% OF CLUTCHES*

<u>AREA</u>	<u>TOTAL NESTS</u>	<u>NEST/ACRE</u>	<u>DAYS OF LAYING</u>
F	51	65	34
H	27	75	33
A	37	80	38
B	47	86	31
G	37	88	30
D	106	109	39

* Only the first 90% of the clutches are considered, to avoid including second clutches.

Although nest densities in the six areas varied widely, they were not reflected in the spread of laying in each area, which suggests the obscuring influence of numbers of young breeding birds in the colony.

3.13 Meteorological effects

The relative importance of the various external environmental factors which help regulate breeding in warm-blooded animals is the subject of continuing debate, and the part these factors play in conjunction with the neuro-endocrinological state of the animal is still uncertain. Marshall (1961) concisely summarised the often conflicting literature and concluded (vol. II, p.327) "we are still unaware of the precise combination of external factors that regulates the seasonal breeding of even the London Sparrow". Most attention has centred on light and temperature, both separately, and in combination, and Marshall states (p.318) "today most people seem to be agreed that it is the seasonal appearance of a specific and appropriate day length, not merely increasing day length, that sets the avian neurohormonal machinery in motion and (once the regeneration period is past) starts the seasonal gametogenesis". Further, (p.332) for temperate zone birds, other important post regeneration accelerators of the sexual cycle are "warmth (and probably sunshine per se), territory, adequate food, the nest site, nesting materials, and behavioral interactions". Recently Annan (1963) has shown that length of the daily dark period prior to growth of testes is as important as length of day (effective photoperiod) during gonadal growth in migrating thrushes (Hylocichla sp.). Ultimately however, avian breeding is adapted to the time of

year that will provide optimum conditions (particularly food) when the young hatch (Lack, 1950, p.289; & 1954).

Whatever the combination of factors responsible for external regulation of breeding activity it is recognized (Marshall, 1961, p.326) that abnormal weather can alter the start of breeding. By analysing some meteorological data relating to the months prior to breeding for the years 1961-65 I found a correlation between abnormal weather conditions and late breeding in 1963-64. I have paid most attention to the period from mid winter to the start of laying because gonad measurements of 46 adult females and 30 adult males showed most rapid growth occurs only shortly before laying starts (Fordham, 1963 a). Ovaries begin to enlarge slowly from May onwards, with sudden, rapid growth in October and early November, while testes begin slow growth in late June and July, followed by rapid growth in early September. Thus the critical period prior to laying is presumably August to October, i.e. including the two months of sudden rapid growth.

In 1963-64 eight out of eleven colonies began laying later than in the 1964-65 season, and this was attributed to "unfavourable" weather in the spring of 1963-64 (see Table 13). On Somes Is. laying in the same season began later than in any of the four seasons between 1961 and 1965. These dates were:

<u>1961-62</u>	<u>1962-63</u>	<u>1963-64</u>	<u>1964-65</u>
18/10	ca.20/10	29/10	16/10

Meteorological records from mid winter through to the end of summer from 1961-1965 were summarised from the Kelburn Meteorological Station, Wellington, and those referring to mean temperatures, hours of bright sunshine, and mean cloud amount are listed in appendix 7. These records show that from July to September 1963 it was cooler, with less sun and more cloud than for any other season between 1961 and 1965. Further, past records show that in 1963, July had the lowest sunshine hours since 1942, August was the coldest since 1943, and September had the least sunshine since 1906. Cool temperatures and poor light conditions prior to breeding thus appear to have had the combined effect of causing laying to start later than usual in the 1963-64 season. In July 1964 the number of sunshine hours was nearly an all-time record low for any months of the year, although the mean temperature was one of the highest on record, but laying still started in mid October 1964, i.e. earlier than in 1963. The records suggest therefore that the critical months prior to laying are August to October (particularly September) and that weather in July probably does not influence onset of breeding, as long as the subsequent months are not extreme.

3.2 Clutch size

The mean clutch size of 1,258 nests in 10 colonies was

2.44 eggs. Since average clutch size falls as the season progresses (Fordham, 1964 a, p.28) data were collected only from first clutches in nests marked over the whole season, except at Kapiti Is., Baring Hd. and Palliser Spit. In these colonies larger samples were taken at intervals during the laying period, but at Palliser Spit some 85 marked nests were followed during the season as well. At Baring Hd. in 1963-64 one clutch of four eggs was laid (and by report another one as well) but these have been ignored in calculations. Clutch sizes were as follows:

	<u>CLUTCH SIZE</u>	<u>SAMPLE</u>	<u>NO. OF PAIRS</u>
Whale Pt.	2.3	8	8
Mukamuka R. mouth	2.31	44	45
Waiorongomai R.	2.31	63	73
Baring Hd.	2.37	293	640
Te Humenga Pt.	2.46	58	58
Kapiti Is.	2.46	455	600
Somes Is.	2.49	132	1,475
Ngawihi Pt.	2.5	4	4
Palliser Spit	2.53	196	265
Otakaha R. mouth	2.8	6	6
<u>Mean:</u>	<u>2.44</u>	<u>1,258</u>	

There was no direct correlation between nesting density and clutch size, but there appeared to be correlation between

clutch size and the age composition and rate of growth of colonies; i.e. fewer eggs are laid in the most rapidly growing colonies. For instance the approximate rate of growth in the last 20-25 years, and mean clutch size of four large colonies were as follows:

	<u>RATE OF GROWTH</u>	<u>MEAN CLUTCH SIZE</u>
Palliser Spit	x 2	2.53
Kapiti Is.	x 5	2.46
Somes Is.	x 9	2.49
Baring Hd.	x11	2.37

Clutch sizes at Palliser Spit and Baring Hd. were significantly different ($.01 < P < .025$, $v=2$). This is probably a result of faster expansion and consequently a relatively higher proportion of younger birds in the latter colony, thus lowering the mean clutch size because young breeding birds tend to lay fewer eggs than older ones (Coulson & White, 1958, p.46, 1961). It appears therefore that clutch size is relative not only to the time of season (Fordham, 1964 a, p.28) but also to the status of the colony as a whole, i.e. whether it is stable, expanding or declining.

Extensive renesting occurred in two colonies after nests were drowned in early November. At the Ruamahanga R. mouth 21 pairs out of 24 laid a second time after their first clutches were drowned by rising lake water. These second broods were then drowned before clutch sizes could be determined. At the

Lagoon colony Baring Hd. a large area was submerged by a rising stream. Renesting occurred so that a fortnight later relatively more one-egg, and fewer three-egg clutches were counted than in the other two colonies at Baring Hd. Very little renesting was noted in other colonies, but weekly visits made this information difficult to collect with certainty. Single pairs renested at Te Humenga Pt. and Waiorongomai R., and two pairs on Somes Is., but none were definitely recorded elsewhere.

3.3 Egg mortality

Records of first clutches from nine colonies in 1963-64 show that of a total 1,041 eggs laid, a minimum of 332 (32%) did not hatch. The mortality figure is necessarily minimum because visits to the colonies were only possible at weekly intervals. Nevertheless the inspections revealed egg losses varying from 6% in a very small colony, to 85% and 100% in colonies that were predated or drowned (see Table 17).

TABLE 17

EGG MORTALITY 1963-64

	<u>NESTS</u>		<u>EGGS</u>		
	<u>Total</u>	<u>Sample</u>	<u>Laid</u>	<u>Perished</u>	<u>%</u>
Ruamahanga R. mouth	24	24	43	43	100
Waiorongomai R.	73	73	156	133	85
Whale Pt.	8	8	18	6	33
Te Humenga Pt.	58	58	143	41	29
Ngawihi Pt.	4	4	10	2	20

	<u>Total</u>	<u>Sample</u>	<u>Laid</u>	<u>Perished</u>	<u>%</u>
Mukamuka R. mouth	45	45	103	18	18
Somes Is.	1,475	132	329	54	16
Palliser Spit	265	85	222	34	15
Otakaha R. mouth	6	6	17	1	6
			<u>1,041</u>	<u>332</u>	<u>32</u>

The fates of eggs are listed below:

FATES OF EGGS

	<u>TOTAL</u>	<u>%</u>
Ferret predation	124	37.4
Addled	65	19.6
Disappeared	50	15.0
Drowned	43	13.0
Broken in or near nest	19	5.7
Rolled out of nest	15	4.5
Began to hatch but died	9	2.7
Abandoned	3	0.9
Nest collapsed in wind	3	0.9
Human predation	1	0.3
	<u>332</u>	<u>100.0</u>

In 1961-62 egg mortality on Somes Is. was 33.9% (Fordham, 1964 b) which is almost the same as the average losses in all colonies in 1963-64, but considerably higher than the figure for Somes Is. itself. The fates of eggs on Somes Is. were similar in both the studies except that in 1963-64 I recorded

few eggs destroyed and eaten by gulls. Possibly my weekly visits prevented adequate recognition of the signs of such losses, e.g. fragments of shell or egg-contents in or near nests.

The most overwhelming losses in 1963-64 were sustained in two colonies. At the Ruamahanga R. mouth all eggs were drowned by rising lake water (nearly all repeat clutches were also drowned), and some secondary predation by gulls followed abandonment of nests (Plate 15). At Waiorongomai R. 93% of the losses were caused by ferret predation. Over a period of several weeks eggs in this colony disappeared with increasing rapidity, and during that time ferrets were seen moving in the colony, several caches of egg shells were discovered under low willow trees at the edge of the nesting ground, and five dead, partly devoured adult gulls were found about the colony (Plate 12). When there were no eggs or chicks left I set some traps, and three ferrets were caught, their small size and location suggesting they were from one litter. Soon after three more were caught by dogs, so the concentration of ferrets near the colony was apparently fairly high. J. Luttrell stated (pers. comm.) that long grass had gradually established itself in the colony over several years, providing favourable habitat for ferrets, and he suspects ferrets have been present in previous years because there were always very few chicks relative to the size of the colony. In the following season

(1964-65) the colony was flooded several times, so opportunities for predation were slight.

Major causes of egg losses in other colonies were:

	<u>TOTAL EGGS LOST</u>	<u>ADDLED</u>	<u>DISAPPEARED</u>
Somes Is.	54	32 (59.2%)	11 (20.3%)
Te Humenga Pt.	41	8 (19.5%)	19 (46.3%)
Palliser Spit	34	13 (38.2%)	15 (44.1%)
Mukamuka R. mouth	18	8 (44.4%)	

From a larger sample on Somes Is. in 1961-62, 50.6% of eggs lost were addled, and 18.7% disappeared (Fordham, 1964 b).

With all colonies subject to different factors it is difficult to correlate the various causes of egg losses, but if total predation and drowning are ignored, then disappearance of eggs (and their consumption by gulls?) and addling, are the two main fates of eggs. In colonies such as Te Humenga Pt. it seems possible egg losses were inflated by human predation. On Somes Is. in 1961-62 egg losses increased with nesting density (Fordham, 1964 b) but in the comparative breeding study of 1963-64 there was apparently no relationship between egg losses and nesting density in the various colonies (Table 17). The results in the two studies thus appear contradictory and I cannot explain the discrepancy except to suggest that ultimately losses in each colony reflect the influence of some limiting factor such as numbers of birds in relation to the available food, and that the influence of such a factor would vary between colonies in any one year.

Results from Somes Is. and two other colonies not predated during the egg stage in 1963-64 suggested the percentage of eggs addled may be related to nesting density.

	<u>Mean shortest nest distance</u>	<u>No. of eggs addled</u>
Somes Is.	11.0 ft.	32 (59.2%)
Palliser Spit	16.2	13 (38.2%)
Mukamuka R. mouth	25.7	8 (44.4%)

Although there appeared to be a tendency towards more addling in dense areas, data from Somes Is. alone did not lend support.

<u>Area</u>	<u>Mean shortest nest distance</u>	<u>Eggs addled</u>
B	10.3	19 (73.0%)
G	11.5	5 (38.4%)
H	11.5	8 (53.3%)

The results show more eggs addled in the denser area, but the densities of the three areas were not significantly different even at the 90% level, and records from Somes Is. in 1961-62 (Table 18; previously unpublished) showed no correlation between the percentage of eggs addled, and nesting density.

TABLE 18 ADDLING AND NESTING DENSITY

<u>AREA</u>	<u>NESTS/ACRE</u>	<u>EGGS NOT HATCHED</u>	<u>ADDLED</u>
D	109	109	61 (55.9%)
G	88	32	17 (53.1%)
B	86	34	13 (38.2%)
A	80	22	8 (36.4%)
H	75	22	11 (50.0%)
F	65	29	17 (58.6%)

The conclusion therefore is that addling is not related to nesting density.

Other colonies suffered severe egg losses but the relative amounts were not recorded. For instance fairly heavy predation by the Norwegian rat was suspected on Taputeranga Is. where all eggs were taken in some areas, and since rats have been there for many years this sort of predation has almost certainly occurred before. Similar predation was strongly suspected on Kapiti Is. and on at least one small islet off Kapiti; Brown's Is. In the 1964-65 season traps were set in the Taputeranga and Kapiti Is. colonies, and rat burrows were also excavated, but in neither stomach contents of captured rats, nor in burrows were egg remains found.

Predation by Harriers Circus approximans was seen once on Somes Is.; the hawk calmly ate an egg in a nest while gulls swooped overhead giving alarm calls. Although this type of predation was probably infrequent, it undoubtedly occurred in other colonies (Plate 9).

Apart from the Ruamahanga R. mouth nests were drowned in at least two other colonies. At the Lagoon colony, Baring Hd. a blocked outlet in spring 1963 caused the Wainuiomata Stm. to rise and many nests were drowned during the peak laying period. Meteorological records from Kapiti Is., and information from the resident caretaker Mr. G. Fox indicate that rainfall during September 1964 was much greater than usual,

and probably accounted for the water which accumulated and drowned part of the colony in 1964-65.

4. The chicks

4.1 Chick mortality

With the exception of one colony collection of precise records on chick losses proved quite difficult because I could visit the colonies only once a week. This meant that disappearance of chicks especially in the first few days after hatching, had to be ignored. Combined records from nine colonies showed that of a maximum 709 eggs presumed to have hatched, a minimum of 103 (15%) chicks perished before the flying stage. These records are listed below.

TABLE 19

	<u>CHICK MORTALITY</u>	
	<u>EGGS HATCHED</u>	<u>CHICKS DEAD</u>
Waiorongomai R.	23	22 96%
Ngawihi Pt.	8	2 25%
Mukamuka R. mouth	85	16 19%
Te Humenga Pt.	102	18 18%
Somes Is.	275	37 14%
Palliser Spit	188	7 4%
Otakaha R. mouth	16	1 1%
Whale Pt.	12	- -
Ruamahanga R. mouth	-	- -
	<u>709</u>	<u>103 15%</u>

Greatest mortality was found at Waiorongomai R. where all the chicks except two disappeared while ferrets were active in the colony (Plate 12). No signs were ever seen of 11 chicks which I had to assume had hatched, and in view of the fact that only one large chick was known to have survived until late in the season, I have concluded that all the rest were predated by ferrets.

The next most serious predation was at Mukamuka R. mouth where stoats were active. Corpses of 14 chicks were found in the colony including a cache, where several of the bodies had been dragged beneath a log (Plate 16). All bore signs of typical stoat attack with teeth marks in the neck, severed spinal column, and sometimes meat chewed from the breast (Plate 17). Droppings discovered at the site of the cache were identified as those of stoat by B.M. Fitzgerald, and at the end of the season traps were set in the hope of capturing some of the animals, but without success. Although there is only circumstantial evidence I believe more than 14 chicks were killed by stoats, and the 19% mortality of chicks in this colony is therefore less than the true value.

Principal fates of chicks (all colonies combined) were:

Dead; no external injuries	43 (41.7%)
Killed by gulls	25 (24.3%)
Presumed killed by ferret	21 (20.4%)
Killed by stoat	14 (13.6%)
	<hr/>
	103 (100%)

Major causes of losses in the larger colonies visited regularly are listed below.

	<u>Chicks</u> <u>Lost</u>	<u>Dead, no</u> <u>External</u> <u>Injuries</u>	<u>Gull</u> <u>Predation</u>	<u>Stoat</u> <u>Predation</u>	<u>Ferret</u> <u>Predation</u>
Waiorongomai R.	22				21 (95.5%)
Mukamuka R. mouth	16			14 (87.5%)	
Te Humenga Pt.	18	12 (66.6%)	6(33.3%)		
Somes Is.	37	24 (64.9%)	13(35.1%)		

In colonies free from mustelid predation, gull predation accounted for about one third of the chick losses. At the Ruamahanga R. mouth no eggs hatched from first clutches, but from about seven of the 21 repeat clutches at least 10 chicks were produced, five of which later died, leaving five chicks alive and, (except one) flying in mid February. Other colonies worthy of mention with respect to chick losses include Baring Hd., where some stoat predation was encountered at the Lagoon and Lighthouse colonies (but more in the latter), and Kapiti and Taputeranga Is. where predation by Norwegian rats was strongly suspected. On these islands proof was sought, both in 1963-64 and 1964-65, that rats were killing chicks, but all I could deduce was that rats ate dead gulls, so I am forced to do no more than retain a strong suspicion. The evidence collected was as follows:

Rats were abundant in both colonies and could be seen during the day.

A down feather from a chick was found in the stomach of a rat trapped on Kapiti, and a pile of chick feathers were found in one of many excavated burrows.

On Taputeranga Is. a fresh adult gull's heart was found at the entrance of a burrow, the rest of the corpse was nearby.

Numerous corpses of chicks and older birds were found - all gnawed to degrees varying between slight, and complete reduction to heaps of feather vanes (Plate 4). On Kapiti the bones of a small chick were found under a bush, with a hole chewed out of the back of the skull; similar skull damage was found on other corpses.

Although individual nests were not marked there appeared to be fewer chicks than could be expected on Taputeranga Is. and also on Kapiti Is., especially in 1964-65 (allowing for nests drowned early in the season).

A phenomenally low percentage of recoveries of banded chicks was made on Kapiti in each year of banding (section IV: 2), and in comparison with other colonies, e.g. Mana Is. where there are no predators, very few corpses were found at all. But the recovery percentage of Kapiti Is. birds outside the colony was higher than any other colony, which suggested few (if any) live chicks are killed by rats.

Four chicks aged two-six weeks were placed under separate boxes with several entry holes of varying sizes, in rat infested areas on Taputeranga Is. After two days none had been molested,

and the test was abandoned.

The evidence failed to give direct proof that rats kill Black-back chicks, but Buller (1873)* reported wildducks . . . were decreased by R. norvegicus, and Austin (1948) described predation by Norwegian rats in tern colonies. He states (p.61) "the rat consumes only a small fraction of what it destroys . . the daily kill by one individual is from three to 20 birds with but a few mouthfuls eaten from one or two of the victims". "When eggs are available they eat them exclusively" and "when chicks hatch they become the staple diet. The preference is for chicks about three weeks old." Zelenka (1963) described the reverse situation where Great Black-backed Gulls L. marinus ate rats after their rabbit diet failed.

The ages of 80 of the 103 dead chicks were known and are detailed in appendix 8. A summary is given in Table 20.

TABLE 20 AGE DISTRIBUTION OF CHICK DEATHS

	<u>NO. CHICKS</u>	<u>1-2 DAYS</u>	<u>FIRST WEEK</u>	<u>FIRST TWO WEEKS</u>	<u>2-7 WEEKS</u>
Deaths from all causes	80	32.5%	56.3%	71.3%	28.7%
Deaths not by mammal predation	60	36.7%	56.7%	75.0%	25.0%

Over half the losses occurred in the first week, and of the 37 chicks found dead and uninjured 30 (81%) were less than one week old, whereas 15 (65%) of the 23 chicks killed by gulls were one-five weeks of age. This corresponds with

* Brief details given on p.93.

the age at which chicks wander from their own territories, but are not big enough to resist attack. The 10 chicks killed by ferrets were all less than one week old, while eight of the 10 killed by stoats were three-six weeks old. As mentioned before however, it is possible more younger chicks were killed by stoats at the Mukamuka R. colony. Paynter (1949) recorded that nearly 20% of the losses of Herring gull chicks occurred in the first week (c.f. 56.3% for Southern Black-backs).

Because of the differing conditions in each colony I am not prepared to draw any conclusion from the above evidence about chick losses in relation to the above.

relationship between local synchronous breeding and nesting density, but the data were conflicting for reasons suggested below. The following evidence was collected:

During banding in the three colonies at Baring Hd. (ca. 640 pairs) in the 1964-65 season it was apparent that the oldest and biggest chicks were grouped more or less together in part of the Lighthouse colony, showing that a group of gulls had started laying there before those in other parts of the three colonies. Nesting distances in the Lighthouse and Northern colonies were 12.1 and 9.2 feet respectively and these were significantly different at the 99% level, but laying in the former (less dense) colony began earlier than in the latter, thus I could not correlate this slightly asynchronous breeding directly with nesting density. Casual observations made in the previous season (1963-64) suggested that nesting densities in the three colonies were approximately similar to those obtained in 1964-65, but statistically insignificant differences were found in the progress of laying ($0.1 < P < 0.25$, $v=4$) - see below.

CLUTCH SIZES AT BARING HD. 15/11/63

	<u>1 EGG</u>	<u>2 EGGS</u>	<u>3 EGGS</u>	<u>TOTAL</u>
Northern colony	8 15%	26 47%	21 38%	55
Lighthouse colony	44 26%	69 40%	58 34%	171
Lagoon colony	22 17%	67 52%	39 31%	128

However caution was exercised when comparing the state of laying in different areas because the laying of a clutch occupies a relatively short time in the whole breeding season.

Most striking evidence of local breeding synchrony came from Kapiti Is. (ca. 600 pairs) where on 23/11/63 a total census of nests was made to count completed scrapes without eggs, nests with eggs, and nests with chicks (Table 21).

TABLE 21 LOCAL BREEDING SYNCHRONY ON KAPITI IS.

<u>SAMPLE AREA</u>	<u>TOTAL</u>	<u>COMPLETED SCRAPES, WITH NO EGGS</u>		<u>NESTS WITH EGGS</u>		<u>NESTS WITH CHICKS</u>		<u>"P" OF NO*</u> <u>SYNCHRONY</u>
A	139	55	39.6%	77	55.4%	7	5.0%	<.005
B	244	28	11.5%	208	85.2%	8	3.3%	"
C	140	23	16.4%	114	81.4%	3	2.2%	"
D	66	9	13.6%	56	84.9%	1	1.5%	"
	<u>589</u>	<u>115</u>	<u>19.5%</u>	<u>455</u>	<u>77.3%</u>	<u>19</u>	<u>3.2%</u>	

* Expected frequencies = one third the total number of nests in an area.

The results show there was overall synchrony of breeding in the colony, but also a marked local synchrony which confirmed observations made in the previous season (1962-63). At that time I found laying was not evenly spread through the colony, but instead some areas had nests but no eggs, while others had mainly small clutches, or mainly full clutches. Regretably density measurements could not be made till 1964-65 (when flooding spoiled nesting in one of the most important areas), but the measurements taken still indicated the same relative nesting

densities as had obtained in the two previous seasons, and from these no correlation between nest density and state of breeding could be made. The position on Kapiti was possibly affected by rats, but this explanation seems unsatisfactory when it is remembered that the rats, while being everywhere, were in fact particularly numerous in sample area B where on the day of the census there was still a very high proportion of nests with eggs and chicks, whereas they were not so obvious in areas A and D where there were respectively many empty nests, and nests with eggs.

Evidence from Somes Is. (ca. 1475 pairs) was conflicting. In the 1964-65 season there were no marked concentrations of old chicks anywhere, and generally all age groups were evenly distributed. On 14/11/63 in the previous season (just after peak laying) the state of breeding in six areas was checked, and clutch sizes recorded (Table 22). In the table the results have been tabulated in pairs to illustrate the differences in laying between the various areas.

TABLE 22 CLUTCH SIZES ON SOMES IS. 14/11/63

<u>AREA</u>	<u>1 EGG</u>	<u>2 EGGS</u>	<u>3 EGGS</u>	<u>TOTAL</u>
F	1 4%	11 44%	13 52%	25
A	2 8%	11 46%	11 46%	24
1 H	3 14%	14 63%	5 23%	22
2 G	4 18%	12 55%	6 27%	22
3 B	8 28%	11 38%	10 34%	29
D	20 34%	18 31%	21 35%	59

1,2,3 Mean shortest nesting distances were 11.5, 11.5 and 10.3 feet respectively.

The relative proportions of different sized clutches varied between the areas so that for instance the first two areas had fewer one-egg clutches than the last two. Nesting densities were measured only in the areas included in the comparative breeding study, i.e. areas B, G and H, so all areas could not be compared together. However the nesting densities, and also clutch sizes in areas B, G and H were not significantly different ($.25 < P < .5$, $v=4$), while laying in area F was significantly out of phase with that in B and D ($0.025 < P < 0.05$, $v=4$). As mentioned I have no density measurements of D and F in 1963-64, but in 1961-62 these were the areas of extreme nesting density in the colony, with 109 and 65 nests/acre respectively. A census of the state of laying in D and F for that season was taken on 9/11/61, i.e. straight after initial peak laying (see Fordham, 1964 a) with the following results:

<u>Area</u>	<u>1 egg</u>	<u>2 eggs</u>	<u>3 eggs</u>	<u>No. Nests</u>	<u>Ultimate no. of nests</u>
D	14	21	18	53	106
F	7	13	8	28	51

There proved to be no significant difference in laying in the two areas ($0.5 < P < 0.75$, $v=2$), although nesting densities were quite different, which indicated that in this colony density of nesting did not influence breeding synchrony.

Finally, during banding in the big colony on Mana Is. (ca. 2,000 pairs) in 1963-64, I did not detect any areas

noticeably out of phase with the others, and chicks of all ages seemed evenly distributed. Similar conditions obtained in the following season, in areas where nesting densities were significantly different.

To Summarise: Varying degrees of local breeding synchrony were found in parts of the large colonies at Baring Hd., Kapiti Is. and Somes Is., but none was apparent on Mana Is. No direct correlation between local synchrony and nest density could be found, but neither was there satisfactory evidence of an inverse relationship. In view of the direct correlation between nest density, and start and spread of laying in the Kittiwake (Coulson and White, 1960, p.76) the conflicting evidence from the Wellington gull colonies suggests once again that the age composition of the colonies is exerting an influence. All the large colonies have expanded rapidly in the last 20-25 years (Kapiti Is. x 5, Mana Is. x 8, Somes Is. x 9, Baring Hd. x 11) and even in the last 5-10 years, e.g. Somes Is. These colonies must therefore contain high proportions of young birds which are apparently obscuring the effects of nest density. In a sense these colonies are young because they are rapidly growing, and local synchronous breeding may be explained partly in terms of nest density, and partly (as suggested for the Kittiwake by Coulson and White, 1960, p.82) by the existence of local areas of old and young breeding birds. Coulson and White (1960) found that differences in

time of breeding in Kittiwakes were correlated with density, and (p.74) the effect of age composition had little effect, except in young colonies which had a high proportion of young birds.

Despite the obscuring influence of the age composition of the Southern Black-back colonies, and with only preliminary analyses of ethological evidence, I believe as mentioned before, the immediate cause of local synchrony in gulls is behavioural stimulation between mates, and between neighbouring pairs (possibly involving both hostile and courtship displays), an effect which is increased at higher nesting densities. In large gulls like the Southern Black-back, ideal conditions for such stimulation may obtain in big colonies on flat open ground, where with high nesting density each pair contacts several others, rather than in colonies where the topography is dissected, thus effectively dividing the birds into groups. The phenomenon of groups of nests (in more densely populated areas) being out of phase with the rest of the colony was noted in Herring Gulls by Paynter (1949, p.148).

Recent explanations of breeding synchrony in birds differ, but all contain some element of "social stimulation", thus modifying, but not supporting the general principle of the "Darling Effect". In 1938, F.F. Darling discussed breeding in Herring and Lesser Black-backed Gull colonies, and suggested start of laying is earlier, and spread of laying shorter in

large colonies because of the cumulative stimulating effects of courtship behaviour in the colony as a whole. Further, he assumed a numerical threshold in colonies of birds, below which breeding is not completed.

Coulson and White (1960) found nest density in the Kittiwake varied with colony size, and was directly related to breeding synchrony, but inversely related to spread of laying, the opposite of what would be expected from the Darling Effect (see also Vermeer, 1963). They also found (p.75) the incidence of post-arrival displays to be greatest at high densities, and thus postulated the possible influence of social stimulation in the colony, but only in the small group of birds in the immediate vicinity of a nest site, not over the whole colony as suggested by Darling. Coulson and White (op. cit.) speculate that stimulation received in previous breeding seasons is accumulated and affects time of return and breeding in later years, but this is a hypothesis for which support may be hard to find.

Orians (1961) found timing and synchrony of breeding in Blackbirds Agelaius spp. was related to feeding conditions in different habitats (i.e. to ecological variables) and was independent of colony size. Neither was breeding success correlated with colony size per se. Orians suggests social (group) stimulation may also operate in nomadic flocks, but is important prior to start of breeding. Finally, in work on the

Swallow-tailed Gull L. furcatus, an equatorial species breeding all year round, Hailman (1964) determined that local synchrony is due to social stimulation, "and is either as the result of behavioral pleiotropism* or is possibly adaptive", but not to a variable of the environment.

5.2 Overall success and contribution to the population

A summary of the breeding success of first clutches in each of the nine colonies studied is given in Table 23.

TABLE 23 BREEDING SUCCESS 1963-64

	<u>Sample</u> <u>Nests</u>	<u>Eggs</u> <u>Laid</u>	<u>Eggs</u> <u>Hatched</u>	<u>%</u>	<u>Chicks</u> <u>presumed</u> <u>alive at</u> <u>fledging</u>	<u>%</u>	<u>Chicks</u> <u>per Pair</u>
Otakaha R. mouth	6	17	16	94.1	15	99.4	2.50
Palliser Spit	85	222	188	84.7	181	96.3	2.12
Somes Is.	132	329	275	83.6	238	86.5	1.80
Mukamuka R. mouth	45	103	85	82.5	69	81.2	1.53
Whale Pt.	8	18	12	66.6	12	100.0	1.50
Ngawihi Pt.	4	10	8	75.0	6	75.0	1.50
Te Humenga Pt.	58	143	102	71.3	84	82.4	1.45
Waiorongomai R.	73	156	23	14.7	1	4.3	0.01
Ruamahanga R. mouth	24	43	-	-	-	-	0.00
	<u>435</u>	<u>1,041</u>	<u>709</u>	<u>68.1</u>	<u>606</u>	<u>85.5</u>	<u>1.39</u>

* The condition when one factor simultaneously produces multiple effects (Chambers Technical Dictionary, 1961).

Of 1,041 eggs laid by 435 breeding pairs, 709 (68.1%) hatched, giving a maximum of 1.63 chicks per breeding pair at hatching. Of the chicks that hatched 606 (85.5%) were presumed alive at fledging giving an overall maximum yield of 1.39 chicks per breeding pair. The converse of this information is that of the original stock of 1,041 eggs laid, a total of 435 eggs and chicks perished (see Tables 17 and 19) giving an overall minimum mortality of 41.8% to the flying stage. In 1961-62 the overall mortality to the flying stage was 46.9% (Fordham, 1964 b), which suggests the overall mortalities in 1963-64 may be slightly low. The differences are partly explained however by the relative frequency of visits during the two studies. In an experimental area in the Graesholm gull colony Denmark, Paludan (1951) found that about 2.5 chicks hatched per pair of Herring Gulls, and less than two per pair of Lesser Black-backs.

Fledging success in Southern Black-backs is higher than that recorded for most Larus gulls (Table 24) and may be partly due to general environmental conditions as well as to specific characteristics.

TABLE 24 FLEDGING SUCCESS IN LARUS GULLS

<u>SPECIES</u>	<u>LOCALITY</u>	<u>FLEDGED YOUNG/PAIR</u>	<u>AUTHOR</u>
<u>L. argentatus</u> <u>smithsonianus</u>	Kent Is., New Brunswick	0.9*	Paynter (1949)
<u>L. a. argentatus</u>	Summer Isles, Scotland	0.8.(1936)**	Darling (1938)
"	"	1.1 (1937)**	" "

<u>SPECIES</u>	<u>LOCALITY</u>	<u>FLEDGED YOUNG/PAIR</u>	<u>AUTHOR</u>
<u>L. a. argentatus</u>	Graesholm, Denmark	ca.0.5	Paludan (1951)
"	Wilhelmshaven, Germany	0.7	Drost <u>et al.</u> (1961)
"	Skomer, Wales	0.6	Harris (1964a)
<u>L. fuscus</u>	Summer Isles, Scotland	ca.1.1 (1936)**	Darling (1938)
"	"	ca.1.4 (1937)**	" "
<u>L. californicus</u>	Great Salt Lake, Utah	1.77***	Behle & Goates (1957)
<u>L. delawarensis</u>	Green Is., Michigan	ca.0.67	Emlen (1956)
<u>L. glaucescens</u>	Mandarte Is., British Columbia	1.7	Vermeer (1963)
<u>L. dominicanus</u>	Somes Is., New Zealand	1.3	Fordham (1964b)
"	"	1.8	This study
"	Wellington area, New Zealand	(av.)1.39	" "

* Calculated from data on p.156.

** Calculated from the combined data on pp.71-73.

*** Based on the first 100 completed nests, so is almost certainly too high.

Overall success in Wellington colonies varied widely. In the Waiorongomai R. and Ruamahanga R. mouth colonies a total of 97 pairs of gulls contributed a maximum of six chicks to the population; one from the former colony, and five from renesting in the latter (not shown in Table 23). Also for reasons already given, the overall success in the Mukamuka R.

mouth colony is possibly less than appears.

The fledging success of colonies not affected by predation or drowning were as follows:

	<u>BREEDING PAIRS</u>	<u>CHICKS/PAIR</u>
Somes Is.	ca. 1,475	1.80
Palliser Spit	ca. 265	2.12
Te Humenga Pt.	58	1.45
Whale Pt.	8	1.50
Otakaha R. mouth	6	2.50
Ngawihi Pt.	4	1.50

Allowing that conditions varied in each colony, there was no direct relationship between breeding success and colony size. Although Fisher and Lockley (1954, p.174 et seq.) state that small colonies of some seabirds, including gulls, produce fewer young per breeding pair than large colonies, other studies have failed to reveal a relationship between reproductive output and colony size. Hence Darling's (1938) figures from different sized colonies of Lesser Black-backed Gulls were found by Haartman (1945) to be not significantly different. Palmer (1941, p.102) thought that "sensory stimulation" was advantageous in small, uncrowded colonies of Common Terns Sterna hirundo, but could be offset by other factors above a certain density (e.g. interrupted breeding caused by birds being at different stages, thus leading to more nest desertion and chick mortality). Smith (1943) found no

significant difference between the breeding success of a large and small colonies of Red-winged Blackbirds Agelaius phoeniceus, and Orians (1961, p.333) considered breeding success in Agelaius spp. to be related to environmental conditions (e.g. predators, drought) rather than to colony size per se. In seeking a functional explanation, Lack (1954, p.257) concluded that colonial nesting is possible only for species that are comparatively safe from nest-predators, so that mutual warning and defence against predators, rather than the beneficial effect of social stimulation on the sexual cycle, may be the chief advantage of colonial nesting.

In general breeding success varied with the time of season, production from the first 50% of clutches laid being greater than that of the last 50%, but there was some variation between colonies. Except for Somes Is. (1963-64) egg losses were lower in the first 50% of clutches, and apart from the small Te Humenga Pt. colony, chick losses were the same in both halves of the season. These latter findings were supported by the banding data (section IV: 2.2) but both sources of evidence showed that sometimes chick losses were higher (though not significantly) in the first 50% of clutches. No all colonies could be analysed for information about success in the first or second halves of the season because they were either too small, or severely predated. Those tested were:

Somes Is.	(1963-64)	ca. 1,475 pairs	(sample 132)
Palliser Spit	"	265	" (" 85)
Te Humenga Pt.	"	58	" (" 58)
Somes Is.	(1961-62)	ca. 1,450	" (" 310)

The findings are briefly summarised below, and details are given in tables in appendix 9.

BREEDING SUCCESS IN FIRST AND SECOND HALF OF SEASON

Overall Production (Fledged Young/Pair)

(Statistical calculation based on no. of eggs and chicks lost)

Somes Is.	(1963-64)	Not different	(.75 < P < .1)
Palliser Spit	"	Not different	(.05 < P < .1)
Te Humenga Pt.	"	Very different	(P < .005)
Somes Is.	(1961-62)	Very different	(P < .005)

Egg Mortality

Somes Is.	(1963-64)	Not different	(.25 < P < .5)
Palliser Spit	"	Different	(.025 < P < .05)
Te Humenga Pt.	"	Different	(.01 < P < .025)
Somes Is.	(1961-62)	Very Different	(P < .005)

Chick Mortality

Somes Is.	(1963-64)	Not different	(.25 < P < .5)
Palliser Spit	"	Not different	(sig.diff.=8.99°)
Te Humenga Pt.	"	Different	(.025 < P < .05)
Somes Is.	(1961-62)	Not different	(.05 < P < .1)

Although overall production of fledged young was higher in the first 50% of clutches in all cases (appendix 9) the

difference was significant only at Te Humenga Pt., and Somes Is. (1961-62). The evidence indicates that differences in the level of overall production stem principally from differential egg mortality in the first and second 50% of clutches, and that since chick losses are the same in both parts of the season, they do not affect overall production. If however (in the case of Palliser Spit and Somes Is. 1963-64) more chicks (though not significantly more) are lost in the first half of the season, then overall production for the second half of the season is brought nearer to balance with that of the first half. Vermeer (1963, p.60) noted greater production by Glaucous-winged Gulls in the first half of the season. In Herring Gulls Paynter (1949, p.156) concluded that survival rates of young from early and late nesting birds were significantly different, although actual recovery rates of dead young were not different. Paynter ascribed this last observation to searching difficulties as vegetation grew higher during the season, and hid dead chicks from view. Nevertheless he was prepared to base his survival figures of chicks on last sightings made under the same conditions, and from these deduce differences in survival of young from early and late nesters!

Two important considerations arise in connection with breeding success. One is that if, as the evidence indicates, rapidly growing colonies have a lower average clutch size because of the large numbers of young breeders, then hatching

success must be lowered slightly (Fordham, 1964 b) which in turn will be reflected in a lower overall breeding success. Thus in a rapidly growing colony (e.g. Somes Is.) the overall breeding success will be lower than in a stable colony (e.g. Palliser Spit) where a large proportion of old birds lay full clutches. The other consideration is this. If, as the results on Somes Is. in 1961-62 indicate, egg losses are greater at higher densities (Fordham, 1964 b) then one would expect lower hatching success in high density colonies than in low density colonies. But as discussed in section III: 3.3, losses in each colony may be related to some overall limiting factor such as the numbers of birds in relation to the available food supply, and such a factor would have a different effect in each colony in any one year.

To conclude; two factors adversely affect gull breeding in the Wellington area: drowning by rising lakes and rivers or accumulated rain, and mammalian predation. The predators include known ones; rats, stoats, ferrets and humans, and suspected ones; hedgehogs and wildcats. All the mainland colonies are susceptible to predation, and some of the islands have had rats introduced. Few colonies remain free of mammalian predators but those that do include the largest, i.e. Mana and Somes Islands, also Leper and Ward Islands, which together represent 3,611 (63.5%) of the 5,684 counted breeding pairs. One of the largest mainland colonies, Palliser Spit,

(265 breeding pairs) also appears to be free of mammalian predators, thus the bulk of the breeding population (3,876 pairs - 68.2%) nests in comparative safety, and well over half in almost complete safety. In these "safe" colonies (Mana and Somes Islands) predation by neighbouring gulls is important and will be discussed in more detail later (section IV: 3).

It is worthwhile at this stage to estimate the total contribution made by breeding birds to the Wellington population on the basis of a maximum yield of 1.39 fledged chicks per breeding pair. The number of pairs counted in the area in 1963-64 was 5,684 with an estimated upper limit of 6,000 pairs, which implies (if all pairs bred) a contribution of between 7,900 and 8,300 fledged young to the Wellington population in 1964. The varying fledging successes shown in Table 23 indicate that the nine colonies studied contributed about 3,400 fledged young to the population in 1964.

From the available evidence it is apparent that gulls in the Wellington area suffer no lack of resources such as nesting space, nest material, or cover, and the largest colonies which together represent the bulk of the breeding population are free from predation (by mammals). The colonies have, throughout their history, been closely associated with the increase in food supply of human origin (tips, meatworks etc.) and until recent times nearly all breeding colonies in the study area have visibly grown outwards. The inevitable

conclusion is that for over a quarter of a century at least the food supply has been the prime factor permitting growth of the population. Evidence to be discussed in detail later (section IV: 2 & 3) indicates however that in the last few years some colonies (including the largest ones) have come under pressure from increasing demands on a diminished food supply, and it now appears the population is being limited by the food resources.

The mechanism by which populations respond to changes in the supply of essential resources has been the subject of vigorous dispute, especially since Wynne-Edwards' (1959 & 1962) concept of intrinsic population control by conventional, epideictic displays prior to and during breeding. These displays are held to indicate or reflect population density, thus control of numbers breeding, and recruitment for the coming year, is achieved by the birds themselves. The other principal school of thought (as propounded by Lack, 1954) rejects the importance of a controlled annual recruitment by intrinsic means, and maintains instead that the population is trimmed by density dependent mortality, e.g. Southern (1959), Gibb (1961).

The influence of social behaviour in relation to recruitment, or to density-dependent mortality is a most important point about which there is no agreement, and in gulls the whole question of the relationship between breeding pairs awaits

clarification. I suspect from the evidence of varying territory sizes in the breeding colony, and of individual hierarchies in communal flocks, that social hierarchy may also be of importance in the breeding colony. Certainly intra-specific competition for an essential resource does occur during feeding, and is decided by the status of the individual in the flock hierarchy. In feeding flocks dominant birds are the most successful and if the supply of food suddenly diminished, the effect would probably be reduced feeding by subordinate birds in direct relationship to their social status. Shortage of food could therefore impair the overall breeding efficiency of subordinate birds, and perhaps affect their ability to maintain a territory or defend chicks in the breeding colony.

Studies on the southern elephant seal Mirounga leonina and on the Silver Gull led Carrick et al. (1962, p.191) and Carrick and Murray (1964, p.196) to stress the importance of intra-specific competition for food, and to suggest social status could be the means "whereby aspiring newcomers are denied adequate feeding rights within range" of a breeding place. Carrick and Murray (1964, p.195) also assert that in the Silver Gull "there is no evidence that colony size is self-regulated at the breeding site". On the other hand Jenkins et al. (1963, p.365 et seq.) stated numbers of Red Grouse (Lagopus l. scoticus) were apparently limited by the birds' behaviour, probably in relation to their food supply, and

Wynne-Edwards (1962, p.215 et seq.) considered that lek displays in male Black Grouse Lyrurus tetrix and related species are events where a strict social hierarchy determines numbers breeding and subsequent territory size. As previously mentioned however the nature and effects of social interaction amongst breeding pairs of gulls is not yet understood so suggestions about population control mechanisms must be tentative. In section IV: 3, I will return to this subject with evidence which appears to have direct bearing on regulation of recruitment by intrinsic means.

6. Summary

1. In the 1963-64 and 1964-65 breeding seasons information was collected from 20 of the 31 colonies in the Wellington area, and presented as a comparative study.
2. The colonies ranged in size from four pairs to approximately 2,000 pairs and experienced widely differing ecological conditions. Factors that varied a great deal included topography, the degree of disturbance by humans, mustelids and other mammalian predators, susceptibility to drowning, and vegetative cover.
3. Descriptions of the environmental conditions in each colony have been given.
4. Traditional use of breeding grounds may explain why in

some colonies gulls repeatedly nest under adverse conditions, but natural growth of colonies has also caused invasion of some unfavourable areas.

5. When choosing a nest site the gulls appear to respond to a vertical component in the environment and completely bare ground is avoided. Time of breeding does not appear to be influenced by seasonal plant cover in the colony.

6. The nest site is not chosen to necessarily provide shelter for the incubating bird, but even when protective cover for fledglings is thinly spread the majority of nests are sited within 10 feet of some cover. The relationship between shelter for the incubating bird and cover for chicks emphasised the relative importance of cover for chicks.

7. Nesting density increases directly with the size of the colony.

8. An increasing food supply in the area over the last quarter century has favoured formation of splinter colonies, and nesting space appears not to be a critical factor for growth of Wellington colonies.

9. With the exception of extreme conditions such as shear cliffs or shifting substrate, topography does not affect nest density.

10. In some colonies dispersal of nests was affected by mammalian predation.

11. When re-nesting occurred in mass, the distribution

patterns of the nests were similar to the ones before which implies that despite the interruption to breeding activity, the intensity of territorial behaviour remained the same.

12. Start of laying in 11 colonies (1963-64) was spread over 35 days, and in 13 colonies (1964-65) it was spread over 34 days. Although latitude does affect onset of breeding, comparison of the Wellington data with those from a group of sub-antarctic and antarctic colonies showed the effect can be obscured by variation in numbers breeding and nesting density in the colonies.

13. Start of laying was directly correlated with nesting density but the relationship is not as marked as that recorded in other species. It is considered the influence of a large proportion of young birds in the Wellington colonies is superimposed on and obscuring the effect of nest density on start of laying.

14. In an area of low nesting density there was less hostile activity, and attacks occurred with relatively less frequency than in an area of higher density. It is suggested that if hostile disturbances do have a stimulating effect on breeding, then this is a mechanism capable of advancing breeding activity in a high density area.

15. The spread of laying was greatest in dense colonies, thus providing evidence contrary to one aspect of the "Darling effect", but the evidence as a whole was partly obscured by

the influence of numbers of young breeding birds in the colonies.

16. Recent work on the external environmental factors which help regulate breeding has been outlined, and a correlation found between abnormal weather conditions in the late winter and spring of 1963, and delayed breeding in the 1963-64 season.

17. Mean clutch size in 10 colonies was 2.44 eggs, with a range of 2.3 - 2.8. There was no correlation between nesting density and clutch size, but there was an inverse correlation with the age composition and rate of growth of colonies; fewer eggs being laid in the most rapidly growing colonies with a relatively higher proportion of young breeders.

18. Average minimum egg mortality was 32%; extremes were 6% - 100%. Of all eggs lost ferrets predated 37.4%, 19.6% addled, 15% disappeared, and 13% were drowned. The occurrence of addling was not related to nesting density. Rat predation was apparently heavy in some colonies.

19. Average minimum chick mortality was 15%; extremes were no losses in two colonies, and 96% loss in one colony. Most of the dead chicks (41.7%) were found with no external injuries, but 24.3% were killed by gulls, 20.4% presumed killed by ferrets, and 13.6% killed by stoats. In colonies free from mustelid predation gull predation accounted for about one third of the losses. Rat predation was strongly suspected in two colonies.

20. About one third of the chick losses occurred in the first two days; over 56% in the first week; and over 70% in the

first two weeks. Eighty-one per cent of the chicks found dead with no external injuries were less than one week old, while 65% of those killed by gulls were one to five weeks old, the age when chicks wander from their territories, but are not big enough to resist attack.

21. Varying degrees of local synchrony were encountered in large colonies, where breeding activities in different parts were slightly out of phase. No correlation was found between local synchrony and nest density, but the explanation offered is that the rapid expansion of the larger colonies in recent years has resulted in a high proportion of young birds which have obscured the effects of nest density per se.

22. It is suggested that behavioural stimulation between mates and between neighbouring pairs (possibly involving both hostile and courtship displays) is the immediate cause of local synchrony in gulls. The results of some recent studies by other workers have been discussed.

23. The overall success of each colony has been described. Of an initial stock of 1,041 eggs laid by 435 pairs, 68.1% hatched giving a maximum of 1.63 chicks/pair at hatching. The overall minimum mortality to the flying stage was 41.8%, and a maximum of 1.39 chicks/pair were fledged. No relationship was found between breeding success and colony size. Fledging success in other Larus gulls has been compared with that of the Southern Black-back, and the results of other studies on

the relationship of breeding success to numbers breeding have been discussed.

24. In general breeding success varied with the time of season. Egg losses were lower in the first 50% of clutches, but chick losses were the same in both halves of the season, thus differences in overall production of fledged young stemmed mainly from seasonal changes in egg mortality.

25. From the available evidence it is concluded that the overall breeding success of rapidly growing colonies will be lower than that of more stable colonies.

26. Two factors adversely affect gull breeding in the Wellington area: drowning, and mammalian predation. The principal predators are ferrets, stoats and probably rats.

27. The bulk (68.2%) of the breeding population nests in comparative safety, and well over half (63.5%) in almost complete safety. In the "safe" colonies, the most important predation is carried out by gulls.

28. On the basis of a maximum yield of 1.39 chicks per breeding pair, the breeding population of 5,684 counted pairs (estimated upper limit 6,000 pairs) contributed 7,900 - 8,300 fledged young to the Wellington population in 1964.

29. Gulls in the Wellington area suffer no lack of resources such as nesting space, nest material or cover, and until recently growth of colonies has been closely associated with increase in food supply of human origin. However it now appears the

population is being limited by the food resources.

30. Current views on natural regulation of populations have been briefly mentioned and the opinion offered that in the case of gulls at least, conclusions about regulating mechanisms must remain tentative until the nature and effects of social interaction in breeding colonies is better understood.

IV MORTALITY AND DISPERSAL OF BANDED GULLS

1. Banding programme

The first extensive New Zealand programme for colour-banding Southern Black-backed Gulls started on Somes Is. in winter 1961 as part of the banding scheme of the Ornithological Society of New Zealand. Colour-bands were employed so that gulls from different colonies could be distinguished at a glance, and for the next four years this proved very successful. With the co-operation of C.N. Challies and C.P. Gallop colour-bands were also used in the Palliser Spit and Baring Hd. colonies in 1961-62. The following season Kapiti Is. was included, then in 1963-64 when data were collected for the comparative breeding study of Wellington colonies, banding was extended to three more colonies: Mana Is., Mukamuka R. mouth, and Te Humenga Pt. Although time was limited in the 1964-65 season I was able to continue banding in four colonies of special interest: Somes Is., Kapiti Is., Mana Is., and Baring Hd.

Prior to the introduction of colour-bands in 1961 Challies and Gallop had banded chicks in the Palliser Spit and Baring Hd. colonies, and generously made their records available to me. Results to be discussed in this section therefore derive from part or all of this work, which is summarised in Table 25.

Discussion of dispersal of gulls from the colonies also includes reference to some interesting recoveries of birds banded by F.C. Kinsky in the Wellington area before 1958, and to recoveries of birds banded by L.K. Clarke, J.A. Cowie, L. Gurr, S.R. Kennington and K. Rowe in the Nelson-Marlborough region of the South Island. The colonies in which colour-banding occurred are shown in Fig. 12.

TABLE 25 BANDING IN THE WELLINGTON COLONIES

	<u>1958-59</u>	<u>59-60</u>	<u>60-61</u>	<u>61-62*</u>	<u>62-63</u>	<u>63-64</u>	<u>64-65</u>	<u>TOTAL</u>
Palliser Spit	45	142	203	180	220	309	-	1,099
Baring Hd.			364	236	437	399	409	1,845
Somes Is.**				574	728	710	561	2,573
Kapiti Is.					129	280	149	558
Mana Is.						519	427	946
Mukamuka R.						38	-	38
Te Humenga Pt.						37	-	37
	<u>45</u>	<u>142</u>	<u>567</u>	<u>990</u>	<u>1,514</u>	<u>2,292</u>	<u>1,546</u>	<u>7,096</u>

* Colour-Banding started.

** An additional 233 adult and immature birds were banded while roosting in the autumn and winter of 1961, and 104 in 1963, bringing the overall total of gulls banded on Somes Is. to 2,910.

Plastic colour-bands (size P 10) were used, and after the first year five colours emerged as unambiguous or sufficiently intense to ensure their effectiveness after several years' wear. These colours, and the colonies they represented were:

white	Palliser Spit
dark blue*	Baring Hd.
red	Somes Is.
green	Kapiti Is.
black	Mana Is.
black/white (2 bands)	Mukamuka R. mouth
white/red (")	Te Humenga Pt.

* Light blue was tested and found unsuitable.

The bands varied a little in thickness and length, thus the amount of overlap varied, and as a result some showed serious wear after four years. Most wear occurred on the inside and bottom edge of the band, through rubbing against the bird's leg; abrasion of the outer surface appeared to be of relatively less importance. The serial bands used were an aluminium alloy lock-type made in Sweden. Inspection of numerous recovered bands showed marked erosion after three to four years' wear, and this prompted an analysis of the rate of wear. The analysis formed an essential prerequisite to the calculation of mortality rates based on recovered banded birds, and is discussed below (section IV: 4.1).

The banding programme was designed to obtain basic dispersal and mortality data from large colonies in the study area so that the structure of the Wellington population could be better understood. In conjunction with this I was able to test the influence of specific factors such as nesting density ,

topography and cover etc. on the mortality of fledglings and fledged young. The chicks banded were aged between 10 days and seven weeks (flying stage), but the majority were less than five weeks old. Bands were retrieved from dead birds; not transferred to another chick. All my banding was subsequently followed by several trips to each colony to search for dead banded chicks. But since the banding by earlier workers was not always conducted in this way, I have restricted comments on mortality within colonies to the seasons and colonies in which I actually did the banding. This involves one to four seasons' work in seven colonies.

Band returns from all seasons have been closed off at 30/6/65, i.e. half way through the year, and in discussion of mortalities of individual colonies, percentage values of 0.5 and above have been rounded upwards

2. Mortality in the first year

2.1 Fledglings

In this study "fledgling" (defined as a young bird acquiring its first true feathers before flight - Thomson (1964)) is used in preference to the Latin "pullus" (a young animal). Because of careful searching for dead banded young the recovery percentage in the colony was much greater than that outside the colony, and although of course every dead

chick was not found the recovery percentage is fairly close to the real value for mortality in the colony. However banding of young can provide only an approximate value for losses of fledglings because chicks cannot be banded until at least 10 days old, by which time there has already been a heavy mortality (Fordham, 1964 b). This last consideration does not apply to losses of fledged young in the colonies since almost all chicks are banded before they can fly properly.

Of 5,269 chicks banded over four seasons, 393 (7%) were recovered dead before flying; all were found in their natal colonies (Table 26).

TABLE 26

FLEDGLING MORTALITY

<u>COLONY</u>	<u>BANDED</u>	<u>YEARS</u>	<u>DEAD</u>	<u>%</u>
Mukamuka R.	38	1963-64	12	32
Te Humenga Pt.	37	"	4	11
Mana Is.	946	1963-65	101	11
Somes Is.	2,573	1961-65	218	9
Palliser Spit	309	1963-64	21	7
Baring Hd.	808	1963-65	32	4
Kapiti Is.	558	1962-65	5	1
	<u>5,269</u>		<u>393</u>	<u>7</u>

The fates of these birds were as follows:

Killed by breeding gulls	293	74.6%
Dead; no external injuries	74	18.8%
Killed by stoats	14	3.6%

Cause unknown	9
Exposure	1
Swallowed fish hook	1
Swollen foot and leg	1
	<hr/>
	393
	<hr/>

Almost four times as many fledglings were killed by adult gulls, as died with no external injuries apparent, and this underlines the powerful predatory influence of the breeding adults. But very few fledglings were recovered in regurgitated pellets, suggesting that only small (possibly insignificant) numbers are eaten by adults. "Cannibalism" is a marked trait of Herring Gulls (Paludan, 1951, p.97; Harris, 1964 a, p.452), and some other large gulls, e.g. Glaucous-winged Gulls (Vermeer, 1963, p.59), but Emlen (1956, p.236) reported Ring-billed Gulls never ate chicks they killed, so that this type of behaviour is apparently more marked in some species than in others. Heavy predation of young by adults has been described in a number of species by Paynter (1949, p.157), Paludan (op. cit.), Emlen (op. cit.), Vermeer (op. cit.) and Harris (op. cit.).

One other important cause of death was stoat predation, but this concerned only the Baring Hd. and small Mukamuka R. mouth colonies where three and 11 chicks respectively were killed by stoats.

Records of 201 chicks whose ages at death were known are

shown below. The ages were determined by using growth characters described in Fordham (1964 b, p.121).

TABLE 27 AGE DISTRIBUTION OF FLEDGLING DEATHS

<u>WEEKS</u>	<u>1-2</u>	<u>2-3</u>	<u>3-4</u>	<u>4-5</u>	<u>5-6</u>	<u>6-7</u>	<u>TOTAL</u>
Killed by gulls	30	25	26	35	27	9	152 (75.6%)
Dead; no external injuries	10	5	5	16	8	2	46 (22.9%)
Other causes	—	1	1	—	—	1	3
<u>TOTALS</u>	<u>40</u>	<u>31</u>	<u>32</u>	<u>51</u>	<u>35</u>	<u>12</u>	<u>201</u>
<u>CORRECTED TOTALS</u>	<u>40</u>	<u>15</u>	<u>11</u>	<u>13</u>	<u>7</u>	<u>2</u>	<u>88</u>

The above distribution of dead fledglings is biased against the younger age groups because most chicks banded were older than 10 days, and so had already lived successfully through the second, third, fourth, fifth or sixth week of life. Hence these birds were exposed to further risk of death for varying lengths of time. To correct this source of error the recoveries in the oldest (six-seven week) age group have been divided by six, those in the five-six week group by five, and so on. The recoveries in the one-two week age group were divided by one. The correction is not entirely satisfactory because it assumes equal numbers of each age group were banded, whereas in fact few birds were banded in their seventh week. However it presents a more correct picture of the age distribution of fledgling deaths.

The corrected totals indicate 75% (66) of the dead

fledglings were less than four weeks of age, and highest losses (though possibly slightly exaggerated) were in the one-two week age group, i.e. 45.4% (40). As expected, losses of the oldest chicks were relatively lower than those of younger birds.

To find the proportion killed by gulls in the different age groups we can return to the original uncorrected figures because this calculation is not affected by varying sample size.

<u>Age in weeks</u>	<u>1 - 2</u>	<u>2 - 3</u>	<u>3 - 4</u>	<u>4 - 5</u>	<u>5 - 6</u>	<u>6 - 7</u>
<u>Proportion killed</u>	3: 1	5: 1	5.2: 1	2.2: 1	3.3: 1	4.5: 1

The proportion killed was greatest in the two-four week group, which is the age when fledglings begin to wander, but are too small to resist attacks by adults. Studies made on *Somes Is.* (Fordham, 1963 a) showed that growth of the legs and beak is very rapid from the time of hatching to two months of age, whereas the wings and tail do not begin rapid growth till the fifth week. Thus the means to run and escape attack, and to peck and eat (which are all needed early in life) are developed quickly, but the ability to fly is delayed. By about the sixth week fledglings can run, flap their wings and peck to help ward off attacks by adults.

2.2 Fledged young

2.21 Losses in the colony

Of 3,450 young presumed fledged, 162 (5%) were recovered

dead in their natal colonies. Recovery percentages in each colony are shown in Table 28.

TABLE 28 MORTALITY OF FLEDGED YOUNG IN THE COLONY

<u>COLONY</u>	<u>FLEDGLINGS*</u> <u>BANDED</u>	<u>NO. YOUNG</u> <u>FLEDGED</u>	<u>DEAD</u>	<u>%</u>
Somes Is.	2,012	1,850	135	7
Mana Is.	519	461	20	4
Te Humenga Pt.	37	33	1	3
Palliser Spit	309	288	3	1
Kapiti Is.	409	408	3	1
Baring Hd.	399	384	-	-
Mukamuka R.	38	26	-	-
	<u>3,723</u>	<u>3,450</u>	<u>162</u>	<u>5</u>

* All in 1963-64 except Somes Is. (1961-64) and Kapiti Is. (1962-64).

Most of these birds (76.5%) were killed by gulls as shown below.

Killed by breeding gulls	124	76.5%
Dead; no external injuries	34	21.0%
Cause unknown	3	
Rolled on by cow	<u>1</u>	
	<u>162</u>	

The percentage of fledged young killed by gulls in the colony is almost the same as the percentage of fledglings killed by gulls (74.6%) which shows adult predation extends with considerable influence beyond the age of flight (and theoretical

independence). Relative numbers of fledglings and fledged young killed by breeding birds in some of the colonies are shown in appendix 17 and are discussed in section IV: 2.3 concerning the influence of some ecological factors on chick mortality.

2.22 Fates of members of the same brood

Between 1961 and 1965 records were kept of 201 broods in which more than one individual was banded. The work was spread over five colonies in order to band a sufficient number of broods, and to gain an indication of the number of cases in which all members suffered the same fate either in, or outside the colony. The results are shown in Table 29.

TABLE 29 MORTALITY OF BANDED BROODS

<u>BROOD SIZE</u>	<u>BROODS BANDED</u>	<u>NUMBER OF CHICKS RECOVERED</u>			
		<u>0</u>	<u>1</u>	<u>2</u>	<u>3</u>
2	169	115	43	11	-
3	32	18	11	3	-
	<u>201</u>	<u>133</u>	<u>54</u>	<u>14</u>	<u>-</u>

Most of the broods suffered no losses, 54 (26.8%) lost one chick, 14 (6.9%) lost two, and none lost all three. In seven of the 14 broods in which two chicks perished the deaths of both individuals were apparently related, and these all occurred in the colony. A relationship was inferred when both

chicks died in the same locality, at the same time or within a few days of each other. In the other seven broods the chicks died at different ages or places, from different causes. The fates of seven broods (3.5%) in which the deaths of two individuals were apparently related are shown below:

AGES AT DEATH

<u>KILLED BY GULLS</u>		<u>DEAD, NO EXTERNAL INJURIES</u>	
10 days	14 days	14 days	14 days
14 "	21 "	26 "	32 "
54 "	57 " *	31 "	31 "
61 "	61 " *		

* Chicks are fledged at about 49 days of age.

The records suggest that in only a small proportion of cases (3.5%) do the members of a brood die at about the same time, and in the same way. This may be caused by sudden loss of the parents, perhaps by death or desertion.

2.23 Mortality in the first and last halves of the season

Banding extended between December and February with a peak from mid December to mid January; a consequence of peak hatching in early-mid December. The banding season could therefore be conveniently divided in half at the end of December. Comparison of all chick losses in the first and last halves of the season on Somes and Mana Islands (appendix 10) showed no significant difference, nor was there a difference in the losses

resulting from gull predation. This implies that the risk of a wandering chick being attacked by neighbouring adults is the same throughout the period in which there are chicks in the colony, and the results support those obtained in the comparative breeding study (Section III: 5.2).

2.24 Losses outside the colony

By allowing for recovery of dead chicks whose ages were unknown, 3,206 fledged young are presumed to have left the colonies. Of these 112 (3%) were recovered dead in the first year, i.e. 2% less than were recovered in the colonies, giving a total of 274 (8%) fledged young recovered in the first year. Records from separate colonies are shown in Table 30.

TABLE 30 MORTALITY OF FLEDGED YOUNG OUTSIDE THE COLONY

<u>COLONY</u>	<u>FLEDGLINGS*</u> <u>BANDED</u>	<u>FLEDGED YOUNG**</u> <u>LEAVING COLONY</u>	<u>RECOVERED</u> <u>DEAD</u>	<u>%</u>
Mukamuka R.	38	26	2	8
Kapiti Is.	409	402	16	4
Somes Is.	2,012	1,648	59	4
Palliser Spit	309	281	8	3
Mana Is.	519	441	14	3
Baring Hd.	399	376	13	3
Te Humenga Pt.	37	32	-	-
	<u>3,723</u>	<u>3,206</u>	<u>112</u>	<u>3</u>

* All in 1963-64 except Somes Is. (1961-64) and Kapiti Is. (1962-64).

** These figures allow for the recovery in the colony of 82 dead chicks whose ages were unknown.

The 1964-65 banding data could not be incorporated into calculation of losses in the whole of the first year because recoveries were closed off at 30th June, 1965 but they were used to help find the fates of fledged young outside the colony. Thus of 5,550 chicks banded between 1958 and 1964, 158 (3% c.f. Table 30) were recovered dead in the ways shown below, but the majority (68.4%) were simply reported dead.

Found dead	108	68.4%
Shot	17	10.8%
Injured and died (3 - broken wing, 1 - broken neck)	11	7.0%
Sick and died (1 - aspergillosis)	10	6.3%
Hit by car	8	5.1%
Caught by fish hook and line	2	
Hit by plane	1	
Caught in fence	1	
	<u>158</u>	

Despite the locations of the various colonies and their apparent relative exposure to certain hazards, there were few real differences in the fates of the young (appendix 11). For instance Somes Is. is close to Wellington City so one might expect relatively more Somes Is. birds to be hit by cars compared

with other colonies further away from heavily populated areas, but this did not eventuate; the percentage of Palliser Spit birds hit by cars (10%) was slightly higher than that for Somes Is. (8%). One apparent difference was found however between colonies close to and further away from the city, and concerned the danger of being shot. Palliser Spit and Baring Hd. colonies border extensive farmland, and one third of the birds shot came from farms in this area; some as a result of farmers protecting their sheep. Southern Black-backs are protected in New Zealand but farmers may shoot them if they attack any stock, so gulls that frequent farmland may be shot more often than those that mainly frequent towns.

Calculation of the spread of mortality of fledged young in the first year has been based only on my banding from 1961-65 because for these years I recorded losses of fledged young in the colonies. To determine the age of dead gulls it was necessary to choose an arbitrary date that marked the beginning of a year. Although the hatching period is spread, most chicks hatch in December, so it is convenient to follow the calendar, and choose January as the start of a year. However since, as is usual, peak laying is in early-mid November, peak hatching occurs early-mid December, thus peak fledging is six to seven weeks later, at the end of January. Therefore February is the first full month of flight for the majority of fledged young, and in fact is the first month that young of the year

leave their colonies in any numbers to join communal flocks. Some birds do leave their colonies to join communal flocks in January, but are very few in number (Table 1). I have chosen therefore to describe the spread of mortality of fledged young in the first year on the basis of age, and arbitrarily make February the first full month of flight, because this method best fits the actual conditions.

When the high mortality in the colony is combined with losses outside the colony during the rest of the year (Table 31) there is the apparent anachronism of a number of fledged young being killed by adult gulls in March. It should be remembered however that March primarily represents the second full month of flight, and that the young killed by gulls were still in the colony. The fact that breeding adults continue to predate fledged young in their second month of flight is remarkable.

The age distribution of 274 (8%) dead gulls recovered from 3,450 fledged young is summarised below.

TABLE 31 DISTRIBUTION OF FLEDGED YOUNG MORTALITY
IN THE FIRST YEAR

<u>Month of flight</u>	<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>	<u>6</u>	<u>7</u>	<u>8</u>	<u>9</u>	<u>10</u>	<u>11</u>	<u>Total</u>
<u>Calendar month</u>	<u>F</u>	<u>M</u>	<u>A</u>	<u>M</u>	<u>J</u>	<u>J</u>	<u>A</u>	<u>S</u>	<u>O</u>	<u>N</u>	<u>D</u>	
<u>Dead (all causes)</u>	(192)	22	19		8	11	7	6	4	2	3	274
<u>Percentage of mortality</u>		70	78	85	88	92	94	97	98	99	100	100
<u>Recovery percentage</u>	5.6	62	6.8	7.0	7.3	7.5	7.7	7.8		7.9	8.0	

In the above summary I have had to combine recoveries for the first two months of flight because (except for the 1961-62 season on Somo Is.) I could not re-visit the colonies frequently enough after banding to know which of the fledged young had perished in their first, and which in their second month of flight. Seventy percent of the mortality occurred in these first two months of flight, and 88% in the first five, i.e. up to the end of June. Thus losses in the first half of the year are numerically very important c.f. Lack (1946, p.259). It is convenient to use June as a mortality marker because over 80% of the mortalities of fledged young occurred by 30th June, and being the sixth calendar month it facilitates comparison with six-monthly periods in later years.

As previously mentioned losses in each of the first two months of flight were known on Somo Is. in 1961-62. During that season the colony was patrolled daily so that the ages of all dead banded birds were known. Of 542 chicks presumed to reach the flying stage 68 were later recovered dead. Thirty-three (48.5%) of these died in the first month of flight, and 19 (27.9%) in the second, giving 76.4% of the year's mortality in the first two months (c.f. 70% from the combined data in Table 31). Most of the losses (34 - 65.4%) resulted from adult predation (appendix 14). More frequent visits to the colony in 1961-62 probably explains why the recovery percentage for the first two months was higher than that in Table 31.

Considering the whole of the first year, adult predation accounted for 45.3% of the deaths of fledged young (appendix 12) and most of the rest (41.6%) were reported as "found dead". A summary of the fates of all fledged young in the first year is given below; details appear in appendix 12.

Killed by gulls	124	45.3%
Dead; no external injuries	114	41.6%
Injured or sick	13	4.8%
Other causes	12	4.3%
Shot	11	4.0%
	<u>274</u>	<u>100.0%</u>

The 1964-65 banding data could not be used to find the spread of mortality in the whole of the first year because recoveries were closed off at 30th June, 1965 but they were added to the other data to obtain a better idea of losses in the first six months. Thus the recovery percentages of fledged young in the first six months (appendix 13) were slightly lower than those shown in the table for the whole year (Table 31). This resulted from a relatively lower mortality in the colonies in 1964-65. Causes of death in the first six months were similar to those for the whole year but losses in the colony assumed relatively greater importance, thus nearly half the dead young (49.4%) were killed by breeding gulls. As is usual in studies of banded populations, only a small fraction of the birds found dead were reported as being

diseased, although probably a considerable number died from organic complaints (Jennings, 1960 & 1961, Jennings and Soulsby, 1957). However one case is of interest: a young Kapiti Is. bird which had acute aspergillosis was found freshly dead on Mana Is. in April (third month of flight) suggesting that death had resulted from (at the most) four to five months infection.

In a discussion of chick losses in Herring Gulls, Harris (1964 a, p.452) states that when the young of the earliest breeders begin to fly they are usually mobbed by adults, and frequently drown. This does not happen with later chicks which Harris suggests is possibly an important factor selecting against the young of earlier breeders. My results do not agree with those of Harris. I have found mobbing by adults of newly fledged birds, and even those in the second month of flight occurs throughout the second half of the breeding season, not only when the first young fly. Further, any young bird flying (or landing) clumsily and giving the typical tremulous call is likely to be attacked by other gulls. There appears therefore to be no evidence of selection by predation against the young of earlier breeders.

2.25 Total losses

Of the 3,723 banded chicks, 273 (7%) were recovered dead as fledglings, and 162 (4%) as fledged young in the colonies.

If these losses are combined with the 82 young whose ages were unknown, total losses in the colony are 517 (14% recovery). Recoveries of fledged young outside the colony (112 - 3%) provide an overall 17% recovery of banded young in the first year (Table 32).

TABLE 32 RECOVERY OF BANDED YOUNG IN THE FIRST YEAR*

	<u>BANDED</u>	<u>FLEDGLING</u> <u>MORTALITY</u>	<u>FLEDGED</u> <u>YOUNG</u>	<u>MORTALITY</u> <u>IN COLONY</u>	<u>MORTALITY</u> <u>OUTSIDE</u> <u>COLONY</u>	<u>TOTAL</u>
Mukamuka R.	38	12 **	2 5%	12 32%	2 5%	14 37%
Somes Is.	2,012	162	194 10%	364 18%	59 3%	423 21%
Mana Is.	519	58	34 7%	78 15%	14 3%	92 18%
Te Humenga Pt.	37	4	1 3%	5 14%	- -	5 14%
Palliser Spit	309	21	11 4%	28 9%	8 3%	36 12%
Baring Hd.	399	15	13 3%	23 6%	13 3%	36 9%
Kapiti Is.	409	1	19 5%	7 2%	16 4%	23 6%
	<u>3,723</u>	<u>273 (7%)</u>	<u>274 8%</u>	<u>517 14%</u>	<u>112 3%</u>	<u>629 17%</u>

* Based on my banding for the years 1961-64.

** Fledgling recovery percentages given in Table 26.

Recovery percentages in the first year varied widely between colonies and (ignoring the two small colonies in which 37 and 38 birds were banded) ranged from 21% on Somes Is. down to 6% on Kapiti Is. Recovery percentages outside the colony were very similar for all colonies, and major differences arose from recoveries made in the colony. As will be shown in the following section (2.3) this was not a result of unequal

search effort, but genuinely reflected differential mortality in the colonies.

To determine mortality and survival in the first year outside the colony I have combined all available data from 1958-64 (Table 33). Recoveries were closed off at 31st December, 1964.

TABLE 33

LOSSES OUTSIDE THE COLONY¹

<u>YEAR</u>	<u>BANDED</u>	<u>RECOVERED FIRST YEAR²</u>	<u>RECOVERED SECOND YEAR</u>
1958-59	45	-	-
1959-60	142	5	1
1960-61	567	11	6
1961-62	990	27	14
1962-63	1,514	41	19
1963-64	2,292	74	—
	<u>5,550</u>	<u>158</u>	<u>40</u>

1. The table excludes all fledgling recoveries, but includes fledged young recovered in the colony more than six months after banding. This last precaution was taken to account for birds which returned to roost in their natal colony during the first winter, and the period of six months after banding was set to avoid possible fledglings recovered by casual visitors to the colony during the breeding season. A full account of recoveries outside the colony after the first year appears in Table 41.

2. Recoveries outside the colony were taken as from the time of banding. The 158 first year recoveries represent 70.2% of all recoveries (Table 41) which is very similar to the percentages recorded in other large gulls in Britain. Harris (1962 a & b, 1964 b) found that the percentage of recoveries made in the first year was 72.8% in L. argentatus, 70% in L. fuscus and 68% in L. marinus.

Because the data comprised records of a large number of

birds banded in a comparatively short time, I employed a method kindly made available by Prof. J.C. Coulson, Durham University, which he described (pers. comm.) as giving a reasonably reliable estimate of the survival rate. The method depends on the following arguments. If one assumes that the recovery rate is constant then the number of birds recovered in Year 1 is proportional to the number of birds, say N . Then in Year 2, the number of birds available will be $N \times S$, where S is the survival rate. Thus the proportion of the number of recoveries in Year 2 over the number of recoveries in Year 1 is equal to $\frac{N \cdot S}{N} = S$. Thus one must take comparable samples of recoveries in consecutive years, and the survival rate outside the colony is therefore approximately $\frac{40}{84}$ (total recoveries in the second year) divided by $158 - 74$ (recoveries in the first year less those from the 1963-64 season) since the equivalent in the second year is not available i.e. $S = \frac{40}{84}$ which equals 48% survival in the first year. Mortality rate is therefore 52% and the expectation of further life or mean after lifetime (using $\frac{2 - M}{2M}$) = 1.4 years.

From the results of the comparative breeding study it was calculated that the breeding birds in the study area contributed 7,900 - 8,300 fledged young to the population in 1964. By incorporating the banding data it follows that if a minimum 5% of these fledged young died in their colonies, then a maximum of 7,500 - 7,900 fledged young left their

colonies to join communal flocks, and if a minimum 52% died outside the colony in the first year, then a maximum of 3,600 - 3,800 were alive at the end of 1964.

Using a composite life table (treatment of the records from different seasons as if they came from the same season) Paynter (1947) calculated 41.9% mortality in first year Kent Is. Herring Gulls, and expectation of further life was 2.4 years, while for the same species Hickey (1952) derived a figure of 60% for first year mortality. Paludan (1951) calculated 62.3% mortality in first year Danish Herring Gulls, with an expected further life of 2.7 years, but commented that this was probably too high for the reason that casualties among young chicks were more easily observed (in the colony) than those in older age groups. For first year mortality Paludan considered recoveries as from 1st September, i.e. he allowed about five months to elapse after peak laying to avoid including any chicks which died before becoming fully fledged, and to allow for the high proportion of young Herring Gulls that were shot because of their lack of experience and unawareness of the danger. This precaution however was unnecessary for the Wellington Southern Black-backs, first because birds recovered outside the colony were obviously fledged, and second because less than 11% of the recovered young were shot (section IV: 2.24) c.f. about 65% in Danish Herring Gulls. In New Zealand where Southern Black-backs are partly protected,

shooting accounts for only about 13% of the deaths of second year and older birds (section IV: 4.21) and so has limited importance whereas Paludan stated that about 47% of Herring Gulls recovered after the first year had been shot. If however these corrections are made for the Wellington recoveries, and five months are allowed to elapse after peak laying, then records (for the first year only) would be taken as from 1st April and recoveries for the seasons 1958-59 and 1963-64 would number 0, 4, 10, 24, 29, 53 which total 120. By the same reasoning used before this would give a first year survival of $\frac{40}{120-53} = 60\%$, and first year mortality of 40%, which is too low.

Olsson (1958) found from recoveries of Finnish and Scandinavian Herring Gulls that 60% of "juvenile" and 51% adults were shot, hence his mortality figures were probably biased to some extent against first year birds. Olsson based his life table on that of Paludan, and calculated 65.8% mortality in the first year, with an expected further life of 1.9 years. Little else has been published on the mortality rates of other gulls. Lack (1943) calculated 52% mortality in first year Black-headed Gulls L. ridibundus with an expected further life of 1.8 years, but considered this rate of mortality may still have been biased by shooting (although "those shot" were excluded from calculations) because some birds reported as found dead may have been shot. He also calculated that

if the population was stable such high mortality would require a production of 1.7 fledged young per breeding pair which seemed "rather unlikely". But the discrepancy may not be as great as he thought for several Larus species have been found to produce more than one fledged young per pair (see Table 24). From a small number of recoveries of Lesser Black-backed Gulls not reported shot Lack (1943) estimated 57% mortality in the first year (expectation of further life = 1.8 years) but did not consider the figures reliable. Coulson and White (1959) obtained from the Kittiwake Rissa tridactyla the very low figure of 21% for post-fledging mortality in the first year.

2.3 Influence of Some Ecological Factors

As previously mentioned parts of the banding programme were designed to test the effects of certain factors on chick mortality. The method was to choose (where possible) one colony which showed both extremes of a particular factor such as vegetative cover, slope, etc., and analyse recovery percentages within the colony. If a significant result was obtained from a strong comparison within a single colony it was considered safe to extend the results and infer reasons for differences between colonies.

2.31 Disturbance due to banding

Banding always causes a disturbance in the colony, but is modified to a certain extent by the environment, for instance broken landscape, or very scattered nesting may result in fewer gulls being disturbed at once. A measure of the degree of disturbance caused by banding is the number of chicks banded per breeding pair. Using this measure, and assuming the chances of recovery of dead in each colony are not markedly different (see following section, 2.32) I found that losses of young were not related to the number of chicks banded per breeding pair, that is losses were not related to the degree of disturbance caused by the bander (Table 34).

TABLE 34 MORTALITY OF YOUNG IN RELATION TO
DISTURBANCES DURING BANDING

<u>COLONY</u>	<u>BREEDING</u> <u>PAIRS</u>	<u>BANDED</u> <u>1963-64</u>	<u>BANDED</u> <u>PER/PAIR</u>	<u>TOTAL LOSSES*</u> <u>IN COLONY</u>		<u>YOUNG KILLED</u> <u>BY GULLS</u>	
Palliser Spit	265	309	1.16	28	9%	19	67.9%
Te Humenga Pt.	58	37	0.64	5	14%	4	80%
Baring Hd.	640	399	0.62	23	6%	9	39.1%
Somes Is.	1,475	710	0.48	164	23%	109	66.4%
Mana Is.	2,000	519	0.26	78	15%	62	79.4%

* Chicks not killed by gulls were found dead and uninjured.

At Palliser Spit in 1963-64 banding was carried out weekly, instead of at longer intervals as in other colonies, and more chicks were banded per breeding pair than in any other colony, but total losses were lower than in most other

colonies, and the percentage killed by gulls was less than that at Mana Is. which had been visited much less often.

2.32 Difficulties in recovering dead young

Each season banding finished in January or February, and after an interval the colonies were re-visited once or several times to search for dead chicks. In flat fairly open colonies such as Palliser Spit, Baring Hd., Te Humenga Pt. and the Mukamuka R. this was straightforward, and on each occasion at Baring Hd. I was assisted by others. The only difficulty with searching these colonies was the possibility that some dead chicks were partly buried by drifting sand. There is, of course, no measure of these losses, but my own observations suggest that probably no great numbers of birds disappeared in this way.

On Kapiti Is. only a small number of recoveries were made apparently because rats removed the corpses of dead chicks (see following section on predation, 2.33). The Kapiti colony was on a fairly flat boulder area in which patches of thick scrub and long grass hindered searching, but the overall plant cover was no thicker than that of some other colonies (e.g. Somes Is.), and since there was always a group of people searching together, nearly all the available dead chicks must have been found. Rats are common in the colony and gnaw nearly every gull corpse, thus the low recovery percentage was

caused not by inadequate searching, but by rats removing and eating the corpses of dead chicks.

On Mana and Somes Islands sloping or dissected land made searching more difficult, but in each colony the area was covered systematically and on Somes Is. my familiarity with the surroundings aided the searches. At Mana Is. difficulty lay in the nature of the wide rocky beach terraces, and in places, masses of driftwood. However these two islands provided by far the highest recovery percentages (for unpredated colonies) which contrasted with the mortalities of colonies such as Palliser Spit and Baring Hd. that were easier to search.

The search for dead banded chicks was thus hindered to a varying extent in the separate colonies, but only in those colonies where there was mammalian predation, was it considered that the relative recovery percentage was seriously affected. Searching difficulties in unpredated colonies could not by themselves, have accounted for the differences between colonies.

When roosting and breeding grounds coincide, the chances of recovering dead banded fledged young may be greater than when they do not. The reason for this is that when the colony is also a roosting site many birds will continue to return each night after the breeding season, and so are exposed to risk of death in the colony for a longer time. In parts of Somes and Mana Islands roosting often occurs in the colony, whereas at Palliser Spit and parts of Baring Hd. roosting is

not actually in the breeding grounds although it may be close by. Nevertheless while this factor is difficult to assess, it can account for only a small part of the differences in mortality between those colonies which served as roosting sites, and those which did not.

2.33 Predation

Apart from gulls themselves actual or potential predators encountered in this study included Harriers, hedgehogs, rats, stoats, ferrets, wildcats and man. Between the years 1961-65 5,269 birds were banded in seven colonies and 393 fledglings recovered dead. Of this number only 14 (3.6%) were predated; all by stoats. No fledged young were predated in the colonies. Eleven of the predated fledglings came from the small Mukamuka R. colony (45 pairs) in the 1963-64 season (where they represented 91% of the 12 losses in the colony) and three from the lighthouse colony (ca. 250 pairs) at Baring Hd. in 1963-64*. Thus the mortality of banded young in the former colony was grossly affected by predation, while in the latter predators accounted for at least 7% of the 43 recoveries.

As previously mentioned no direct evidence was found of rat predation in the Kapiti Is. colony (ca. 600 pairs). Of

* Signs of predation at Baring Hd. were noted by F.C. Kinsky (pers. comm.) in 1954 when he recovered three banded chicks together under a shrub. The chicks appeared to have been killed by a mammalian predator - probably a stoat.

558 fledglings banded on Kapiti between 1962 and 1965 only 5 (1%) were recovered dead in the colony, and these either died naturally, or were killed by gulls, but had still been gnawed by rats. Obviously more than five banded chicks perished, but intensive searching each season by parties of up to six people did not recover more banded birds and the gnawed corpses that were found indicated that rats removed and ate almost every chick that died. Thus the phenomenally low mortality on Kapiti was due to removal of the dead by rats, and not to very favourable conditions in that colony.

The other large colonies in which banding was carried out (Mana Is., Somes Is. and Palliser Spit) were virtually free of mammalian predators. No evidence was obtained of predation by the semi-wild cat on Somes Is., and no sign of mustelid or rat activity seen on Palliser Spit. Occasional human interference probably occurred at Palliser Spit (and at Baring Hd.) but cannot have resulted in a significant increase in chick mortality.

Thus mammalian predation grossly influenced mortality of young or the recovery of dead in the Mukamuka R., and Kapiti Is. colonies, and apparently had a limited effect in the Baring Hd. colony. Therefore in subsequent discussions of other factors affecting chick mortality, the figures for Mukamuka R. and Kapiti Is. have had to be ignored, and those from Baring Hd. treated with caution.

2.34 Proximity of colony to major "artificial" food sources

Some colonies, especially the largest in the area, are fortuitously placed in relation to the number of adjacent major "artificial" food sources (i.e. refuse tips, meatworks etc.). For example there are at least eight major food sources within six and a half miles of Somes Is., and no other colony is so well supplied, although Mana Is. has two within four and a half miles. The Palliser Spit and Te Humenga Pt. colonies have no known major artificial food sources near them, and presumably the birds feed mainly on the coast and surrounding farmland. Losses in each colony (Table 35) showed that shortage of major feeding sites near a colony was not in itself related to higher losses of young, for instance the number of fledglings which perished on Somes Is. (with ready access to major food sources) and Palliser Spit (with no ready access to known major food sources) were not significantly different ($.25 < P < .5$, $v=1$).

TABLE 35 MORTALITY OF BANDED YOUNG IN THE COLONY IN
RELATION TO THE PROXIMITY OF FOOD SOURCES

<u>COLONY</u>	<u>PAIRS</u>	<u>DISTANCE (IN MILES)</u> <u>TO NEAREST MAJOR</u> <u>FOOD SOURCES</u>	<u>TOTAL**</u> <u>MORTALITY</u>	<u>FLEDGLING</u> <u>MORTALITY</u>
Somes Is.	ca.1,475	2, 2 $\frac{1}{2}$ *, 2 $\frac{1}{2}$ *, 4, 5 $\frac{1}{2}$, 6, 6 $\frac{1}{2}$, 6 $\frac{1}{2}$	18%	9%
Mana Is. ¹	ca.2,000	4 $\frac{1}{2}$, 4 $\frac{1}{2}$, 10, 10, 11*, 12 $\frac{1}{2}$	14%	11%
Baring Hd. ²	ca.640	7, 8, 10 $\frac{1}{2}$, 12*	5%	4%
Palliser Spit	ca.265	Farmland and coast	9%	7%
Te Humenga Pt.	58	Farmland and coast	14%	11%

* Meatworks

** Based on the following number of banded birds:

Somes Is.	2,573	{1961-65}
Mana Is.	946	{1963-65}
Baring Hd.	808	{1963-65}
Palliser Spit	309	{1963-64}
Te Humenga Pt.	37	{1963-64}

1 A sewer outfall is within 2 miles.

2 Sewer outfalls are within 3 miles and $5\frac{1}{2}$ miles respectively.

Large numbers of gulls frequent major artificial feeding sites: the 1965 aerial survey of the study area (section II: 3.32) showed that nearly 49% of the birds were at or near refuse tips and meatworks, while in the Wellington and Hutt Valley districts over 63% were at or near tips and meatworks. Analysis of 129 gull stomachs from Somes Is. and the Wellington City area in 1961-62 revealed that offal and refuse made up 49% and 37% respectively of the stomach contents, and that 86% of the animal food consumed was offal (Fordham, 1963 a). Together with analyses of regurgitated pellets from Somes Is. the data indicated that the diet of Somes Is. birds contained a fairly high proportion of offal and refuse.

When the artificial food sources are considered in relation to their geographical location, and the number of birds frequenting them from various colonies, it appears the largest colonies are subject to greater feeding pressure than colonies further away from the city, and I consider there is a relationship between losses of young and the numbers of breeding birds competing for available food. Although

mortality figures from the small Te Humenga Pt. colony are not inconsistent with this hypothesis, I cannot explain why they appear relatively high, in view of the fact that the habitat is similar to that of the Palliser Spit colony. I can only suggest the figures may have been biased by the small number banded. Evidence presented in section IV: 3 adds support to the hypothesis that competition for food influences chick mortality.

Although refuse tips collectively attract thousands of birds, the food obtained may not have as much nutritional value as the offal scraps discarded from meatworks. Following a suggestion by Dr. R.A. Falla (pers. comm.) that rubbish tips may provide the gulls with food of low quality, I sought evidence relating to general feeding habits in each colony. Notes of food remains (usually in the form of pellets) showed that offal and/or rubbish, together with locally obtained natural foods, was eaten to a varying extent by birds in all colonies. For example offal (from nearby farms) and scraps from fishermen were found with locally obtained natural foods such as native bees Paracollectes sp., many species of shellfish, krill Munida gregaria, grasshoppers etc. in several discrete colonies in the Lake Wairarapa-Palliser Bay area including Ruamahanga R. mouth, Mukamuka R. mouth, Palliser Spit, Otakaha R. mouth, Ngawihi Pt.

On Mana Is. a number of banded young recovered in the

1963-64, and 1964-65 seasons appeared light in weight, some almost emaciated, and I gained the impression in both years that the occurrence of such dead birds was greater than in other colonies. Artificial food sources for the large Mana colony (ca. 2,000 pairs) include a sewer, which very few gulls frequent, two refuse tips within four and a half miles, and three other tips 10-13 miles distant. There are no meatworks in the area. During the 1965 aerial survey only one of the two tips close to the colony was inspected, but 740 (37.3%) of the 1,981 birds in the Porirua Harbour basin were found to be present. Therefore the only local artificial food sources offering are refuse tips which a considerable number of Mana Is. birds frequent. As yet there is no proof that refuse is generally of low nutritional value, but if it is, then chicks may become starved and less able to withstand attacks from neighbouring adults. Thus the numerous underweight chicks, and generally high mortality of young on Mana Is. may be partly explained. In the case of Somes Is. there are two meatworks close to the colony which provide offal scraps presumably of some nutritional value, but many Somes Is. birds feed at tips, and some of the losses of young may be related to the proportion of refuse eaten. Further discussion of chick losses in relation to food supply appears in section IV: 3.

2.35 Sloping and flat ground

During post-banding trips to search for dead banded young it was found that in colonies with steeply sloping ground, such as Somes and Mana Islands, most of the corpses were on flat ground at the bottom of the slopes (Plates 5-8). On Somes Is. 370 recoveries of dead banded young were distributed as follows:

Flat ground, mainly beaches	269	(73%)
Sloping ground	84	(23%)
Locality unknown	17	(4%)
	<u>370</u>	<u>100%</u>

The distribution of corpses prompted analysis of the mortality and fate of chicks banded on flat and on sloping ground in the Somes Is. colony, and this showed that although most of the chicks that died on sloping ground ended up at the bottom of the slope there was no significant difference between the losses sustained in the two types of ground ($.25 < P < .5$, $v=1$).

	<u>BANDED</u>	<u>TOTAL</u> <u>LOSSES</u>		<u>KILLED</u> <u>BY GULLS</u>		<u>DEAD, NO EXTERNAL</u> <u>INJURIES</u>		<u>FATE</u> <u>UNKNOWN</u>
Slope	1,265	225	18%	158	70.2%	38	16.9%	29
Flat	734	145	20%	104	71.7%	30	20.7%	11

Nor was there any significant difference in the number of young killed by gulls on flat or sloping ground ($.5 < P < .75$, $v=1$), so that apparently chicks were able to escape adult

attacks on sloping ground as readily as on flat ground. When fledged young losses were considered separately no significant differences were found between the mortality of slope and flat areas, which indicated that birds attempting to fly in the two habitats were exposed to the same degree of hazard.

2.36 Even and uneven ground

When chicks are attacked by gulls they run away, and on rough ground often stumble and fall, thus exposing themselves to more attacks. For this reason losses of young banded on even and uneven ground on Somo Is. were compared to see if more young were killed by gulls on uneven ground. Smooth pasture or smooth beach were classified as even ground, and all other ground was classified as uneven (Plates 7-8).

	<u>BANDED</u>	<u>TOTAL</u>	<u>KILLED</u>	<u>DEAD, NO EXTERNAL</u>	<u>FATE</u>
		<u>LOSSES</u>	<u>BY GULLS</u>	<u>INJURIES</u>	<u>UNKNOWN</u>
Even ground	519	98 19%	71 72.4%	15 15.3%	12
Uneven ground	1,480	272 18%	191 70.2%	53 19.5%	28

There was no difference between the losses on even and uneven ground ($.25 < P < .5$, $v=1$), nor between the number killed by gulls ($.5 < P < .75$, $v=1$), thus the nature of the ground surface cannot influence chick losses.

2.37 Availability of protective cover

Plants, driftwood, rocks etc. offer chicks protection from the elements, from attacks by breeding adults, and from some predators. In the 1964-65 season the availability of cover for chicks was measured on Somes Is. and at Baring Hd. by the method described before, i.e. for each nest I assessed whether there was protective cover within a distance of three feet, three-ten feet, or greater than ten feet. Protective cover was defined as that plant or other type of cover where a fledgling could hide with reasonable safety. It was found that although the nest site was not necessarily chosen to provide shelter for the incubating bird, the majority of nests were sited within 10 feet of some cover (section III: 2.1). Thus cover for chicks appeared to be related to choice of nest site. The observation that newly hatched chicks often die if left exposed to the sun, and that fledglings sometimes move away from their nests to seek shade during the day (thus occasionally exposing themselves to attacks from neighbouring adults) suggested that a supply of cover (i.e. shade) in the territory would be advantageous, and consequently that the building of nests near to cover may be functional behaviour. For these reasons I searched for evidence of a relationship between availability of cover, and mortality of Southern Black-back fledglings.

On Somes Is. measurements of cover were made in six

areas, which were then grouped according to those with relatively more available cover, and those with relatively less (Plates 6-7). These measurements (appendix 15) showed the amount of available cover in the two habitats was highly significantly different ($P < .005$, $v=2$). The losses of fledglings and fledged young in the two habitats in 1964-65 are presented below; (unfortunately owing to changes in vegetation in some areas it was not possible to incorporate banding results from previous seasons).

	<u>BANDED</u>	<u>TOTAL LOSSES</u>		<u>KILLED BY GULLS</u>		<u>DEAD, NO EXTERNAL INJURIES</u>	<u>FATE UNKNOWN</u>
More cover	149	26	17%	21	14%	4	1
Less cover	120	14	12%	13	11%	1	-

The mortality in the two areas was not significantly different ($.1 < P < .25$, $v=1$), neither were the numbers killed by gulls ($.25 < P < .5$, $v=1$). Fledglings alone revealed similar results:

	<u>BANDED</u>	<u>FLEDGLING LOSSES</u>		<u>KILLED BY GULLS</u>		<u>DEAD, NO EXTERNAL INJURIES</u>
More cover	149	19	13%	15	10%	4
Less cover	120	11	9%	10	8%	1

Numbers lost in the two areas were not significantly different ($.25 < P < .5$, $v=1$), nor were the number killed by gulls ($.5 < P < .75$, $v=1$).

At Baring Hd. cover was measured in the three colonies

(appendix 15) and it was found that the amount of available cover in the Northern and Lighthouse colonies (Plates 10-11) was significantly different ($.005 < P < .01$, $v=2$). Because no marked vegetative changes had occurred at Baring Hd. since 1963, I combined banding records for the 1963-64 and 1964-65 seasons. These were:

	<u>BANDED</u>	<u>TOTAL</u> <u>LOSSES</u>		<u>KILLED</u> <u>BY GULLS</u>		<u>DEAD, NO</u> <u>EXTERNAL</u> <u>INJURIES</u>	<u>STOATS</u>	<u>FATE</u> <u>UNKNOWN</u>
More cover (Northern)	117	3	3%	2	2%	1	-	-
Less cover (Lighthouse)	359	21	6%	14	4%	1	3	3

All but two of the losses (whose fates and ages were unknown) were fledglings. Mortality in the two areas was highly significantly different ($P < .005$, $v=1$), (even excluding the three killed by stoats); that is relatively more fledglings perished in the area of less cover. The number of fledglings killed by gulls in the Northern colony was too small for use of the X^2 test (expected value < 5), but comparison of the percentages by angular transformation showed them to be not significantly different (signif. diff. = 6.45°).

Thus on Somes Is. the amount of available cover apparently did not affect either the number of young that perished, or the number killed by gulls, whereas at Baring Hd. the number that perished, but not the number killed by gulls was apparently related to the amount of available cover. The different

results on Somes Is. and at Baring Hd. may be a reflection of the type of substrate and total amount of vegetation in the two colonies. Although the availability of cover in the two colonies was not significantly different ($.05 < P < .1$, $v=2$, see Table 9) there was much more vegetation on Somes Is. (including pasture). Also there were no areas of sand, and very few areas of smooth boulders in which nesting was possible. Thus the amount of solar radiation reflected by the grey-sand substrate at Baring Hd. was probably greater than that resulting from the largely non-reflecting substrate on Somes Is., and as a consequence chicks were exposed to less favourable heat conditions in the former colony. In the area of less cover at Baring Hd. lack of shade may have been sufficient to accentuate heat reflection from the sand and cause chicks to wander in search of shade. On Somes Is. the effect of lack of shade was not aggravated by heat reflection from the substrate.

In the 1964-65 season January was exceptionally warm and sunny (see appendix 7) and at Baring Hd. relatively more fledglings were killed by gulls, than in the previous season, but the figures proved to be not significantly different:

	<u>BANDED</u>	<u>FLEDGLINGS LOST</u>	<u>KILLED BY GULLS</u>
1963-64	399	15 (4%)	9 (2%)
1964-65	409	17 (4%)	16 (4%)

At Mana Is. in 1964-65 relatively more of the banded young were killed by gulls in the exceptionally hot period between

January and February, than in December.

	<u>BANDED</u>	<u>TOTAL LOSSES</u>	<u>KILLED BY GULLS</u>
Dec.	116	21 (18%)	11 (9%)
Jan. & Feb.	311	36 (12%)	33 (11%)

However the differences in 1964-65 were not significant, and like the data from Baring Hd. do no more than suggest the possible influence of temperature and lack of shade.

Results of studies on other species suggest cover has an influence on chick mortality. In Herring Gulls Paludan (1951, p.98) observed that "in many cases the surviving chicks were the ones which selected good hiding places", and Harris (1964 a, p.449) noted that chicks were adversely affected by extremes of weather. Vermeer (1963, p.59) also thought that extremes of weather may have an adverse effect on the young of Glaucous-winged Gulls, and (p.62) that shrub cover may reduce losses in hot weather. Emlen (1956, p.237) stated that killing of Ring-billed Gull chicks by breeding adults appeared to be affected by scarcity of shade, and exposed areas of ground were avoided by chicks, which wandered to the shade of nearby bushes when their parents were away.

2.38 Nesting density

Although nesting density varied within colonies, the differences were often not significant, and this restricted the possibilities of obtaining suitable areas and numbers of

banded birds from which to test the influence of nesting density on chick mortality. However ample supporting evidence came from comparison of various colonies in which nesting densities were significantly different.

Comparison of two areas on Mana Is. in which nesting densities in 1964-65 were significantly different at the 95% level showed significantly more young perished in the low density area ($P < .005$, $v=1$), also more young were killed by gulls ($P < .005$).

<u>MEAN SHORTEST NESTING DIST.</u>	<u>BANDED</u>	<u>TOTAL LOST</u>		<u>KILLED BY GULLS</u>	
10.2 feet	137	16	12%	10	7%
12.6 "	80	24	30%	19	24%

This result is the opposite of what would be expected if density was a critical factor in chick mortality.

At Baring Hd. in 1964-65 nesting densities in the Northern and Lighthouse colonies were significantly different at the 99% level but the number of fledglings lost, and the numbers killed by gulls were not significantly different (signif. diff. = 9.8°).

<u>MEAN SHORTEST NESTING DISTANCE</u>		<u>BANDED</u>	<u>TOTAL LOST</u>		<u>KILLED BY GULLS</u>	
Northern	9.2 feet	49	1	2%	1	2%
Lighthouse	12.1 "	164	9	5%	8	5%

Comparison of two areas on Somes Is. in 1961-62 in which nesting densities were extreme showed no significant difference

in mortality of young ($.25 < P < .5$, $v=1$), nor in the numbers killed by gulls ($.5 < P < .75$, $v=1$).

<u>NESTS/ACRE</u>	<u>BANDED</u>	<u>TOTAL LOST</u>		<u>KILLED BY GULLS</u>		<u>DEAD, NO EXTERNAL INJURIES</u>
109	96	15	16%	8	8%	7
65	45	8	18%	5	11%	3

The evidence from single colonies thus failed to reveal a correlation between nesting density and chick mortality, and comparison between colonies gave similar results. In 1963-64 densities at Somes Is. and Palliser Spit were totally different, but although relatively more fledglings perished on Somes Is. the difference was not significant ($.05 < P < .1$, $v=1$). Similarly the numbers of fledglings killed by gulls were not significantly different ($.05 < P < .1$, $v=1$). It is of interest that recorded losses in the small Te Humenga Pt. colony were higher than those on Somes Is. and Palliser Spit.

	<u>MEAN SHORTEST NESTING DIST.</u>		<u>BANDED</u>	<u>FLEDGLING LOSSES</u>		<u>KILLED BY GULLS</u>	
Somes Is.	11	feet	710	73	10%	60	8%
Palliser Spit	16.2	"	309	21	7%	16	5%
Te Humenga Pt.	58.5	"	37	4	11%	3	8%

Nesting densities on Mana Is. and Somes Is. in 1964-65 were significantly different at the 95% level, but the percentage of fledglings lost, and the numbers killed by gulls were identical.

	<u>MEAN SHORTEST NESTING DIST.</u>	<u>BANDED</u>	<u>FLEDGLING LOSSES</u>		<u>KILLED BY GULLS</u>	
Mana Is.	10.5 feet	427	43	10%	35	8%
Somes Is.	12.1 "	561	56	10%	43	8%

Comparison of colonies whose nesting densities were identical (Mana Is. and Baring Hd. in 1964-65; appendix 16) showed that fledgling mortalities were significantly different, therefore all the evidence indicates mortality of young in the colony is not affected by nesting density, and that differences between colonies must arise from other causes. Vermeer (1963, p.62) found nesting density did not affect fledging rates in Glaucous-winged gulls.

2.39 Age composition and rate of growth of colony

Under favourable conditions such as an increased food supply, gull colonies expand, and those which grow rapidly contain relatively more young breeding birds than stable colonies. Records show such rapid expansion has occurred in some Wellington colonies. It is difficult to see what influence these young breeding birds could have on chick mortality, and while losses were higher in colonies with the most rapid growth in recent years (Table 36) the causes were probably not related to the presence of young breeders as such, but rather to the total numbers of breeding birds involved, and the consequent pressure on feeding sites adjacent to the colony.

TABLE 36 LOSSES OF YOUNG IN RELATION TO GROWTH OF COLONY

<u>COLONY</u>	<u>RATE OF GROWTH IN LAST 20-25 YEARS</u>	<u>PRESENT SIZE</u>	<u>TOTAL LOSSES OF YOUNG</u>
Baring Hd.	X 11	ca. 640 pairs	5%*
Somes Is.	X 9	ca. 1,475 "	18%
Mana Is.	X 8	ca. 2,000 "	14%
Palliser Spit	X 2	ca. 265 "	9%

* Removal by stoats of the corpses of dead young may have been a cause of the apparently low mortality in this colony.

2.4 Comparison of the colonies

From the evidence presented above it appears that apart from mammalian predation, mortality of young in the colonies is influenced by the numbers of birds involved in relation to the food supply, and possibly by the nutritional value of the food consumed. In some colonies lack of adequate shade may have an effect. Factors found to have no apparent or significant influence included disturbances during banding, difficulties in searching for dead banded birds, proximity of major artificial food sources to the colony, degree of slope of the ground, evenness of the ground, amount of available cover (at least in some colonies with a non-reflecting substrate), nesting density (per se.) and the proportion of young birds in the colony. At this stage therefore an attempt will be made to explain some of the differences between mortalities in different colonies.

A general summary of the mortality of young in colonies that were apparently not affected by mammalian predation (except Baring Hd.) is given in appendix 17, and the principal results are summarised below. Because the extent of mammalian predation at Baring Hd. was not known, results from this colony have been treated with caution, while those from the small Te Humenga Pt. colony have been largely ignored. Amongst the large colonies, Somes and Mana Islands suffered the greatest losses, and the number of fledglings found dead with no external injuries were similar. Hence the major differences arose from the numbers killed by gulls.

<u>Total losses in the colony</u>	Somes Is. (18%) greater than Mana Is. (14%) (.025 < P < .05, v=1)
	Mana Is. (14%) greater than Palliser Spit (9%) (.01 < P < .025, v=1)
<u>Fledgling losses</u>	Mana Is. (11%) greater than Somes Is. (9%) (.025 < P < .05, v=1)
	Somes Is. (9%) not different to Palliser Spit (7%) (.25 < P < .5, v=1)
<u>Fledglings killed by gulls</u>	Mana Is. (9%) greater than Somes Is. (6%) (.01 < P < .025, v=1)
	Somes Is. (6%) not different to Palliser Spit (5%) (.25 < P < .5, v=1)
<u>Fledglings dead, no external injuries</u>	Somes Is. (2%) not different to Mana Is. (2%)
	Mana Is. (2%) not different to Palliser Spit (2%)
<u>Fledged young losses</u>	Somes Is. (6%) greater than Mana Is. (3%) (P < .005, v=1)
	Mana Is. (3%) greater than Palliser Spit (1%) (.025 < P < .05, v=1)

Fledged
young killed
by gulls

Somes Is. (5%) greater than Mana Is. (3%)
($P < .005$, $v=1$)

Mana Is. (3%) not different to Palliser Spit (1%)
($.05 < P < .1$, $v=1$)

Fledged young
dead, no
external
injuries

Somes Is. (1%) greater than Mana Is. (0.5%)
($.025 < P < .05$, $v=1$)

Each colony is now considered briefly.

Somes Is. (ca. 1,475 pairs, 1961-62) Overall losses were the highest of any colony and resulted from a relatively high mortality of fledged young, as well as of fledglings (use of Somes Is. as a roosting site may have slightly increased the percentage of recoveries). The factors which apparently influenced this colony were the food supply (a proportion of which may have been of low nutritional value), and the large number of birds involved. Mammalian predation was negligible. Somes Is. birds compete for food not only with each other, but also with nearly 300 pairs from the five other colonies in the harbour area, various small colonies around the south-west coast of Wellington, and some birds from Baring Hd. and Mana Is. Thus it appears likely food resources of Somes Is. birds were under considerable pressure.

Mana Is. (ca. 2,000 pairs, 1963-64) Overall losses were high, and fledgling mortality was greater than that of any other colony. Inadequate food supply (most of which may have been of low nutritional value), and possibly insufficient shade appeared to be the main factors affecting chick mortality.

Roosting in parts of the colony may have contributed slightly to the recovery percentage. There was no mammalian predation. Palliser Spit (ca. 265 pairs, 1963-64) Total losses were half those on Somes Is. although fledgling losses were similar. Past records show the colony has grown slowly, and suggest it may have reached equilibrium with the food supply some time ago. There were no major "artificial" food sources near the colony, so presumably the proportion of refuse eaten was smaller than in the other main colonies. Heat reflection from the sand, and possible lack of shade late in the season when the sand-poppy plants die (Plate 18), may have contributed to the relatively high percentage of fledglings killed by gulls.

Te Humenga Pt. (58 pairs, 1963-64) Allowing for the small size of this colony, the number of young killed by gulls was relatively high, and was possibly influenced by lack of shade and heat reflection from the sand.

Baring Hd. (ca. 640 pairs, 1963-64) I cannot explain the apparently low mortality of young in this colony except to suggest that mammalian predators (stoats and wildcats) had a greater effect than appears from the recoveries. In February W. Kemp (Lighthouse Keeper at Baring Hd.) reported 12 sightings of stoats (including some on the beaches) and several wildcats. Since stoats may make a cache of their prey, it is likely that at least some of the chicks killed were not found. Thus a situation similar to that on Kapiti may have obtained; where

predators removed corpses of dead chicks from the colony.

Apart from predation, lack of shade and heat reflection from the sand apparently affected losses in the colony.

Kapiti Is. and Mukamuka R. mouth (ca. 600 pairs, 1963-64 and 45 pairs 1963-64, respectively) Recovery of dead chicks was affected by rats on Kapiti, while at the Mukamuka R. mouth stoat predation had an important influence.

To conclude: three of the largest colonies (Mana Is., Somes Is. and Palliser Spit) were free of mammalian predation and gulls bred in comparative safety. In these colonies predation by the gulls themselves became important. The results outlined above emphasise the extent of this predation, especially on Mana and Somes Islands, and further indicate that overall breeding success in a relatively stable colony such as Palliser Spit is higher than that in an expanding colony for which essential resources are under pressure.

3. Mortality of young on Somes Is. in relation to the food supply

3.1 Results

Recovery data from Somes Is. for the years 1961-65 are given below.

TABLE 37

MORTALITY ON SOMES IS.

(1) <u>OVERALL LOSSES</u>								
<u>YEAR</u>	<u>BANDED</u>	<u>TOTAL*</u>	<u>KILLED BY GULLS</u>		<u>DEAD, NO EXTERNAL INJURIES</u>			
1961-62	574	81 14%	45	8%	34	6%		
1962-63	728	119 16%	85	12%	32	4%		
1963-64	710	164 23%	109	15%	24	3%		
1964-65	561	88 16%	68	12%	13	2%		

(2) <u>FLEDGLING LOSSES</u>				(3) <u>FLEDGED YOUNG LOSSES</u>			
<u>YEAR</u>	<u>TOTAL</u>	<u>KILLED BY GULLS</u>		<u>TOTAL</u>	<u>KILLED BY GULLS</u>		
1961-62	32 6%	11	2%	49 9%	34	6%	
1962-63	57 8%	50	7%	32 4%	22	3%	
1963-64	73 10%	60	8%	54 8%	46	6%	
1964-65	56 10%	43	8%	32 6%	25	4%	

* Differences between grand totals and group totals are caused by birds whose fates, or ages at death were unknown.

The records show that between 1961-62 and 1963-64 more young perished; the difference between 1962-63 and 1963-64 was highly significant ($P < .005$, $v=1$), more young were killed by gulls; the difference between 1961-62 and 1963-64 was highly significant ($P < .005$, $v=1$), and fewer were found dead with no external injuries. More fledglings were killed by gulls each season, but the number of fledged young killed fluctuated. As previously mentioned the proportion of fledglings killed by gulls was greatest in the two-four week age group; when they begin to wander. In the following

season (1964-65) nesting density was not significantly different at the 95% level from that of the 1963-64 season (mean shortest nesting distances were 11 feet (1963-64), and 12.1 feet (1964-65)), but overall mortality was significantly lower ($P < .005$, $v=1$), and the percentage of young killed also dropped. Similarly on Mana Is. in 1964-65 mortality was lower than in 1963-64 (appendix 16).

The Somes Is. mortality figures are considered to have far-reaching implications. Between 1961 and 1964 increasing numbers of young were killed by neighbouring gulls, while the percentage dying of other causes actually dropped. This suggests either that the intensity of territorial behaviour rose, or chicks wandered more giving increased opportunities for attacks by neighbouring adults. The evidence discussed previously indicates that chick mortality is not influenced by topography or by nesting density (as such), and suggests that cover has only a limited effect in some colonies; on Somes Is. however cover apparently had no effect. What then was the factor, or combination of factors responsible for the steady increase in mortality until 1963-64, then decline in the following season?

Firstly, banding procedure and the subsequent searches for recoveries were the same in each season. Mammalian predation was negligible, there being no evidence to suggest any predation by the one semi-wild cat on the island. Since

nest density has no effect on losses of young, then an increase in intensity of territorial behaviour cannot be explained simply as a response to a decrease in size of territory. Nor can it be ascribed to lack of nest material or some related resource. Examination of the meteorological records for the four seasons in question (appendix 7) failed to reveal a correlation between temperature or bright sunshine, and chick losses. Thus one important factor remains: food.

Because the whole question of food supply in Wellington therefore appears of prime importance I collected evidence which provided a measure of the available food at major feeding sites. In Wellington there are two main types of feeding site: refuse tips, and the outfall from abattoirs or meatworks (see Fig. 4), and records of the establishment of these sites are given below:

<u>Meatworks:</u>	Petone	1883
	Ngauranga	1889
<u>W.C.C. Abattoir:</u>	Ngauranga	1909
<u>Refuse tips:</u>	Hutt R. mouth	1905 - 1964
	Eastbourne	1920 (?) - 1938 (small)
	Gollans Valley ¹	1938 - 1964
	Wilton Rd.	1949
	Houghton Bay	1950 - 1963
	Wingate	1956
	Porirua E.	1958 supplies Mana Is.

Wainuiomata	1959 supplies Baring Hd., Somes Is. (?)
Moonshine (U. Hutt)	1960 (?) supplies Mana Is. (?)
Johnsonville	1961 supplies Somes Is. & Wellington west coast
Plimmerton	1964 (small) supplies Mana Is.
Island Bay ²	1964
Korokoro ³	1964 (small)

1, 2, 3 Replacements for Eastbourne, Houghton Bay, and Hutt R. mouth respectively.

Prior to 1958 six tips were opened in the Wellington area and four of these were closed by 1964. After 1958 seven more tips were opened but two were replacements for ones which were closed before and this left five new tips (and two established ones) in operation. But the sites of the new tips have mostly followed new centres of human population which have been away from Wellington Harbour. Thus of the tips opened since 1958 two supply Mana Is. birds almost exclusively (especially during breeding); one supplies Baring Hd. birds; and two supply some Somes Is. birds. In effect therefore the number of feeding sites for breeding birds on Somes Is. has not increased very much since 1958, although the Somes Is. population has grown much larger in the same period (section II: 2.1). The proximity of major feeding sites to the colonies is shown in Table 35. It is probably true that over the years the bulk of refuse dumped at the tips

has increased, but to a certain extent at least this is balanced by tipping practice. First, refuse is usually tipped in a limited area so that the actual space in which food can be collected is restricted. Second, refuse is soon covered with earth so feeding time is not unlimited. So although the amount of refuse has probably risen gradually, new sites are situated away from the harbour, and feeding space has not been greatly extended.

The W.C.C. abattoir, and two meatworks represent the other major "artificial" source of food for gulls in Wellington Harbour. They have been in operation many years so that gulls would have adjusted to their presence long ago, particularly as the maximum killing period is November-February (McIlwaine, 1964), which coincides with the presence of chicks in the colony. The point in question is by how much and at what rate have killing figures at the works increased over the years, and has there been a change in the method of discharging effluent. The evidence obtained from the companies involved, and presented below, is quite clear on this point: the numbers of animals killed per annum has increased (with some fluctuations) over the years, but the availability of offal has, for several reasons, been cut down steadily to a fraction of the former quantity.

Since 1956 output from the two meatworks in Wellington increased in step with a similar increase throughout the country

(Dept. of Statistics, 1965) and in one the slaughtering of cattle, and of sheep and lambs increased by 10% and 2.7% p.a. respectively. The figures for meat production in one of the Wellington companies are given below expressed in thousands of freight carcasses; a freight carcase = 60 pounds of meat.

1956	419.6
1957	415.4
1958	457.2
1959	468.7
1960	482.7
1961	498.4
1962	519.5
1963	495.1
1964	544.9

The overall production of the meatworks therefore increased more or less steadily, with at least one company showing a drop in 1963 - the year of highest chick mortality on Somes Is. The decreased mortality of young in the following season (1964-65) was probably related to the marked rise in meat production in 1964.

Despite the general rise in production two events took place prior to 1961 which eventually resulted in a diminution of the quantity of offal available to gulls. First the Wellington Harbour Board laid down new regulations relating to the discharge of sewerage and industrial waste into the harbour with the result that meatworks began to alter their treatment of slaughtering bi-products, which in turn steadily reduced the quantity of offal discharged. At Ngauranga production of tallow, blood and bone and other products was stepped up, so

that the tallow tanks now process about twice as much raw material as before, and blood production has increased by 200%. Whereas originally pieces of intestine, skin, fat, bone and blood regularly emerged from discharge pipes in the harbour, and sometimes lay along the foreshore, now the effluent comprises bloody water, scraps of fat and offal. The result is that since 1961 when I first began regular observations at Ngauranga, the quantity of offal and size of individual fragments in the effluent has visibly reduced. The reduction will be even greater in the future because (I was informed) the W.C.C. Abattoir plans to redirect its effluent into the City sewerage system.

The second event which has steadily affected the availability of food in Wellington was Government reclamation of the foreshore which started in 1960 and still continues in 1965. The result of this reclamation was that feeding space for gulls at Ngauranga was seriously reduced, and the activity of machinery and workmen were a constant disturbance. By February 1962 the reclamation reached the effluent discharge pipes at Ngauranga, which soon after were shortened and opened directly into the stream which entered the harbour at the same place. Construction work continued round the pipes and the stream was bridged so that by 1965 effluent emerged into the stream in a gap in the reclamation. In mid September 1965 less than 10 Southern Black-backs were seen feeding at Ngauranga,

whereas at the other meatworks in Petone, where there has been no alteration to the discharge pipes themselves, numerous gulls were present.

To summarise: offal and rubbish compose the major part (86%) of the food eaten by Wellington gulls, but the total quantity of food available at meatworks has decreased considerably, particularly since 1961, and as far as the Somes Is. colony is concerned there has been only a slight increase in the number of refuse tips available to breeding birds.

Historical records show the whole population has grown rapidly in the last 20-25 years, and regular counts in the harbour showed a marked increase in numbers even since 1961 (Fig. 5). This increase coincided with increased loss of young in the Somes Is. colony. Nest counts on Somes Is. indicate the colony itself has increased in size between 1961 and 1965: in some areas numbers of nests declined, but in others they rose, and in addition new ground was occupied. Three of the study areas contained 116 pairs in 1961-62, and 134 pairs in 1963-64; an increase of over 15%. Counts in other parts of the colony revealed 270 nests in 1961-62, and 285 nests in 1964-65. In view of the evidence concerning numbers of feeding sites and the actual quantity of food available it appears likely that, precipitated by similar expansion of other colonies in the Wellington area, the Somes Is. population may have reached equilibrium with the food supply some

time before 1963-64, and the subsequent steady increase in numbers of gulls in the area placed food resources under great pressure.

Returning to the Somes Is. mortality data we find the recovery percentage of fledged young outside the colony was near to 3% each year, although there was a fractional rise in 1963-64 (appendix 16) thus increased mortality occurred almost entirely in the colony during breeding, not outside the colony after breeding. The increased losses on Somes Is. stemmed mainly from an increased mortality of fledglings, while losses of fledged young fluctuated. The reason for this is that once fledged, a bird can leave the colony and can also defend itself more efficiently against attacks, thus killing of young by adults was focused on fledglings, that is birds not ready or able to leave the colony. However in comparison with other colonies the mortality of fledged young was very high on Somes Is., which suggests that here (and on Mana Is. too) predation by adults extended to fledged young to a greater extent than in other colonies. The important point is that the increased mortality did not result from more young simply dying, but from a steadily increased predation by adults, and this suggests the numbers of fledged young leaving the colony were regulated by the gulls themselves through predatory behaviour.

It is not clear how insufficient food, (or for that matter food of low nutritional value) could influence attack by adults.

Possibly starved chicks are inclined to wander more, thus exposing themselves to more attacks, or the territorial behaviour of adults increases in intensity, perhaps in relation to the social hierarchy. A puzzling feature is that the gulls rarely ate dead of their own species, including dead chicks, although they often ate dead of other animals. However this is possibly a specific trait which may not break down even during food shortage. Similar behaviour has been observed in Ring-billed Gulls by Emlen (1956), and F.C. Kinsky noted (pers. comm.) that Antarctic Skuas Stercorarius skua maccormicki did not eat dead of their own species in the colony while scavenging any other corpses, but Young's (1963) conclusions suggest this species may turn to cannibalism in the event of food shortage.

Finally; mortality of young in the Somes Is. colony increased while losses outside the colony remained the same, and in default of adequate explanation in terms of other measured factors (such as nest density, topography and cover) the evidence suggests an intrinsic population regulation of the type proposed by Wynne-Edwards (1962), acting in response to a diminished food supply. Because the study did not cover a long enough period, I prefer not to attempt correlation of the chick mortalities with population size either after breeding, or in the preceding winter and spring. Instead I will draw attention only to the correlation between rising chick mortalities, and increased population size coupled with a

diminished food supply.

Predation, and even cannibalism of young by breeding adults is one of the main causes of mortality in other Larus species including the Ring-billed Gull, Glaucous-winged Gull, Great Black-backed Gull and Herring Gull (Paynter, 1949, p.157; Paludan, 1951, p.97; Emlen 1956; Vermeer, 1963, p.59; Harris, 1964 a, p.452). Such predation is almost certainly caused by intense territorial behaviour, released by the intrusion of wandering chicks (Herrick, 1909; Emlen, 1956, p.238) and Kirkman (1937, p.117) thought that many deaths of Black-headed Gulls were due to unmated "rogue" gulls which had acquired the predatory habit. Goethe (1956, p.80) observed that killed Herring Gull chicks may be eaten not only by adults into whose territory they wandered, but also by their parents.

3.2 Interpretation of the results

Before considering the significance of adult predation of young gulls I will briefly review some researches and current hypotheses concerning the regulation of animal, especially bird populations. The subject has been discussed by several authors in recent years, including particularly Lack (1954), Ratcliffe (1958), Andrewartha (1961), Gibb (1961, 1962) and Wynne-Edwards (1962), while Wynne-Edwards' (1955 & 1959) papers sparked off a controversy over the interpretation of results of ecological studies. Because the dispute has been vigorous

in recent years, I have paid most attention to the period following Wynne-Edwards' papers.

Apart from factors which are largely density-independent e.g. climate, the principal factor agreed upon by a number of authors as probably having the greatest importance in limiting populations is the supply of essential resources (particularly food) e.g. Lack (1951, p.437 & 1954, p.151); Fisher and Lockley (1954, p.122), Southern (1959), Wynne-Edwards (1959, p.438 & 1962, p.8), Gibb (1961, p.438), Myers and Poole (1963), Kluyver (1963), Murton et al. (1964, p.496), Carrick and Murray (1964, p.196). A recent departure from this view however was expressed by Pearson (1965) who investigated the feeding times of seabirds and suggested that many of the species studied "were not exploiting their maximum food gathering potential", that "the minimum amount of time consonant with survival was taken up in food gathering", and "it could thus be postulated that food is not a limiting factor in controlling the populations".

One subject in dispute among ecologists is the role of territorial behaviour in population-ecology. Thus Lack (1954, p.260) considers that although territorial behaviour spaces out breeding pairs, it is not of importance in limiting numbers present, and Hinde (1956, p.354) concluded that the available evidence did no more than suggest territory regulates density of many species in the most favoured areas. On the

other hand Ratcliffe (1958, p.86), Southern (1959, p.435), Wynne-Edwards (1959, p.438 & 1962, p.149 et seq.) and Gibb (1960, p.204) take the view that territories aid dispersion in relation to the supply of essential resources, while Tinbergen (1957, p.24), Jenkins (1961, p.183), and Jenkins et al. (1963, p.366) point out that territorial behaviour is not altogether essential in ensuring dispersion and a supply of essential resources, which may be achieved by intra-specific hostility alone. However Andrewartha (1961, p.114) considered the "chief selective value" of territorial behaviour is that an animal in its home range is "more secure against predators and other hazards" than one not established in familiar surroundings, and his treatment of the subject (see also p.169 et seq.) leads one to infer that he considers territories are not related to food supply or other resources. Andrewartha also questions the value of the term "competition" as applied to intra- and inter-specific interactions for essential resources.

Carrick (1963, pp.749 & 750) found that territorialism and sexual interactions in Australian Magpies Gymnorhina tibicen virtually limited successful breeding to a quarter of the adult population. Further (p.751) he considered the food supply was always adequate, and concluded there was no evidence that flock birds (non-territorial) came up against the food limit. Similarly Brown and Watson (1964, p.97) concluded

that numbers of Golden Eagles Aquila chrysaetos must ultimately be limited by food, "but home-range size is fixed so high that a critical food level is probably very rarely reached".

Brown and Watson comment (p.96) that although the numbers of adult eagles are not related to the total food supply, breeding success may be related to the supply of live food for eaglets.

Apart from arguments about whether social interactions such as territorial behaviour, and food or other resources do in fact act in concert to limit the numbers of a species, there is disagreement over how and when they take effect, either separately or together, and Ratcliffe (1958, p.87) confessed he did not know "whether the populations of most, or even many, species are regulated in nature with any high degree of promptitude or precision". Hence there is division into those who maintain that variation of the reproductive rate is the most important regulating mechanism (Wynne-Edwards, 1955, 1959, 1962; Jenkins, 1961; Jenkins et al., 1963), and those who consider mortality to be the most important (Lack, 1951 & 1954; Southern, 1959; Gibb, 1961; Perrins, 1963; Murton et al., 1964).

Protagonist of the view that recruitment, not mortality, is the main variable is Wynne-Edwards (1955, 1959, 1962, esp. p.484 et seq.). In agreement with many other ecologists Wynne-Edwards considers that in most cases food is the ultimate factor, but suggests animal populations are not regulated

primarily by direct competition for food or other essential resources in a density-dependent way, but instead there is competition by means of conventional behaviour, in relation to the social hierarchy, for an objective such as territory so that the population is maintained below the level where resources are in danger. The intensity of this behaviour which is termed epidiectic (Wynne-Edwards, 1959, p.440; 1962, p.16) is directly related to the population density, and being intimately affected by the physiological systems of the individual (Wynne-Edwards, 1962 in lectures at Victoria University of Wellington) serves to indicate the productivity of the environment. The social interactions affect recruitment in various ways such as altering the number of females fertilized.

A slightly different type of reaction to over-population was described in voles Microtus agrestis by Chitty (1957) who suggested that periodic heavy mortality and a hereditary lessened viability was related to intra-specific strife at high densities.

Wynne-Edwards' hypothesis has received support from Jenkins (1961, p.184) who noted a correlation between chick mortality in the Partridge Perdix perdix and the frequency of intra-specific interactions between adults during the previous winter, while Jenkins et al. (1963, p.371) found breeding success of Red Grouse was related to the survival and presumably

the condition of the parents in early spring. Further (p.371) clutches were large and chick survival good when heather (the chief food of Red Grouse) was green in spring, and poor when it was brown in spring. The authors concluded that at all population densities grouse numbers were apparently limited by the birds' behaviour, probably in relation to their food supply. Recently Lack (1965, p.238) expressed the opinion that "it is important to study evolutionary ecology in the natural habitat of a species, as many of its ecological adaptations may not be well suited to habitats modified by man", and (p.239) questioned the relevance of the work of Jenkins et al. (1963) to the functions of territory, on the grounds that the observations were made in a habitat modified by man and densities of grouse "were far higher than those where the territorial behaviour in question was presumably evolved".

Kluyver (1951, 1963) observed that the reproductive rate of tits varied slightly in accordance with conditions of the environment, and population density, but agreed with Lack (1954, p.69) that the small changes in reproductive rate could not significantly affect numbers breeding in the following year. Gibb (1961, p.433) concurred with this view. Lack (1954, p.36) further stated that clutch size was probably adapted to the food supply when the young hatch, i.e. the ultimate factor (having survival value) was the amount of food provided by the

parents, but mentioned that in some birds food may have a proximate (physiological and behavioural) effect on the number of eggs laid. He concluded (Lack, 1951, p.424 and 1954) however that density-dependent mortality was the main factor regulating population size. Likewise in Tawny Owls Strix aluco Southern (1959, p.434) recorded the initial response to poor hunting (for rodents) was to omit breeding, but decided that this density-dependent effect on birth rate could equally well be included under the heading of mortality since "it is a fine point whether an egg should fall into different categories according to whether it dies inside or outside the parent's body". Thus Southern contemplated extending his view that density-dependent mortality is the main limiting factor to include the period prior to the laying of eggs, and suggested (p.434) the term "repression" for one process including the effects of food and population density on birth- and death-rate.

Underlying the controversy is the question at what level must natural selection operate to bring about necessary population controls? Wynne-Edwards' hypothesis is described in terms of conventional behaviour between potential breeding birds which serves to indicate population density and reflect the state of essential resources (ultimately food). Thus social behaviour regulates recruitment and natural selection favours those groups best able to vary their reproductive rate,

the normal figure of which lies somewhere between zero and a potential maximum, and is capable of being profoundly influenced by social conventions (Wynne-Edwards, 1962, p.485, see also Dobzhansky, 1957). Those ecologists who do not accept the concept of intrinsic regulation of recruitment as being the main limiting mechanism reject evolution at the group level, in favour of Darwinian selection of the individual (e.g. Lack, 1954, 1965; Orians and Willson, 1964). Thus Lack (1954, p.22) contends that "in most birds clutch size has been evolved through natural selection to correspond with the largest number of young for which the parents can on the average find enough food". Further, if there is a hereditary difference in egg production, the more fecund type must come to predominate "(even if there is over-population) - unless for some reason the individual laying more eggs leaves fewer, not more, eventual descendants".

Wynne-Edwards hypothesis has been further criticized by those who, while recognizing the importance of social status in competition for essential resources, consider that the right to breed and eventually breeding success is not decided in the colony, but outside it. Thus studies on elephant seals and Silver Gulls led Carrick et al. (1962, p.191) and Carrick and Murray (1964, p.196) to suggest social status could be the means whereby newcomers are denied adequate feeding rights within range of a breeding place so that their growth

and sexual development is retarded. Ashmole (1963, p.460) also contended that competition for food within range of a breeding place limited the breeding of tropical oceanic birds, while Rowan (1965, p.58) extended this idea by suggesting that competition may continue all year (see also Lack, 1954, p.141) and affect "inexperienced" young birds more severely than adults. My own experience with Southern Black-backs has been that immature gulls quickly display feeding techniques as varied as diving into water and capturing small terrestrial and fresh-water insects. Also food analyses (Fordham, 1963 a) suggest they exploit the same range of habitats as adults, and their age does not significantly handicap their searches for food. Nelson (1964, p.77) came to a similar conclusion over the fishing ability of young Gannets Sula bassana. By experimentation Nelson showed that the parents were well able to raise an extra chick above the normal one, and allowed (p.75) that the results could be explained by Wynne-Edwards' (1962) hypothesis since "he (Wynne-Edwards) would expect that even if the habit of laying two eggs did lead to more young surviving, as it apparently does, it would not necessarily spread if it would be against the long-term interests (in terms of exploitation of local food) of the species".

While acknowledging the need for more data, Robertson (1964, p.50) discounted competition between Sooty Terns Sterna fuscata during breeding as a limiting factor. He stated that

the site tenacity of adults, and the tendency of late arrivals to choose insecure nest sites near the colony, rather than more secure sites further away, appeared to operate in a density-dependent manner to limit populations. Rowan (1965, p.55) made a similar suggestion regarding the burrow-nesting Great Shearwater Puffinis gravis, and attributed the behaviour to the "tolerance and absence of territorial behaviour" of nest owners which didn't drive other birds to new ground. Finally Brown (1965) has drawn attention to the possible stimulative value of copulation (at the intra- and inter-pair level) in Lesser Black-backed gulls, and suggests that it is this object, rather than "counting heads" which is the function of epidictic displays.

In the foregoing account I have briefly summarised some current ideas on the natural regulation of animal populations, and attempted to illustrate the divergent and conflicting opinions that exist. So far, it appears, relatively few people have made critical life history studies of bird numbers in relation to their food supply, but those that have in recent years present results which serve only to add fuel to the dispute over what regulating system is the more important. Included amongst such studies are the works of Southern (1959), Gibb (1960), Jenkins et al. (1963), Murton et al. (1964), Nelson (1964), Brown and Watson (1964).

We are faced therefore with the problem that some species

of birds appear to be limited primarily by variation in birth-rate, while others appear to be primarily limited by variation in death-rate. Both systems act in a density-dependent manner. It may be some while before sufficient work has been carried out to indicate the overall position more clearly and at this stage it does not seem out of place to ask whether we are justified in trying to compare groups of animals that are totally divorced taxonomically or ecologically with the hope of deriving a common method by which each limits its numbers. Is it not possible that, because of the differing ecological adaptations and genetic structure of different groups and species, in any particular species one regulating system may be more developed and have relatively greater effect than any other system? Could not more than one system operate, perhaps in a complementary manner similar to that suggested by Gibb (1962)? Capildeo and Haldane (1954, p.220) state that fertility and death-rates vary considerably from year to year, but on the average they are pretty steady. Further, they conclude that it seems likely bird populations are mainly regulated by changes in effective fertility which, on their definition, includes the effects of mortality in the first year. Coulson and White (1959, p.102) suggest it is possible that fecundity, adult mortality and the age of first breeding may all change to produce a relatively static population.

With the thought in mind that the results may not implicate

all other birds or even all other gulls (except possibly the larger members of Larus) let us return to the case of the Somes Is. Southern Black-backed Gulls. Here we have a species that has developed the scavenging habit to a high level, so that in Wellington the major part of its diet comprises food ultimately derived from man's activity. Investigations showed the gulls were most strongly represented at meatworks and refuse tips, Somes Is. birds were sedentary, and birds from other colonies were attracted to feeding sites in the city. During the study the local gull population increased markedly, while at the same time the number and production of artificial feeding sites fell. Coincident with these events was first a rise in chick mortality on Somes Is., caused principally (indeed almost entirely) by increased adult predation, and second a steady recovery percentage of young outside the colony. Losses in the colony were almost certainly related to increased territoriality of breeding adults (although chicks may have wandered more) but only a very small proportion of young killed were eaten by gulls, i.e. there was no significant rise in cannibalism. Losses in the colony were not related to measured factors such as nesting density, but there was an inverse correlation to the amount of available food.

After consideration of the evidence from banding and breeding studies in a number of colonies, and from fluctuations in the food supply and local population of gulls, I conclude

the Somes Is. colony was regulated in a density-dependent way in relation to the food supply. The regulation occurred in the colony during breeding, not outside it after breeding, and involved young before they became independent of their parents. This fairly constitutes an adjustment to the level of recruitment, and its effect as a regulating mechanism for the population was relatively much greater than any density-dependent mortality outside the breeding season. It appears therefore that the results can be explained more satisfactorily in terms of Wynne-Edwards' hypothesis, than by other means.

In searching the literature I found that few population studies of gulls have been made from which the authors have been tempted to suggest how and when regulating mechanisms act, but Paludan (1951, pp. 121 & 122) anticipated my own conclusions regarding the significance of chick losses through adult predation when he suggested in a general discussion of population balance in Herring Gulls (though not from specific data) that "in some way or other" chick mortality is the actual mechanism of population regulation. And it may have been Paludan's writings which later prompted Fisher and Lockley (1954, p.246) to state that "cannibalism may be regarded as an effective controlling factor in the population of large gulleries".

On the whole mortality data from Southern Black-backs would be accommodated by the suggestion of Ashmole (1963, p.463) that density-dependent mortality of adults from starvation,

outside the breeding season, is not an important factor in regulating the numbers of most species of seabirds. In the same work however Ashmole (p.464) discussed Paludan's (1951) conclusions that in Herring Gulls "the population could be potentially controlled by density-dependent variation in the production of young, operating by increased eating of young by adults, when a high population has made feeding difficult". Ashmole states "it is not necessary to suppose . . . that eating of chicks by adults has evolved, by group selection, as a mechanism for limiting the population; it could have evolved through individual selection favouring those adults which found food for their young, even though it consisted of their neighbours' offspring". It is at once clear that such explanations cannot apply to Southern Black-backs which did not (except for insignificant numbers) eat the young they killed, or for that matter to Ring-billed Gulls which also kill many chicks but do not eat them (Emlen, 1956). Finally, in a recent population study on Silver Gulls Carrick and Murray (1964, p.195) assert that "there is no evidence that colony size is self-regulated at the breeding site".

4. Mortality after the first year

4.1 The durability of bands

As mentioned earlier in the outline of the banding programme, an analysis was made of wear on the size S lock-type aluminium serial bands. The reason for this was that after a certain number of years gulls begin to lose their bands with the result that a bias is immediately introduced into the recovery rate, and increases with time. Gulls that have lost their bands cannot be identified on recovery, thus analysis of recovery data over a period of years shows mortality in the first few years as disproportionately high in comparison with later years. The question was how quickly did the S bands used in New Zealand become worn away so that they were likely to either break off, fall open, or be pecked off by the bird carrying them?

Since bird banding commenced in New Zealand, three types of bands have been employed on Southern Black-backs: size L butt-end, size L lock-type, and in recent years size S lock-type. The last is the lightest of the three, and was the type I used in the present study. These bands are stamped in Sweden from strip alloy, and since their introduction to New Zealand for use in gull banding, have not altered in composition (F.C. Kinsky, pers. comm.). However weights of some recovered bands suggest that in certain years (e.g. 1960, 1963) bands sent to New Zealand were very slightly heavier than those

in other years, so it is possible that the strip metal may have varied fractionally in thickness, and that from year to year the average potential life of a consignment of bands may also have varied fractionally. Bands also vary in weight individually, thus 12 new (1965) S bands selected from 100, varied as much as 0.02 grams from the mean.

From my own material, and from that held in the files of the Ornithological Society of New Zealand I examined 80 bands recovered from gulls banded and found dead since 1959. These were weighed to 0.01 grams and the amount and areas of wear noted in relation to the time the band had been worn. Also 150 unused (1965) bands in the S- 27,000 series were weighed together, and the mean weight of 1.22 grams obtained. These measurements appear in Fig. 11a, and details are given in appendix 18. The worn bands were not all collected at the same time, but were recovered over several years (most occurring in the first few months of each year) so that to find the mean annual loss of weight (Table 38) I considered only bands recovered in the last six months of each year.

TABLE 38

MEAN WEIGHT LOSS OF BANDS*

<u>YEAR</u>	<u>NUMBER</u>	<u>MEAN WEIGHT LOSS</u>
$\frac{1}{2}$ - 1	13	0.04 gms.
$1\frac{1}{2}$ - 2	12	0.04 "
$2\frac{1}{2}$ - 3	5	0.11 "
	<u>30</u>	

* Mean initial weight = 1.22 gms.

FIGURE 11

- A Loss of weight of bands with age. Mean initial weight = 1.22 gms. (1965 bands). The line shows mean weights based on six-monthly intervals.
- B Examples of worn bands showing parts of the inner surface most subject to abrasion. Vertical outlines of bands indicate degree of erosion.

B

S-2141
3 yr. 6 m.

S-3990
1 yr. 8 m.

S-6488
2 yr. 8 m.

S-3443
3 yr. 4 m.

S-2817
4 yr. 8 m.

0 2 cm.

The line showing mean weights of recovered bands in Fig. 11a was derived from mean values based on six-monthly intervals from years one to four. Weight loss was constant and mean annual loss of weight per band = 0.052 gms. (4.3% of the initial weight). This value is less than the real value because not all bands were recovered at the end of a year interval. Olsson (1958) recorded about 5% annual weight loss in bands worn by Herring Gulls, while Coulson and White (1959) found bands worn by Kittiwakes lost an average 9.3% of their initial weight each year, and became partly illegible after two years.

Extreme loss of weight was shown by some New Zealand S bands e.g. S- 5542 lost 16.4% of its initial weight after only one year, and S- 2817 lost 39.3% of its initial weight after four years eight months. This band (Fig. 11b) was eroded to paper thickness and could not have remained intact much longer, which suggests bands may start to fall off in the sixth year. Extrapolation of the line of mean weight indicates that on the average bands would have eroded to the level of S- 2817 (0.74 gms.) in less than nine years, which suggests marked loss of bands by about the tenth year. Poulding (1954) recorded that a lock-type band on a Lesser Black-backed Gull lost 32% of its original weight after three and a half years.

Bands lose weight in three main ways: irregular abrasion

of the outer surface, continuous abrasion of the inner surface, chemical corrosion of all free surfaces. Of the three, abrasion of the inner surface against the bird's leg appears to have the greatest effect, but there is no doubt all three interact. Variation between bands arises from the habits of individual birds; those frequenting certain habitats (such as chemically polluted water) cause their bands to be exposed to relatively more corrosion.

Unlike butt-end bands the lock-type are not evenly balanced on the bird's leg but tilt from front to back. Thus bands wear especially at the base against the lock, and at the top in front (Fig. 11b), so that (if the band is clipped on correctly) the serial number is the last part of the inscription to become illegible. Providing a band has been put on correctly there is virtually no chance of the lock opening, so bands may be lost only as a result of the combined effects of corrosion and abrasion. By comparison Poulding (1954) found evidence to suggest Herring Gulls were able to remove worn butt-end bands.

Records of individual banded birds show that the larger gulls are potentially long-lived. Gross (1940, p.148) and Paludan (1951, p.105) site Herring Gulls that lived for at least 24 and 26 years respectively in the wild, and Paludan referred to a gull that lived 64 years in partial liberty. Vermeer (1963, p.88) mentioned that a Glaucous-winged Gull was

recovered after 21 years. It is therefore clear that if the bands used in New Zealand are likely to fall off after about six years wear, then the recovery data obtained are accurate for only part of the potential life of the bird, and that mortality rates after about the sixth year will probably be biased.

Olsson (1958, p.162) drew attention to the oldest recoveries (appearing in life tables) of Herring Gulls in five different countries: Germany 26 years, Denmark 26 years, Finland 17 years, America 17 years and Sweden 15 years. He concluded that the shapes of survivorship curves from U.S.A., Denmark and Fennoscandia did not reflect real differences in the wearing ability of the bands used. But the evidence from New Zealand shows bands of Swedish metal carried by gulls may wear out relatively quickly, and therefore it seems important to first establish "mortality rates" of the bands used, before attempting to deduce mortality rates of the birds themselves, let alone to compare different populations. For future work in New Zealand it is suggested that when the annual consignment of bands arrives, a sample of every type subject to serious wear in the field should be weighed, so that when life tables are compiled reference can be made to initial weights of new bands.

4.2 Mortality and survival

4.21 Fates of gulls, and spread of mortality

The fates of gulls recovered after the first year are shown below. The data relate to recoveries of birds banded between 1958-59 and 1963-64 and so cover a maximum period of six years. Details of the colonies involved are shown in appendix 19.

FATES OF GULLS AFTER THE FIRST YEAR

Found dead (including 11 dead in their natal colonies)	47	70.1%
Shot	9	13.4%
Sick and died	3	4.4%
Hit by car	3	4.4%
Injured and died (including 2 with broken wings)	3	4.4%
Electrocuted	2	3.3%
	<u>67</u>	<u>100.0%</u>

The fates are very similar to those found in the first year outside the colony (section IV: 2.24) which indicate there are no important differences between the causes of death in first year and older birds. This is largely a reflection of the fact that the law does not permit gulls to be shot (except by farmers) so that, unlike Scandinavia where shooting is permitted, Southern Black-backs in New Zealand are not

seriously exposed to a hazard which has a relatively greater effect on "inexperienced" young gulls (Lack, 1943; Paludan, 1951). As with most other population studies based on recoveries of dead birds there is no precise knowledge of the fates of the numerous birds "found dead". The reports of Kaschula and Truter (1951), Jennings and Soulsby (1957) and Macdonald (1963) however show that poisoning, organic disorders, disease and parasitism are all important, though seldom described causes of death in gulls.

The spread of mortality of second year and older birds is shown in Table 39. Details of the four colonies involved are given in appendix 20.

TABLE 39	<u>SPREAD OF MORTALITY AFTER THE FIRST YEAR</u>												
	<u>J</u>	<u>F</u>	<u>M</u>	<u>A</u>	<u>M</u>	<u>J</u>	<u>J</u>	<u>A</u>	<u>S</u>	<u>O</u>	<u>N</u>	<u>D</u>	<u>TOTAL</u>
<u>Number Recovered</u>	6	7	12	9	7	2	3	4	2	2	6	7	67
<u>Percent of Mortality</u>	9	19	37	51	61	64	67	75	78	81	90	100	
	25			18			9			15			
	37%			27%			13%			23%			
	20			28			9			10			
	30%			42%			13%			15%			

Half the losses occurred by the end of April, and 64% by the end of June (c.f. 88% in the first year). After April mortality was relatively low until November. Most (48 - 72%) of the losses occurred in the summer and autumn months, i.e. December through to May, while greatest losses (42%) were in

autumn. This pattern of mortality is similar to that described in British Herring Gulls by Harris (1964 b). Although peak mortality in adult gulls does not occur in winter, the papers of Ash (1964), and Dobinson and Richards (1964) indicate that non-migratory gulls are affected to varying degrees, depending on their feeding habits, by spells of unusually cold weather.

Further data relating to the spread of mortality were obtained from the unique beach-patrol records of the Ornithological Society of N.Z. These records are collected throughout the country by numerous people who at intervals walk along stretches of coastline noting all the dead birds. The observations are then analysed by the Society and published annually (see Bull and Boeson, 1961 a, 1961 b, 1963, and Boeson, 1964, 1965). Records of gulls however were extracted from the original beach-patrol cards, which revealed 47 gull corpses found between 1951-59 and 388 between 1960-63. Because most observers either made no mention of the age of the specimen, or simply wrote "juvenile" or adult, all ages have been treated together. And because dessicated corpses often retain their original shape so long, I omitted all birds which the observer thought had been dead longer than three weeks, or for which there was no indication of the time of death. Deletion of these doubtful records reduced the number of corpses to 157, which appear in Table 40. Further details are shown in appendix 21.

TABLE 40

DEAD GULLS FOUND ON BEACHES 1951-63

	<u>J</u>	<u>F</u>	<u>M</u>	<u>A</u>	<u>M</u>	<u>J</u>	<u>J</u>	<u>A</u>	<u>S</u>	<u>O</u>	<u>N</u>	<u>D</u>	<u>TOTAL</u>
<u>Number</u>	16	11	18	10	13	18	9	18	17	5	9	13	157
<u>Percent Mortality</u>	10	17	29	35	43	55	61	72	83	86	92	100	
	45 29%			41 26%			44 28%			27 17%			
	40 25%			41 26%			45 29%			31 20%			

The beach-patrol records suggest the over half (55%) of the annual mortality occurs by the end of June and that 51% (81) of the losses occur in summer and autumn (December-May). Although these data agree in broad detail with the distribution of dead banded gulls (Table 39) they appear to show a relatively higher mortality in winter months. Several factors contribute to this discrepancy. First, as mentioned the beach-patrol records included young birds as well as second year or older birds, thus the presence of first year birds would increase the mortality figures in the autumn and winter months (see Table 31). Second, although beach patrollers usually collect records throughout the year, they tend to be especially active after storms, in the hope of making unexpected finds. This again biased the figures towards higher winter mortality because of the number of gales at that time of year. Third, not all people recorded the corpses of birds so common as gulls, so that the evenness of reporting varied throughout the country.

4.22 Survival and population balance

All the recoveries made outside the colony up to the end of 1964 are shown in Table 41. Since the recoveries concern a maximum period of six years, loss of bands must be considered negligible (see section IV: 4.1). Data referring to the first and second years have already appeared in Table 33.

TABLE 41 MORTALITY OUTSIDE THE COLONY
RECOVERIES IN YEARS AFTER BANDING*

<u>SEASON</u>	<u>BANDED</u>	<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>	<u>6</u>	<u>TOTAL</u>	<u>%</u>
1958-59	45						1	1	2.2
1959-60	142	5	1	1		2		9	6.3
1960-61	567	11	6	5	4			26	4.6
1961-62	990	27	14	14				55	5.6
1962-63	1,514	41	19					60	4.0
1963-64	2,292	74						74	3.2
	<u>5,550</u>	<u>158</u>	<u>40</u>	<u>20</u>	<u>4</u>	<u>2</u>	<u>1</u>	<u>225</u>	<u>4.1</u>
		158	40	20	-----7-----				
		of	of	of	of				
<u>Percent</u>		5,550	3,258	1,744	754				
<u>Recovered</u>		2.8	1.2	1.1	0.9				

* Recoveries outside the colony in the first year were taken as from the time of banding.

The recovery percentage in the first year (2.8%) was more than twice as great as that in the second year. After the first year the percentage recovered (ca. 1%) was fairly steady, which suggests a relatively constant rate of mortality.

It has been shown by Lack (1951) that in a number of birds

mortality after the first year is independent of age, and I assume in the Southern Black-back that the mortality rate is relatively constant from the second year onwards. Thus returning to the figures in Table 41, and employing the method used in section IV: 2.25 to derive first year mortality, an average survival value after the first year is obtained by combining the proportion of recoveries for Years 2, 3 and 4. Years 5 and 6 are omitted as the samples are too small.

Survival rate after the first year therefore equals $\frac{20 + 4}{21 + 6} = \frac{24}{27} = .89\%$, and average annual mortality = 11%. Expectation of further life is 8.5 years.

Although there are no longevity records available, it is probable that the potential life of Southern Black-backs is very similar to that of its close relatives the Herring Gull and Lesser Black-backed Gull. Records for these species indicate a potential life of between 20 and 30 years for wild birds, and in excess of 40 years for captive birds (Gross, 1940; Paynter, 1947; Paludan, 1951, Olsson, 1958 and Harris, 1964 b). Paludan (1951) also mentioned a semi-wild Herring Gull which lived 64 years.

Drost et al. (1961) calculated 10% average adult mortality in German Herring Gulls (with an expected further life of 9.5 years) by recording the annual survival of banded adults in the breeding colony. Using a similar method Coulson and White (1959) determined the average annual mortality in Kittiwakes

was 12.4% and expectation of further life was 7.6 years. Paludan (1951) obtained an average 15% mortality for Danish Herring Gulls from a composite life table, but was unable to correlate it with known production of young.*

By comparison other authors calculate much higher mortality rates for adult gulls, which they derive from composite life tables. Some of these mortality rates include 33% in Black-headed Gulls, but this value may not be reliable (Lack, 1943), 31% in North American Herring Gulls (Paynter, 1949, recalculated by Lack, 1951 to give 30%), 27% in North American Herring Gulls (Hickey, 1952), and 28-32% in Finnish and Scandinavian Herring Gulls (Olsson, 1958). No doubt future studies on the mortality rates of gulls will take into account factors other than those directly concerned with the environment. For instance Boyd (1962, p.381) has found a strong inverse correlation between death-rate and body size in Charadrii.

I will now turn to the important question of population balance in Southern Black-backed Gulls, i.e. the relationship between adult mortality and production of young. Although the age at which the gulls first breed is not definitely known,

* Despite the apparent low annual mortality of gulls, these results do not, of course, support Grinnell's (1920) contention that the "existence" of seabirds is a relatively safe one, compared to that of landbirds. It is doubtful whether any habitat can be described in terms of "danger" to the species living there - rather the argument should be reversed so that the success of a species is measured by the degree of its adaptation to the environment.

gonadal measurements of adult and immature Southern Black-backs, and behavioural observations of immature gulls in the breeding colony suggest that most birds begin to breed in their fourth year, and that some probably breed in their third year (Fordham, 1963 a, 1964 b, unpublished observations). This is similar to other large Larus gulls (Wynne-Edwards, 1955; Drost et al., 1961).

Recovery data from the Wellington area reveal an average 11% annual mortality after the first year which means that given 100 pairs of breeding adults (200 birds) 11 pairs (22 birds) will die after one year. If the population neither grows nor declines, then it must be maintained by a production of young such that at least 11 pairs (hatched several years before) survive to breed in that year.

Average production of fledged young per breeding pair in various colonies was 1.39 in 1963-64, and 1.3 on Somes Is. alone in 1961-62 (Table 24). Taking the more recent figures 100 breeding pairs produce approximately 140 fledged young, of which 5% (7) die in the colony. The remaining 133 leave the colony and 52% (ca. 69) die in the first year. Assuming the majority of birds breed for the first time towards the end of their fourth year, then the remaining 64 birds are subject to an average 11% mortality for almost three years. Thus seven birds die annually (a total of 21 after three years) and 43 birds, i.e. 21 pairs survive to replace the 11 pairs of

adults that died.

Even if the 1961-62 production figure of 1.3 fledged young per breeding pair is taken, then 100 pairs produce 130 fledged young of which 41, i.e. 20 pairs, survive four years to replace the 11 pairs of adults which died. And if the age of first breeding is set at three years, then the percentage surviving is relatively greater again.

The relationships between production of young, age of first breeding, and adult mortality have been examined by Capildeo and Haldane (1954) and their valuable analyses facilitate calculation of the net fertility of breeding birds.* Net fertility ($\underline{f}$) may be obtained from the expression

$$\underline{f} = \frac{\text{Number of young living one year produced per breeding female}}{2 \times \text{Annual adult survival rate}}$$

$$= \frac{1.4 \times (1-0.05) \times (1-0.52)}{2 \times (1-0.11)} \text{ where } 1.4 = \text{average number of}$$

young fledged per pair; 0.05 = fledged young mortality in the colony; and 0.52 = proportional mortality in the first year outside the colony. Thus $\underline{f} = 0.36$.

If most of the gulls start to breed in their fourth year, then the rate of growth of the population is equal to $S \cdot \underline{f}$, where S = the adult survival rate, and may be derived from Table I given by Capildeo and Haldane. When $\underline{f}$ (net fertility) = 0.36, S (adult survival rate) = 0.89, and the

* Interpretation of the terms fertility and fecundity varies in the literature. For the sake of clarity I shall use "fertility" as chosen by Capildeo and Haldane.

age of first breeding (a) is assumed to be 4, then $\underline{x} = 1.1818 - 1.2202$. By interpolation $\underline{x}$ is calculated as 1.2048.

Thus $S.\underline{x}$ is equal to 1.072, and the annual growth rate of the population is 7.2%. If a is taken as intermediate between 3 and 4, then the value of $S.\underline{x}$ is greater.

If, instead of taking the average 1963-64 production figure of 1.4 young fledged per pair we take the *Somes Is.* figure of 1.8 young fledged per pair, then using the same methods as before $\underline{f} = 0.46$, and the growth rate of the colony is 10.4%.

Capildeo and Haldane show that if the population settles down to a steady state, then $\underline{f}$ becomes equal to $\frac{1 - S}{S a}$ that is $\underline{f} = \frac{0.11}{(0.89)^4}$, which equals 0.18. Thus if the population is to become static, then fertility (effectively the number of young surviving one year) must fall from 0.36 to 0.18, i.e. a 50% reduction.

As far as the Wellington gulls are concerned, one important feature of adult mortality remains outstanding. It concerns the sex ratio. In 1961-62 a random sample of 139 gulls shot or found dead in Wellington indicated that after the first year, the ratio of males to females dropped until in the adult stage females outnumbered males by about 2:1 (Fordham, 1963 a). At that time I suggested the cause may have been differential mortality rates in males and females because a change in sex ratio with increasing age is not uncommon in birds

(Latham, 1947; Lack, 1954). I also mentioned that there was no evidence that males or females followed different patterns of activity during the year. This last remark was prompted by Johnston (1956, p.136) who considered differential migration of male and female Californian Gulls contributed to the changing sex ratio during the non-breeding season. On re-analysis of the 1961-62 data however, I found some evidence to suggest that fewer males are present in autumn and winter, than in spring and summer. So any difference in the mortality rates of males and females may not be as important as I thought. Further it is tempting to conclude there is differential behaviour of males and females in the non-breeding season, i.e. the dispersal pattern of males may be different from that of females. Results are given in Table 42, and details appear in appendix 22.

TABLE 42 APPARENT SEASONAL CHANGE IN SEX RATIO

	<u>ADULTS</u>			<u>ALL AGES</u> (First year-adult)		
	<u>Male</u>	<u>Female</u>	<u>Ratio</u>	<u>Male</u>	<u>Female</u>	<u>Ratio</u>
<u>Spring and summer</u>	12	14	1:1.2	23	24	1:1.0
<u>Autumn and winter</u>	8	24	1:3.0	33	62	1:1.9

There appears to be a change in sex ratio with age (appendix 22) but this may be a result of unequal sampling during the year which emphasised any differential behaviour of males and females. This suggestion is made quite tentatively however, and may be modified later by the evidence of larger samples.

To summarise: the data presented above show clearly that production of fledged young in recent years is sufficient to considerably exceed the combined mortality of adults, and of immature birds. Calculations show that the Wellington population has been expanding at the rate of not less than 7.2% annually, and this fact helps to explain its steady growth over the last quarter century (see section II: 2).

Of the previous population studies on gulls only Coulson and White (1959), working on Kittiwakes, have been able to correlate production with mortality, and relate both to population balance. Drost et al. (1961) also calculated production and adult mortality rates of Herring Gulls, but did not comment on their relationship. Olsson (1958, p.163) claimed that the 28% annual adult mortality calculated for Finnish and Scandinavian Herring Gulls was balanced by production of young, but based this opinion on general observations made during banding. Other authors have not been able to correlate mortality rates with production. Thus Paludan (1951, p.119) required a production twice as great as observed to maintain a population of Danish Herring Gulls, and Marshall (1947), Paynter (1947, 1949), Hickey (1952) could not correlate production with their respective calculated mortality figures for North American Herring Gulls. In each of the last four studies mentioned mortality rates apparently exceeded the known or suspected production. It seems clear that the question of

population balance cannot be adequately discussed without first measuring production, and periodically carrying out sample censuses. Then apparent mortality rates can be viewed in perspective, relative to the overall trends of the population.

5. Dispersal of gulls in the study area

Banding was carried out in the five largest colonies in the study area (Kapiti, Mana & Comes Islands, Baring Hd. and Palliser Spit) and in two of the small colonies (Mukamuka R. and Te Humenga Pt.). Only 75 chicks were banded in these last two however (Table 25) so that most discussion will centre on the five large colonies. The location of these colonies in relation to mountain country, built-up areas and towns, is shown in Fig. 12. A considerable part of the study area is at an altitude of more than 1,000 feet (i.e. a habitat relatively "unattractive" to seagulls) and the built-up areas are concentrated round Wellington Harbour, thus the chances of a dead bird being recovered varied throughout the study area. Large thinly populated areas and high country occupy most of the lower part of the North Is., and also the upper part of the South Is. (Figs. 12 & 22) so that similar conditions affected chances of recovery in regions adjacent to the study area.

This apparent spatial bias in recovery rate is however not as important as first appears. Aerial surveys of the

FIGURE 12

Location of colonies in which banding was carried out, and the high country and built-up areas of the southern North Is. Sites of meatworks outside the study area were obtained from the N.Z. Meat Grade Book 7th. Ed. (1962) published by the N.Z. Meat Producers' Board.

study area and adjoining coast (section II: 3.2) showed clearly that during the period of peak population in the non-breeding season, 84.1% of the birds were within 11 miles of Wellington Harbour (Fig. 3) and the contrast between the number of birds on thickly inhabited and uninhabited coasts was strong - 108.9 birds/mile in Wellington Harbour and 0.4 birds/mile on uninhabited coast. Nearly all the birds were in or near centres of human activity and the distribution and density of gull flocks was strongly correlated with the distribution and density of the human population.

Many observations (from the air as well as the ground) of gulls in flight over country that is uninhabited by other gulls indicate that the time taken to fly from one preferred area (or flock site) to another probably represents only a small fraction of the total daily activity. Most of the time during which a bird is exposed to risk of death is spent in the company of its fellows in roosting flocks, breeding colonies or communal flocks that are closely associated with human activity. On Little Barrier Island Turbott (1961, p.158) noted that gulls avoided rocky coasts where scavenging opportunities were few. I consider therefore that the small number of recoveries from uninhabited or mountain country (described below) does not significantly distort the picture of gull dispersal but instead truly reflects habitat preferences and distribution.

The recovery data discussed below derived from the years 1959-65, during which the number and yield of feeding sites near Wellington Harbour diminished, and up to at least 1964 were frequented by increasing numbers of gulls. Although the number of potential feeding sites may increase in the future, there are indications that the total amount of available food will continue to drop so that dispersal patterns of Wellington gulls may be slightly modified in the future. However the increased mortality of young in the colonies suggests that the population is already adjusting to the changed food supply, so that any modifications to the dispersal patterns (e.g. relatively more birds recovered outside Wellington City and Hutt Valley) may be very slight.

5.1 First year

5.11 Recovery distance

Direct line measurements from the colony to the point of recovery are shown in Figs. 13-16 and summarised in Table 43.

TABLE 43

RECOVERY DISTANCE FIRST YEAR (MILES)*

	0-10	10-20	20-30	30-40	40-50	50-60	>60	TOTAL	AV. DIST.
¹ Somes Is.	53 91%	3 5%		1			1	58	7.9
² Baring Hd.	13 43%	11 37%	5 17%			1		30	13.6
³ Mana Is.	7	5				1	1	14	16.4
⁴ Kapiti Is.	2	3	6	1	2	2		16	27.5
⁵ Palliser Spit	4 13%	11 37%	10 33%		2	1	2	30	31.3
	<u>79</u>	<u>33</u>	<u>21</u>	<u>2</u>	<u>4</u>	<u>5</u>	<u>4</u>	<u>148</u>	<u>16.8</u>
	53.4%	22.3%	14.2%	1.3%	2.7%	3.4%	2.7%		

1,2,3,4,5, Recoveries in the colony: 1: 8, 2: 1, 3: 0, 4: 2,
5: 1.

* Recoveries in the colony are excluded. Only dead recoveries in complete years up to the end of 1964 are included so there are small differences between the recovery distances shown in Figs. 13-16, and the dispersal patterns shown in Figs. 17-22 in which some sight recoveries are included.

The average recovery distance in the first year was 16.8 miles, and a recovery over 60 miles was exceptional. There was a strong contrast between the average recovery distances of birds from Kapiti Is. (27.5 miles) and Palliser Spit (31.3 miles), and those of birds from the other three colonies. These differences were fairly constant throughout the year (Figs. 13-16) and there was only a slight tendency towards longer flights ("wandering") in the second six months.

The number of Somes Is. birds recovered within 10 miles (53 - 91%) was much greater than for any other colony, in fact

FIGURE 13

Recovery distance of Somes Is. gulls.

Somes Is.

1st Yr.

2nd-3rd Yrs.

FIGURE 14

Recovery distance of Baring Hd. gulls.

Baring Hd.

1st Yr.

2nd-4th Yrs.

FIGURE 15

Recovery distance of Palliser Spit gulls.

Palliser Spit

1st. Yr.

2nd-6th Yrs.

FIGURE 16

Recovery distance of Kapiti Is. and Mana Is. gulls.

Kapiti Is.

1st Yr.

Mana Is.

1st Yr.

most (46 - 79%) were recovered within five miles. This suggested that dispersal movements of Some Is. birds were suppressed, and similarly (to a slightly lesser extent) those of Baring Hd. and Mana Is. birds. The location of recoveries from each colony supported this hypothesis (see following section - 5.12).

Some individuals dispersed quickly and a Mana Is. gull was recovered about 30 miles from its colony only three weeks after banding. No doubt this bird was near to flying when banded. Other recoveries involving long distances in a relatively short time are shown below.

<u>Length of time banded</u>		<u>Recovery distance</u>	<u>Natal colony</u>
<u>Months</u>	<u>Weeks</u>	<u>Miles</u>	
-	3	28	Mana Is.
2	1	55	Palliser Spit
2	3	41	" "
2	3	42	Kapiti Is.
3	1	44	"
3	1	62	Mana Is.
4	-	57	Kapiti Is.
8	-	120	Somes Is.
9	-	280	Palliser Spit

In most of the cases mentioned above the gulls would have become fledged several weeks after banding so that dispersal was probably quicker than appears. The recoveries indicate

that a first year bird may travel at least 280 miles from its colony in less than nine months.

In Britain the average recovery distance of Great Black-backed Gulls in the first year is just under 100 miles (Harris, 1962 b) while similar figures for the dispersal of Herring Gulls from two separate colonies in Denmark were ca. 53 and 140 miles respectively (calculated from Paludan, 1953). By comparison therefore Wellington gulls are remarkably sedentary in the first year.

5.12 Direction of movement

Location of recoveries in the first year is shown in Fig. 17 and 19-21 (see below). The figures include dead recoveries and also some representative sight recoveries (either of colour-bands or serial bands) up to 30th June 1965 to give more complete dispersal patterns. Numerous sightings of birds from all colonies were made in the Wellington area and suggested marked dispersal to the city, but these sight recoveries were not obtained in a random manner throughout the study area, so have been excluded (except in special cases) from the discussions that follow. Recoveries in natal colonies have also been excluded.

A summary of the directions of movement in the first year is given in Table 44.

TABLE 44 LOCATION OF DEAD RECOVERIES FIRST YEAR

	<u>WELLINGTON & HUTT VALLEY</u>		<u>IN THE STUDY AREA</u>		<u>OUTSIDE THE STUDY AREA</u>		<u>TOTAL</u>
Somes Is.	61	90%	66	97%	2	3%	68
Baring Hd.	20	59%	31	91%	3	9%	34
Palliser Spit	10	33%	17	57%	13	43%	30
Mana Is.	11	55%	18	90%	2	10%	20
Kapiti Is.	6	32%	13	68%	6	32%	19
	<u>108</u>	<u>63.2%</u>	<u>145</u>	<u>84.8%</u>	<u>26</u>	<u>15.2%</u>	<u>171</u>

Movement was generally restricted, and 84.8% of the recoveries were inside the study area. Most movement away from the study area came from the Kapiti Is. and Palliser Spit colonies which were near the edge, whereas for the other three colonies 90-97% of recoveries were made in the study area. The number of recoveries from Wellington City alone ranged from 32% (Kapiti Is.) - 90% (Somes Is.) and averaged 63.2%. This was directly related to the distance of the colony from the city. Nearly all the recoveries were made in or near towns or built-up areas and very few (only three outside the study area) were made on the coast. Records from the Wairarapa and Manawatu districts suggest some birds were attracted to local meatworks and abattoirs (Fig. 12).

The dispersal from each colony is summarised below.

- 1) Somes Is. (Fig. 17). Nearly all the dead recoveries (61 - 90%) were made in Wellington City and Hutt Valley, and all but two (i.e. 66 - 97%) in the study area. Three (4%)

FIGURE 17

Dispersal of Somes Is. gulls banded as fledglings.

FIGURE 18

Dispersal of gulls banded while roosting on Somes Is.

FIGURE 19

Dispersal of Baring Hd. gulls banded as fledglings.

2nd-4th yrs.

- Dead
- Sight record

1st yr.

FIGURE 20

Dispersal of Palliser Spit gulls banded as fledglings.

2nd-6th yrs.

- Dead
- Sight record

FIGURE 21

A Dispersal of Kapiti Is. gulls banded as fledglings.

B Dispersal of Mana Is. gulls banded as fledglings.

1st & 2nd yrs.

A Recoveries of Mukamuka R. and Te Humenga Pt. gulls banded as fledglings.

B Wellington recoveries of gulls banded in the northern South Is. colonies.

- 1 Nelson
- 2 Wairau River
- 3 Wairau Lagoons
- 4 Grassmere
- 5 Flaxbourne R. mouth
- 6 Clarence R. mouth

birds were recovered in the Wairarapa, but none in the South Is., thus movement away from the harbour was very restricted.

ii) Baring Hd. (Fig. 19). Twenty (59%) of the dead recoveries were made in the Wellington Harbour area, but only two in the Wairarapa so that there was apparently a major direction of movement towards Wellington. Thirty-one (91%) of the 34 birds were recovered in the study area, but none in the South Is.

Between 1951 and 1955 F.C. Kinsky banded 290 fledglings at Baring Hd. of which only one (a first year bird) was recovered in the South Is.; in the Marlborough region.

iii) Palliser Spit (Fig. 20). Ten (33%) of the 30 dead recoveries were made in Wellington City or Hutt Valley, while 14 (47%) came from the lower-middle Wairarapa, thus there were two main groups of recoveries; on either side of the high country (Rimutaka Range) to the west of the colony (see Fig. 12). Seventeen (57%) of the recoveries were in the study area and two in the South Is., one of the latter being the longest dead recovery (ca. 280 miles) of a Wellington gull.

iv) Kapiti Is. (Fig. 21 a). Of the 19 dead recoveries six (32%) were in Wellington City and Hutt Valley (plus a number of sight recoveries) and six scattered in the Manawatu province. Thirteen (68%) were in the study area, but none in the Wairarapa or the South Is. There were therefore two main groups of recoveries; north and south of Kapiti and west of the unbroken high country represented by the Rimutaka, Tararua and Ruahine

Ranges (Fig. 12). The longest recovery of a first year Kapiti Is. bird (banded by F.C. Kinsky in 1957) was made in Hawkes Bay - a distance of ca. 100 miles.

v) Mana Is. (Fig. 21 b). Eleven (55%) of the 20 recoveries were in Wellington City and Hutt Valley, one in the Wairarapa and one in the South Is., but none in the Manawatu. Dispersal was therefore mainly towards Wellington where a number of sight recoveries were also made. Eighteen (90%) were recovered in the study area.

vi) Mukamuka R. and Te Humenga Pt. (Fig. 22 a). Only four (two dead and two sight) recoveries were made outside the colonies, and three of these were in the study area.

The overall picture of dispersal in the first year shows only limited wandering which varied markedly between colonies. Movements of Somes Is. birds (and to a slightly less extent those of Baring Hd. and Mana Is. birds) indicate suppressed dispersal which can be directly related to the food supply and number of potential feeding sites in the vicinity of the colony. Olsson (1958, p.121 et seq.) observed that a good food supply will halt or slow down dispersal of Swedish Herring Gulls, and Murray and Carrick (1964, p. 183) considered food likely to be a critical factor in dispersal of Silver Gulls in Australia..

5.2 After the first year5.21 Recovery distance

Available data on dispersal after the first year were as follows: Kapiti Is. 2nd year, Somes Is. 2nd - 3rd years, Baring Hd. 2nd - 4th years, Palliser Spit 2nd - 6th years. Recovery distances for these colonies are shown in Figs. 13-16 and summarised in Table 45. In the table all years have been treated together because there were no apparent differences between them.

	0-10	10-20	20-30	30-40	40-50	>50	TOTAL	AV. DIST.
¹ Somes Is.	26 84%	3 10%		1		1	31	9.8
² Kapiti Is.	1	1					2	10.0
³ Baring Hd.	2	3	1	1			7	16.4
⁴ Palliser Spit		9	3		1	1	14	24.3
	<u>29</u>	<u>16</u>	<u>4</u>	<u>2</u>	<u>1</u>	<u>2</u>	<u>54</u>	<u>14.4</u>
	53.7%	29.6%	7.4%	3.7%	1.9%	3.7%		

1,2,3,4,

Recoveries in the colony: 1: 2, 2: 0, 3: 5, 4: 6.

* Recoveries in the natal colony, and sight recoveries are excluded.

The average recovery distance was 14.4 miles, so there was only a slight tendency towards reduced dispersal after the first year. Such differences as there were between the first and subsequent years arose from an increase of recoveries

in the 10-20 mile range, and a decrease in the 20-30 mile range. The percentage of recoveries in the 0-10 mile range (53.7%) was almost identical with that in the first year.

5.22 Direction of movement

The location of recoveries after the first year is shown in Figs. 17-22. As before (section 5.12) some sight recoveries have been included to give more complete dispersal patterns, but unless specifically stated these have not been included in the discussions to follow, neither have recoveries in natal colonies. Recoveries in the second, third etc. years have been grouped because in general they showed similar dispersal patterns, but ages are given for any that were significantly different from the rest.

A summary of the directions of movement after the first year is given in Table 46.

TABLE 46 LOCATION OF DEAD RECOVERIES AFTER THE FIRST YEAR

	<u>WELLINGTON & HUTT VALLEY</u>		<u>IN THE STUDY AREA</u>		<u>OUTSIDE THE STUDY AREA</u>	<u>TOTAL</u>
Somes Is.	26	74%	33	94%	2	35
Palliser Spit	6		14		4	18
Baring Hd.	5		7		1	8
Kapiti Is.			2		1	3
	<u>37</u>	<u>57.8%</u>	<u>56</u>	<u>87.5%</u>	<u>8</u>	<u>64</u>

Recovery percentages in Wellington City and Hutt Valley (57.8%), and in the study area as a whole (87.5%) were almost the same as in the first year, and the directions of movement were similar except relatively more Palliser Spit birds dispersed to the city. The dispersal pattern of gulls banded while roosting on Somes Is. was not different to that of birds born on the island. The dispersal from each colony is summarised below.

i) Somes Is. (Fig. 17). Of the 35 dead recoveries 26 (74%) were in Wellington City and Hutt Valley. Thirty-three (94%) were in the study area and one sight recovery was made in the South Is. However, overall dispersal was restricted.

During the winters of 1961 and 1963 337 gulls of all ages were banded while roosting on Somes Is. Because marked gulls from other colonies were also captured while roosting, thereby indicating that not all birds banded would have originally belonged to Somes Is. I decided to treat the dispersal of this group separately (Fig. 18). Location of the recoveries showed however that dispersal was again very restricted; 46 (84%) of the 55 birds (including 15 on Somes Is.) were in Wellington City and Hutt Valley, and 52 (95%) were in the study area. A single sight recovery in Auckland (ca. 300 miles distant) of a Somes Is. bird of unknown age, was the longest recovery of a Wellington gull.

ii) Baring Hd. (Fig. 19). Five of the eight dead recoveries

were in Wellington city, and only one bird was recovered outside the study area. Therefore as in the first year movement was largely in one direction; towards the city.

iii) Palliser Spit (Fig. 20). Six of the 18 dead recoveries were in Wellington City and five in the lower Wairarapa.

Fourteen were in the study area and relatively more dispersed west towards Wellington, than in other directions.

iv) Kapiti Is. (Fig. 21 a). The three dead recoveries were all on the coast adjacent to the colony, but sight records suggested some dispersal towards Wellington.

When the recovery data of all ages are combined (appendix 23) we find that the mean distance travelled was only 16.1 miles, 61.7% of the birds were recovered in Wellington and the Hutt Valley, and 85.5% in the study area. Mean dispersal from two separate colonies of Danish Herring Gulls was ca. 56 and 135 miles respectively (Paludan, 1953) thus the Wellington Gulls are much more sedentary than the Scandinavian representatives of a species that is closely related both ecologically and taxonomically. Overall the Wellington recoveries showed only a slight tendency towards greater dispersal in the first year, but there was no evidence of movement northwards in winter, i.e. there was no seasonal migration (as defined by Thomson, 1964, p.465) of the population as a whole. Neither did the birds disperse in a common direction.

There are no previous accounts of dispersal of banded

Southern Black-backs with which I can compare the Wellington data but Murphy (1936, p.1064 et seq.) summarised general observations made by various authors in the southern oceans. He concluded that migratory movements of L. dominicanus depend on the latitude and considered that in "milder parts of the range, as in northern Peru, migration is doubtless irregular and sporadic, and likely to lead the wandering bird in either direction along the coast". On isolated islands such as S. Georgia, Macquarie, or wherever the climate permits, the gulls are generally sedentary, and the majority stay the whole year (Ainsworth, 1915, p.195). In west Antarctica however the species is definitely migratory (Gain, 1914, p.102) and at the Falklands and S. Shetlands a good proportion of gulls depart during winter (Abbott, 1861, p.165; Lester, 1923, p.185). Murphy states it is not certain whether the gulls fly north into the open sea, or move to the S. American continent, and speculates that enforced migration in the S. Atlantic may have originally led the birds to islands such as Gough and Tristan da Cunha. Regardless of how the species reached these mid Atlantic islands I consider that the dispersal of a bird which mainly inhabits coastal regions would be strongly influenced by land masses.

Dispersal of Wellington Southern Black-backs is remarkably similar to that of the British Herring Gull as outlined by Harris (1964 b). He found (p.189) that the majority of

recoveries from all colonies occurred in areas most populated by man, regardless of the direction from the colony, and there was "little evidence" to show that young birds wandered further afield than adults. Further, he considered it doubtful whether Herring Gulls ever migrated out of Britain. Clearly, this sort of dispersal pattern is essentially the same as that of the Southern Black-back.

Seasonal migration in the Larinae is well marked in only a few species, the remainder showing simple, but not seasonal, dispersal (Dorst, 1962, p.38). The Lesser Black-back is a notable migrant which travels south in winter from breeding colonies in northern Europe and the British Isles (e.g. Tinbergen, 1953, p.40; Harris, 1962 a) while the Mediterranean Gull L. melanocephalus and Slender-billed Gull L. genei migrate primarily from east to west between breeding grounds in the Black Sea, and the Mediterranean (Dorst, 1962, p.40). In North America only Franklin's Gull L. pipixcan has, according to Smith (1959, p.97) a true seasonal migration.

In the remainder of the Larinae the degree of dispersal and nomadism varies between species, and also between different populations (Dorst, 1962, p.317). Dorst comments that even within a population some individuals are sedentary, whereas others reveal a more or less marked migratory tendency, and Lack (1944) found that in some birds there is a cline towards more migratory behaviour in east and north Europe than in the

west and south which involves young birds and females more than adult males. In Europe limited dispersal (the partial migration of Dorst, 1962) is found in Herring Gulls, Common Gulls L. canus, Great Black-backed Gulls, and Black-headed Gulls (e.g. Witherby et al., 1941; Munk, 1951; Paludan, 1953; Tinbergen, 1953, p.38; Olsson, 1958; Dorst, 1962; Radford, 1960 & 1962; Harris, 1962 b & 1964 b) with immature birds, especially in the first year, tending to disperse further than adults. But as mentioned the distance and direction travelled, and the degree of nomadism occurring during dispersal varies between species and populations so that in Scandinavia and north Europe Black-headed Gulls and Herring Gulls tend to wander more, while in Britain, together with Common Gulls and Great Black-backs they tend to be more sedentary.

In N. America, Herring Gulls disperse great distances and Gross (1940) determined the mean for the first year Kent Is. birds was 861 miles, while that for third year and adult birds was ca. 290 miles. Smith (1959) and Hofslund (1959) found Michigan and Minnesota Herring Gulls also dispersed widely. Such movements contrast strongly with those of Danish Herring Gulls from the Jordsand and Graesholm colonies whose mean recovery distances were ca. 56 and 135 miles respectively (Paludan, 1953), and British Herring Gulls which Harris (1964 b) found to be rather sedentary. The longest recovery recorded by Paludan was ca. 404 miles (650 km.) whereas in N. America

Gross (1940) dealt with recoveries greater than 3,000 miles.

Amongst the Laridae and Stercorariidae the greatest seasonal migratory movements are found in the skuas and terns, several members of which annually travel from breeding grounds in the high latitudes of one hemisphere to wintering quarters in the mid-high latitudes of the other hemisphere (Dorst, 1962, p.174 et. seq.). Thus by comparison migratory movements of Larinae are conservative, and within the Larinae behaviour of the Southern Black-back in Wellington is revealed as sedentary, with a dispersal showing similarities to that of some of the other large, non-migratory Larus gulls, particularly the British Herring Gull. The other species most closely related to L. dominicanus is L. fuscus whose alarm calls are very similar (Fordham, 1964 b, p.212) so it is interesting that L. fuscus is a migrant while L. dominicanus is migratory only at the southern extreme of its range.

5.3 Colour-band survey of Wellington Harbour and west coast

In May 1964 during the period of peak harbour population a concentrated search for colour-banded gulls was made in Wellington Harbour, and along the west coast between Titahi Bay and Waikanae R. (Fig. 3). The route followed round Wellington Harbour was the same as for the monthly counts (Fig. 5 a) and was divided into southern (city) and northern

(Petone) portions. The northern portion included the two meatworks, and thus attracted many gulls. Communal flocks were located and the legs of over 4,000 gulls were inspected for red, blue, black, green and white colour-bands. The sightings were then grouped into areas, all ages together (Table 47) and the results compared with the dispersal patterns obtained from dead recoveries alone (sections 5.12 & 5.22). In Table 47 the total numbers of birds counted refer only to those whose legs were visible, and the percentages refer to the number banded.

TABLE 47

COLOUR-BAND-SIGHTINGS

	WELLINGTON HARBOUR*					WEST COAST**		TOTAL
	SOUTHERN END		NORTHERN END		TOTAL			
¹ Somes Is.	33	3.2%	114	4.8%	147 4.4%	2	0.2%	149
² Baring Hd.	11	1.0%	7	0.3%	18 0.5%	1	0.1%	19
³ Mana Is.	3		6		9 0.3%	5	0.5%	14
⁴ Kapiti Is.	-		3		3 0.1%	9	1.0%	12
⁵ Palliser Spit	5		4		9 0.3%	2	0.2%	11
	52	5.1%	134	5.7%	186 5.5%	19	2.0%	205 4.7%
<u>Total birds counted</u>	1,021		2,337		3,358	934		4,292

* Counted 7/5/64

** Counted 26/5/64

1 Red 2 Blue 3 Black 4 Green 5 White

Since the fading pattern of each colour was known, and search effort remained the same during the survey, it was

considered safe to use the band sightings for comparison of gull distribution in different areas. The survey clearly showed the concentration of banded gulls in the harbour (particularly Some's Is. and Baring Hd. birds) and indicated dispersal patterns similar to those previously described except that relatively more Mana Is. and Kapiti Is. birds were located in the general vicinity of their colonies than was indicated by dead recoveries. It also provided new information which had not been apparent in analyses of dead recoveries. First, Some's Is. birds were concentrated at the northern end of the harbour (because of the feeding sites) and second Baring Hd. birds were concentrated at the southern end, i.e. the end nearest their colony. The results are listed below. Where the figures (taken from Table 47) require or permit a statistical test, this has been made.

- i) The total number of banded birds at the southern and northern ends of the harbour were similar ($.25 < P < .5$, $v=1$), but there were many more round the harbour than on the west coast.
- ii) There were more Some's Is. gulls at the northern end of the harbour than at the southern end ($.01 < P < .025$, $v=1$), and many more in the whole harbour than on the west coast.
- iii) Many more Baring Hd. birds were recovered at the southern end of the harbour than at the northern ($P < .005$, $v=1$), and only one bird was seen on the west coast.
- iv) Numbers of Mana Is. birds on the west coast and in the

harbour were fairly similar.

v) Relatively more Kapiti Is. birds were seen on the west coast than in the harbour.

vi) Numbers of Palliser Spit birds in the harbour and on the west coast were fairly similar.

6. Other dispersal movements

6.1 Dispersal to and from the study area

As explained in the description of colonies contributing to the Wellington population (II: 1.1) there is a gap of about 41 miles between Kapiti Is. on the north-west edge of the area and the next major breeding colony (near the Rangitikei R. mouth), while from Cape Palliser to beyond Castle Pt. on the east coast there are only a few small scattered roosting or breeding colonies (Fig. 2). There has been no banding in these colonies, consequently there are no data on dispersal of fledged young, but in view of the very limited dispersal shown by gulls from various Wellington colonies I consider the majority of birds from these adjacent colonies would not move into the study area. At the northern end of the South Is. however there are six breeding colonies in which fledglings have been banded fairly regularly in recent years. These colonies are at Nelson, Wairau R., Wairau Lagoons, Lake Grassmere, Flaxbourne R. mouth, and Clarence R. mouth (Fig. 22 b).

Between 1959 and 1964 1,378 fledglings were banded in the six colonies, and up to the end of 1964 there were six recoveries in the colonies and 34 outside; 25 (1.8%) dead, and nine sight (appendix 24). Nearly half the dead and all the sight recoveries were made in the study area, and all but two of these were in or near Wellington City, thus some movement across Cook Strait was indicated. Dispersal of birds from the six colonies is probably influenced by several factors including the generally mountainous nature of the northern South Is. which makes much of the country a relatively "unattractive" habitat; the relatively scattered towns and settlements which offer only a limited supply of food; and the daily traffic of the Cook Strait ferry (and other vessels) between Wellington and Picton. Gulls have been observed (F.C. Kinsky & E.B. Slack pers. comm.) to accompany the ferry across Cook Strait where, presumably, some join local communal flocks.

It is difficult to determine exactly what proportion of Wellington gulls travel to the South Is., but recoveries of dead suggest it is small. Of the 235 recoveries of first year and older birds outside their colonies only four (three first year and one adult), plus one sight recovery were made in the South Is. But the overall pattern of dispersal of Wellington birds is restricted, thus it appears the small number of South Is. recoveries reflects limited movement across Cook Strait.

There is also a small amount of immigration from other parts of the country, at least during the non-breeding season, and gulls from as far south as Awarua (Southland) and as far north as Auckland have been sighted or found dead in Wellington. This indicates populations throughout the country are mixed to a slightly greater degree than that resulting from mixing of local communal flocks alone. Dorst (1962, p.39) states that repeat recoveries of Black-headed Gulls wintering in central Europe show that many populations mingle, and he considers that this prevents geographical segregation. Similarly Murray and Carrick (1964, p.183) found considerable intermixing of Australian Silver Gulls from different breeding centres in winter and during the immature years, but the identity of the breeding colonies was maintained by return migration.

6.2 Range of dispersal

There is no question that the Southern Black-back has adapted to populated areas and the various food supplies which result. This adaptation has the characteristic that gulls are geographically and numerically associated with centres of human population while being poorly represented in uninhabited areas. Although gull activity is generally most intense on the coast the species ranges over a much wider area which extends from alpine regions to the open sea. My own observations in various mountain regions of the North and South Islands, some of which were published in Fordham (1961), together with those of

C.N. Challies and A.H.C. Christie (pers. comm.), Stead (1932, p.45), Bull and Falla (1951, p.81), Oliver (1953 a & 1955), Taylor (1953), Caughley (1958), and Turbott (1959, p.39) reveal that gulls may be seen occasionally in remote areas, or at altitudes in excess of 7,000 feet, and some even breed in the mountains.

Turning to the marine environment we find that although gulls are not prominent members of the diverse group of surface-feeding seabirds which inhabit open water, a few individuals range beyond the coastal waters where they are most often recorded while following ships. Thus in the course of four trans-Pacific voyages between New Zealand and Panama Southern Black-backs were recorded only in and around the approaches to Waitemata Harbour, Auckland (Falla and Sibson in Fleming, 1950, pp.179 & 180). Between Auckland and Singapore Laird (1956) noted the last gulls eight miles north of the Three Kings, the last New Zealand landfall, and travelling south from Wellington Dell (1960, p.293) observed that a small flock of gulls followed the ship until land was almost out of sight. Mr. J. Graham told me that gulls occasionally followed his fishing trawler up to 25 miles from the coast, and Dr. E.B. Slack (pers. comm.) noted that a flock of about 40 gulls once followed a large fishing vessel out into north Tasman Bay, over 30 miles from the coast. Dawson (1962) often sighted Southern Black-backs in the coastal waters of the west coast, South Is., and recently

Norris (1965, p.103), who made his observations from a submarine operating round New Zealand, recorded that Southern Black-backs were the only gulls seen outside coastal waters. His sightings are all the more valuable because, presumably, some of the gulls were not in the presence of surface ships. By plotting the latitude and longitude of the observations I found on two occasions four-five gulls were seen about 25 miles from the coast, twice birds were observed about 20 miles out, and on the remaining six occasions a single bird, or groups of 2-18 were seen up to 15 miles out.

Dispersal out to sea need not be limited to daily traffic from the land since I have often observed on Somes Is. that varying numbers of gulls will roost all night at sea, regardless of the weather.

It appears therefore that while the vast majority of birds frequent populated areas, a small number disperse to habitats as diverse as alpine regions and the open sea, and in so doing illustrate the wide range of a versatile species.

Wynne-Edwards (1935, p.240) found in the north Atlantic that smaller gulls such as the Common Gull, Black-headed and Bonaparte's Gull L. philadelphia frequented the inshore zone (high tide-five miles) and were never out of sight of land except on migration. However larger species including the Herring Gull, Lesser Black-back, Glaucous Gull L. hyperboreus and Iceland Gull L. leucopterus ranged further to off-shore

waters (five miles to the edge of the continental shelf) but seldom ventured beyond the 100 fathom line, probably on account of their food. Sparck (1951), Lemmetyinen (1963) and Harris (1965) have discussed the food and feeding habitats of several species of gulls and their reports indicate that Common Gulls and Black-headed Gulls are mainly land birds; Great Black-backs and Kittiwakes are mainly shore birds, though the former is a notable predator, and the latter frequents coastal waters; Lesser Black-backs and Herring Gulls are also shore-birds, but both feed off the land as well, and Herring Gulls are more associated with civilization. However the feeding preferences of the species tend to vary throughout their respective ranges, and to overlap with each other to a greater or lesser extent. In an ecological survey of the Barents Sea, Arctic Ocean, Belopol'skii (1960, p.305) described Larus species as "sanitary scavengers" which in summer (p.26) were confined to the coastal zone, generally not ranging beyond 10-15 km. (ca. six-nine miles).

Some gulls and terns, and the skuas are more typical surface-feeding seabirds that are not always closely associated with land. For instance Laughing Gulls L. atricilla winter at sea within sight of the coast, while Kittiwakes spend most of the year on the open ocean, coming to land only to breed (Dorst, 1962, p.171 et seq.). Also some skuas and terns undertake very long annual migrations between one hemisphere and the other (Dorst, 1962, p.174 et seq.) and winter on the

high seas, e.g. Arctic Terns Sterna paradisae. Wynne-Edwards (1935, p.302 et seq.) concluded that the Pomarine Jaeger Stercorarius pomarinus, Parasitic Jaeger S. parasiticus, and Long-tailed Jaeger S. longicaudus all wintered on the ocean.

In comparison with other gulls (and some terns and skuas) the Southern Black-back is remarkably sedentary, but disperses from mountains to off-shore waters, and thus behaves no differently to some of the other large Larus gulls that also encounter a wide range of habitats.

7. Summary

1. In 1961 a programme for colour-banding Southern Black-backed Gulls was started in Wellington. The results of this programme were combined with the banding records of some other workers so that mortality and dispersal data were extracted from records of 7,423 gulls banded in seven Wellington colonies up to the end of the 1964-65 breeding season. Some banding records from colonies in the Nelson-Marlborough region of the South Is. were also examined. Plastic colour-bands were used and the serial bands were an aluminium lock-type made in Sweden. Wherever possible the results from different colonies have been compared.

2. Average minimum fledgling mortality was 7%, with a range of 1%-32%. Of those recovered 74.6% were killed by breeding

gulls, 18.8% were dead with no external injuries and 3.6% killed by stoats. Incidence of cannibalism was insignificant.

3. Dead fledglings were aged using known growth characters, and the approximate spread of mortality was determined.

Seventy-five percent of the dead fledglings were less than four weeks of age, and 45.4% were one-two weeks of age. The proportion of fledglings killed by gulls varied with age, and was greatest in the two-four week age group, which is the age when fledglings begin to wander, but are too small to resist attacks by adults.

4. Of the young presumed fledged 5% were recovered dead in their natal colonies; the range was 0%-7%. Of those recovered 76.5% were killed by breeding gulls which shows predation by adults extends with considerable influence beyond the age of flight, and theoretical independence.

5. Records of 201 broods in which more than one individual was banded indicate that in only a small proportion of cases (3.5%) do the members of a brood die at about the same time and in the same way.

6. There was no significant difference between chick losses in the first and last halves of the season, nor was there a difference in the losses resulting from gull predation.

7. Of the young presumed to have left the colonies an average of 3% were recovered in the first year; the range was 0-8%.

8. Outside the colony 68.4% of the fledged young recovered

were reported as "found dead" and 10.8% were shot. Most of the rest were reported sick, injured or hit by cars. Despite the apparent relative exposure of various colonies to certain hazards, there were few real differences between colonies in the fates of the young.

9. February was chosen as the first full month of flight, and the spread of mortality in fledged young determined. Seventy percent of the mortality occurred in the first two months of flight, and 88% in the first five, i.e. up to the end of June. The results of the 1961-62 season alone indicate that about 49% of the year's losses of fledged young may occur in the first month, and 28% in the second.

10. Adult predation accounted for 45.3% of the deaths of fledged young, and most of the rest (41.6%) were "found dead".

11. Mob attacks of newly fledged birds occur throughout the season, not just early in the season, so there is no evidence of selection against the young of early breeders.

12. In the first year 7% of the banded young were recovered dead as fledglings, 4% as fledged young in the colonies, and total losses in the colony (including those whose ages were unknown) was 14%. Outside the colony an average of 3% of the fledged young were recovered dead. Recovery percentages outside the colony were very similar for all colonies and major differences arose from mortality in the colony.

13. Proportional mortality in the first year outside the

colony was 52%, and expectation of further life was 1.4 years.

14. The breeding colonies in the study area contributed 7,900-8,300 fledged young to the Wellington population in 1964. A minimum of 5% of these died in their colonies, and 52% died outside the colony, thus a maximum of 3,600-3,800 were alive at the end of 1964.

15. Shooting accounted for less than 11% of the recoveries, and so did not grossly affect mortality in the first year. The results of other studies have been discussed.

16. Part of the banding programme was designed to test the influence of some ecological factors on chick mortality. These tests indicated the following conclusions:

(a) Losses of young were not related to the number of chicks banded per breeding pair, i.e. losses were not related to the degree of disturbance caused by the bander.

(b) In unpredated colonies searching difficulties could not by themselves account for differences between colonies. The recovery percentage of dead fledged young may be slightly higher in colonies that also serve as roosting sites, because some birds continue to return to the colony after the breeding season.

(c) Mammalian predation seriously affected mortality of young and the recovery of dead because predators removed corpses.

(d) Shortage of major artificial feeding sites near a

colony was not, in itself, related to higher losses of young, but there was an apparent relationship between losses of young and numbers of breeding birds competing for available food. Thousands of gulls feed at refuse tips. If the food obtained at tips is generally of a low nutritional value, then chicks in certain colonies may become starved and less able to withstand attacks from neighbouring adults.

(e) The degree of slope of the breeding grounds did not affect chick losses.

(f) Evenness of the ground surface did not affect chick losses.

(g) Chick losses were apparently related to lack of cover, but only in those colonies where the substrate (e.g. grey sand) served to reflect heat from the sun. In colonies with a non-reflecting substrate chick losses were apparently not related to lack of cover.

(h) There was no relationship between chick losses and nesting density.

(i) Chick mortality was probably not related to the presence of young breeders as such, but rather to the total numbers of breeding birds involved, in relation to the available food.

17. The differences between various Wellington colonies in chick mortality have been discussed, and attention drawn to the relative importance of gull predation in colonies that are

free of mammalian predation. The overall breeding success of a relatively stable colony appears to be higher than that of an expanding colony for which essential resources are under pressure.

18. The mortality of young on Somes Is. between 1961 and 1965 has been discussed in relation to the food supply. Mortality of young in the colony rose, almost entirely as a result of steadily increased predation by adults, while losses outside the colony remained the same. In default of adequate explanation in terms of other measured factors the evidence suggests an intrinsic population control, acting in response to an expanding population and a diminished food supply.

19. Some recent researches and current hypotheses concerning regulation of animal populations have been reviewed, and their relevance to the results of this study considered. It is concluded that adjustment to the level of recruitment had a relatively much greater affect on the population than post-breeding density-dependent mortality, and that the results can be explained more satisfactorily in terms of Wynne-Edwards' hypothesis of population regulation than by other means. The point is made however that the results may not implicate all other birds, or even all other gulls, except possibly the larger members of Larus.

20. Mean annual loss of weight of Swedish lock-type bands was constant and not less than 4.3% of the initial weight. Bands

may begin to fall off in the sixth year, and there may be marked loss of bands by about the tenth year. Variations in the rate of wear of bands arise from fractional differences in the thickness of individual bands, or in the average thickness of yearly consignments, and from the habits of individual birds. Because gulls are potentially long-lived, loss of bands has considerable importance in population studies, and it is suggested that "mortality rates" of bands should be determined before calculating those of the birds themselves.

21. After the first year 70.1% of the recovered birds were "found dead" and 13.4% were shot. The remainder were reported sick, injured, electrocuted or hit by cars. Thus the fates were very similar to those experienced by first year birds.

22. Recoveries after the first year indicate half the annual losses occurred by the end of April, after which mortality was relatively low until November. Most (72%) of the losses occurred in summer and autumn, (42% in autumn) which is similar to the pattern in British Herring Gulls.

23. Beach-patrol records for all ages combined suggest 51% of the annual mortality occurs in summer and autumn. These records appear to show a relatively higher mortality in winter than do the recoveries of banded birds. Reasons for this discrepancy have been discussed.

24. The recoveries outside the colony cover a maximum period of ⁶ six years. The recovery percentage in the first year (2.8%)

was more than twice as great as that in the second year, and after the first year the percentage recovered (ca. 1%) was fairly steady, which suggests a relatively constant rate of mortality.

25. Assuming the mortality rate is relatively constant from the second year onwards the average adult mortality is 11% and expectation of further life is 8.5 years. Adult mortality rates suggested by other gull studies have been discussed.

26. Most Southern Black-backs probably begin to breed in their fourth year, and some probably breed in their third year. By correlating production of young in recent years with calculated mortality rates it has been shown that production of fledged young in Wellington is about twice that required to balance the population, and the annual growth rate of the population is not less than 7.2%. This helps to explain the steady growth of the Wellington population over the last quarter century. If the population was to become static, then fertility (effectively the number of young surviving one year) would have to fall by 50%.

27. Re-analysis of data collected in 1961-62 suggests fewer males are present in autumn and winter than in spring and summer. It is tentatively suggested that males and females display differential behaviour in the non-breeding season, i.e. perhaps the dispersal pattern of males is different from that of females.

28. The apparent relationships between production and mortality suggested by other gull studies have been discussed, and the suggestion made that the question of population balance can only be discussed when production rates and overall population trends are known.

29. The dispersal of gulls from seven Wellington colonies has been discussed and the affect of mountain country and built-up areas on the distribution of recoveries considered. The large number of recoveries in towns or populated areas does not distort the picture of gull dispersal, but instead truly reflects habitat preferences and distribution.

30. The average recovery distance in the first year was 16.8 miles (range 7.9-31.3 miles) and a recovery over 60 miles was exceptional. Differences between colonies were fairly constant throughout the year, and there was only a slight tendency towards longer flights in the second six months.

31. Some birds dispersed quickly and indicated that a first year bird may travel at least 280 miles from its colony in less than nine months.

32. Compared with other gulls the Wellington Southern Black-backs are remarkably sedentary in the first year.

33. 84.8% of the recoveries of first year birds were in the study area, and 63.2% were in Wellington City and Hutt Valley. Overall there was only limited movement in the first year which varied between colonies, and indicated suppressed dispersal

which can be directly related to the food supply and number of potential feeding sites in the vicinity of the colony.

34. Dispersal data for the second to sixth years were treated together because there were no apparent differences between any years. Average recovery distance was 14.4 miles (range 9.8-24.3 miles) which indicated only a slight tendency towards reduced dispersal after the first year.

35. The percentages of recoveries in the study area as a whole (87.5%) and in Wellington City and Hutt Valley (57.8%) were almost the same as in the first year, and the directions of movement were similar.

36. The dispersal pattern of gulls banded while roosting on Somes Is. was not different to those of birds born on the island.

37. The combined recovery data for all ages indicate the mean distance travelled was only 16.1 miles, 85.5% of the recoveries were in the study area, and 61.7% in Wellington and Hutt Valley. There was no evidence of any movement northwards in winter.

38. Migratory movements of Southern Black-backs in the high latitudes of the southern hemisphere have been mentioned, and the dispersal of other Larinae discussed. On the whole migratory movements of the Larinae are conservative and Southern Black-backs in Wellington are largely sedentary, but show similarities to some of the other large non-migratory Larus gulls, particularly the British Herring Gull. The other species most closely related to the Southern Black-back is the Lesser Black-backed

Gull, which is migratory.

39. A survey of colour-banded gulls in Wellington Harbour and on the west coast showed clearly the concentration of banded birds in the harbour (particularly those from Some Is. and Baring Hd.) and indicated dispersal patterns similar to those of dead banded birds, except that relatively more Mana Is. and Kapiti Is. gulls were located in the general vicinity of their colonies. Some Is. birds were concentrated at the northern end of the harbour, because of the feeding sites, and Baring Hd. birds were concentrated at the southern end, i.e. the end nearest their colony.

40. Although there are no banding data available, it is considered the majority of gulls from North Is. colonies outside the study area would not move into the study area.

41. Recoveries of gulls banded in six colonies at the northern end of the South Is. indicate some movement across Cook Strait to Wellington. Dispersal of Wellington gulls to the South Is. appears to be very limited. The immigration of birds from other parts of New Zealand to Wellington, at least during the non-breeding season, suggests populations throughout the country are mixed to a slightly greater degree than that resulting from integration of local communal flocks alone.

42. The range of dispersal of Southern Black-backs has been briefly compared with that of other gulls, terns and skuas. Although they are concentrated in populated coastal areas

V GENERAL SUMMARY

1. In 1963 a population-ecology study of Southern Black-backed Gulls was started in Wellington. The study area centred on Wellington Harbour and included numerous breeding and roosting colonies of varying sizes. The specific problem examined was the structure and balance of the Wellington population.

2. The problem was approached from three aspects:

- (a) The size, distribution, structure, history and general growth trends of the population.
- (b) The comparative breeding success of a number of colonies.
- (c) The mortality and dispersal of banded gulls.

Detailed summaries of the results of this work have been presented at the ends of sections II, III and IV respectively. Correlation of all the data suggests a number of general conclusions.

3. Distribution of gulls in the study area was influenced enormously by human habitation, and in comparison with a region where the human population was not dense, the study area had an inflated population of gulls. The concentration of

gulls in Wellington was particularly marked because dispersal from breeding colonies was restricted. Restricted dispersal was apparently related to the number of potential feeding sites near a colony, and these also apparently affected the proportion of birds from each colony that joined the Wellington population.

The structure and dispersion of the population was complex. It comprised breeding colonies, night roosting flocks and daily communal flocks which were interrelated by the social activities and dispersal of the birds. The organisation of communal flocks did not simply involve discrete units of gulls which regularly attended the same site every day. Instead each flock was composed of a group of more or less regular members, and a varying number of irregular, itinerant members which moved between roosting flocks and communal flocks, and tended to integrate the whole population. Further mixing of the population was achieved by the immigration of a certain proportion of birds from outside the Wellington area. Communal flocks were subject to seasonal fluctuation in size and age composition. The sex ratio may have varied during the year.

4. Breeding colonies experienced a wide range of ecological conditions which influenced overall breeding success in each. In some colonies mammalian predation and drowning were very important factors. Breeding was apparently influenced by

the rapid growth of the whole population in the last five to 10 years, thus effects were noted in nesting density, clutch size, spread of laying and overall breeding success.

5. The Wellington population has expanded considerably since last century, especially in the last 20-25 years. This growth was apparently stimulated by an increase in the number of artificial feeding sites. In recent years at least, production of young has been twice that required to maintain the population which has grown at the rate of not less than 7.2% annually. The influence of several factors on chick mortality has been examined, and the conclusion drawn that the principal factor limiting the population is the food supply in relation to the number of birds.

In the last five years the population has continued to expand, but the food supply has diminished so that the gulls have been subjected to an increase in feeding pressure. The largest colonies were apparently most affected and on *Somes Is.* the result was a significant rise in chick mortality, though losses outside the colony remained fairly steady. The losses arose almost entirely from increased adult predation which suggests that major regulation of the population was achieved by the birds themselves in the colony.

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* Reference not seen.

VII APPENDICES

Appendix 1LIST OF BIRDS MENTIONED IN TEXT

Common and scientific names follow the New Zealand Checklist (Ornithological Society of N.Z., 1953) except in the case of species referred to in the literature.

Giant Petrel	<u>Macronectes giganteus</u>
Great Shearwater	<u>Puffinis gravis</u>
Gannet	<u>Sula bassana</u>
Black Swan	<u>Cygnus atratus</u>
Paradise Duck	<u>Casarca variegata</u>
Golden Eagle	<u>Aquila chrysaetos</u>
Harrier	<u>Circus approximans</u>
Partridge	<u>Perdix perdix</u>
Red Grouse	<u>Lagopus lagopus scoticus</u>
Black Grouse	<u>Lyrurus tetrix</u>
Turkey	<u>Meleagris galopavo</u>
Pukeko	<u>Porphyrio porphyrio</u>
North Is. (variable) Oystercatcher	<u>Haematopus unicolor</u>
Antarctic Skua	<u>Stercorarius skua maccormicki</u>
Pomarine Jaeger	<u>S. pomarinus</u>
Parasitic Jaeger	<u>S. parasiticus</u>
Long-tailed Jaeger	<u>S. longicaudus</u>
Ring-billed Gull	<u>Larus delawarensis</u>
Common Gull	<u>L. canus</u>
Herring Gull	<u>L. argentatus</u>

Lesser Black-backed Gull	<u>Larus fuscus</u>
Californian Gull	<u>L. californicus</u>
Great Black-backed Gull	<u>L. marinus</u>
Glaucous-winged Gull	<u>L. glaucescens</u>
Glaucous Gull	<u>L. hyperboreus</u>
Iceland Gull	<u>L. leucopterus</u>
Laughing Gull	<u>L. atricilla</u>
Franklin's Gull	<u>L. pipixcan</u>
Silver Gull	<u>L. novaehollandiae novaehollandiae</u>
Red-billed Gull	<u>L. n. scopulinus</u>
Mediterranean Gull	<u>L. melanocephalus</u>
Black-billed Gull	<u>L. bulleri</u>
Black-headed Gull	<u>L. ridibundus</u>
Slender-billed Gull	<u>L. genei</u>
Bonaparte's Gull	<u>L. philadelphia</u>
Swallow-tailed Gull	<u>L. furcatus</u>
Kittiwake	<u>Rissa tridactyla</u>
Caspian Tern	<u>Hydroprogne caspia</u>
Common Tern	<u>Sterna hirundo</u>
Arctic Tern	<u>S. paradisea</u>
White-fronted Tern	<u>S. striata</u>
Sooty Tern	<u>S. fuscata</u>
Tawny Owl	<u>Strix aluco</u>
Thrush	<u>Hylocichla sp.</u>
Red-winged Blackbird	<u>Agelaius phoeniceus</u>
Starling	<u>Sturnus vulgaris</u>
Australian Magpie	<u>Gymnorhina tibicen</u>

Appendix 2COLONIES ADJACENT TO THE STUDY AREA

In the North Is. there are six breeding colonies and two roosting flocks adjacent to the study area (Fig. 2). Briefly these are as follows:

Santoft Forest (ca. nine miles north of Rangitikei R. mouth)

In 1962-63 D.B. Seager (pers. comm.) estimated this colony at 150-175 pairs, but the following season found it had "increased considerably" while the nearby Rangitikei colony appeared to decrease in size.

Rangitikei (ca. two miles north of Rangitikei R. mouth)

This colony comprised ca. 100 pairs in 1962-63, but in 1963-64 it appeared to have reduced in size (D.B. Seager, pers. comm.).

Manawatu R. mouth North Andrew (1960) recorded a "small colony" breeding one to two miles north of the estuary.

Manawatu R. mouth South In December 1962 I. Andrew (pers. comm.) found five scattered nests two-three miles south of the estuary.

Waiwiri Stm. mouth A roosting flock was recorded by I. Andrew (pers. comm.) at the Waiwiri Stm. mouth, nine to 10 miles north of the Otaki River.

Mangatainoka N.H. Hodgetts reported (pers. comm.) that a flock of 20-30 gulls roosts in paddocks by the Manawatu R. at Mangatainoka.

Castle Pt. At Castle Rock in mid November 1945 Cunningham (1946) found 80-100 birds present, and 26 nests.

Black Hd. In mid November 1962 M.J. Parsons (pers. comm.) found 10 nests at Black Hd., about five miles north of Cape Palliser.

The largest of the six breeding colonies mentioned are the ones near Santoft Forest and the Rangitikei R. mouth. These are approximately 41 and 48 miles respectively from the study area.

In the South Is. there are six colonies adjacent to the study area, but all are more than 30 miles from Wellington (Fig. 22 b). These colonies are: Rabbit Is., Nelson; Wairau R.; Wairau Lagoons; Lake Grassmere; Long Pt., north of the Flaxbourne R. mouth; Clarence R. mouth. Dispersal of banded birds from these colonies is discussed in section IV: 6.

Appendix 3SUB-REGIONAL TOTALS FOR AERIAL CENSUS OF 30/7/64

Waikanae R. south to, but excluding Karehana Bay (Also including Kapiti Is.)	583	8.1%
Porirua Harbour (Karehana Bay to and including Titahi Bay)	1,037	14.3%
Titahi Bay south to, but excluding Ohiro Bay (Also including Mana Is.)	282	3.9%
Wellington Harbour (Ohiro Bay - Pencarrow Hd.) and environs, and Hutt Valley	4,664	64.6%
Pencarrow Hd. - Turakirae Hd.	259	3.6%
Palliser Bay and lower Wairarapa	396	5.5%
	<u>7,221</u>	<u>100.0%</u>

COASTAL DISTRIBUTION OF GULLS IN AERIAL CENSUS OF 30/7/64

	<u>Miles of Coast</u>	<u>No. of Gulls</u>	<u>Gulls per Mile</u>
Waikanae R. south to, but excluding Karehana Bay (also including Kapiti Is.)	18.75	583	31.1
Porirua Harbour (Karehana Bay to, and including Titahi Bay)	17.25	1,037	60.1
Titahi Bay to but excluding Ohiro Bay (also including Mana Is.)	33.75	282	8.3
Wellington Harbour (Ohiro Bay - Pencarrow Hd.)	38.25	3,000	78.4
Pencarrow Hd. - Turakirae Hd.	7.5	259	34.5
Turakirae Hd. - W. end Palliser Spit	11.25	3	0.3
Palliser Spit - Cape Palliser	23.25	396	17.0
	<u>150</u>	<u>5,560</u>	<u>37.1av.</u>

Appendix 4ADULT TO FIRST YEAR RATIO IN COMMUNAL FLOCKS

	<u>1961</u>		<u>1962</u>		<u>1963</u>		<u>1964</u>		<u>1965</u>	
	<u>CITY</u>	<u>PETONE</u>	<u>CITY</u>	<u>PETONE</u>	<u>CITY</u>	<u>PETONE</u>	<u>CITY</u>	<u>PETONE</u>	<u>CITY</u>	<u>PETONE</u>
Jan.*			-	-			-	-	-	-
Feb.			9.7	1.0			11.1	3.5	4.0	3.3
Mar.			7.2	6.2	7.9	4.8	12.1	5.7	4.4	3.6
Apr.			9.0	3.5	8.7	8.7	8.9	6.3	3.9	6.8
May			4.7	3.9	8.5	12.3	9.6	7.4		
Jun.			4.9	4.8	5.0	3.2	4.7	8.3		
Jul.	3.8	3.2			4.8	3.1	3.4	4.6		
Aug.	1.7	4.2			3.4	3.2	2.7	6.7		
Sep.	1.2	2.2			1.8	3.5	1.7	1.3		
Oct.	1.0	1.5			1.2	3.2	0.9	1.6		
Nov.	0.7	0.6			0.7	2.4	1.2	0.7		
Dec.					0.4	0.8	0.6	0.5		

* Ratios in this month were too high to measure.

Appendix 5

ATTENDANCE OF BREEDING BIRDS IN THE COLONY DURING THE DAY.

A Somes Is. 12/11/64

B " " 20/11/64

C " " 21/11/64

Counts at 5 minute intervals. The dotted line represents the average attendance of 24.4 (81.3%) birds.

D Northern colony Baring Hd. 24/11/64

Counts at 15 minute intervals. The dotted line represents the average attendance of 157 (79.3%) birds.

Appendix 6LAKE WAIRARAPA LEVELS AT WESTERN LAKE GAUGE:OCTOBER - FEBRUARY 1953-1965

100.0 ft. = High Water Ordinary Spring Tide at Lake Onoke

Islet at Ruamahanga R. Mouth on Lake Wairarapa = ca. 101.5 ft.

NO. OF DAYS LAKE WAS AT FOLLOWING LEVELS

<u>Feet</u>	<u><101</u>	<u>101-102</u>	<u>102 - 103</u>	<u>103 - 104</u>	<u>>104</u>
1953-54	65	40	32	5	9
1954-55	102	25	24	1	-
1955-56	94	50	8	-	-
1956-57	93	38	11	3	5
1957-58	84	36	15	16	-
1958-59	76	50	20	5	1
1959-60	82	38	11	11	9
1960-61	60	53	23	7	8
1961-62	86	34	18	8	5
1962-63	95	35	18	3	-
1963-64	49	48	37	16	2
1964-65	99	26	19	3	4

Appendix 7METEOROLOGICAL RECORDS FOR JULY - FEBRUARY FROM KELBURN,
WELLINGTON.DEPARTURES FROM THE NORMAL

		<u>Spring</u>					<u>Summer</u>			
		<u>Jul.</u>	<u>Aug.</u>	<u>Sep.</u>	<u>Oct.</u>	<u>Nov.</u>	<u>Dec.</u>	<u>Jan.</u>	<u>Feb.</u>	
<u>Mean Monthly Temperatures</u> <u>°F.</u>	<u>1961</u>	+0.3	-0.9	-1.2	+3.6	+0.7	+2.9			
	<u>1962</u>	+2.2	+0.9	+0.9	+3.5	+2.3	+0.7	+3.3	+0.5	
	<u>1963</u>	-0.1	-1.9	-0.2	+1.4	-1.8	-0.6	+1.1	+2.6	
	<u>1964</u>	+2.2	+0.8	-0.4	+0.2	+0.2	+1.5	-1.5	+1.2	
	<u>1965</u>							+4.5	+0.0	
<u>Bright Sunshine</u> <u>Hrs.</u>	<u>1961</u>	+4	-14	-18	+45	+18	+75			
	<u>1962</u>	-16	-11	-4	-6	+48	+30	+42	+31	
	<u>1963</u>	-28	-18.5	-55	+6	+40	+20	+25	+1	
	<u>1964</u>	-34	+16	-6	+40	+0.0	-1	+20	+41	
	<u>1965</u>							+70	+6	
<u>Mean Cloud Amount at 0.900 hrs.</u> <u>Oktas</u>	<u>1961</u>	-0.1	+0.3	+0.0	-0.8	+0.2	-0.8			
	<u>1962</u>	+0.0	+0.3	+0.1	+0.4	-0.1	+0.0	-0.7	-0.1	
	<u>1963</u>	+0.6	+0.3	+0.8	-0.2	+0.1	-0.4	-0.2	+0.2	
	<u>1964</u>	+0.5	(less than usual)				-	-	+0.1	-0.9
	<u>1965</u>							-	-	

Appendix 8AGE DISTRIBUTION OF CHICK DEATHS

	<u>Dead & Uninjured</u>	<u>Killed by Gulls</u>	<u>Killed by Stoats</u>	<u>Killed by Ferrets</u>	<u>Totals</u>
Hatched	7	1	-	-	8
1-2 days	12	2	1	3	18
2-7 days	11	1	-	7	19
1-2 weeks	3	8	1	-	12
2-3 weeks	1	3	-	-	4
3-4 weeks	2	1	4	-	7
4-5 weeks	1	3	2	-	6
5-6 weeks	-	1	2	-	3
6-7 weeks	-	3	-	-	3
	<u>37</u>	<u>23</u>	<u>10</u>	<u>10</u>	<u>80</u>

Appendix 9SEASONAL SUCCESS OF FIRST CLUTCHES

* Significantly different. ** Highly significantly different.

SOMES IS. (1963-64) ca. 1,475 pairs, (sample 132)

	<u>Nests</u>	<u>Eggs laid</u>	<u>Eggs lost</u>	<u>Chicks lost</u>	<u>Chicks/pair</u>
<u>First 50%</u>	67	171	25 14.6%	22 15.1%	1.85
<u>Last 50%</u>	65	158	29 18.3%	15 11.6%	1.75

PALLISER SPIT (1963-64) 265 pairs, (sample 85)

	<u>Nests</u>	<u>Eggs laid</u>	<u>Eggs lost</u>	<u>Chicks lost</u> [†]	<u>Chicks/pair</u>
<u>First 50%</u>	43	123	13 10.6%	5 5.5%	2.44
<u>Last 50%</u>	42	99	*21 21.2%	2 2.6%	1.80

TE HUMENGA PT. (1963-64) 58 pairs, (sample 58)

	<u>Nests</u>	<u>Eggs laid</u>	<u>Eggs lost</u>	<u>Chicks lost</u>	<u>Chicks/pair</u>
<u>First 50%</u>	29	78	16 20.5%	7 11.3%	1.89
<u>Last 50%</u>	29	65	*25 38.5%	*11 27.5%	**1.00

SOMES IS. (1961-62) 1,450 pairs, (sample 310)

	<u>Nests</u>	<u>Eggs laid</u>	<u>Eggs lost</u>	<u>Chicks lost</u>	<u>Chicks/pair</u>
<u>First 50%</u>	157	393	114 29%	50 17.9%	1.46
<u>Last 50%</u>	153	348	**137 39.4%	47 22.3%	**1.07

†. These numbers were too small to use X^2 so the percentages were compared by angular transformation (Fisher and Yates, 1948, p.56); see also Snedecor (1950, p.449) for tables.

Appendix 10MORTALITIES IN THE FIRST AND LAST HALVES OF THE BANDING SEASONSOMES IS.

		<u>BANDED</u>	<u>TOTAL LOST</u>	<u>KILLED BY GULLS</u>	<u>DEAD, NO EXTERNAL INJURIES</u>	<u>FATE UNKNOWN</u>
(1962-63)	<u>Dec.</u>	485	71	55	15	1
	<u>Jan.</u>					
&	<u>Feb.</u>	243	47*	30**	17	1

* Not different ($.1 < P < .25$, $v=1$) ** Not different ($.25 < P < .5$, $v=1$)

(1963-64)	<u>Dec.</u>	389	95	66	15	14
	<u>Jan.</u>					
&	<u>Feb.</u>	321	69*	43**	9	17

* Not different ($.25 < P < .5$, $v=1$) ** Not different ($.1 < P < .25$, $v=1$)

MANA IS.

		<u>BANDED</u>	<u>TOTAL LOST</u>	<u>KILLED BY GULLS</u>	<u>DEAD, NO EXTERNAL INJURIES</u>	<u>FATE UNKNOWN</u>
(1963-64)	<u>Dec.</u>	276	42 (15%)	34 (12%)	6	2
	<u>Jan.</u>					
&	<u>Feb.</u>	243	36 (15%)	28 (11.5%)	5	3
(1964-65)	<u>Dec.</u>	116	21	11	8	2
	<u>Jan.</u>					
&	<u>Feb.</u>	311	36*	33**	3	-

* Not different ($.05 < P < .1$, $v=1$) ** Not different ($.5 < P < .75$, $v=1$)

Appendix 11FATES OF YOUNG RECOVERED OUTSIDE THE COLONYIN THE FIRST YEAR

	<u>Somes</u> <u>Is.</u>	<u>Palliser</u> <u>Spit</u>	<u>Baring</u> <u>Hd.</u>	<u>Kapiti</u> <u>Is.</u>	<u>Mana</u> <u>Is.</u>	<u>Total</u> *
Found dead	46	14	22	13	11	108
Shot	3	6	4	1	3	17
Sick and died	4	3	1	1		9
Hit by car	5	3				8
Injured and died	2	3	2			7
Broken wing	3					3
Caught on fish hook	1	1				2
Broken neck	1					1
Aspergillosis				1		1
Hit by plane			1			1
Caught in fence		1				1
	<u>65</u>	<u>31</u>	<u>30</u>	<u>16</u>	<u>14</u>	<u>158</u>

* Mukamuka R. mouth - 2 found dead.

Te Humenga Pt. - no recoveries.

Appendix 12DISTRIBUTION OF FLEDGED YOUNG MORTALITY IN THE FIRST YEAR*

<u>Month of flight</u>	<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>	<u>6</u>	<u>7</u>	<u>8</u>	<u>9</u>	<u>10</u>	<u>11</u>	<u>Total</u>	
<u>Calendar month</u>	<u>F</u>	<u>M</u>	<u>A</u>	<u>M</u>	<u>J</u>	<u>J</u>	<u>A</u>	<u>S</u>	<u>O</u>	<u>N</u>	<u>D</u>		
Killed by gulls	(122)					1					1	124	45.3%
Found dead	(44)		19	14	7	8	1	4	3	2	2	114	41.6%
Shot		4		1	1		4	1				11	4.0%
Injured (including 3 broken wings)	1		2	2		1			1			7	2.6%
Sick (including 1 aspergillosis)	1	2		1		1	1					6	2.2%
Hit by car	1	2					1	1				5	1.8%
Caught in fish- ing line	1		1		1							3	
Cause unknown		(3)										3	
Rolled on by cow	1											1	
	(192)	22	19	8	11	7	6	4	2	3		274	

* Based on 3,723 fledglings banded 1961-64.

Appendix 13MORTALITY OF FLEDGED YOUNG UP TO THE END OF JUNE*

<u>Month of flight</u>	<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>	<u>Total</u>	
<u>Calendar month</u>	<u>F</u>	<u>M</u>	<u>A</u>	<u>M</u>	<u>J</u>		
Killed by gulls	(155)					155	49.4%
Found dead	(66)		29	16	10	121	38.5%
Hit by car	1	3	1	2	1	8	2.5%
Shot		4		2	1	7	2.2%
Injured (including 3 broken wings, & 1 broken leg)	1		2	3	1	7	2.2%
Sick (including 1 aspergillosis)	2	2	2			6	1.9%
Cause unknown	(6)					6	1.9%
Caught in fishing line	1		1	1		3	
Rolled on by cow	1					1	
	(242)		35	24	13	314	

Recovery percentage of 5.0% 5.7% 6.2% 6.4%
 4,876 young presumed
 fledged. (c.f. Table 31)

* Based on 5,269 fledglings banded 1961-65.

Appendix 14DISTRIBUTION OF FLEDGED YOUNG MORTALITY IN THE FIRST YEAR1961-62 DATA

<u>Month of flight</u>	<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>	<u>6</u>	<u>7</u>	<u>8</u>	<u>9</u>	<u>10</u>	<u>11</u>	<u>Total</u>
<u>Calendar month</u>	<u>F</u>	<u>M</u>	<u>A</u>	<u>M</u>	<u>J</u>	<u>J</u>	<u>A</u>	<u>S</u>	<u>O</u>	<u>N</u>	<u>D</u>	
<u>Killed by gulls</u>	22	12										34
<u>Dead, other causes</u>	11	7	3	2	1	5	1	2	1	-	1	34
<u>Totals</u>	<u>33*</u>	<u>19**</u>	<u>3</u>	<u>2</u>	<u>1</u>	<u>5</u>	<u>1</u>	<u>2</u>	<u>1</u>	<u>-</u>	<u>1</u>	<u>68</u>

* 48.5% of the year's losses; 6.1% of the 542 young presumed fledged.

** 27.9% of the year's losses; 9.6% of the 542 young presumed fledged.

Appendix 15AVAILABLE PROTECTIVE COVER FOR CHICKS SOMES IS. (1964-65)

<u>DISTANCE FROM NEST</u>	<u>NESTS WITH MORE COVER</u>		<u>NESTS WITH LESS COVER</u>	
0-3 feet	84	63.6%	49	36.8%
3-10 "	38	28.8%	35	26.4%
> 10 "	10	7.6%	49	36.8%
	<u>132</u>	<u>100%</u>	<u>133</u>	<u>100%</u>

AVAILABLE PROTECTIVE COVER FOR CHICKS BARING HD. (1964-65)

<u>DISTANCE FROM NEST</u>	<u>NORTHERN COLONY</u>		<u>LIGHTHOUSE COLONY</u>		<u>LAGOON COLONY</u>	
0-3 feet	36	58.1%	29	31.5%	26	42.6%
3-10 "	14	22.6%	34	37%	20	32.8%
> 10 "	12	19.3%	29	31.5%	25	24.6%
	<u>62</u>	<u>100%</u>	<u>92</u>	<u>100%</u>	<u>61</u>	<u>100%</u>

Appendix 16MORTALITY AT MANA ISLAND AND BARING HD. 1964-65

	<u>MEAN SHORTEST NESTING DIST.</u>	<u>BANDED</u>	<u>FLEDGLING LOSSES</u>	<u>KILLED BY GULLS</u>
Mana Is.	10.5 feet	427	43 10%	35 8%
Baring Hd.	10.6 "	409	17 4%	16 4%

MORTALITY ON MANA ISLAND IN 1963-64 & 1964-65

<u>YEAR</u>	<u>BANDED</u>	<u>TOTAL LOSSES</u>	<u>KILLED BY GULLS</u>	<u>DEAD. NO EXTERNAL INJURIES</u>	<u>FLEDGLINGS KILLED</u>	<u>FLEDGED YOUNG KILLED</u>
1963-64	519	78 15%	62 12%	10 2%	47 9%	15 3%
1964-65	427	57 13%	44 10%	11 3%	35 8%	9 2%

RECOVERIES OF SOMES IS. FLEDGED YOUNG OUTSIDE THE COLONY
IN THE FIRST YEAR

<u>YEAR</u>	<u>BANDED</u>	<u>RECOVERED DEAD OUTSIDE COLONY</u>
1961-62	574	16 2.8%
1962-63	728	20 2.7%
1963-64	710	23 3.2%

Appendix 17

LOSSES OF YOUNG IN THE COLONY

	<u>BANDED</u>	<u>TOTAL LOSSES IN COLONY</u>	<u>FLEDGLING LOSSES</u>	<u>FLEDGLINGS KILLED BY GULLS</u>	<u>FLEDGLINGS DEAD, NO EXTERNAL INJURIES</u>	<u>FLEDGED YOUNG LOSSES</u>	<u>FLEDGED YOUNG KILLED BY GULLS</u>	<u>FLEDGED YOUNG DEAD, NO EXTERNAL INJURIES</u>
¹ Somes Is.	2,573	452 18%	218 9%	164 6%	47 2%	167 6%	127 5%	36 1%
² Mana Is.	946	135 14%	101 11%	82 9%	16 2%	32 3%	24 3%	5 0.5%
³ Te Humenga Pt.	37	5 14%	4 11%	3 8%	1 3%	1 3%	1 3%	- -
⁴ Palliser Spit	309	28 9%	21 7%	16 5%	5 2%	3 1%	3 1%	- -
⁵ Baring Hd.	808	43 5%	32 4%	25 3%	3 0.3%	* -	- -	- -

¹1961-65 ²1963-65 ³1963-64 ⁴1963-64 ⁵1963-65

* No fledged young were found dead, but 11 birds were recovered whose ages at death were unknown. Some of these birds may have been fledged young.

Appendix 18WEIGHTS OF 80 RECOVERED BANDS*

<u>YEAR</u>	<u>0 - $\frac{1}{2}$</u>	<u>$\frac{1}{2}$ - 1</u>	<u>1 - $1\frac{1}{2}$</u>	<u>$1\frac{1}{2}$ - 2</u>	<u>2 - $2\frac{1}{2}$</u>	<u>$2\frac{1}{2}$ - 3</u>
No.	19	13	11	12	10	5
Total wt.	23.05	15.33	12.82	13.71	11.07	5.13
Range	1.17-1.26	1.02-1.25	1.11-1.21	1.08-1.20	1.04-1.18	0.96-1.08
Mean	1.21	1.18	1.17	1.14	1.11	1.03
Mean loss	0.01	0.03	0.01	0.03	0.03	0.08

<u>YEAR</u>	<u>3 - $3\frac{1}{2}$</u>	<u>$3\frac{1}{2}$ - 4</u>	<u>4 - $4\frac{1}{2}$</u>	<u>$4\frac{1}{2}$ - 5</u>
No.	6	1	2	1
Total wt.	6.23	1.06	2.01	0.74
Range	1.00-1.09	-	1.00-1.01	-
Mean	1.04	-	1.01	-
Mean loss	-	-	-	-

* Mean weight of 150 new (1965) size S lock-type bands was 1.22 gms.

Appendix 19FATES OF GULLS AFTER THE FIRST YEAR

<u>FATE</u>	<u>SOMES</u> <u>IS.</u>	<u>PALLISER</u> <u>SPIT</u>	<u>BARING</u> <u>HD.</u>	<u>KAPITI</u> <u>IS.</u>	<u>TOTAL</u>
Found dead	19	12	5	-	36
Dead in the colony	2	4	4	1	11
Shot	5	1	2	1	9
Sick and died	2	-	1	-	3
Hit by car	1	2	-	-	3
Electrocuted	1	1	-	-	2
Broken wing	2	-	-	-	2
Injured and died	1	-	-	-	1
	<u>33</u>	<u>20</u>	<u>12</u>	<u>2</u>	<u>67</u>

Appendix 20SPREAD OF MORTALITY AFTER THE FIRST YEAR

	<u>J</u>	<u>F</u>	<u>M</u>	<u>A</u>	<u>M</u>	<u>J</u>	<u>J</u>	<u>A</u>	<u>S</u>	<u>O</u>	<u>N</u>	<u>D</u>	<u>TOTAL</u>
Somes Is.	2	1	9	4	4	1	3		1		3	5	33
Palliser Spit	1	4	2	4	2			1	1	2	2	1	20
Baring Hd.	2	2	1	1	1	1		2			1	1	12
Kapiti Is.	1							1					2
	<u>6</u>	<u>7</u>	<u>12</u>	<u>9</u>	<u>7</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>2</u>	<u>2</u>	<u>6</u>	<u>7</u>	<u>67</u>

Appendix 21

BEACH PATROL RECORDS OF THE ORNITHOLOGICAL
SOCIETY OF NEW ZEALAND

	<u>1951-59</u>	<u>1960</u>	<u>1961</u>	<u>1962</u>	<u>1963</u>	<u>TOTAL</u>
Jan.		1		2	13	16
Feb.	1	6		2	2	11
Mar.	3	3	12			18
Apr.		3	2		5	10
May	2	1	2	1	7	13
Jun.		4	1	2	11	18
Jul.	1	4			4	9
Aug.		5	3		10	18
Sep.		4	2	8	3	17
Oct.		1		1	3	5
Nov.		2	1		6	9
Dec.		2	6	1	4	13
	<u>7</u>	<u>36</u>	<u>29</u>	<u>17</u>	<u>68</u>	<u>157</u>

Appendix 22SEX RATIO OF GULLS*

	<u>FIRST YEAR</u>		<u>SECOND & THIRD</u> <u>YEAR</u>		<u>ADULT</u>		<u>TOTAL</u>
	<u>Male</u>	<u>Female</u>	<u>Male</u>	<u>Female</u>	<u>Male</u>	<u>Female</u>	
<u>Spring and summer</u> (breeding season)	4	5	7	5	12	14	47
					(1:1.2)		
<u>Autumn and winter</u> (non-breeding season)	18	23	7	15	8	24	95
	(1:1.3)		(1:2.1)		(1:3.0)		
	<u>22</u>	<u>28</u>	<u>14</u>	<u>20</u>	<u>20</u>	<u>38</u>	<u>142</u>
	(1:1.3)		(1:1.4)		(1:1.9)		

SEX RATIO, ALL AGES

	<u>Male</u>	<u>Female</u>	<u>Ratio</u>
<u>Spring and summer</u>	23	24	1:1.0
<u>Autumn and winter</u>	33	62	1:1.9
	<u>56</u>	<u>86</u>	<u>1:1.5</u>

* Ratios of males to females are shown in parentheses.

Appendix 23MEAN RECOVERY DISTANCE (ALL AGES)

<u>COLONY</u>	<u>RECOVERIES</u>	<u>DISTANCE</u>
Somes Is.	89	8.6 miles
Baring Hd.	37	14.2
Mana Is.	14	16.4
Palliser Spit	44	25.2
Kapiti Is.	18	25.6
	<u>202</u>	<u>16.1</u>

LOCATION OF RECOVERIES (ALL AGES)

	<u>WELLINGTON & HUTT VALLEY</u>		<u>IN THE STUDY AREA</u>		<u>OUTSIDE THE STUDY AREA</u>		<u>TOTAL</u>
Somes Is.	87	84.5%	99	96.1%	4	3.9%	103
Palliser Spit	16	33.3%	31	64.6%	17	35.4%	48
Baring Hd.	25	59.5%	38	90.5%	4	9.5%	42
Kapiti Is.	6	27.3%	15	68.2%	7	31.8%	22
Mana Is.	11	55.0%	18	90.0%	2	10.0%	20
	<u>145</u>	<u>61.7%</u>	<u>201</u>	<u>85.5%</u>	<u>34</u>	<u>14.5%</u>	<u>235</u>

Appendix 24RECOVERIES FROM SOUTH ISLAND COLONIES

<u>COLONY*</u>	<u>BANDED 1959-64</u>	<u>DEAD IN COLONY</u>	<u>DEAD OUTSIDE COLONY</u>	<u>RECOVERIES IN THE STUDY AREA</u> **	
				<u>DEAD</u>	<u>SIGHT</u>
1. Nelson	186		2		
2. Wairau R.	190		11	2	4
3. Wairau Lagoon	406	2	3	3	
4. Lake Grassmere	34				1
5. Flaxbourne R. mouth	120	2	4	4	3
6. Clarence R. mouth	442	2	5	3	1
	<u>1,378</u>	<u>6</u>	<u>25</u>	<u>12</u>	<u>9</u>

* Numbering as in Fig. 22.

** All but 2 in the Wellington Harbour region.

PLATE 1

Aerial photograph of the communal flock at
Plimmerton, about 12.45 p.m. 30/7/64,
altitude approximately 800 feet.

PLATE 2

Flock feeding and resting in a refuse tip
(Wilton Rd., Wellington).

1

2

PLATE 3

Kapiti Is.: an area of dense nesting (1963-64) in the north end colony in which Norwegian rats were common. This area was partly flooded for a period early in the following season.

PLATE 4

Cranium of a dead fledgling that had been gnawed by Norwegian rats on Kapiti Is. (north end colony).

4

PLATE 5

Mana Is.: showing steep slopes, some driftwood, and
the wide rocky beach terrace of the west coast.

5

PLATE 6

Somes Is.: area A, a slope area at the north end showing plant cover provided by Scirpus nodosus and Mariscus ustulatus.

PLATE 7

Somes Is.: area F (south end) showing dispersed clumps of Scirpus nodosus on grazed pasture, and some even ground.

6

7

PLATE 8

Somes Is.: area H, a beach area on the western side, showing uneven ground and clumps of flax Phormium colensoi, toe toe Arundo conspicua and Scirpus nodosus.

PLATE 9

Somes Is.: egg predated by Harrier Circus approximans; note shell fragments dropped about the edge of the nest bowl.

8

9

PLATE 10

Baring Hd.: Northern colony with driftwood and sand
poppy Glaucium flavum cover on a coarse grey sand beach.

PLATE 11

Baring Hd.: Lagoon colony with scattered Scirpus
nodosus on smooth boulders and sand. Part of the
area flooded in 1963-64 is to the centre and right.

10

11

PLATE 12

Waiorongomai R.: long grass in January 1964 which grew during the season and provided cover for ferrets. Some of the eggs predated by ferrets were cached under the willow tree on the right. An adult gull corpse, partially eaten by ferrets, is in the foreground.

PLATE 13

Waiorongomai R.: fresh shingle brought down by the river covering much of the colony in October 1964.

12

13

PLATE 14

Ruamahanga R. mouth: part of Lake Wairarapa and the islet colony showing cover of Juncus spp., Scirpus spp., Mariscus ustulatus etc.

PLATE 15

Ruamahanga R. mouth: flooding in the colony after the level of Lake Wairarapa rose, November 1963.

14

15

PLATE 16

Mukamuka R. mouth: the cache (foreground) where stoats left chick corpses, and the colony showing sparse vegetation on the stony beach terrace.

PLATE 17

Mukamuka R. mouth: chick killed by stoat, showing damage to the neck, and meat chewed from the breast.

16

17

PLATE 18

Palliser Spit: the colony, an area of grey sand
with cover of sand poppy Glaucium flavum.

18