ECOLOGICAL STUDIES ON GULL ISLAND, WITLESS BAY, WITH PARTICULAR REFERENCE TO THE AVIFAUNA

CENTRE FOR NEWFOUNDLAND STUDIES

TOTAL OF 10 PAGES ONLY
MAY BE XEROXED

(Without Author's Permission)

KAROLE HAYCOCK

354736

CENTRE FOR NFLD. STUDIES
FEB 25 1974
MEMORIAL UNIVERSITY OF NEWFOUNDLAND

ECOLOGICAL STUDIES ON GULL ISLAND, WITLESS BAY, WITH PARTICULAR REFERENCE TO THE AVIFAUNA

by

© Karole Haycock, B.Sc.

A thesis submitted in Partial Fulfillment
of the Requirements for the Degree
Master of Science,
Memorial University of Newfoundland

1973

ACKNOWLEDGEMENTS

I would like to thank Dr. William Threlfall for suggesting this study, and for contributing valuable data to it, as well as for his encouragement and support throughout the project.

I am grateful to Mr. William White and Mr. Henry Yard of Witless Bay for their help and co-operation in transporting me to and from the study area, to Wayne Bradley, Sandra Clarke, Eldon Eveleigh, and John Maunder, and to the many others who helped in the field work.

Roy Ficken is responsible for many of the photographic reproductions.

I would especially like to thank Dr. L. M. Tuck, of the Canadian Wildlife Service, for providing freely of his time, unpublished information, and valuable criticism and Dr. R. Strickler for providing the computer programs and for his help with the statistics.

This work was supported by a National Research Council Grant (NRCC-A3500) and a University Fellowship.

Finally I would like to acknowledge the perseverence and patience of Mrs. Renée Daggett and her colleagues at Technical Typing in typing this thesis.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

INTRODUCTION

The breeding biology of colonial sea-birds in the coastal regions of the North Atlantic has been extensively studied during the past forty years, particular emphasis being placed on those species in which the populations have begun to increase (Darling, 1938; Lockley, 1942, 1953; Fisher, 1952b; Fisher & Lockley, 1954; Coulson and White, 1956; Uspenski, 1956; Belopol'skii, 1957; Bourne, 1963; Grenquist, 1965; Nelson, 1966; Ashmole, 1971).

However, few of these studies have been concerned with the northwestern North Atlantic populations (Winn, 1950; Gross, 1935, 1945; Kadlec and Drury, 1968; Tuck, 1961; Wilbur, 1969; Bédard, 1969), comparatively little being known about the large, important breeding colonies in the subarctic environment of Newfoundland (Tuck, 1961; Huntington, 1963; Threlfall, 1968c; Maunder and Threlfall, 1972; Nettleship, 1972).

Newfoundland possesses boreal vegetation, a sparse island fauna, and an abundance of rocky shores, isolated cliffs and islands of the type apparently ideal for nesting sea-birds (Fisher and Lockley, 1954). Around its coast, offshore banks support in abundance the fish and invertebrate fauna used as food by sea-birds during the breeding season (Templeman, 1948; Pitt, 1958).

Gull Island, 27 km south of St. John's, Newfoundland, was chosen for the site of this study because 8 of the 15 species of sea-birds nesting in Newfoundland (Godfrey, 1966) breed here, because it is uninhabited, lacks mammalian predators, and is a Provincial Sea-bird Sanctuary. The purpose of this study was to provide data on climate, vegetation, and avian populations of the island, and where possible to draw inferences as to their interactions. Also, in the light of recent widespread increases of gull populations in the North Atlantic, (Gross, 1945; Kadlec and Drury, 1968; Harris, 1970), it was proposed to study the breeding biology of the gulls.

MATERIALS AND METHODS

The use of all the following procedures was dependent upon access to the island: weather conditions sometimes prevented landing on the island or made travel on Witless Bay inadvisable.

Topography and Mapping

Information on topography of the island was taken from a map prepared by Eastern Resources Ltd. for the Canadian Wildlife service (1969). Slope of terrain was determined using a planimeter constructed of a ruler, plumb line and protractor.

For use in vegetation mapping and estimating numbers of burrow-nesting birds, a grid was set up over the whole island, the lines running North-South and East-West, either 50 or 75 m apart. Trees along grid lines were marked with spray paint.

Climate

Maximum and minimum temperatures were read daily at 0600 hrs. for the preceding 24 hours, using a maximum-minimum recording thermometer.[1] Daily notes were kept on weather conditions (wind, fog, rain, and cloud cover).

Vegetation

All plant species found on the island were collected and identified and a number were stored as herbarium specimens. Plants were identified with the aid of Fernald (1950), Conard (1956), and

---

[1]Taylor recording thermometer

Hale (1969).

The vegetation was mapped using the grid mentioned above, a 4 m square in the north east corner of each major quadrat being examined for plant species present and the percentage cover by each.

In addition a record was kept of dates of flowering and stages of development of the vegetation.

Avifauna

Terrestrial birds

A survey was made of the terrestrial birds present on the island, a record being kept of all birds seen or heard on each visit to the island. Locations and numbers of each species were marked on maps. Birds were identified using Chapman (1968) and Peterson (1963).

Marine Birds

Records were kept of all aquatic and shore birds seen near or on the island. Locations and numbers were recorded in the same manner as for terrestrial birds, and they were identified using Peterson (1963).

Numbers of breeding sea-birds. In order to estimate the number of burrow-nesting sea-birds (petrels *Oceanodroma leucorhoa*, and puffins *Fratercula arctica*), all burrow openings were counted in each of the 4 m squares used for vegetation mapping. The average burrow density was then extrapolated over the whole area utilized by the species for nesting.

For ground-nesting gulls (herring gull *Larus argentatus* and great black-backed gull *L. marinus*) a complete count of nests was carried out during the last week of May and the first week of June. By walking back and forth over the whole area utilized by the birds, the number of nests overlooked was minimized. Each nest was marked with spray paint when counted. The nests of great black-backed gulls were not distinguishable with any degree of certainty from those of herring gulls; hence the number of breeding pairs of the former was determined by observing the birds at their nests.

Two methods were used in the censuses of cliff-dwelling birds (murres *Uria aalge*, razorbills *Alca torda*, and kittiwakes *Rissa tridactyla*). The first was direct observation. The murres were counted several times during the course of incubation and chick-rearing, that is, between mid-June and mid-July. On less crowded ledges the eggs and young were also counted. The razorbills were counted by observing the behaviour of pairs of birds in June and July, and where possible searching the areas they frequented for their eggs. Kittiwakes' nests, excepting those not visible from the island, were counted from the tops of the cliffs, during the first two weeks of July (Maunder and Threlfall, 1972).

The second method was photographic; sections of the cliff that were not visible from the island itself were photographed from a boat. The nests were later counted from the negatives. This method was used for a census of kittiwakes on overhanging cliff faces. Murres and razorbills were not distinguishable by this method.

The number of breeding pairs of black guillemots (*Cepphus grylle*) and of spotted sandpipers (*Actitus macularia*) was estimated from observations of the behaviour of adult birds. Areas where birds were suspected of nesting were searched.

Breeding biology of the gulls. During May to August of 1969 to 1971, the breeding biology of the gulls was studied. Aspects investigated included the density of nests in various parts of the colony, nesting materials, time course of egg-laying, incubation period, size and weight of eggs, growth of embryos and chicks, loss of eggs and young, and food.

The density of gulls' nests in various regions of the island was determined in 1969 to 1971 during the first half of June. Five to fifteen squares were measured (10 m x 10 m) in each of the areas shown in Figure 12. The nests in these squares were counted, the average number of nests per 10 m square being taken as the nest density for that area. Random placement of the squares was attempted.

Progress of egg-laying was followed in two areas, the Point (Fig. 2,b) and an area on the east side, (Fig. 2,c) which was measured off to contain a comparable number of nests. In each of these areas, the number of nests containing 0, 1, 2, and 3 eggs were counted approximately once a week, from mid-May, when the first visits were made to the island, until the eggs began to hatch. The peak laying time for each area was then calculated.

Egg-laying, incubation, and fate of eggs and young were investigated by making regular observations at a number of nests. Nests without eggs were chosen in mid-May, and later as they were built. Each nest to be studied was identified by painting a number on an adjacent rock. Individual eggs, and later chicks, were identified. The order of laying in the clutch was indicated by placing a piece of masking tape on different regions of the eggs. In each brood, the first-hatched chick was marked with a spot of picric acid solution on the head, the second on the back, and the third, on the tail. A strip of adhesive tape bearing the nest number was placed around the tarsus until the chick was large enough for banding with a U.S. Fish and Wildlife Service Number 6 band. Observations were made daily for the presence of eggs and chicks.

Nests in 1969 and 1970 were checked until the young were a few days old, while in 1971, 113 nests were followed until the chicks were about 5 weeks old, daily counts being replaced by checks at 2-to-7 day intervals when the chicks were about 3 weeks old.

The marked nests were also used to obtain information on incubation period, size of eggs, and weight changes of eggs during incubation. Eggs were measured with Vernier calipers and weighed in a plastic bag suspended below a spring balance.[2]

Embryonic growth was studied using 25 known-age herring gull eggs, taken at various stages of incubation. The embryos were dissected from their extraembryonic membranes and preserved in 5% formalin. They were later drained on a paper towel and weighed.[3] Measurements of body parts were taken as shown in Fig. 3.

---

[2]Ohaus model 8011, 250 g capacity, accurate to ± 5 g.

[3]Ohaus 2610 g capacity triple beam balance, accurate to 0.1 g for embryos heavier than 5 g.

Thirty 3-egg clutches were designated for a study of chick growth. Seventeen of the nests (9 herring gull and 8 great black-back) were surrounded with pens, while the remainder (herring gulls) were not. Pens were made of ½ inch mesh hardware cloth, and measured 1.2 m in diameter and 0.6 m high, except for that surrounding Number 1 black-back nest, which was 0.3 m high.

Chicks were weighed in a plastic bag suspended below a spring balance.[4] Culmen and tarsus were measured in the same way as the embryos. Wing measurements were commenced after primaries had erupted from their sheaths and were taken along the natural curve of the wing. Measurements were made daily (less frequently in older chicks) at about the same time, until the chicks fledged or disappeared. Observations were made on body pterylosis.

Records were kept of regurgitations of chicks, food found at the nests, and pellets found on visits to the study areas.

Eight nests were collected in early July, frozen, and later thawed and weighed.[5] The materials used in nest-building were identified.

A number of gonads were obtained from gulls taken in the summers of 1966 to 1968 during the course of a parasite study (Threlfall, 1968a, b.). Gonads were frozen and later thawed and weighed.

---

[4]Ohaus model 8011, 250 g capacity, or Ohaus model 8014, 2000 g capacity, accurate to ± 10 g.

[5]Fisher direct reading balance, 4500 g capacity.

Figure 1

Location of Gull Island, and surrounding sea bottom contours. Square on the map of Newfoundland shows the area of inset map. A dash alternating with 2 dots indicates 20 fathoms, (36.6 m); a dash alternating with 5 dots indicates 50 fathoms (91.5 m).

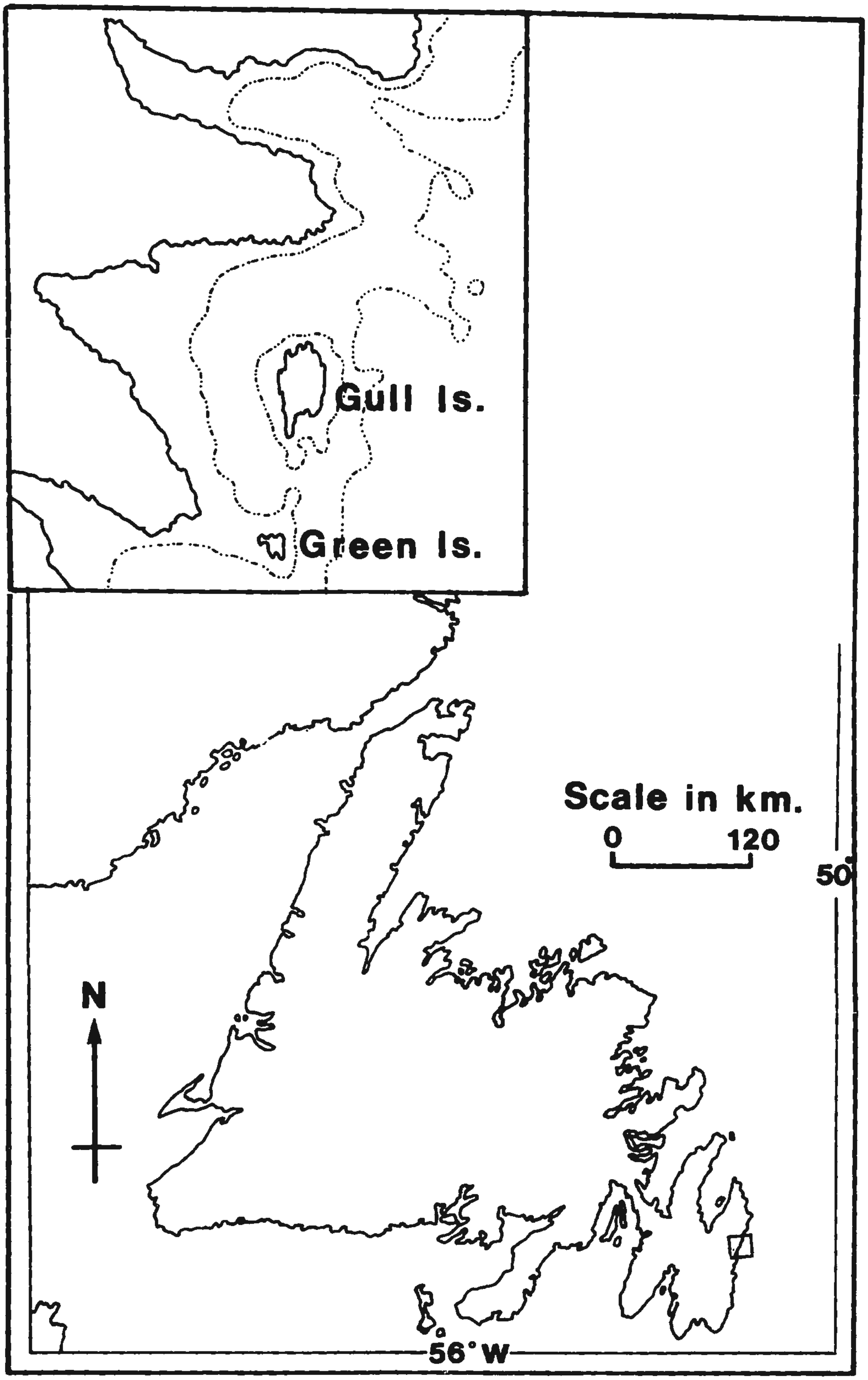

Gull Is.
Green Is.
Scale in km.
0
120
50°
N
56° W

Figure 2

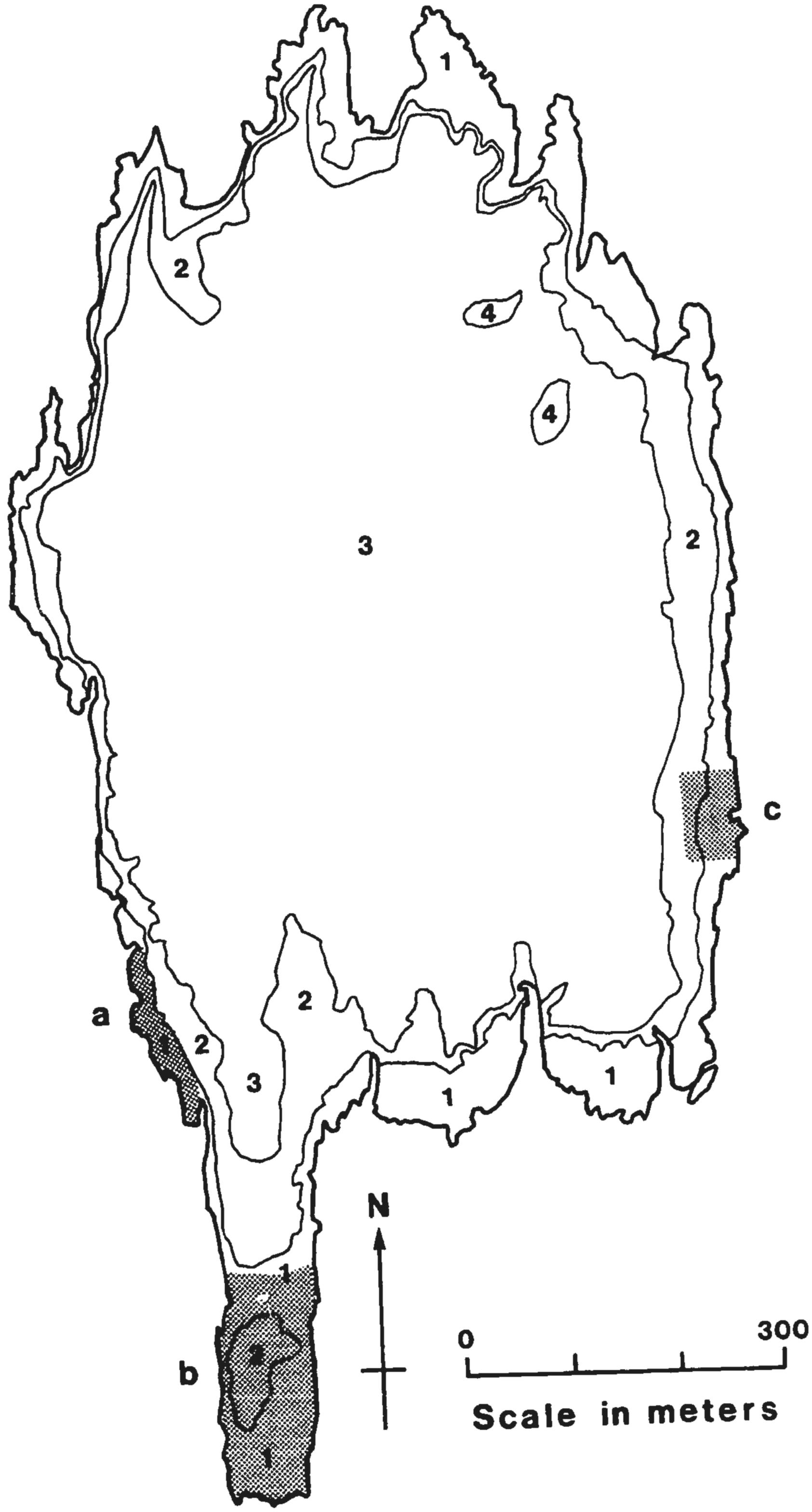
Gull Island, showing vegetation zones and gull study areas.

Vegetation:

1. exposed rock with lichens
2. grass and exposed peat
3. forest
4. open-water bogs

Gull Study areas

a. Predation Nest area
b. the Point
c. the East Side Square



1
2
4
4
3
2
c
a
2
2
3
1
1
N
1
0
300
b
2
1
Scale in meters

Figure 3

Measurements taken on herring gull embryos.

A head length

B head width

C culmen

D eye diameter

E shoulder to tail length

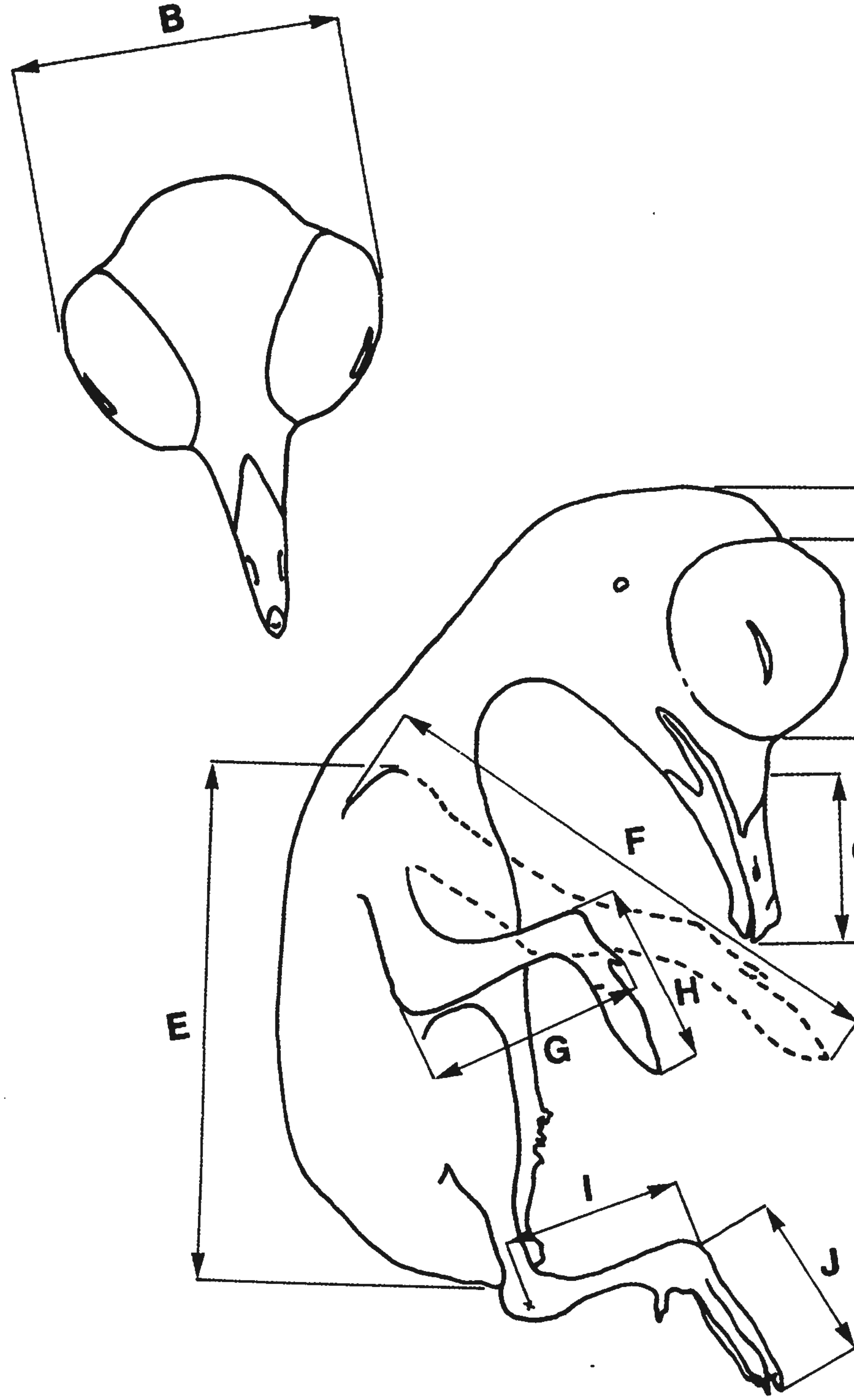
F arm length

G forearm

H hand

I tarsus

J middle toe


B
A
D
C
E
F
H
G
I
J

RESULTS AND DISCUSSION

Topography

Gull Island lies at 47°15'N., 52°46'W., 2 km off the coast of the Avalon Peninsula, approximately 27 km south of St. John's, Newfoundland. It is the northernmost of the 3 islands (Gull, Green, and Great Islands) which comprise the Witless Bay Sea-bird Sanctuary (Fig. 1). Heavily wooded, with a perimeter of grass and rock, its maximum width is 800 m, and maximum length is 1600 m. The longitudinal axis of the island lies in a true north-south direction.

The east coast of the Avalon Peninsula is formed of strongly folded sandstone and conglomerate of late Proterozoic or early Cambrian age (Rose, 1952). Easterly tending bays and inlets have been glaciated across these beds in Quaternary times. Contours of the sea bottom surrounding Gull Island are shown in Figure 1. The bedrock of Gull Is. is medium fine grained red sandstone of the Signal Hill Formation. The strike of the beds is in a true north-south direction, parallel to the long axis of the island, and they dip towards the east at 50 - 55°. The incline of the strata has given rise on the eastward-facing exposures to relatively smooth cliffs lying to a large extent along the bedding planes (Fig. 4, a), and on western exposures, to broken, overhanging cliffs with numerous ledges (Fig. 10, c & d). The north and south coastlines are indented with long narrow coves roughly parallel to the direction of the strata.

The maximum height of cliffs on Gull Island is 35 m, but much of the western coastline lacks cliffs being much less precipitous than the deeply incised north and south ends, and the east side. The relief of the central portion of the island is generally gently sloping toward the south.

A north-south ridge extends along either side, the eastern one attaining an elevation of 69 m.

The southernmost tip of the island, the Point (maximum elevation 22 m), is almost separated from the rest of the island by a depression which attains a maximum height of only 9 m above sea level (Fig. 4, a).

Climate

The cold waters of the Labrador Current exert a moderating influence on both summer and winter temperatures of the Avalon Peninsula. Winter minimum temperatures seldom drop below -18°C, but the cold waters and sea ice retard warming in spring. Summers are brief and without extreme heat, temperatures reaching a maximum of about 27°C. The mean annual frost-free period at St. John's Airport Weather Office, Torbay (37 km north of Gull Island), is 125 days. Annual precipitation is 152 cm (60 inches) and is distributed fairly evenly throughout the year. The frequent occurrence of fog in coastal areas during the spring and summer also contributes to their low summer temperatures (Hare, 1952).

Wind is a constant feature of the environment: long-term records (1942-1969) of the Torbay weather office indicate an average windspeed of 15.4 mph. Winter winds are particularly strong. The area lies on the winter storm track, with heavy precipitation and high seas accompanying the periods of strong winds: in Jan. 1969, gusts of 80 mph and sustained winds of 55 mph were recorded.

In summer, the prevailing wind direction is southwest: in winter it is generally westerly but more variable.

Windspeeds at Torbay Airport and Gull Island were probably similar, due to the exposed, coastal nature of both locations. However the summer temperatures on Gull Island tended to be slightly lower (Table 1), probably due to the cooling influence of the surrounding ocean, and the greater incidence of fog: frequently the island was fog-shrouded while the sun shone on the adjacent headlands of Witless Bay.

Vegetation

The vegetation of the island can be subdivided into four zones (Fig. 2). Immediately above high tide line there is an area of rock, around the perimeter of the island. This area is for the most part devoid of vegetation, except for lichens (*Xanthoria parietina* and *Haematomma* sp.); where there is a constant trickle of run-off water, the green alga *Prasiola crispa* forms a layer over the rocks.

The zone above the rock is characterized by grassy slopes ("Puffin Slopes", Maunder & Threlfall, 1972) and meadows, exposed peat, and outcropping boulders. Grasses, especially *Festuca rubra,* cover the greater part of this area. *Deschampsia flexuosa* is found near sheltering vegetation such as dead trees or shrubs and aggregations of *Rubus idaeus* (red raspberry). On the Puffin Slopes (Fig. 10, c), sorrels (*Rumex Acetosella* and *R. Acetosa*) grow in

Table 1

Summer Temperatures on Gull Island and at St. John's Airport

Month	Year		Temperature °C. Gull Island	Temperature °C. St. John's Airport
May	1969	Mean	5.8	5.0
		Mean min.-mean max.	2.4-9.2	2.3-7.8
	1970	Mean	6.3	7.1
		Mean min.-mean max.	1.4-11.1	1.9-12.3
	1971	Mean	8.2	11.0
		Mean min.-mean max.	4.7-11.7	6.1-15.9
June	1969	Mean	11.1	12.5
		Mean min.-mean max.	6.7-15.8	7.2-17.5
	1970	Mean	10.2	11.7
		Mean min.-mean max.	5.6-14.7	6.3-17.0
	1971	Mean	10.8	11.9
		Mean min.-mean max.	5.8-16.1	6.1-17.8
July	1969	Mean	13.3	13.6
		Mean min.-mean max.	9.2-17.2	9.4-17.5
	1970	Mean	14.2	15.5
		Mean min.-mean max.	9.7-18.3	10.0-20.8
	1971	Mean	15.0	16.1
		Mean min.-mean max.	9.9-20.0	10.3-21.9

association with the grasses.

The soft peat soil of this zone is riddled with puffin, and to a lesser extent, petrel burrows, which undermine the stability of the turf. During periods of heavy rains, washouts frequently occur. Large areas of exposed peat on the east and south sides provide testimony to past erosion: in Peat Valley (Fig. 12), little recolonization of the soil by plants is taking place, but on a large exposed area on the east side (Fig. 4, b), *Stellaria media* (common chickweed), was observed apparently growing actively in October 1970, covering a slope that was bare in May. Turf at the tops of the coves is continually being undercut and slipping into the sea, or onto the strewn boulders below. Subsidence and headwall scars are evident at the top of some coves

Waves wash over the lowest area of the point every winter. On the Point, a region bared by high seas during a particularly violent winter storm in 1967 is gradually being covered by vegetation (Fig. 1, c and d). The main colonizing species in this case are *Festuca rubra* and *Stellaria media.* These and others (*Polygonum, Juncus bufonius, Plantago* & *Ligusticum scothicum*) are encroaching in cracks in the rock area, and on rocks partly covered with *Prasiola crispa.*

The third zone is forested and covers the largest area of the island. The most abundant tree species is *Abies balsamea* (balsam fir), which occurs throughout the zone. Dead and stunted specimens stand along the edges of the wooded area on the east and south sides of the island (Fig. 5, b). *Picea glauca* (white spruce) is fairly common on the south end of the island. *Acer spicatum* (mountain maple), *Betula* *papyrifera* (silver or white birch), *Pyrus americana* (dogberry or mountain ash) and *Alnus crispa* (mountain alder) are found in open thickets.

The understory in these areas consists of a dense covering of *Dryopteris spinulosa* (wood fern), *Ribes glandulosum* (skunkcurrant) and seedlings of the deciduous trees and shrubs, while the understory of the closed *Abies* forest is sparse, except for mosses (*Mnium* spp., and *Polytrichum* spp.) and small flowering plants (*Cornus canadensis* and *Trientalis borealis*), these latter being especially abundant where the canopy is less dense. Each winter, several large *Abies* trees are blown over and uprooted, creating openings for deciduous growth.

On the west side, large trees occur up to and overhanging the edge of a steep grassy slope near the edge of the island. Trees at this edge are undermined when the soil is leached away from their roots during periods of rain, and the vegetation here is slowly but continuously sliding downslope.

Lichens such as *Usnea* spp., *Ramalina* spp., and *Parmelia* spp., occur with great frequency on trees in the more open woods (Fig. 5, c, d). The filaments of *Usnea* in some instances attain a length of 1.5 m, while in nearby areas on the Avalon Peninsula, lichens are less varied and abundant, the usual maximum length of *Usnea* strands being approximately 0.5 m. The vigour of the lichens on the island may be the result of the damp foggy climate, and manuring by birds such as herring gulls, which roost in the trees and soar over the forest.

The fourth zone consists of small bogs, characterized by

Figure 4

Vegetation and topography

a. the Point, (middle ground) as seen from the south-east extremity of Gull Island.

b. area of a large washout on the east side.

c. looking south on the Point in 1967. A storm the previous winter had washed away most of the vegetation. (Photo by W. Threlfall).

d. same area as c., showing the greater extent of vegetation in 1970 (October).


a
b
c
d

Figure 5

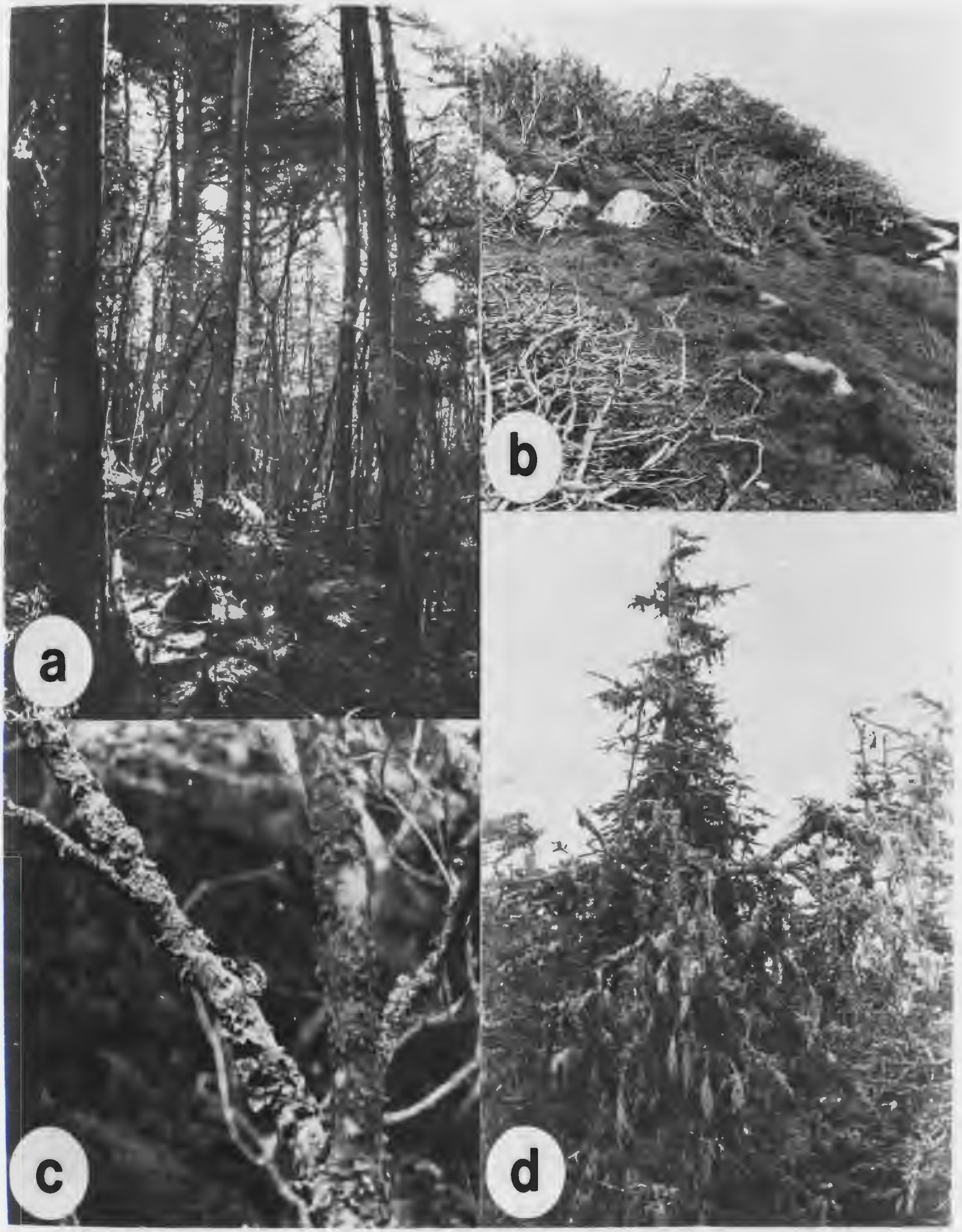
Vegetation of Gull Island

a. moderately open spruce-fir forest with some fallen trees, on the west side.

b. stunted dead fir trees on the east side of the Base of the Point.

c. Lichen (*Lobaria* sp.) on a living maple tree, in open west side woods.

d. Lichen (*Usnea* sp.) on a living fir tree in open west side woods.


a
b
c
d

some open water, *Sphagnum* sp., *Myrica Gale*, *Vaccinium Oxycoccus* (marshberry or small cranberry) *Kalmia polyfolia* and *K. angustifolia* (laurels), *Ledum groenlandicum* (Labrador tea), *Carex* spp. (sedges), *Calamagrostis inexpansa* and other grasses, and *Larix laricina* (tamarack). In the surrounding area *Osmunda cinnamomea* (cinnamon ferns) predominate; the bogs are drained by small intermittent streams which are also bordered with this species.

A systematic list of all plant species found on Gull Island is presented in Appendix I.

The development of vegetation in spring was quite uniform from year to year. By mid-May, *Ribes* leaves were fully developed, but *Dryopteris* (fiddleheads) were less than 3" high: its fronds were not fully extended until 9 to 15 June. *Cornus canadensis* leaves were unfolding by 30 May and flowering began 9 June. *Trientalis borealis*, *Ledum groenlandicum*, *Festuca rubra*, and *Rumex Acetosella* began flowering about 16 June. Leaves of *Acer spicatum*, *Alnus*, and *Pyrus* developed between 5 and 16 June. Comparison of the dates of flowering and development of vegetation with May and June temperatures on the island (1969 to 1971) failed to reveal any correlation.

Terrestrial Birds

During the summers of 1969 to 1971, 40 species of terrestrial birds were seen on Gull Island (Appendix 2). During 1967 and 1968, only 15 species were seen, probably because observations were made on fewer days during these years.

Three species of land birds are particularly abundant on Gull

Island, namely the northern waterthrush (*Seiurus noveboracensis*), the fox sparrow (*Passerella iliaca*), and the boreal or brown-capped chickadee (*Parus hudsonicus*). Nests and young of the former two species have been found, and very probably the boreal chickadee also breeds on the island as its constant presence in large numbers in habitat similar to its breeding locations on the adjacent Avalon Peninsula suggests. All three species are found throughout the wooded parts of the island.

Other breeders are less in evidence due to their smaller numbers or inconspicuous habits. Juvenile robins (*Turdus migratorius*), gray-cheeked and olive-backed thrushes (*Hylocichla minima* and *H. ustulata*) were seen with plumage (tail feathers) not sufficiently developed for long flights over open water. A pair of ravens (*Corvus corax*) nested on a cliff in one of the southern coves in 1968 and on a different cliff in 1972 (W. Threlfall, pers. comm.).

Some species for which there was no direct evidence of breeding were seen consistently and in numbers sufficient to suggest breeding. Golden-crowned kinglets (*Regulus satrapa*) were regularly seen in 1970 and 1971, and a case of courtship feeding was observed. (Ruby-crowned kinglets (*R. calendula*) were also seen, but only sporadically in any given year). Wrens (*Troglodytes troglodytes*) sang each morning from certain fixed locations until late July. Savannah sparrows (*Passerculus sandwichensis*) frequented grassy headlands (for instance the Base of the Point), their preferred summer habitat (Tuck, 1967). The number of observations (Appendix 2) give a minimum estimate of their abundance, for they frequented areas exposed to reconnoitering gulls (*Larus argentatus* and *L. marinus*) and were extremely wary and difficult to observe. The brown creeper (*Certhia familiaris*), and mourning and black-polled warblers (*Oporornis philadelphia* and *Dendroica striata*) were seen in each month. A mourning warbler sang from a certain tree each morning; as this species breeds on Great Island, 7½ km south south west of Gull Island (L. M. Tuck, pers. comm.), it is reasonable to suspect it breeds here.

The return of migratory birds to the area or site occupied during the preceding summer may be taken as evidence of breeding (Welty, 1962, pp. 225-227). During the course of a blood parasite study (W. Threlfall, pers. comm.), 158 passerine birds were caught in mist nets and banded. Recaptured birds were found in the net of their original capture, or one next to it, a distance of less than 50 m from the site of banding (Table 2). From this evidence, it appears that the blackpoll warbler and the pine grosbeak (*Pinicola enucleator*) breed here.

Yellow warblers (*Dendroica petechia*) were seen in small alder thickets, and other deciduous growth, in openings in the west side woods, a habitat similar to that in which they abound on the adjacent mainland, but which is restricted to the areas of windfalls on Gull Island.

Juncos (*Junco hyemalis*), swamp sparrows (*Melospiza georgiana*), rusty blackbirds (*Euphagus carolinus*) and white throated sparrows (*Zonotrichia albicollis*) are characteristic of cultivated areas, second growth deciduous vegetation, or wet areas on the adjacent Avalon Peninsula. Swamp, open fresh water and second growth woodland

Figure 6

Distribution of sightings of robin and gray-cheeked thrush, 1970 and 1971.


Robin
1
> 5
Gray-cheeked
Thrush
1
> 5

Table 2

Recoveries of Passerine Birds Banded on Gull Island, 1970 and 1971

Species	Same Year			Following Year	
	Number Banded	Number of Individuals Recovered	Total Number of Recoveries	Number of Individuals Recovered	Total Number of Recoveries
Turdus migratorius	5	1	3	0	0
Hylocichla minima	9	1	1	2	2
Dendroica striata	2	0	0	1	1
Seiurus noveboracensis	46	11	13	5	12
Pinicola enucleator	3	0	0	1	2
Passerella iliaca	80	19	23	10	17

habitats are much restricted on Gull Island and these species have probably failed to become established on the island due to a scarcity of suitable habitat.

Birds which are uncommon summer residents or locally distributed in Newfoundland are casual visitors on Gull Island (the red breasted nuthatch, *Sitta canadensis;* the yellow bellied sapsucker, *Sphyrapicus varius;* and the purple finch,*Carpodacus varius*). Others may occur in migration (the myrtle warbler, *Dendroica coronata*), or may be blown off corse as drift-migrants (Tuck, 1967, 1971a): the barn swallow (*Hirundo rustica*) has occasionally been seen in the area, whilst the wheatear (*Oenanthe oenanthe*) has been definitely recorded only twice in Newfoundland (L. M. Tuck, pers. comm.).

Some species were less frequently seen than might be expected. The water pipit (*Anthus spinoletta*) a common breeder on grassy headlands (Tuck, 1967) and seen on the headland bounding the north side of Witless Bay wase rarely seen on Gull Island. The black-capped chickadee, the olive-backed thrush, and the ruby-crowned kinglet were rarely found on Gull Island, where their congenors were common, whilst on the adjacent Avalon Peninsula all these species are common. Of the three species of thrushes (*Turdidae*) both the robin and gray-checked thrush were common, while the olive-backed thrush was less frequently seen (Appendix 2). Robins were observed on and near open grassy areas, and very frequently, near clearings with deciduous shrubs in the forest. Gray-cheeked thrushes were seen in similar areas but also deeper in the forest, their ranges overlapping (Fig. 6). According to Godfrey (1966), grassy areas and open and broken woodlands, and second growth forests are favored breeding habitats of robins, while the gray-cheeked thrush prefers dense and stunted coniferous forests. On Gull Island no such distinct segregation exists. Morse (1971) found that habitat utilization by two species of thrush was expanded in the absence of a third species, and that when the third species arrived, each was more specific in its habitat utilization. Islands, being characterized by fewer species than a comparable mainland area, are also subject to niche expansion by bird species that breed there (Lack, 1969a, b). It is possible that the relative scarcity of the olive-backed thrush, and the island location, have contributed to a habitat expansion of robin and gray-cheeked thrush. Thus the terrestrial avifauna is less complex than that of adjoining mainland areas, a situation due rather to lack of complexity of habitat and possibly superior adaptations of the first colonists, than infrequency of invasions (Lack, 1969b).

Aquatic and Shore birds

All the aquatic and shore birds seen on or near Gull Island during this study are listed in Appendix 3. Nine species are regular breeders, and at least five more breed in the area. The eider (*Somateria mollissima*) and harlequin duck (*Histrionicus histrionicus*) are winter residents and typically much less common in summer, the dovekie (*Plautus alle*) arrives from the north in October and stays until May and is only rarely observed during summer (Peters & Burleigh, 1951).

The glaucous gull (*Larus hyperboreus*) is a winter resident and a rare visitant in summer (Peters & Burleigh, 1951). It breeds in the arctic islands and northern Labrador (Godfrey, 1966). Both records near Gull Island were immature birds in white plumage.

The black-headed gull (*Larus ridibundus*) is an Old World species which has in the past 10 years become a familiar part of the winter avifauna in Newfoundland and has been recorded in every month of the year (Tuck, 1971a). Birds have been seen in breeding plumage and Tuck (1971a) anticipates reports of breeding in the new world. The bird seen on Gull Island, in breeding plumage, was flying about an eastward-facing cliff occupied by nesting kittiwakes.

Species seen during their migration include the harlequin duck, black duck (*Anas rubripes*), and semi-palmated sandpiper (*Ereunetes pusillus*) (Godfrey, 1966). The common loon (*Gavia immer*) migrates along the coast before settling on inland lakes for breeding, and possibly the individual seen was in migration.

A number of pelagic sea-birds summer in the Newfoundland and Grand Banks area where they find abundant food resources (Brown, 1968; Templeman, 1966) though they do not breed here. The fulmar (*Fulmarus glacialis*) is present in large numbers on the Banks until the ice disappears in August (Fisher, 1952a), yet generally it stays so far from land that it is unknown to local fishermen. Two individuals were seen on a foggy day, devouring the carcass of a kittiwake (*Rissa tridactyla*). Sightings of other pelagic species were also made during periods of foggy weather. Greater, sooty, and Manx shearwaters (*Puffinus gravis, P. griseus,* and *P. puffinus*) were seen under such conditions. These species, especially the former, are very common on the Banks but are more frequently seen inshore than the fulmar. Both species of sea-going phalaropes (*Phalaropus fulicarius* and *Lobipes lobatus*) were seen on Witless Bay, during and after periods of strong winds.

A few of the species seen were probably blown off course or transported by storms far from their normal range. The American egret (*Casmerodius albus*) breeds inland, southward from the extreme southermost tip of Canada (Godfrey, 1966) and has occasionally wandered to Newfoundland, usually in the autumn (October & November) (L. M. Tuck, pers. comm.). The black tern (*Chilidonias niger*) breeds as far north as New Brunswick. It is a rare transient in Prince Edward Island and Nova Scotia (Godfrey, 1966), but has been previously recorded only twice in Newfoundland (Tuck, 1967). No previous Newfoundland record exists of the lesser black-backed gull (*Larus fuscus*), a European breeder which has been seen at least five times on the Eastern Seaboard of North America (Finch, 1972). Brown (1968) observed lesser black-backs at sea, between Greenland and Newfoundland, and postulated that the species may have recently extended its range by beginning to breed in Greenland.

Of the other species mentioned in Appendix 3, the common loon, the black duck, and the greater yellowlegs (*Totanus melanoleucus*) normally breed in Newfoundland (Peters and Burleigh, 1951; Godfrey, 1966). White-winged scoters (*Melanitta deglandi*) are constant summer residents of Witless Bay, numbering usually about a dozen individuals (W. White, pers. comm.).

Five marine species known to breed on the Avalon Peninsula, or less than 140 km from Gull Island, are the gannet (*Morus bassanus*), the double-crested cormorant (*Phalacrocorax auritus*), the common and arctic terns (*Sterna hirundo* and *S. paradisaea*), and the thick-billed murre (*Uria lomvia*). Thick-billed murres were seen daily (Appendix 3), due to the proximity of a breeding colony on Green Island of (almost) 3000 individuals (L. M. Tuck, pers. comm.). On one occasion (20 July 1970), a thick-billed murre was observed sitting on the nesting ledges of the common murre (*Uria aalge*) on Gull Island, among members of this species. Terns were seen during May, June and July hovering over the island, or fishing near Witless Bay wharf. Their occurrence coincides with the presence of capelin (*Mallotus villosus*) in the bay. Tern breeding activities probably are not over by the end of July (Bent, 1921).

Gannets breed at 3 stations in Newfoundland, Funk Island, Baccalieu Island and Cape St. Mary's (approximately 280,100, and 180 km by sea from Gull Island). Gannets are offshore feeders and may travel up to several hundred km a day in search of food (Nelson, 1966), a fact which may account for them being seen at all, though rarely, near Gull Island. Two of the birds were in subadult plumage. Double crested cormorants breed at Cape Ballard, only 64 km south of Gull Island, on the Avalon Peninsula (Tuck, pers. comm.). However they do not range as far as the gannets while feeding. Cormorants were seen in groups of 30 birds or more, presumably about the time of migration (May, August and October) (Bent, 1922; Peters and Burleigh, 1951). The larger groups could not be approached closely enough to determine their species. Three individual birds seen from about 10 m were great cormorants (*Phalacrocorax carbo* L.), which do not breed closer than the west and south-west coast of Newfoundland (Tuck, 1967). Thus the flocks resting on the island may have been either species.

The species of marine and shore birds which breed regularly on Gull Island are the Leach's petrel *(Oceanodroma leucorhoa)*, the spotted sandpiper *(Actitus macularia)*, the great black-backed gull and the herring gull *(Larus marinus* and *L. argentatus)*, the black-legged kittiwake *(Rissa tridactyla)*, the razorbill *(Alca torda)*, the common murre *(Uria aalge)*, the black guillemot *(Cepphus grylle)*, and the common puffin *(Fratercula arctica)*. Each species will be discussed separately. The *Larus* gulls, which were the subject of a special study on breeding biology, will be treated last.

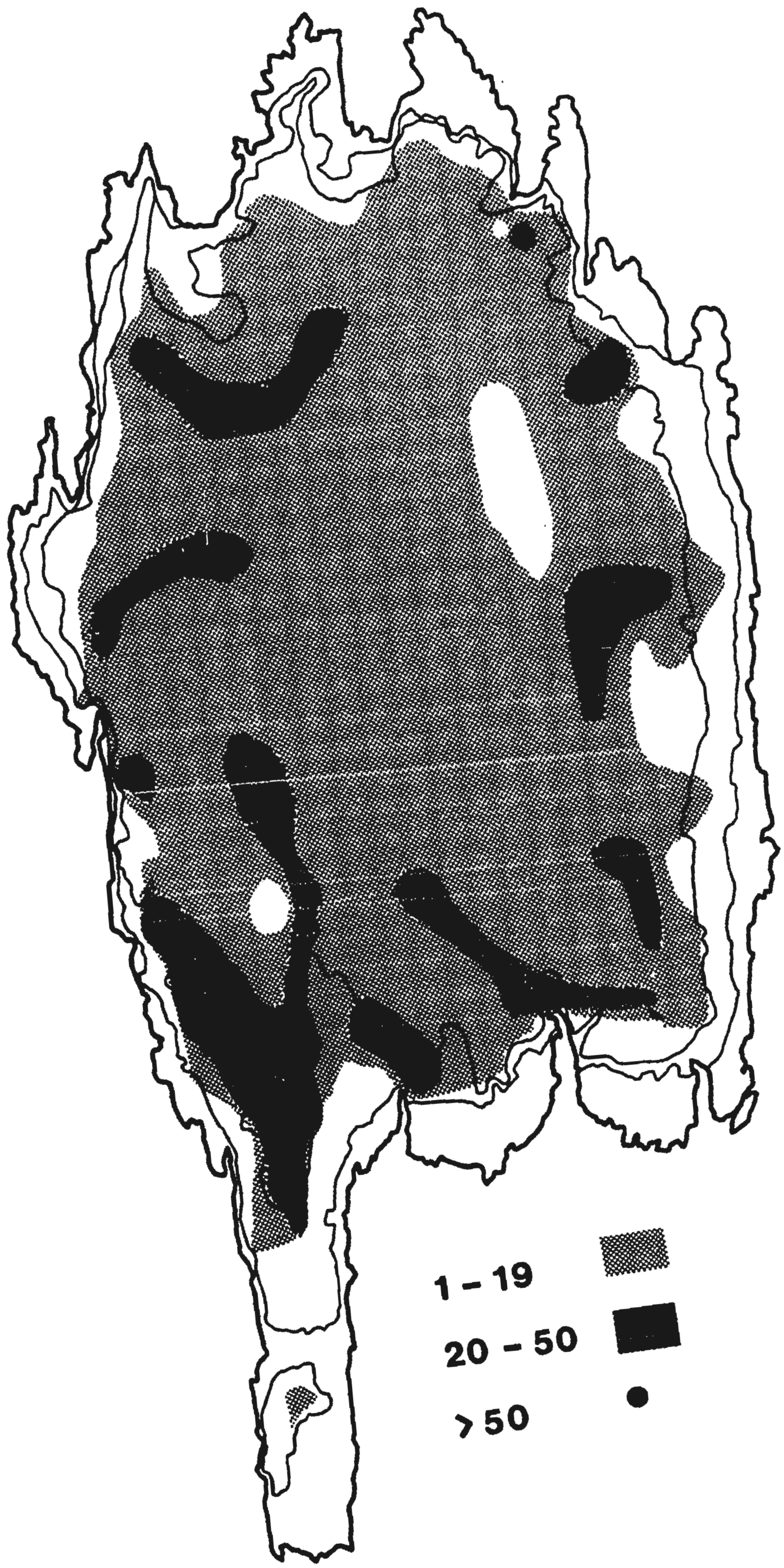
Leach's petrel, *Oceanodroma leucorhoa*

In the north Atlantic, Leach's petrels are found along the coasts of the British Isles, the Faeroes, Iceland, Southern Labrador, and Newfoundland, and at scattered colonies south to Massachusetts, usually nesting in dense colonies on coastal islands (Voous, 1960; Palmer, 1962). Less than 40 years ago the Newfoundland colonies were practically unknown in the scientific literature (Ainslie and Atkinson, 1937, Templeman, 1945), and Peters and Burleigh (1951) estimated the total breeding population at 22 Newfoundland colonies in 1942 to 1945, at only 13,000 pairs, the colonies being larger and more numerous on the east coast. They estimated the population on Gull Island in 1942, to be 500 pairs; however they did not land on this island (Tuck, pers. comm.). Huntington (1963), by counting occupied burrows in seven 3 m - square plots, made an extrapolated estimate

Figure 7

Density of Petrel Burrows

Number of openings per 4 meter square


1 – 19
20 – 50
> 50

that in 1960, 400,000 pairs of petrels occupied the Gull Island colony.

A census taken in 1969 using 4 m - square plots all over the island, estimated the number of petrel burrows at 625,000. Of these 75 per cent (Huntington, 1963) or almost 500,000 are probably occupied. Tuck (pers. comm.) estimated that at least 3 million petrels now occupy 4 of Newfoundland's large colonies (Gull Island, Great Island, Baccalieu Island and Wadham Islands).

It seems doubtful that such a drastic increase in petrel numbers would have occurred between 1942 and 1960, while during the subsequent 9 years there was little increase. Peters and Burleigh's figure was undoubtedly an underestimate. However, the petrel population may be approaching its limit on Gull Island. Eggs were occasionally seen above ground, a phenomenon which may be indicative of crowded conditions for burrow-nesting procellariiforms (Huntington, 1963; Rowan, 1965). Also two burrows which contained eggs were marked May 29 (1970). When checked later both eggs were gone, but on June 25 both burrows again had an egg. Unless the petrels laid a second clutch, which could be the case (Wilbur, 1969), the burrows may have been deserted and soon afterwards reoccupied; this might indicate crowded conditions in part of the colony. Although not all the burrows were occupied, it seems that most of the areas available to petrels were in use, some intensively, only the open grassy or peat areas and very wet places being avoided (Figure 7).

While the petrel population has increased to a high level on Gull Island, in the southerly North American colonies (Kent Island, Bay of Fundy, Grand Manan archipelago, and Maine), populations are decreasing, principally as a result of predation by mammals introduced by man (Gross,1935), and increased numbers of herring gulls and great black-backed gulls. A change in food availability may also be a factor (Huntington, 1963).

Banding returns on Kent Island showed that although a high percentage of breeders return to the area of the burrow previously occupied (50-70 per cent), only 0.5 per cent of the nestlings are ever encountered again (Huntington, 1963). Since the Gull Island colony and some other Newfoundland colonies are of an unprecedented size in the entire North Atlantic, Huntington suggests that they exert a tremendous influence on other colonies by supplying them with first-time breeders.

Petrel burrows are distributed all over Gull Island wherever there is organic soil, with the exception of wet areas and recent washouts (Fig. 7). Petrels sometimes nest in areas which later become flooded; at this time the nests appear to have been abandoned. Burrows often wind under rocks or tree roots and are usually horizontal or slope slightly downward from the entrance. In sloping areas the resultant depth of the nest is as much as 45 cm, while on level ground it is a little as 10 cm. In grassy areas where there are puffin burrows, the petrel burrows often open into the entrances of these; the petrels thus avoid the necessity for penetrating the dense roots of the grass.

Petrels were heard underground on the island when observations began in mid-May. The first egg observed was seen above ground on 5 June 1969. Two fresh eggs were found on 17 July 1971. Evidence of hatching (egg-shells at a burrow mouth and a small chick inside) was first observed on 13 July 1969. By 18 July 1971 there were both large and newly hatched young. Chicks were still hatching on 4 August 1969. On 23 October 1970, many young petrels were still in their burrows, fully feathered though retaining some down on the nape and flanks (Figure 10,a). One was seen walking above ground. At this time a great number of petrel remains and gull pellets were seen. Some burrows in the woods, where the forest floor lacked vegetation, had been dug open. Bent (1922:144) reported a "Northwest crow" digging open a petrel burrow. On Gull Island the digging could have been the work of crows *(Corvus brachyrhynchos)*, ravens, or *Larus* gulls.

Spotted sandpiper, *Actitus macularia*

The spotted sandpiper is a common breeder all across Canada south of the tree line (Godfrey, 1966) and is an abundant summer resident of Newfoundland, where it breeds along streams, ponds and coasts (Peters and Burleigh, 1951). On Gull Island, observations of spotted sandpipers were concentrated at a few specific locations on the south and west sides (Figure 8). The nest near the north end was found among *Ribes-Dryopteris* understory, 15 m from the shore, near the edge of the fir forest. It was constructed of *Dryopteris* fronds and fir needles, and contained four eggs (a complete clutch) when found on 22 June 1970. These eggs had hairline fractures on 9 July. Thus if the incubation period is 20 to 22 days (Godfrey, 1966) and if incubation began immediately, the clutch would have been completed between 18 and 20 June 1970. Downy chicks were seen on 30 June 1969.

Tuck (pers. comm.) found the date of clutch completion in 31 spotted sandpiper nests ranged from 13 June to 29 July, the first chicks hatching on 28 June. The average hatching date of first chicks was 7 July.

The nest found on the west side of Gull Island contained no eggs on 2 June 1970, and was not subsequently located, though a pair of sandpipers invariably flushed from the area when disturbed. Thus it was inferred that a pair might be nesting here. In at least three other locations, a pair of adults were regularly seen calling and flying about as the area was approached. Therefore probably 3 to 5 pairs nested on the island. The largest numbers seen on a single day were 20 and 30 (14 and 25 August, 1970). These may have been adults and young of the year from Gull Island, or birds on migration.

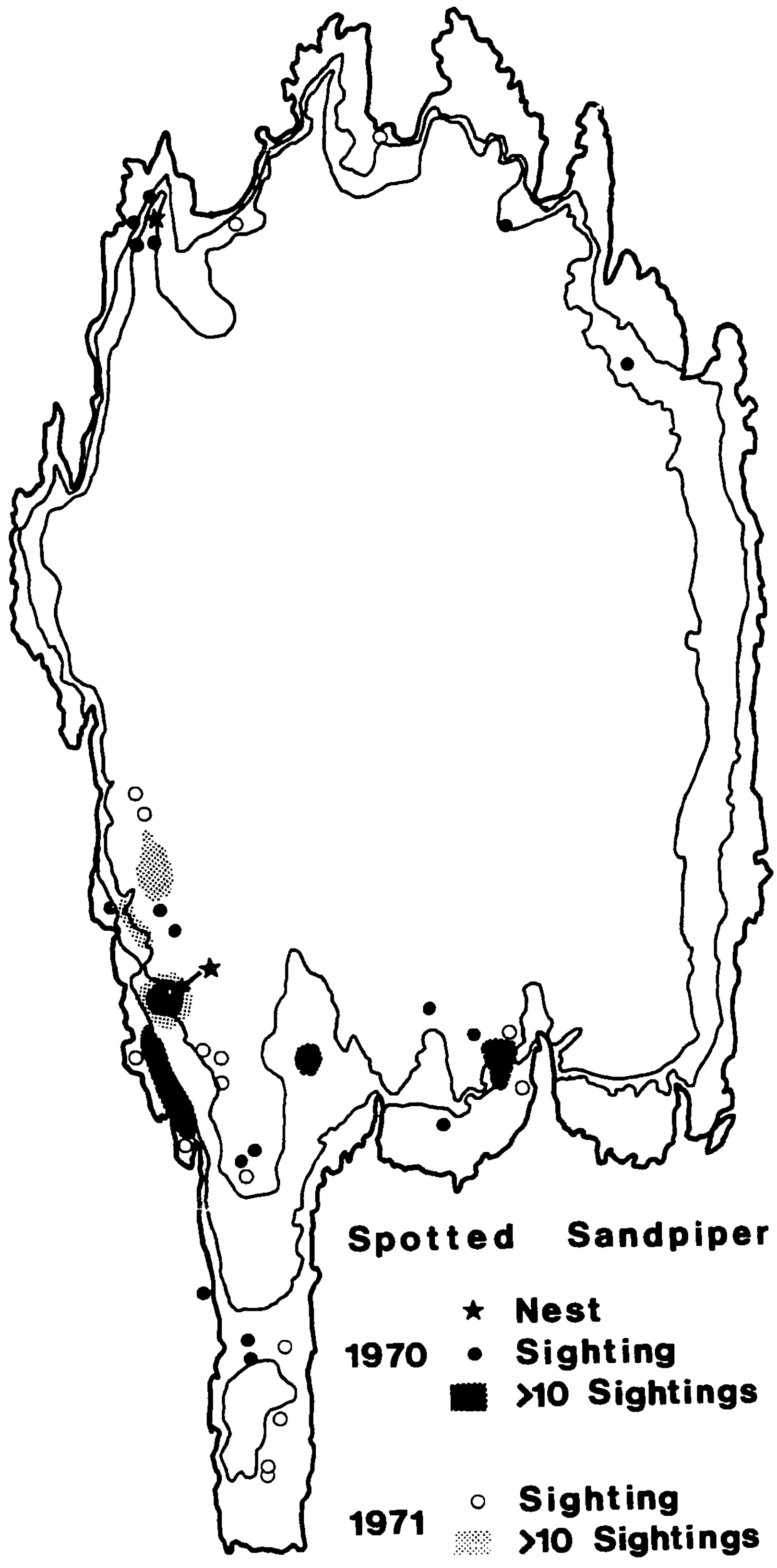
Razorbill, *Alca torda*

The razorbill is one of the subarctic to temperate group of alcids, together with the common murre and common puffin (Dement'ev *et al.*, 1951). It is found in the Atlantic Ocean and the adjoining waters of the Davis Strait and Arctic Ocean (Voous, 1960). On the North American side it breeds from the Gulf of St. Lawrence to Northern Labrador, with a northerly outpost on Baffin Island. The species also breeds on the west coast of Greenland (Bédard, 1969), a region warmed by the west Greenland current.

Peters and Burleigh (1951) found only six colonies in Newfoundland in the early 1940's. In 1959, about ten pairs bred on Gull Island (Tuck, pers. comm.).

Figure 8

Sightings and nests of spotted sandpipers, 1970 and 1971.


Spotted Sandpiper
★ Nest
1970 • Sighting
>10 Sightings
1971 ○ Sighting
>10 Sightings

In 1969, 39 or 40 pairs nested on Gull Island, 47 pairs nested in 1970, and at least 37 in 1971. Figure 9 shows the locations of nests found in 1971. The decrease in numbers of nests in 1971 is possibly due to a lack of time available for the observations necessary to locate nests in inacessible areas, as much as to a decrease in the number of birds. In two of the three accessible locations, the numbers of nests had increased from that of the previous years; and there was no noticeable change in numbers wherever the birds could be frequently observed during the course of other work.

Bédard (1969), estimating that there were 50,000 to 100,000 razorbills nesting in the western sector of the North Atlantic, suggested that competition with rapidly increasing murre populations where the two species nested in mixed colonies, might result in decreases in razorbill numbers, as it has in the Northeastern Atlantic (Belopol'skii, 1957). There was no evidence of this competition on Gull Island.

Razorbills generally nested at the same sites from year to year: the locations shown in Fig. 9 were occupied in all 3 years of the study, except for one site, beneath a boulder on the east side of the Point, which was occupied by one pair in 1970, and by two in 1971. Razorbills nest singly or in small groups (two to seven pairs), often among murres, and infrequently in unmixed colonies (Dement'ev, *et al.*, 1951). They are found on less exposed ledges than the common murre, often under overhangs and boulders (Kartaschew, 1960). The overhanging cliffs of the west side of the Point on Gull Island provide many such locations: 17 pairs of razorbills nested here in 1970. A concentration of 9 nests was found on the precipitous sides of the south east cove in 1970. The east side of the island is more exposed with few overhanging cliffs. Eighteen pairs nested here in 1970, in somewhat exposed locations or under loose boulders on the cliff. In contrast to Bédard's (1969) observation, no nest material was used: the egss were laid on bare rock or soil.

Bédard (1969) found egg-laying began in the Gulf of St. Lawrence on 27 May, and Belopol'skii (1957) calculated the average date of first razorbill eggs over a 12-year period on the Seven Islands preserve in Eastern Murman as 29 May. Gull Island razorbills were courting in groups of up to eight individuals in mid-May. The first eggs were seen on 25 May 1969, 4 June 1970, and 29 May 1971. Hatching was first observed on 28 June 1969, 23 June 1970, and 1 July 1971. The incubation period of this species has been quoted as 36 to 37 days (Plumb, 1965; Bédard, 1969), thus the first egg must have been laid at least as early as 18 May 1970.

The first large, fully feathered chick disappeared and presumably fledged on 14 July 1969. In 1970 all the chicks had gone by 29 July.

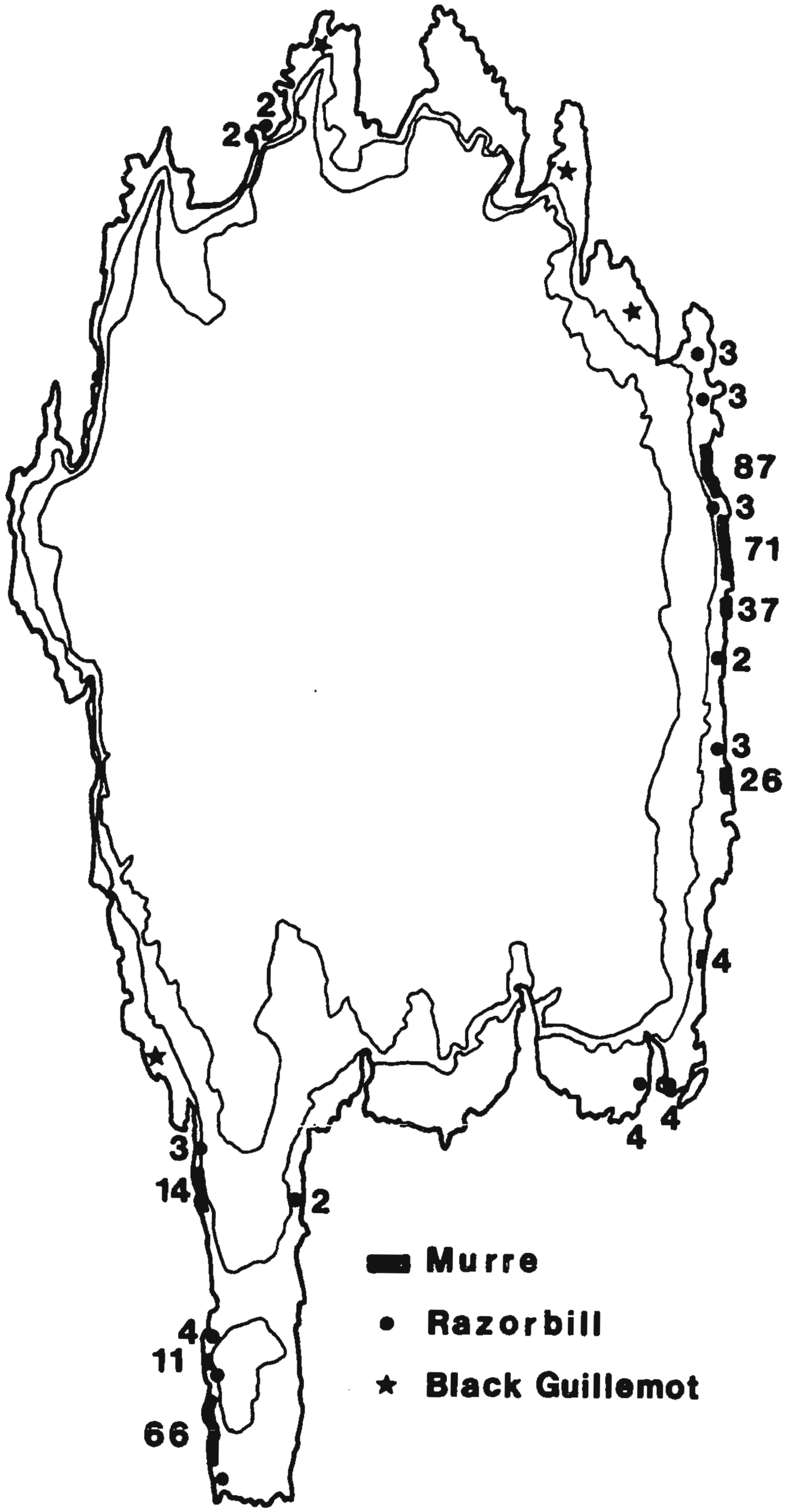
Common murre, *Uria aalge*

In the North Atlantic the common murre breeds in dense colonies from Iceland, Bear Island and Novaya Zemlya, south as far as Bird Rocks near the Magdalen Islands on the Western Atlantic Coast, and as far south as Portugal on the east. The largest colonies occur at the centre of this range: in the northern extremities, relatively few

Figure 9

Nests of Alcids, except Puffins

Number and locations of murres' and razorbills' nests in 1971, and those of black guillemots in 1970.


2
2
3
3
87
3
71
37
2
3
26
4
4
4
3
14
2
4
11
66
Murre
Razorbill
Black Guillemot

individuals are found breeding with extremely large colonies of thick-billed murres (Uspenski, 1956; Belopol'skii, 1957), while in the Gulf of St. Lawrence, the populations remain small, despite legal protection from excessive exploitation which diminished their numbers drastically previous to first quarter of the twentieth century. Changes in the marine environment may be responsible for the continuing low numbers in the Gulf of St. Lawrence (Tuck, 1961:62).

The common murre population of Newfoundland on the other hand has increased at a tremendous rate in the past 20 to 25 years (Tuck, 1967). The species first colonized the Witless Bay Islands (Green Island) about 1936 (Tuck, 1961:59). By 1959 the number of breeding pairs had grown to 50,000, and has since been continuing to increase (Tuck, pers. comm.), though the recently introduced use of gill nets (Tuck, 1971b) and oil pollution (Gillespie, 1968) now threaten the populations.

The colony on Gull Island appears to be still more recent than that of neighbouring Green Island. While Peters and Burleigh (1951) reported 50 pairs breeding on Gull in 1942, Tuck (pers. comm.) saw loitering murres but no eggs or chicks, from 1951 to 1961. In 1962, four or five pairs nested on Gull Island. During recent years, the murre population of Gull Island has increased substantially. One hundred and thirty-six pairs were counted in 1969, 260 in 1970, and 316 in 1971. Though there are seasonal and diurnal rhythms in the number of birds occupying a murre colony (Tuck, 1961:119), eggs, chicks and brooding adults were visible in most locations, and were counted to give a minimum estimate.

All the areas shown in Fig. 9 were occupied by murres in all three years of the study, except for one area on the east side which was newly colonized in 1971 (Fig. 9, the colony of 37 pairs).

Common murres nest on ledges of sea cliffs and on flat outcrops on top of them. Less frequently they nest under overhangs and even under boulders (Belopol'skii, 1957). The single egg is laid on bare rock. On Gull Island the murres were found predominantly on the east side, where there are narrow ledges on rather precipitous cliffs. The west side of the island for the most part lacks cliffs and therefore murres; however there is an increasing colony among the kittiwakes and razorbills on the west side of the Point, on slightly recessed ledges (Fig. 10 c,d). There is some disagreement about the nature or existence of competition for nest sites between murres and kittiwakes: it seems to vary with geographical location (Tuck, 1961: 123). However Maunder (1971) cites an occasion where "in 1970, one area of the large northeastern cliff [on Gull Island] was almost devoid of Kittiwake nests, in the vicinity of a completely new murre concentration of approximately 50 pairs." This area had in the preceding year been occupied by about 200 kittiwake nests. Belopol'skii (1957) found that during the course of colonization, common and thick-billed murres usurped kittiwake nesting area, by actually sitting on kittiwake nests; possibly large numbers of the heavy bodies of rapidly flying murres were discouraging the kittiwakes from nesting among them. A murre egg was found in a kittiwake nest where the two species nest together in close association on Gull Island Point, but no behavioral interactions were noted.

The first murre egg was seen on 30 May 1969 and laying continued until at least 17 July. Tuck (1961) gives the egg date for Newfoundland (Green Island) as 22 May. The process of egg-laying on Gull Island extended well into the hatching period. Some of these late eggs may have been replacements of eggs lost earlier, or the product of inexperienced birds breeding for the first time (Tuck, 1961).

Murre chicks on Gull Island were first seen on 25 June 1969, 23 June 1970, and 19 June 1971. Hatching had begun previous to this date on Green Island, where it was estimated about half the chicks had hatched by 16 June 1970.

Fledgling murres flutter down to the sea, usually in the evening, at 18 to 25 days of age, and thereafter swim directly out to sea with one or more adults (Greenwood, 1964; Tuck, 1961). The first chicks departed from Gull Island between 7 and 10 July 1969, and on 7 July 1970. By the first or second week in August (after 4 August 1969; 7 August 1970), all the murres had departed from Gull Island.

The lateness of the breeding season on Gull Island was in contrast to that of Green Island, where the first young of the year were seen on the water about two weeks earlier (24 June 1970) and half were gone by mid-July. Insufficient social stimulation in the smaller colonies (Darling, 1938), or more probably a higher proportion of inexperienced breeders (Tuck, 1961) in the new colonies of Gull Island, may have given rise to the comparatively late nesting phenology here.

Black guillemot, *Cepphus grylle*

The black guillemot's range is almost circumpolar. It breeds along the western side of the Atlantic as far south as the Bay of Fundy and Maine (Godfrey, 1966). It nests in substantial numbers around the coasts of Newfoundland but is not colonial. It is a year-round inshore resident (Tuck, 1967). Owing to difficulties in locating the nests, the actual number of breeders is hard to determine.

Three nests were found in 1969, and again located, as well as one additional nest in a new location, in 1970. In 1971 only two of these sites were found; the others either were missed or did not contain nests (Fig. 9). At least three other areas, close to which pairs of birds habitually flushed or roosted, probably included nests. Altogether 85 adults were counted around the coastline of Gull Island on 10 July 1970; thus an estimate of 10 to 20 breeding pairs on the island is probably highly conservative. There was no discernable change in black guillemot numbers during the period of this study.

Black guillemots nest in the area above the intertidal zone and below the limit of growing vegetation. They nest under boulders, in crevices and among piles of broken rock (Winn, 1950) or talus slides (MacLean and Verbeck, 1968). The eggs are usually found on gravel or small pebbles, and a dry site is always chosen. Figure 10,b shows a black guillemot nest site typical of those found on Gull Island: a narrow fissure along the tilted strata, with rock rubble usually obscuring the nest (in this case, part of the incubating bird was visible through the opening indicated by the arrow).

Figure 10

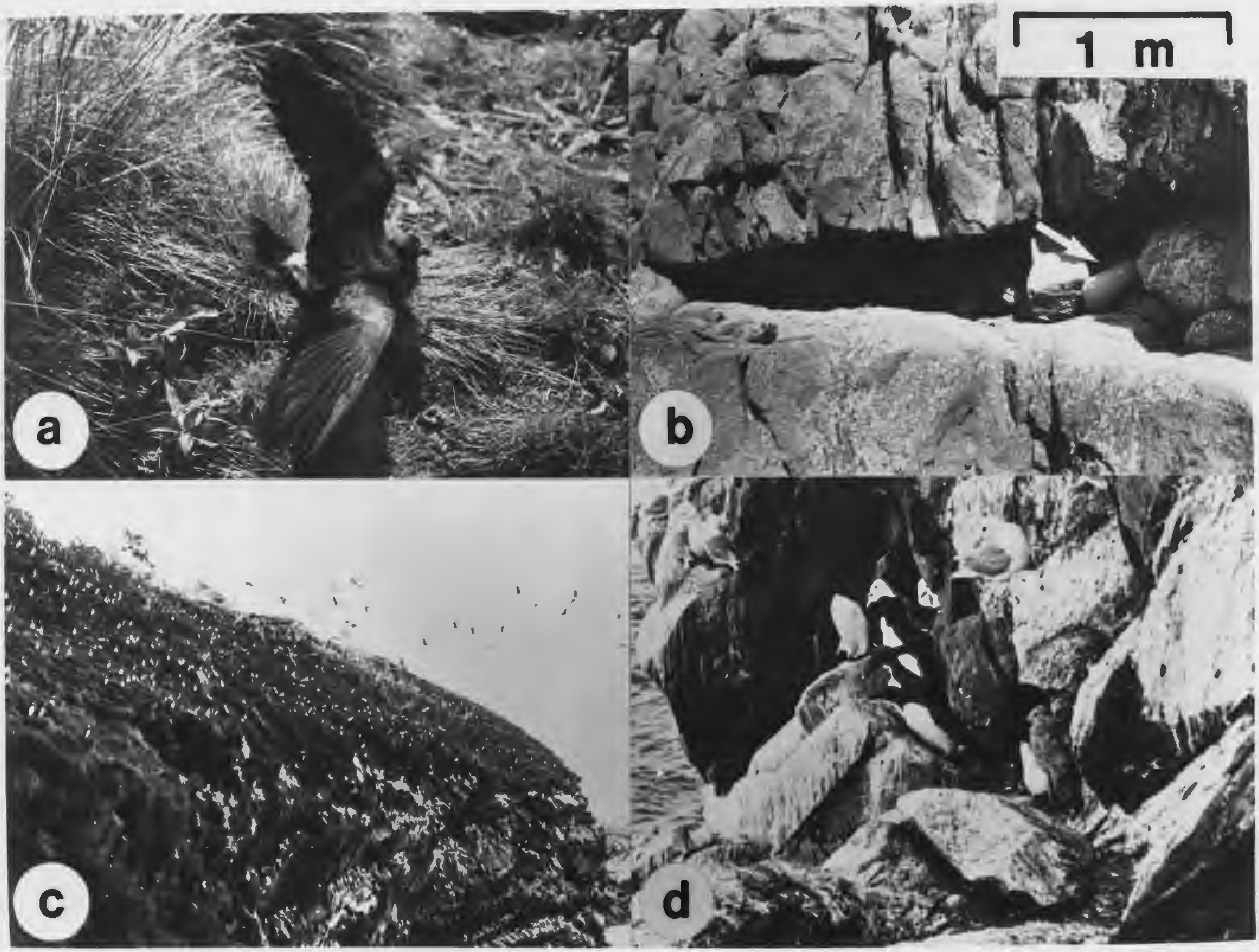
Breeding Sea-birds and their Habitat

a. Leach's petrel chick near fledging age, at the edge of the west side woods, October 1970.

b. Nest site of black guillemot, 1970 and 1971, viewed from almost directly above.

c. Puffin slopes, and cliff with nesting kittiwakes and murres, west side of the Base of the Point.

d. Nesting murres and kittiwakes on the west side of the Point. A gull chick has wandered onto the ledge.


1 m
a
b
c
d

Wm. White (1970, pers. comm.) pointed out a crack on the west side of the island in which black guillemots had nested for many years. However for the previous two or three summers the bottom of it had been inundated by drainage from the sagging soil above, and no guillemots had nested there during that time.

Winn (1950) found that Bay of Fundy black guillemots laid their eggs during June and early July. In two cases, replacement clutches were laid in late June. On Gull Island, completed clutches of two eggs were found on 23 June 1970 (2 nests), and 10 and 20 June 1971. An incubating bird was seen 10 July 1969. Two chicks approximately four days old (aged according to Winn, 1950) were found in one nest on 14 July 1970.

The area around one nest (Fig. 10,b) was in 1971 disturbed daily for 15 to 45 minutes by the author making a tally of gull eggs and chicks. One of the black guillemot's eggs was found outside the nest, wedged under a rock, and the other was later found emptied through a round hole in the shell, of the type made by gulls when eating eggs. At the time there were many large herring gull chicks in the area, and the periodic disturbances may have caused some of them to take refuge in the guillemot crevice. Two chicks disappeared from another nest between 4 and 7 July 1970. They were too young to have fledged, since the combined incubation and fledging period is 68 days (Winn, 1950), and were probably taken by a predator. Winn (1950) found 74 per cent loss of eggs and young up to 30 days old, due among other things to tides and high seas, crows, and young herring gulls.

Common Puffin, *Fratercula arctica*

The puffin breeds from Greenland, Jan Mayen, Spitzbergen and Novaya Zernlya, south to Iceland, Britain and France, and in the western Atlantic on the coast of Labrador as far north as Nain (Godfrey, 1966) and south to the Gulf of St. Lawrence, with scattered colonies as far south as Maine. It breeds in Newfoundland mainly on the southeast coast (from the Wadham Islands to Witless Bay) and also on small islands of St. Pierre and Miquelon (Tuck, pers. comm.). It nests on offshore islands possessing turf. At some formerly large colonies in the eastern Atlantic, puffin numbers have been rapidly decreasing in recent years, from unknown causes (Flegg, 1972; Brooke, 1972; Parslow *et al.*, 1972).

On the Witless Bay Islands, the number of puffins has increased tremendously during the past quarter century (Tuck, 1967). Templeman (1945) had heard a report of puffins breeding "in numbers" on Great Island but had not visited the area. Peters and Burleigh (1951) enumerated 13 colonies with an estimated 13,870 breeding pairs. They reported 1000 pairs bred on Gull Island in 1942. Wm. White, (pers. comm.), having fished in Witless Bay since the early 1930's, recalled that puffins at that time nested only in a small area near the base of the Point, gradually colonizing the rest of the grassy slopes and reaching the north end last. The 1969 estimate, made by counting burrow openings in the plots used in the petrel census and vegetation mapping, is that there were 80,000 to 100,000 puffin burrows on Gull Island.

In 1969 the density of burrows appeared to be as high at the north end (up to 30 per 4 m square) as at the site of the original colony, and all the grassy areas except flat ones (with slope less than 10°) were in use. The frequent occurrence of slides and washouts can be attributed largely to the high density of puffin burrows (Darling, 1947, in Fisher and Lockley, 1954). Puffins nested on all of the grassy seaward slopes of Gull Island (Fig. 10,c). In addition, they regularly nested in burrows in marginal locations such as bare loose peat (many of these burrows collapsed during heavy rains), and among tangled roots and dead trees which hampered take-off and landing, so that the birds had to creep around these obstructions for up to 1 m before taking flight. One puffin was found dead, skewered by a sharp twig and hanging by a flap of skin.

Puffins were also found nesting among boulders at the base of the north cove, and at two locations on the southern Point. One of the latter nests was found in a deep crevice and was plainly visible from above, while the other was under a small rock only two-thirds of a meter across. Since both nests were relatively exposed and on flat terrain in the centre of a herring gull colony, 50 m from the water's edge, the danger of gull predation must have been extreme. Nettleship (1972) found that breeding success of puffins on Great Island was significantly lower in the flat habitats inland from the cliff edge, than on the sloping cliff edge, due to kleptoparasitism and predation by gulls. Thus it appears that the more favourable sites for puffins were all or nearly all occupied on Gull Island by 1969.

Puffin eggs were first seen on 20 May 1969, 18 May 1970, and

20 June 1970, and by mid-July 1971 many puffins were carrying small fish to the burrows. The first fledgling was seen on the water on 25 July 1970, several were seen on 8 August and one on 10 October of the same year. On nearby Great Island, egg-laying takes place from the second week in May to late June, the peak of hatching occurs during the last week in June and the first week in July, and fledging begins early in August and continues until the end of September (Nettleship, 1972).

Black-legged Kittiwake, *Rissa tridactyla*

This pelagic gull is a circumpolar breeder, reaching very high latitudes (Godfrey, 1966). A study of its breeding biology on Gull Island has recently been completed (Maunder and Threlfall, 1972). The population on Gull Island has apparently continued to increase, approximately 10,000 nests being counted in 1971 (Table 9). However, this figure is suspect because of disagreement in the distribution of the population with that found by Maunder (1971). The technique of photographing cliffs may be at fault as it proved difficult in some cases to distinguish genuine nests from roosting places.

Herring gull, *Larus argentatus*

The herring gull breeds on coasts and across central and north central Canada south as far as the Great Lakes, and in Greenland, Iceland, Northern Siberia and Western Europe (Godfrey, 1966). Voous (1960) regards it as the nearctic member of an almost circumpolarly distributed group, whose palearctic member is the lesser black-backed gull (*L. fuscus*), and postulates invasion of Europe by the herring gull during or after the most recent ice age. Since 1930, herring gull populations in Europe have undergone spectacular increases (Voous, 1960; Harris, 1970), and have extended their range (Géroudet, 1968) and type of nesting habitat (Goethe, 1960; Cramp, 1971). In North America, similar increases have been taking place. Where at the turn of the century egging and taking of chicks had reduced the herring gull population of the New England States and Maritime Provinces to a low level, legal protection and progressive urbanization has allowed it to recover, to the extent that numbers have been doubling every 12 to 15 years since the early 1900's (Kadlec and Drury, 1968). Because of the increasing threat of gull strikes on air craft (Drury, 1963) their encroachment on waterfowl (Amadon, 1958; Grenquist, 1965), pollution of reservoirs, and possible role in the dissemination of disease (Silverman and Griffiths, 1955; Brough, 1969), their biology has been intensively studied in recent years.

Templeman (1945) noted that the herring gull was the most common Newfoundland "sea-bird." Both Peters and Burleigh (1951) and Tuck (1967) reported that its numbers were increasing. On Gull Island, the number of breeding pairs almost doubled during the five year period when nests were counted (Table 3). The average annual increase of 14.5 per cent is comparable with some of the most rapidly increasing colonies reported (Brown, 1967; Parsons, 1969).

Changes in Gonad weights. Herring gulls occupy the Gull Island colony in February or March each year and probably there is some enlargement of the gonads at this time. Harris (1964) found that herring gull testes began to increase in February and were heaviest in

Table 3

Number of Gulls' Nests Counted on Gull Island, 1967 to 1972

Area (see Figure 12)	1967	1968		1969		1970		1971		1972	
	Number of Nests	Number of Nests	% Change	Number of Nests	% Change	Number of Nests	% Change	Number of Nests	% Change	Number of Nests	% Change
a. North-East Sector	-*	-		244		398	+64	479	+20	468	-2
b. East Side	399			881		1102	+25	1040	-6	1235	+18
c. South Side	755	1639	+42	321	-15	398	+24	400	0	416	+4
d. Peat Valley and Base of Point				199		204	+3	173	-15	226	+31
e. The Point	235	249	+6	269	+8	263	-2	282	+7	318	+13
f. West Side	-	95		119	+25	179	+50	165	-8	-	
Total Counted	1389	1983	+36**	2033	-10**	2544	+25	2539	0	2663	+12**

*Area not counted.

**Percent overall change in all areas counted both in that year and the preceding year.

Table 4

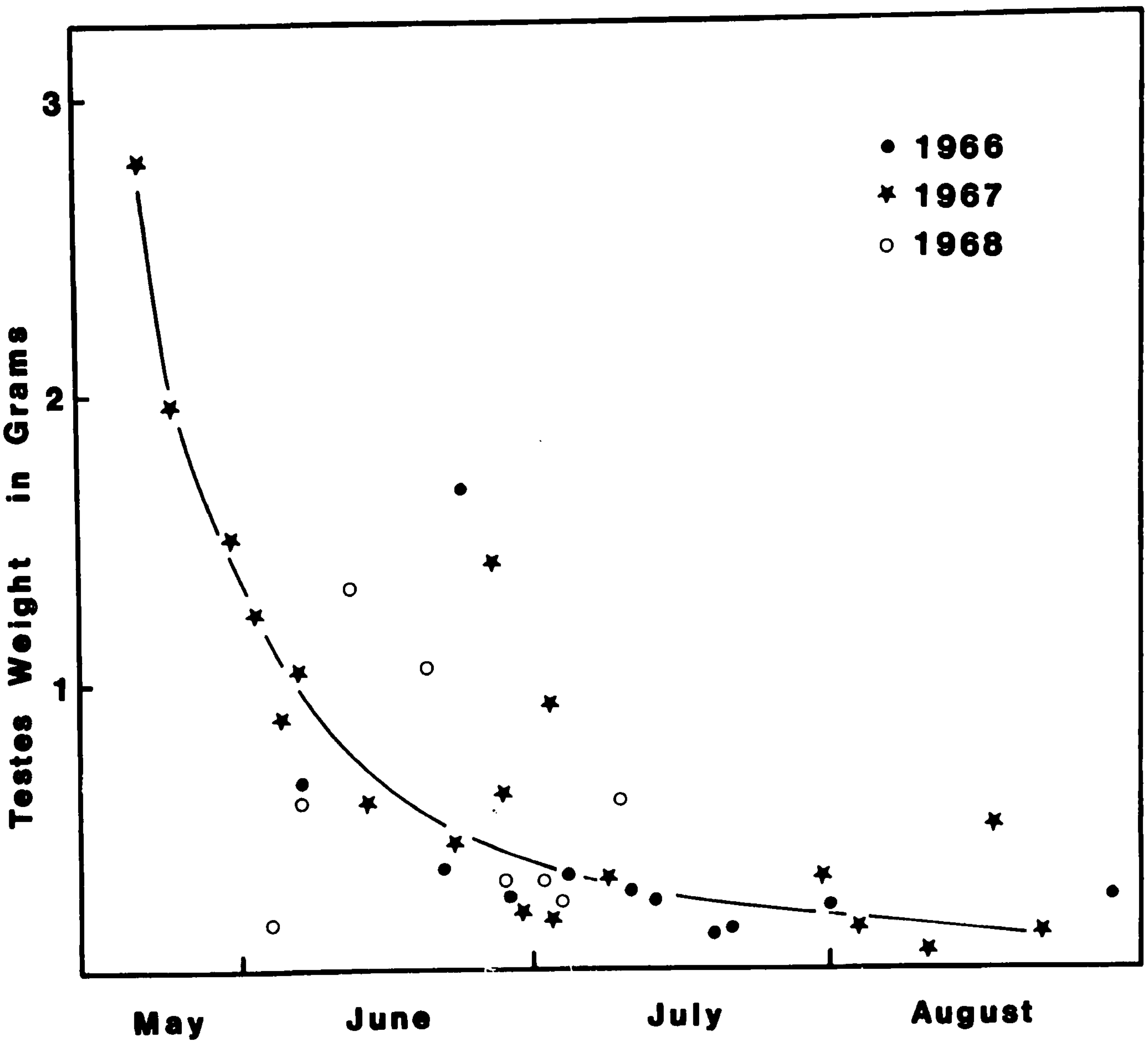
Weight of Gonads of Herring Gulls in Adult Plumage, from Gull, Green, and Great Islands, 1966 to 1968

	Testes (left and right combined)			Ovaries		
	Mean Weight in Grams		Range	Mean Weight in Grams		Range
May 13-31	1.85	(15)*	.98-2.91	1.11	(3)	.80-1.28
June 1-15	.92	(44)	.58-1.65	1.53	(20)	.29-5.48
June 16-30	.67	(46)	.09-4.30	.76	(21)	.20-1.25
July 1-15	.30	(33)	.10-1.70	.37	(13)	.12- .61
July 16-31	.19	(20)	.09- .52	.34	(4)	.22- .50
August 1-15	.18	(12)	.05- .41	.43	(7)	.18-1.12
August 16-31	.22	(10)	.04- .85	.35	(3)	.11- .65

*Figures in parentheses indicate number of samples in mean.

Figure 11

Weight of testes from herring gulls taken on Gull, Green, and Great Islands



1966
1967
1968
3
2
1
Testes Weight in Grams
May
June
July
August

April and May, the period during which copulation and egg-laying were most frequent. Ovary weights reached a peak slightly later. Generally testes remained enlarged for a longer period than ovaries. In the latter, one follicle enlarged from 2 mm to 40 mm in diameter in approximately 6 days before ovulation, and the whole maturation period was confined to the month prior to laying (Harris, 1964).

Gonads of herring gulls taken on the Witless Bay Islands (Gull Green and Great), show a recession in weight from May until August, most markedly between mid-May and the end of June (Table 4). The high testes weights in late June (Fig. 11) were probably due to laying of replacement or unusually late clutches, since most of the first clutches were complete by this time. Belopol'skii (1957) showed that when their eggs were systematically collected, herring gulls produced second or more clutches, and their gonad weights and breeding capacity remained high (testes averaging over 2 gm) for an extended period (30 to 40 days or more). Harris (1964) found rapid recession in both testes and ovary weights after the onset of incubation, in the great black-backed gull.

Nesting habits. To determine if any changes in nest density had taken place during the period of increase, nests were counted in randomly placed 10 m squares and various areas were compared (Table 5, Figure 12). A great deal of variation was found; which generally did not reflect the population changes in the same regions of the island (Table 3). Thus either the placement of squares or the placement of nests was non-random, within the area. Random placement of squares was difficult over large areas, and errors from non-random placement

Table 5

Density of Gulls' Nests in Various Regions
of Gull Island

	Numbered Areas in Figure 12	Number of nests/100 sg. m.		
		1969	1970	1971
a. North-East Sector	1	3.0	2.2	-
	2	-	2.6	-
	3	4.5	3.0	4.4
b. East Side	4	2.5	3.5	4.2
	5	2.6	2.7	3.0
	6	2.7	2.4	2.8
	7	6.6	3.5	7.0
c. South Side	8	6.2	3.2	4.1
	9	4.2	2.9	3.3
d. Peat Valley and Base of Point	10	3.4	3.4	2.8
e. The Point	11	5.0	2.9	3.9
f. West Side	12	2.1	3.2	2.8

Figure 12

Various regions of Gull Island, and locations of areas sampled for density of gulls' nests.

a. north-east sector

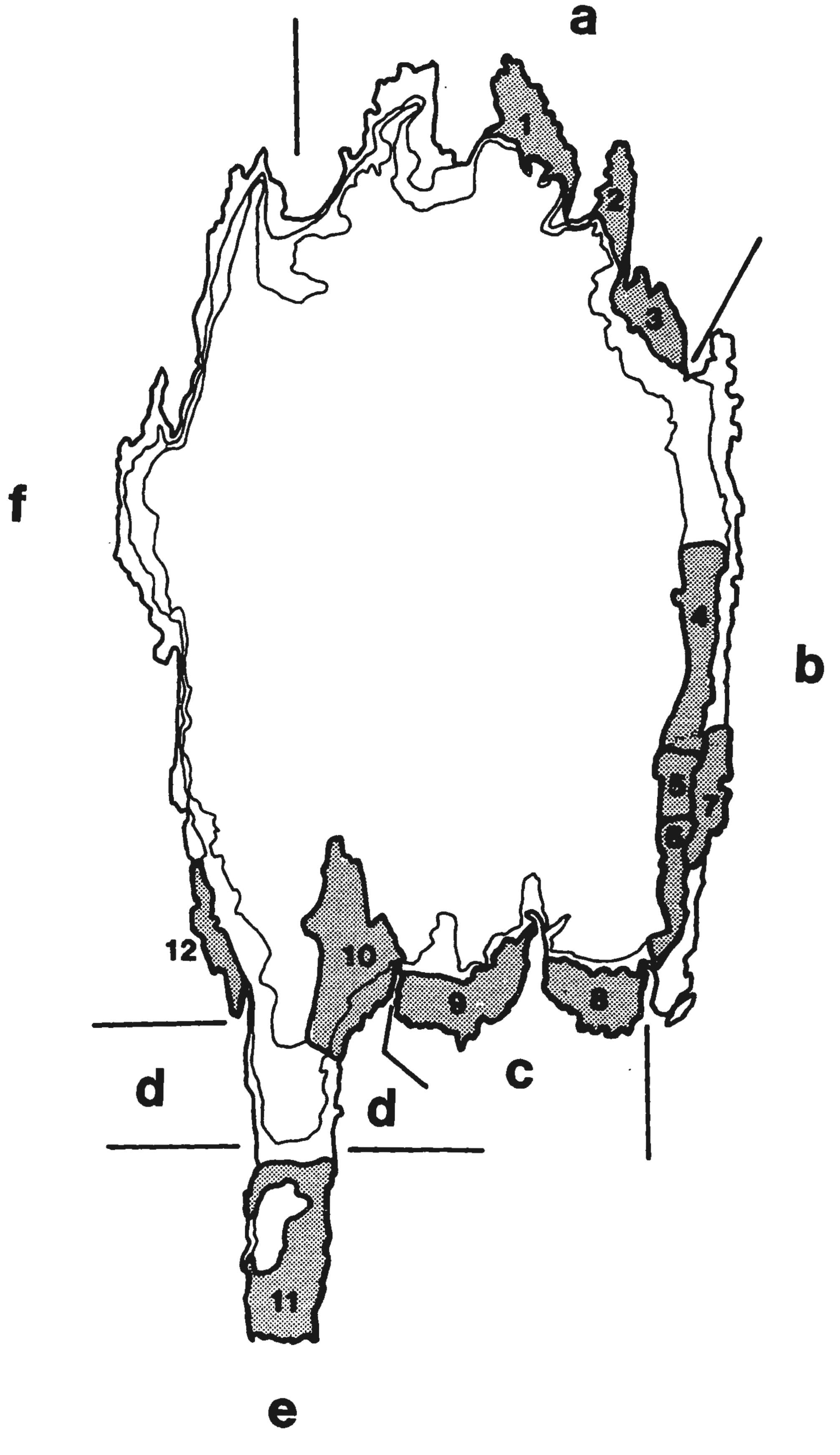
b. east side

c. south side

d. Peat Valley (area 10) and the Base of the Point

e. the Point

f. west side


a
1
2
3
4
5
6
7
8
9
10
11
12
b
c
d
d
e
f

were accentuated by the small sample size (5 to 15 squares per area). However the more important factor was non-random placement of nests. Nests were built on rock, or on grass and bare peat. Nest density was higher on the rock surfaces than on the grass (3.98 vs. 3.07/10 m square, $P < 0.01$) and still higher at the interface between them (8/100 square meters). In Area 4 (Fig. 12), the density of the southern half was approximately twice that of the northern half, although the habitat appeared identical; possibly this indicates a spread from the more densely occupied Area 7. Even minor variations in topography result in changes in spacing of nests. Intervisibility of nests is important (Bongiorno, 1970); on bare peat visibility was totally unobstructed, and very few gulls nested here. On grass, with a few additional obstructions such as dead trees, nests were more numerous, but still more widely spaced than on the rough, craggy terrain of the rock area. On the rocks, nests were occasionally placed as little as 30 cm apart, though on different levels, or where the view was obstructed between them.

On grassy slopes there was a strong tendency to place nests at the base of some prominence, such as a boulder, tree or tree stump. No gulls nested among dense shrubs such as raspberries (*Rubus idaeus*), but a few herring gulls (30 pairs) nested up to 4 m into open woods, usually building the nest under a fir tree. In these cases there was a well worn access tunnel through the vegetation. About 20 nests were found in small clearings high in the woods, on terrain sloping toward the sea.

Nests were situated in a small depression, crack or crevice, 6 to 15 cm deep (the nest-scrape, Tinbergen, 1953). Suitable depressions are numerous on the rock surfaces of the Point (Fig. 4,c and d) and the east side (Fig. 4,b). Particular sites were used year after year. On large areas of the Point, the locations of many nests were identical in 1970 and 1971. Salomonsen (1939) attributed the high tenacity of rock nesting herring gulls to their nest sites (compared to those nesting in grass) to the comparative difficulity of finding a suitable depression.

Nest building was well underway by mid-May, and continued until hatching of the chicks. As various plant species developed they were added to the nests. During inclement weather all nest building activity ceased, for as much as a week; with improvement in the weather, much new material appeared on the nests. Nest building was at a peak on the day immediately following a period of rain. Maunder (1971) found a similar correlation between periods of rain and nest building in kittiwakes, but associated this with softness of the turf, which kittiwakes may require in order to take the roots and earth they use in their nests. Roots and earth formed only a minor component of most herring gulls' nests; apparently the rain had an inhibiting effect on the normally frequent collection of nesting material in this species.

The major component of nearly all herring gulls' nests was *(Festuca, Deschampsia)*. Nests surrounded by grass were composed mainly or exclusively of grass. Nests on rock and peat had a more varied composition, incorporating up to 25 per cent other vegetation, such as raspberry canes *(Rubus idaeus)*, *Rumex Acetosella*, *Lathyrus* *japonicus*, or *Stellaria media*, usually available within 50 to 100 m from the nest. Fern fronds (*Dryopteris*, *Osmunda cinnamomea*) formed the major component of nests in the north east sector, where these ferns were abundant. Several nests in Peat Valley, where there was no vegetation except stunted dead fir trees on the bare peat, were composed almost wholly of the weathered twigs that were lying about in the area.

Nests usually contained gull feathers and the indigestible remains of food, such as bones, shells of mussels (*Mytilus*), sea urchin (*Strongylocentrotus*) tests, and petrel feathers. Nests occasionally contained such man-made objects as plastic gill net floats or prayer beads.

The usual inside diameter across the top of the nest cup was 20 cm. The external width at the base of the nest varied from 40 to 60 cm, and the height of the rim from 8 to 15 cm above the substrate.

As vegetation continued to accumulate and decay, the nests became heavier. One large nest of compacted grass, mosses, roots and earth, weighed 3177 g on 4 July 1970. An exceptional nest, made of dry twigs, weighed only 192 g at this time.

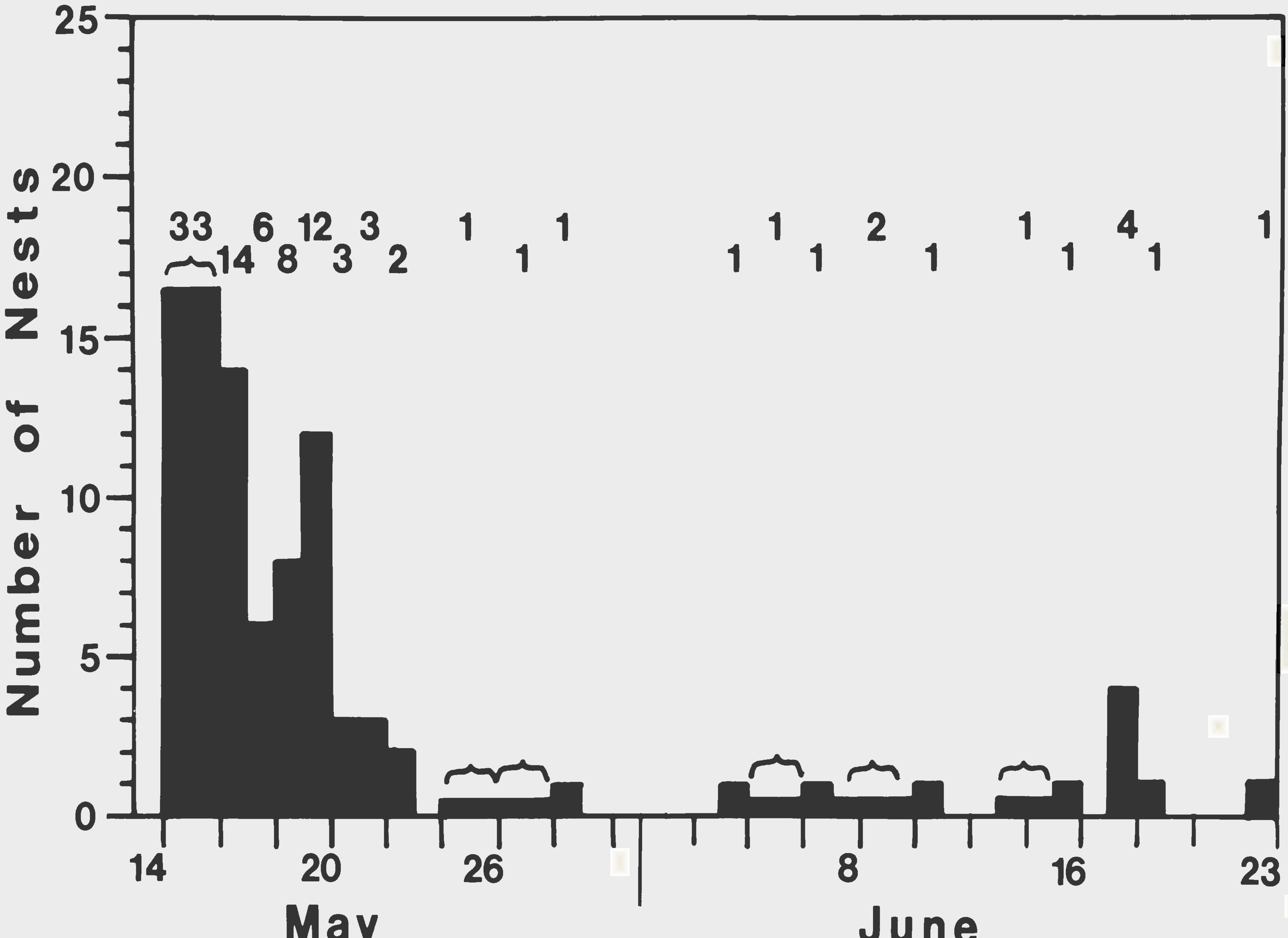
Egg-laying. By the time the first observations were made on Gull Island (19 May 1969, and May 1970 and 1971), egg-laying had already begun. The continuing progress of laying was followed on the Point and in the east side square (Fig. 2).

Average clutch size reached a maximum earlier (25 May 1971) in the square than on the Point (30 May 1971) and the rate of

Figure 13

Pattern of clutch commencement in herring gulls, 1971.

Number of nests in which the first egg was laid on a given date.



25
20
15
10
5
0
Number of Nests
33
14
6
8
12
3
3
2
1
1
1
1
1
1
2
1
1
1
4
1
1
14
20
26
8
16
23
May
June

egg-laying (measured by the increase in average clutch size) was also greater in the east side square, indicating a greater synchrony in this area. Hatching began in the east side square before anywhere else on the island (22 May 1967, 31 May 1970, and 22 May 1971). Taking the incubation for herring gulls as 28 days, the first successfully hatched eggs must have been laid on 24 April, 1967 and 1971. Goethe (1937) and Paynter (1949) found that hatching (and therefore laying) first took place in areas of highest nest-density, from which it radiated outward as the season advanced. The same situation obtains on Gull Island, chicks first being noted in the densely populated east side square.

The pattern of clutch initiation in 1971, in a set of marked nests on the Point, is shown in Fig. 13. It is similar to the latter half of the clutch-initiation pattern found by Paludan (1951) and Harris (1964). Thus by comparison with the above studies, the probable mean date of clutch initiation on Gull Island (the Point) would be about 10 to 14 May 1971. This date is comparable to the mean laying date at more northerly colonies in the eastern Atlantic, such as Troms, Norway (16 May; Barth, 1968), Priest Island, Scotland (15 May; Darling, 1938), and the Isle of May, Scotland (18 May; Parsons, 1971a). In North American coastal colonies the mean laying dates (calculated from hatching dates) were 1 June on Kent Island, Bay of Fundy (Paynter, 1949) and 14 to 27 May in several New England colonies (Kadlec and Drury, 1968). Thus while egg-laying tends to be delayed with increasing latitude, there are exceptions and reversals, of which several European colonies (Paludan, 1951; Barth, 1968; Drent, 1970) and Gull Island are examples. Light regime, which is a constant and dependable factor of the environment, directly related to latitude, is an important factor in the timing of avian breeding cycles; however, modifying or supplementary factors in local conditions seem also to be critical (Marshall, 1959; Farrer, 1964).

Often clutches begun late in the season are replacements of those lost earlier (Paludan, 1951; Parsons, 1971a). Seven of the last eight clutches shown in Fig. 13 were replacements of clutches which had been destroyed. Of these, one was begun 30 to 32 days, and another 22 days, after the loss of the original clutch. In the other five, laying commenced 12 to 14 days (mean, 12.6 days) after the disappearance of the first clutch. Twelve to fourteen days is the time reported in other populations between loss of the entire first clutch or even very small chicks, and the beginning of a second clutch (Paludan, 1951; Parsons, 1971a). The nest in which an egg was first seen 30 to 32 days after the loss of the first clutch was subject to heavy predation. It was situated in a shallow depression about 10 m wide, and 2 m below a meadow upon which at least 10 pairs of great black-backed gulls were nesting. Three eggs were laid, each being eaten in turn before it was 48 hours old. A new nest was built 1.5 m from the old one, and a week later, two eggs were found in it. The contents of both had been eaten by a predator. In this case, and possibly in the other (22 days), heavy predation may have obscured the actual pattern of repeat laying, since predators such as great black-backed gulls and herring gulls sometimes fly off with a whole egg before devouring its contents.

The average clutch size is one measure of the productivity of a gull population. The normal clutch for the herring gull is three eggs, but some lay two, a few lay one, and exceptionally few lay four (Paludan, 1951). On Gull Island, only two nests containing four eggs were seen among the 5000 nests examined in 1970 and 1971. The average clutch size was 2.70 in 1970, and 2.73 in 1971. Clutch size for 1970 was taken as the maximum average clutch size reached in periodic surveys of the Point and east side square; for 1971 it was the average of 109 marked nests on the Point. Although there are inherent biases towards underestimation in these methods, clutch size on Gull Island was comparable to Harris' (1964) average of 2.77 and Parsons' (1971a) of 2.73. Paynter (1949) found a mean clutch size of 2.46, Paludan (1951) found 2.91, and Brown (1967), 2.56. Parsons (1971a) suggested that differences in clutch size may reflect the techniques used in the various studies, and the amount of disturbance of the nests, more than real geographical differences.

Coulson and White (1961) found that the average size of clutches laid by kittiwakes decreased as the season advanced. This effect was due partially to inexperienced birds, which tend to lay smaller clutches, laying late in the season. However there was also a true seasonal affect, causing birds of the same age to lay smaller clutches if commenced later in the season. Paynter (1949) and Harris (1964) found no such decrease, while Brown (1967) and the present author did find one (Table 6). A decrease in clutch size from 2.91 to 2.3 during the month of May was noted by Parsons (1971a), who excluded replacement clutches from his calculations, as they may be

Table 6

Season Variation in Clutch Size of Herring Gulls

Gull Island 1971			Walney Island (Brown, 1967)		
Date of commencement of clutch	Number of clutches	Average clutch size	Date of commencement of clutch	Number of clutches	Average clutch size
14-17 May	61	2.75	Until 2 May	40	2.77
18-21 May	31	2.77	3-7 May	40	2.50
22-25 May	5	2.20	8-12 May	29	2.51
26-29 May	4	2.00	After 12 May	30	2.40
After 29 May	12	2.67			

intrinsically smaller. The exclusion of replacements, and his large sample size (677 nests) leave little doubt that a seasonal decrease in clutch size is also a characteristic of herring gull populations on the Isle of May. (Replacement clutches in the Gull Island data appear only after 29 May.) Parsons found no evidence of a declining food supply, and postulated that intrinsic factors are responsible for decreasing clutch size. With replacement clutches this could be the short period (12 days) before laying, compared to the longer pre-egg stage of the original clutch (Parsons, 1971a).

Eggs. The eggs were blotched brown or black on a pale gray to olive brown ground colour. Egg size varied with order of laying within the clutch. The mean widths and lengths of 56 first-laid eggs were 48.5 mm and 70.9 mm, mean measurements of 56 second eggs were 48.2 mm by 70.3 mm, and 53 third eggs averaged 48.0 mm by 68.0 mm. There was no significant difference in the sizes of first and second eggs, but the third egg was smaller than the first two ($P < .005$). This phenomenon has been noted before (Keith, 1966; Brown, 1967; Barth, 1968; Parsons, 1971a), and seems not to be related to lack of materials but to a waning of the physiological processes associated with egg production (Harris, 1964). Parsons (1971a, 1972) views it as a means of synchronizing the hatching of the eggs, and of giving rise to a reduced survival rate in the third chick during adverse conditions, thus improving the chance of survival of the other two.

The third egg tended to have a greater shape index $(\frac{\text{width} \times 100}{\text{length}})$ than the first two, though this was not statistically significant.

In two cases where both original and replacement clutches were measured, the replacements had a slightly lower total volume than the original clutch.

Two abnormally small eggs were found. One of these, measuring 30.8 mm by 40.7 mm, was found in a nest which also contained two normal sized eggs. The other, of a similar size, was found in a nest with one normal egg. The shells were rough and pitted while their colouration and markings were normal. Neither contained an embryo. Goethe (1937) reported frequently finding such eggs, which he speculated had formed from the laying down of albumen and membranes upon traces of yolk.

Incubation. The progress of incubation was followed by recording temperatures of eggs as "warm" or "cold" to the touch. Two of the clutches (12.5 per cent) were warm on the day following laying of the first egg; the proportion of warm clutches steadily increased until 15 (93.8 per cent) were warm on the fifth day after clutch commencement. The time required to complete a clutch of three averaged 5.9 days for this area (Fig. 2,a). The high attentiveness may have been accentuated by frequent rain and drizzle (Drent, 1970). Parsons (1971a) showed that some embryonic development does take place in the first and second eggs, prior to the laying of the third egg.

The incubation periods of 44 first eggs, 48 second, and 28 third eggs were determined to within ±1 or 1.5 days (Moreau, 1946), and averaged 29.4, 28.2 and 27.1 days respectively. Incubation period is influenced by the size of the egg (Parsons, 1972) and by laying date (MacRoberts and MacRoberts, 1972). Parsons found the incubation period of first-laid eggs over 76 cc in volume (volume = width^2 x length x 0.476) was 29.98 ± 0.08 days. For those under 76 cc, the mean incubation period was 29.31 ± 0.11 days. The Gull Island eggs, having an average volume of 79 cc, and an incubation period of 29.4 ± 1 days, were similar to the Scottish eggs.

During incubation the weight of the eggs decreases due to loss of gaseous wastes and water vapour through the porous shell (Harris, 1964). The original weight of the 24 eggs averaged 95 g, and ranged from 65 to 105 g. The rate of weight loss varied substantially among individual eggs, losses during the incubation period ranging from 10.3 to 24.7 per cent original weight. The average weight loss was 15.8 per cent. These figures agree closely with Harris' (1964) mean of 15 per cent and range of 9 to 24 per cent.

Development of the embryo during incubation was examined. Weight of the embryos reached 50 per cent of the embryonic maximum at 22 days. Initially there was a period of very rapid gain in weight, followed by a period of steady logarhythmic growth when embryos were 8 to 18 days of age (Fig. 15). After 18 days, the rate of weight gain decreased, as energy became concentrated on organogenesis rather than growth (Harris, 1964). Drent (1970) found a steadily declining rate of weight gain, while Harris' (1964) curve showed an exponential increase in weight until the 15th day, followed by a sharp falling off in the rate of increase. The average rate of weight increase noted by Harris (1964) over the whole incubation period was 2.0 g per day, compared to 1.9 g per day on Gull Island.

Figure 14

Herring gull embryos (a-g), and great black-backed gull embryo showing position during hatching (h). Age is expressed in days after laying of the egg.

a. 6 days

b. 7 days

c. 11 days

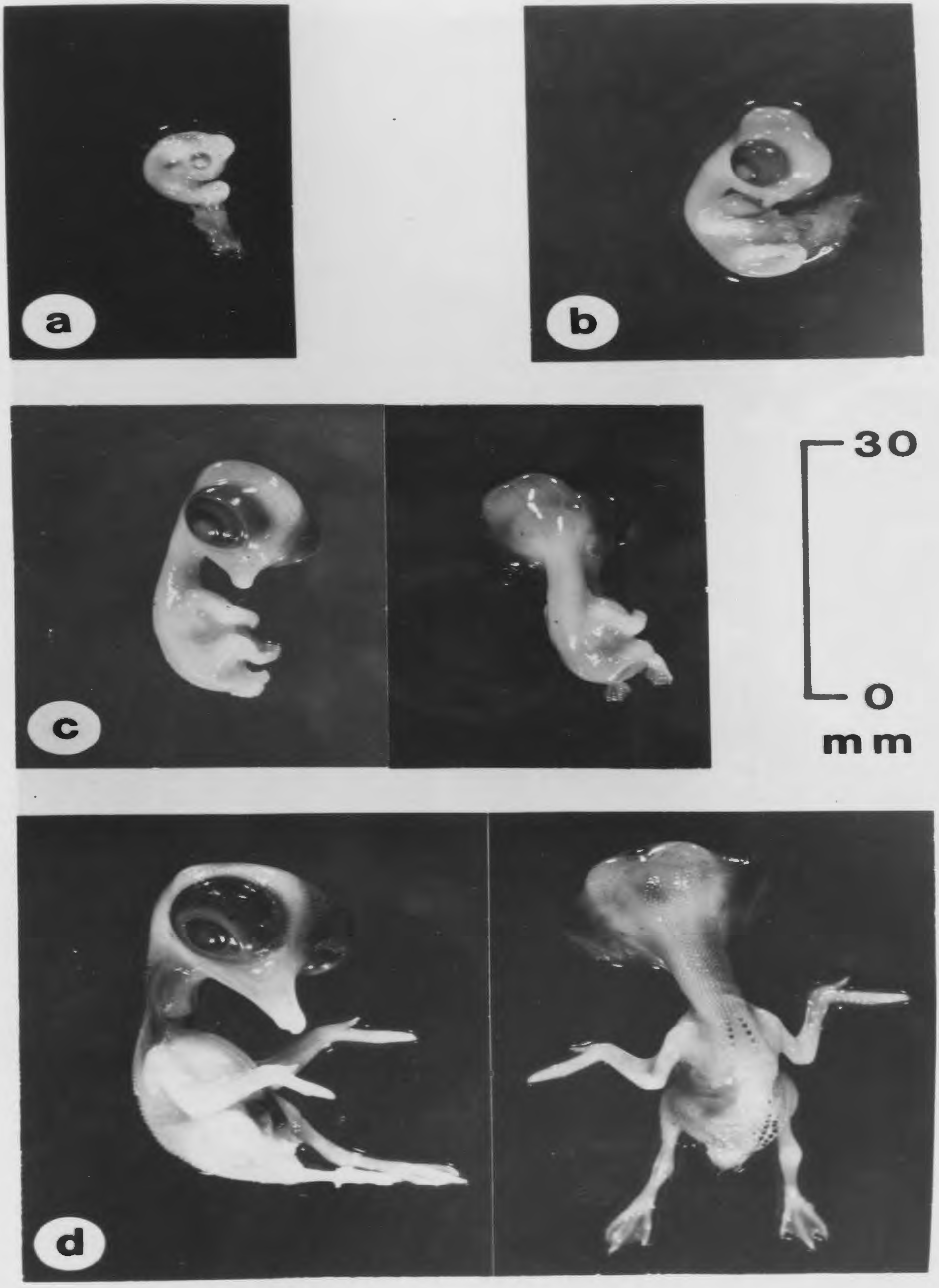
d. 13 days

e. 16 days

f. 18 days

g. 28 days

h. from pipped egg


a
b
c
d
30
0
mm

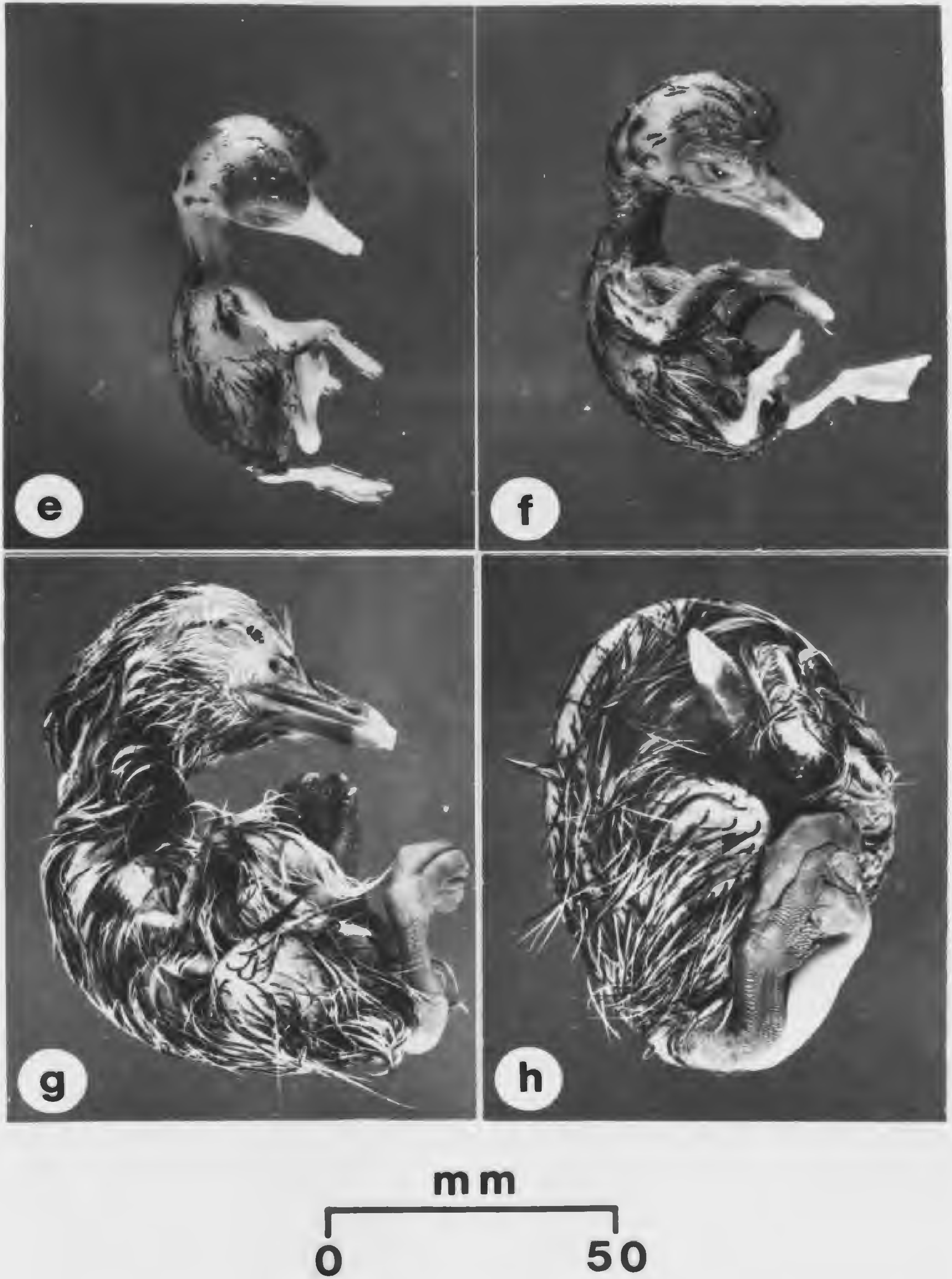
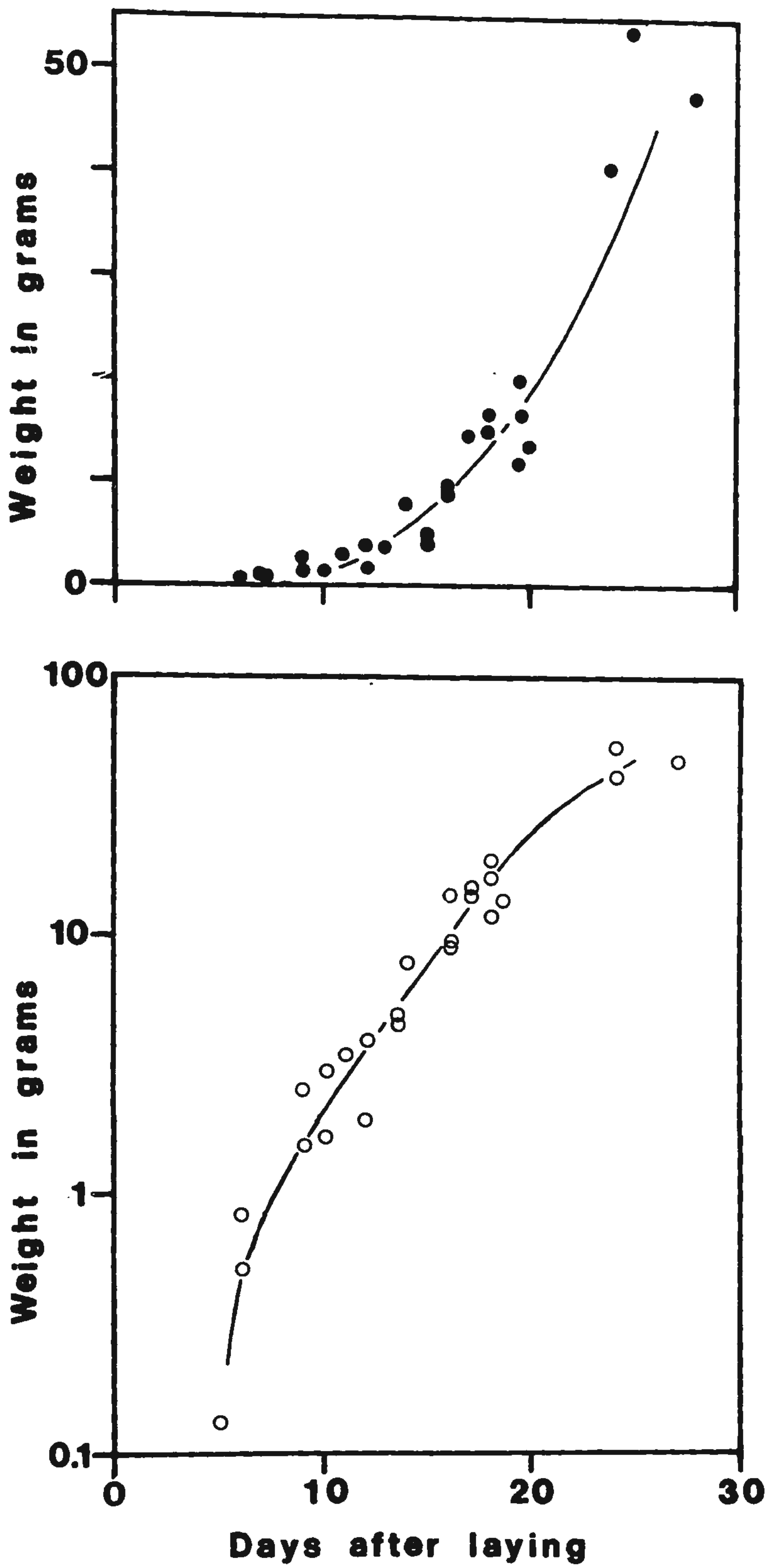

e
f
g
h
mm
0
50

Figure 15

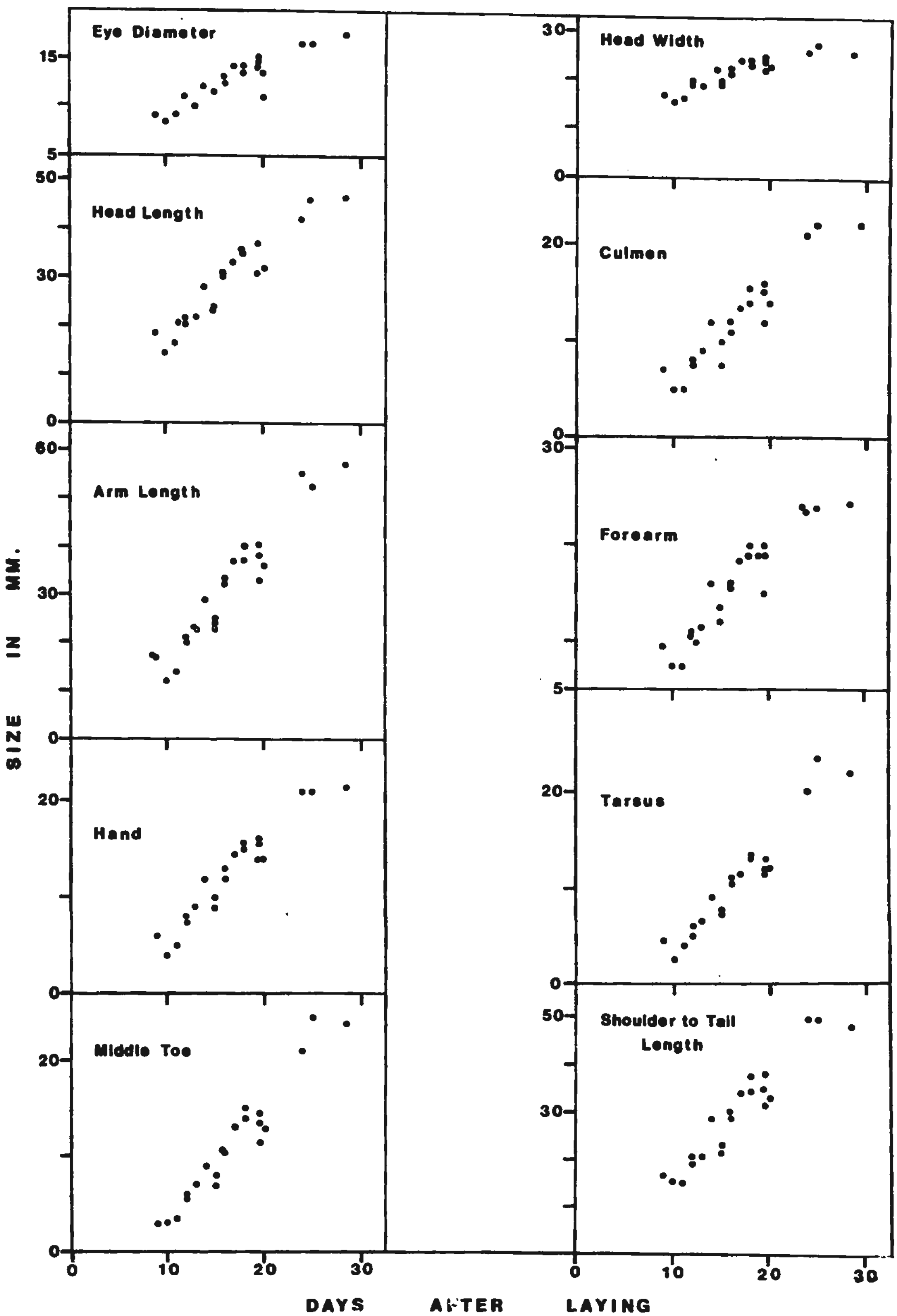
Weights of herring gull embryos, plotted on linear and logarhythmic scales.



50
0
Weight in grams
100
10
1
0.1
Weight in grams
0
10
20
30
Days after laying

Figure 16

Measurements of various parts of herring gull embryos taken at various stages of incubation.


Eye Diameter
Head Width
Head Length
Culmen
Arm Length
Forearm
Hand
Tarsus
Middle Toe
Shoulder to Tail Length
SIZE IN MM.
DAYS AFTER LAYING

By six days the embryonic heart, brain and lens of the eye were well formed. Small forelimbs and the buds of the hind limbs were visible (Fig. 14,a). At 7 days (Fig. 14,b) rudimentary digits had appeared on the forelimb. The mouth and bill were visible and the eye-lid was beginning to grow out to cover the prominent heavily-pigmented eye. The fore- and mid-brain had grown rapidly. By 11 days of age (Fig. 14,c) the feather tracts (pterylae) could be seen. The eyes, eyelids and bill were further developed. The forelimbs by this stage were distinctly wing-like, the three anterior toes of the feet webbed. During the next few days feather papillae became pigmented (Fig. 14,d) and the hallux and alula became prominent as the chick grew. By this time (13 days), 50 per cent of the embryonic growth of the body length (shoulder to tail) and bill length (culmen) were attained (Fig. 16). Half the embryonic growth of the head width, head length, and diameter of the eye had already been accomplished by 10, 13 and 12 days respectively.

Further growth after 13 days involved a gradual covering of the eyes by the eyelids, eruption and growth of the feathers, formation of the egg-tooth and toe nails (by the 16th day), hardening of the bill, and, an increase in body size (Fig. 14,e to g). Arm length increased at a steady rate from the 10th day to the 28th day, reaching the mid-point of embryonic growth about the 15th day, at about the same time of its components (hand, and forearm). Tarsus and middle toe began their development late, their growth accelerating after the 11th or 12th day; Tarsal length reached 50 per cent of the embryonic maximum by the 16th day, while the middle toe did not reach this point until

18 to 20 days. It would have been expected that development of the kittiwake and herring gull embryos would be parallel, as they are evolutionarily closely related, but that the feet (middle toe) of the kittiwake might show accelerated growth as an adaptation for clinging to its precipitous habitat. Maunder's (1971) growth curves for kittiwake embryos show a time course of development almost identical to that of the herring gull (Fig. 16). The middle toe reaches the midpoint of its embryonic growth on the 19th day, as it did in the herring gull. However the tarsus of kittiwake embryos reached this point later (18 days) than those of herring gull embryos (16 days). Thus at hatching the legs are relatively underdeveloped compared to the herring gull. The slow development of the legs (but not the feet) in the kittiwake may be correlated with the chicks' precipitous habitat and tendency to crouch when alarmed (Cullen, 1957), in contrast to herring gull chicks, which tend to run when frightened.

Hatching. A series of fractures appeared around the larger end of the egg about the 26th day after laying, and a day or two later the egg was pipped, that is, a small hole was pierced in the shell through which the bill of the chick was visible. Usually about 24 hours sufficed after this for the chick to force the end of the shell away and emerge. Hatching of the first and second-laid eggs took place 1 to 4 days before that of the third egg. Details of the timing are lacking because observations were made only once a day.

Development of the chicks. At hatching, the chick retains a remnant of yolk in the small yolk sac, and lives on these reserves for a day or two until its first feeding. Weight is lost until resorption of the yolk sac is complete or feeding has begun (Harris, 1964). Weights of the chicks used in the growth study are given in Appendix 4. Preliminary plotting of these results showed a great deal of individual variation in maximum weight attained and time required to attain it, as well as large daily fluctuations in the weight of individuals, which apparently resulted from their feeding schedules and whether they regurgitated before being weighed. An analysis of variance among measurements on chicks which eventually fledged, showed that there was a significant difference in growth among the chicks, even among those treated in the same way (kept in pens, or free). Therefore averaging the growth curves to compare the effect of the treatment (penning the chicks) would have no meaning: individual curves had to be compared rather than the average growth curves.

The general shape of the growth curves was quite uniform, and similar to a third order (cubic) function. Thus a third order regression line $y = b(o) + b(1)\ x + b(2)\ x^2 + b(3)\ x^3$ was fitted to each curve by the method of Fisher (1967). This gives the best fitted curve, assuming the cubic equation is the one which best represents the true growth curve.

Once the coefficients (b(o) . . . b(3)) of a curve are known, biologically important data can be calculated from it. The maximum (maximum weight, wing length, etc.) is a point where the first derivative of the equation, that is, $y' = b(1) + 2b(2)X + 3b(3)X^2$ is equal to zero. Solving for x gives the time at which the maximum is reached, and solving for y in the original cubic equation gives the maximum value attained.

The highest growth rate occurs at the inflection point of the curve, that is, the point where the second derivative y" = 2b(2) + 6 b(3) x is equal to zero. Again this equation can be solved for x, the time at which the maximum growth rate y", the maximum growth rate; and y, the weight (or length) at which the maximum rate occurred.

The regression lines were calculated and plotted (Appendix 5) using a desk computer* which was also programmed to give age and weight at the maximum, growth rate (or slope) at the inflection point, age and weight at the inflection point, slope from hatching to inflection point and from the inflection point to maximum. Assuming the regression line fits the true growth curve well, the whole set of measurements on growth of the chick can be reduced to the set of parameters b(o), b(1), b(2) and b(3) with very little loss of information.

The parameters characteristic of each chick were used to test whether there were any differences in growth among herring gulls in pens and not in pens, and great black-backed gulls (which were penned in the same way as herring gulls), using a multivariate analysis.** Penned and unpenned herring gulls were the same and the penned great black-backs were different from them. Repeating this analysis without the black-backs revealed that growth of herring gull chicks in the

---

*Wang-720, with Plotter 702.

**Stepwise discriminant analysis (Program BMD07M of the Health Sciences Computing Facility, UCLA). R. Strickler, pers. comm.

two groups still was not significantly different, although the groups showed some tendency to separate.

There were six broods of 3 herring gull chicks, nests 5, 7, 15, 17, 19 and VI (See Appendix 4). The same analysis was applied, and no significant differences were found in the growth of first, second, and third hatched chicks.

From the first and second derivatives mentioned above, the maximum growth rate in herring gull chicks took place on the 15th day after hatching; at this time the chicks were gaining 34 g a day. Penned and unpenned chicks were then about the same weight (445 ± 72 g; 468 ± 67 g). The weight at which the chicks fledged was highly variable, ranging from 630 to 1090 g, and averaged 900.6 g.

Large individual differences in the weights attained by gull chicks were also found by Harris (1964), Kadlec *et al.* (1969), and Smith and Diem (1972). Since the variation does not seem to be related to order of hatching in the brood, and the experimental pens had little if any effect, differences may be partly due to sexual dimorphism. Adult male herring gulls taken at Witless Bay were somewhat heavier than adult females, 32 males ranging from 1093 to 1336 g, and nine females ranging from 937 to 1118 g. Goethe (1956) found similar ranges (1025 to 1315 g for males, 865 to 1090 g for females) in weights of birds taken in November of their first year, that is, at about 5 months of age. Thus it is not unreasonable to suspect that the sexes may fledge at different weights. Harris (1964) found that brood size was correlated with fledging weight, where parents were forced to travel over long distances (ten miles) to reach the food source for the chicks; it may have been impossible for them to carry back enough food so that the chicks in broods of three could fledge with as high a weight as those in smaller broods. With the abundant food sources in Witless Bay, this sort of correlation did not arise on Gull Island. Inherent genetic variability, rivalry among siblings, and parental care are probably also important factors causing individual differences in growth (Brown, 1967; Smith and Diem, 1972).

For the purposes of this study, fledging period will be defined as the age at the first strong flight. Gull chicks do not usually leave the colony until several days after they are able to fly (Moreau 1946; Drent *et al.*, 1964). The mean fledging age of twelve chicks in 1970 was 45.2 days, ranging from 42 to 48 days, various other authors reporting a variety of times (Paynter, 1949, mean, 43 days; Kadlec *et al.*, 1969, mean, 51 days; Goethe, 1956, 43 to 62 days).

Culmen growth rate changed very little through the whole pre-fledging period; its growth gradually slowed and was probably almost complete at fledging (approximately 50 mm or 93% of the adult size). Tarsi developed rapidly between hatching and 25 days, attaining 64 mm (95 per cent of the adult size) by this time. The average growth rate of wings was practically constant between 12 and 40 days (Appendix 5). Parsons (1971a) used wing length for aging chicks between 16 and 28 days of age.

Stages in the development of the chicks are shown in Fig. 17. The young at first sit in the nest, but begin to walk short distances within two or three days after hatching. In a sample of 21 chicks, the egg tooth disappeared between 3 and 12 days of age (mean 6.0 days).

Figure 17

Herring gull chicks. Age is expressed in days after hatching

a. less than one day, with sibling in pipped egg

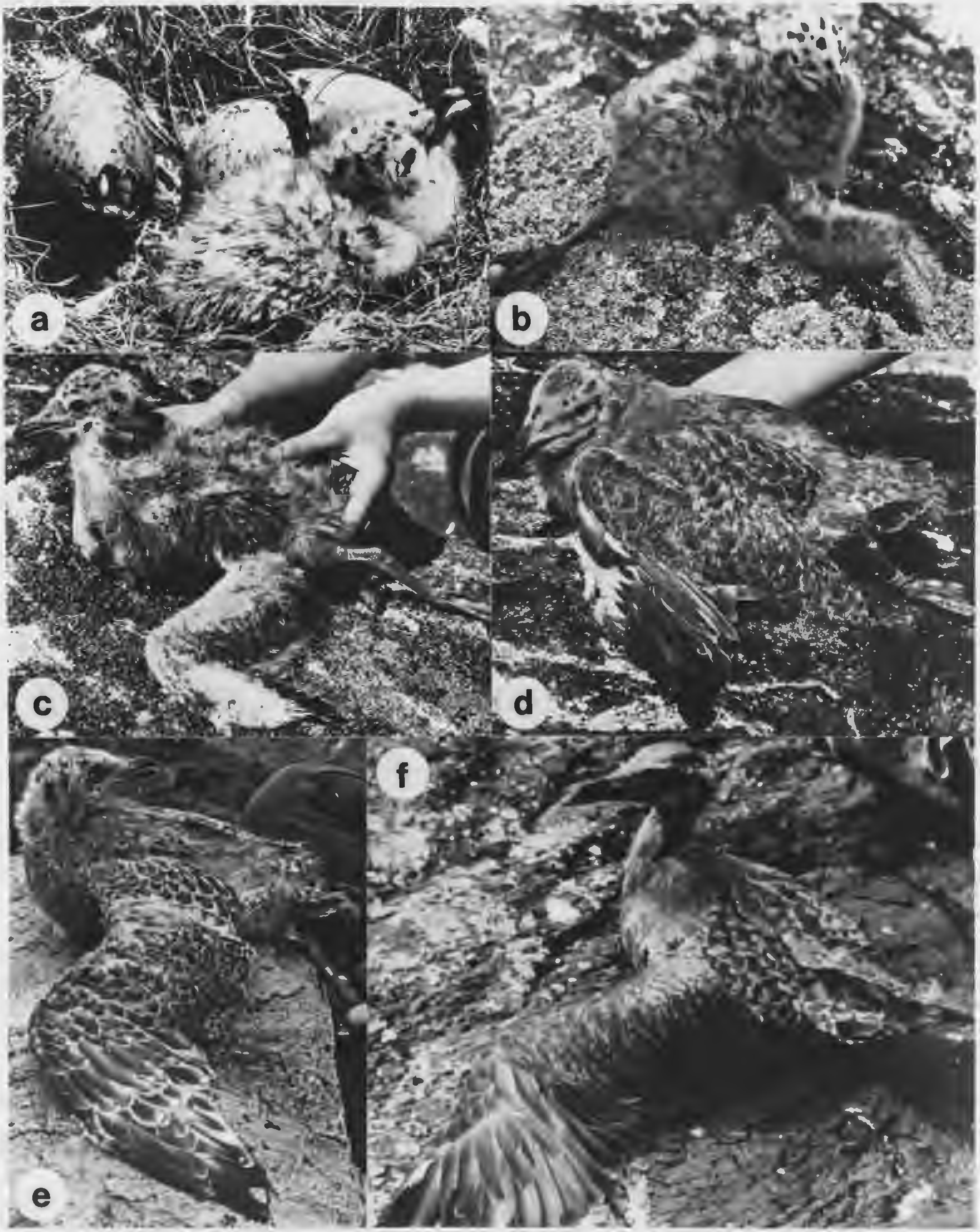
b. 11 days

c. 22 or 23 days

d. 30 days

e. 31 days

f. 36 days


a
b
c
d
e
f

By 11 to 12 days, the sheaths of the scapulars and ventral contour feathers were well developed, and the primary sheaths were prominent, but extended only slightly past the edge of the wing.

By 20 days, the primaries were 1 to 3 cm long, the secondary coverts began to emerge, the scapulars and contour feathers of the ventral pterylae were well formed, and the dorsal contour feathers, upper tail coverts and rectrices appeared. At 24 or 25 days, the rectrices protruded past the surrounding down. The auriculars were visible, but emerging feathers at the centre of the crown were still obscured by the surrounding down.

Development of contour feathers then spread from the above-mentioned areas until the ventral and dorsal surfaces were covered (30 to 35 days). At 35 days the head was completely feathered except for a fringe of down on the post orbital crease and occipital region. The top of the bill, chin and neck were still downy, but feather sheaths were developing in these regions. Down also remained on the flanks at this time. By the time of fledging (about 44 days) only a few strands of down could be seen.

On Gull Island, the rate of plumage development differed among individuals as did the weight. The wing coverts of the 31-day-old chick shown in Fig. 17,e were far more advanced than those of another chick (Fig. 17,d) at 30 days, though both chicks appeared healthy. Development of plumage may compete with other growth processes for the energy resources of nesting birds (Kahl, 1962): Kadlec *et al.* (1969) found that some herring gull chicks which appeared sick and soon died, showed markedly delayed feather development.

Breeding success. On the Point in 1971, a total of 199 chicks hatched from 273 eggs, with a hatching success of 72.9 per cent. Of 88 eggs in 35 nests in the predation nest area (Fig. 2,a) in 1969, 62.5 per cent hatched. These figures are similar to the findings of Paynter (1949), Harris (1964), Brown (1967), Kadlec *et al.* (1969), and Parsons (1971a), who reported 71%, 64.1%, 66.6%, 79.1%, and 64.3 to 69.9% hatching success, respectively. All these authors also indicated a reduced hatching success in one- and two-egg clutches. A similar trend was evident on Gull Island, even though the sample size was small (76.4 per cent for 57 clutches of 3, and 34.5 per cent for 18 clutches of one or two). This was probably the result of carelessness or inexperience in the individual laying less than the normal clutch, and maybe an illustration of a low reproductive drive (Parsons, 1971a).

The causes of egg loss are presented in Table 7. The third egg in a clutch appears subject to higher mortality than the first two. The most frequent cause of failure in these eggs was parental neglect during pipping. Often by the time the third chick was about to hatch, the first and second chicks had already hatched, and the parents had made the behavioral transition from incubation to feeding of the young. Frequently the third egg, with the dead chick partially emerged, was crushed, presumably trampled on by the parents.

The incidence of infertility ("Dead, no embryo" column, Table 7) was low, but there may have been a real trend toward higher infertility in the third egg.

Eggs which "disappeared without trace" were considered to have been taken by predators, since eggs are frequently stolen rather

Table 7

Hatching Success of Eggs and Sources of Embryonic Mortality of Herring Gulls

Order of laying, in clutch	Hatching Success			Mortality						
	Number laid	Number hatched	% hatched	Predated	Disappeared without trace	Dead, no embryo	Dead, with embryo	Rejected[1]	Died while pipping	Accidental breakage by investigator
First	102	74	72.5	2 (2%)	11 (11%)	4 (4%)	3 (3%)	2 (2%)	6 (6%)	0 (0%)
Second	95	74	77.9	2 (2%)	5 (5%)	3 (3%)	2 (2%)	2 (2%)	5 (5%)	2 (2%)
Third	76	51	67.1	2 (3%)	6 (8%)	5 (7%)	0 (0%)	2 (3%)	8 (11%)	2 (3%)
Total	273	199	72.9	6 (2%)	22 (8%)	12 (4%)	5 (2%)	6 (2%)	19 (7%)	4 (1%)

[1]An egg was designated "rejected" if abandoned in a nest, or if found intact within a short distance (0.5 m .) of the nest.

Table 8

Early Mortality of Herring Gull Chicks
1969 to 1971

Area/Treatment	Year	Number hatched	Number/Percent dead or missing in age class			
			0-5 days	6-10 days	11-25 days	more than 25 days
Area a, Fig. 1	1969	28	13/46.4	2/13.3	-	-
Area b, Fig. 1 (Point)	1969	32	5/15.6	-	-	-
Area a	1970	70	21/29.6	-	-	-
Area b; penned nests	1970	22	3/13.6	1/5.3	1/5.6	4/23.5
Area b; un-penned nests	1970	35	4/14.2	0/0	2/6.9	4/14.3
Area a	1971	33	4/12.1	0/0	2/6.9	-
Area b	1971	147	24/16.3	4/3.3	13/10.9	-
Combined	1969-1971	367	75/20.4	7/3.2	18/9.2	8/17.8

– = "no information"

than devoured at the owner's nest.

Thus predation amounted to a 10 per cent loss of all eggs laid, and failures concerning the behavioral transition of parents at the end of incubation accounted for a further 7 per cent loss. The losses due to death of the embryo or rejection of the egg during incubation were slight. Drent (1970) found that egg loss due to predation from other gulls was highest at the beginning and end of the incubation period, when attentiveness was relatively low. Whether the daily disturbance of the gulls when the nests were checked resulted in an increase in predation is not known. However that such an effect was important, seems doubtful considering the high observed hatching success.

The chick mortality described in Table 8 represents the maximum mortality which could have occurred, since all chicks which disappeared before 38 days of age were assumed to have died. Probably some of the older ones did survive to fledge.

Most of the chicks which died before fledging, did so before they were six days old (Table 8). Paynter (1949), Paludan (1951), Harris (1964), Brown (1967) and Kadlec and Drury (1968) all reported that highest mortality occurred during the first week to ten days of life. In some studies, a major source of mortality was predation by great black-backed gulls (Paynter, 1949; Paludan, 1951) or adult herring gulls (Brown, 1967; Parsons, 1971b). However, this phenomenon was rarely in evidence at Gull Island (Appendix 6). No partially eaten chicks were seen in 1970 and 1971, despite the fact that several carcasses were lying about in various states of decay. In 1967, a large number of chicks of all ages were found dead from unknown causes, but none of these carcasses showed signs of being eaten (W. Threlfall, pers. comm.). Although thousands of herring gull chicks were banded on the island each year, no regurgitated bands were found near nests of great black-backed gulls or herring gulls, in contrast to the findings of Harris (1964) and Parsons (1971b). However, the remains of petrels were found by many nests of both species, and the headless corpses of murre and puffin chicks were frequently found near certain nests of the great black-backed gull. Brown (1967) suggested that herring gulls might turn to cannibalising the young of their own species in dense colonies where other food is less readily available. If so, the dense murre colony on Green Island, and the abundance of petrels and puffins on Gull Island, may have provided an adequate alternative to herring gull chicks.

To some extent, the low density of gulls' nests, compared to Brown's colony (Walney Island), or individual food preferences (Parsons, 1971b), may have helped account for the infrequency of cannibalism on Gull Island.

Kadlec *et al.* (1969) felt that mortality from all causes until the young are partially independent, is fundamentally a result of problems in behavioral transition of the adults from incubation to brooding and feeding the young. This is clearly seen in the present study, since mortality from other causes (such as predation) was low: chicks were sometimes built into the nest, or found dead beside it. Mortality of gull chicks was sometimes seen after sudden temperature changes or rains: small dead chicks were seen after heavy rains

28 June 1970, possibly as a consequence of chilling due to inadequate brooding.

Mortality of chicks later in the pre-fledging period was associated most frequently with injuries to the occipital region of the skull. The skin of the area was usually denuded of feathers and often the skull was broken. Usually there were no injuries elsewhere on the body. Kadlec *et al.* (1969) and Parsons (1971b) associated this type of injury with territorial behaviour of the adults when chicks wandered (or were frightened by human disturbance) onto their territory.

Another source of mortality was drowning. Some chicks went to sea before they were able to swim strongly, and were caught in the swells and unable to land.

The mortality after 25 days (Table 8) is abnormally high, due to confinement of the chicks. Four of the dead chicks were enclosed in pens and had been losing weight rapidly for the previous few days. These chicks appeared weak and emaciated. Harris (1964) noted this phenomenon in some of his chicks kept in pens. Only one, or possibly two, of the unpenned chicks in the present study demonstrated extreme weight loss and death after 25 days of age (Appendix 4). However, even including the penned nests, the probable number of chicks fledging from the 23 nests of the growth study was 22. Thus the overall breeding success was slightly less than one fledged chick per nest. This figure is high compared to the breeding success reported by Paynter (1949); .03 to 1.0 chick per nest, Drost *et al.* (1961), 0.7 chick per nest, Harris (1964) 0.6, and Parsons (1971a), 0.7 to 0.9. Kadlec and Drury (1968) found that productivity in several New England colonies was usually between 0.8 to 1.4 fledged young per nest. Year after year, certain of these colonies had a higher breeding success than others only a few miles away. The islands farthest from the coast had a conspicuously low reproductive success, this being a situation similar to that reported by Paludan (1951) (about 0.5 chicks/nest). Kadlec and Drury felt that this low breeding success represented the natural reproduction rate of gulls, while the higher ones reflected easy access to human garbage.

Herring gulls are opportunists, feeding on fish found near the surface, crustaceans and molluscs, small birds and mammals, fish stolen from other sea-birds, and the young of various sea-bird species (Hatch, 1970; Nettleship, 1972), but where human waste and garbage are available, these form a large part of their diet (Mills, 1957; Harris, 1965; Threlfall, 1968c,d; Vauk and Löhmer, 1969; Löhmer and Vauk, 1969, 1970). Harris (1965) and Parsons (1971a) found that gulls breeding near fishing ports fed heavily on fish dock waste. Local availability of a prey species or food source is the main factor affecting the gulls' diet (Meijering, 1954) but individual preference is important where food is abundant (Harris, 1965).

Because of the large murre, puffin and petrel colonies on Gull and Green Islands, and the presence of the two fish processing plants in the coastal community of Witless Bay, food for the gulls was plentiful and accessible. Three million pounds of cod (*Gadus* *morhua*) in the round, were processed at one of the fish plants in 1971, where production had been steadily increasing for several years (A. O'Brien, pers. comm.). Large numbers of herring gulls and kittiwakes frequented the area near the Witless Bay wharf, picking up floating offal.

In June of each year, large schools of capelin (*Mallotus villosus*) move in to Witless Bay to spawn on the beaches. Many of these fish, as well as other species, and codfish offal were stored outside the other plant prior to processing into fish meal. Hundreds of gulls often gathered on top of this unsavoury pile, fighting to secure morsels. When capelin were spread on gardens as fertilizer, they were frequently stolen by gulls. Herring gulls were also seen near the dump which received refuse from several communities near Witless Bay. Thus human activities have provided the gulls with several readily available food sources.

The arrival of capelin during the third or fourth week in June was associated with a major change in food habits of the gulls (Appendix 6). The proportion of petrels, *Mytilus*, human refuse, and offal, which had been the major food items during the previous month, dropped abruptly as the gulls began to concentrate on capelin. The arrival of capelin and the shift in food corresponded closely to the peak of hatching of the chicks. Goethe (1937) and Meijering (1954) reported such changes from hard (*Carcinus* and insects) to soft food (fish and *Asterias*) when the chicks hatched, and it is probable that the great abundance and accessibility of capelin at the appropriate time is a major factor in the high breeding success of the herring gull on Gull Island.

A more accurate measure of breeding success is the number of young which actually live to reproduce. The highest mortality, after the chicks have fledged, takes place in the first autumn of their life (Nisbet and Drury, 1972; W. Threlfall, pers. comm.). Herring gulls and other gull species defend feeding areas in winter, but tolerate intrusion of juveniles (Carrick and Murray, 1964; Drury and Smith, 1968; Ingolfsson, 1969); thus if food were limiting, the young of less aggressive birds, or young neglected by their parents, would suffer proportionately higher mortality. However with the increasing and dependable food supply provided by garbage and sewage, mortality during the critical post-fledging period would be decreased. Harris (1970) suggested that rapid increases in herring gull populations (up to 25 per cent/year) can be explained without postulating immigration, if conditions are optimal for high breeding success over an extended number of years.

Great black-backed gull, *Larus marinus*

The great black-backed gull breeds along the east Coast of North America from New York to Labrador, also nesting on the west coast of Greenland, Iceland, the Faeroes, Spitzbergen, Bear Island, Northern Norway, and south as far as the British Isles, Denmark, and northern France. Its range has expanded both to the north and south since 1920 (Voous, 1960; Godfrey, 1966). Concurrent with the North American southward expansion, there was also a sudden increase in numbers (Gross, 1945). Deliberate destruction of the eggs of great black-backed gulls was begun in Britain (Skokholm Island) in 1949, after the gull population had begun to increase noticeably, in an effort to decrease its depredations on puffins and Manx shearwaters (Harris, 1965, 1970).

However Kadlec and Drury (1968, Fig. 7) reported that North American great black-backed gulls had not increased substantially in numbers, even after a control programme, initiated in the 1940's had ended.

The great black-backed gull is a common resident in Newfoundland; Tuck (cited in Peters and Burleigh, 1951) found it present in winter with herring gulls in the ratio of about 1 to 10. Peters and Burleigh (1951) and Tuck (1967) reported no increase in great black-backed gull numbers. It usually nests with larger numbers of herring gulls (for example 1:23), and occasionally in pure colonies (L. M. Tuck, pers. comm.).

A small population of great black-backed gulls nested on Gull Island, the 36 to 40 pairs (Table 9) forming only 2 per cent of the total number of nesting gulls. This species occupied the most elevated knoll on the Point (Fig. 4,c) and an adjoining grassy area, forming a loose colony. The nests were placed further apart than those of herring gulls. As they were composed only of small amounts of grass, they were well hidden among the hummocks. Other pairs nested solitarily along the east side and the north-east sector, often in prominent elevated locations, such as inaccessible outcrops at the tops of coves. This habit of nesting at vantage points, and on grass, is well documented (Gross, 1945; Harris, 1964).

Because many of the nests of great black-backed gulls already

Table 9

Censuses and Estimates of Numbers of Pairs of Marine Birds Nesting on Gull Island, 1969 to 1971

	1969	1970	1971
Oceanodroma leucorhoa	625,000	-*	-*
Larus marinus	-	36	40
Larus argentatus	2000	2508	2500
Rissa tridactyla	6977**	8306**	10,140
Alca torda	39	46	37
Uria aalge	136	260	316
Cepphus grylle	estimate (10-20)	10-20	10-20
Fratercula arctica	approximately 100,000	-*	-*

*No estimates made in these years, but no obvious changes evident.

**Maunder and Threlfall, 1972.

contained a full clutch of 3 eggs by mid-May, while half to one-third of the herring gull nests were still empty, a tendency of great black-backs to lay earlier (noted by Norton and Allen, 1931; Harris, 1964; and Erwin, 1971) seems also to obtain on Gull Island.

Although the eggs were indistinguishable in colour and markings from those of the herring gull, they were somewhat larger in size. The mean length and width of five first-laid eggs of the black-backed gull were 78.9 x 53.3 mm, six second eggs averaged 76.3 x 52.4 mm, and four third eggs, 75.0 x 51.5 mm. The weight loss of 5 eggs (mean fresh weight, 105 g) during incubation ranged from 10.7 to 23.5 per cent (mean, 18.1 per cent). Harris (1964) found that weight loss in great black-backed gulls' eggs amounted to only 12.8 per cent (range, 10 to 18 per cent in 18 eggs), but the small sample sizes could account for this discrepancy.

The mean incubation period of two first-laid eggs was 31.5 ± 1 days, and of five second eggs was 29.8 ± 1. Two third eggs hatched 30 ± 1 day after laying. The shorter incubation period reported by Lockley (1932) for British great black-backed gulls (27 to 28 days) may be related to the smaller size of its eggs (Harris, 1964; Parsons, 1972).

Twenty eggs were laid in nine marked nests in 1971 (mean clutch size, 2.2 eggs/nest). Of these, ten hatched (50 per cent). Of the eggs which failed, two contained no sign of an embryo, one was broken though containing an embryo, and one was crushed while pipped. Of the other six, one was eaten by a predator, and five disappeared, presumably also taken by predators. The behaviour of the black-backed gulls indicated that the daily checking of marked nests caused much greater disturbance to this species than to the herring gull. At the approach of the observer, the black-backs would become alarmed and fly from their nests long before the herring gulls. They circled higher over the nest, settled later after the disturbance was over, and rarely made the swooping attacks frequently seen in the herring gulls. Norton and Allen (1931) noted the wariness of the great black-backed gull, and reported that it moved to more remote breeding grounds if disturbed. Erwin (1971) found a very low hatching success (44 per cent) among great black-backed gulls breeding near herring gulls in Rhode Island. His observations were made only every 3 days, yet he felt the disturbance created by them was "undoubtedly a significant factor" (p. 155) affecting hatching success. In addition he postulated that since the black-backs were laying eggs at a time of much aggression among the herring gulls (for example, in establishing territorial boundaries), this disturbance may have led them to neglect, or even desert their nests, thus allowing predation of the eggs by other gulls. Nest neglect, permitting attacks by predators or chilling and death of young embryos (Parsons, 1971a), and behavioural lapses resulting in breakage of the eggs, could account for the low hatching success on Gull Island. Whether the cause was human or avian, it appears that the productivity of the great black-backed gull was very sensitive to disturbance, a phenomenon not noted by Harris (1964) in British great black-backed gulls.

Of the ten chicks which hatched in the marked nests, five were found dead before 13 days of age, and two others disappeared by six days of age. Probably at most 3 chicks from the nine nests survived to fledge.

Growth studies were also restricted by desertion of the penned nests, often before the eggs hatched, and weight recessison in penned chicks at abnormally early ages (Appendices 4 and 5). Chick number 1-1, in a pen only half as high as the others, presenting little barrier to its movements, did not show weight loss until its 25th day, at which point the pen was removed and the chick grew rapidly (Appendix 4).

The food of the great black-backed gull is included with that of the herring gull (Appendix 6) due to uncertainty as to which species owned various nests. The adult puffins, however, were found only at one or two nests of great black-backs; these were the same nests at which headless murre and puffin chicks were most frequently found.

In contrast to the British great black-backed gulls, which kill thousands of Manx shearwaters and puffins each year and eat large numbers of young herring gulls and lesser black-backed gulls (Harris, 1965), few of the Gull Island black-backs appeared to specialize in taking the large sea-birds, or gull chicks. Capelin was eaten when available, salmon was stolen from gill nets up to 2 m (1 fathom) below the surface, tomcod (*Microgadus tomcod*) and small codfish were taken, and to some extent, fish plant offal was eaten. Threlfall (1968c) attributed at least 1000 petrel deaths a year to the herring and great black-backed gulls on the Witless Bay Islands.

Garbage was rarely seen by the nests of black-backed gulls.

If great black-backed gulls do not feed on garbage and fish-plant wastes to the extent that herring gulls do, this fact, combined with a low reproductive success, may be responsible for the slower growth of the population.

GENERAL DISCUSSION

Southeastern Newfoundland lies at the boundary of the boreal or subarctic marine zone, and the low arctic marine zone (Dunbar, 1968; Ashmole, 1971), near the convergence of the warm, eastward-flowing Gulf Stream and the cold, subarctic water of the Labrador current (Tempelman, 1966). Because of the similar densities of these water masses, the upper layers are characterized by intense mixing and high nutrient content, and thus high productivity, over a long productive season (Bourne, 1963). In the waters over the broad continental shelves, the abundant ichthyofauna, especially herrings (Clupeidae), sand eels (Ammodytidae), codfishes (Gadidae) and capelin (*Mallotus villosus*), form an important part of the diet of the sea-birds (Belopol'skii, 1957; Tuck, 1961; Pearson, 1968). These sea-bird colonies of the boreal and low arctic zones in Newfoundland and Labrador the British Isles, Norway, Iceland, and the Murman Coast of the USSR, are among the largest in the world, as precipitous,coastal cliffs and islands suitable for sea-bird nesting are also abundant here (Fisher and Lockley, 1954).

The increases in bird numbers reported on Gull Island in the past forty years, and in particular from 1969 to 1971, are parallelled by those in other North Atlantic colonies. A widespread and general increase has occurred in the numbers of fulmars (Fisher, 1952a,b), gannets (Nelson, 1966), kittiwakes (Coulson and White, 1956), gulls (Harris, 1970) and murres (Tuck, 1961), mostly since the turn of the present century and in many cases accompanied by range expansions. Other species, such as the puffin (Flegg, 1972) and certain of the Laridae (Nisbet, 1971) have been decreasing in some regions.

Since most sea-birds are long-lived, and have a low reproductive rate and delayed maturity (Lack, 1966, 1968) and may experience yearly fluctuations in breeding numbers (Fay and Cade, 1959), changes in their populations are usually slow, and detection of the causes is difficult. A number of factors such as availability of food and nesting sites, predation, and oceanographic changes, seem to be important (Ashmole, 1971).

The long-term oceanographic changes associated with climatic amelioration may have allowed range expansion in, among others, the fulmar (Fisher, 1952b; Gudmundsson, 1958) and great black-backed gull (Voous, 1960).

Predation by man was an important factor until the early 20th century. After the passing of the Migratory Birds Act (1916), the North American populations of gannets, murres, puffins and gulls have recovered from their former low levels (Bent, 1919; Tuck, 1961; Kadlec and Drury, 1968). To some extent the increase of gannet populations in the British Isles may have been due to cessation of taking the birds for food, and reduction of human disturbance at the colonies during the war years (Nelson, 1966). Predation by rats and other mammals can exterminate colonies of burrow-nesting birds (Gross, 1935) and cause desertion or destruction of the eggs in some gull species (Emlen *et al.*, 1966; Kadlec and Drury, 1968). Mortality due to man's activities (from oiling, entanglement in fishing nets, and pesticides) reduces the numbers of some species (Tuck, 1959, Gillespie, 1968;

Tull *et al.*, 1972; Hays and Riseborough, 1972). Excessive recreational use of islands may reduce productivity of such species as puffins and petrels (Jouanin, 1970).

If the number of nest sites is insufficient, some birds must nest in marginal locations or not at all in a given year. Kittiwakes and gulls nesting at the periphery of a colony demonstrate lower reproductive success than those of the centre (Coulson, 1968; Patterson, 1965).

Uspenski (1956) and Tuck (1961) found that clearing ledges of soil and debris resulted in an increased number of breeding murres.

Food appears to be the single most important factor influencing population changes in many sea-birds. Their breeding period often closely corresponds to the arrival inshore of vast numbers of their prey animals (Marshall, 1951), the superabundance of food minimizing competition (Lack, 1946). Pearson (1968) showed that different species would be able to avoid competition if food became scarce, by utilizing different foraging ranges, and taking prey at different depths.

The more dispersed food available in winter may lead to density dependent mortality, especially of young birds (Kadlec and Drury, 1968); thus the increased year round food source from fish waste (and formerly whaling) may have decreased mortality in species which have developed the scavenging habit (Fisher, 1952a; Harris, 1970). Declines due to fishing pressure in the stocks of cod and other fish preying on capelin, may have allowed capelin numbers to increase (Templeman, 1966); such an increase might be beneficial to the pelagic alcids.

Small fish, mostly capelin, were eaten by murres, razorbills, puffins, kittiwakes (Maunder and Threlfall, 1972) and gulls breeding on Gull Island. The period of capelin abundance coincided with the growth period of the chicks in all the above species except puffins. It is to be expected that changes in the abundance of capelin might eventually be reflected in the numbers of the birds (Belopol'skii, 1957), if availability of nest sites were not limiting and mortality rates were not abnormally high.

Since the area utilized by murres and kittiwakes increased noticeably from 1969 to 1971, there did not appear to be any serious scarcity of nesting sites for these species on Gull Island. Puffin and petrel habitat may be nearing saturation point, whilst some sites apparently suitable for razorbills and black guillemots are still unoccupied. Gulls occupied the whole unforested area of the island, and their nest density increased during the period of the study (5 years).

No predatory mammals exist on Gull Island. Human predation has decreased since 1963 when the Witless Bay Provincial Sea-Bird Sanctuary was established. Prior to Confederation (1949), although all nesting birds were protected by the Colony, sea-birds such as gulls, puffins and murres were legally taken for food. Since 1949, and the application to the new Province of the Federal Migratory Birds Convention Act, all these so-called migratory non-game birds are protected throughout the year. However, in 1958, an amendant was made to the Act to allow resident Newfoundlanders the traditional right to take murres (but not gulls or puffins) for food during the non-breeding season. A trend toward urbanization, and an increase in tourism has been followed by a decline in the poaching of alcids, but increasing numbers perish in gill nets. Interavian predation did not appear substantial, except for the taking of petrels by the large gulls; petrel losses might increase if gull numbers continue to rise, or if alternative food sources were not available to the gulls.

SUMMARY

The topography, climate and vegetation of Gull Island are described. The terrestrial avifauna is described and evidence is presented to show which species probably bred there during the period of the study.

Nine aquatic and shore bird species nested on the island: their numbers, habitat, and nesting phenology are described. No change was noted in the numbers of petrels, puffins, or black guillemots. Herring gull, kittiwake and murre numbers increased substantially during the period of the study, but great black-backed gull and razorbill numbers did not change markedly.

A special study was carried out on the breeding biology of the herring gull. Weight recession of the gonads was rapid after mid-May, especially in males.

The nests of the gulls are described, with respect to size, composition, immediate surroundings, and density in various areas of the island.

Egg-laying began as early as 22 April and reached a peak about 10 to 14 May. New clutches were begun an average of 12.6 days after the loss of the original clutch. The average clutch size was 2.70 in 1970 and 2.73 in 1971. Clutch size decreased as the season progressed.

Measurements of eggs revealed that the third laid egg was smaller than the first two. Weight loss of the eggs during the course of incubation amounted to 16 per cent of the fresh weight. The mean incubation period was 29.4, 28.2 and 27.1 days for first, second and third eggs.

Development of embryos and hatching of the chicks are described. Chick growth curves for weight, culmen, tarsus and wing measurements are presented. There was no difference in growth of chicks in pens and at large, and no significant differences in the growth of first, second, and third hatched chicks in a brood. The development of the plumage is described.

Breeding success was measured by hatching success (62.5%-72.9%) and chick mortality up to 25 days of age (24.9%). On a small sample (23 nests) an average of just less than one chick per nest survived to fledge.

The food of the gulls is described, and the possible influence of food availability on breeding success and population growth is discussed.

A low breeding success (hatching success = 50 per cent) and apparent sensitivity to disturbance, compared to the herring gull, were observed in the great black-backed gull.

Some possible causes of the general increase in sea-bird species are discussed.

LITERATURE CITED

*Amadon, D. 1958. The encroachment of Herring Gulls *(Larus argentatus)* on more desirable sea-fowl in the eastern United States. Bull. Int. Comm. Bird Preserv. 7:114.

Ainslie, J. A. and R. Atkinson. 1937. On the breeding habits of Leach's fork-tailed petrel. Brit. Birds 30:234-248.

Ashmole, N. P. 1971. Sea bird ecology and the marine environment, pp. 223-286. In D. S. Farner and J. R. King [ed.] Avian Biology. Vol. 1. Academic Press, New York and London. 586 p.

Barth, E. K. 1968. Egg dimensions and laying dates of *Larus marinus*, *L. argentatus*, *L. fuscus*, and *L. canus*. Nytt. Mag. Zool. 15:5-34.

Bédard, J. 1969. Histoire naturelle du Gode, *Alca torda* L. dans le golfe Saint-Laurent, province de Québec, Canada. Etude du Service Canadien de la Faune-No. 7. Ottawa. 79 p.

Belopol'skii, L. O. 1957. Ecology of sea colony birds of the Barents Sea. [Transl. from Russian, 1961. Israel Program for Scientific Translations, Jerusalem. 346 p.]

Bent, A. C. 1919. Life histories of North American diving birds. U.S. Nat. Mus. Bull. 107:1-245.

________. 1921. Life histories of North American gulls and terns. U.S. Nat. Mus. Bull. 113:1-337.

________. 1922. Life histories of North American petrels and pelicans and their allies. U.S. Nat. Mus. Bull. 121:1-343.

Bongiorno, S. F. 1970. Nest-site selection by adult laughing gulls. Anim. Beh. 18:434-444.

Bourne, W. R. P. 1963. A review of oceanic studies of the biology of seabirds. Proc. XIII Int. Ornithol. Congr., pp. 831-854.

Brooke, M. de L. 1972. The puffin population of the Shiant Islands. Bird Study 19:1-6.

Brough, T. 1969. Damage by gulls. Ibis 111:445-446.

Brown, R. G. B. 1967. Breeding success and population growth in a colony of herring gulls and lesser black-backed gulls *Larus argentatus* and *L. fuscus*. Ibis 109:502-515.

---

*Not seen

Brown, R. G. B. 1968. Sea Birds in Newfoundland and Greenland Waters Apr-May 1966. Can. Field Natur. 82:88-102.

Carrick, R. and M. D. Murray. 1964. Social factors in population regulation of the Silver Gull, *Larus novaehollandiae* Stephens. C.S.I.R.O. Wildl. Res. 9:189-199.

Chapman, F. M. 1968. The warblers of North America. [Reprint of 1917 edition.] Dover Publications, New York. 307 p.

Conard, H. S. 1956. How to know the mosses and liverworts. Wm. C. Brown Co., Dubuque, Iowa. 226 p.

Coulson, J. C. 1968. Differences in quality of birds nesting in the centre and on the edges of a colony. Nature 217:478-479.

________ and E. White. 1956. A study of colonies of the kittiwake *Rissa tridactyla*. Ibis 98:63-79.

________. 1961. An analysis of factors influencing the clutch size of the kittiwake. Proc. Zool. Soc. London 139:207-217.

Cramp, S. 1971. Gulls nesting on buildings in Britain to Ireland. Brit. Birds 64:476-487.

Cullen, E. 1957. Adaptations of the kittiwake to cliff-nesting. Ibis 99:275-302.

Darling, F. F. 1938. Bird flocks and the breeding cycle. A contribution to the study of avian sociality. University Press, Cambridge.

Dement'ev, G. P. and N. A. Gladkow [ed.] 1951. Birds of the Soviet Union. VOL. II [Transl. from Russian, 1969. Israel Program for Scientific Translations, Jerusalem. 553 p.]

Drent, R. H. 1970. Functional aspects of incubation in the herring gull. Behav. Suppl. 17:1-132.

Drent, G. F. van Tets, F. Tompa, and K. Vermeer. 1964. The breeding birds of Mandarte Island, British Columbia. Can. Field Natur. 78:208-263.

Drost, R., E. Focke and G. Freytag. 1961. Entwicklung and Aufbau einer Population der Silbermöwe. J. Orn. 102:404-429.

Drury, W. H., Jr. 1963. Results of a study of herring gull populations and movements in southeastern New England. From Colloque: le Problème des oiseaux sur les aérodromes. Nice, les 25, 26 et 27 novembre, 1963.

Drury, W. H., Jr. and W. J. Smith. 1968. Defense of feeding areas by adult herring gulls and intrusion by young. Evolution 22: 193-201.

Dunbar, M. J. 1968. Ecological development in polar regions: a study in evolution. Prentice-Hall, Englewood Cliffs, N.J. 119 p.

Emlen, J. T., D. Miller, R. M. Evans and D. H. Thompson. 1966. Predator-induced parental neglect in a ring-billed gull colony. Auk 83:677-679.

Erwin, R. M. 1971. The breeding success of two sympatric gulls, the herring gull and the great black-backed gull. Wilson Bull. 83:152-158.

Farner, D. S. 1964. The photoperiodic control of reproductive cycles in birds. Amer. Sci. 52:137-156.

Fay, F. H. and T. J. Cade. 1959. An ecological analysis of the avifauna of St. Lawrence Island, Alaska. Univ. Calif. Publ. Zool. 63:73-149.

Fernald, M. L. [ed.] 1950. Gray's Manual of Botany. 8th edition. American Book Co., New York 1632 p.

Finch, D. W. 1972. Regional reports; the fall migration, August 16, 1971 to November 30, 1971; Northeastern Maritime Region. American Birds 26:34.

Fisher, J. 1952a. A history of the fulmar *Fulmarus* and its population problems. Ibis 94:334-354.

________. 1952b. The Fulmar. Collins, London. 496 p.

________ and R. M. Lockley. 1954. Sea-Birds. Collins, London. 320 p.

Fisher, R. A. 1967. Statistical methods for research workers. 13th ed. Hafner, New York. 356 p.

Flegg, J. J. M. 1972. The puffin on St. Kilda. Bird Study 19:7-17.

Géroudet, P. 1968. L'expansion du goéland argenté *Larus argentatus michahellis* dans le bassin du Rhône et en Suisse. Nos Oiseaux 29:313-335.

*Gillespie, D. L. 1968. A summary of oil pollution in Newfoundland's coastal waters, 1949-1968. Unpublished typescript report, Canadian Wildlife Service. 13 p.

---

*Not seen

Godfrey, W. E. 1966. The Birds of Canada. National Museum of Canada, Bulletin No. 203. Queen's Printer, Ottawa. 428 p.

Goethe, F. 1937. Beobachtungen und Untersuchungen zur Biologie der Silbermöwe (*Larus argentatus argentatus* Pontoppidan) auf der Vogelinsel Memmertsand. J. Orn. 85:1-119.

________. 1956. Die Silbermöwe. A. Ziemsen Verlag, Wittenberg Lutherstadt. 95 p.

________. 1960. Felsbrutertum und weitere beachtenswerte Tendenzen bei der Silbermöwe. Proc. XII Int. Ornithol. Congr., pp. 252-258.

Greenwood, J. 1964. The fledging of the guillemot (*Uria aalge*) with notes on the razorbill (*Alca torda*). Ibis 106:469-481.

Grenquist, Pekka. 1965. Changes in abundance of some ducks and sea-bird populations off the coast of Finland 1949-1963. Riistatieteellisiä Julkaisuja, Helsinki. 27:7-114.

Gross, A. O. 1935. The life history of Leach's petrel (*Oceanodroma leucorhoa* L.) on the outer sea islands of the Bay of Fundy. Auk 52:382-399.

________. 1945. The present status of the great black-backed gull on the coast of Maine. Auk 62:241-256.

*Gudmundsson, F. 1958. The effect of the recent climatic changes on the bird life in Iceland. Proc. X Intern. Ornith Congr., pp. 502-514.

Hale, M. E. 1969. How to know the lichens. Wm. C. Brown Co., Dubuque, Iowa. 226 p.

Hare, F. K. 1952. The climate of the island of Newfoundland. Can. Dep. Mines Tech. Surv., Geog. Bull., No. 2, 1952. pp. 36-88.

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

________. 1965. The food of some *Larus* gulls. Ibis 107:43-53.

________. 1970. Rates and causes of increase of some British gull populations. Bird Study 17:325-335.

Hatch, J. J. 1970. Predation and piracy by gulls at a ternery in Maine. Auk 87:244-254.

Hays, H. and R. W. Riseborough. 1972. Pollutant concentrations in abnormal young terns from Long Island Sound. Auk 89:19-35.

---

*Not seen

Huntington, C. E. 1963. Population dynamics of Leach's petrel, *Oceanodroma leucorhoa*. Proc. XIII Int. Ornithol. Congr., pp. 701-705.

Ingolfsson, A. 1969. Behaviour of gulls robbing eiders. Bird Study 16:45-52.

*Jouanin, C. 1970. L'avenir des oiseaux pélagiques. Courr. Nature-Homme Oiseau 13:1-4.

Kadlec, J. A. and W. H. Drury. 1968. Structure of the New England herring gull population. Ecology 49:644-676.

Kadlec, J. A., W. H. Drury, Jr., and D. K. Onion. 1969. Growth and mortality of herring gull chicks. Bird Banding 40:222-233.

Kahl, M. P. Jr. 1962. Bioenergetics of growth in nestling wood storks. Condor 64:169-183.

Kartaschew, N. N. 1960. Die Alkenvögel des Nordatlantiks. A. Ziemsen Verlag, Wittenberg Lutherstadt. 154 p.

Keith, J. A. 1966. Reproduction in a population of herring gulls (*Larus argentatus*) contaminated by DDT. J. Appl. Ecol. 3 (supplement):57-70.

Lack, D. 1946. Competition for food by birds of prey. J. Anim. Ecol. 15:123-129.

________. 1966 Population studies of birds. Clarendon Press, Oxford. 341 p.

________. 1968. Ecological adaptations for breeding in birds. Methuen & Co. Ltd., London. 409 p.

________. 1969a. Population changes in the land birds of a small island. J. An. Ecol. 38:211-218.

________. 1969b. The numbers of bird species on islands. Bird Study 16:193-209.

Lockley, R. M. 1932. Incubation-periods of lesser and greater black-backed and herring gulls. Brit. Birds 25:310-313.

________. 1953. Puffins. Dent & Sons, London.

Lohmer, K. and G. Vauk. 1969. Nahrungsökologische Untersuchungen an übersommernden Silbermöwen (*Larus argentatus*) auf Helgoland im August/September 1967. Bonn. Zool. Beitr. 1:110-124.

Löhmer, K. and G. Vauk. 1970. Ein weitere Beitrag zur Ernährung Helgoländer Silbermöwen. Die Vogelwarte 25:242-245.

MacLean, S. F. Jr. and N. A. M. Verbeck. 1968. Nesting of the black guillemot at Point Barrow, Alaska. Auk 85:139-140.

MacRoberts, M. H. and B. R. MacRoberts. 1972. The relationship between laying date and incubation period in herring and lesser black-backed gulls. Ibis 114:93-97.

*Marshall, A. J. 1951. Food availability as a time factor in the sexual cycle of birds. Emu 50:267-282.

Marshall, A. J. 1959. Internal and environmental control of breeding. Ibis 101:456-477.

Maunder, J. E. 1971. The breeding biology of the black-legged kittiwake (*Rissa tridactyla* L.) on Gull Island, Newfoundland. B.Sc. (Honours) Thesis. Memorial University of Newfoundland. 57 p.

Maunder, J. E. and W. Threlfall. 1972. The breeding biology of the black-legged kittiwake in Newfoundland. Auk 89:789-816.

Meijering, M. P. D. 1954. Zur Frage der Variation in der Ernährung der Silbermöwe, *Larus argentatus* Pontoppidan. Ardea 42: 163-175.

Mills, D. H. 1957. Herring gulls and common terns as possible predators of lobster larvae. J. Fish. Res. Bd. Canada 14:729-730.

Moreau, R. E. 1946. The recording of incubation and fledging periods. Brit. Birds 39:66-70.

Morse, D. H. 1971. Effects of arrival of a new species upon habitat utilization by two forest thrushes in Maine. Wilson Bull. 83:57-65.

Nelson, J. B. 1966. The breeding biology of the Gannet *Sula bassana* on Bass Rock, Scotland. Ibis 108:584-626.

Nettleship, D. N. 1972. Breeding success of the common puffin (*Fratercula arctica* L.) on different habitats at Great Island, Newfoundland. Ecol. Monographs 42:239-268.

Nisbet, I. C. T. 1971. The laughing gull in the Northeast. American Birds 25:677-683.

---

*Not seen

Nisbet, I. C. T. and W. H. Drury. 1972. Post-fledging survival in herring gulls in relation to brood-size and date of hatching. Bird Banding 43:161-240.

Norton, A. H. and R. P. Allen. 1931. Breeding of the great black-backed gull and double-crested cormorant in Maine. Auk 48:589-592.

Palmer, R. S. [ed.] 1962. Handbook of North American Birds. Vol. 1. Loons through Flamingos. Yale University Press, New Haven. 567 p.

Paludan, K. 1951. Contributions to the breeding biology of *Larus argentatus* and *Larus fuscus*. Vidensk. Medd. Dansk Naturh. Foren. 114:1-128.

Parslow, J. L. F., D. J. Jefferies, and M. C. French. 1972. Ingested pollutants in puffins and their eggs. Bird Study 19:18-33.

Parsons, J. 1969. Chick mortality in herring gulls. Ibis 111:443-444.

________. 1970. Relationship between egg size and post-hatching chick mortality in the herring gull (*Larus argentatus*). Nature 228:1221-1222.

________. 1971a. The breeding biology of the herring gull (*Larus argentatus*) Ph.D. Thesis. University of Durham. 219 p.

________. 1971b. Cannibalism in herring gulls. Brit. Birds 64: 528-537.

________. 1972. Egg size, laying date and incubation period in the herring gull. Ibis 114:536-541.

Patterson, I. J. 1965. Timing and spacing of broods in the black-headed gull. Ibis 107:433-459.

Paynter, R. A. 1949. Clutch size and egg and chick mortality of Kent Island herring gulls. Ecology 30:146-166.

Pearson, T. H. 1968. The feeding biology of sea-bird species breeding on the Farne Islands, Northumberland. J. Anim. Ecol. 37:521-552.

Peters, H. S. and T. D. Burleigh. 1951. The birds of Newfoundland. Dep. Natur. Resources, Prov. Newfoundland, St. Johns. 431 p.

Peterson, R. T. 1963. A field guide to the birds. Houghton Mifflin, Boston. 290 p.

Pitt, T. K. 1958. Distribution, spawning and racial studies of the capelin, *Mallotus villosus* (M.) in the offshore Newfoundland area. J. Fish. Res. Bd. Canada 15:275-293.

Plumb, W. J. 1965. Observations on the breeding biology of the razorbill. Brit. Birds 58:449-456.

Rowan, M. K. 1965. Regulation of seabird numbers. Ibis 107:54-59.

Rose, E. R. 1952. Torbay Map-Area, Newfoundland. Geological Survey of Canada Memoir No. 265, Canada Dep. Mines & Tech. Surveys. Queen's Printer, Ottawa. 64 p.

Salomonsen, F. 1939. Oological studies in gulls. 1. Egg-producing powers of *Larus argentatus* Pont. Dansk Orn. Foren. Tidsskr. 33:113-133.

*Silverman, P. H. and R. B. Griffiths. 1955. A review of methods of sewage disposal in Great Britain, with special reference to the epizoology of *Cysticercus bovis*. Ann. Trop. Med. Parasitol. 49:436-450.

Smith, Jean E. and K. L. Diem. 1972. Growth and development of young California gulls (*Larus californicus*) Condor 74: 462-470.

Templeman, W. 1945. Observations on some Newfoundland sea-birds. Mimeo. report. Dep. Natur. Resources, Prov. Newfoundland, St. John's. 24 p.

________. 1948. The life history of the capelin (*Mallotus villosus* O. F. Müller) in Newfoundland waters. Nfld. Gov. Lab. Res. Ser., Bull. No. 17. 151 p.

________. 1966. Marine resources of Nfld. Ottawa, Fish. Res. Bd. Canada, Bulletin No. 154. 170 p.

Threlfall, W. 1968a. Studies on the helminth parasites of the American herring gull *Larus argentatus* Pont. in Newfoundland. Can. J. Zool. 46:1119-1126.

________. 1968b. The helminth parasites of three species of gulls in Newfoundland. Can. J. Zool. 46:827-830.

________. 1968c. The food of three species of gulls in Newfoundland. Can. Field Natur. 82:176-180.

________. 1968d. The food of herring gulls in Anglesey and Caernarvonshire. Nature in Wales 11:67-73.

---

*Not seen

Tinbergen, N. 1953. The herring gull's world. Collins, London. 255 p.

Tuck, L. M. 1959. Oil pollution in Newfoundland. Proc. Int. Conf. Oil Pollution of the Sea. Copenhagen, 1959. pp. 76-79.

________. 1961. The murres. Canadian Wildlife Series, No. 1. Queen's Printer, Ottawa. 260 p.

________. 1967. The birds of Newfoundland, pp. 265-316. In J. R. Smallwood [ed.] The Book of Newfoundland, Vol. III. Newfoundland Book Publishers Ltd., St. John's.

Tuck, L. M. 1971a. The occurrence of Greenland and European birds in Newfoundland. Bird Banding 42:184-209.

________. 1971b. Mortality of local murres due to gill nets. In Canadian Wildlife Service monthly report for August 1971.

Tull, C. E., P. Germain and A. W. May. 1972. Mortality of thick-billed murres in the West Greenland salmon fishery. Nature 237 :42-44.

Uspenski, S. M. 1956. The bird bazaars of Novaya Zemlya. Can. Wildl. Serv., Transl. Russ. Game Rep. (1958) 4:1-159.

Vauk, G. and K. Löhmer. 1969. Ein weitere Beitrag zur Ernährung der Silbermöwe (*Larus argentatus*) in der Deutschen Bucht. Veröff. Inst. Meeresforsch. Bremerh. 12:157-160.

Voous, K. H. 1960. Atlas of European birds. Nelson and Sons, London. 284 p.

Welty, J. C. 1962. The life of birds. Saunders, Philadelphia and London. 546 p.

Wilbur, H. H. 1969. The breeding biology of Leach's petrel, *Oceanodroma leucorhoa*. Auk 86:433-442.

Winn, H. E. 1950. The black guillemots of Kent Island, Bay of Fundy. Auk 67:477-485.

Appendix 1.

Plant species found on Gull Island

Classification of Lichens is as given in Hale and Culberson, 1966; classification of mosses and liverworts as given in Conard, 1956; and classification of vascular plants according to Fernald, 1950.

Lichens:

Lobaria pulmonaria (L.) Hoffm.

Lobaria scrobiculata (Scop.) DC.

Cladonia coniocraea (Flörke) Spreng.

Cladonia fimbriata (L.) Fr.

Cladonia sp.

Haematomma spp.

Lecanora muralis (Schreb.) Rabenh.

Lecanora subfusca (L.) Ach.

Cetraria sp.

Hypogymnia sp.

Parmelia aurulenta Tuck.

Parmelia subaurifera Nyl.

Parmelia sulcata Tayl.

Parmelia sp.

Parmeliopsis aleurites (Ach.) Nyl.

Ramalina farinacea (L.) Ach.

Ramalina intermedia Del. ex Nyl.

Ramalina miniscula (Nyl.) Nyl.

Ramalina pollinaria (Westr.) Ach.

Usnea comosa (Ach.) Ach.

Usnea longissima Ach.

Usnea sp.

Anaptychia galactophylla (Tuck.) Trev.

Xanthoria parietina (L.) Th. Fr.

Xanthoria polycarpa (Ehrh.) Oliv.

Mosses:

Sphagnum sp.

Polytrichum Commune Hedw.

Polytrichum ohioense R. & C.

Dicranum fuscescens Turn.

Dicranum scoparium Hedw.

Ulota crispa (Hedw.) Brid.

Mnium hornum Hedw.

Rhytidiadelphus loreus (Hedw.) Warnst.

Liverworts:

Ptilidium pulcherrimum (Web.) Hampe

Calypogeia trichomanis (L.) Corda

Cephalozia media Lindb.

Nowellia curvifolia (Dicks.) Mitt.

Odontoschisma denudatum (Nees) Dumort.

Lophocolea heterophylla (Schrad.) Dumort.

Vascular plants:

OSMUNDACEAE

Osmunda cinnamomea L.

Osmunda claytoniana L.

POLYPODIACEAE

Dryopteris spinulosa (O. F. Muell.) Watt

Polypodium virginianum L.

TAXACEAE

Taxus canadensis Marsh.

PINACEAE

Abies balsamea (L.) Mill.

Lavix laricina (Du Roi) K. Koch

Picea glauca (Moench) Voss

Picea mariana (Mill.) BSP.

GRAMINEAE

Alopecurus pratensis L.

Anthoxanthum odoratum L.

Calamagrostis inexpansa Gray

Deschampsia flexuosa (L.) Trin.

Festuca ovina L.

Festuca rubra L.

Poa pratensis L.

Puccinellia paupercula (Holm) Fern. & Weath.

CYPERACEAE

Carex canescens L.

Carex paleacea Wahlenb.

Carex scoparia Schkuhr

Carex trisperma Dewey

Eriophorum angustifolium Honckeny

JUNCACEAE

Juncus bufonius L.

Juncus effusus L.

Luzula multiflora (Retz.) Lejeune

LILIACEAE

Clintonia borealis (Ait.) Raf.

Maianthemum canadense Desf.

Smilacina stellata (L.) Desf.

Smilacina trifolia (L.) Desf.

Streptopus amplexifolius (L.) DC.

IRIDACEAE

Iris Hookeri Penny

MYRICACEAE

Myrica Gale L.

CORYLACEAE

Alnus crispa (Ait.) Pursh

Betula papyrifera Marsh.

POLYGONACEAE

Polygonum Persicaria L.

Polygonum sp.

Rumex Acetosa L.

Rumex Acetosella L.

Rumex crispus L.

CHENOPODIACEAE

Atriplex sp.

CARYOPHYLLACEAE

Cerastium vulgatum L.

Cerastium sp.

Sagina nodosa (L.) Fenzl

Spergula arvensis L.

Spergularia rubra (L.) J. & C. Presl

Stellaria media (L.) Cyrillo

RANUNCULACEAE

Ranunculus acris L.

Ranunculus repens L.

Thalictrum polygamum Muhl.

CRUCIFERAE

Cochlearia cyclocarpa Blake

Coronopus didymus (L.) Sm.

SAXIFRAGACEAE

Ribes glandulosum Grauer

ROSACEAE

Amelanchier Bartramiana (Tausch) Roemer

Fragaria virginiana Duchesne

Potentilla anserina L.

Potentilla norvegica L.

Pyrus americana (Marsh.) DC.

Pyrus fioribunda Lindl.

Rosa sp.

Rubus Chamaemorus L.

Rubus idaeus L.

Rubus pubescens Raf.

LEGUMINOSAE

Lathyrus japonicus Willd.

Trifolium pratense L.

Trifolium repens L.

EMPETRACEAE

Empetrum nigrum L.

ACERACEAE

Acer spicatum Lam.

ONAGRACEAE

Epilobium angustifolium L.

Epilobium glandulosum Lehm.

ARALIACEAE

Aralia nudicaulis L.

UMBELLIFERAE

Angelica sp.

Anthriscus sylvetris (L.) Hoffm.

Ligusticum scothicum L.

CORNACEAE

Cornus canadensis L.

Cornus suecica L.

PYROLACEAE

Moneses uniflora (L.) Gray

Pyrola secunda L.

ERICACEAE

Chamaedaphne calyculata (L.) Moench

Gaultheria hispidula (L.) Bigel.

Kalmia angustifolia L.

Kalmia polyfolia Wang.

Ledum groenlandicum Oeder

Vaccinium angustifolium Ait.

Vaccinium macrocarpon Ait.

Vaccinium myrtilloides Michx.

Vaccinium Oxycoccus L.

Vaccinium uliginosum L.

Vaccinium Vitis-Idaea L.

PRIMULACEAE

Trientalis borealis Raf.

LABIATAE

Galeopsis Tetrahit L.

Glechoma hederacea L.

PLANTAGINACEAE

Plantago juncoides Lam.

Plantago major L.

CAPRIFOLIACEAE

Linnaea borealis L.

Lonicera villosa (Michx.) R. & S.

Viburnum cassinoides L.

CAMPANULACEAE

Campanula rotundifolia L.

COMPOSITAE

Achillea Millefolium L.

Aster spp. (2).

Leontodon autumnalis L.

Matricaria matricarioides (Less.) Porter

Prenanthes trifoliolata (Cass.) Fern.

Senecio sylvaticus L.

Senecio vulgaris L.

Solidago macrophylla Pursh

Taraxacum officinale Weber

Appendix 2.

Terrestrial birds observed on Gull Island, 1969 to 1971.

The figures in the body of table indicate the number of days on which the sp. was seen.

Month	May	June	July	August	October	Comments
Total number of observing days	47	76	73	13	2	
Species						
Haliaeëtus leucocephalus L.	1	-	-	-	-	
Megaceryle alcyon L.	-	-	-	1	-	
Sphyrapicus varius L.	-	1	-	-	-	
Dendrocopos villosus L.	4	4	5	1	-	
Empidonax flaviventris Baird & Baird	-	1	-	-	-	
Iridoprocne bicolor Vieillot	1	17	36	2	-	
Hirundo rustica L.	-	1	-	-	-	
Corvus corax L.	19	12	20	13	2	breeding
Corvus brachyrhynchos Brehm	13	8	1	1	2	
Parus atricapillus L.	1	-	-	-	-	
Parus hudsonicus Forster	47	76	73	13	2	abundant
Sitta canadensis L.	-	3	-	-	-	
Certhia familiaris L.	3	10	4	1	-	
Troglodytes troglodytes L.	29	67	70	13	-	
Turdus migratorius L.	35	49	57	7	-	
Hylocichla ustulata Nuttall	-	8	8	-	-	juvenile seen
Hylocichla minima Lafresnaye	1	20	6	-	-	juvenile in net 1971
Regulus satrapa Lichtenstein	2	10	17	-	-	courtship feeding 1971
Regulus calendula L.	3	2	1	1	-	
Anthus spinoletta L.	1	2	1	-	-	
Sturnus vulgaris L.	15	31	51	13	-	flock 50 -60 July 1971

Appendix 2.(Continued)

Month	May	June	July	August	October	Comments
Total number of observing days	47	76	73	13	2	
Species						
Mniotilta varia L.	3	-	-	-	-	
Dendroica petechia L.	-	7	1	5	-	
Dendroica coronata L.	1	-	-	-	-	
Dendroica virens Gmelin	1	2	-	-	-	
Dendroica striata Forster	7	22	14	2	-	
Seiurus noveboracensis Gmelin	28	76	73	12	-	juveniles July 1971
Oporornis philadelphia Wilson	1	30	38	5	-	
Wilsonia pusilla Wilson	-	3	-	1	-	
Setophaga ruticilla L.	-	3	7	1	-	immature + adults
Euphagus carolinus Müller	-	1	2	-	-	
Carpodacus purpureus Gmelin	-	1	-	-	-	
Pinicola enucleator L.	-	3	26	4	-	
Acanthis flammea L.	2	8	3	-	-	
Spinus pinus Wilson	13	12	4	-	-	
Loxia curvirostra L.	-	3	2	-	-	
Passerculus sandwichensis Gmelin	7	3	-	4	-	
Junco hyemalis L.	1	-	-	-	-	
Passerella iliaca Merrem	47	76	73	13	-	juveniles seen 1971
Melospiza georgiana Latham	1	1	-	-	-	
Other species seen in 1967 and/or 1968.						
Oenanthe oenanthe L.						
Zonotrichia albicollis Gmelin						Nest 1967

Appendix 3.

Aquatic and shore birds observed on and around Gull Island, 1969 to 1971.

The figures in the body of the table indicate the number of days on which the species was seen.

Month	May	June	July	August	October	Comments
Total number of observing days	47	76	73	13	2	
Species						
Gavia immer Brunnich	1					
Fulmarus glacialis L.	1					
Puffinus gravis O'Reilly	1	3		1		
Puffinus griseus Gmelin		1		1		
Puffinus puffinus Brunnich				1		
Oceanodroma leucorhoa Vieillot	47	76	73	13	2	breeding
Morus bassanus L.	2	2		1		
Phalacrocorax sp.	4			2	2	
Casmerodius albus L.				1		
Anas rubripes Brewster	1		3	3		
Histrionicus histrionicus L.	7	1	1			
Somateria mollissima L.	11	1	1	1	1	
Melanitta deglandi Bonaparte	1	1	1			
Actitus macularia L.	22	68	62	20	-	breeding
Totanus melanoleucus Gmelin			1			
Ereunetes pusillus L.			3	3		
Phalaropus fulicarius L.	2					
Lobipes lobatus L.	4	1				
Larus hyperboreus Gunnerus	1	1				second year birds
Larus marinus L.	47	76	73	13	2	breeding
Larus fuscus L.	1					
Larus argentatus Pontoppidan	47	76	73	13	2	breeding
Larus ridibundus L.	1					seen briefly
Rissa tridactyla L.	47	76	73	13		breeding

Appendix 3.(Continued)

Month	May	June	July	August	October	Comments
Total number of observing days	47	76	73	13	2	
Species						
Sterna hirundo L.	)					
	)4	6	2			
Sterna paradisaea Pontoppidan	)					
Chlidonias niger L.	1					
Alca torda L.	47	76	73	10	-	breeding
Uria aalge Pontoppidan	47	76	73	10	-	breeding
Uria lomvia L.	47	76	73	10	-	
Plautus alle L.					2	
Cepphus grylle L.	47	76	73	13	2	breeding
Fratercula arctica L.	47	76	73	13	-	breeding

Appendix 4

Weights of herring gull and great black-backed gull chicks, 1970

Weights are expressed in grams

Dashes indicate that measurements were not made on that day. A indicates that the bird was absent (could not be located), F that the bird was present but able to fly, and a cross (+) that the chick was found dead.

WEIGHT OF HERRING GULL CHICKS 1970

UNPENNED

CHICK NO. / DAY	3-1	5-1	5-2	5-3	6-1	6-2	8-1	8-2
1	68	86	69	72	--	72	76	66
2	--	90	86	80	80	93	80	65
3	88	114	114	100	108	112	84	80
4	95	144	125	120	116	144	114	114
5	--	152	164	118	152	157	144	131
6	144	188	180	143	173	180	167	150
7	170	206	185	160	205	187	---	180
8	186	216	220	---	230	235	218	182
9	215	265	230	215	280	255	235	235
10	248	270	---	250	290	290	285	200
11	300	---	320	270	340	---	290	---
12	---	---	345	---	340	365	---	240
13	290	415	360	290	---	375	385	275
14	400	440	---	330	435	410	370	310
15	440	---	415	400	455	---	430	---
16	460	470	460	410	510	455	---	370
17	---	600	560	440	---	520	475	400
18	535	610	530	415	530	590	490	460
19	645	580	580	490	560	---	600	445
20	660	600	550	490	640	630	610	470
21	---	615	630	---	---	585	640	465
22	740	650	620	---	690	680	635	480
23	730	---	---	610	645	730	650	525
24	820	---	---	640	730	---	665	545
25	800	---	795	---	780	---	710	---
26	750	810	735	670	---	790	---	605
27	835	770	---	700	---	820	720	615
28	920	---	810	---	810	---	765	---
29	900	790	865	---	790	895	---	705
30	990	840	---	---	---	830	925	715
31	---	---	---	695	850	---	915	---
32	1015	---	---	700	850	---	---	---
33	1065	---	840	---	---	---	---	---
34	---	860	905	---	---	915	---	725
35	1115	870	---	---	---	840	940	800
36	1085	---	---	695	910	---	990	---
37	---	---	---	730	---	---	---	---
38	---	---	---	---	---	---	---	825
39	---	865	940	A	---	---	980	785
40	1095	940	---	---	---	885	---	815
41	1130	---	940	675	---	---	950	---
42	---	A	---	---	A	A	---	A
43	---	---	A	---	---	---	A	---
44	---	A	---	---	A	A	---	A
45	---	---	---	795	---	---	A	---
46	A	---	---		A	---	---	---
47	---	---	A		---	---	---	---
48	A	A			---	A	---	A

WEIGHT OF HERRING GULL CHICKS 1970

UNPENNED

CHICK NO. / DAY	9-1	9-2	10-1	10-2	10-3	11-2
1	61	65	72	59	--	62
2	80	76	67	--	66	--
3	96	80	--	80	96	70
4	104	110	113	104	96	106
5	130	145	132	119	115	107
6	173	136	164	146	154	148
7	164	155	190	172	174	162
8	220	177	220	196	200	178
9	225	---	245	250	200	---
10	---	250	270	285	218	260
11	290	275	330	300	235	270
12	340	320	335	330	235	280
13	390	---	370	325	+	340
14	---	315	375	---		---
15	450	430	---	420		410
16	590	490	435	450		440
17	540	480	500	480		470
18	590	490	510	---		---
19	610	450	---	540		545
20	575	570	570	540		560
21	730	565	560	650		650
22	710	---	700	700		620
23	---	---	720	640		670
24	---	710	670	675		660
25	890	705	735	700		760
26	845	---	740	720		740
27	---	715	810	---		---
28	850	800	---	---		---
29	930	---	---	780		860
30	---	---	930	725		780
31	---	---	855	---		---
32	---	725	---	825		860
33	845	740	965	810		885
34	810	---	870	---		---
35	---	---	---	---		---
36	---	---	---	---		---
37	---	+	---	830		875
38	870		---	790		855
39	A		780	---		---
40	---		---	---		---
41	A		---	---		---
42	---		---	---		---
43	A		---	A		A
44	---		A	---		---
45	---		---	A		A
46	---		A	---		---
47	A		---	A		A
48			A	---		---

WEIGHT OF HERRING GULL CHICKS 1970

UNPENNED

CHICK NO. / DAY	12-1	12-2	12-3	13-1	13-2	14-1	15-1	15-2	15-3
1	76	67	70	68	--	69	--	80	66
2	77	--	96	87	89	90	100	--	80
3	97	100	104	--	125	108	112	106	84
4	120	120	117	115	110	124	---	125	112
5	137	152	144	170	---	130	150	136	130
6	175	160	152	170	120	152	195	170	146
7	184	193	---	---	170	---	187	192	170
8	197	215	215	200	210	192	232	---	195
9	265	265	295	260	210	245	280	230	240
10	295	---	290	300	250	260	270	275	270
11	---	305	---	270	240	---	---	300	275
12	315	405	325	330	---	220	385	335	---
13	375	390	275	335	325	325	410	365	330
14	420	---	410	430	---	410	475	---	365
15	---	460	405	415	---	425	485	430	430
16	455	550	430	---	420	450	---	485	---
17	500	590	410	---	435	445	535	540	475
18	550	560	---	535	---	530	615	---	550
19	580	580	455	540	545	525	680	570	590
20	580	560	---	---	550	---	---	700	590
21	590	640	---	640	---	---	725	700	640
22	630	635	470	650	---	540	850	715	595
23	645	---	465	---	---	625	860	800	710
24	---	---	---	---	610	---	850	705	650
25	---	720	605	---	690	745	890	800	---
26	770	695	600	740	---	725	850	815	---
27	725	---	---	770	---	---	900	---	740
28	---	780	---	---	---	---	910	---	775
29	825	820	---	---	---	---	---	845	---
30	800	---	650	---	770	840	---	895	775
31	---	---	---	---	---	860	1000	---	830
32	---	---	---	830	860	---	960	960	---
33	---	---	---	---	---	---	---	975	---
34	810	---	---	830	845	---	1080	---	---
35	---	---	660	---	---	---	1075	---	900
36	---	---	A	790	---	---	---	---	820
37	---	---	---	---	---	900	---	920	---
38	---	---	A	---	A	---	---	900	---
39	780	A	---	---	---	A	1070	---	---
40	A	---	620	830	---	---	1100	---	930
41	---	A	---		780	---	---	---	890
42	A	---	---			---	---	820	---
43	---	A	---			A	---	A	880
44	755	---	565				1040	---	---
45	---	---					F	740	920
46	---	---					---	---	---
47	---	A					F	675	---
48	A						---	---	---

WEIGHT OF HERRING GULL CHICKS 1970

UNPENNED

CHICK NO. / DAY	16-1	16-2	16-3	17-1	17-2	17-3
1	88	91	68	--	76	43
2	92	96	80	73	78	64
3	--	--	98	82	102	87
4	132	143	112	92	130	95
5	165	172	142	120	145	130
6	176	192	150	150	180	135
7	202	222	190	150	195	152
8	230	280	240	190	202	168
9	260	300	245	208	265	190
10	290	---	255	215	275	---
11	330	395	315	265	---	225
12	345	385	---	285	325	290
13	415	455	355	---	370	320
14	415	475	410	330	420	---
15	---	---	470	380	---	325
16	465	560	---	410	480	390
17	540	580	475	---	510	430
18	570	650	500	440	590	455
19	---	---	560	510	600	440
20	615	650	560	560	620	455
21	640	680	540	570	615	530
22	720	800	565	580	700	535
23	745	+	670	570	745	---
24	730		640	650	---	---
25	760		---	660	---	620
26	850		---	---	820	615
27	830		790	---	805	---
28	---		780	740	---	675
29	---		---	735	850	720
30	980		825	---	910	---
31	975		860	790	---	---
32	---		---	830	---	---
33	1005		---	---	---	710
34	1040		---	---	970	860
35	---		880	---	900	---
36	---		780	---	---	---
37	---		---	---	---	---
38	1090		---	---	---	---
39	990		---	---	---	---
40	---		---	---	---	---
41	---		865	---	---	F
42	---		---	---	930	---
43	---		810	---	---	630
44	A		---	F	835F	---
45	---		750	---	---	---
46	900		---	A	---	---
47	---		---	---	---	A
48	A		---	---	A	

WEIGHT OF HERRING GULL CHICKS 1970

PENNED

CHICK NO. / DAY	1-1	2-1	2-2	2-3	7-1	7-2	7-3	18-1	18-2
1	68	67	84	61	68	--	58	--	--
2	76	80	97	80	--	86	--	92	82
3	--	90	97	98	88	91	92	100	85
4	116	94	124	--	103	--	125	---	--
5	118	115	154	134	---	141	128	150	122
6	142	156	---	180	144	166	162	190	160
7	156	---	200	200	170	167	190	186	172
8	250	185	260	---	177	---	210	187	202
9	215	240	275	250	214	230	280	275	225
10	250	260	---	300	246	240	285	290	255
11	315	---	350	390	265	300	310	---	300
12	325	305	380	400	---	330	365	405	330
13	360	340	440	410	345	335	360	395	345
14	390	400	490	405	325	370	---	430	390
15	---	430	530	480	485	395	465	480	400
16	475	480	515	505	400	---	480	---	---
17	480	425	590	525	---	510	520	520	475
18	510	530	565	---	510	540	---	600	540
19	---	540	605	625	540	560	625	610	550
20	605	555	---	645	570	---	650	---	---
21	650	---	690	---	---	605	770	690	590
22	710	680	655	775	625	625	---	710	630
23	705	625	---	820	640	760	840	800	690
24	740	---	850	---	780	---	800	860	710
25	765	765	845	---	---	750	830	840	690
26	800	790	---	---	800	705	890	835	685
27	775	---	---	645	745	750	---	910	770
28	865	---	---	590	790	770	---	930	790
29	---	---	700	---	820	---	1040	---	---
30	915	645	620	---	---	---	985	---	---
31	875	655	---	625	---	860	---	1000	860
32	---	---	---	625	920	795	1025	995	835
33	1025	---	530	590	860	---	955	---	---
34	920	625	530	---	---	850	---	1075	880
35	---	610	590	460	870	870	---	1040	920
36	---	650	---	---	810	---	---	---	---
37	---	---	480	A	---	---	775	---	---
38	860	535	---	---	---	---	730	---	---
39	890	---	A	---	---	730	---	---	980
40	---	A	---	---	650	680	---	1080	860
41	---	---	---	+	610	---	---	---	---
42	960	---	---		---	---	---	---	---
43	830	---	+		---	---	+	---	---
44	860	725			---	---		---	---
45	---	---			---	+		---	---
46	A	---			565*			---	---
47	---	870			---			A	A
48					750				

*Released

WEIGHT OF HERRING GULL CHICKS 1970

PENNED

CHICK NO. / DAY	18-3	19-1	19-2	19-3	20-1	21-1	VI-1	VI-2	VI-3
1	62	88	84	68	--	48	72	--	76
2	65	99	100	--	82	--	--	106	84
3	--	--	---	92	97	57	112	105	--
4	76	138	136	88	106	74	112	---	126
5	102	136	146	124	127	83	---	168	152
6	104	174	176	162	163	108	172	190	154
7	132	230	225	174	181	136	198	215	210
8	165	248	255	200	210	165	241	254	230
9	180	275	264	244	255	178	280	280	275
10	204	300	300	290	280	230	310	330	---
11	255	360	365	325	315	230	340	---	360
12	250	405	395	365	315	260	---	425	390
13	245	435	420	340	---	290	460	440	425
14	+	440	410	---	415	---	490	490	470
15		---	---	425	445	365	560	545	---
16		545	530	455	470	415	600	---	525
17		585	535	490	---	400	---	620	585
18		620	570	---	545	---	660	675	620
19		---	---	480	565	500	735	730	---
20		630	650	550	680	505	760	---	690
21		630	600	570	---	590	---	760	780
22		770	770	630	710	660	825	840	810
23		820	720	630	675	600	930	860	840
24		790	770	600	760	560	990	880	890
25		735	735	650	810	660	1000	910	870
26		780	790	630	---	600	1030	925	970
27		830	800	---	---	---	1020	960	910
28		---	---	---	880	---	1120	960	945
29		---	---	790	850	750	1070	975	---
30		930	910	745	---	775	1065	---	1065
31		910	875	---	925	---	---	1045	1030
32		---	---	815	910	835	1180	1050	---
33		975	930	790	---	810	1200	---	1100
34		890	870	---	---	---	---	1120	1180
35		---	---	---	---	---	1195	1100	---
36		---	---	---	930	---	1090	---	---
37		---	---	770	940	770	---	---	---
38		920	800	800	---	730	---	---	1040
39		970	780	---	---	---	---	1045	1040
40		---	---	---	---	---	1085	1040	---
41		---	---	---	---	---	1135	---	---
42		---	---	---	---	---	---	---	1050
43		---	---	---	---	---	---	1080	1085
44		---	---	---	870	---	1165	1020	---*
45		---	---	F	---	A	1090	F	1020
46		630	F	---	870	---	F	---	---
47		---	---	A	---	A	---	A	F
48		A	A	---	---	---	A	---	---

*Released

WEIGHT OF GREAT BLACK-BACKED GULL CHICKS 1970

PENNED

CHICK NO. / DAY	1-2	1-1	4-1	4-2	4-3	7-1	7-2	8-1	8-2
1	77	--	80	94	90	80	90	82	83
2	88	118	110	114	99	100	94	74	--
3	130	140	105	---	116	97	136	--	126
4	---	165	112	145	---	126	149	128	136
5	125	---	128	160	152	155	185	140	167
6	148	170	162	---	---	198	235	140	190
7	---	190	---	190	215	246	245	180	208
8	---	250	215	---	---	224	208	194	235
9	+	230	---	260	215	238	270	208	295
10		250	285	275	270	315	190	290	325
11		225	300	320	---	210	---	350	365
12		---	360	---	325	---	---	370	410
13		320	---	395	325	---	+	400	390
14		---	375	360	450	+		385	---
15		---	430	490	---			---	565
16		400	550	---	460			505	605
17		420	---	590	335			560	680
18		---	620	385	---			640	---
19		445	485	---	310*			---	695
20		585	---	340*				675	790
21		---	450*					710	700
22		---						710	630
23		---						620	540
24		725						520	+
25		690						+	
26		---							
27		---*							
28		825							
29		835							
30		795							
31		---							
32		850							
33		---							
34		1020							
35		---							
36		---							
37		---							
38		1315							
39									
40									
41									
42									
43									
44									
45									
46									
47									
48									

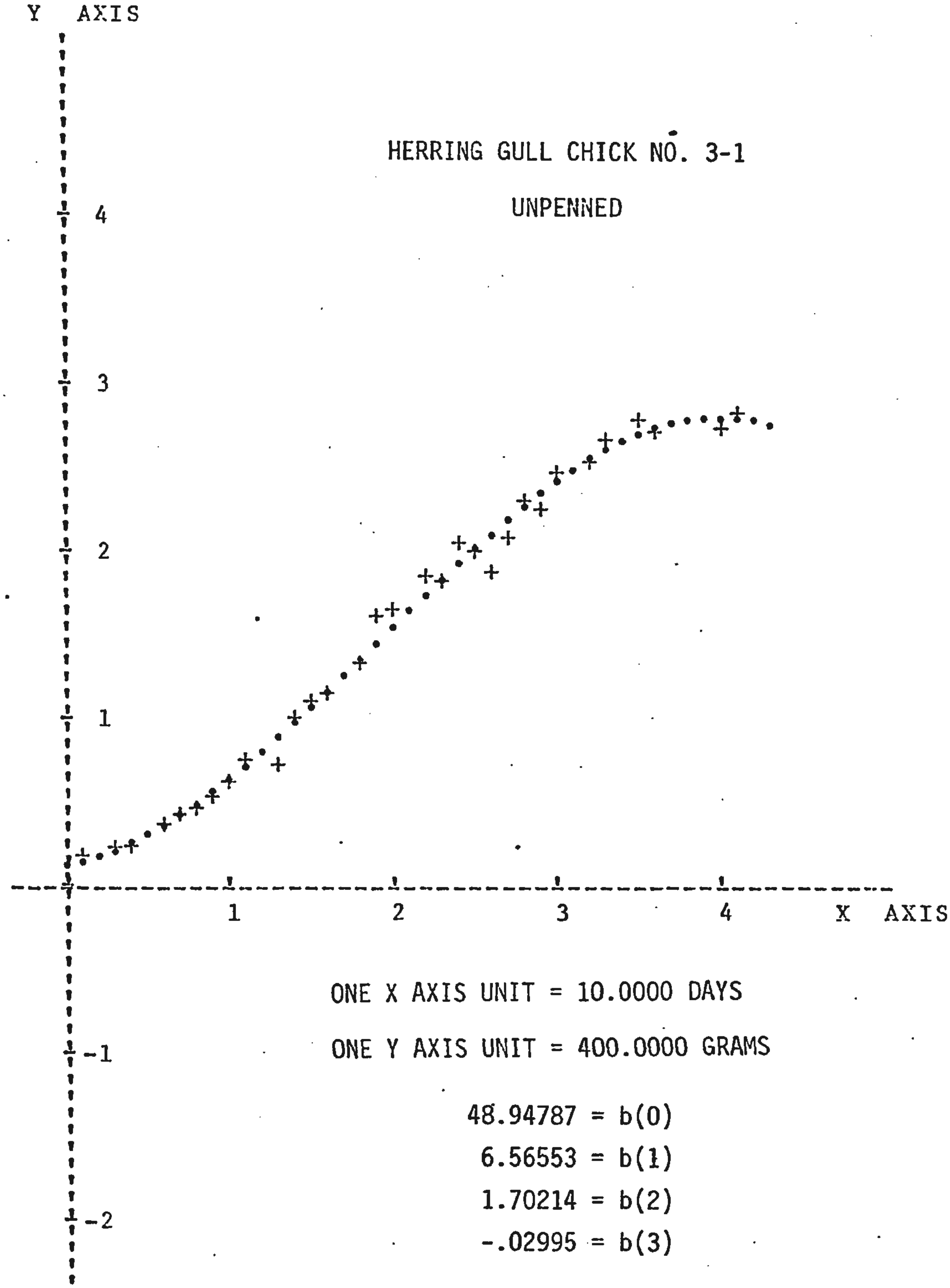
*Released

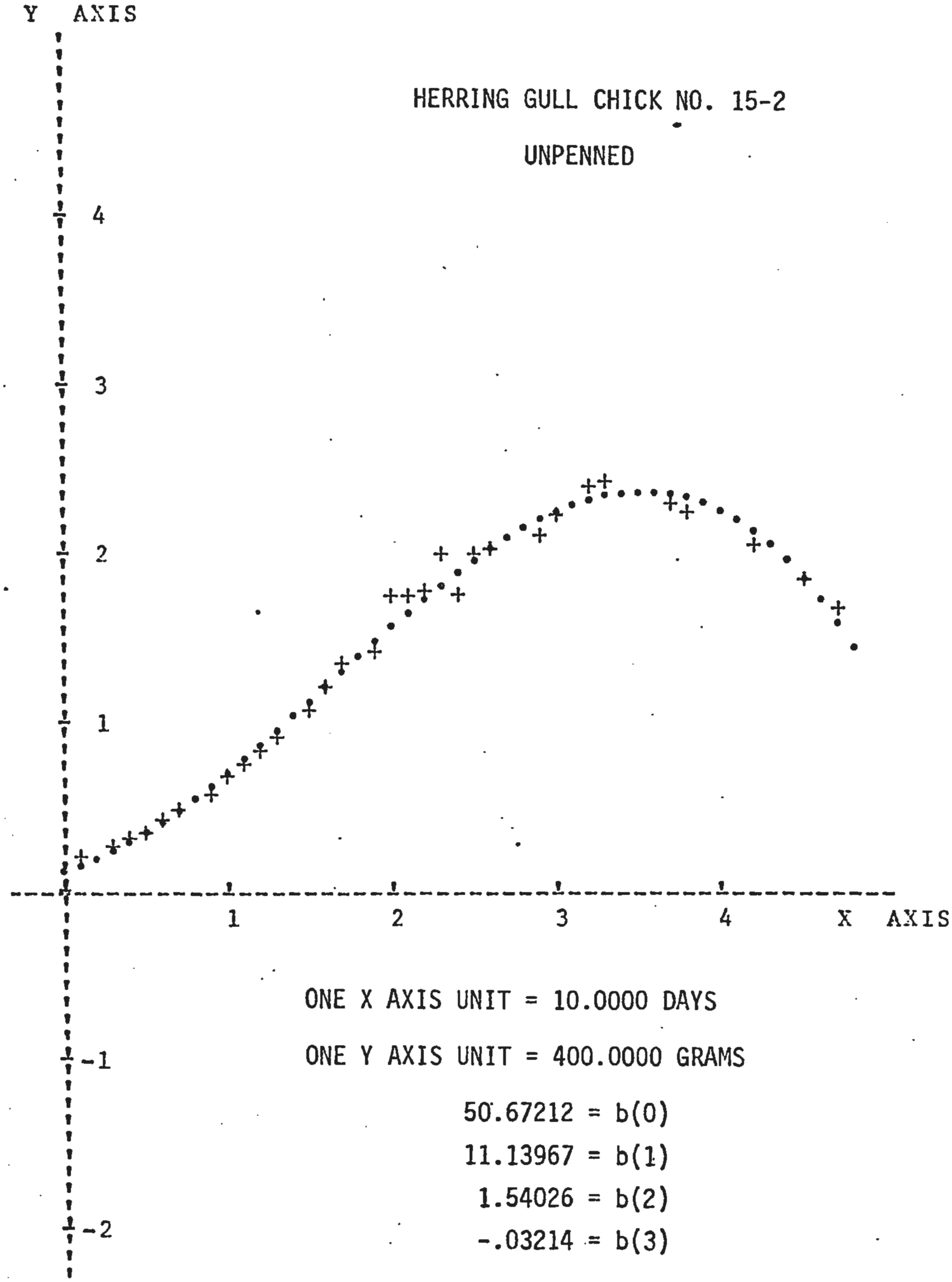
Appendix 5

Growth curves of herring gull and great black-backed gull chicks.

Growth in weight of individual chicks

Average growth of various body parts


Y AXIS
HERRING GULL CHICK NO. 3-1
UNPENNED
4
3
2
1
-1
-2
1
2
3
4
X AXIS
ONE X AXIS UNIT = 10.0000 DAYS
ONE Y AXIS UNIT = 400.0000 GRAMS
48.94787 = b(0)
6.56553 = b(1)
1.70214 = b(2)
-.02995 = b(3)



ONE X AXIS UNIT = 10.0000 DAYS

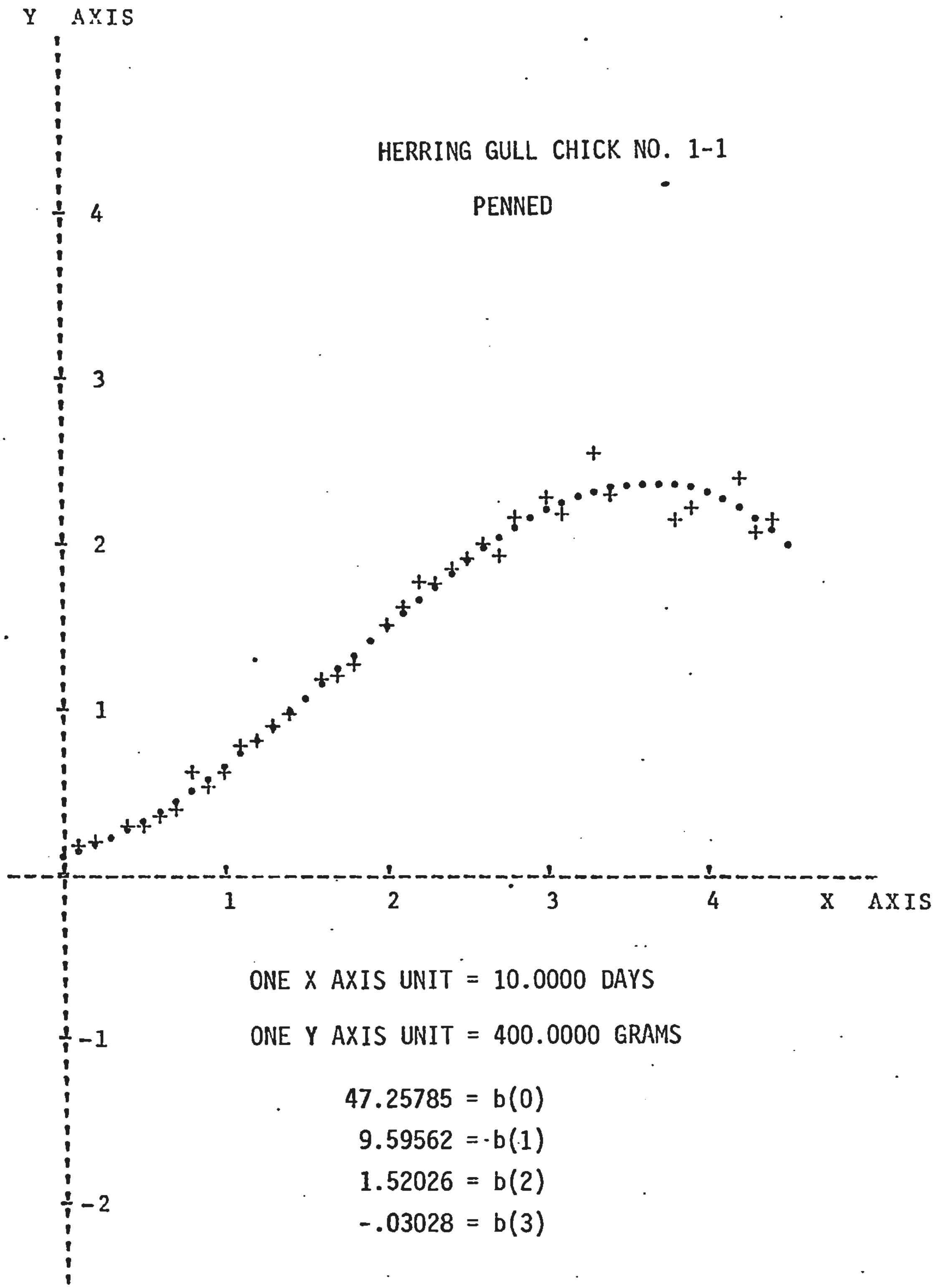
ONE Y AXIS UNIT = 400.0000 GRAMS

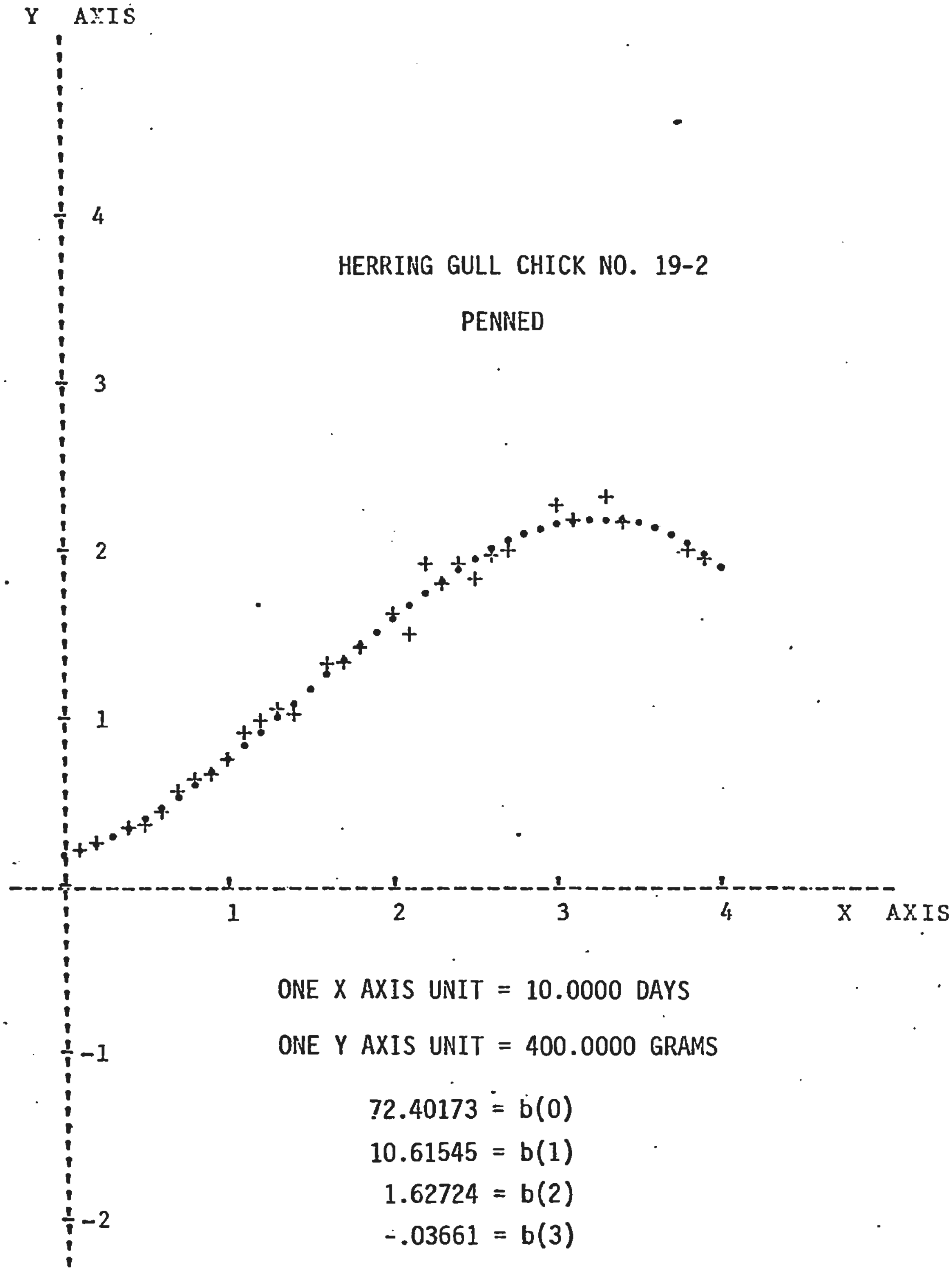
50.67212 = b(0)

11.13967 = b(1)

1.54026 = b(2)

-.03214 = b(3)

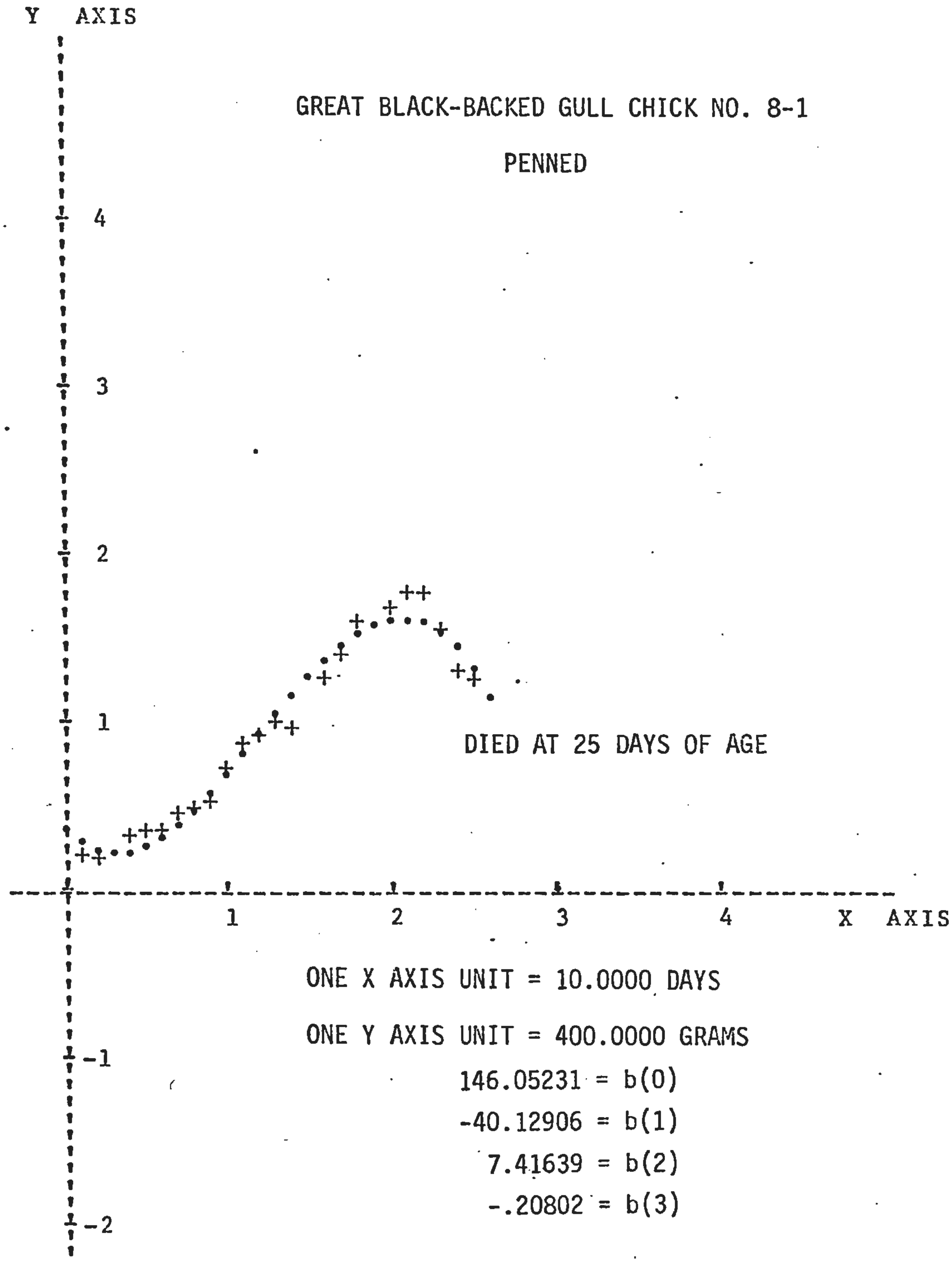

Y AXIS
HERRING GULL CHICK NO. 1-1
PENNED
4
3
2
1
-1
-2
1
2
3
4
X AXIS
ONE X AXIS UNIT = 10.0000 DAYS
ONE Y AXIS UNIT = 400.0000 GRAMS
47.25785 = b(0)
9.59562 = b(1)
1.52026 = b(2)
-.03028 = b(3)



ONE X AXIS UNIT = 10.0000 DAYS

ONE Y AXIS UNIT = 400.0000 GRAMS

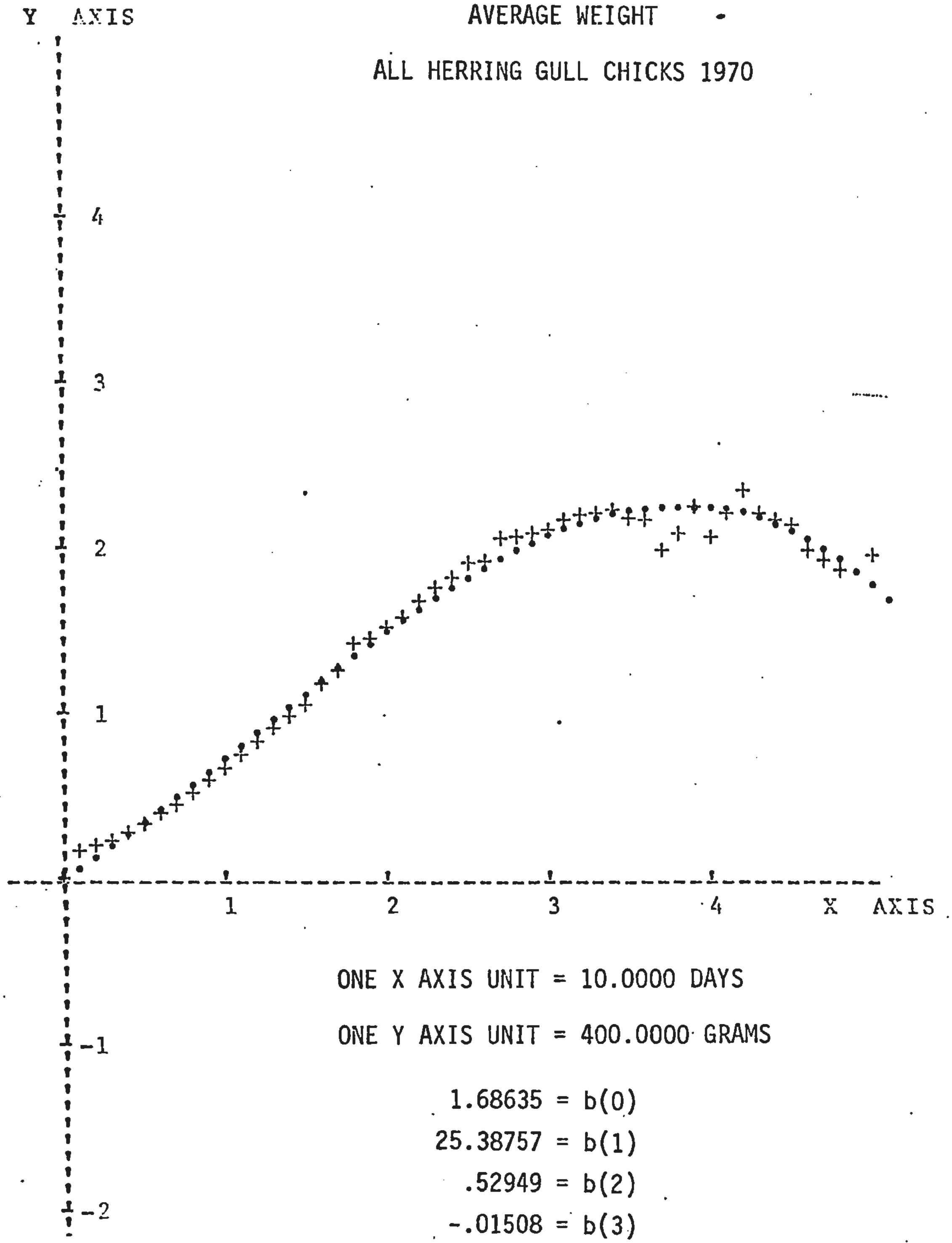
72.40173 = b(0)
10.61545 = b(1)
1.62724 = b(2)
-.03661 = b(3)



Y AXIS
GREAT BLACK-BACKED GULL CHICK NO. 8-1
PENNED
4
3
2
1
-1
-2
DIED AT 25 DAYS OF AGE
1
2
3
4
X AXIS
ONE X AXIS UNIT = 10.0000 DAYS
ONE Y AXIS UNIT = 400.0000 GRAMS
146.05231 = b(0)
-40.12906 = b(1)
7.41639 = b(2)
-.20802 = b(3)

AVERAGE WEIGHT

ALL HERRING GULL CHICKS 1970



ONE X AXIS UNIT = 10.0000 DAYS

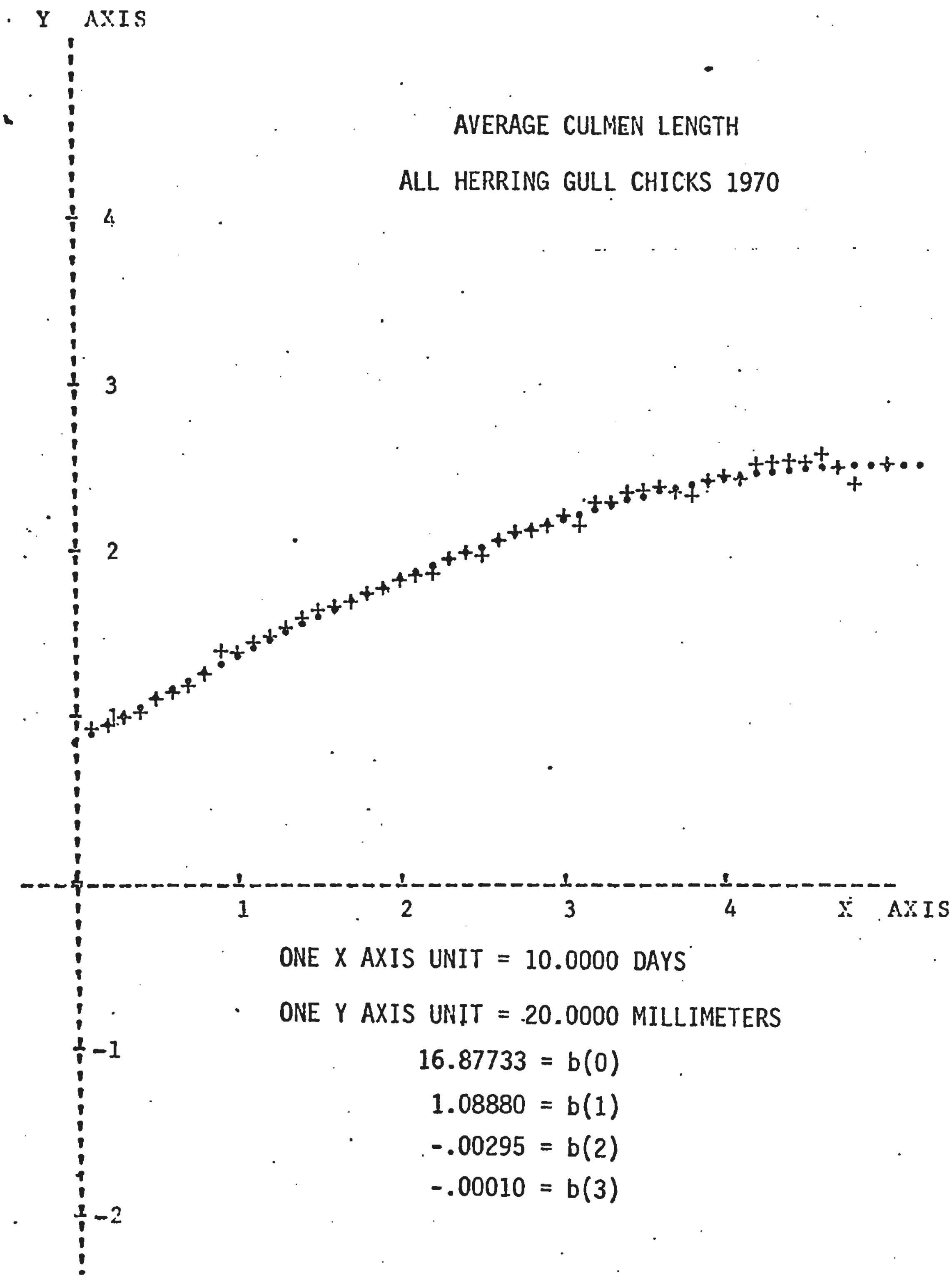
ONE Y AXIS UNIT = 400.0000 GRAMS

1.68635 = b(0)

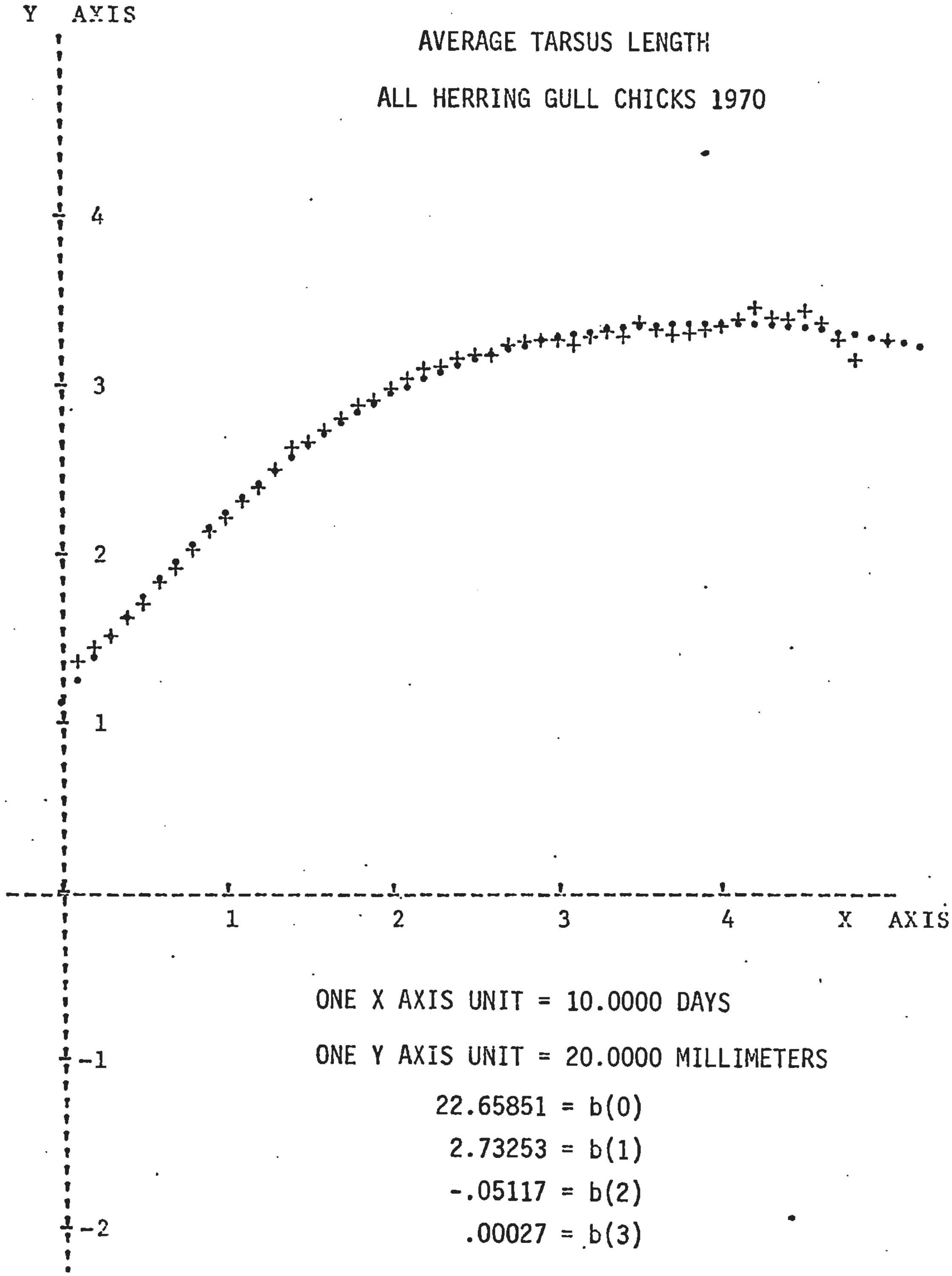
25.38757 = b(1)

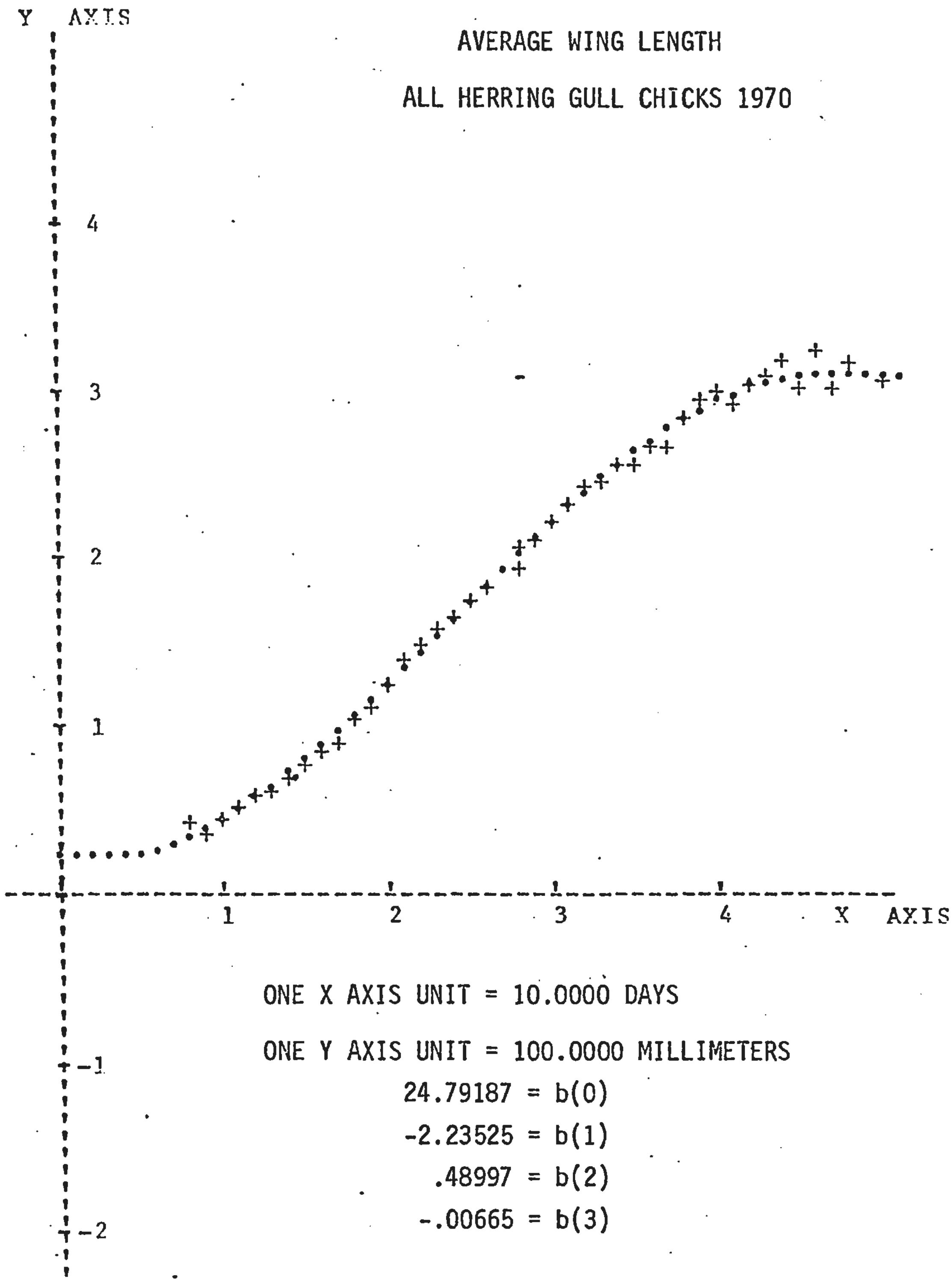
.52949 = b(2)

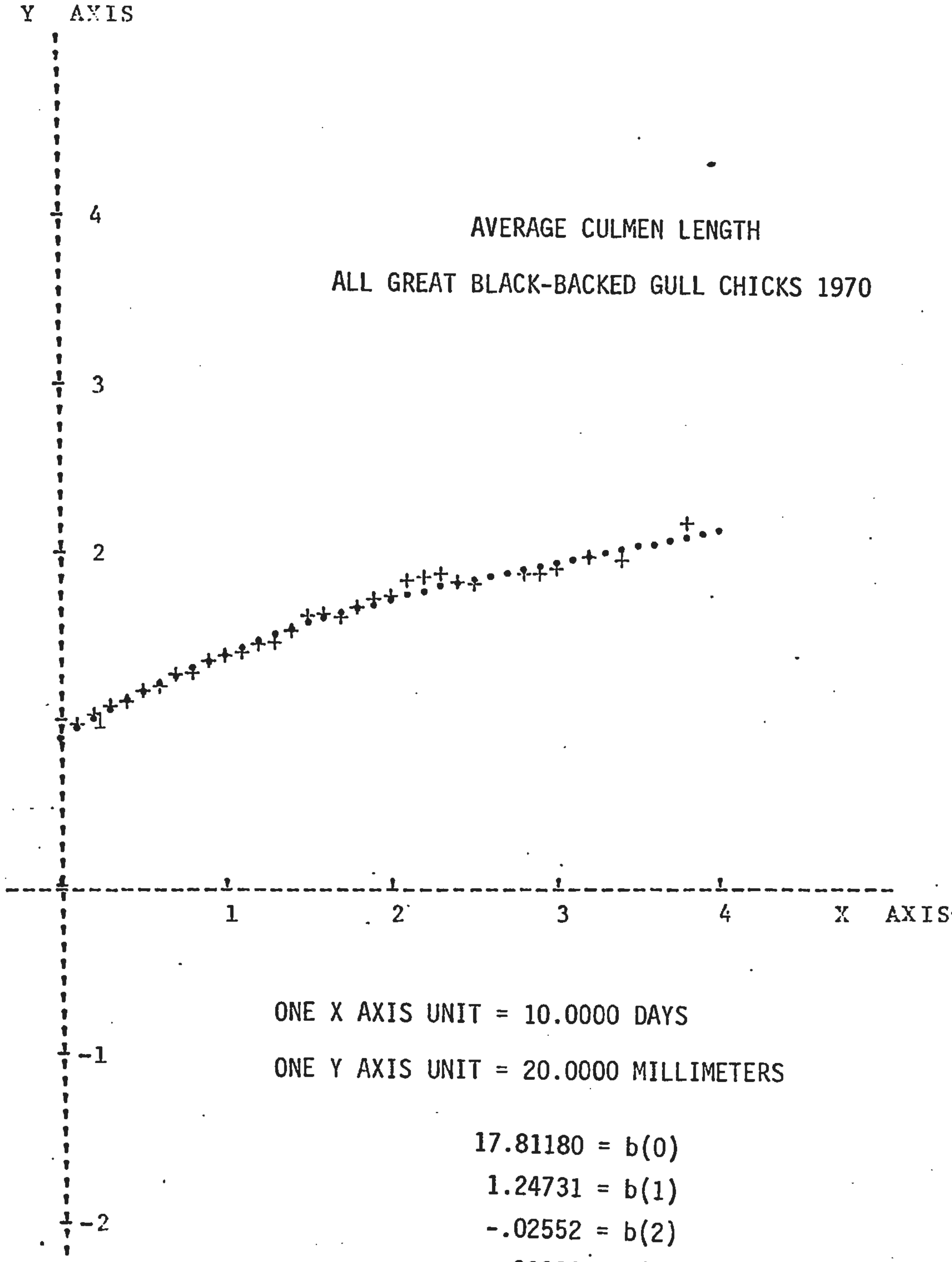
-.01508 = b(3)


Y AXIS
AVERAGE CULMEN LENGTH
ALL HERRING GULL CHICKS 1970
4
3
2
-1
-2
1
2
3
4
X AXIS
ONE X AXIS UNIT = 10.0000 DAYS
ONE Y AXIS UNIT = 20.0000 MILLIMETERS
16.87733 = b(0)
1.08880 = b(1)
-.00295 = b(2)
-.00010 = b(3)

AVERAGE TARSUS LENGTH
ALL HERRING GULL CHICKS 1970



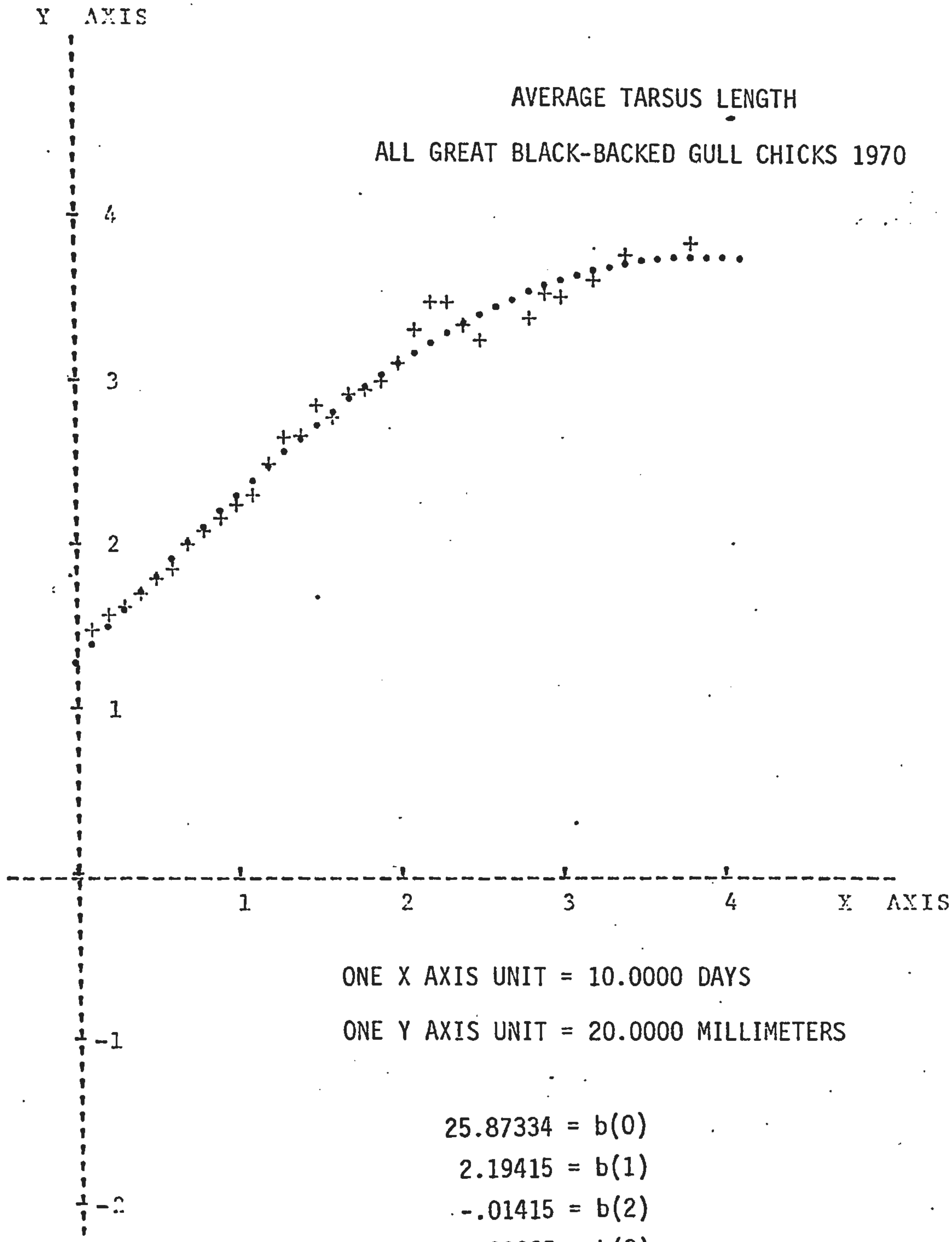

AVERAGE WING LENGTH
ALL HERRING GULL CHICKS 1970
Y AXIS
4
3
2
1
-1
-2
1
2
3
4
X AXIS
ONE X AXIS UNIT = 10.0000 DAYS
ONE Y AXIS UNIT = 100.0000 MILLIMETERS
24.79187 = b(0)
-2.23525 = b(1)
.48997 = b(2)
-.00665 = b(3)



ONE X AXIS UNIT = 10.0000 DAYS

ONE Y AXIS UNIT = 20.0000 MILLIMETERS

17.81180 = b(0)
1.24731 = b(1)
-.02552 = b(2)
.00024 = b(3)


Y AXIS
AVERAGE TARSUS LENGTH
ALL GREAT BLACK-BACKED GULL CHICKS 1970
4
3
2
1
-1
-2
1
2
3
4
X AXIS
ONE X AXIS UNIT = 10.0000 DAYS
ONE Y AXIS UNIT = 20.0000 MILLIMETERS
25.87334 = b(0)
2.19415 = b(1)
-.01415 = b(2)
-.00025 = b(3)

Appendix 6.

Food of Gulls:

Major components of gull regurgitations and pellets, 1970 and 1971.

Food item	mid-May to mid-June	mid-June to mid-July	mid-July to mid-August
	Number of Occurrences	Number of Occurrences	Number of Occurrences
Invertebrates:			
Hyas sp. crab	2	0	0
Oniscus sp. woodlice	0	2	0
Odonata dragonflies, *Hymenoptera F. Formicidae* flying ants, & *Coleoptera F. carabidae* beetles	0	1	2
Trichoptera caddisflies	0	0	1
Chironomidae larvae	0	2	0
Acmaea sp. limpet	1	0	0
Mytilus edulis	90	1	12
Illex illecebrosus	0	0	2
Asterias sp.	0	1	1
Strongylocentrotus drobachiensis	17	0	6
Vertebrates:			
Clupea harengus	0	0	2
Microgadus tomcod and small *Gadus morhua*	30	1	3
Mallotus villosus	3	80	13
Ammodytes americanus	0	0	7
Rana clamitans	0	2	0
Oceanodroma leucorhoa	65	8	21
Fratercula arctica adults	17	0	2
Fratercula & *Uria* chicks	0	4	12
Fratercula & *Uria* eggs	4	2	1
Gull (*Larus* sp.) chicks	0	1	3
Gull (*Larus* sp.) eggs	9	6	1

Appendix 6.(Continued)

Food item	mid-May to mid-June	mid-June to mid-July	mid-July to mid-August
	Number of Occurrences	Number of Occurrences	Number of Occurrences
Rissa tridactyla chicks	0	0	2
Plants:			
Vaccinium angustifolium blueberries	-	-	13
Miscellaneous:			
Gadus morrhua offal	36	2	19
Assorted refuse: balogna ends, vegetables, meat, fat, chicken bones, seal bones, shoelaces, bath sponge, plastic forks, crockery etc.	17	1	9
Total number of samples	291	114	132