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Distribution, abundance and biomass of a summer community of birds in the region of the Admiralty Bay (King George Island, South Shetland Islands, Antarctica) in 1978/1979*

ABSTRACT: In the region of the Admiralty Bay 12 nesting bird species were encountered of a total abundance of 40890 pairs and biomass amounting to about 395000 kg. Three penguin species constituted 91.7% in abundance, their biomass constituting 98.7% of the whole community. Densities of abundance and biomass of adult birds in relation to the living area of penguins (i.e. 775 km^2) ranged from 32.3 to 121.4 indiv. km^{-2} and from 115.1 to 473.0 kg km^{-2}.

Key words: Antarctic, birds, distribution, numbers, biomass.

1. Introduction

The aim of the present study was to estimate the distribution, abundance and biomass of a summer community of birds in the region of the Admiralty Bay (King George Island, South Shetland Islands). So far, the avifauna of this region has been investigated in the neighbourhood of Thomas Point by Gain (1914), Rakusa-Suszczewski (1977) and Presler (1980). The above mentioned authors recorded the nesting of the following bird species: *Pygoscelis papua* (Forster), *Pygoscelis adeliae* (Hombron et Jacquinot), *Pygoscelis antarctica* (Forster), *Macronectes giganteus* (Gmelin), *Oceanites oceanicus* (Kuhl), *Chionis alba* (Gmelin), *Stercorarius skua maccormicki* (Saunders) and *Stercorarius skua lonnbergi* (Mathews) as well as *Larus*

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dominicanus Lichtenstein and *Sterna vittata* Gmelin. The quantitative census of the penguin rookery in the area was carried out by: Gain (1914), Stephens (after Conroy 1975), White (after Kirkwood, Croxall 1979), Trivelpiece and Volkman (1979).

2. Study area

Investigations were conducted from 5 December 1978 to 27 February 1979 at King George Island, in the region of Admiralty Bay (62°09′S, 58°28′W). The island lies in the zone of oceanic Antarctic climate. The total area of the island is 1337 km^2. The percentage of the area which is not covered with ice is only 1.9% of the total area of the island. The investigated area covered 388 km^2, of which 131 km^2 constituted the surface area of the Admiralty Bay and 19 km^2 an area of land free of ice (Rakusa-Suszczewski 1980), the rest being the surface of glaciers. The study area was situated between Red Hill and Chabrier Rock. In this area the total length of the coast-line was 91 km.

3. Methods

3.1. Phenology

Literature data and own observations based on large frequency of countings allowed to distinguish four periods for which the abundance and biomass of bird community were separately estimated (Tabs. III, V—VIII, XI—XVIII). Since three pygoscelid species, and especially *Pygoscelis adeliae*, were the most abundant bird species in the Admiralty Bay region the assessment of these periods was mainly based on the phenology of penguins. These periods were following: 1. 10—24 December; 2. 25 December—10 January; 3. 11 January—1 February; 4. 2–16 February. Detailed data on the terms in which nesting places were occupied and the terms in which eggs were laid were obtained by the courtesy of Dr. A. Łukowski.

3.2. Abundance

The abundance of penguins occurring in colonies of more than 100 and less than 500 pairs was determined in the countings within 1 m wide transects separated with cord and on the basis of photographs taken from the surrounding cliffs. In colonies of more than 500 nests, the abundance was determined in the following way: test areas were chosen and nests within these areas were counted in 1 m wide transects (zones); finally on the basis of aerial photographs of the whole rookery the approximate abundance of penguins occurring in the whole area was estimated. All the countings of penguins were preceeded by studies on quantitative changes of penguin population on land over the 24 hour period (Jabłoński, in press). Data obtained from these investigations enabled to adjust the time of counting to the 24 hours' rhythm of changes in the number of penguins.

Searching for the nests of *O. oceanicus* was conducted mainly from 21.00 to 2.30 hrs of the local time, because of its intensive courtship flights at that time, which made it easier to detect calling males. The abundance of this species is underestimated due to difficulties in detecting nests in places of difficult access. In the literature, there is recorded a method of the estimation of the abundance of this species in large areas on the basis of the knowledge of abundance in test areas and recalculating of these data for the whole study area (Beck and Brown 1972). However, this method could not be used in the region of the Admiralty Bay due to strong mosaic-like character of the breeding habitats. In the course of searching for *O. oceanicus, Fregetta tropica* (Gould.) was also discovered, but this species was not counted.

The abundance of other species was determined on the basis of systematic searching of the study area. Many data on the distribution of the breeding places were also obtained from the participants of the II-nd and III-rd Antarctic Expeditions of the Polish Academy of Sciences.

3.3. Phenological breeding state and age structure of chicks

The age of penguin chicks in the test areas and the chicks of other species was determined on the basis of characteristic features of plumage and on the basis of their body weight. Precise data on the mean individual body weight and the range of its variation in subsequent days of life were obtained by weighing marked chicks. The contents of nests and age structure of penguin chicks were investigated in experimental areas, in which the counting of breeding pairs was carried out. These materials enabled the author to estimate the representativeness of the size of an area and reliability of data on the number of breeding pairs and number of eggs and chicks in the population. Differences between the assessment of abundance obtained by means of the above method and by the methods of direct countings in transects were from 1.6% to 12.8%.

3.4. Weight and biomass

Birds and eggs were weighed using the Pesol spring scales to the nearest 1.5 and 10 g. Dried shells of eggs were weighed to the nearest 0.01 g.

The estimation of the biomass of the summer community of birds was carried out on the basis of the mean number of individuals observed between 5 December 1978 and 27 February 1979, and the mean body weight in this period. This estimate does not take into account the species occurring sporadically and *F. tropica* whose numbers and individual body weight were however negligible in relation to all community. Phenological changes in the biomass of this community were estimated on the basis of changes in the individual body weight of most abundant species, i.e. pygoscelid penguins and *O. oceanicus*; for the remaining species, due to the low number of weighed individuals, data on the mean body weight for the whole summer were used.

The numbers of eggs and chicks necessary to assess biomass in subsequent periods were determined on the basis of the contents of nests in the test areas. Data on the weight of eggs (Appendix 1) used for the estimation of their biomass stand for their mean weight during the incubation period. The weight of chicks in the first day of their life was determined considering the changes in the body weight of a hatchling. The mean weight of chicks in subsequent age classes was calculated on the basis of changes in their body weight during five days' growth periods (Appendix 2, 3, 4). The biomass of chicks was determined separately for subsequent age classes, in which the abundance of the chicks was determined on the basis of their age structure in test areas.

3.5. Comparability of the estimation of abundance and biomass of birds

The problem of the comparability of estimations of abundance and biomass of birds in Antarctic region is difficult due to the patchy occurrence of their communities along the coast-line and poorly known distance of feeding penetration from the colony towards the sea. Prevost (1963) and Holdgate (1967) assessed the density of biomass of nesting birds in relation to the area free of ice, but they analysed the role of birds only in the land ecosystem. However, this ecosystem depends on transport of organic matter from the sea. For this reason the most proper area for relating data on abundance and biomass of birds should be the area of their penetration, i.e. the area of sea and land together. On the basis of observations carried out from m/s "Antoni Garnuszewski", from a cutter and from a helicopter, it was found that most of specimens of particular flying bird species penetrate only the area of the Admiralty Bay (131 km^2) or its coast-line (91 km). Only part of the specimens of *O. oceanicus*, *F. tropica*, *Phalacrocorax atriceps* King, *Daption capensis* (Linn.) and of penguins, sought for food outside the Admiralty Bay. *P. adeliae* penetrated the sea up to 25 km from the coast and

P. antarctica up to 20 km. In this work, the abundance and biomass of birds were related to the area free of ice, the area of the bay and both these areas taken together (i.e. 150 km^2). Values obtained in this way are overstimated nevertheless they were here included to meet the needs of other specialists working in this area in the field of ecology. In the discussion another calculation was done taking into account the larger area penetrated by the community, i.e. 150 km^2 of the region of the Admiralty Bay and 625 km^2 (25×25 km) of the Bransfield Strait (total 775 km^2). The concept of such an area penetrated by birds was obtained due to the possibility of the observation of marked penguins using a helicopter and a cutter and estimation in this way of the range of their penetration. In most of ornithological investigations from the region of the Antarctic, observations were conducted only on the shores, the length of which may easily be calculated on the basis of a map. Recalculations of the abundance of birds in relation to linear values are widely used in studying birds inhabiting the coastal lines of rivers, lakes and seas, because in these environments there are difficulties in assessing the area penetrated by birds. The most important argument against such recalculations of data from polar regions is the occurrence of glaciers along the coastal lines, which are not settled by birds. During the investigations conducted in the region of the Admiralty Bay it was determined that many species were feeding in the region of the glaciers. Ice cliffs with their foot unveiling on the low tide constituted about 26% of the coast line of the investigated area. During the low tide species consuming *Amphipoda* and scavenging species fed in such places. The reason was that below this type of ice cliffs there happened to occur elephant seals killed by ice-falls (e.g. between Red Hill and Patelnia Point and under Ecology Glacier). Searching for food by species feeding in the tidal zone consisted in regular flights along the coastal line, irrespective of its type. Such feeding penetration was represented by *M. giganteus* and *S. vittata*, and partially by *D. capensis*, *S. skua*, *L dominicanus* and *Ch. alba*. The first three species made their feeding flights along the distance of 25—30 km from the colony, two subsequent ones along about 10—15 km, whereas *Ch. alba* along 5 km (occasionally to 10 km). *S. vittata* also fed close to the mouths of rivers flowing out from under glaciers. This species also used moraines on glaciers as resting places (e.g. on the Baranowski Glacier). These facts evidence that birds occur also within the limits of the ice coast-line and due to this the calculation of their abundance and biomass for 1 km of the coast-line may be useful also in the conditions of Antarctic investigations. The only thing which is questionable is the problem of topographical representativeness of the coast line of the region of the Admiralty Bay in respect to the whole of the island and the problem of proper length of the coast line. From Thomas Point to Red Hill the coasts have character similar to that at Stranger Point and in the remaining regions of the south-western part of King George Island. On the other hand, the remaining part of the coast line is specific for the Admiralty Bay due to the presence of three fiords (Ezcurra, Martel, Mackellar Inlets). In connection with the fact that most of birds were grouped to the west of Thomas Point one can assume that the results are representative for the south-western part of the King George Island. The length of the investigated coast-line (91 km) exceeded the length of the feeding flights at least three times and, consequently, one can assume that this length is representative for quantitative estimation.

4. Results

4.1. Abundance

4.1.1. Distribution and abundance of community of birds in the breeding season

The coasts of the Admiralty Bay are settled by birds in an uneven way (Figs 1—7, Tab. I). Particular species nested in specific habitats. 55% of nests of *P. papua* were built on storm-ridges, 40% on raised terraces and dry moraines on weathered lava flows and 5% of nests were situated in other places. *P. adeliae* nested most abundantly (82% of nests) on raised terraces and slightly sloping faces of cliffs which were covered with pebble and situated in the vicinity of flat coasts. *P. antarctica* built their nests on rocky slates: 49% of nests of this species were situated on slopes of over 40° (Chabrier Rock and Demay Point). Tracks leading to these colonies had a slope of over 70°. 89% of nests of *M. giganteus* were at the edges of steeply sloping moraines or rocks. Such nesting places occurred mostly on Rescuers Hills and Vaureal Peak. The nesting places of *D. capensis* were concentrated around Demay Point on coastal vertical cliffs with numerous ledges. The nests of *O. oceanicus* occurred mainly under large pieces of rock, and only 14.8% of the nests were situated in the slits of rock. This species was most abundant in the region of Thomas Point and Demay Point, where extensive heaps of rock debris occurred. A colony of *Ph. atriceps* was situated on a small rocky islet at Chabrier Rock. The nests occurred between narrow, vertical rocks. Colonies of *L. dominicanus* usually occurred on platforms topping vertical rocks situated at the coast. Such nesting habitats occurred at Thomas Point, Keller Peninsula, Demay Point, Blue Dyke and Hennequin Point. In the above mentioned regions there nested 62% of the pairs of gulls. *S. vittata* inhabited vast heaps of pebble and loose moraines, which occurred between Blue Dyke and Demay Point as well as on the Keller Peninsula. The abundance of nesting aggregations

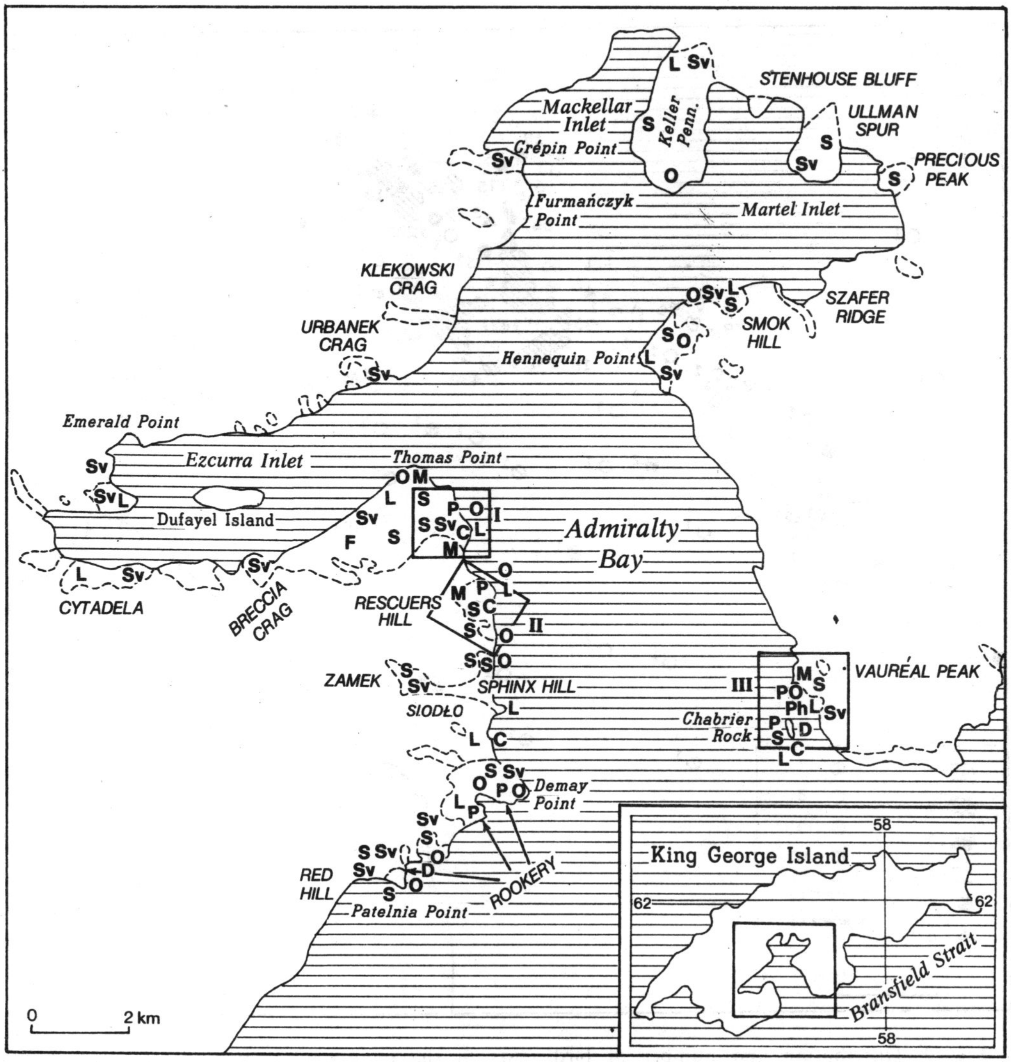

Fig. 1. Distribution of the breeding regions of birds at the coasts of the Admiralty Bay in the season of 1978/79 (Sv — *Sterna vittata*, S — *Stercorarius skua*, O — *Oceanites oceanicus*, D — *Daption capensis*, L — *Larus dominicanus*, P — *Pygoscelis*, C — *Chionis alba*, M — *Macronectes giganteus*, F — *Fregetta tropica*, Ph — *Phalacrocorax atriceps*). Rectangles I, II, III refer to regions of high concentration of breeding colonies of various species: I — Thomas Point (Fig. 2), II — Llano Point (Fig. 3), III — Chabrier Rock (Fig. 4). Rookery — localization of the colonies of Pygoscelis antarctica: at Demay Point, at Uchatka Point, at Patelnia Point (Figs. 5–7). The broken line refers to the limits of areas free of ice and glaciers.

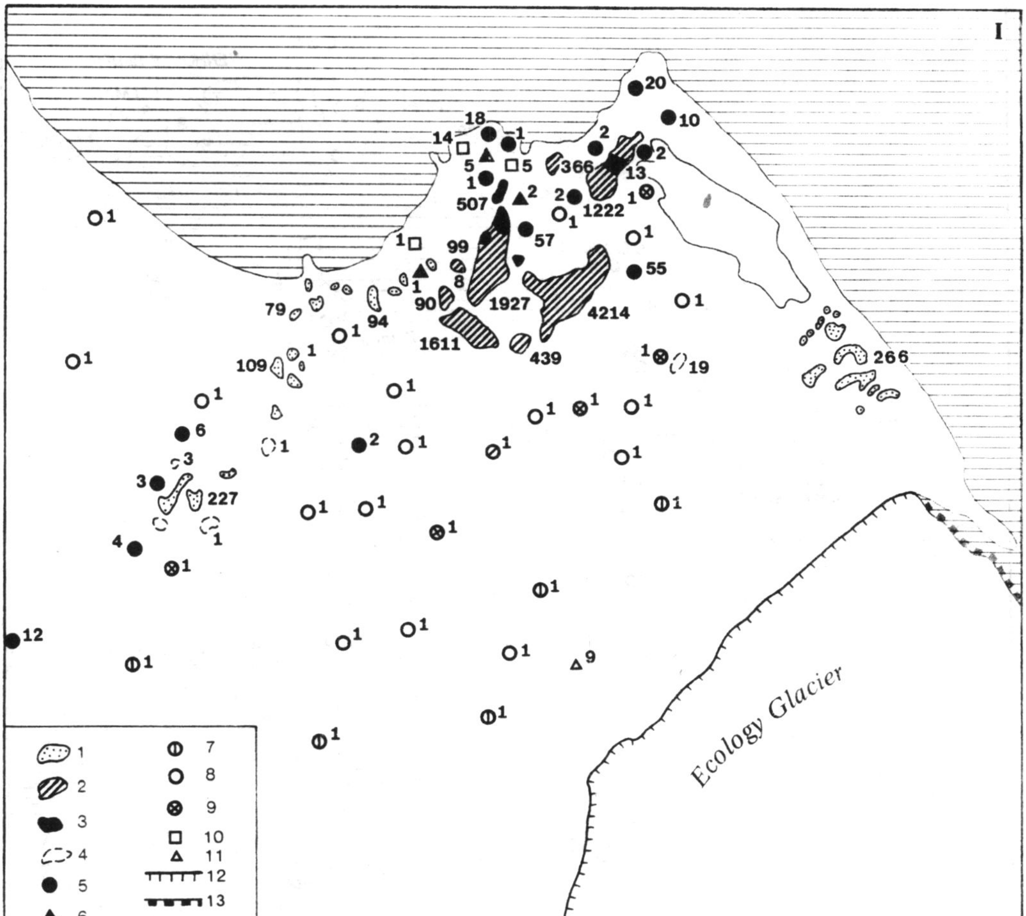

Fig. 2. Distribution and number of bird nests in the region of Thomas Point close to Penguin Ridge (rectangle I in Fig. 1): 1 — *Pygoscelis papua*, 2 — *Pygoscelis adeliae*, 3 — *Pygoscelis antarctica*, 4 — *Macronectes giganteus*, 5 — *Oceanites oceanicus*, 6 — *Chionis alba*, 7 — *Stercorarius skua maccormicki*, 8 — *Stercorarius skua lonnbergi*, 9 — mixed pairs of *S. skua maccormicki* and *S. skua lonnbergi*, 10 — *Larus dominicanus*, 11 — *Sterna vittata*, 12 — limits of areas free of ice and glaciers, 13 — ice cliff. Figures at symbols 1—11 stand for the number of nests.

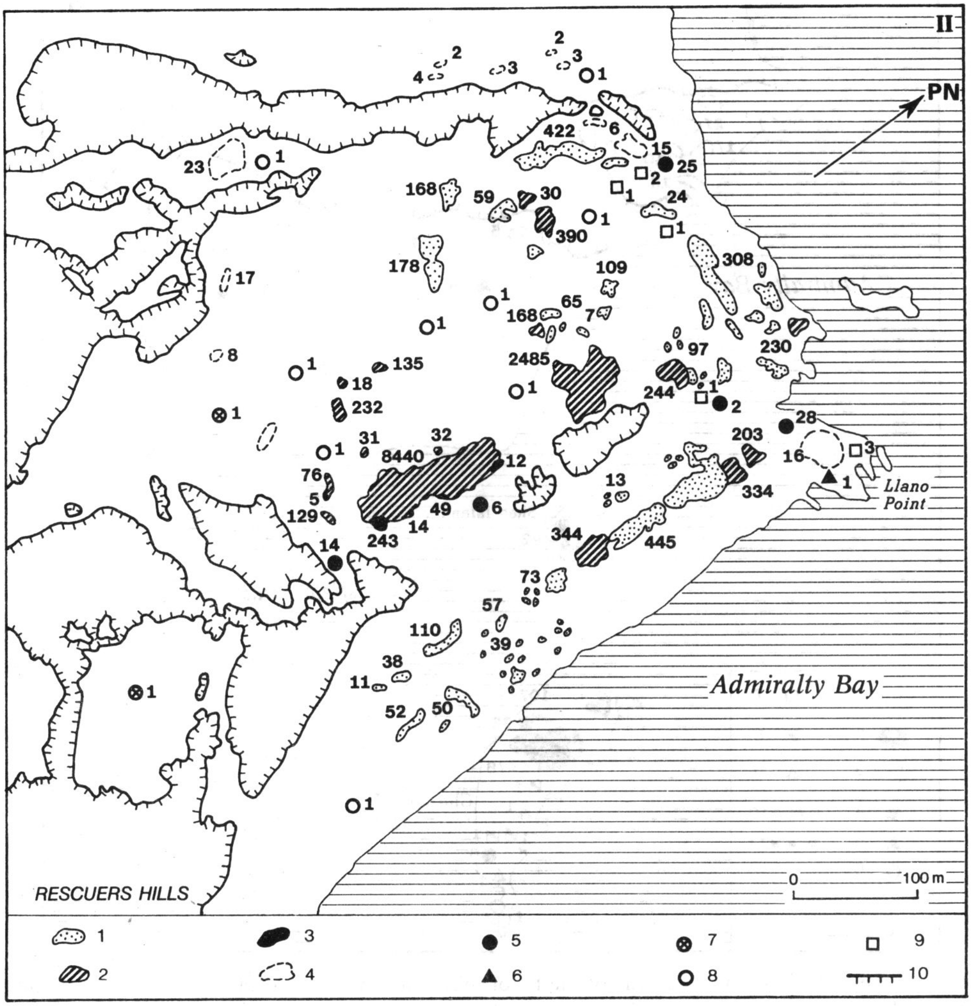

Fig. 3. Distribution and number of nests of birds in the region of Llano Point and Rescuers Hills (rectangle II in Fig. 1). Symbols as in Fig. 2. 7 — mixed pairs of *S. skua maccormicki* and *S. skua lonnbergi*, 9 — *Larus dominicanus*; other symbols as in Fig. 2.

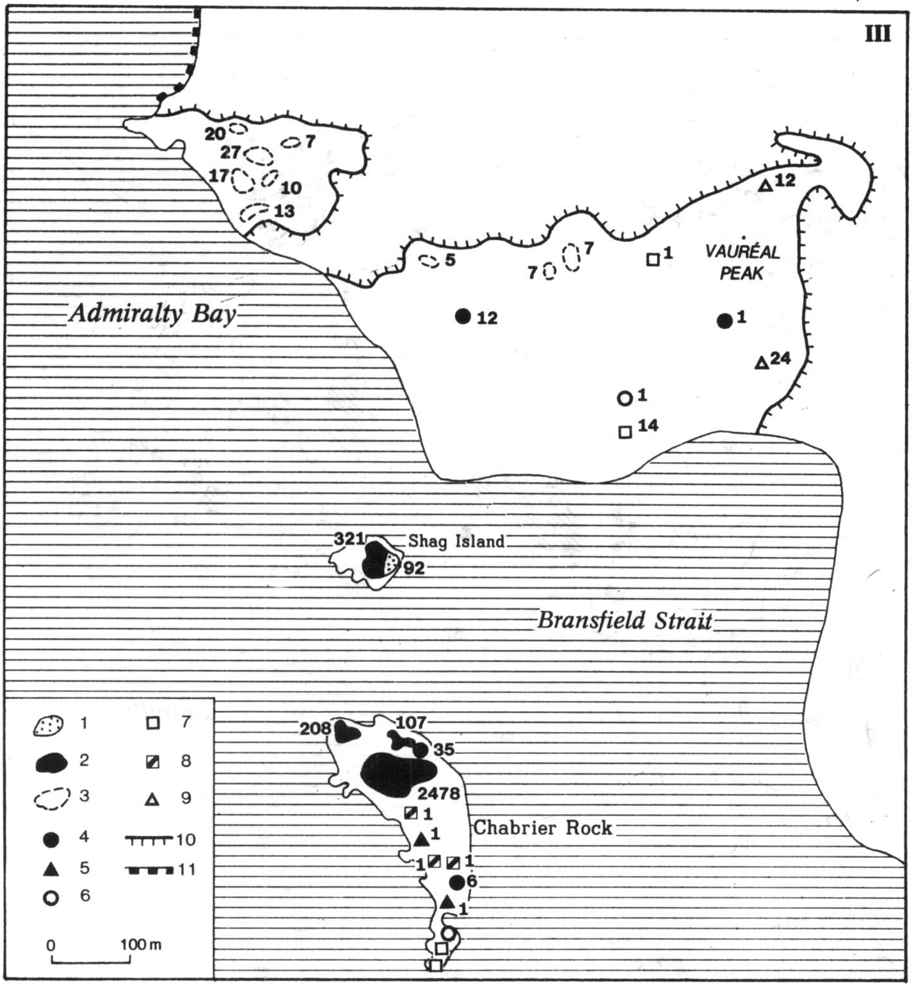

Fig. 4. Distribution and number of nests of birds in the region of Chabrier Rock and Vaureal Point (rectangle III in Fig. 1) 1 — *Phalocrocorax atriceps*, 2 — *Pygoscelis antarctica*, 3 — *Macronectes giganteus*, 4 — *Oceanites oceanicus*, 5 — *Chionis alba*, 6 — *S. skua lonnbergi*, 7 — *Larus dominicanus*, 8 — *Daption capensis*, 9 — *Sterna vittata*, 10 — limits of areas free of ice and glaciers, 11 — ice cliff

Demay Point

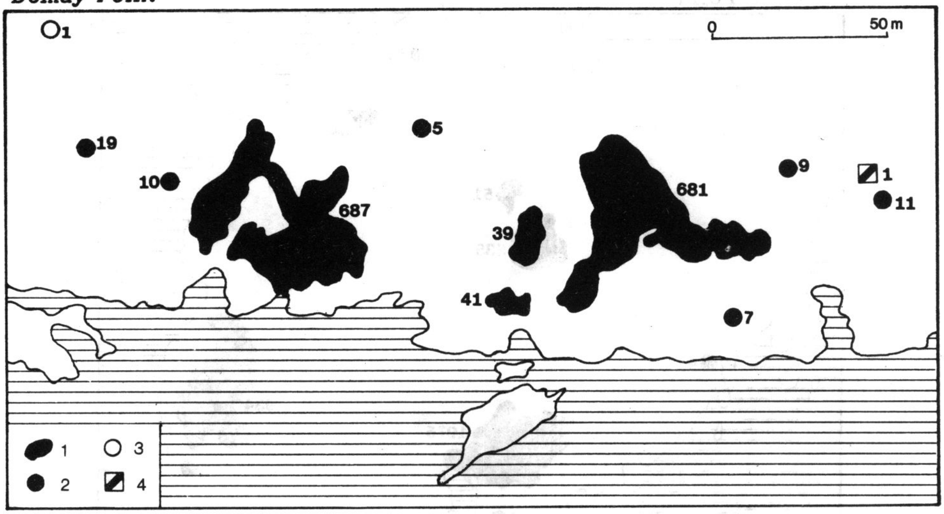

Fig. 5. Distribution and number of nests of birds in the region of Demay Point
1 — *Pygoscelis antarctica*, 2 — *Oceanites oceanicus*, 3 — *S. skua lonnbergi*, 4 — *Daption capensis*.

Uchatka Point

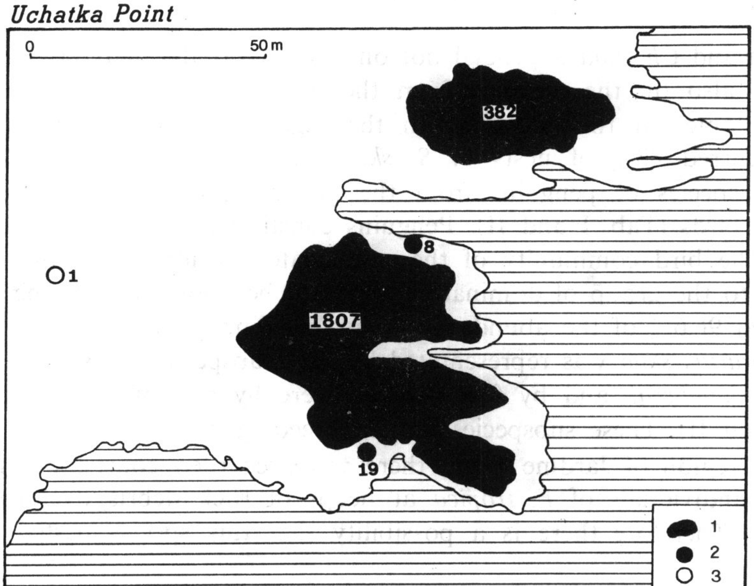

Fig. 6. Distribution and number of nests of birds in the region of Uchatka Point
Symbols as in Fig. 5.

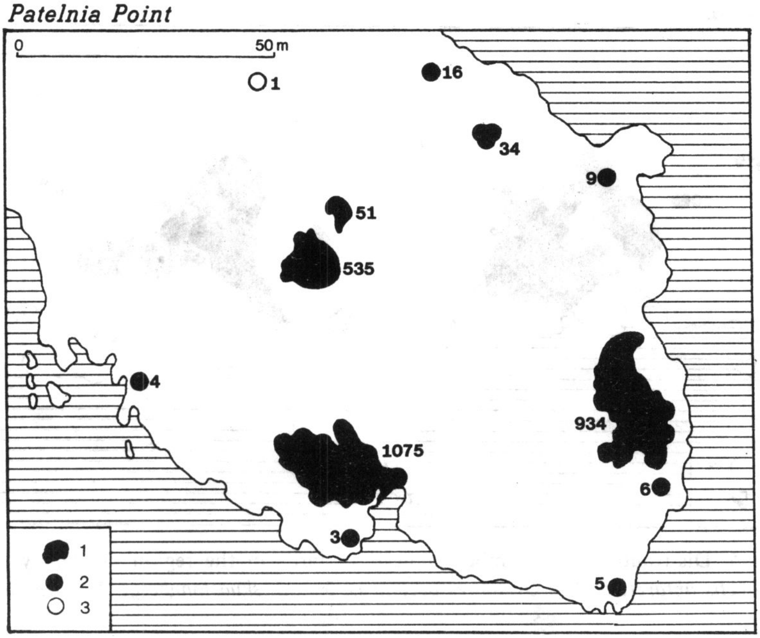

Fig. 7. Distribution and number of nests of birds in the region of Patelnia Point
Symbols as in Fig. 5.

of *S. skua* and *Ch. alba* depended not only on favourable habitats for laying eggs, but also on the distance from the feeding regions, which occurred in the colonies of the penguins. In the regions of the penguin colonies there occurred 83% of nests of *S. skua* and 71% of nests of *Ch. alba*.

Three species of penguins from the genus *Pygoscelis* were the most abundant birds (Tab. I and II). Penguins constituted 91,2% of all breeding pairs in the bird community of the investigated region. *O. oceanicus* also belonged to the group of dominating species. These four dominating species constituted 96,6% of the abundance of all breeding pairs.

Stercorarius skua was representated by two subspecies: *S. s. maccormicki* and *S. s. lonnbergi*, and by forms which were hybrids of these subspecies (Tab. I and II). These subspecies formed breeding pairs.

In the region of Jardine Peak, there were recorded courtship flights of 200—250 individuals of *F. tropica* at heaps of rock debris overgrown by *Usnea* sp. Therefore there is a possibility that this species nested in this habitat.

In the region of the Admiralty Bay sporadic visitors were following species: *Eudyptes chrysolophus* (Brandt) — (17, 20, 21, 22 December 1978 in the region of Penguin Ridge and on 7 January 1979 on the Patelnia Point); *Phoebetria fusca* (Hilsenberg) — (27 February 1979 at the outlet of the Admiralty Bay); *Fulmarus glacialoides* (Smith) — (10 January 1979 in the

Table I

Distribution and abundance of nests of birds in the Admiralty Bay region

Species	Number of nests in particular regions of the Admiralty Bay																			Total
	Red Hill	Patelnia Point	Blue Dyke	Uchatka Point-Demay Point	Siodło-Zamek-Sphinx	Rescuers Hills	Thomas Point	Breccia Crag	Cytadela	Point Hill	Emerald Point	Urbanek Crag	Crepin Point	Keller Peninsula	Ulman Spur	Precious Peak	Szafer Ridge	Smok Hill	Hennequin Point	Chabrier Rock — Vaureal Peak	
Pygoscelis papua	–	–	–	–	–	2334	783	–	–	–	–	–	–	–	–	–	–	–	–	–	3117
Pygoscelis adeliae	–	–	–	–	–	13521	10140	–	–	–	–	–	–	–	–	–	–	–	–	–	23661
Pygoscelis antarctica	–	2629	–	3637	–	321	638	–	–	–	–	–	–	–	–	–	–	–	–	3325	10550
Macronectes giganteus	–	–	–	–	–	102	37	–	–	–	–	–	–	–	–	–	–	–	–	113	253
Daption capensis	–	–	3	38	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	3	44
Oceanites oceanicus	–	43	281	835	2	187	614	–	–	–	–	–	–	10	–	–	–	–	70	162	2210
Phalacrocorax atriceps	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	92	92
Chionis alba	–	–	–	1	–	1	12	–	–	–	–	–	–	–	–	–	–	–	–	3	17
Stercorarius skua lonnbergi	1	2	3	8	3	8	23	–	–	–	–	–	–	11	–	–	1	2	10	2	74
Stercorarius skua maccormicki	1	–	2	1	–	2	7	–	–	–	–	–	–	10	2	2	–	1	9	–	37
mixed pairs of S. s. lonnbergi and *S. s. maccormicki*	–	–	–	1	–	1	8	–	–	–	–	–	–	–	–	–	–	–	–	–	19
Larus dominicanus	–	–	7	16	6	8	22	3	8	11	–	–	–	51	–	–	–	10	5	17	164
Sterna vittata	4	20	159	152	8	4	53	18	8	9	5	1		146	3	–	–	13	7	36	652
																			Total		40890

Table II

Abundance and density of bird community from the Admiralty Bay region in Antarctic summer 1978/1979
(+ — species occurring sporadically, abundance not estimated; ? — abundance unknown)

Species	Number of individuals			Abundance	Density per 1 km²		
	breeding	non--breeding	Total	per 1 km of shoreline	land	bay	land and bay together
Pygoscelis papua	6234	576	6810	77.4	358.4	52.0	45.3
Pygoscelis adeliae	47322	8970	56362	640.5	2966.4	430.2	375.0
Pygoscelis antarctica	21100	1999	23099	262.5	1215.7	176.3	153.7
Eudyptes chrysolophus	–	3	3	+	+	+	+
Phoebetria fusca	–	1	1	+	+	+	+
Macronectes giganteus	506	39	545	6.2	28.7	4.2	3.6
Fulmarus glacialoides	–	1	1	+	+	+	+
Daption capensis	88	–	88	1.0	4.6	0.7	0.6
Pagodroma nivea	–	3	3	+	+	+	+
Oceanites oceanicus	4420	–	4420	50.2	232.6	33.7	29.4
Fregetta tropica	?	?	?	?	?	?	?
Phalacrocorax atriceps	184	111	295	3.3	15.5	2.2	2.0
Chionis alba	34	5	39	0.4	2.0	0.3	0.3
Stercorarius skua maccormicki	74	6	80	0.9	4.2	0.6	0.5
Stercorarius skua lonnbergi	148	53	201	2.3	10.6	1.5	1.3
S.s. maccormicki × *S.s. lonnbergi* (hybrids)	38	6	44	0.5	2.3	0.3	0.3
Larus dominicanus	328	209	537	6.1	28.3	4.1	3.6
Sterna vittata	1304	299	1603	18.2	84,4	12.2	10.7
Total	81780	12281	94131	1069.5	4953.7	718.3	626.3

region of the lighthouse); *Pagodroma nivea* (Forster) — (25, 26 February 1979 in the Ezcurra Inlet and Ecology Glacier).

Non-breeding individuals constituted 13% of the whole community of birds. The density of the community in relation to the area free of ice and the area of the Admiralty Bay was very high (Tab. II).

4.1.2. Phenology, breeding efficiency and age structure of penguins

The periods of maximal abundance of penguins occurred in the second half of December and first half of January (Tab. III). The maximal abundances of chicks of particular species occurred in various terms of the breeding period. This refers first of all to the most abundant species, i.e. *P. adeliae* and *P. antarctica*.

Pygoscelis papua. First individuals appeared in the nesting regions between 27 – 30 August 1978 (Łukowski, personal communication). The first egg was laid on 21 October. The last chick hatched on 14 January 1979. The breeding efficiency was analysed on the basis of observations of 110 nests in the region of Thomas Point. In the 110 nests, there were 214 eggs (1.95 egg per nest). 184 chicks hatched from them (1.67 chicks per nest) and to the end of January (i.e. to the end of fledging) 146 of them (i.e. 1.33 indiv. per nest) had survived.

Pygoscelis adeliae. First individuals appeared in the region of the colony on 15 September 1978 (Łukowski, personal communication). Regular investigations on the breeding efficiency were conducted in two breeding colonies: in the largest breeding colony from the region of Thomas Point (Fig. 3) and in a peripheric one; in the former colony the breeding of 468 and in the latter of 58 pairs were monitored. Due to considerable variability of breeding efficiency in these colonies (Tab. IV) additional data were collected from 1354 nests occurring in colonies of various size. In these colonies only the recording of the number of eggs and chicks which had survived up to the end of fledging was carried out. The results are as follows: 2542 eggs in 1352 nests, i.e. 1.88 eggs per nest, and 1709 chicks, i.e. only 1.26 chick per nest, had survived to the end of fledging. Further fate of the chicks from this colony was monitored only on the basis of individuals marked in 125 nests, in which there were 225 eggs. It was determined that till the time when the colony became deserted 120 young birds had survived. The final efficiency amounted to 0.96 young birds per nest.

Pygoscelis antarctica. First individuals arrived to the regions of the colony at Thomas Point between 20—24 October 1978 and the first egg was laid on 20 November (Łukowski, personal communication). Hatching started between 20 and 23 December. The efficiency of the breeding was investigated in the sample of 153 nests which occurred in a colony mixed

Table III

Abundance of penguins of the genus *Pygoscelis* in particular periods

	Pygoscelis papua				*Pygoscelis adeliae*				*Pygoscelis antarctica*			
	A	B	C	D	A	B	C	D	A	B	C	D
Number of countings	2	2	1	2	1	1	4	5	4	2	3	2
breeding pairs (individuals)	3117 (6234)	3099 6.198	3055 (6110)	– –	23661 (47322)	23212 (46424)	– –	– –	10550 (21190)	10510 (21020)	10500 (21000)	– –
non-breeding individuals	576	598	585	–	9040	7430	–	–	1999	2522	2150	–
adult individuals (total)	6810	6796	6695	1418	56362	53854	630	12	23099	23542	23150	15826
young individuals	5232	5953	4071	1451	37147	29865	12167	499	–	14959	13889	12745

A — 10–24 Dec. 1978, B — 25 Dec. 1978–10 Jan. 1979, C — 11 Jan.–1 Feb. 1979, D — 2–16 Feb. 1979.

Table IV.

Breeding efficiency of *Pygoscelis adeliae* in breeding colonies of various number of nests (A — in the period of sitting on eggs, B — hatching, C — fledging at the age of about 40 days)

Number of nests	A		B		C	
	number of eggs	number of eggs per nest	number of chicks	number of chicks per nest	number of juv.	number of juv. per nest
468	842	1.80	622	1.33	500	1.07
58	101	1.74	66	1.14	34	0.59

with *P. adeliae* in the region of Thomas Point. 301 eggs were recorded in these nests (1.97 eggs per nest); from them 246 chicks hatched, i.e. 1.61 per nest. 202 of them had survived to the end of fledging (i.e. 1.32 chicks per nest).

Data on the number of chicks of all three penguin species in subsequent phases of life, necessary for estimation of the biomass dynamics, were calculated. These data were obtained on the basis of the age distribution of chicks in test areas (Tab. V, VI, VII).

4.1.3. Phenology, breeding efficiency and age structure of flying birds

Macronectes giganteus. First individuals began to occupy their colonies on 25 July 1978, and abundant occupying occurred between 28 July and 31 July. The first egg was laid on 10 November and by 13 November eggs had been laid in most of the nests (Łukowski, personal communication). The hatching of chicks started on 31 December. Survey of the abundance of chicks was conducted regularly in four breeding groups on Rescuers Hills and Llano Point, where there occurred 102 nests. Until 24 December 71 nests contained eggs and 31 were empty. Till 10 January 61 chicks has hatched (i.e. 59.8% from 102 nests), and in the remaining 10 nests eggs were still present (9.8% of nests). In the period preceeding the hatching parents occupied the nests enduringly and that is why in this period there were no losses caused by *Stercorarius skua.* At the end of January 54 chicks were in nests (i.e. 52.9% of nests). Also in the same period 3 nests with eggs were recorded (2.9%). Till 16 February 50 chicks (49.0%) had survived. Losses in the broods were caused mainly by *S. skua.* It should be assumed that the extent of losses in general is much lower than in the described colonies, because parents sitting on eggs were scared away during the investigations. On the basis of these data the number of chicks and eggs of the whole population inhabiting the Admiralty Bay was determined (Tab. VIII). The

Table V

Changes of the abundance of young *Pygoscelis papua* in various stages of their development

Periods	10–24 Dec. 1978		25 Dec. 1978–10 Jan. 1979			11 Jan.–1 Feb. 1979			2–16 Feb. 1979	
Age of young birds in days	1–10	11–20	5–10	11–20	21–30	11–25	26–35	36–45	30–40	>40
Number of young birds in test nests	481 (69.7%)	209 (30.3%)	223 (8.5%)	1121 (42.5%)	1293 (49.0%)	5 (1.1%)	32 (7.4%)	395 (91.5%)	26 (5.2%)	474 (94.8%)
Number of young birds in the whole population	3647	1585	506	2530	2917	45	301	3725	75	1376
Total number of young birds in the whole population	5232		5953			4071			1451	

Table VI

Changes of the abundance of young *Pygoscelis adeliae* in various stages of their development

Periods	10–24 Dec. 1978			25 Dec. 1978–10 Jan. 1979			11 Jan.–1 Feb. 1979		2–16 Feb. 1979
Age of young birds in days	1–10	11–20	21–30	11–20	21–35	21–35	35–45	45	45
Number of young birds in test nests	645 (28.7%)	773 (34.5%)	827 (36.8%)	16 (1.2%)	68 (5.3%)	1209 (93.5%)	24 (5.0%)	458 (95.0%)	–
Number of young birds in the whole population	10661	12816	13670	358	1583	27924	608	11559	499
Total number of young birds in the whole population	37147			29865			12167		499

assessment of the age of the chicks, necessary for calculating their biomass, was carried out between 25 December and 10 January, in the sample of 48 chicks from the colonies on Rescuers Hills and Llano Point. On 4 January the age structure of this colony was as follows: 13 chicks 1—2 days old (27.1%), 17 chicks 3—5 days old (35.4%), and 18 chicks 5 days old (37.5%). Because of unequal rate of hatching it was assumed that the average age of chicks between 31 December and 10 January was 5 days. In the remaining periods the age of chicks was estimated basing on the monitoring of all

Table VII.

Changes of the abundance of young *Pygoscelis antarctica* in various stages of their development

Periods	25 Dec. 1978 – – 10 Jan. 1979		11 Jan. – 1 Feb. 1979			2 – 16 Feb. 1979		
Age of young birds in days	1 – 10	11 – 20	11 – 20	21 – 30	31 – 40	16 – 25	26 – 35	36 – 45
Number of young birds in test nests	158 (92.4%)	13 (7.6%)	450 (29.9%)	425 (28.2%)	631 (41.9%)	144 (28.7%)	155 (30.9%)	203 (40.4%)
Number of young birds in the whole population	13822	1137	4153	3917	5819	3658	3938	5149
Total number in the whole population	14959		13889			12745		

nests of the Admiralty Bay region. At the end on January eggs were present in 7 nests and the age of 134 chicks was following: 13 chicks were about 5 days old, 35 were 11—15 days old, 35 chicks were 16—20 days old, 32 were 21—25 days old and 19 chicks were about 30 days old. In the middle of February one egg was found in one nest, while the age of 123 chicks varied widely: 4 of them were between 6—10 days old, 27 chicks between 11—20 days old, 57 were 21—25 days old, 25 chicks were 26—33 days old and 10 were 36—45 days old.

Daption capensis. First eggs in the colony at Demay Point were laid on 19 October 1978 (Łukowski, personal communication). When the colony was monitored between 8 and 10 January, the presence of 38 pairs with 39 eggs was recorded (in one nest there were two eggs). During inventorying the colony carried out between 8 and 10 February, 29 chicks were recorded in the nests. The mean weight of 10 chicks amounted to 317 g (from 290 to 340 g). This weight is reached by the chicks of D. capensis at the age of 15 days (Despin 1977).

Oceanites oceanicus. First individuals appeared in the breeding places on 10 October 1978 (Łukowski, personal communication). The occupying of breeding sites occurred from 11 December to 12 January. It was recorded, however that one egg was laid as late as on 20 February. Routine monitoring of 293 nests at 2—3 week intervals proved that eggs were laid only in 140 nests (47.8%). Due to the long period of egg laying it was difficult o determine the percentage of breeding individuals in the population.

Phalocrocorax atriceps. Monitoring of the colony was conducted on 4 January. On the whole, 114 nests were recorded. Out of these, 22 nests (19.3%) were empty, in 14 (12.3%) there were eggs, and in 78 (68.4%) there were chicks (Tab. IX).

Chionis alba. Courtship behaviour started on 9 September 1978 (Łukowski, personal communication). Abundant egg laying ended between 15 and 20 December. First hatchlings appeared on 11 January, and the last on 20 January. From 10 to 24 December 17 pairs, which laid 36 eggs (2.11 eggs per nest) stayed in the region of the Admiralty Bay. At the end of January in the nests there were 30 chicks which were 10—15 days old, and between 2 and 20 February 26 fledging ones which were 20—25 days old. In 9 nests which were continually controlled 19 eggs were found (2.11 eggs per nest). 16 chicks hatched out of them (1.78 chicks per nest) and till 20 February 14 fledging chicks remained there (1.56 per nest). The decrease in the number of chicks was due to the fall of pieces of rock and to the predation by *Larus dominicanus*.

Stercorarius skua maccormicki. First hatchlings appeared on 24 December. The period of egg laying ended on 10 January. The efficiency of the breeding was investigated in a sample of 10 nests in which there were 19 eggs (1.90 eggs per nests). 15 chicks hatched there (1.50 chicks per nest) and 12 chicks had survived to the final period of fledging (1.20 per nest). The period of laying and hatching was rather long. This is proved by the following details: in the period 10—24 December there were 7 pairs with newly-constructed nests and 30 pairs with 57 eggs (including 1 with a hatchling); between 25 December and 10 January there were 25 eggs in 13 nests and 36 chicks in 24 nests. In the course of the age control of chicks, which was done on 10 January, 2 hatchlings were noticed, 8 chicks were 5 days old, 9 were 6—10 days old and 17 chicks were between 11 and 15 days old. From 11 January to 1 February there were 11 nests with 21 eggs and 26 nests with 40 chicks. The age structure of the chicks at the end of January was the following: 4 of them were 6—10 days old, 24 were 11—20 days old, 10 chicks were 21—30 days old and 2 were 35 days old. In the period 2—16 February in 2 nests there were 4 chicks which were 5 days old and in 35 nests there were 40 chicks, 4 of which were 16—20

Abundance of a summer community of birds in
(in brackets — percentage

Species	10–24 Dec. 1978			25 Dec. 1978–	
	Number of individuals		Number of eggs	Number of individuals	
	adult	young		adult	young
Pygoscelis papua	6810 (7.2%)	5232 (12.3%)	571	6796 (7.4%)	5953 (11.6%)
Pygoscelis adeliae	56362 (59.9%)	37147 (87.2%)	5004	53845 (85.4%)	29865 (58.1%)
Pygoscelis antarctica	23099 (24.6%)	–	19482	23542 (25.6%)	14959 (29.1%)
Macronectes giganteus	506	–	176	506	151
Daption capensis	88		45	88	–
Oceanites oceanicus	4420	–	821	4420	–
·*Fregetta tropica*	?	?	?	?	?
Phalacrocorax atriceps	295	?	?	295	150
Chionis alba	39	–	36	39	–
Stercorarius skua maccormicki	80	–	57	80	36
Stercorarius skua lonnbergi	201	–	127	201	93
S. s. maccormicki × *S. s. lonnbergi* (hybrids)	44	–	25	44	6
Larus dominicanus	537	234	–	537	170
Sterna vittata	1603	234	441	1603	–
Pygoscelis (together)	86271 (91.7%)	42379 (99.4%)	25057 –	84193 (91.5%)	50777 (98.8%)
Flying birds (together)	7813	234	1728	7813	606
Total	94084	42613	26785	92006	51384
Density of the community (individuals per 1 km shore line)	1068.3	484.2		1045.5	583.9
Density of the community per 1 km^2: Land free of ice	4951.8	2242.8		4842.4	2704.4
Bay	717.7	325.3		702.3	392.2
Land and bay (together)	626.0	283.5		612.1	341.9

Table VIII

the Admiralty Bay region in particular periods
share in the community)

Periods						
Jan. 1979	11 Jan. – 1 Feb. 1979			2–16 Feb. 1979		
Number of eggs	Number of individuals adult	Number of individuals young	Number of eggs	Number of individuals adult	Number of individuals young	Number of eggs
140	6695 (17.5%)	4071 (13.2%)	36	1418 (5.7%)	1451 (9.5%)	–
601	630 (1.6%)	12167 (39.5%)	–	12 (0.05%)	499 (3.3%)	–
3073	23150 (60.5%)	13889 (45.1%)	1266	15826 (63.2%)	12745 (83.3%)	–
25	506	134	42	506	123	1
45	88	?	?	88	29	–
703	4420	–	703	4420	–	703
?	?	?	?	?	?	?
27	295	?	?	290	?	?
36	39	30	–	39	26	–
25	75	40	21	75	44	–
15	193	89	7	193	74	4
17	44	?	5	44	18	5
–	537	111	–	537	111	–
515	1603	295	234	1603	173	158
3811	30475	30124	1302	17256	14695	–
–	(79.6%)	(97.7%)	–	(68.9%)	(96.1%)	
1408	7800	699	1012	7795	598	870
5219	38275	30826	2314	25051	15293	870
	434.9	350.3		284.7	173.8	
	2014.5	1622.4		1318.5	804.9	
	292.2	235.3		191.2	116.8	
	254.7	205.1		166.7	101.7	

days old, 24 were 21—30 days old and 12 were 31—45 days old. 5 dead adult individuals were found between 15 January and 16 February.

Table IX

Breeding stages in the colony of *Phalacrocorax atriceps* on 4 January 1979

Estimated age of young birds (days)	Contents of nests	number of nests	% nests	Total (eggs and young birds)
–	empty	22	19.3%	0
–	1 egg	1	12.3	1
	2 eggs	13		26
1 – 10 (lack of fluff)	1 chick	4	3.5	4*)
	2 chicks	8	7.0	16
	3 chicks	1	0.9	3
11 – 20 (fluff)	1 chick	6	5.9	6
	3 chicks	1	0.9	3
20 – 30 (fluff on remiges)	1 chick	1	0.9	1
	2 chicks	25	21.9	50
31 (walking round the colony)	1 juv.	2	1.7	2
	2 juv.	21	18.4	42
	3 juv.	9	7.9	27
Total		114	100%	27 eggs 150 chicks

*) dead chicks that were not included in the total sum of 150 living ones

Stercorarius skua lonnbergi. First individuals arrived on 21 October 1978 and courtship behaviour and occupying of breeding territories began on 24 October. The main period of laying continued from 18 to 27 November 1978 (Łukowski, personal communication), but 4 pairs of *S. s. lonnbergi* constructed nests as late as in February. First hatchlings appeared on 24 December, but abundant hatching occurred between 30 December and 4 January. The breeding efficiency was investigated on the basis of 31 pairs nesting in the region of Thomas Point, Demay Point and Blue Dyke. In 31 nests 56 eggs were laid (1.81 eggs per nest). 38 chicks survived the period of fledging (1.22 chicks per nest). Between 10 and 24 December 70 pairs with 127 eggs were recorded. Between 25 December and 10 January there were 15 eggs in 14 nests, and 93 chicks in 56 nests. Monitoring of the age of the chicks which was conducted on 10 January showed that there were 4 hatchlings, 42 chicks about 5 days old, 33 chicks were 6 to 10 days old and 14 were 11—15 days old. From 11 January to 1 February in 5 nests there were 7 eggs, and in 60 nests 89 chicks. The age structure of the chicks was as follows: 1-st day — 2 chicks, about 5 days old — 9 chicks, between 6—10 days — 28 chicks, between 11—15 days — 30 chicks, between 16—25 days — 17 chicks and between 26—35 days — 8 chicks. From 2 to 16 February 2 pairs had newly-constructed nests, 2 pairs were sitting on their eggs and 61 pairs had 74 chicks, three of which were about 5 days old, 3 were between 6 and 10 days old, 4 chicks between 16 and 25 days, 39 between 26 and 35 days and 15 chicks between 35 and 40 days. Between 11 January and 16 February 8 dead adult individuals were found in the area.

In mixed pairs of *Stercorarius skua maccormicki* and *S. s. lonnbergi* on the average there were 1.90 eggs per nest, and 1.21 chicks per nest survived to the period of fledging. The breeding period of particular pairs varied widely. This is proved by the following data: from 10 to 24 December two nests were empty, and in 13 nests there were 25 eggs, between 25 December and 10 January there were 17 eggs in 9 nests, in three nests there were 6 chicks about 5 days old and three nests were destroyed; from 11 January to 1 February three new nests with 5 eggs appeared and one nest was under construction; between 2 and 16 February 15 pairs and 18 chicks 30—40 days old were recorded, in three nests there were eggs and one nest was under construction.

Larus dominicanus. Arriving to the breeding colony occurred on 13 September 1978 (Łukowski, personal communication). The hatching lasted from 11 to 24 December. The breeding efficiency was investigated using a sample of 28 nests in which there were 64 eggs at the end of the hatching (2.25 eggs per nest). Till 10 January 29 chicks (1.04 per nest) had survived. At the beginning of February there were 19 chicks in the colony (0.68 per nest). A low breeding efficiency was due to the predation of *Chionis alba.* On the basis of breeding efficiency and known number of breeding pairs (Tab. I) the abundance of chicks of *L. dominicanus* was calculated for the whole region of the Admiralty Bay (Tab. VIII). Short hatching period, which lasted only 14 days, enabled the age of chicks to be easily determined in particular periods: between 10 and 24 December chicks were 1—15 days old, between 25 December and 10 January — 16—30 days old, between 11 January and 1 February — 35—50 days old, and between 2 and 16 February — 50—65 days old.

Sterna vittata. Arriving to the colony occurred on 18 September 1978, and first eggs appeared on 18 November (Łukowski, personal communication). However the period of laying within the area of the colony lasted to the end of January. The first hatchling appeared on 11 January, but abundant hatching began between 16 and 21 January. The breeding efficiency was determined on the basis of 134 nests from the region of Demay Point, Weight of individuals (in g) and biomass of a bird community

Species	Number of weighed birds	Mean individual weight
Pygoscelis papua	48	5976 *) (5150 – 6600)
Pygoscelis adeliae	73	4400 (3500 – 5800)
Pygoscelis antarctica	59	4378 (3600 – 5300)
Macronectes giganteus	6	4575 (4350 – 4910)
Fulmarus glacialoides	1	550
Eudyptes chrysolophus	1	3280
Phoebetria fusca	1	2460
Daption capensis	11	419 (390 – 435)
Pagodroma nivea	1	265
Oceanites oceanicus	61	34.7 (27 – 42)
Fregetta tropica	0	?
Phalacrocorax atriceps	10	2540 (2180 – 2880)
Chionis alba	9	630 (580 – 665)
Stercorarius skua maccormicki	4	1190 (980 – 1309)
Stercorarius skua lonnbergi	13	1452
S. s. maccormicki × *S. s. lonnbergi* (hybrids)	**)	1320
Larus dominicanus	17	1113 (940 – 1295)
Sterna vittata	5	170 (160 – 179)
Pygoscelis (total)		
Flying birds (total)		
Total		

*) range in the brackets

**) — mean body weight of hybrids was estimated on the basis of mean weights of both subspecies

Blue Dyke, Keller Peninsula and Thomas Point. In 134 nests there were 184 eggs (1.37 eggs per nest). The number of layings in particular periods was as follows: till 25 December — 91 eggs (49.4% of 184 eggs); between 25 December and 10 January — 45 eggs (24.4%); between 11 January to 1

Table X

(in kg) in the Admiralty Bay region in the summer 1978/79

Biomass of the bird community	Density of biomass per 1 km²		
	land free of ice	Admiralty Bay	Land free of ice and the Admiralty Bay together
40696.56	2141.92	310.66	271.31
247992.80	13052.25	1893.07	1653.28
101127.42	5322.50	771.97	674.18
2493.38	131.23	19.03	16.62
+*)	+	+	+
+	+	+	+
+	+	+	+
36.87	1.94	0.28	0.25
+	+	+	+
154.7	8.14	1.18	1.03
?	?	?	?
749.30	39.44	5.72	4.99
24.57	1.29	0.19	0.16
95.20	5.1	0.73	0.63
291.35	15.36	2.23	1.95
58.12	3.06	0.44	0.39
597.68	31.46	4.56	3.98
272.51	14.34	2.08	1.82
389816.78 (98.8%)	20516.67	2953.16	2598.77
4774.18 (1.2%	251.27	36.17	31.82
394590.96 (100%)	20767.94	2989.33	2630.59

February — 48 eggs (26.1%, of these 32 eggs till 20 January — 17.4%). 124 chicks hatched from 184 eggs (0.93 chicks per nest). 71% chicks survived 5 days, 50% — 10 days, and 33.3% — 25 days. For the most part, losses were caused by the avalanches of stones. On the basis of the above data and known number of breeding pairs (Tab. I) the changes in the numbers of eggs and chicks for the region of the Admiralty Bay (Tab. VIII) were determined.

4.1.4. Phenological changes in the abundance of bird community

The level of abundance of the whole community depended on phenological changes in the abundance of penguins (Tab. VIII), because adult penguins constituted from 91.7% to 68.9% of all birds in a community. The highest abundance of penguins, and thus of the whole community occurred between 10 December and 10 January. At that time mass hatching occurred there. In the course of hatching also those individuals which had lost their nests and a considerable part of the non-breeding population returned to the colony, which is in agreement with the opinions of Sapin-Jaloustre (1960) and Taylor (1962). In the periods of the highest abundance of the community the share of adult *Pygoscelis adeliae* amounted to 59.9 and 58.1% of the total abundance of birds, respectively. Since the second half of January the abundance of the community decreased due to the fact that *Pygoscelis adeliae* started to leave the rookery. The share of adult individuals of this species amounted to 1.6 and 0.05% of the total abundance respectively. In the second half of the breeding period (i.e. since the half of January) the dominance of *P. antarctica* increased because of the difference in timing between *P. adeliae* and *P. antarctica* (Tab. VIII). In the second part of the breeding period the share of other species in the community also increased due to emigration of penguins from the rookery. Flying birds were characterized by later breeding than penguins (Tab. VIII). This refers especially to two most abundant species of this group, i.e. *O. oceanicus* and *S. vittata*.

4.2. Weight and biomass of birds

4.2.1. Biomass of the bird community in the breeding period

The biomass density was very high in areas free of ice (Tab. X) due to the colonial habits of birds in the breeding period. Due to the feeding penetration the biomass of flying birds, of *P. papua*, and of some individuals of *P. antarctica* was also concentrated over the surface of the Admiralty Bay. The biomass of feeding *P. adeliae* and most of feeding individuals of *P. antarctica* was also distributed in the Bransfield Strait.

The biomass of adult individuals of three pygoscelid species constituted 98.8% of the biomass of the whole community in summer. Therefore precise monitoring of phenological changes in the biomass of the penguins was necessary.

4.2.2. Phenological changes in the biomass of adult penguins

The individual weight of penguins was highest in February, i.e. at the beginning of fledging (Tab. XI). However, the highest concentration of the biomass occurred in December and the first half of January (Tab. XII), i.e.

Table XI

Changes in the body weight of adult penguins in particular periods

Species / Periods	10–24 Dec. 1978	25 Dec. 1978 – 10 Jan. 1979	11 Jan. – 1 Feb. 1979	2–16 Feb. 1979
Pygoscelis papua	6.0 (5.7–6.2)*) N = 20	5.8 (5.2–6.0) N = 8	5.7 (5.2–6.1) N = 11	6.3 (5.7–6.6) N = 9
Pygoscelis adeliae	4.1 (3.7–4.5) N = 24	4.1 (3.7–4.4) N = 7	4.5 (3.5–5.0) N = 21	4.9 (3.9–5.8) N = 21
Pygoscelis antarctica	3.9 (3.6–4.3) N = 14	3.9 (3.6–4.4) N = 10	4.2 (3.8–4.4) N = 14	4.8 (4.0–5.3) N = 21

*) in brackets — range, N — number of weighed individuals

Table XII

Biomass (in kg) of adult penguins in particular periods

Species / Periods	10–24 Dec. 1978	25 Dec. 1978 – 10 Jan. 1979	11 Jan. – 1 Feb. 1979	2–16 Feb. 1979
Pygoscelis papua	41044 (11.3%)	39213 (11.1%)	38496 (27.5%)	8962 (10.6%)
Pygoscelis adeliae	229506 (63.4%)	220801 (62.6%)	2822 (2.0%)	59 (0.1%)
Pygoscelis antarctica	91241 (25.2%)	92755 (26.3%)	98386 (70.4%)	75427 (89.3%)
Total	361791 (99.9%)	352769 (100%)	139705 (99.9%)	84448 (100%)
Density of biomass per 1 km² of area free of ice	19041.6	18566.8	7352.9	4444.6
Density of biomass per 1 km² of the bay	2761.8	2692.9	1066.4	644.6
Density of biomass per 1 km² of area free of ice and the bay	2411.9	2351.8	931.4	563.0

in the period when the share of *P. adeliae* biomass in the total biomass of the penguins was the highest (Tab. XII). At that time also, the rookery was most numerous. When *P. adeliae* were leaving the rookery, most of its biomass consisted of *P. antarctica* (Tab. XII).

Table XIII

Biomass of penguin eggs (in kg) in particular periods

Species	Periods					
	10 – 24 Dec. 1978		25 Dec. 1978 – 10 Jan. 1979		11 Jan. – 1 Feb. 1979	
	eggs	shells	eggs	shells	eggs	shells
Pygoscelis papua	66.8	9.2	16.4	2.3	4.2	0.6
Pygoscelis adeliae	485.9	78.3	58.3	9.4	–	–
Pygoscelis antarctica	1887.8	274.7	297.8	43.3	122.7	17.8
Total	2440.5	362.2	372.5	55.0	126.9	18.4
Density of biomass per 1 km^2 area free of ice	128.4	19.1	19.6	2.9	6.7	1.0

4.2.3. Biomass of penguin eggs and chicks in subsequent periods of breeding

The highest biomass of penguin eggs occurred between 10 and 24 December (Tab. XIII). At that time 13.3% of *P. adeliae* and the whole population of *P. antarctica* were still sitting on their eggs. Between 25 December and 10 January the biomass of the eggs considerably decreased due to the abundant hatching of *P. antarctica*. By the middle of January the last chicks of *P. papua* and *P. antarctica* had hatched. The biomass of eggs between 11 January and 1 February amounted only to 5.1% as compared to its value in December.

The highest biomass of penguin chicks was recorded between 25 December and 10 January (Tab. XIV). The high value of the biomass in this period

Table XIV

Biomass of young penguins (in kg) in particular periods

Species / Periods	10–24 Dec. 1978	25 Dec. 1978–10 Jan. 1979	11 Jan.–1 Feb. 1979	2–16 Feb. 1979
Pygoscelis papua	3529 (8.9%)	9127 (7.2%)	14270 (16.2%)	5768 (15.5%)
Pygoscelis adeliae	36134 (91.1%)	111518 (88.8%)	47562 (54.2%)	1953 (5.2%)
Pygoscelis antarctica	–	4486 (4.0%)	25930 (29.5%)	29551 (79.3%)
Total	39663 (100%)	125631 (100%)	87762 (99.9%)	37272 (100%)
Density of biomass per 1 km^2 of area free of ice	2087.5	6612.1	4619.0	1961.7

was mostly due to the high individual weight of growing up *P. adeliae* chicks before leaving the rookery, to the increase in individual body weight of growing up *P. papua* and to the beginning of hatching in *P. antarctica*. In this period the biomass of chicks of *P. adeliae* amounted to 88.8% of the total biomass of all penguin chicks. When *P. adeliae* were leaving the rookery (i.e. between 10 January and 1 February) the biomass value of the young penguins decreased despite the increase in the biomass of *P. antarctica*. In the first half of February the biomass of young penguins in the region of the Admiralty Bay reached its lowest values. This was connected with leaving the rookery by *P. adeliae* and beginning of the migration period of *P. papua* and *P. antarctica*.

4.2.4. Phenological changes in the biomass of flying birds

The biomass of flying birds reached its highest values in December (Tab. XV). At the turn of December chicks had hatched from most of eggs and from that time onwards the biomass of eggs decreased.

Table XV

Changes in the egg biomass of flying birds (in g)

Species	Periods							
	10 – 24 Dec. 1978		25 Dec. 1978 – – 10 Jan. 1979		11 Jan. – 1 Feb. 1979		2 – 16 Feb. 1979	
	eggs	shells	eggs	shells	eggs	shells	eggs	shells
Macronectes giganteus	39512	4641.12	5612.5	659.25	1571	184.59	224.5	26.37
Daption capensis	2668.5	249.75	2668.5	249.75	?	?	–	–
Oceanites oceanicus	8374.2	525.44	7170.6	449.92	7170.6	449.92	7170.6	449.92
Phalacrocorax atriceps	?	?	1676.7	180.50	?	?	?	?
Chionis alba	1728.0	115.56	1728.0	115.56	–	–	–	–
Stercorarius skua maccormicki	4970.4	475.38	2180.0	208.50	1831.2	175.14	–	–
Stercorarius skua lonnbergii	11925.3	1027.43	1408.5	121.35	657.3	56.75	357.6	32.36
S.s. maccormicki × *S.s. lonnbergi* (hybrids)	2170.0	208.50	1482.4	141.78	434.0	36.75	434.0	36.75
Larus dominicanus	4876.8	2380.05	–	–	–	–	–	–
Sterna vittata	8820.0	1300.95	10300.0	1519.25	4660	680.36	3140.0	463.15
Total	85045.2	10924.18	34227.2	3645.86	16326.1	1583.29	11344.7	1008.55
Density of biomass per 1 km^2 of area free of ice	4476.1	574.9	1801.4	191.9	859.3	83.3	597.1	53.1

The egg biomass of *M. giganteus, O. oceanicus* and *S. vittata* constituted 67.8% of egg biomass of all flying birds at the begining of the breeding period; 67.4% between 25 December and 10 January; and 82.1% at the end of January. Till the middle of February *O. oceanicus* and considerable

Table XVI

Changes in the biomass of young flying birds (in kg)

Species	10–24 Dec. 1978	25 Dec. 1978–10 Jan. 1979	11 Jan.–1 Feb. 1979	2–16 Feb. 1979
Macronectes giganteus	–	61.3 (32.8%)	220.3 (55.2%)	260.5 (47.2%)
Daption capensis	–	–	?	9.2 (1.7%)
Phalacrocorax atriceps	?	?	?	?
Chionis alba	–	–	4.9 (1.2%)	7.7 (1.4%)
Stercorarius skua maccormicki	–	7.5 (4.0%)	20.0 (5.0%)	35.0 (6.3%)
Stercorarius skua lonnbergi	–	23.4 (12.5%)	43.7 (11.0%)	88.6 (16.1%)
S. s. maccormicki × *S. s. lonnbergi* (hybrids)	–	0.97 (0.5%)		35.2 (6.4%)
Larus dominicanus	28.3 (100%)	93.7 (50.1%)	98.7 (24.7%)	98.4 (17.8%)
Sterna vittata	–	–	11.6 (2.9%)	17.2 (3.1%)
Total	28.3 (100%)	186.87 (99.9%)	399.2 (100%)	551.8 (100%)
Density per 1 km² of area free of ice	1.5	9.8	21.0	29.0

Table XVII

Biomass of *Oceanites oceanicus* (in kg) in particular periods (in brackets — range)

Periods	Number of weighed individuals	Mean weight of an individual (g)	Biomass of the population (kg)
10–24 Dec. 1978	18	34.7 (30–40)	153
25 Dec. 1978–10 Jan. 1979	24	30.4 (27–32)	134
11 Jan.–1 Feb. 1979	19	37.2 (34–42)	164

part of the population of *S. vittata* were still sitting on eggs. The egg biomass of these three species constituted 90.1% of egg biomass of all flying species in February.

Chicks of *Ph. atriceps* have hatched the first of all the flying bird species; a monitoring of nests conducted on 4 January showed that 47.3%

of chicks were already about 30 days old. *L. dominicanus* were next to hatch. The other species of flying birds hatched at the turn of December. In the course of the investigations chicks of *Ph. atriceps* were not weighed and therefore the percentage share of the biomass of other species was somewhat overestimated (Tab. XVI). Due to the low abundance of *Ph. atriceps* it may be assumed that the biomass of flying birds till 10 January was determined by the biomass of *L. dominicanus* and *M. giganteus*. A high share of the biomass of young gulls was caused by fast increase in their body weight in the second week of their life and still low body weight of hatchlings of other species at that time. Since 11 January the main share in the biomass of chicks of flying birds constituted *M. giganteus* (Tab. XVI) which resulted from high increase in their body weight between 20—25 days of their life. The biomass of young *L. dominicanus*, *M. giganteus* and *S. s. lonnbergi* amounted to 95.4% of the biomass of all young flying birds between 25 December and 10 January, to 90.9% between 11 January and 1 February, and to 81.1% between 2 and 16 February.

Phenological changes in the body weight of adult individuals of flying birds were monitored only in *O. oceanicus* (Tab. XVII). The biomass of adults of other species of flying birds was calculated on the basis of Tab. VIII and Tab. X, and included in Tab. XVIII.

4.2.5. Phenological changes in the total biomass of a bird community

The highest biomass of the community of adult birds was recorded in December and first half of January (Tab. XVIII). At that time the biomass of penguins constituted 98.7% of its total value. Since the second half of January the biomass of mature birds decreased due to migration of penguins from the breeding rookery. The biomass of young birds reached its highest value between 25 December and 10 January, i.e. during a high abundance of penguins and advanced development of *P. adeliae* chicks. The biomass of penguin chicks constituted up to 99.9% of the biomass of all chicks in the community. The share of the biomass of penguin eggs in December and January amounted to 96.6% and 84.0% of egg biomass of the whole community. In February there remained only part of eggs of flying birds. In connection with the dominating role of the biomass of adult and young penguins, changes in the biomass of the whole community depended on the phenological rhythm of pygoscelid penguins.

5. Discussion

The three penguin species inhabiting the Admiralty Bay displayed different preferences in respect to their breeding habitats. Within the studied area

Changes in the biomass of the bird community in the Admiralty Bay region

	Periods	Biomass in kg			Density	Density per 1 km^2		
		Pygoscelis	Flying birds	Total	per 1 km of coastline	land free of ice	bay	land and bay together
Adult	10–24 Dec. 1978	361791 (98.7%)	4773	366564	4165.50	19292.8	2798.0	2423.8
	25 Dec. 1978– –10 Jan. 1979	352770 (98.7%)	4753	357523	4062.9	18817	2729.3	2383.5
	11 Jan.– –1 Feb. 1979	139705 (96.7%)	4766	144471	1641.7	7603.7	1102.8	963.1
	2–26 Feb. 1979	84448 (94.7%)	4754	89202	1013.6	4694.8	680.9	594.7
Young	10–24 Dec. 1978	39663 (99.9%)	28	39691	451.0	2089.0	303.0	264.6
	25 Dec. 1978– –10 Jan. 1979	125631 (99.8%)	187	125818	1429.8	6622.0	960.5	838.8
	11 Jan.– –1 Feb. 1979	87762 (99.5%)	399	88161	1001.8	4640.0	673.0	587.7
	2–16 Feb. 1979	37272 (98.5%)	552	37824	429.8	1990.7	288.7	252.2
Adult and young together	10–24 Dec. 1978	401454 (98.9%)	4801	406255	4616.5	21381.8	3101.2	2708.4
	25 Dec. 1978– –10 Jan. 1979	478401 (99.0%)	4940	483341	5492.7	25439	3689.8	3222.3
	11 Jan.– –1 Feb. 1979	227467 (97.8%)	5165	232632	2643.5	12243.8	1775.8	1550.9
	2 Feb.–16 Feb.	121720 (95.8%)	5306	127026	1443.5	6685.6	969.6	816.8
Eggs (shells)	10–24 Dec. 1978	2440 (96.6%) (362)	85 (11)	2525 (373)	29.1 (4.31)	132.9 (19.63)	–	–
	25 Dec.– –10 Jan. 1979	372 (91.5%) (55)	34 (4)	406 (59)	4.6 (0.66)	21.4 (3.10)	–	–
	11 Jan.– –1 Feb. 1979	127 (88.8%) (18)	16 (2)	143 (20)	1.57 (0.22)	7.5 (1.05)	–	–
	2–16 Feb. 1979	–	11 (100%) (1)	11 (1)	0.12 (0.01)	0.6 (0.05)	–	–

penguins also formed mixed colonies, occupying different parts of the terrain in mosaic-like environments. This enabled small areas free of ice and snow to be more efficiently used. Mixed colonies were composed of *P. papua* and *P. adeliae* as well as *P. antarctica* and *P. adeliae*. On the other hand, there were no common breeding places of *P. papua* and *P. antarctica*, which proves their distinct preferences to the definite breeding habitats. In the region of Rescuers Hills single nests of *P. adeliae* within breeding groups of *P. papua* (0.2% of their total number) were also recorded. The gradient of the slope and kind of substrate on which the nests of *P. adeliae* were constructed within the breeding groups of *P. papua* did not differ from the places occupied by *P. papua*. In the region of the H. Arctowski Station there nested 36 pairs of *P. papua* on the border of a breeding groups of *P. adeliae* (4.6% of the total number of individuals of this species). In this case also no differences in the substrate occupied by these two species was recorded. From these observations it follows that only a small part of the population of both species occupies similar breeding habitats. Only 959 pairs out of the total 10550 pairs of *P. antarctica* occurred in breeding groups mixed with *P. adeliae*. Of these 959 pairs 781 occupied breeding places distinctly different from those of *P. adeliae*, i.e. places between rocks. As regards the situating of the remaining 178 nests of *P. antarctica* (1.7% of the total number) no difference in relation to the localization of the nests of *P. adeliae* were recorded. Consequently, it is probable that in the area where mixed breeding groups of both these species occur, the abundance of the pairs of *P. antarctica* may be partially limited by *P. adeliae*, the more that they occupy breeding regions earlier than *P. antarctica*. Trivelpiece and Volkman (1978) recorded that there also occurred competition between these species, resulting in the limitation of the breeding efficiency.

Close to the H. Arctowski Station, the abundance of penguins was estimated in several breeding seasons: 1909 (Gain 1914), 1957 (Stephens after Conroy 1975, Croxall and Kirkwood 1979), 1966 (White after Croxall and Kirkwood 1979), 1977 (Trivelpiece and Volkman 1979) and in the season 1978/79 (Jabłoński, this study). The data of the above-cited authors prove the occurrence of a multiannual tendency to increase in penguin abundance in the region of the Admiralty Bay, despite the fact that during present investigations no breeding place of *P. antarctica* was recorded at Hennequin Pt., and of *E. chrysolophus* at Dufayel Island. Data from the literature and own data confirm Conroy's (1955) assumption about the increase in the abundance of penguins in various regions of their occurrence. According to Sladen (1964), this process was caused by considerable extermination of whales, which were potential food competitors.

In the breeding season 1978/79 the mean body weights of mature *P. papua* were higher from those given by Volkman, Presler and Trivelpiece (1982) for the summer of 1977/78. On the other hand, individual body weights of males of *P. adeliae* and *P. antarctica* weighed by the same authors were close to mean weights from the whole season of 1978/79. Possibly, the higher body weights in 1978/79 were due to different dates of weighing the penguins, whose individual body weight varied together with the phenological rhythm of the rookery.

The density of the breeding community of birds in the region of the Admiralty Bay was high and varied, in different phenological periods, from 626.0 to 166.7 of adult birds per 1 km^2 (Tab. VIII), while the biomass value of adult and young birds fluctuated from 3222.3 to 816.8 kg per 1 km^2 (Tab. XVIII). The high density of abundance and biomass of birds in breeding regions in the summer season was discussed by Prevost (1963), Holdgate (1967) and Everson (1977). Prevost (1963) and Holdgate (1967), while considering the influence of birds on the land ecosystem, gave the density of the biomass of breeding communities of birds in areas free of ice. According to these authors, the biomass of the summer community of birds ranged from 15 to 40 g per 1 m^2, and in breeding colonies approached 10 kg per 1 m^2. Biomass density in the area free of ice in the region of the Admiralty Bay amounted in the peak period to 25 g per 1 m^2 (Tab. XVIII), and thus remained within the range of data for Antarctic Continent and for South Georgia.

In the region of the Admiralty Bay, penguins constituted the dominant group of breeding birds (91.7—68.9% of the abundance of the community). The value of their biomass amounted to 98.7—94.7% of the biomass of the whole community. Part of the penguin biomass was used by predatory and scavenging birds (*S. skua, Ch. alba, M. giganteus* and *L. dominicanus*). A tentative estimation of the diet of *S. skua* and *Ch. alba* enabled the author to determine that these species consume, in various periods, from 0.7 to 1.4% of the total penguin biomass (i.e. eggs, young and adult birds together). Adult penguins also constituted the food of *Orcinus orca* Linné, *Hydrurga leptonyx* (Blainville) and *Arctocephalus gazella* (Peters).

The weight of the food consumed in the period of study by penguins constituted 97—99% of food weight of the whole bird community (Jabłoński, unpublished data). Krill was the basic diet for the whole community. *S. skua* and *Ch. alba* collected from the penguin colony, in various periods, from 0.1 to 0.6% of krill caught by the three pygoscelid species (Jabłoński, unpublished data).

Because pygoscelid penguins played dominating role in the community of birds the density estimations should be referred to the area penetrated by penguins. The area of feeding penetration of most of the penguins extended beyond the limits of the Admiralty Bay and that is why the abundance (Tab. VIII) and biomass density estimations of the bird community (Tab. XVIII) calculated for smaller areas were overestimated. If we assume for the sake of simplification that feeding regions of the penguins in the sea were evenly distributed the area of the sea penetrated (25×25 km) amounts to 625 km^2. To this value the areas of the Admiralty Bay (i.e. 131 km^2) and land free of ice (19 km^2) should be added. As a result, the approximate area penetrated by the investigated population of penguins in the summer of 1978/79 amounted to 775 km^2. Fluctuations in the density of abundance of adult birds for this area in subsequent periods amounted from 121.4 to 32.3 indiv./km^2 and of their biomass from 473.0 to 115.1 kg/km^2.

According to Everson (1977) the biomass of birds in the open waters of the Southern Ocean amounted to about 0.12 mg/m^2 of water surface area. This value is very low in comparison with the biomass of the investigated area of the coastal oceanic zone ($625\ km^2 + 131\ km^2 = 765\ km^2$) that amounted from 118 to 485 mg/m^2.

6. Conclusions

The bird community in the region of the Admiralty Bay is a typical community occurring in a little diversified environment under the influence of intensive abiotic factors. Under these conditions a low number of species of diversified preferences for breeding habitats and a low number of dominant species of high abundance occurred. In the region of the Admiralty Bay the abundance of adult individuals of the three species of penguins (*P. papua*, *P. adeliae* and *P. antarctica*) constituted 91.7% of the abundance of the breeding community of birds. Adult penguins constituted 98.7% of the biomass of the whole community.

On the other hand in the second half of the breeding season there occurred an increase in the biomass of flying birds, which was caused by later terms of their hatching. According to Spellenberg (1975) the phenomenon of later hatching terms of these birds in relation to penguins is caused by the fact that they are predators and scavengers feeding on eggs and chicks of the pygoscelid penguins.

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7. Резюме

Исследования проводились с 5 декабря 1978 года до 27 февраля 1979 года в районе бухты Адмиральти (остров Кинг Джордж, 62°09′ ю.ш. и 58°28′ з.д.). Район исследований охватывал отрезок побережья от Ред Хилл до Шабрие Рок (рис. 1). Большинство гнездовых скоплений было локализировано со стороны пролива Брансфилда (рис. 2, 3, 4, 5, 6, 7). Берега бухты Адмиральти, отдаленные от открытого моря, заселяли только некоторые виды летающих птиц (табл. 1).

В районе бухты Адмиральти гнездились 12 видов птиц. *Stercorarius skua* был представлен двумя подвидами: *S. s. maccormicki* и *S. s. lonnbergi*. Плотность гнездовой группировки составляла 626.0 до 166.7 зрелых особей на 1 км² поверхности свободной ото льда и поверхности бухты Адмиральти вместе взятых (табл. VIII), а вместе с поверхностью ареалов питания пингвинов в море — с 32.3 до 121.4 особей на 1 км² Уровень численности группировок птиц зависит от фенологического ритма колонии пингвинов, которые составляли от 68.9 до 91.7% всех гнездящихся пар (табл. VIII). Биомасса зрелых птиц достигала более 366 000 кг (табл. XVIII). Плотность биомассы зрелых и молодых птиц на поверхности свободной ото льда достигала 25 439 кг/км², а по отношению к поверхности бухты Адмиральти — 3 689 кг/км². Плотность биомассы птиц на всей поверхности жизненной активности пингвинов колебалась от 115 до 473 кг/км² Биомасса пингвинов составляла 94.7—98.7% биомассы всей группировки. *S. skua* и *Ch. alba* съедали в различных периодах от 0.7 до 2.4% биомассы пингвинов (взрослых, молодых и их яиц вместе взятых).

8. Streszczenie

Badania prowadzono od 5 grudnia 1978 do 27 lutego 1979 roku w rejonie Zatoki Admiralicji (Wyspa Króla Jerzego 62°09′S i 58°28′W). Teren badań obejmował odcinek wybrzeża od Red Hill do Chabrier Rock (Rys. 1). Większość lęgowych skupień ptaków zlokalizowana była od strony Cieśniny Bransfielda (Rys. 2, 3, 4, 5, 6, 7) Brzegi Zatoki oddalone od otwartego morza zasiedlały tylko niektóre gatunki ptaków latających (Tab. I).

W rejonie Zatoki Admiralicji gnieździło się 12 gatunków ptaków. *Stercorarius skua* reprezentowany był przez dwa podgatunki: *S. s. maccormicki* oraz *S. s. lonnbergi*. Zagęszczenie lęgowego zgrupowania ptaków wynosiło od 166.7 do 626.0 dorosłych osobników na km² powierzchni wolnej od lodu oraz powierzchni Zatoki Admiralicji razem (Tab. VIII), a łącznie z areałem penetracji żerowiskowej morza pingwinów — od 32.3 do 121.4 osobników na km². Poziom liczebności zgrupowania ptaków zależał od fenologicznego rytmu kolonii pingwinów, które stanowiły od 68.9 do 91.7% wszystkich par lęgowych (Tab. VIII). Całkowita biomasa dorosłych ptaków wynosiła ponad 366000 kg (Tab. XVIII). Zagęszczenie biomasy dorosłych i młodych na powierzchni wolnej od lodu dochodziło do 25439 kg/km², a w odniesieniu do powierzchni Zatoki Admiralicji — do 3689 kg/km². Zagęszczenie biomasy ptaków na całej powierzchni penetracji pingwinów wahało się od 115 do 473 kg/km². Biomasa pingwinów stanowiła 94.7—98.7% biomasy całego zgrupowania. *S. skua* i *Ch. alba* zjadały w różnych okresach od 0.7 do 2.4% biomasy pingwinów (dorosłych, młodych i jaj łącznie).

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Biometry of eggs of breeding species in the Admiralty Bay region

Species	Eggs		
	N	Size (in mm)	
		length	breadth
Pygoscelis papua	27	67.8 (63.4 – 71.9)	56.8 (51.6 – 60.9)
Pygoscelis adeliae	69	70.3 (42.9 – 74.1)	54.2 (40.4 – 58.2)
Pygoscelis antarctica	153	67.4 (60.2 – 74.4)	52.2 (46.0 – 55.8)
Macronectes giganteus	108	105.7 (96.6 – 115.1)	66.4 (57.4 – 70.8)
Daption capensis	27	63.2 (58.6 – 67.4)	43.9 (41.6 – 45.8)
Oceanites oceanicus	58	34.9 (30.2 – 36.0)	24.5 (23.5 – 24.8)
Phalacrocorax atriceps	15	65.5 (63.2 – 66.5)	40.9 (39.9 – 41.9)
Chionis alba	19	57.9 (54.0 – 61.2)	38.8 (36.9 – 41.2)
Stercorarius skua maccormicki	10	74.6 (72.4 – 76.6)	50.4 (48.8 – 51.2)
Stercorarius skua lonnbergi	31	73.1 (69.8 – 76.5)	52.2 (49.9 – 58.9)
S. s. maccormicki × *S. s. lonnbergi* (hybrids)	11	71.5 (66.7 – 74.8)	50.7 (48.8 – 53.8)
Larus dominicanus	21	71.7 (67.9 – 74.8)	50.2 (46.2 – 53.2)
Sterna vittata	184	45.1 (42.8 – 49.4)	33.7 (31.1 – 35.1)

Appendix 1

(in brackets — range) N — number of measurements

Shells of eggs				Hatchlings
Weight (in g)	N	Weight (in g)	N	Weight (in g)
117.0 (112.0 – 123.0)	10	16.14 (15.45 – 16.51)	54	97.0 (80.0 – 117.0)
97.1 (83.0 – 115.0)	14	15.65 (14.29 – 16.24)	161	85.0 (70.0 – 100.0)
96.9 (84.0 – 117.0)	10	14.10 (12.44 – 15.07)	17	88.0 (68.0 – 110.0)
224.5 (170.0 – 270.0)	6	26.37 (25.10 – 27.10)	40	189.0 (170.0 – 210.0)
59.3 (54.0 – 63.0)	6	5.55 (4.73 – 6.10)	–	–
10.2 (7.4 – 13.5)	16	0.64 (0.58 – 0.76)	–	–
62.1 (58.0 – 64.0)	7	6.70 (5.81 – 7.82)	–	–
48.0 (44.7 – 52.5)	10	3.21 (2.86 – 3.58)	9	36.5 (29.0 – 40.0)
87.2 (84.0 – 92.0)	6	8.34 (6.59 – 9.22)	4	73.0 (71.0 – 75.0)
93.9 (82.0 – 115.0)	16	8.09 (6.54 – 9.04)	12	76.2 (71.0 – 81.0)
86.8 (84.0 – 90.0)	7	7.35 (5.90 – 8.90)	–	–
76.2 (70.0 – 81.0)	16	6.45 (5.54 – 7.25)	19	53.1 (49.0 – 59.0)
20.0 (16.0 – 25.0)	14	2.95 (2.68 – 3.15)	24	15.8 (13.0 – 18.0)

Appendix 2

Increase in the body weight of young penguins (in brackets — range)
N — number of weighed young birds, W — body weight in g

Days of life	*Pygoscelis papua* N	*Pygoscelis papua* W	*Pygoscelis adeliae* N	*Pygoscelis adeliae* W	*Pygoscelis antarctica* N	*Pygoscelis antarctica* W
1.	54	97 (80 – 117)	101	85 (70 – 100)	17	88 (68 – 110)
5.	50	226 (160 – 260)	150	359 (200 – 450)	15	221 (200 – 250)
10.	41	701 (530 – 870)	136	551 (425 – 750)	15	374 (290 – 500)
15.	39	1174 (860 – 1490)	127	1098 (680 – 1600)	13	814 (550 – 1060)
20.	38	1562 (1100 – 1950)	120	1525 (750 – 1900)	12	1138 (950 – 1360)
25.	38	2139 (1530 – 2660)	110	2404 (2000 – 3100)	12	1767 (1500 – 2000)
30.	36	2465 (1890 – 2990)	105	2913 (2400 – 3500)	12	2279 (1900 – 2700)
35.	36	3078 (2340 – 3810)	105	3523 (3000 – 4000)	12	2827 (2500 – 3200)
40.	36	3545 (2640 – 3980)	100	3970 (3500 – 4300)	12	3117 (2700 – 3400)
45.	36	4199 (2990 – 4900)	87	4011 (3100 – 4500)	12	3358 (2800 – 3800)
50.	36	4338 (3250 – 5000)	80	3877 (3000 – 4500)	11	3656 (3250 – 3800)
55.	36	4505 (3900 – 5000)	80	3852 (3000 – 4500)	11	3756 (3600 – 4000)

Appendix 3

Increase in the body weight of young *Macronectes giganteus* (in brackets — range) N — number of weighed young birds, W — body weight in g

Days of life	N	W
1.	40	189 (170 – 210)
5.	37	406 (270 – 500)
12.	37	876 (600 – 1400)
18.	36	1230 (900 – 1500)
22.	35	2000 (1500 – 2500)
30.	35	2980 (2500 – 3500)
35.	31	3480 (2800 – 4000)

Appendix 4

Increase in the body weight of young flying birds (in brackets — range)
N — number of weighed young birds, W — body weight in g

Days of life	*Chionis alba* N	*Chionis alba* W	*Stercorarius skua maccormicki* N	*Stercorarius skua maccormicki* W	*Stercorarius skua lonnbergi* N	*Stercorarius skua lonnbergi* W	*Larus dominicanus* N	*Larus dominicanus* W	*Sterna vittata* N	*Sterna vittata* W
1.	9	36.5 (29 – 40)	4	73.0 (71 – 75)	12	76.2 (71 – 81)	19	53.1 (49 – 59)	24	15.8 (13 – 18)
5.	9	59.5 (48 – 65)	4	133.7 (100 – 160)	12	191.2 (110 – 250)	10	99.0 (72 – 120)	17	34.1 (25 – 44)
10.	8	124.4 (100 – 140)	4	205.0 (180 – 240)	12	349.2 (2Φ0 – 450)	10	146.0 (130 – 170)	12	72.1 (60 – 82)
15.	8	206.2 (170 – 230)	4	357.5 (300 – 400)	12	535.8 (380 – 650)	10	248.0 (210 – 270)	11	109.4 (90 – 123)
20.	8	287.5 (260 – 310)	4	587.5 (550 – 620)	12	800.8 (600 – 960)	10	413.0 (350 – 460)	11	124.6 (105 – 140)
25.	8	309.4 (285 – 340)	4	827.5 (800 – 890)	12	1111.7 (840 – 1250)	8	571.0 (490 – 630)	8	124.2 (100 – 138)
30.	8	341.2 (320 – 360)	4	952.5 (880 – 1000)	12	1388.3 (1150 – 1550)	7	972.0 (780 – 1100)	–	–
35.	–	–	4	1122.5 (1090 – 1200)	11	1496.4 (1300 – 1600)	5	912.0 (750 – 1100)	–	–
40.	–	–	4	1225.0 (1150 – 1350)	11	1640.1 (1550 – 1750)	–	–	–	–
45.	–	–	4	1110.0 (1050 – 1150)	11	1616.3 (1510 – 1730)	–	–	–	–