INCREASES IN PENGUIN POPULATIONS AT SIGNY ISLAND, SOUTH ORKNEY ISLANDS

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ABSTRACT. A census of the breeding population of four species of penguin at Signy Island, South Orkney Islands, was conducted in 1978–79. Most colonies were counted during early incubation but for counts of chicks and nests near hatching time correction factors were applied to estimate the original number of breeding pairs present. The current breeding population is calculated to be 80 000 pairs of chinstrap penguin, 37 000 pairs of Adélie penguin, 390 pairs of gentoo penguin and 11 pairs of macaroni penguin. Comparison with earlier counts for various parts of Signy Island indicates that both Adélie and chinstrap populations may have doubled between 1947–48 and 1957–58, and that subsequently chinstrap penguins have increased five-fold, whereas Adélie penguins have only doubled. In conjunction with this, mean increases over 20–30 years have been 3–4% per annum for Adélie penguins but 7–10% for chinstrap penguins. The population increases are attributed to enhanced food availability and it is calculated that the present Signy Island penguin population will remove at least 150 000 tonnes of krill from surrounding waters during the summer months. Numerical changes at selected colonies are now being followed on an annual basis and the comprehensive census will be repeated in not less than 10 years' time.

THE status of penguin populations in the Antarctic is of interest for two main reasons. First, penguins are believed to have increased in both numbers and distribution over at least the last 20 years (Sladen, 1964; Conroy, 1975) but the actual field evidence for this is rather sparse. Secondly, they are the main avian consumers of Antarctic marine resources, especially krill *Euphausia superba* (see Mougin and Prévost, 1980; Croxall, in press) and it is of increasing importance to be able to assess the size and impact of their populations.

For both these reasons it was decided to undertake a complete census of the populations of the four species of penguin (Adélie *Pygoscelis adeliae*, chinstrap *P. antarctica*, gentoo *P. papua* and macaroni *Eudyptes chrysolophus*) that breed at Signy Island, South Orkney Islands. The British Antarctic Survey established a research station there in 1947 and since then a number of counts of breeding penguins in selected areas have been made, although never a complete census, and it is therefore possible to assess rates of population increase for some colonies. The present survey was also intended to permit selection of colonies for annual monitoring of breeding numbers and reproductive performance in order to accumulate data that might ultimately be used to investigate the effects of commercial harvesting of krill (see Croxall and Prince, 1979). Recently, Signy Island has also been nominated as one of the United Kingdom sites for long-term monitoring of selected species of Antarctic seabirds ([Croxall], [1980]).

This paper presents the methods used in and results of the Signy Island Penguin Survey, and discusses the results in comparison with earlier counts.

METHODS

Mapping

The area covered by each colony (regarded here simply as a recognizably discrete group of breeding penguins) was mapped in the field on to the 1 : 10 000 DOS map of Signy Island or, for complex areas, on to photographic enlargements of this map. Numerous field sketches were made and photographs taken to assist final production of maps.

In addition, a plane-table survey of Pageant and Pantomime Points was conducted and a detailed colony map prepared for these areas.

Counts

Individual marking

Using a paint brush attached to the end of a 0.6 m pole each incubating bird was marked with a small dab of paint. Because the nests of pygoscelid penguins are reasonably well spaced

(usually 0.75–1.00 m apart), this is a highly accurate and effective method and causes little disturbance. A careful, slow-moving observer can mark about 700 birds per hour. This method would cause excessive disturbance in an eudyptid penguin rookery.

Individual marking was attempted for counting chicks but these were too mobile for it to be successful. Overall, this method was used to count 81.8% of all Adélie penguins and 98.4% of all incubating chinstrap penguins.

Tally counts

A hand-tally counter was used to record the number of incubating birds in small and medium-sized colonies only. Usually, and nearly always with medium-sized colonies, two observers made independent counts and the average of their counts, providing they did not differ by more than 10%, was taken as the true value. If they differed by more than 10%, a re-count was made. For small colonies, this technique was assessed as at least 95% accurate; for medium-sized ones it was probably 90–95% accurate. 12.7% of all Adélie penguins were counted in this way and 1.6% of incubating chinstrap penguins.

Direct tally counts could also be used for very small colonies at the chick stage and 5.6% of chinstrap penguins at this stage were so counted. The remainder were also tally counted but in groups of 100–200 chicks.

Groups of this size were created by chicks huddling in response to observers walking very slowly through the colony. By careful management, normally involving several observers, even very large colonies could be counted in this way and with an estimated accuracy level of about 90%. Ultimately, 65% of chinstrap penguins were counted at the chick stage.

Because it was impossible to count all chinstrap penguins during the incubation stage, a number of colonies which were counted then were re-counted when the other chick counts were made to provide a value to convert chick counts to the original number of nests.

Results

The location of all colonies mentioned in the text is shown in Fig. 1. Detailed maps showing the exact position and extent of all colonies are deposited in the archives of the British Antarctic Survey, together with full details (including dates and methods used) of the field counts for each colony.

A summary of the data for these chinstrap penguin colonies counted during incubation and again when chicks were present is given in Table I. Only one really anomalous colony was recorded (at Pageant Point) with a value of 1.62 chicks per pair but this cannot be excluded as totally impossible. With it the mean and standard deviation of the values for the 18 colonies is 1.06 ± 0.24; without it 1.01 ± 0.17. Either value agrees well with that of 1.00 derived by Trivelpiece and Volkman (1979) from their studies in the South Shetland Islands. As it seems preferable to err on the conservative side in this paper, the value of 1.06 will be used as the divisor to convert chick counts to the original number of breeding pairs.

It is also possible to apply a very rough correction for the pairs that fall between laying and the census date. The mean and range of first laying and hatching dates for Adélie, chinstrap and gentoo penguins at Signy Island are shown in Table II, together with the corresponding dates for the 1978–79 season. The census dates of the Adélie penguin colonies were classified as laying, hatching and incubation half or three-quarters complete. Chinstrap penguin colonies were classifiable as laying or incubation one-third complete. All gentoo penguin colonies were counted near the hatching date.

Annual egg losses in a number of seasons for various studies of Adélie penguin have been recorded as follows:

Cape Royds	33%, 63%, 12%, 37% (Yeates, 1968).
Cape Bird	20.3%, 43.3%, 27.7%, 20.4%, 28.3% (Spurr, 1975).

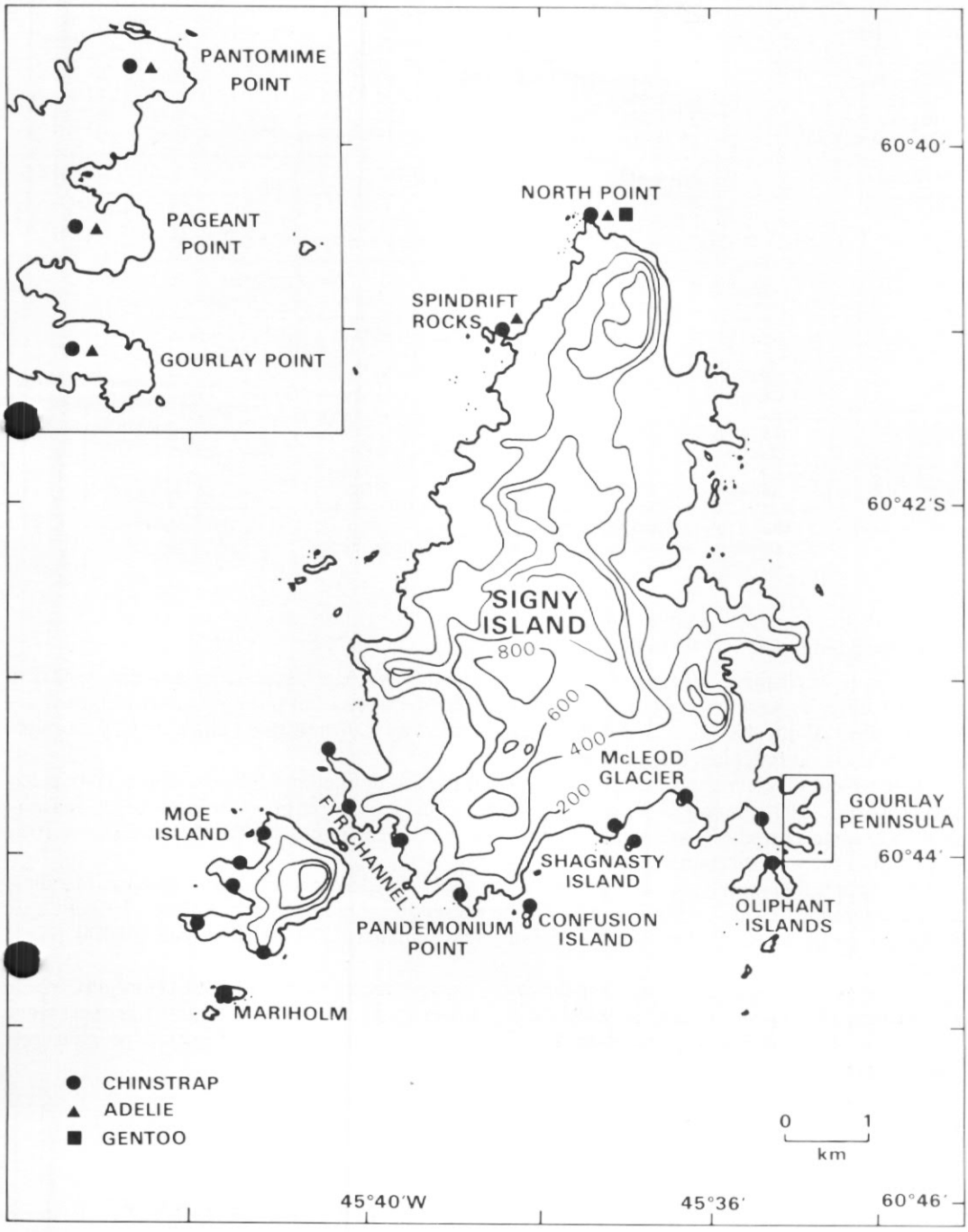

Fig. 1. Signy Island, showing location of penguin colonies.

TABLE I. CHINSTRAP PENGUIN: RELATIONSHIP BETWEEN NEST AND CHICK COUNTS

Area	*Colonies*	*Nest count*	*Date*	*Chick count*	*Date*	*Chicks per pair* Mean	Range
North Point	8	1 491	6–7 Dec. 1978	1 260	2 Feb. 1979	0.85	0.81–1.22
Gourlay Point	3	1 084	13–15 Dec. 1978	1 190	16 Feb. 1979	1.10	1.09–1.10
Pageant Point	3	1 084	14 Dec. 1978	1 538	16 Feb. 1979	1.42	0.92–1.62
Pantomime Point	4	1 143	15 Dec. 1978	1 119	16 Feb. 1979	0.98	0.72–1.28
OVERALL	18	4 802		5 107		1.06	0.72–1.62

TABLE II. DATE OF FIRST LAYING AND HATCHING FOR PENGUINS AT SIGNY ISLAND

Species	*Laying dates* Mean	Range	*Hatching dates* Mean	Range
Adélie	27 Oct.	22 Oct.–3 Nov. (17)	30 Nov.	29 Nov.–6 Dec. (14)
1978–79	27 Oct.		30 Nov.	
Chinstrap	25.5 Nov.	21 Nov.–1 Dec. (12)	31 Dec.	27 Dec.–9 Jan. (12)
1978–79	26 Nov.		1 Jan.	
Gentoo	30 Oct.	19 Oct.–14 Nov. (11)	4 Dec.	26 Nov.–10 Dec. (7)
1978–79	27 Oct.*		5 Dec.	

* Date of 50% laid and hatched, respectively.
The number of seasons for which data available in parentheses.

Cape Hallett 31.4% (Reid, 1964).
South Shetland Islands 30.8% (Trivelpiece and Volkman, 1979).

The average of all these values is 31.6%. If we assume that egg losses occur at a constant rate and that all pairs have two eggs (i.e. on average 15.8% of pairs fail during incubation), then we might expect about 8%, 12% and 16% to have failed by half and three-quarters way through incubation and at hatching, respectively.

The only data for chinstrap penguin come from the South Shetland Islands, where Trivelpiece and Volkman (1979) reported 42.9% of eggs lost. For present purposes, it is probably reasonable to assume that losses are similar to those of Adélie penguin and that they are about 10% one-third of the way through incubation.

The uncorrected and corrected figures for the various Adélie and chinstrap penguin breeding sites are summarized in Tables III and IV. The present total breeding populations of Adélie and chinstrap penguins at Signy Island are thus approximately 37 000 pairs and 80 000 pairs, respectively.

For gentoo penguins, egg losses appear to be low and recent work at South Georgia (Croxall and Prince, 1979) gives a value of 9.6% for egg losses to hatching. If we assume this represents the failure of about 5% of pairs, then the original breeding population of gentoo penguin (see Table VII) would be 390 pairs.

Eleven pairs of macaroni penguins were found, singly in eleven Adélie and chinstrap penguin colonies in six areas of the island.

DISCUSSION

Previous counts for appropriate areas of Signy Island are presented in Tables V–VII, in which the percentage mean annual increase between some of them is also calculated. For the Adélie penguin (Table V), Ewer and Anderson's (1948) estimate was made at the time of laying. Scotland's (1958) count was of chicks and it has been assumed that this is equal to the original num-

TABLE III. BREEDING PAIRS OF ADÉLIE PENGUINS AT SIGNY ISLAND, 1978–79

Area	*Breeding pairs*	
	Counted	*Original**
North Point	8 824	10 504
Spindrift Rocks	5 898	7 021
Gourlay Point	6 174	7 350
Pageant Point	378	450
Pantomime Point	10 533	11 882
TOTAL	31 807	37 207

* For correction factors see text.

TABLE IV. BREEDING PAIRS OF CHINSTRAP PENGUINS AT SIGNY ISLAND, 1978–79

Area	*Field counts*		*Breeding pairs (originally*)*
	Chicks	*Pairs*	
North Point		7 126	7 126
Spindrift Rocks		128	128
Fyr Channel	5 416		5 109
Pandemonium Point	14 543		13 720
Confusion Island	7 736		7 298
McLeod Glacier (west)	1 651		1 558
Shagnasty Island	2 837		2 676
McLeod Glacier (east)		585	650
Oliphant Channel		143	159
Oliphant Islands	4 502		4 247
Gourlay Point		13 115	14 572
Pageant Point		1 219	1 354
Pantomime Point		5 426	6 029
Moe Island	11 622		10 964
Mariholm	4 149		3 914
TOTAL	52 456		79 504

* For correction factors see text.

TABLE V. ADÉLIE PENGUIN COUNTS, SIGNY ISLAND

Area	*Breeding pairs*	*Date*	*Reference*	*Percentage mean annual increase (to next count)*
North Point	*c.* 3 000	21 Oct. 1947	Ewer and Anderson, 1948	4.2
	4 535	6 Jan. 1958	Scotland, 1958	4.1
	10 504	5–6 Dec. 1978	This paper	
Spindrift Rocks	*c.* 2 500	21 Oct. 1947	Ewer and Anderson, 1948	4.3
	3 816	6 Jan. 1958	Scotland, 1958	2.9
	7 021	1 Dec. 1978	This paper	
Gourlay Peninsula	*c.* 5 000	21 Oct. 1947	Ewer and Anderson, 1948	26.0
	c. 10 000	1950–51	Sladen, 1958	2.4
	19 682	13–30 Nov. 1978	This paper	

ber of breeding pairs (see p. 48). The data, with these assumptions, give rise to apparently fairly consistent mean annual increases for North Point and Spindrift Rocks. For Gourlay Peninsula, however, there is considerable discrepancy between the figures of Ewer and Anderson (1948) and Sladen (1958) for estimates only 3 years apart. If we use the mean annual increase between 1957/58 and 1978/79 for North Point and Spindrift Rocks combined (3.6%) to back-calculate the 1957/58 figures for Gourlay Peninsula (from the known 1978–79 values), this gives 9 365 pairs. In turn, using the mean annual increases for the same two areas between 1947–48 and 1957–58 (4.2%), this results in an estimate of 5 534 pairs for Gourlay Peninsula in 1947–48. This would seem to suggest that Ewer and Anderson's (1948) figures were more accurate than

Sladen's (1958). Nevertheless, it must be remembered that Sladen was actually conducting a penguin study on Gourlay Peninsula and his assessment may well have been based on more detailed knowledge than Ewer and Anderson's. If Sladen's (1958) figures were accurate, then, assuming the Gourlay Peninsula population increased at the same rate as North Point and Spindrift Rocks, the 1947–48 population would have been *c.* 8 800 pairs and the 1957–58 population *c.* 12 000 pairs.

In terms of the whole island, we can suggest that the population increase may have taken the following course:

1947–48: 10 000–14 000 (depending on the Gourlay Peninsula population),
1957–58: 18 000–20 000,
1978–79: 37 000.

The increase has thus perhaps been a fairly steady one, with the population doubling in the first 10 years or so and doubling again in the next 20 years.

For chinstrap penguin (Table VI), although there is more information, it is still patchy and we

TABLE VI. CHINSTRAP PENGUIN COUNTS, SIGNY ISLAND

Area	*Breeding pairs*	*Date*	*Percentage mean annual increase (to present)*
North Point	A few	1947–48	8.9
	1 289	1958–59	
	700	20 Jan. 1964	
	7 126	5–7 Dec. 1978	
Fyr Channel	500	Dec. 1958	12.3
	300	Jan. 1965	
	5 109	1978–79	
Pandemonium Point	2 200	Dec. 1958	9.6
	1 200	Jan. 1965	
	13 720	1978–79	
Confusion Island	2 000	Dec. 1958	6.7
	2 000	28 Jan. 1964	
	7 298	1978–79	
Shagnasty Island	1 500	Dec. 1958	2.9
	700	28 Jan. 1964	
	2 676	1978–79	
McLeod Glacier (east)	*c.* 130	19 Dec. 1976	112
	585	15 Dec. 1978	
Oliphant Islands	240	1947–48	9.7
	4 247	1978–79	
Gourlay Point	2 680	19 Jan. 1964	2.6
	10 128	17 Dec. 1968	
	12 115	13–15 Dec. 1968	
Pageant Point	250	19 Jan. 1964	2.8
	921	17 Dec. 1968	
	1 219	14 Dec. 1978	
Pantomime Point	903	23 Dec. 1955	8.1
	3 429	19 Dec. 1968	4.7
	5 426	15 Dec. 1978	
Gourlay Peninsula	*c.* 5 000	1947–48	4.5
	c. 10 000	1950–51	2.5
	c. 5 000	17 Nov. 1957	6.8
	14 478	17–19 Dec. 1968	3.2
	19 760	13–15 Dec. 1978	

1947–48; from Ewer and Anderson (1948).
1950–51; from Sladen (1958).
1955; from Scotland (1956).
1957; from Scotland (1958).
1958–59; from P.A. Richards *in* Croxall and Kirkwood (1979).
1964, 1965; from R. W. Burton *in* Croxall and Kirkwood (1979).
1968; from J. W. H. Conroy and D. A. Brown *in* Croxall and Kirkwood (1979).
1976; from R. I. L. Smith *in* Croxall and Kirkwood (1979).
1978–79; this paper.

do not know the precise dates of some previous records. The 1968 counts in the important Gourlay Peninsula area were made near hatching, as were the 1978 counts. Consequently, the actual, and not the corrected, counts are used as these are the most directly comparable. The data for 1964 and 1965 seem consistently low, sometimes substantially so, and they have not been used in calculations.

Leaving aside Gourlay Peninsula, and excepting Shagnasty Island and McLeod Glacier, mean annual increases, mainly from the late 1950's, are in the range 7–12%. This is considerably higher than the value for Adélie penguin over a similar period. The large increase at the McLeod Glacier site has clearly been considerably fuelled by immigration. The small increase at Shagnasty Island is attributable to the restrictions on space imposed by the small size of the island and the large colony of blue-eyed shag *Phalacrocorax atriceps*. In the three parts of Gourlay Peninsula we are dealing mainly with increases since 1968. These are appreciably less than those from a decade earlier and more similar to the typical values for Adélie penguin. With the exception of the 1957 figure, early counts for the whole peninsula, however, suggest that average rates of increase overall may never have been much higher, with a maximum of 5.2% for the period 1947–48 and 1968–69. Gourlay Peninsula has always been an important breeding area for penguins on Signy Island. It is possible, therefore, that space for expansion is more limited here than elsewhere. This might indeed be the case for Gourlay Point and Pantomime Point but cannot be so for Pageant Point.

Another possibility is that there has been greater disturbance to Gourlay Peninsula populations. The area is readily accessible from the main station and is naturally much visited, although no intensive penguin research has been conducted there since 1950–51. However, considerable research has been undertaken at the nearby terrestrial reference sites (Tilbrook, 1973). Workers and visitors make extensive use of the Gourlay Peninsula hut, sited at the base of Pageant Point and it may be significant that, in proportion to its area, rather smaller numbers of penguins breed here.

There are several areas for which previous information is lacking. Spindrift Rocks were probably first colonized in about 1970 and the McLeod Glacier, Oliphant Channel and many Fyr Channel colonies started little if any earlier. Even in well-populated areas (e.g. Gourlay Peninsula), a comparison of the present map with one prepared in 1950–51 (see Croxall and Kirkwood, 1979, maps 20.4 and 20.3, respectively) shows quite a number of new colonies.

Computations of past Signy Island chinstrap penguin populations depend extensively on extrapolation using the mean annual increases in Table VI. The best data, prior to 1978, are for 1958 and the overall mean annual increase to 1978 is 9.0%. If this value is used to derive estimates for the population of Gourlay Peninsula and Oliphant Islands in 1958, these are 6 000 and 750 pairs, respectively. The former is much lower than Sladen's (1958) estimate of the population in 1950 but accords better with Scotland's (1958) estimate for 1957. Alternatively, we might extrapolate back from the Gourlay Peninsula counts of 1968 using their mean increase to 1978 of 3.2% per annum. This would give a figure of 10 500 pairs, somewhat closer to Sladen's value for 1950. The total 1958–59 population would therefore be between 12 500 and 17 000 pairs. In similar fashion, we can derive values for the 1968–69 population at areas away from Gourlay Peninsula working back from 1978 (assuming an increase of 3.2% per annum) or forward from 1958–59 (using the appropriate annual increase for each colony from then to 1978). This gives overall maximum and minimum populations of 35 000 and 55 000 pairs. To get an idea of 1947 population levels, we can only work back from 1958–59 data, coupled with Ewer and Anderson's estimate of 5 000 pairs at Gourlay Peninsula in 1947–48. This gives a total of 9 000 pairs, which is not likely to be an underestimate.

The following course of population increase in the chinstrap penguin at Signy Island can be tentatively suggested:

1947–48:	9 000,
1958–59:	15 000,

1968–69: 45 000,
1978–79: 77 000.

Thus, like Adélie penguin, the population may have nearly doubled in the first 10 years but then increased five-fold (rather than doubling) in the next 20 years. The bulk of this increase may have occurred in the 1960's. Gentoo penguin populations (Table VII) have fluctuated appreciably and there is no real evidence of any consistent increase. The 11 breeding pairs of macaroni penguin is the highest total recorded since breeding was first confirmed in 1955–56. It would be unwarranted, however, to assume that the increase is of any real significance.

TABLE VII. GENTOO PENGUIN COUNTS, SIGNY ISLAND

Breeding pairs	*Date*	*Reference*
300	20 Oct. 1948	Laws, 1949
314	6 Jan. 1958	Scotland, 1958
200	20 Jan. 1964	R. W. Burton *in* Croxall and Kirkwood (1979)
255	14 Dec. 1976	B. Despin *in* Croxall and Kirkwood (1979)
370	13 Nov. 1978	This paper

There is thus unequivocal evidence for a substantial increase in Adélie and chinstrap penguin populations at Signy Island. This would accord with earlier statements on increases in Antarctic and sub-Antarctic penguin populations (Sladen, 1964; Conroy, 1975) which attributed this to the reduction in whales making available increased quantities of krill to penguins. These assertions, however, were based on little firm evidence. Sladen (1958) had noted the increase in extent of the Hope Bay, Antarctic Peninsula, colony of Adélie penguins between 1902 and 1947. This colony had increased further by 1963–64 (Lefeuvre, 1963). No other consistent increases were demonstrated as Conroy's (1975) data for Point Thomas, King George Island, South Shetland Islands, are incorrect. For chinstrap penguin, Sladen (1964) summarized much evidence for increased dispersion and recorded some indications of an expanded breeding range. Subsequently, however, there seems to have been little, if any, increase at these new sites (Conroy, 1975). Stonehouse (1967) did establish that breeding populations at Cooper Bay, south-east South Georgia, had increased between 1947 and 1955 but with more extensive data (see Croxall and Kirkwood, 1979) only very few of the increases suggested by Conroy (1975) for the South Shetland Islands can be substantiated. The recent compilation by Croxall and Kirkwood (1979) presents additional clear evidence for increases in both species (but principally in chinstrap penguin), and provides a wealth of more anecdotal data, and thus supports the earlier contentions. Signy Island is, however, currently the best-documented example of an increasing Antarctic penguin population.

Although the potentially favourable influence of recent Antarctic climatic amelioration has been noted (Conroy, 1975; unpublished manuscript by J. Horwood), there seems little reason to doubt that enhanced food availability is responsible for the increases in penguin numbers. It is also plausible that the gentoo penguin, which tends to eat less krill than the other pygoscelid penguins (Croxall and Prince, 1980; Volkman and others, 1981), should have shown least sign of an increase.

It is not at all clear why the chinstrap penguin appears to have increased faster than the Adélie penguin. Where space is limited, it can displace Adélie penguins from nest sites (Trivelpiece and Volkman, 1979) but this cannot have been the case at the majority of breeding sites on Signy Island.

The chinstrap penguin occupies a latitudinal breeding range that is essentially intermediate between the gentoo penguin (most abundant at sub-Antarctic islands) and the Adélie penguin (extremely abundant around the periphery of the Antarctic continent). The South Orkney Islands

are thus at the heart of the breeding range of the chinstrap penguin but much less so for the Adélie penguin. If breeding distributions reflect ecological and physiological adaptations in some way, then it might be expected that conditions at Signy Island would be slightly more favourable to chinstrap than to Adélie penguin. In addition, there are suggestions (see Croxall and Kirkwood, 1979) that northerly Antarctic penguin populations have increased more than southerly ones and it can be suggested, following Sladen (1964), that this reflects the fact that most whaling was done in the more northerly Antarctic regions. Chinstrap penguins would thus stand to benefit more than Adélie penguins.

The Signy Island census work is being followed up in three ways. First, colonies have been chosen for annual monitoring of number of breeding pairs, chicks hatched and chicks fledged (i.e. reproductive performances). For Adélie penguin, four colonies, with a range of 240–630 nests, have been chosen. For chinstrap penguin, because of the additional interest in the progress of some of the smaller recently formed colonies, eight were chosen with a range of 5 to 850 nests. Secondly, a complete re-count of the whole Signy Island population will be carried out in not more than 10 years' time. The results of the annual monitoring work will indicate a suitable timing for this. Thirdly, research into the diet and feeding ecology (and related topics) of chinstrap and Adélie penguins has been started. Amongst other things, this will seek to quantify the impact of Signy Island penguins on the marine resources of the surrounding waters.

In addition to the breeding birds, there is also a substantial non-breeding penguin population, all of which will be coming ashore to moult during the breeding season and much of which must be foraging in similar areas to the breeding stock. Being unrestricted by the need to feed chicks, they will, however, be able to forage somewhat further afield. Using information on Adélie penguin age-specific survival and recruitment to the breeding population from Ainley and DeMaster (1980) (and inserting the conservative survivorship value of 0.150 for 1-year-old birds in their table 7), we can deduce that there are at least three-quarters as many non-breeders as breeding birds. If the chinstrap penguin is similar in this respect to the Adélie penguin, the 233 000 breeding birds at Signy Island are accompanied by 175 000 non-breeders, giving a total population of just over 400 000 birds. They represent about 90% of the avian biomass at Signy Island and are of prime importance as local consumers of krill.

Thus in the 6 months that the population is in the vicinity of Signy Island, assuming standard metabolic rate follows Lasiewski and Dawson (1967), resting metabolic rate is 1.7 times this (Baudinette and Schmidt-Nielsen, 1974) and the demands of swimming four times that (Prange and Schmidt-Nielsen, 1970), then with 75% assimilation efficiency and the approximate calorific value of krill 1 kcal g^{-1} wet weight, the population might consume about 150 000 tonnes of krill, excluding the additional demands made by the chicks themselves (probably less than 10 000 tonnes).

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