Population sizes of king, rockhopper and macaroni penguins and wandering albatrosses at the Prince Edward Islands and Gough Island, 1951-1986

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An international survey of Antarctic seabirds (ISAS) was recommended by SCAR to monitor population changes in selected species. Fluctuations in these populations might aid in detecting any changes in relative abundance of prey resources, chiefly krill. Insufficient data exist from the Prince Edward islands, southern Indian Ocean, to comment on population changes in the king penguin Aptenodytes patagonicus *and rockhopper penguin* Eudyptes chrysocome. *but macaroni penguins* E. chrysolophus *may have increased in numbers at Marion Island since 1977. The rockhopper penguin population at Gough Island, south Atlantic, may have increased in size. The wandering albatross* Diomedea exulans *may have decreased in numbers at Marion Island over the last 12 years. Existing data on the wandering albatross populations of Prince Edward and Gough islands preclude any comment on population trends. Standard techniques in monitoring different species should be employed and it is important to continue monitoring the wandering albatross which is decreasing in numbers at several localities throughout its range.*

'n Internasionale opname oor Antarktiese seevoëls is deur SCAR aanbeveel om bevolkingveranderings by bepaalde spesies te moniteer. Veranderings in die bevolkingstalle kan help by die vasstel van enige veranderings in die relatiewe aanwesigheid van prooibronne, hoofsaaklik kril. Daar is nie voldoende gegewens om kommentaar te kan lewer oor bevolkingveranderings by koningpikkewyne Aptenodytes patagonicus *en geelkuifpikkewyne* Eudyptes chrysocome *op die Prins Edward-eilande in die suidelike Indiese Oseaan nie, maar die macaroni pikkewyne* E. chrysolophus *by Marioneiland het waarskynlik sedert 1977 vermeerder. Die geelkuifpikkewyn-bevolking by Gough-eiland in die suidelike Atlantiese Oseaan het waarskynlik vermeerder. Die bevolking van die grootalbatros* Diomedea exulans *op Marioneiland kon oor die laaste 12 jaar verminder het, maar by die Prins Edward-eiland daar naby het dit oor die laaste tien jaar vermeerder. Daar vind moontlik 'n versterking van dié spesie van ander sub-Antarktiese eilande af plaas. Die beskikbare gegewens oor die grootalbatros op die Prins Edward-eiland en op Gough-eiland sluit enige kommentaar oor bevolkingsneigings uit. Standaard-tegnieke moes vir die monitering van die verskillende voëlsoorte gebruik word. Waar die getalle van die grootalbatros afneem op verskeie plekke binne sy leefgebied, moet die monitering daarvan voortgesit word.*

Introduction

Monitoring changes in breeding numbers of selected seabird species in the Southern Ocean could aid in detecting population changes of their prey resources (such as krill) in the advent of overexploitation by man (Anon. 1979a). In 1976 the SCAR (Scientific Committee on Antarctic Research) Subcommittee on Bird Biology, realizing that the importance penguins play in the Southern Ocean ecosystem was being underestimated, recommended that an international survey of Antarctic seabirds (ISAS) be undertaken. ISAS was commissioned at a meeting of the BIOMASS (Biological Investigation of Marine Antarctic Systems and Stocks) Working Party on Bird Ecology in October 1980 when plans for ISAS were reviewed (Anon. 1982a). The programme was initially planned to cover two seasons, namely 1981-1982 and 1982-1983 (Anon. 1980).

Although at sub-Antarctic islands ISAS gave high priority to royal/macaroni penguins *Eudyptes chrysolophus*, king penguins *Aptenodytes patagonicus* and wandering albatrosses *Diomedea exulans*, censuses of as many other seabird species as possible were encouraged. For example, the rockhopper penguin *E. chrysocome* is also an abundant and widespread species breeding at sub-Antarctic islands. Species were selected for long-term monitoring on the following criteria (Anon. 1979b):

(a) Birds that are a major component of the avian biomass in the sub-Antarctic and feed on krill.

(b) Species that are important krill predators at the secondary level, such as the king penguin.

(c) Species that have a small world population which might be particularly vulnerable to prey stock changes e.g. the wandering albatross.

Features that facilitate a population census of such species are their large size, visibility, approachability and colonial (penguins in particular) surface-nesting habits.

The emphasis for ISAS was on the islands close to, and south of, the Antarctic Polar Front where sites ranged geographically from near to, and far from, areas likely to be subjected to commercial exploitation. Sites were selected where relevant baseline data existed or where appropriate research was being undertaken (Anon. 1979b).

This report lists the population sizes of king, rockhopper, and macaroni penguins and wandering albatrosses at the Prince Edward islands (46°54'S; 37°45'E) and Gough Island (40°21'S; 09°53'W) since Rand's (1955) first attempt to count penguins at Marion Island in the summer of 1951-1952. All counts made after 1979 are unpublished data. These counts can be considered as baseline counts for future intensive monitoring that may attempt to relate predator to prey abundance.

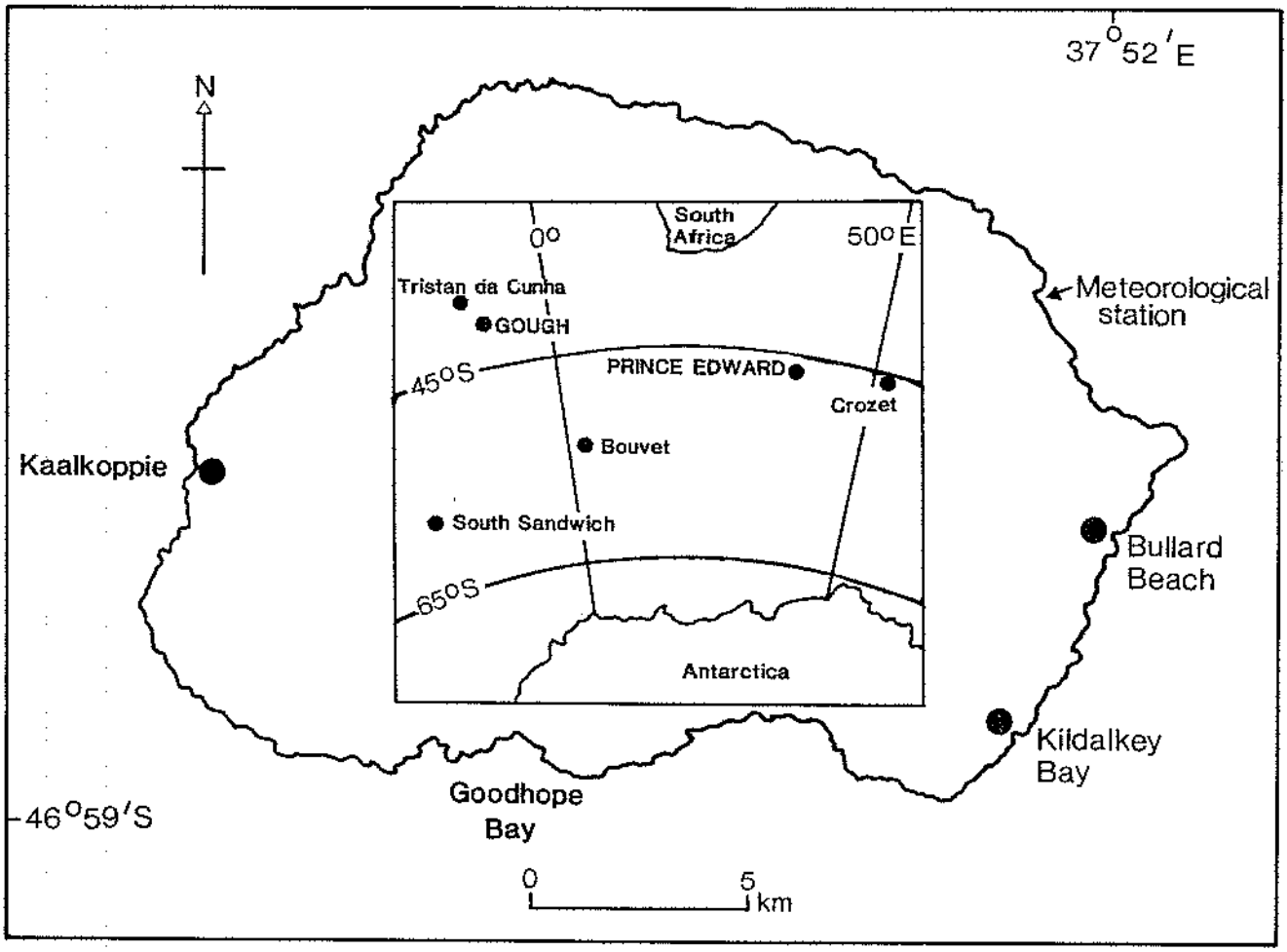

Fig. 1. Position of the Prince Edward islands and Gough Island in the Southern Ocean. Place names on Marion Island are referred to in the text.

Methods

King penguin

The large colony at Kildalkey Bay, Marion Island (Fig. 1) has been surveyed by photographing 10 m² quadrats from the ground and calculating the colony area from aerial photographs (Lindeboom 1979, Williams *et al.* 1979). Smaller colonies were counted by head counts from the ground or from photographs, usually of chick creches. Due to the difficulty of counting king penguins because their breeding cycle is not synchronized and lasts for some 13 months (Stonehouse 1960, Barrat 1976) and because of their susceptibility to disturbance (pers. obs.), few estimates of population size have been made.

Rockhopper penguin

All censuses of this species at the Prince Edward islands are ground estimates. Grindley's (1981) count at Prince Edward Island is an underestimate since the western half of the island was not surveyed.

Ground counts of occupied nest sites during the incubation/guard stage were made between North-east Point and Rockhopper Point (44 % of the total coastline) on the eastern side of Gough Island in November 1984 (Fig. 2). Access to colonies in the area was made by inflatable rubber dinghy. A ground estimate was made for offshore Penguin Island since large numbers nest among high tussock grass *Poa flabellata* and are not readily accessible. The remainder of Gough Island was surveyed by three independent counts (regional totals averaged) utilizing binoculars from the M.V. *S.A. Agulhas* while sailing around the island.

Macaroni penguin

Rand (1955) obtained his figures of larger colonies by multiplying the estimated surface areas of breeding colonies by eight birds/m². Van Zinderen Bakker Jr (1971) used an average of three birds/m² for Bullard Beach and Kildalkey Bay, Marion Island colonies (Fig. 1). Ten quadrats of 10 m² were established and photographed in the Bullard Beach and Kildalkey Bay colonies by Lindeboom (1979). A mean density of 4,5 birds/m² was obtained from counts on these photographs. Total area of the colonies was estimated from aerial photographs. Aerial and ground counts were used in the 1974 and 1976/1977 censuses which covered most of Marion Island (Williams *et al.* 1975, Williams *et al.* 1979). During April 1983 the very large Bullard Beach and Kildalkey Bay colonies were tacheometrically surveyed and mapped. Sampling quadrats (14 at Bullard Beach, 18 at Kildalkey Bay) of 25 m² were established in the monitoring colonies. The sizes of the breeding populations at these two localities were estimated by multiplying the mean number of occupied nest sites in horizontal and inclined sampling quadrats (nest sites tend to be more dense on horizontal ground and in the centre of the colony) by the total area of

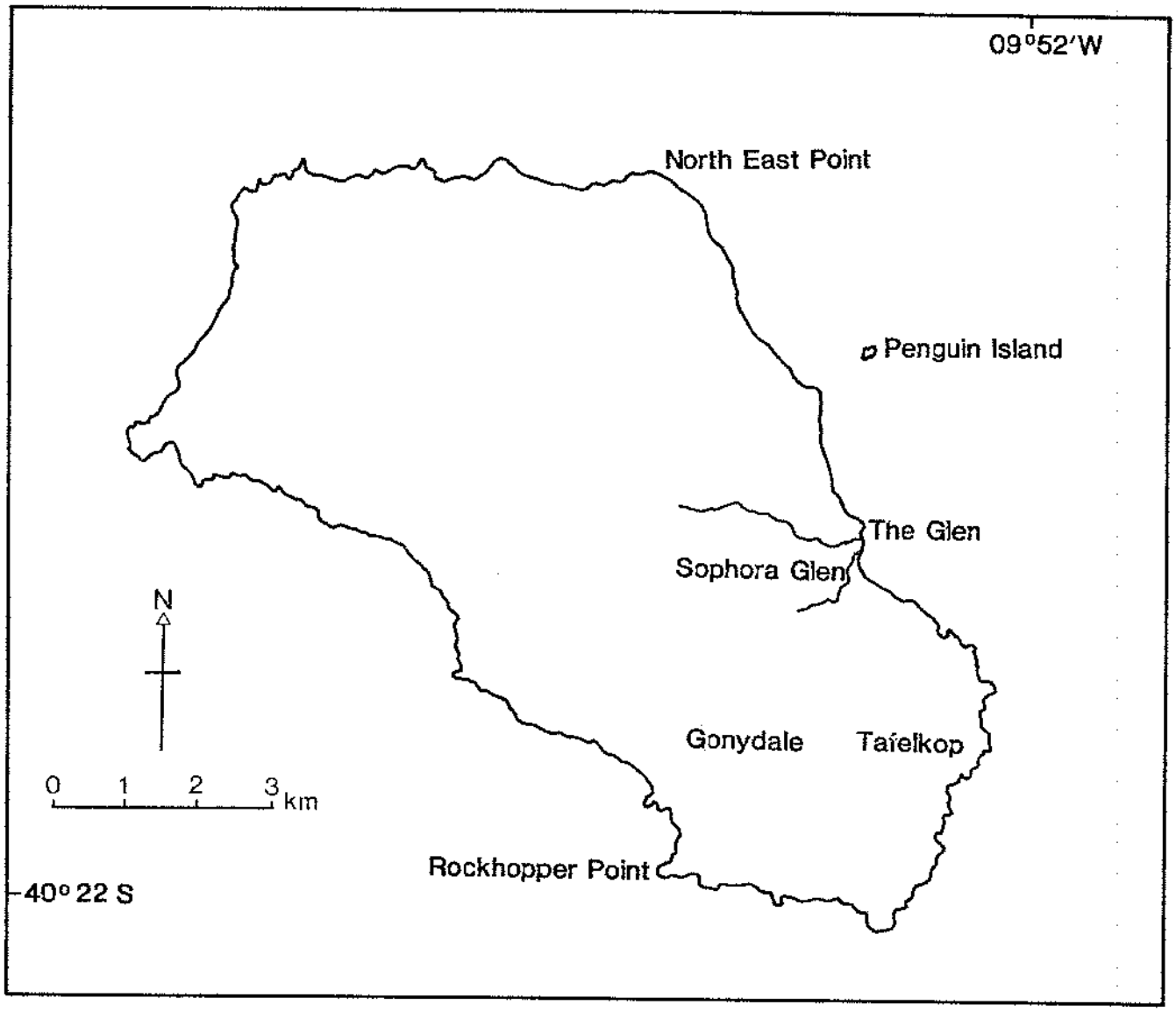

Fig. 2. Gough Island and place names referred to in the text.

horizontal and inclined ground occupied by the incubating birds (Watkins *et al.* in prep.). The remaining colony sizes were determined by ground and photographic counts. A complete census of incubating macaroni penguins at Marion Island was conducted in November 1983.

Wandering albatross

Total island populations have been estimated by making ground counts of chicks every year during takeover visits, usually in April/May at the Prince Edward islands and from September to November at Gough Island. These counts are underestimates of the total breeding demipopulations (breeding pairs in one season: wandering albatrosses normally breed every second year, Tickell 1970) since egg and chick mortality has not been taken into consideration (see Table 7). Individuals (up to 20 per cent of the population) may breed in two successive seasons if they are unsuccessful in the first season (Tickell 1968, Croxall 1979). A count made at Prince Edward Island in 1985 was incomplete due to inclement weather. Complete counts of chicks were made in 1979 and 1982 on Gough Island; near-complete counts were made in 1980 and 1981. Due to bad weather only incomplete counts were made at Gough Island in 1983 and 1984.

Results and discussion

King penguin

King penguins breed at Marion Island and at Prince Edward Island. Ten breeding colonies at Marion Island and

Table 1

Total estimates and counts of breeding pairs of king penguins at the Prince Edward islands

Date	Marion Island	Prince Edward Island	Total	Source
April 1974 – April 1975	—	4 879	—	Grindley (1981)
January 1974 – April 1975	215 230	5 000	220 230	Williams *et al.* (1979)

three at Prince Edward Island are known. A total of 220 230 pairs has been estimated for these 13 colonies (Table 1) from counts conducted between January 1974 and May 1977.

King penguins breed on flat, open terrain and require gentle sloping beaches of sand, pebbles or small boulders on which to land (Stonehouse 1985); consequently they avoid the west coasts of Marion and Prince Edward islands which lack suitable landing beaches (N.J. Adams pers. obs.).

Recently, king penguins have increased in numbers at South Georgia and recolonization has occurred at Heard Island and the Falkland Islands (Wilson 1983), which may in part be attributed to cessation of their exploitation for oil in the nineteenth century (Conroy & White 1973). Rounsevell & Copson (1982) maintain that the population recovery (78-fold over a period of 50 years) at Macquarie Island has not been demonstrated to have resulted from a reduction in whale stocks. Based on the recent establishment of two small breeding colonies south of Bullard River and at Goodhope Bay (Fig. 1), king penguins may be increasing in numbers at Marion Island. Existing data preclude any comment on population trends at Prince Edward Island.

Rockhopper penguin

Rockhopper penguins breed at the Prince Edward islands and Gough Island. Totals of 128 290 pairs at the Prince Edward islands (Table 2) and 144 235 pairs at Gough Island (Table 3) are the most recent estimates.

From recently conducted censuses (Table 3) it is likely that the 1955-1956 assessment of the rockhopper penguin population on Gough Island was a considerable overestimate as discussed by Williams (1980). Counts at The Glen and Sophora Glen were of *c.* 1 000 and *c.* 10 000 pairs in 1955-1956 (Swales 1965), 400 and 800 individuals in 1981 (Williams & Imber 1982) and the 1984 census gave 733 and 1 379 pairs respectively. Williams & Imber's (1982) figures are based on personal communications from meteorological team members and may not represent an accurate count. N.M. Wace (pers. comm. to J. Cooper) obtained the impression that more birds were nesting at The Glen in 1956 than in 1984. Holdgate (1958) stated that there "were hardly any penguins" on Penguin Island in 1955-1956; in 1984 the population of this offlying rock was estimated to be *c.* 1 500 pairs. Considerable numbers of rockhopper penguins at Sophora Glen and at other localities are nesting in previously unoccupied tussock grass (pers. obs.), and based on this evidence, it is possible that the rockhopper penguin population is increasing in size at Gough Island. However, rockhopper penguins may have been forced to nest farther inland, and therefore in areas previously unoccupied, due to encroachment by the Amsterdam Island fur seal *Arctocephalus tropicalis* (pers. obs.) which is increasing in numbers at Gough Island (Bester 1980). There is no good evidence of a decrease in the population as stated by Williams (1984) from illegal taking of penguins to bait crayfish pots and from legal captures for export to zoos. Williams' (1980) figure for the whole island for 1979 is 38 per cent lower than the 1984 census (Table 3) but this is attributed as much to a more accurate census in 1984 than to any increase in population size. Insufficient data exist for the Prince Edward islands to comment on population trends in rockhopper penguins.

Moors (1986) reports a decrease in the numbers of rockhopper penguins on Campbell Island during the last 40 years. Attempts to work out the timing and extent of the decrease have been hampered by a shortage of information about the penguin population in the past but it is clear that the total breeding population of rockhopper penguins at Campbell Island is now only a small fraction of an estimated population of over one million birds in the mid-1940's. There are indications that the Antipodes Island population may also have decreased in size (Moors 1986).

Macaroni penguin

Macaroni penguins breed at Marion and Prince Edward islands. Marion Island supported 33 breeding colonies in 1983 with 90 per cent of the islands' population breeding at Bullard Beach and Kildalkey Bay. Prince Edward Island supports three colonies. Most recent estimates of breeding

Table 2

Total estimates and counts of breeding pairs of rockhopper penguins at the Prince Edward islands

Date	Marion Island	Prince Edward Island	Total	Source
1965 – 1966	—	—	*c.* 1 000 000	van Zinderen Bakker Jr (1971)
April – May 1973	—	< 50 000	...	Grindley (1981)
January 1974 – March 1974	212 300*	...	—	Williams *et al.* (1975)
April 1976 – May 1977	93 285	35 000	128 290	Siegfried *et al.* (1978), Williams *et al.* (1979)

* thought to include non-breeding individuals

Table 3

Total estimates and counts of breeding pairs of rockhopper penguins at Gough Island

Date	Total	Source
1889	"millions"	Verrill (1895)
November 1955 – May 1956	*c.* 2 000 000	Swales (1965)
October 1979	89 300	Williams (1980)
November 1984	144 235	FitzPatrick Institute records

birds for the Prince Edward islands are 405 084 pairs at Marion Island and 17 000 pairs at Prince Edward Island (Table 4).

The macaroni penguin is one of the key species of ISAS (Anon. 1979b) and presents fewer problems than the king and rockhopper penguins in estimating population size. It, like the rockhopper penguin, breeds annually with a short breeding season, is highly colonial and is tolerant of human disturbance (pers. obs.). Macaroni penguins breed on flat or sloping terrain mainly on the older grey lava at Marion Island (Williams 1978). No colonies are found on recent black lavas characterized by cliffs and scree which are favoured by the smaller and more agile rockhopper penguins (Williams 1978). Competition for nest space between these two species is thus avoided. Prior to the volcanic eruption at Kaalkoppie, Marion Island, which occurred some time between February and October 1980 (Verwoerd *et al.* 1981), 7 571 pairs of macaroni penguins bred there in 1976-1977 (Siegfried *et al.* 1978). In November 1980 less than 300 pairs were incubating on the scree summits of Kaalkoppie and less than 100 pairs on the broken lava of the nearby beach (Berruti 1982). A new colony of approximately 200 pairs was found 2 km north of Kaalkoppie (Berruti 1981). By November 1983 the colony at Kaalkoppie was showing rapid signs of recovery with 3 552 pairs present.

A comparison of two photographs taken at Kildalkey Bay in 1949 (Crawford 1982) and in 1977 (Lindeboom 1979) shows an increase in the breeding area, by means of erosion at the edges of the macaroni penguin colony. Estimates made from quadrat counts and colony area at Bullard Beach and Kildalkey Bay colonies have fluctuated over the last five years but since 1977 (Lindeboom 1979) there appears to have been an increase in overall numbers at these two large colonies which together comprise 90 per cent of the estimated island population.

Macaroni penguins have increased in numbers at South

Table 4

Total estimates and counts of breeding pairs of macaroni penguins at the Prince Edward islands

Date	Marion Island	Prince Edward Island	Total	Source
1965 – 1966	—	—	*c.* 2 000 000	van Zinderen Bakker Jr (1971)
April – May 1973	—	10 – 20 000	—	Grindley (1981)
April 1976 – May 1977	450 000	17 000	467 000	Williams *et al.* (1979)
November 1983	405 084	—	—	FitzPatrick Institute records

Table 5

Total estimates and counts of breeding pairs of wandering albatrosses (demipopulations) at the Prince Edward islands

Date	Marion Island	Prince Edward Island	Total	Source
1951 – 1952	700*	—	—	Rand (1954)
1965 – 1966	—	—	*c.* 3 000	van Zinderen Bakker Jr (1971)
1973	—	758**	—	Grindley (1981)
1974	1 557	847	2 404	Williams *et al.* (1975)
1976 – 1977	1 852	966	2 818	Williams *et al.* (1979)
1982	1 207	957	2 164	FitzPatrick Institute records
1983	1 137	1 135	2 272	..
1984	1 184	1 277	2 461	..
1985	1 168	913**	2 081	..
1986	1 096	—	—	..

* presumably applies to demipopulation
** incomplete count

Table 6

Total estimates and counts of breeding pairs of wandering albatrosses (demipopulations) at Gough Island

Date	Total	Source
1889	*c.* 2 000*	Verrill (1895)
1955 – 1956	*c.* 2 000	Swales (1965)
1979	792	FitzPatrick Institute records
1980	661**	..
1981	431**	..
1982	798	..

* presumably applies to demipopulation
** incomplete count

Table 7
Estimated total breeding demipopulation (original count plus mortality figure) of wandering albatrosses at Marion Island, 1982-1986 from FitzPatrick Institute records

Date	No. eggs laid in study colonies	No. chicks hatched in study colonies	Hatching success %	Total count of chicks soon after hatching	Estimated total breeding demipopulation
1982	98	85	86.7	1 207	1 368
1983	107	85	79.4	1 137	1 371
1984	111	103	92.8	1 184	1 269
1985	90	83	85.6	1 168	1 336
1986	98	88	89.8	1 096	1 208

Georgia (Croxall & Prince 1979) and further monitoring is required at the Crozet Islands to determine any population trends there (Jouventin *et al.* 1984).

Wandering albatross

Wandering albatrosses breed at the Prince Edward islands and Gough Island. At least 2 461 pairs bred at the Prince Edward islands in 1984 (the most recent year with a complete census) (Table 5) and at least 798 pairs on Gough Island in 1982 (Table 6). These figures refer to demipopulations.

Suitable breeding areas for wandering albatrosses are generally confined to flat open areas free of tall vegetation or other obstructions to facilitate landing and becoming airborne (Tickell 1970). Nests may be placed hundreds or several metres apart. Marion Island's interior is characterized by steep slopes and valleys; wandering albatrosses nest in the low-lying (up to 200 m altitude) grassland. At Gough Island, most low altitude areas are either too steep or covered with dense vegetation so wandering albatrosses are confined to high altitude or westfacing areas where slopes are gentler and vegetation does not hamper running take-off, although several pairs nest on steep west facing slopes at Gough Island, e.g. at Gonydale and Tafelkop (pers. obs.), where nearby access to flat areas exists.

Breeding wandering albatrosses are relatively easy to count compared to penguins but it is important to count breeding populations in successive years since they are biennial breeders (Tickell 1970). It is also essential to measure breeding success, which varies from year to year (Table 7), since failed birds may breed again in the following year and thus distort the assessment of the total breeding population. Presumably Verrill's (1895) and Swales' (1965) estimates for Gough Island are equivalent to demipopulations. The first assessment on Marion Island was of 700 pairs in 1951-1952 by Rand (1954). Later counts are too few to comment accurately on population fluctuations; but if any trend is developing it would appear to be a decrease in the breeding population since 1974 (Table 5 & 7). There is some evidence that an increase in human activity has led to a decrease in the number of breeding wandering albatrosses in the vicinity of the meteorological station at Marion Island (van Zinderen Bakker Jr 1971, Grindley 1981) as is the case on Kerguelen Island (Jouventin *et al.* 1984).

The time of year that counts were made at the Prince Edward islands must be borne in mind: the later in the chick stage the higher the preceding mortality and thus the greater underestimation of the size of the breeding population. For this reason, and due to incomplete counts, no trend can be discerned for the wandering albatross population of Prince Edward Island.

Feral cats *Felis catus* at Marion Island have been seen carrying an apparently freshly killed gentoo penguin *Pygoscelis papua* chick and a living rockhopper penguin chick and feeding on the carcass of a lightmantled sooty albatross *Phoebetria palpebrata* chick. These observations all took place between October 1980 and March 1981, and it is possible that cats had actually killed the chicks in one or all of these instances (Berruti 1981). However, there is as yet no evidence that cats have killed wandering albatross chicks at Marion Island, although it is of interest to note that two chicks of the similarly sized royal albatross *D. epomophora* were killed by feral cats at Taiaroa Head, New Zealand between 1951 and 1959 (Westerskov 1963).

Wandering albatrosses have decreased in numbers at the Crozet and Kerguelen islands (Jouventin *et al.* 1984, Voisin 1984), at South Georgia over the last 20 years (Croxall 1979) and at Macquarie Island over the last 17 years (Rounsevell & Brothers 1984, Tomkins 1985). Man has exterminated the breeding population on Tristan da Cunha (Swales 1965) but at nearby Inaccessible Island four pairs were breeding in 1982 (Fraser 1983) the relic of a larger population of at least 200 pairs (Thomson 1877, Stoltenhoff 1952). In contrast, Heard Island had one pair of wandering albatrosses reported breeding for the first time in 1980 (Johnstone 1982).

Croxall (1979) does not consider a lowered breeding success to be an adequate explanation for the decrease at South Georgia. Croxall *et al.* (1984) and Jouventin *et al.* (1984) suggest that the decreases of the breeding populations at South Georgia and the Crozet Islands might be attributed to accidental or deliberate killing by fishermen, and of entanglement in fishing nets and lines of birds wintering off eastern Australia. Such reasons could also be causing a decrease in the number of wandering albatrosses at Marion Island. It is thus important to continue monitoring this species, which is decreasing in numbers at several localities throughout its range.

Conclusions

Accurate assessments of population sizes of these species present problems. Difficulties in counting rockhopper and macaroni penguins are encountered since they are abundant at many localities and often breed in inaccessible areas. Problems have arisen in attempting to count wandering albatrosses at Gough Island and Prince Edward Island during limited time and inclement weather. Quadrat counts

extrapolated over a previously surveyed area (Croxall & Prince 1979, Watkins *et al.* in prep.) are probably the most reliable method for determining the sizes of large penguin populations. Aerial photography has been used by a number of workers for estimating seabird populations in the Antarctic and elsewhere (e.g. Butler & Müller-Schwarze 1977, Harris & Lloyd 1977, Shelton *et al.* 1982), but errors result from overlaps or omissions in photographs and may be compounded by disturbance by aircraft within the colony. Furthermore, aircraft (either fixed-wing aeroplanes or helicopters) are often not present at sub-Antarctic islands at the dates required (normally during the incubation periods). Ground photography is a useful technique where vantage points exist for taking oblique photographs since it is non-disruptive to the breeding birds and is useful in providing permanent records. Observer variability in ground and aerial counts is unavoidable (Harris & Lloyd 1977, Shelton *et al.* 1982) but if monitoring over a long-term period is envisaged then standard techniques employed at the correct stages of breeding must be used for each species as recommended by the BIOMASS Working Party on Bird Ecology (Anon. 1982 a,b).

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