Southern Royal Albatross *Diomedea epomophora epomophora* census on Campbell Island, 4 January-6 February 1996, and a review of population figures

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Abstract

A census of breeding Southern Royal Albatross was undertaken at Campbell island during the period 4 January to 6 February 1996 of the 1995-96 breeding season. A total of 7787 occupied nests was counted. Comparisons of different field census techniques and a measure of the rate of egg loss suggest that 8200-8600 pairs were nesting in the 1995-96 breeding season. The count was 23% higher than in January-February 1995, much of which could be explained by some larger survey blocks being counted more thoroughly. Interpretation of population trend data from previous censuses is difficult because of the likely variability in counting effort between years. Nevertheless, numbers of nests have increased since the first census in January-February 1958, and increased or fluctuated since the 1970s. Accurate counts at study areas (1988-1996) show that numbers are currently increasing.

l. Introduction

The Southern Royal Albatross, *Diomedea epomophora epomophora,* breeds almost exclusively on Campbell Island 52° 33' S 169° 09' E (Marchant & Higgins 1990). Numbers of Southern Royal Albatross have traditionally been surveyed during the incubation period, but at irregular intervals since the survey done in January-February 1958 (Westerskov 1963) (Appendix 1). Surveys between 1969 and 1983 recorded between 4208 and 5336 pairs breeding annually (Taylor *et al.* 1970, Dilks & Wilson 1979, Dilks & Grindell 1983; Appendix 1). Counts were made in several consecutive years during this period, and for the purposes of the counts the island was divided arbitrarily into 10 survey blocks (Fig. 1; Dilks and Wilson 1979). There was a 12 year gap between the Jan-Feb 1983 census (when 4243 breeding pairs were counted; Dilks & Grindell 1983), and the Jan-Feb 1995 census (when 6308 pairs were counted; Moore *et al.* 1997).

It is possible that a number of factors may be influencing the population dynamics of albatrosses in the Southern Ocean region and on Campbell island itself. In the years since the 1983 count, concern had arisen over the impact of fisheries bycatch mortality on various albatross populations around the world (Weimerskirch & Jouventin 1987, Croxall *et al.* 1990; Brothers 1991). Although Southern Royal Albatrosses have not been reported as bycatch in the New Zealand region (Bartle 1991; Murray et al. 1993), they have been caught as bycatch in other parts of the world (NZ Banding Scheme). In addition, environmental change has been indicated as a possible cause of the declines of marine-dependent species populations in the subantarctic. For example, sea-surface temperature change was thought to be influential in the dramatic decline of Rockhopper Penguins, *Eudyptes chrysocome,* at Campbell Island, where the population declined by 94% between the 1940s and mid 1980s (Cunningham & Moors 1994). There have been significant and continuing

changes to the vegetation of Campbell Island since feral sheep (*Ovis aries*) were systematically removed from parts of the island between 1970 and 1990 (Meurk 1982, Meurk *et al.* 1994) The Royal Albatross censuses on Campbell Island in the 1970s and 1980s were prompted mainly by the possible effects of sheep-grazing on albatross nesting habitat (Taylor *et al.* 1970, Dilks & Wilson 1979).

The census programme initiated in 1995 (Moore et al. 1997) was motivated by the need to re-establish the population trend base-line to assess what changes may have occurred since 1983. It was planned that the 1996 census be the second in a series of annual counts, necessary to estimate the current breeding population size.

Southern Royal Albatross nests are spread sparsely across the Poa litorosa dominated tussock grassland meadows. This zone is between the upper edge of the *Dracophyllum* scrub zone (150-200 m a.s.l.) and the high alpine tundra mosaics (350-400 m)(Mcurk & Given 1990). Eggs are laid from late November to early December and chicks hatch in mid to late February (Sorensen 1950). The species is a biennial breeder, which means that birds that are successful breeders usually breed at two year intervals, whereas birds that fail at the egg or early chick stage usually return the following year. Thus, a series of annual counts combined with information on breeding success and breeding frequency are required to interpret population trends.

Study areas at Col and Moubray, which are smaller parts of the larger survey blocks (Fig. 1), were monitored for nest numbers and breeding success in 1987-88 (Moore & Moffat 1990), and annually since 1991-92. Since the 1940s, a large number of albatrosses have been banded on Campbell Island, by staff of the Meteorological Station (closed in 1995) or researchers visiting the island. Banding effort was sporadic, but concentrated at Col study area and, to a lesser extent, Moubray study area. In some years, most breeding partners at Col were banded (Paull & Surrey 1969, P. Dilks, unpubl. data), and in others, nearly every chick on the island was banded (M. Crompton pets. comm.). In 1994-95, more intensive effort was applied to the Col study area to identify all breeding partners for future information on adult survival and recruitment.

A team of four people carried out a census of nesting Southern Royal Albatross and conducted study area work on Campbell Island from 4 January to 6 February 1996. This report summarises results of the survey.

2. Aims

1. Monitor the trend in population of Southern Royal Albatross on Campbell Island.
2. Compare different counting methods
3. Collect information towards understanding population parameters such as adult survival and recruitment.

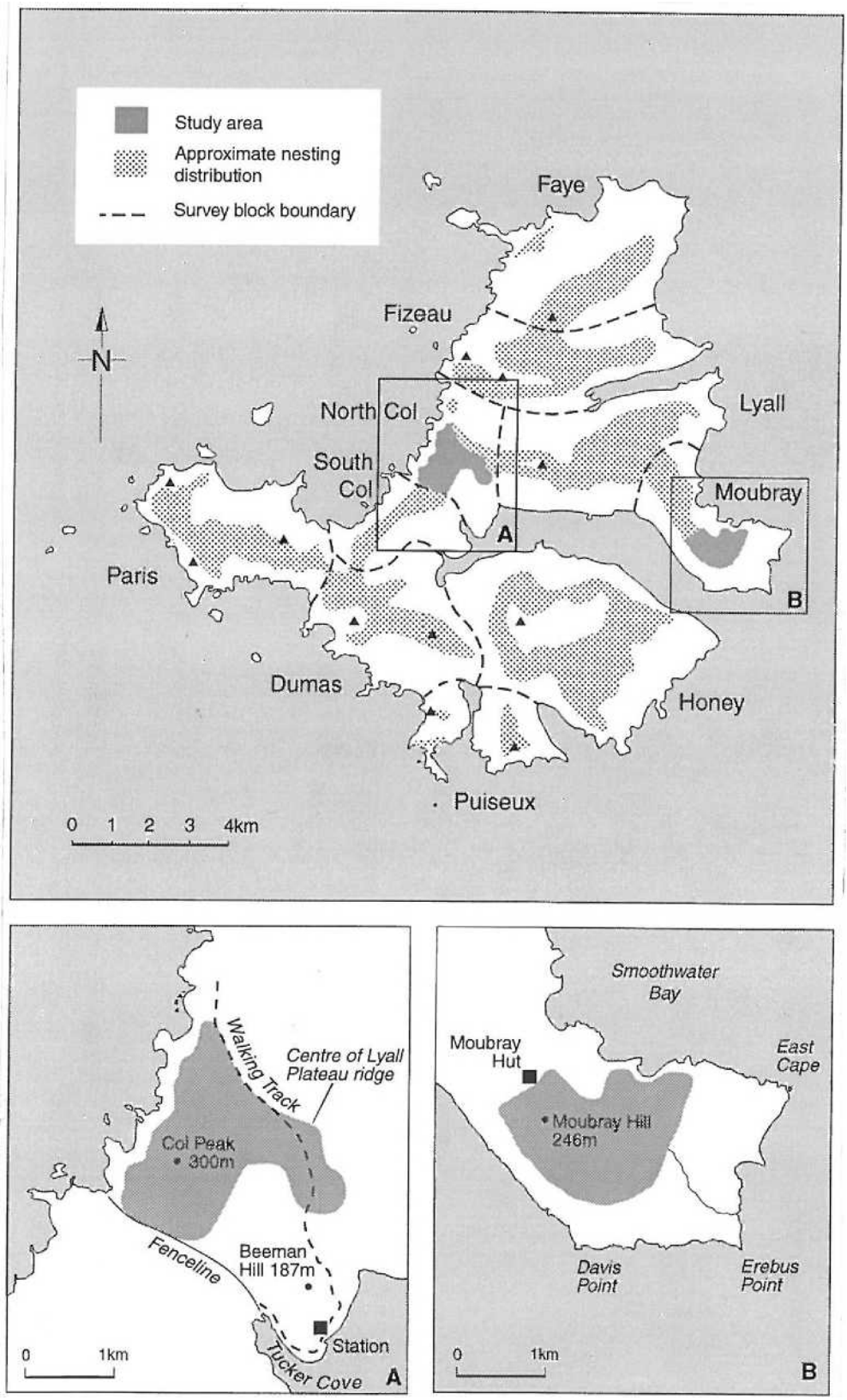

FIGURE 1. SOUTHERN ROYAL ALBATROSS SURVEY AREAS AND APPROXIMATE NESTING DISTRIBUTION ON CAMPBELL ISLAND, 1995. A = MOUBRAY STUDY AREA, B = COL STUDY AREA.

3. Methods

The general method used in the past for counting albatrosses on Campbell island has been described as "ground was searched systematically on foot and by scanning with binoculars. Precise techniques varied with the terrain and the range at which observations were made. Usually the two observers stayed together, sometimes checking each other's counts ... however, when traversing broken country it was usual for each to search a separate area" (Taylor *et al.* 19-0). "Whenever possible, counting was carried out by scanning areas from a vantage point .... Undoubtedly some resting birds were counted as nesting, and some nests would have been obscured in the vegetation, but separate counts by each observer for the same area varied little" (Dilks & Wilson 1979).

Three methods of counting Royal Albatross nests were employed in 1996. These have been termed: "intensive nest count", where an effort was made to find every nest within study areas; "ground search", where as many nests as possible were counted within the time constraints of the census; and "binocular or telescope vantage point" surveys, where nests were counted from viewpoints.

3.1 INTENSIVE NEST COUNT

On the initial visit, the country was covered by intensively zigzagging, and every nest that was found was marked. Nests were revisited or their mark identified from different directions to make sure none was missed, and searching peripheral zones (e.g., the upper edge of the scrub zone). On subsequent visits, the gaps between nests were checked for other nests that may have been missed. In this way, almost all the nests in an area would have been found, apart from nests that may have failed between egg laying and the first visit.

3.1.1 Col study area

The Col study area (Fig. 1) was searched for nests by all four workers on 2.5 days from 6-8 January. Nests were marked with numbered orange PVC pipe. Four more weekly visits were made to the study area up until 5 February 1996. Unbanded birds were banded at the nest and bands were read on most visits.

The relative positions of nests were measured using compass bearings and a measuring tape. This was to assist with re-finding of nests and to provide a nest distribution map. Many birds were photographed, to assist with assessing sex (from plumage and relative size).

3.1.2 Moubray study area

Searches for nests in the Moubray study area (Fig. 1) were made by all four workers on 10-12 January 1996. Nests in the central area (marked by poles) were marked with numbered orange pipe, and the incubating birds in the outer area -were spotted with spray paint as a temporary mark. The band numbers of breeding birds were recorded, but no new bands were applied. The positions of

nests in the central area were measured on 11 January, and a final visit to the area was made on 6-7 February 1996 to check for nest failures.

3.2 GROUND SEARCH

Ground searching was the main survey method for the census of the island. The island was divided into the 10 blocks that have been used in previous surveys (Fig. 1), and the census was conducted during the period 4 January to 6 February 1996.

The ground search survey method involved searching areas systematically on foot, in order to find the majority of nests. The idea was to choose an optimal coverage of the area that would minimise nests being missed or counted twice. Usually an initial viewpoint was used to assess the extent of the nesting area. The survey of that area combined searching for nests by zigzagging the countryside, while using prominent ridge-lines, edges of gullies, edges of terraces, and hillocks from which to view small areas from above. Peripheral areas, such as the scrub margin, were searched if birds were visible from above or occasional forays into the zone revealed nests were present. The way a particular area was surveyed depended on the terrain type and the number of personnel available on the day. Areas of even terrain or uniform terraces were searched by making parallel zigzags along the contours, while noting geographical features to avoid counting birds twice from different altitudes. This was done by one person doing several sweeps or two to three people walking in parallel, within earshot or radio contact. The distance between sweeps was up to 100 m for very easy country- (i.e., nests were not obscured), 20-50m for denser tall tussocks or uneven ground, and to less than 20 m for scattered scrub. For some terrain types, such as narrow ridge/gully systems it was more efficient to walk up and down the slope.

During ground searches, birds were counted if they were sitting on a nest with a posture suggesting they were brooding an egg (sitting tight with a profile that was smooth with the nest bowl). Birds that were sitting on nests -without eggs, or sitting on the ground were excluded from the count. These birds could be distinguished by the posture they adopted (birds without eggs usually sat with their folded wings and posterior slightly raised) or by approaching them to make them stand up. It was expected that ground searches would be less accurate than intensive nest counts as some obscured nests would be missed, some nests would be counted twice from different angles and some non-breeders might have been mistaken for nesting birds.

3.3 BINOCULAR OR TELESCOPE VANTAGE POINTS

During the Jan-Feb 1995 census, some larger areas were searched using binoculars from an adjacent hillside. This method was used when the vantage point gave unobstructed views of steep slopes that were less than two km away, and that were known to have been counted in the same manner previously (P. Dilks, pers. comm.). Generally, the method was not favoured because of the chance of missing obscured birds, or counting non-breeding

birds, and the difficulties of defining boundaries with areas that were later to be counted on foot. Consequently, in Jan-Feb 1996 this method was used only at the western pocket of nests in Faye (as viewed from Faye ridge). The lower slopes of the southern side of Fizeau ridge were counted by telescope by one person, while in radio contact with the other workers, who were conducting a ground search of the upper slopes.

3.4 COMPARISON OF SURVEY METHODS

A limited comparison was made of the effectiveness of "ground searches" compared with "intensive nest counts". Unfortunately, although it had been the intention to do several comparisons in different parts of the island, there was not enough time to do so.

It was assumed that the "intensive nest counts" were as close as possible to representing the total number of nests in an area. Therefore, the intensive nest counts at the Col and Moubray study areas formed the basis for our comparison with the more coarse survey methods. These areas offered a comparison of two different habitat types - Col study area consisted of smooth, tussock-clad slopes across a steep ridge, and the Moubray area was dissected by small gullies, with a margin of scrubby vegetation.

At Col study area, a "ground search" was carried out by two teams of two on 5 January 1996, prior to the "intensive nest count" in the area on the following three days. One observer had prior knowledge of the area, from previous years, and the others were given broad indications of nesting distribution. On 9 January 1996 at Moubray study area, a "ground search" was undertaken by two teams of two (in different combination to the Col counts), each surveying a different half of the area, prior to the "intensive nest count" on the following three days. At times the pair would operate in tandem and at other times counted small sectors independently.

4. Results

4.1 I NTENSIVE NEST COUNTS

During the initial search period (6-8 January 1996) of the "intensive nest count" at Col study area, 200 nests were found. One further nest was found during the second visit, bringing the total to 201 nests (189 in 1995). The Lyall Plateau boundary was marked with poles to avoid the confusion that occurred previously. At Moubray- (10-12 January), 508 nests were found (489 in 1995). There was a decrease between years from 204-183 in the central core area of Moubray and an increase from 285 to 325 nests counted in the peripheral zone

4.2 CENSUS

A total of 7757 Southern Royal Albatross nests was counted on Campbell Island between 4 January and 6 February 1996. There was an increased number of nests recorded in all blocks compared with the 1995 count (Table 1).

TABLE l. THE NUMBER OF NESTS COUNTED AND AMOUNT OF EFFORT USED DURING CENSUS AND STUDY AREA WORK, CAMPBELL ISLAND, 1995 AND 1996.

AREA	JAN–FEB 1995 NO. NESTS COUNTED	NO. DAYS FOR COUNT	NO. PERSON HOURS	NO. PEOPLE WHO COUNTED	JAN–FEB 1996 NO. NESTS COUNTED	NO. DAYS FOR COUNT	NO. PERSON HOURS	NO. PEOPLE WHO COUNTED	% CHANGE IN NEST NOS. 1995 TO 1996
Faye	1072	2	38	3	1266	1	36	4	+18
Fizeau	842	3	8	3	1334	2	52	4	+58
Lyall	780	5	20	2	1126	2	48.5	4	+44
Moubray	905	2	20	2	989	2	29	4	+9
N. Col	213	1	12	2	245	1	31	4	+15
S. Col	222	1	10	2	220	1	18.5	4	-1
Paris	676	2	24	2	716	2	29.5	3	+6
Dumas	495	2	18	3	522	2	36	4	+5
Honey	993	1	34	4	1279	2	62	4	+29
Puiseux	110	1	6	2	90	1	10	3	-18
total	6308	11 [a]	190		7787	15	352.5		+23
Col study area						9	225.5		
Moubray study area						5	99		
total days						26 [b]			
extra travel time						6 [c]	272 [d]		

[a] Some areas were counted by different personnel on the same day, hence total
[b] Census + study area days=26, including 3 days when both activities carried out.
[c] Days when travel was the only field activity.
[d] Number of person hours (additional to counting time) spent walking to and from counting areas.

The weather during the 1996 survey was ideal (fine and calm) for far more of the time than is usual for the island, yet the five weeks were barely adequate for the census and study area work combined. Low cloud or bad weather disrupted or prevented work on part of a few days and three whole days. Fieldwork was conducted on 32 out of the 35 days available (Table 1). The amount of effort has been itemised in Table 1 to assist with planning future censuses and to provide a guide for comparison between years. Because usually three to four

people worked in the same block in 1996, as opposed to two in 1995, effort in terms of person hours was correspondingly higher, yet the number of days extra was only four. An attempt was made in 1996 to make the level of effort consistent over the whole island. Areas were rushed in 1995 because of lack of time (e.g., Honey), were done in a piecemeal fashion by different people on several days in 1995 (e.g., Fizeau, Lyall), or had "binocular vantage point" (Fizeau) counts. Hence these areas had the greatest discrepancy in numbers and effort between years (Table 1).

4.3 COMPARISON OF SURVEY METHODS

As mentioned in the methods, the "intensive nest counts" were the basis for our comparison with the more coarse survey methods of "ground search" and "vantage point". It is possible that nests were overlooked, although at Col study area only one further nest was found on the second of five visits to the area, and at Moubray study area none were found on two further visits to the central core area.

A "ground search" by two teams of two people at Col study area on 5 January 1996 located 98.5% and 99.0% of the number of nests that were found in the "intensive nest count" over the following three days.

At two halves of Moubray study area, two different teams counted 94.7 and 95.8% of the number of nests that were found in the "intensive nest count".

Thus, the mean accuracy of "ground searches" in the study areas was 97.0%. The range in figures were used as correction factors to adjust the census figures in other census blocks (Table 2).

4.4 BREEDING FAILURES AND ACCURACY ESTIMATES

Although no known failures occurred in the 1994-95 breeding season because of human disturbance at the nest, there were at least two cases in the 1995-96 season. One very nervous bird ran off after banding, and although it was herded back on the nest it deserted when it saw a person in the area two days later. There were problems at four other nests (two flew away but returned, one ran away but was herded back, and one dented its egg with the band). One that had flown had failed within two weeks of this disturbance for unknown reasons, but the other three were still successful by 5 February. To keep the levels of disturbance as low as possible, birds were banded at the nest and eggs were removed while banding very nervous birds. Apart from the two failures that were definitely human-induced, two nests failed in the first week after 6-8 January, none in the second, four in the third and two in the fourth, or 4% overall (5.7% failed during a similar period of 1995). Five out of 183 (2.7 %) marked nests failed between 12 January and 6 February at Moubray study area. Depending on what date a particular block of the island was censused, the success rate at Col study area was used to adjust the figures (Table 2).

From the above, the census figure of 7787 nests was corrected to about 8100-8400 nests present at the start of the census in early January 1996 (Table 2). A further adjustment could be made to allow for 1.8% of eggs lost between laying (November-December) and early January (1966-67, 1967-68 data, Paull & Surrey 1969; 1985-86 data, Poole, unpubl.).

TABLE 2. ESTIMATE OF NUMBER OF SOUTHERN ROYAL ALBATROSS NESTS PRESENT ON CAMPBELL ISLAND IN JANUARY-FEBRUARY 1996.

SURVEY BLOCK	DATE OF CENSUS	A: NO. NESTS COUNTED	B: ESTIMATED PROPORTION OF NESTS FOUND [1]	C: SUCCESS OF NESTS AT COL [2]	D: CORRECTED NO. OF NESTS D=(A/B)/C
Faye	25 Jan	1266	0.947-0.99	0.97	1318-1379
Fizeau	23,26 Jan	1334	0.947-0.99	0.97	1389-1452
Lyall	19-20 Jan	1126	0.947-0.99	0.99	1149-1201
Moubray study area	9 Jan	483	0.951	1	508
Moubray remainder	12 Jan	506	0.947-0.99	0.99	516-540
Col study area	5 Jan	199	0.99	1	201
N. Col remainder	5 Jan	46	0.947-0.99	1	46-49
S. Col	4 Jan	220	0.947-0.99	1	222-232
Paris	4,6 Jan	716	0.947-0.99	0.96	753-788
Dumas	23-24 Jan	522	0.947-0.99	0.99	533-557
Honey	30 Jan, 1 Feb	1279	0.947-0.99	0.96	1345-1408
Puiseux	31 Jan	90	0.947-0.99	0.96	95-99
total		7787			8075-8414

[1] Proportions of nests found at Col and Moubray study areas during comparisons of the "ground search" and "intensive nest count".
[2] Proportion of nests successful at Col study area at the date of survey of the particular block.

4.5 BANDING

Both partners were identified at 198 nests at Col study area, with the remaining three having failed and been abandoned before both birds were seen. Because of the previous banding history at Col and Moubray study area, the proportion of birds already banded was high compared to other parts of the island. Nevertheless, banded birds were found at all localities where the legs of breeding birds were checked (Table 3).

TABLE 3. PROPORTION OF BIRDS PREVIOUSLY BANDED AT DIFFERENT LOCALITIES OF CAMPBELL ISLAND, ,JANUARY-FEBRUARY 1996.

AREA	NO. BANDED IN EARLIER YEARS	NO. NESTING BIRDS CHECKED FOR BANDS	% BANDED
Col	230	400	57.5
Moubray	198	483	41.0
S. Col	11	34	32.3
N. Col	4	8	50
Faye	6	50	12
Fizeau	7	49	14.3
Honey	1	36	2.8
Puiseux	3	17	17.6

As noted previously (Moore & Moffat 1990, Moore *et al.* 1997), there is a problem with bands which have been applied badly (including O-bands which are too small), or have sprung open. These become embedded in birds' legs, causing a large gall of inflammatory tissue, often crippling the bird. We tightened any bands that were slightly opened or moved them to the other leg if they were crippling the birds. At Col study area, three out of 230 previously banded birds had bands embedded in their legs. A new observation was that two of the apparently unbanded birds and a banded bird had galls on their legs, and at least two of these appeared to have a band inside (i.e., they had embedded in the leg and tissue had grown over the band). Thus, six out of 233 (2.6%) birds had problems resulting from poor banding. At Moubray study area, the proportion was four out of 268 (1.7%) birds.

5. Discussion

The census of the 1995-96 breeding season carried out in Jan-Feb 1996 recorded 23% more Southern Royal Albatross nests on Campbell Island than were found the previous season. There are three possible explanations for this increase.

Firstly, because the species is a biennial breeder, this difference could be explained by a poor breeding season the previous year or in the recent past. For example, Wandering Albatross (*D. exulans)* can take 10 years to return to equilibrium after a perturbation (Tickell 1968). Annual fluctuations in numbers of the biennial breeding Grey-headed Mollymawk (*D. chysostoma*) can be as high as 45% (Prince 1985). However, although not even- year has been monitored on Campbell island, and early egg losses and late chick losses were not studied, breeding success data suggests that most recent years have been

successful at Col and Moubray study areas. With over 75% of nests producing chicks which were likely to fledge (Appendix 2), the success was higher than the average success estimated for the period 1942-1972. (Appendix 2). As a comparison, average breeding success of Wandering Albatross at South Georgia was 64%, but increased by 13% from 1976-1987, with possible explanations of improved feeding conditions or changes in population age structure (Croxall *et al.* 1990).

A second explanation would be a natural increase in numbers. In part this may be true, since "intensive nest counts" at Moubray and Col study areas were 4-6% higher in 1995-96 than in 1994-95 (Appendix 3).

The third explanation is that greater effort produced higher counts. This probably contributed the most to the 23% increase in counts between the two years. There is not a simple relationship between effort and the number of nests counted, since individual people walk at different rates, and two people walking in parallel will not survey an area in exactly the same way as one person. Nevertheless, at most of the larger survey blocks, particularly Fizeau, Lyall and Honey, an increased amount of effort resulted in 29-58% higher counts. Overall, the effort in Jan-Feb 1996 was more consistent between survey blocks than in Jan-Feb 1995. Therefore, the total count of 7800 is more likely to be a reliable figure than the 6300 counted in 1995.

The potential variability in counting effort means that the results of censuses of Southern Royal Albatross on Campbell Island conducted since 1958 are not likely to be comparable. The methods fall along a continuum in effort from "intensive nest count" to "ground search" to "vantage point" counts. It is assumed that the intensive nest counts are the most repeatable between surveys, and can be used to give correction factors to censuses using the other coarse methods. Unfortunately, it is difficult to determine the relative use of "ground searches" versus "vantage points" or the reliability of the previous surveys.

It had originally been intended that the method be similar to previous census methods (Taylor *et al.* 1970, P. Dilks, pers. comm.), however not enough information was available on the amount of effort used, the walking routes or the relative use of searching by foot versus viewpoints to exactly reproduce the previous methods. Because we wanted to count a consistently high proportion of the nests, the "ground search" method used in 1995 and 1996 is not strictly comparable to previous methods used. It is likely that "vantage points" were used much more in the past, as observers tended to walk along ridges and count birds from promontories by scanning with binoculars, only thoroughly searching an area if the terrain looked particularly complex (P. Dilks, pers. comm.). The difference in effort between the two methods is consequently substantial. For instance, one person was able to count a large block like Honey in one day during 1983, whereas four people took two days to survey the same area in 1996. The increasing stature of vegetation in the post-sheep era undoubtedly has a bearing on the level of effort required to find albatross nests. However, the terrain type is just as important. For example, gullies and small hollows can hide nests, and this type of terrain makes the Paris block one of the most difficult areas to survey, despite it being the last area to have sheep eliminated.

Comparisons of the "ground search" and "intensive nest count" in 1996 showed that the former were consistently close to the expected maximum number of nests present. "Ground-searches" at Col study area found 99% of the number of nests that were found by more intensive searching. Although this seems very high, apart from small areas of tall tussocks, most of the area is of relatively easy terrain and smooth slopes, providing good visibility of nests. The "ground search" at Moubray study area was slightly less accurate at about 95%, as the area has complex terrain with high, scrubby vegetation in places. This result differed from 1995 when the comparison was 87% at Col and 97% at Moubray (two teams, but one person common to both). One person who was part of three different teams in 1995 and 1996 had figures of 97, 99 and 95%, which suggests that 87% was an anomalous figure and/or individual variation in counting was greater in 1995. Although it may follow that over the larger survey blocks, higher count errors were made at times (because of different terrain, overlap errors between count sweeps, fatigue etc.) our impression was that we were relatively consistent overall in 1996.

The only figure found which is comparable to our tests of "intensive nest counts" and "ground searches" was in 1977-78, when P. Dilks censused the Col study area and counted 81% of the number of nests he later marked as study nests (P. Dilks, unpubl, data). This falls between the "vantage point" end of the spectrum (72-77% nests counted; Moore et al. 1997) and the 1996 "ground searches" (95-99% of nests counted). The only published indications of counting error are anecdotal: e.g. "nests have unquestionably been overlooked in such difficult terrain where the nesting albatrosses prefer the corries and other small depressions for their nest sites" Westerskov (1963); "careful ground searches of a few places previously scanned from distant vantage points suggested that numbers could have been underestimated by as much as 10% in some of the more crowded areas" (Taylor et al. 1970); "separate counts by each observer for the same area varied little" (Dilks & Wilson 1979).

Between 1969 and 1983 there was good continuity and overlap between the chief observers (P.R Wilson in 1969, 1971, 1979-80; P.J. Dilks in 1971, 1975-76, 1977, 19',7-78 and 1983 ((Taylor *et al.* 1970, Wilson & Elliott 1981, Dilks & Wilson 1979, Dilks & Dunn 1978, Dilks & Grindell 1983). They attempted to make their counts consistent by following similar routes through the survey blocks each year (P. Dilks pers. comm.). Table 4 shows that although the number of days taken each year to complete the census varied little, there were substantial differences in person hours depending on the number of observers present. Prior to 1995 this variability may be misleading as observers usually walked in pairs, rather than walking in parallel or dividing up to count different areas (P. Dilks pens. comm.). If that was generally the case, then the actual counting time was closer to 60-90 hours from 1969-1983, increasing to 190-353 hours in 1995 and 1996.

Another potential problem in evaluating albatross census data is that they have been conducted in the mid-late incubation period, allowing no estimate of nest failure prior to the survey period (i.e., total nest numbers would be underestimated). It appears though, from years when nests were found close to laying time, that few eggs were lost in December (mean= 1.7%, range 0-4%, n=3

TABLE 4. SURVEY EFFORT FOR CENSUS OF SOUTHERN ROYAL ALBATROSS ON CAMPBELL ISLAND.

YEAR	NO. OBSERVERS	NO. WHOLE DAYS SPENT COUNTING	ESTIMATED PERSON HOURS	DATA SOURCE
1969	2	14	180	Taylor *et al.* 1970
1975-76	2	12	c.160	Dilks & Wilson 1979, Dilks unpubl. diaries
1977	1	12	c.85	Dilks, unpubl. diaries
1977-78	2	10	c.120	Dilks, unpubl. diaries
1979-80	2	14		Wilson & Elliott 1981
1983	1	11	c.75	Dilks & Grindell 1983
1995	4	11	190	Moore *et al.* 1997
1996	4	15	353	this study

years), compared with January-early February (mean=3.9%, range 1-6, n=3 years; Paull & Surrey 1969, Poole unpubl.).

The January 1996 estimate of 8200-8600 nests is the most reliable estimate to date for the annual breeding population, because the effort was high and consistent, and correction factors have been used for the proportion of nests missed or failed prior to the survey. From the above discussion it follows that it is difficult to comment with confidence on population trends shown from census data from 1976-1996. Up to 20% variation in "ground search" counts is possible between different observers, and up to 30-58% between different counting techniques. Prior to 1995, the highest count of nests was 5336 nests in 1975-76 (Fig. 2, Appendix 1). For this to be equivalent to the 1996 estimate, only 62-65% of nests would have been counted in 1975-76. If we assume that 81% of nests were counted in 1975-76, as they were at the Col study area in 1977-78 by one of the same observers (P. Dilks, unpubl. data), and correct for average egg loss during December-February, there may have been 6700 nests present. Numbers apparently fluctuated below this level in the late 1970s-early 1980s, but increased by nearly 2000 nests from the 1970s to 1990s. Study area data supports evidence for a recent increase, as numbers there have increased since "intensive nest counts" began in 1988, particularly at Moubray (Fig. 3, Appendix 3). The "ground search" or "vantage point" counts made at the study areas in earlier years are less easy to interpret because of the likely variable observer effort, but suggest that since the 1970s, numbers have fluctuated at similar levels to the 1980s and 1990s. Probably, these data reflect long-term fluctuations in population level.

Looking further back in time, it is assumed that the overall difference between 2300 nests counted in 1958 (Westerskov 1963) and 4208-5336 nests counted in the 1970s also represents a real increase, especially as estimates for the 1960s fall in-between these figures. A cautionary note, though, comes from the 1940s comment that "there cannot be less than 5000 mated pairs nesting on Campbell Island each year" (Sorensen 1950). This is probably doubtful, as it was based on a density estimate at Faye, and a similar extrapolation he made for Rockhopper

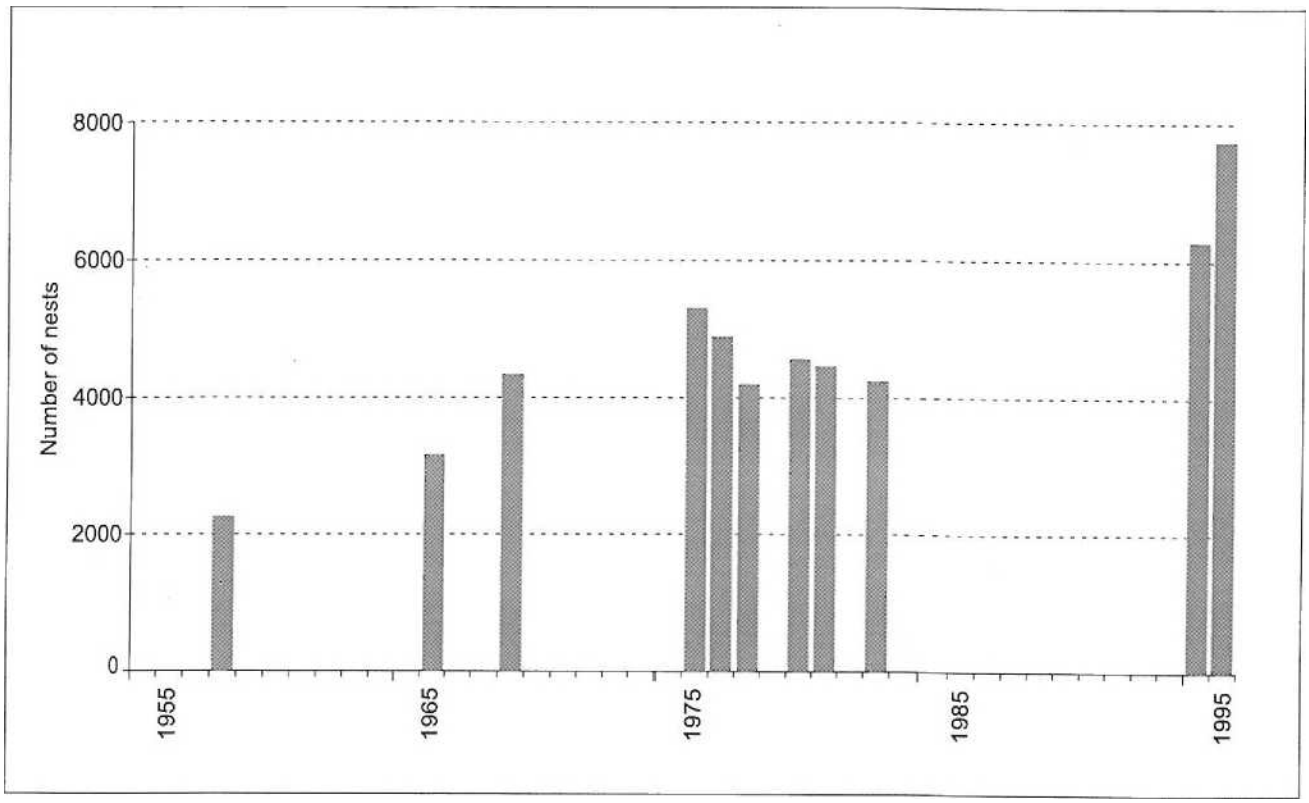

FIGURE 2. COUNTS OF SOUTHERN ROYAL ALBATROSS NESTS ON CAMPBELL ISLAND (APPENDIX 1). N.B. THE YEAR REFERS TO THE BREEDING SEASON, E.G., 1995 = 1995-96 SEASON, ALTHOUGH THE CENSUS OCCURRED IN JAN-FEB 1996.

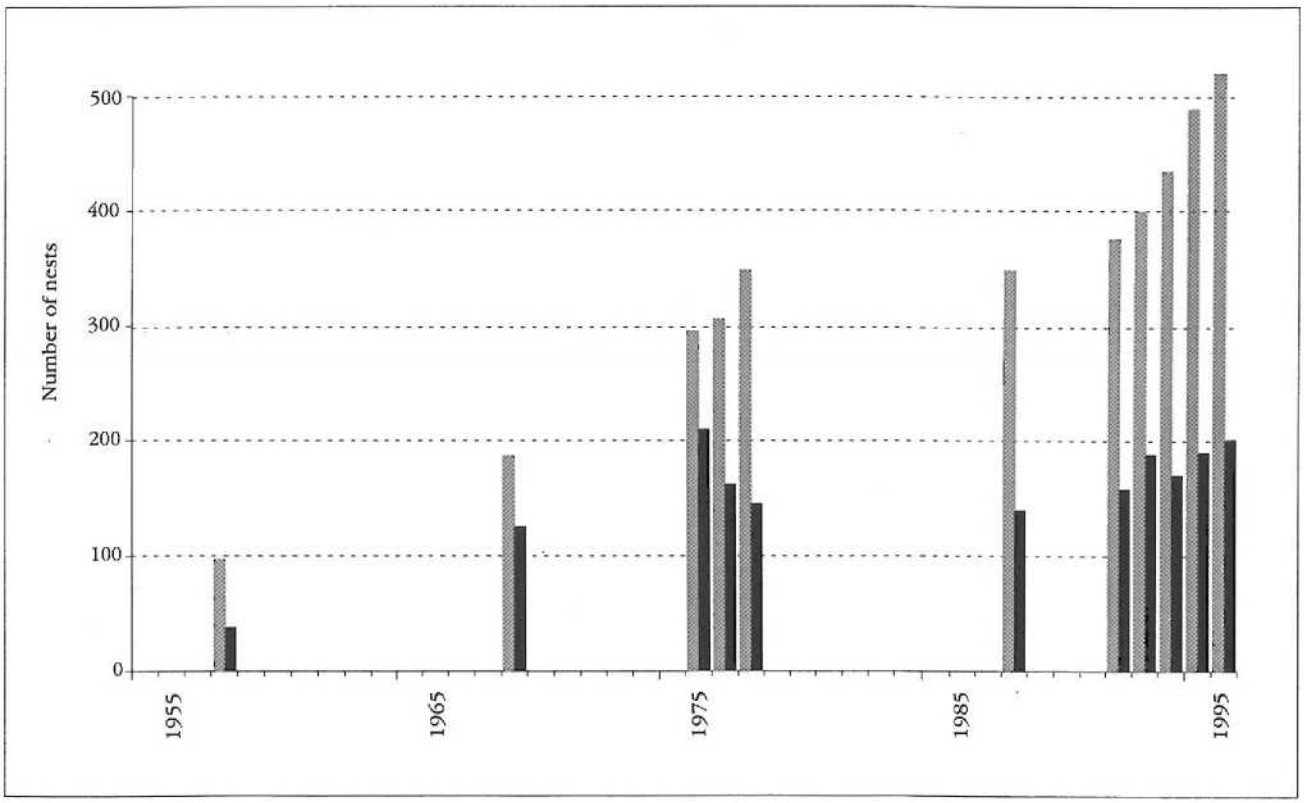

FIGURE 3. COUNTS OF SOUTHERN ROYAL ALBATROSS NESTS AT COL (LIGHT) AND MOUBRAY (DARK) STUDY AREAS (APPENDIX 3).

Penguins greatly overestimated the population on Campbell Island (Cunningham & Moors 1994).

Dilks & Wilson (1979) extrapolated directly back from two data points in 1975-76 and 1958 to estimate 650 pairs present in the 1920s. Although this is a dubious calculation, albatrosses were apparently diminishing in numbers in the 1920s, as they could not be found in areas where they were known to be previously (Guthrie-Smith 1936). This was thought to be because of degradation of the dense tussock nesting habitat from overgrazing by sheep and burning by the farmers between 1895-1931, predation of adults by sheep dogs, and predation of eggs and adults by sealers, whalers and farmers (Guthrie-Smith 1936, Atkinson & Bell 1973, Kerr 1976, Kerr & Judd 1978). Sheep numbers diminished from the peak of 8500 in 1910 (Meurk 1977) to fewer than 1000 by 1961 (Wilson & Orwin 1964). However, once the sheep developed feral traits (Rudge 1986), their numbers began to increase, and there was great concern for the vegetation, landforms and the potential effect on Royal Albatross nesting habitat (Taylor et al. 1970, Dilks & Wilson 1979). There was even concern that sheep trampled nests and birds were pulled off their nests when they grabbed sheep that approached too closely (Paull & Surrey 1969). Consequently, sheep were gradually removed from the island by constructing fences and culling sectors of the island; the north in 1970, the south in 1984 and, finally, the west in 1990-92. The effect of sheep was never resolved. At times, numbers of both sheep and albatrosses apparently increased, and it was suggested that changes in the food supply may be more important in influencing albatross numbers (Dilks & Wilson 1979).

The census of Southern Royal Albatross on Campbell Island in Jan-Feb 1996 was a useful exercise in terms of determining a reliable overall population estimate for the island. The census method used is sensitive to the amount of effort put in by observers, and this has been variable for the several censuses conducted since 1958. Consequently, accurate population trends cannot be determined outside the study areas. When areas are counted thoroughly enough to find 95-99% of nests, the census of the whole island is very time-consuming, and a physically and mentally demanding exercise. To establish accurate population trends in the future, it would be better to select smaller areas representative of different parts of the island and habitat types, in addition to the two study areas, and conduct "intensive nest counts" each year.

6. Acknowledgements

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APPENDIX 1. NUMBERS AND DISTRIBUTION OF SOUTHERN ROYAL ALBATROSS ON CAMPBELL ISLAND 1958-1996.

	AREA (ha)	1958[1]	1964-68[2]	1969[3]	1971[4]	1975-76[4]	1977[4]	1977-78[5]	1979-80[6]	1980-81[7]	1983[8]	1995[9]	1996[10]
Faye	1376	465	419	657		897	772	910	794	801	692	1072	1266
Fizeau	1204	544	697	748		944	841	654	735	683	643	842	1334
Lyall	1326	321	530	504		652	697	532	604	535	682	780	1126
Moubray	787	233	400	569		694	561	593	485	567	509	905	989
North Col	604	59	137	148		230	185	156	172	167	139	213	245
South Col	466	39		59	123	139	129	94	94	90	127	222	220
Paris	1011	99	281	389	429	490	535	241	431	423	373	676	716
Dumas	1194	135	233	305	299	393	344	266	302	323	301	495	522
Honey	2300	365	473	897	804	814	775	696	914	846	717	993	1279
Puiseux	570	18	46	68	54	83	67	66	44	58	60	110	90
Nth of fence		1622	2183	2626		3417	3056	2845	2790	2753	2665	3812	4960 2827
Sth of fence		656	1033	1718	1709	1919	1850	1363	1785	1740	1578	2496	
Totals		2278	3216	4344		5336	4906	4208	4575	4493	4243	6308	7787

Data Sources: [1] Jan-Feb 1958, Westerskov 1963; [2] Guard 1968 (boundaries between areas differ from other studies); [3] 8-26 Jan 1969, Taylor *et al*. 1970; [4] 31 Jan-10 Mar 1971, 12 Dec 1975-14 Feb 1976, 1 Jan-13 Feb 1977, Dilks and Wilson 1979; [5] 23 Dec 1977-31 Jan 1978, Dilks and Dunn 1978; [6] 23 Dec 19-9-15 Jan 1980, Wilson and Elliott 1981; [7] 29 Dec 1980-7 Feb 1981, Foggo and Meurk in Wilson and Elliott 1981; [8] 14 Jan-11 Feb 1983, Dilks and Grindell 1983; [9] 12 Jan-10 Feb 1995, Moore el al. 1991; [10] 4 Jan-6 Feb 1996, this study.

APPENDIX 2. BREEDING SUCCESS OF SOUTHERN ROYAL ALBATROSS ON CAMPBELL ISLAND.

BREEDING SEASON	NO. NESTS	% SUCCESS - RAW DATA[1]	% SUCCESS ADJUSTED[2]	SOURCE	MONTH MONITORING STARTED	MONTH MONITORING CEASED
Col						
1942-43	7	43	43	Sorensen 1950	?	Nov
1943-44	8	88	88	Sorensen 1950	<Jan	?
1944-45	7	57	57	Sorensen 1950	late Nov	
1957-58	101	74	80	Westerskov 1963	Jan-Feb	Oct
1964-65	88	72	72	C. Clark, unpubl.[3]	Jan-Feb	Sep
1965-66	98	77	77	C.G. Surrey, unpubl.[3]	late Dec	Oct
1966-67	96	47	49	D. Paull, unpubl.[3]	Nov-Dec	Oct
1967-68	86	60	61	Paull & Surrey, unpubl.[3]	Nov-Dec	May-Aug
1969-70	109	56	56	M. Crompton, unpubl.	Jan	late Jul
1970-71	138	61		M. Crompton, unpubl.	Nov	?
1971-72	160	59		M. Crompton, unpubl.	Nov	?
1985-86	23	65	68	R. Poole, unpubl.	Nov-Dec	Oct
1987-88	128	70	70	Moore & Moffat 1990	early Jan	late Aug
1991-92	158	81	81	J. Amey, unpubl.	early Jan	late Aug
1993-94	157	83	83	J. Henderson, unpubl.	early Jan	late Aug
1994-95	203	76	76	G. Mitchell, unpubl.	early Jan	late Aug
mean, s.d		66.8, 12.9	68.6, 13.6			
mean, s.d 1942-1972		63.0, 13.3	64.7, 15.1			
mean, s.d. 1985-1995		75.1, 7.7	75.7, 6.7			
Moubray						
1987-88	344	76	76	Moore & Moffat 1990	early Jan	late Aug
1991-92	376	77	77	J. Amey, unpubl.	early Jan	late Aug
1993-94	435	81	81	J. Henderson, unpubl.	early Jan	late Aug
1994-95	204	77	77	G. Mitchell, unpubl.	early Jan	late Aug
mean, s.d.		77.8, 2.4				

[1] Total breeding success from egg to chick (to final visit prior to fledging in October).

[2] Data adjusted to correspond to nests found in January and checked in late August for comparison with data collected in 1988-1995.

[3] Data compiled in Paull & Surrey (1969).

APPENDIX 3. COUNTS OF SOUTHERN ROYAL ALBATROSS NESTS AT COL AND MOUBRAY STUDY AREAS.

DATE	YEAR	COL STUDY AREA	MOUBRAY STUDY AREA	COUNT TYPE	OBSERVER/REFERENCE
Jan-Feb	1958	36	97	ground search	Westerskov 1963
	1964-68	125 [1]			Guard 1968
Jan 1969	1969	125	185	ground search	Taylor *et al.* 1970
Dec 1975	1975-76	210	295	ground search	Dilks & Wilson 1979
Jan 1977	1977	161	307	ground search	P. Dilks, unpubl. data
Dec 1977-Feb 1978	1977-78	141	346	intensive nest count (Col) ground search (Moubray)	P. Dilks, unpubl. data
Jan 1988	1987-88	128	344	intensive nest count	Moore & Moffat 1990
Jan 1992	1991-92	158	376	intensive nest count	J. Amey unpubl. data
Jan 1993	1992-93	187	400	intensive nest count	J. Amey unpubl. data
Jan 1994	1993-94	170 [2]	435	intensive nest count	J. Henderson unpubl. data
Dec 1994-Jan 1995	1994-95	189	489	intensive nest count	Moore *et al.* 1997
Jan 1996	1995-96	201	508	intensive nest count	this study

Figures from 1957-1978 were estimated from maps of nest distribution to make them comparable to the study areas used from 1987-1996.

[1] Includes a larger area than the 198'-96 study area (Guard 1968). The study area in those years was the west shoulder of bit. Lyall, Col-Lyall saddle and the Col ridge to southwest of Col Peak and 88-100 nests were monitored each year (Paull 8c Surrey 1969).

[2] Raw count was 157, but did not include the Col Lyall plateau, therefore an extra 13 nests were estimated from 1995-96 results.