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RESEARCH AND MANAGEMENT PROJECTS ON CAMPBELL ISLAND 1987-88

by

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CONTENTS

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SUMMARY

1. Fieldwork on Campbell Island was conducted between October 1987 and October 1988. Results of studies on yellow-eyed penguins and mollymawks are presented in separate reports.

2. Rockhopper Penguin
Previous population studies were continued at Penguin Bay. Fifty percent of nests produced chicks close to fledging time (or 0.5 chicks per nest). This is a higher breeding success than some previous seasons. Chicks prior to fledging weighed 2.02kgs. This species is in decline and a population estimate in the 1980s was 103,000 birds.

3. Southern Royal Albatross
The breeding success of albatrosses at Col and Moubray was studied. Success was high, with 74% of nests having chicks in late August. Counts of nests in the study areas and previous full surveys of the island suggest a stable population of 4200-4600 pairs per season.

4. Wandering Albatross
Three nests were found at Moubray, and two chicks were alive in August 1988.

5. General Bird Observations
A new record for the island was a migratory tattler, probably a Siberian tattler.

6. Southern Elephant Seal
At least six pups were born in October 1987. Peak numbers of 150-200 non-breeding seals occurred in December.

7. Hooker's Sea Lion
At least 56 pups were born in 1987-88. Most were found at Perseverance Harbour and Northwest Bay within 500m of the coast. Other potential natal areas were not searched. It was estimated that the adult population was 70-150 females and 120-200 males. The most popular beach for non-breeding males was Sandy Bay, with a peak count in February of 114.

8. New Zealand Fur Seal
In late December 1987 338 adults and 126 pups were counted at Rocky Bay.

9. Leopard Seal
   Eight individual leopard seals were seen in 1987-88.

10. Southern Right Whale
    Whales were present from late March to early September 1988. The peak period at Northwest Bay was June-August, when 8-12 (max. 19) whales were usually present. The evidence suggests that fewer than 30 whales frequent Campbell Island waters, with little change in numbers over the last 40 years.

11. Sheep
    In late January 1988, 1105 sheep were counted west of the 1984 fenceline. This is an increase of 200-300 since 1984. Over-grazing and erosion is severe in some areas.

12. Norway Rat
    Rat indices of abundance of 16 captures/100 trap nights in early April and 36 captures/100 trap nights in early September 1988 were lower than had been found in 1984-85. The population is abundant compared with mainland populations.

13. Feral Cat
    Cats are rarely seen. A bait trial was unsuccessful.

14. Vegetation
    A DSIR photopoint series was continued to monitor vegetation changes. Transects either side of the 1984 fenceline were re-surveyed. Vegetation in areas released from grazing pressure is taller, more luxuriant, and has an increased prevalence of species that are sensitive to grazing. The spruce tree continues to accelerate in growth.

15. Historic Sites
    A few unrecorded sites were found, including finger-posts at Northeast and Perseverance Harbours.

16. Coastal Resources Inventory
    Preliminary coastal information, including photographs, was collected.

17. Track Maintenance
    Board-walking was constructed on damaged sections of walking tracks.

CHAPTER ONE: INTRODUCTION

1.1 THE ISLAND

Campbell Island is administered by the Department of Conservation as a Nature Reserve for the protection of its indigenous flora, fauna and natural features (McKerchar and Devine 1982). It lies about 660km south of the mainland of New Zealand at latitude 52° south (Department of Lands and Survey 1983). Its nearest neighbour is the Auckland Islands, 350km to the northwest. Campbell Island is over 11,000 ha in area and the highest peak is Mt. Honey at 558m. The coastline is mainly cliffs but there are several harbours and bays with less steep shores (Fig. 1).

The harbour edges are largely vegetated by *Dracophyllum* scrub up to about 180m above sea level. Tussock grassland of *Chionochloa* and *Poa,* megaherbs such as *Pleurophyllum,* the lily *Bulbinella,* and alpine herbfields characterise the island's vegetation.

The climate is typified by overcast skies, frequent drizzle and strong persistent westerly winds.

1.2 FAUNA

Seventy-five species of birds have been recorded at Campbell Island (Appendix 1). At least 30 have been confirmed as breeding species, including 3 penguin species, 5 albatrosses, 6 petrels, 2 shags, 2 ducks, 4 gulls and terns, and 8 passerines. Most of the small burrowing seabirds and the rare flightless Campbell Island teal are now confined to the offshore islands where rats are absent.

Four species of seal are found on the island, three of these breeding, and normally one species of whale in adjacent waters. The introduced mammals are sheep, Norway rats and feral cats.

1.3 HISTORY

Campbell Island was discovered in 1810 and thereafter was visited by sealing expeditions. There were also several scientific expeditions last century and early this century, such as the French attempt to observe the transit of Venus in 1874 and the Canterbury Institute Expedition in 1907. The island was farmed from 1895 to 1931 and there were two whaling stations between 1909 and 1916 (Kerr 1976).

During World War II, as part of a subantarctic operation in the New Zealand region, code-named the "Cape Expedition", a station was set up at Tucker Cove to watch for enemy shipping. This heralded the start of meteorological observations, which have operated at the present station at Beeman Cove since 1958.

1.4 RECENT SCIENTIFIC EXPEDITIONS

Because of the problem of access to Campbell Island, scientific investigations have generally been sporadic and short in duration. Many of the expeditions since the 1940s are described below.

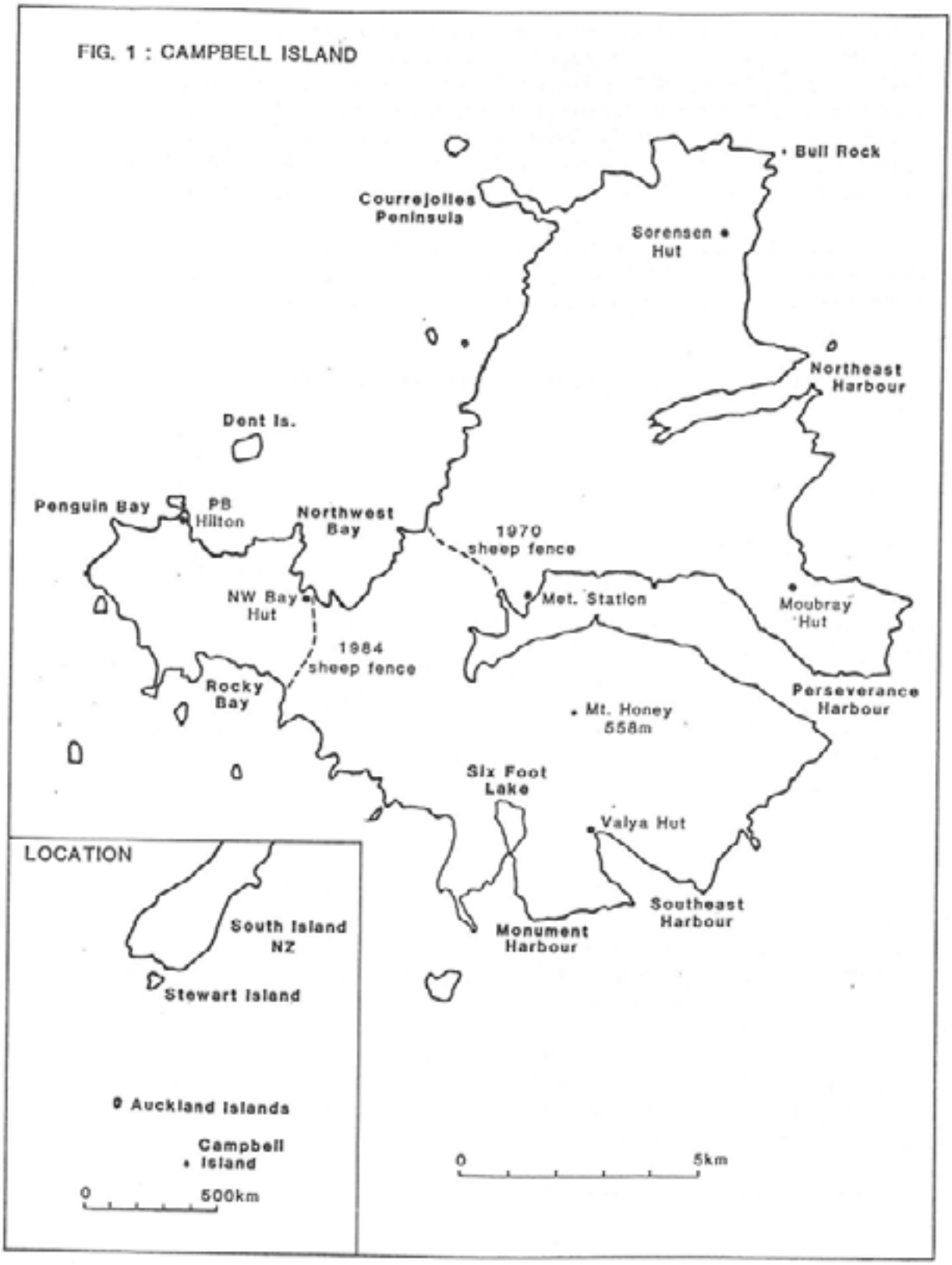


FIG. 1 : CAMPBELL ISLAND
Bull Rock
Courrejolles Peninsula
Sorensen Hut
Northeast Harbour
Dent Is.
Penguin Bay
PB Hilton
Northwest Bay
1970 sheep fence
NW Bay Hut
Met. Station
Moubray Hut
1984 sheep fence
Rocky Bay
Perseverance Harbour
Mt. Honey 558m
Six Foot Lake
Valya Hut
Southeast Harbour
Monument Harbour
LOCATION
South Island NZ
Stewart Island
Auckland Islands
Campbell Island
0 500km
0 5km

J. Sorensen contributed greatly to the knowledge of Campbell Island fauna during his years as a Cape Expedition coast-watcher and when in charge of the meteorological station during the 1940s (Sorensen 1942-47, 1950a,b,c, 1951, 1954aa,b, 1969, Oliver and Sorensen 1951, Bailey and Sorensen 1962). In 1958 a party from the Denver Museum of Natural History visited the island for six weeks to study the wildlife and collect specimens (Bailey and Sorensen 1962, Westerskov 1959, 1960, 1963).

The next major expedition was for five weeks in 1961, when several scientists from DSIR, universities and museums visited, mainly to study the sheep population (Wilson and Orwin 1964). Another visit in 1969 (Taylor *et al.* 1970, Bell and Taylor 1970) led to the 1970-71 expeditions to construct a sheep fence and begin vegetation monitoring. The effects of this work were investigated and other studies conducted in the summer of 1975-76 by multidisciplinary teams from universities, museums and government departments. Further work was conducted in 1984 when the second sheep fence was constructed (e.g. Meurk 1984, Ballance 1985), and smaller expeditions continued the monitoring programmes (e.g. Wilson and Elliot 1981).

One of the most recent studies on Campbell Island was of Norway rats in 1984-85 by Taylor (1986a, b), who was the first scientist since World War II to spend a whole year on the island. Shorter trips have been made since 1984 to study the decline of rockhopper penguins (Moors 1986).

1.5 1987-88 EXPEDITION

In recognition of the value of having scientists based on Campbell Island for a whole year, the Department of Conservation (DOC) organised a two person team to conduct research from October 1987 to October 1988. Peter Moore (Science & Research Division, DOC, Wellington) led the team and Roger Moffat was on contract for the year, having spent the previous year as mechanic for the Ministry of Transport at the meteorological station.

Two major tasks were to investigate the status of yellow-eyed penguins and on Campbell Island. The results from these studies are presented separately (Moore and Moffat 1989a, b). While stationed on the island there was also an opportunity to continue previous work on rockhopper penguins, and improve knowledge on albatrosses, seals, whales, sheep, rats and vegetation. A further aim was to assist with the management of the nature reserve, with tasks such as track maintenance, and setting up or refining monitoring studies of animals and vegetation so that they could easily be repeated in the future. These activities are described in this report.

Accommodation was at the Meteorological Service (MoT) station at Beeman Cove. Approximately 60% of nights were spent at base, 35% at huts and 5% in tents. The varied nature of the work undertaken necessitated frequent short trips, including trips, from the base to the various study areas.

1.6 STRUCTURE OF REPORT

The report is divided into chapters dealing with each study or activity. Each chapter is dealt with in terms of introduction, aims, results, discussion and recommendations.

CHAPTER 2: ROCKHOPPER PENGUIN

2.1 INTRODUCTION

The rockhopper penguin, *Eudyptes chrysocome,* is a widespread species, found at many subantarctic islands as well as further north in the South Atlantic and South Indian Oceans. Campbell Island has been regarded as a major breeding area for the species as a result of a population estimate of several million birds, based on observations made during the 1940s (Bailey and Sorensen 1962). This estimate was far too high, since it was based on an improbably high nesting density (Moors 1986). Nevertheless, it is likely that the population was still more than 1.5 million breeding birds (P. Moors and D. Cunningham pers. comm.).

In recent years it became apparent that the rockhopper penguin population on Campbell Island had declined (Robertson 1980). In order to determine the extent and timing of the decline and to investigate the possible causes, in 1984 a study of the species was begun by Moors (Royal Australasian Ornithologists Union, Melbourne, Australia) and Cunningham (Science & Research Division, DOC).

Inspection of historical photographs of breeding colonies taken since the 1940s showed that the decline had been dramatic, with most colonies being greatly reduced and several disappearing. This decline has continued to the present day (Moors 1986) and the current population is estimated at 103,000 breeding birds (Moors and Cunningham pers. comm.). Permanent photopoints have been established to monitor the population changes.

Moors and Cunningham have conducted their more intensive research in study areas at Penguin Bay. They have looked at the population structure, breeding success and survival, and investigated causes for the decline.

At the beginning of the study it was thought that predation by rats may have been involved. Another factor considered was disease after some penguins were found dying from infection by the bacteria *Pasteurella multocida* (Moors *et al.* 1988). However, there is increasing evidence that the rockhopper penguin population crash may be related to increasing sea temperatures which have changed food availability or quality (Moors and Cunningham pers. comm.).

2.2 AIMS

In 1987-88 it was aimed to:

1 Document the breeding success of rockhopper penguins at Penguin Bay;
2 Collect morphometric data on eggs, chicks and adults;
3 Record band numbers of previously banded penguins;
4 Collect tissue samples of dead chicks to investigate reasons for their death;
5 Repeat the photopoint series of major penguin colonies.

2.3 METHODS

Methodology was provided by P. Moors.

2.3.1 Breeding Success

The nesting cycle of the rockhopper penguin at Penguin Bay was followed from November to February in four study grids (up to 20m by 2.5m) in three colonies (Central, Foreshore and Ravine). Band numbers of nesting birds were recorded, unbanded nesting birds were banded and the position of nests in the grids were mapped.

The contents of the nests in the study grids were recorded on 8, 15 November 1987, 13, 15, 17, 23, 28 December 1987 and 7 February 1988. The hatch dates of chicks were estimated on the basis of size for 13 December and thereafter on the interval between visits. Chicks were tagged on their foot webs in late December for subsequent identification in early February, when they were flipper-banded.

2.3.2. Weights and Measures

Weights and measurements of 37 completed clutches of eggs were made in Central A grid on 8 November using spring balances and vernier calipers.

During two 24 hour periods, on 23/24 and 30/31 December 1987, weights of a sample of 20 single chicks and 5 sets of twins were taken every four hours. In addition, random samples of 30 chicks in the four study grids were weighed once on 30 December. All the chicks in the study grids were weighed on 7 February. Another sample of fledged chicks was weighed at the Central landing beach on 13 February.

Weights of 20 breeding pairs from each of Central B and Ravine grids were taken at the egg stage (10 November) and again when the chicks had hatched (15 December).

2.3.3. Band Records

Band numbers of previously banded penguins were recorded throughout the Penguin Bay colonies, during the November, December and February visits, as well as during the adult moulting period of April.

2.3.4. Photopoints

Photographs were taken of the main colonies of the Paris, Yvon Villarceau, and Penguin Bay coastline in December. Approximate positions of the photopoints are shown in Appendix 6, with more detailed maps held on Campbell Island, Invercargill and Wellington.

2.3.5. Samples

Several dead chicks were dissected for tissue samples for later epidemiological analyses. Ticks were collected from penguins in February.

Small-scale excavations in areas adjacent to the Penguin Bay colonies were made to investigate the presence of penguin bones.

2.4 RESULTS

2.4.1 Breeding Success

The rockhopper penguin study grids were first visited during the peak laying period of 8-15 November 1987. There were 309 nests in the four study grid lines (Table 1), and the overall nesting density was about 1.9 nests/sq. metre.

The normal clutch of eggs was two, although two nests in the study grids had 3 eggs. Rockhopper penguins lay a small egg(A) followed by a larger egg(B). Some eggs were undoubtedly unrecorded because of early predation by skuas and accidental loss, therefore only 254 A-eggs and 276 B-eggs were recorded as having been laid. This made a total of 528 eggs from the 309 breeding pairs, or 1.7 eggs per nest.

The second visit to Penguin Bay, from 12-17 December, was planned to coincide with the period of peak hatching. The mean hatch date of 13 December is approximate because hatch dates before 12 December and from 17-23 December were estimated on the basis of chick size. Chicks in Central grids hatched earlier on average than the other areas.

Of the original 309 nests, 193 (62%) produced chicks, but only 20 of these nests were recorded as having twins. Central A grid was the most successful, with 81% of the nests hatching chicks, while only 53% of Foreshore nests were successful. In total, 213 (40%) of the original 528 eggs hatched, and it was estimated that 76% of the successful eggs were the larger B-eggs.

Rockhopper chicks fledged and began leaving the colonies in mid-February. On 7 February 1988, 156 (73%) of the chicks had survived to approximately two months of age. This represented a success of 51% of the original breeding pairs or 81% of those nests that had hatched chicks in December. None of the original 20 sets of twins remained complete in February; therefore the overall success was 0.5 chicks per nest.

The chick mortality between 7 February and departure from the colonies is unknown, however, during visits to the colonies on 19 February and 17 March, the remains of six dead banded chicks were found. Therefore, the maximum number of fledglings could have been 150 (70%) of the 213 chicks that hatched.

Table 1: Rockhopper penguin nesting success at Penguin Bay 1987-88

	COLONY				
	Central		Foreshore	Ravine	TOTAL
	A	B			
No. nests with eggs	68	64	95	82	309
No. eggs	117	108	167	136	528
Hatch dates: Mean	13	13	14	14	13
(December) S.D.	1.5	1.5	2.1	1.5	1.8
Range	12-20	11-20	11-20	12-16	11-20
HATCHING SUCCESS					
No. nests with chicks	55	41	50	47	193
% of orig. nests[A]	81	64	53	57	62
No. chicks	63	44	55	51	213
% of orig. eggs[B]	54	41	33	38	40
Twin sets hatched	8	3	5	4	20
CHICK SURVIVAL TO 7 FEB.					
No. chicks alive	44	30	45	37	156
% nests that hatched chicks[C]	80	73	90	79	81
% of chicks[D]	70	68	82	73	73
% of orig nests[E]	65	47	47	45	50
OVERALL SUCCESS					
Mean no. chicks/nest[F]	0.65	0.47	0.47	0.45	0.50

SUCCESS DEFINITIONS
A: Percent of the original number of nesting attempts that hatched out chicks..
B: Percent of the original number of eggs recorded that hatched out chicks.
C: Percent of nests with chicks still alive close to fledging time.
D: Percent of chicks that survived close to fledging.
E: Percent of the original number of nests that produced chicks close to fledging.
F: Mean number of chicks per pair or nest.

2.4.2 Weights and Measures

Egg measurements are shown in Table 2. The A (first) and B (second) eggs were significantly different ($p<0.001$) for dimension and weight when compared by t-test.

Table 2: Rockhopper penguin egg measurements and weights shortly after laying, 8 November 1987

	EGG A			EGG B		
	Mean	S.D.	N	Mean	S.D.	N
LENGTH (mm)	63.2	2.5	37	70.8	2.3	37
WIDTH (mm)	47.7	1.3	37	53.9	1.3	37
WEIGHT (g)	79.6	6.0	37	112.0	6.5	37

The mean of a random sample of chicks on 30 December, when they were about 2.5 weeks of age, showed that chicks were heaviest at Central B grid and lightest in Foreshore colony (Table 3). This may reflect slight differences in average chick age between the colonies (Table 1). The overall mean of 750g represented a range of 365-1285g.

The mean weight of chicks at 8 weeks of age was 1900g (range 1100-2570g) (Table 3), with no significant differences between the colonies. One week later 44 nearly fledged chicks were weighed at the main Central landing beach. The mean weight was 2020g (S.D. 190, range 1700-2400g).

Table 3: **Rockhopper penguin chick weights at 2.5 and 8 weeks**

COLONY	WEIGHT (g)					
	30 Dec			7 Feb		
	Mean	S.D.	N	Mean	S.D.	N
CENTRAL A	780	163	30	1930	317	44
CENTRAL B	810	144	30	1920	330	29
RAVINE	720	98	30	1850	244	37
FORESHORE	680	151	30	1910	327	44
TOTAL	750	147	120	1900	306	154

Table 4 shows the change in weight of single and twin chicks throughout 24 hour periods on 23 and 30 December 1987. Most positive weight gains were in periods 3 and 4 (1500-2300 Hours NZST), which represents the normal feeding time by the female. During the other periods when they were not fed, most chicks lost weight through respiration and excretion, hence the negative values.

Table 4: **Weight changes of rockhopper penguin chicks through 24 hour periods**

		Initial weight (g)	WEIGHT INCREMENT (g) DURING FOUR HOUR PERIOD[a]						SUM[b] (g)	NET[c] (g)
			1	2	3	4	5	6		
23 DECEMBER SINGLE CHICKS										
(N=20)	Mean	563	-34	0	20	141	-27	-40	219	60
	S.D.	133	13	85	67	108	37	12	51	75
TWIN CHICKS										
(N=10)	Mean	440	-19	-20	28	90	-8	-30	137	42
	S.D.	214	12	12	57	73	39	13	62	65
23 DECEMBER SINGLE CHICKS										
(N=18)	Mean	800	-21	-4	45	95	-41	-38	209	39
	S.D.	131	38	97	132	151	24	21	131	130
TWIN CHICKS										
(N=10)	Mean	688	-28	-26	-22	200	-40	-43	204	43
	S.D.	270	19	20	13	133	21	23	129	82

KEY a: Four hour periods beginning at 0700 hrs (NZST)
b: Sum=mean sum of positive weight increments
c: Net= mean overall weight changes for 24 hours

The mean SUM of positive weight increments is an approximate guide to the level of food intake of the chicks. On 23 December the SUM was about 219g and on 30 December it was 209g for single chicks. Four chicks were not fed at all during the 24 hour series on 30 December, so if these are omitted from the calculations, the SUM for those that were fed was 270g. This suggests that meal sizes were larger but less frequent than on 23 December. Actual meal sizes were probably about 240g (43% of chick body weight) and 300g (38% of body weight) on the two dates, the higher figures allowing for respiration and excretion of 20-40g between being fed and being weighed.

Although twins received smaller meals than single chicks there were no significant differences in terms of initial weight, SUM and NET, or between sibling twins in terms of SUM and NET. However the smaller members of the twin pairs were significantly lighter ($p<0.05$) in initial weight than their larger siblings.

The change in adult rockhopper penguin weights between egg laying in November and hatching of chicks in December is shown in Table 5. Males increased in weight whereas females decreased. Weight differences between the sexes and between the months were all significant ($p<0.001$).

Table 5: **Rockhopper penguin adult weights**

	10 NOVEMBER			15 DECEMBER		
	Mean (kg)	S.D.	N	Mean (kg)	S.D.	N
MALE	2.55	0.19	20	2.90	0.21	20
FEMALE	2.81	0.17	20	2.38	0.14	20

2.4.3 Band Records
During visits to Penguin Bay 2609 records of 754 banded birds were made. A further 174 adults and 164 chicks were banded in the study grids (Appendix 2).

2.4.4 Photopoints
Photographs of major colonies were taken and added to the collection held by D. Cunningham (Science & Research Division, DOC, Wellington).

2.4.5 Samples
From nine dead chicks blood smears were taken, pieces of liver, lung and kidney for epidemiology, other tissue samples for genetic analyses and stomach samples for dietary analysis (Appendix 7).

Ticks were collected from rockhopper chicks and moulting adults and frozen in liquid nitrogen for later identification of viruses. A few other samples of ticks preserved in alcohol were identified as *Ixodes uriae* (A. Heath pers. comm.) (Appendix 7d).

Assistance was given on 20 February to J. Darby (Otago Museum, Dunedin) who collected blood samples from 13 adult penguins for genetic analysis by A. Baker (Royal Ontario Museum, Toronto, Canada).

Small excavations of soil between colonies at Penguin Bay revealed penguin bones but there was no consistent pattern of layering to suggest periods of occupancy.

2.5 DISCUSSION

The 1987-88 rockhopper penguin breeding season was more successful than some previous seasons because of a lower chick mortality. Sixty-three percent of nests hatched chicks and only 7% of chicks were lost in the first two weeks by 28 December. In 1984-85 although 60% of pairs hatched chicks, 75% of chicks were lost by 3 January (Taylor 1986a). Similarly, in 1985-86 70% of nests hatched chicks but 69% were lost by 31 December (D. Cunningham pers. comm.). There was apparently a high level of mortality caused by bacterial infection during that season (Moors *et al.* 1988).

The overall breeding success of 0.5 chicks per breeding pair (or less in some seasons) is at the low end of the scale of available information for other penguins that normally lay two eggs. For example royal penguins produce up to 0.5 chicks per pair (Carrick 1972), adelie penguins 0.8 (Ainley *et al.* 1983), gentoo penguins 0.6-0.7 (Croxall and Prince 1979) and 1.0 (Robertson 1986), and yellow-eyed penguins 1.4 chicks per pair (Moore and Moffat 1989a). Although poor breeding success could have contributed to the rockhopper population decline, the low level of fecundity compared with most other species may be usual for rockhoppers but is offset by other life history characteristics such as age at first breeding, juvenile mortality and longevity. Changes to the population size could be a result of factors acting outside the breeding season, such as the food supply.

The relatively sheltered colonies at Penguin Bay, which have suffered a 57% decline in 40 years may be more successful during the breeding season than the more exposed colonies of the western Paris coastline which have declined by 97% (Moors and Cunningham pers. comm.). Exposure to the full force of westerly seas and weather patterns of landing sites or some feature of the colonies themselves may be involved in this localised effect. Presumably, factors such as food supply and outside the breeding season would act equally on the different colonies. Population changes prior to the 1940s are unknown but there may have been some human influence at accessible colonies such as Penguin Bay. For example, the whalers of Northwest Bay blew penguin eggs for sale as curios in New Zealand (Kerr and Judd 1978). It is also possible that population levels during the 1940s were at a high point in normal long-term fluctuations, or as a response to food supply changes brought about by depletion of marine mammal populations during the whaling and sealing era.

The 24 hour weighing series of penguin chicks was based on that developed for petrels by 1984. This weighing series provided information on the size, frequency and timing of feeds given to the chicks. During the December guard phase the rockhopper penguin males remained with the chicks while the female made daily trips to sea to collect food. On 30 December, the weighing series showed that visits to the nest by the female were less frequent and of shorter duration than on 23 December, presumably because the

increased meal size required longer to collect. Although sibling twins were significantly different in weight, in two of the five pairs both birds were alive on 7 February (in contrast to the twins of the study grids where only one bird survived of each twin set).

Weights of chicks about to leave the colony of 2.02 kg compare well with 2.0kg on Campbell Island in 1985 (Taylor 1986a) and 2.2kg on the Falklands Islands (Strange 1982).

At the time of laying, females were heavier than males, presumably a result of males fasting for longer at that stage. The situation had reversed by the time eggs hatched as males had just recently returned after 7-10 days at sea (Strange 1982) in preparation for their fast during incubation.

A more complete analysis of rockhopper penguin breeding ecology and population dynamics on Campbell Island will result from this work as part of the overall study conducted since 1984 by Moors and Cunningham.

2.6 RECOMMENDATIONS

Further work, involving the monitoring of banded rockhopper penguin adults and chicks, is necessary to determine survivorship, age at first breeding etc. Therefore, recoveries of band numbers by meteorological station staff would be valuable data to collect when DOC staff are unable to visit Campbell Island. Colonies at Penguin Bay should be visited in November, particularly the grid lines marked by aluminium pegs. By moving slowly and thoroughly through the colonies band numbers of penguins (breeding and nonbreeding) can be read by eye or binoculars.

If sheep remain on Campbell Island they should be excluded from Penguin Bay (a small amount of fencing would achieve this) or regularly shot. This would limit disturbance to the colonies and halt the severe erosion caused by over-grazing in the area. The Paris-Yvon coastline should be periodically checked for recolonisation by sheep.

CHAPTER 3: SOUTHERN ROYAL ALBATROSS

3.1 INTRODUCTION

Breeding of the royal albatross (*Dioinedea epomophora*) is restricted to the New Zealand region (Kinsky 1970). The Southern race (*D. e. epomophora*) breeds mainly at Campbell Island, where there are about 7500 pairs, and at the Auckland Islands, where there are only about 60 pairs (Robertson 1985). Southern royals lay their eggs from late November to early December (Filhol 1885, Sorensen 1950a) and after 79 days incubations chicks hatch in about mid-February. Most young are reared in about 240-260 days and depart in October and November (Sorensen 1950a). Because of this lengthy breeding season successful adults breed every two years. Pairs which lose eggs or young chicks at the guard stage return the following season for another breeding attempt (C. Robertson pers. comm.). Thus, in any one season more than half the breeding population is present.

In the 1920s royal albatrosses on Campbell Island were apparently diminishing in numbers because of farming activities (Oliver 1930, Guthrie-Smith 1936, see Chapter 11). Based on the rate of increase of the albatross population between 1958, when 2300 pairs were counted (Westerskov 1963) and 1976, when 5300 pairs were counted, it has been suggested that possibly only 650 pairs were present in 1927 (Dilks and Wilson 1979). From 1978-1983 counts have varied from 4200-4600 pairs per year (Wilson and Elliott 1981, Dilks and Grindell 1983).

Since the 1940s nearly 25,000 albatross chicks and over 9,000 adults have been banded on Campbell Island, mainly by meteorological station staff. Most band recoveries or sightings away from the island have been from the coasts of Chile and Argentina, and also from Brazil, the Falkland Islands, South Africa, New Zealand, Australia and Tahiti (Sorensen 1954b, Robertson 1969, 1972, Robertson and Kinsky 1972, Enticott 1986, R. Cossee pers. comm.). This shows a circumpolar dispersal of adolescent birds and between breeding years (Robertson 1973).

3.2 AIMS

Following advice from C. Robertson, an aim of the 1987-88 expedition was to set monitoring studies that could be easily repeated by meteorological station staff in future years. Study areas at Moubray and Col would the band returns, since much of the banding conducted in previous years was in these areas.

In 1987-88 it was aimed to:

1 Census the population of albatrosses in the Col and Moubray study areas;
2 Determine the breeding success;
3 Record band numbers of adults;
4 Apply bands to the chicks.

3.3 METHODS

3.3.1. Study Areas

Col: all albatross nests between the 1970 sheep fence and the north-eastern boundary marked by the Col-Lyall walking track and the centre of the flat ridge that runs from Lyall peak (Fig. 2).

Moubray : all albatross nests to the east of Moubray hut (Fig. 3)

3.3.2 Study Periods

The nest surveys were chosen to coincide with the periods following egg laying, after chick hatching and before chick departure.

	Suggested period	Actual period 1988
Nest search	20 Dec-5 Jan	3-8 January
Chick search	1-10 March	5-9 March
Chick banding	20-30 August	23 Aug-2 Sept

Each survey took two people 1-2 full days at Col or 3-4 full days at Moubray.

3.3.3. Breeding Survey

An attempt to find every nest in the study areas was made by two people walking in parallel lines and communicating with hand-held radios. At Col it was usually easiest to walk along the contours of the Col ridge, whereas at Moubray it was necessary to walk up and down all the gullies. For the first two surveys painted wooden sticks were placed beside each nest to avoid counting them twice.

During the nest search only nests with eggs were counted. For the second survey all chicks and eggs that were apparently viable were counted. Infertile eggs were not included in the tally. These were identified by carefully handling the egg to see if the contents were sloppy or smelt rotten.

3.3.4. Banding

On the third survey two people worked together as a team and visited every nest to band the chicks. Metal bands (Size R) were applied to the right leg.

N.B. Future inexperienced workers should note that correct band application is essential to avoid crippling the bird, because a partly open band can imbed in the leg. The applied band should be a circle around the leg or, preferably, an oblong in the shape of the leg cross section. The ends of the band should meet flush in the same plane, with a very slight gap to prevent the band springing open. When catching the chick for banding it is useful to grab the beak first to prevent the chick vomiting.

3.3.5. Sampling

Samples of feathers and ticks were collected (Appendix 7).

FIG. 2 : COL ROYAL ALBATROSS SURVEY AREA

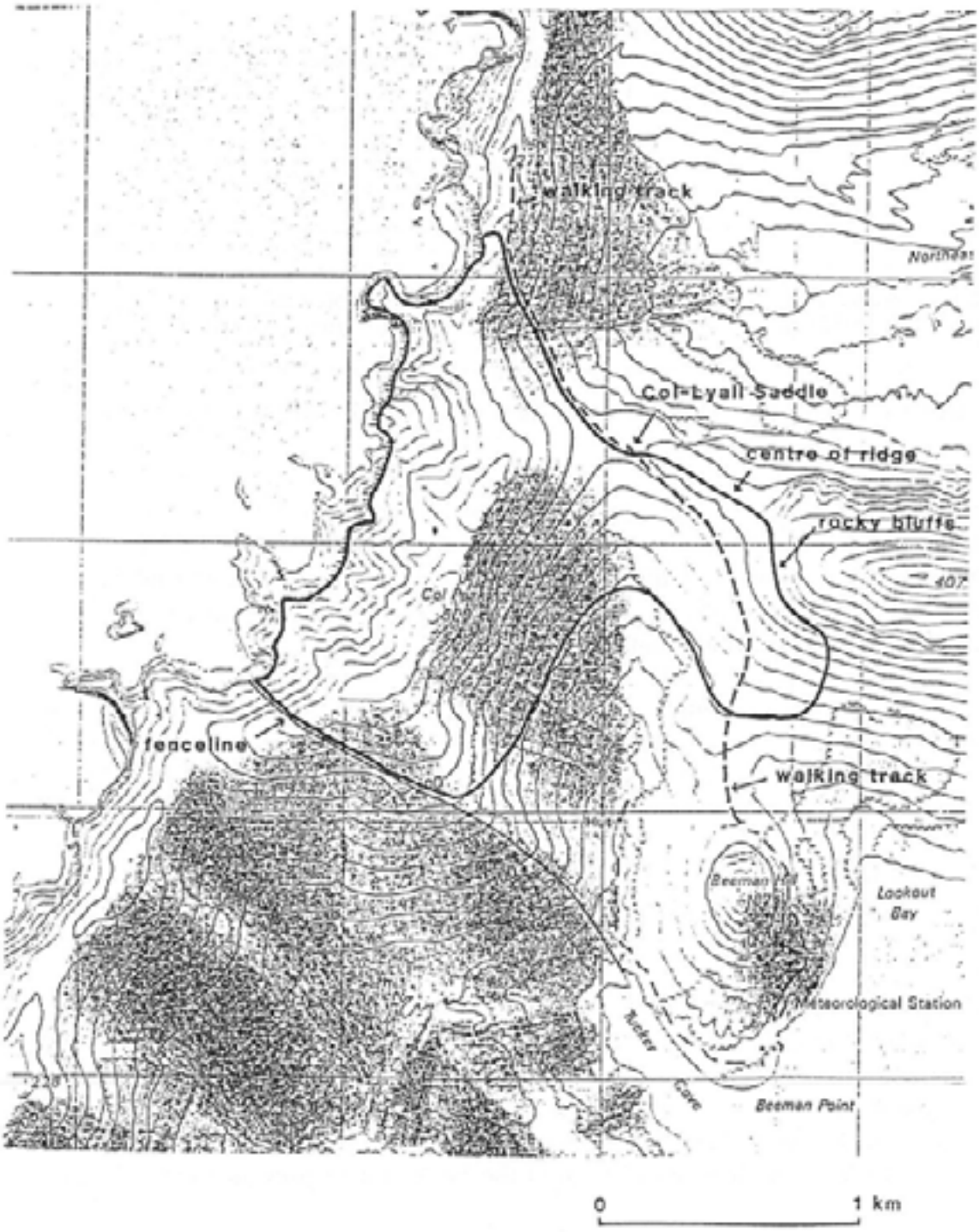
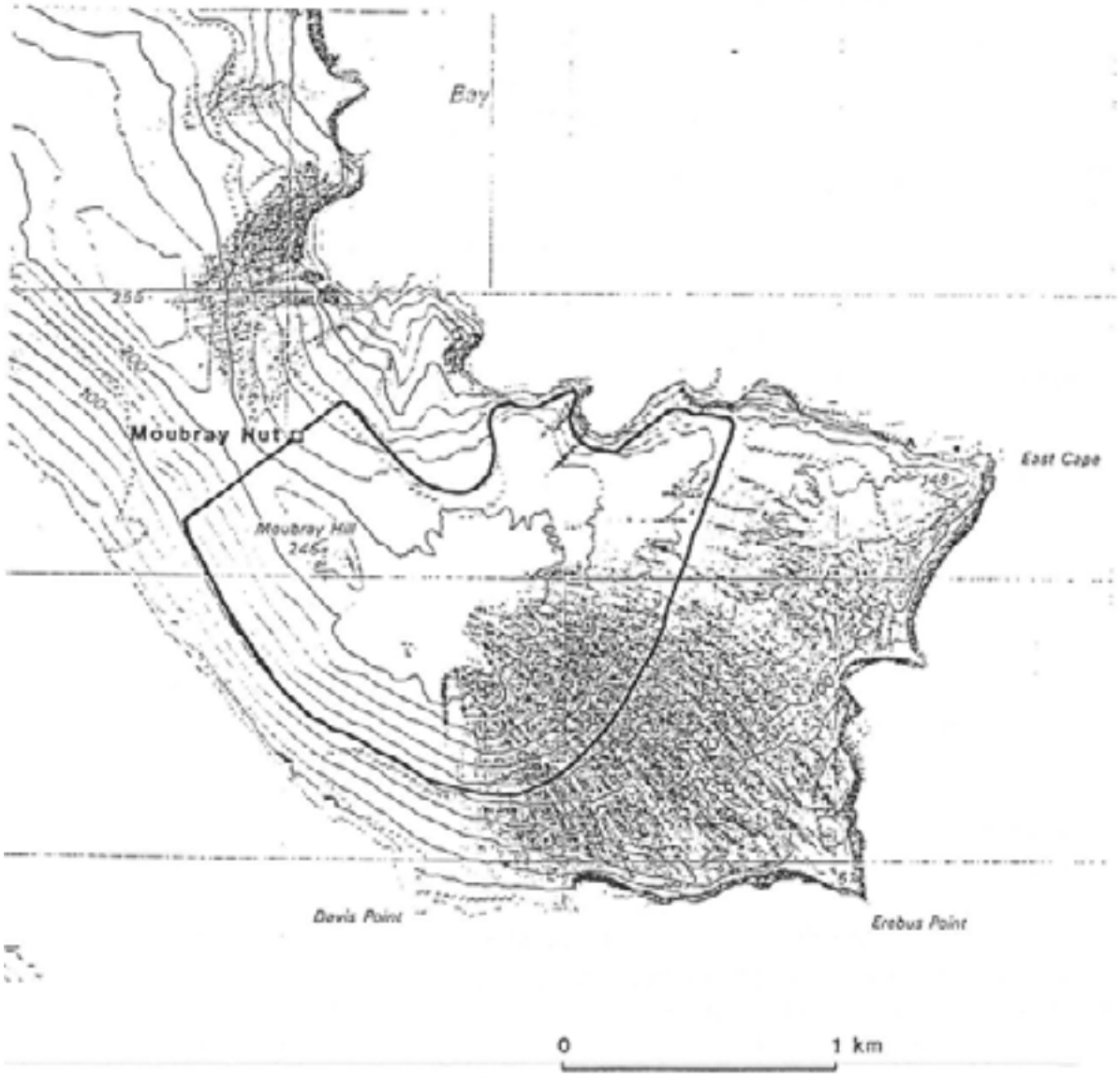


FIG. 3 : MOUBRAY ROYAL ALBATROSS SURVEY AREA



3.4 RESULTS

3.4.1 Breeding Success

The breeding success of royal albatrosses is summarised in Table 6. It is assumed in the table that the apparently viable eggs found in March later hatched. If they did not hatch, the hatch success was 79% and the chick success was 94%. These results do not account for early egg losses which would have occurred before the first survey. Similarly, some chicks may have died after the last survey.

Table 6: Breeding success of royal albatross on Campbell Island 1988

STUDY AREA	JANUARY	MARCH	HATCH[a] SUCCESS %	AUGUST	CHICK[b] SUCCESS %	OVERALL[c] SUCCESS %
Col	128 egss	95 chicks 3 eggs		89 chicks		
			76.6		90.8	69.5
Moubray	344 eggs	279 chicks 7 eggs		262 chicks		
			83.7		91.6	76.1
TOTAL	472 eggs	374 chicks 10 eggs		351 chicks		
			81.4		91.4	74.4

SUCCESS DEFINITIONS
a : Percent of nests/eggs that hatched
b : Percent of chicks that survived to near fledging time
c : Percent of nests/eggs that produced chicks close to fledging age

A less thorough survey west of the 1984 sheep fence was conducted in January, and about 426 adults on nests were counted.

Including areas outside the Moubray and Col study areas, there were 375 band recoveries of 312 individual royal albatrosses in 1987-88. Forty-five birds were rebanded, including 19 old worn aluminium bands, 22 that had imbedded in legs or 'ankles' and crippled the birds, and four that were the wrong size (O band). Many other poorly applied bands were refitted to prevent injury to the birds.

The oldest bird of known age recorded during the study was 26 years old (Appendix 3), but there were also several records of birds that were banded as adults in the 1960s. The youngest bird that was recorded breeding was six years old, whereas all others were at least 8 years old. There were no recoveries of birds of four years of age or less.

3.4.2 SAMPLING

Feathers from 23 adults and 30 chicks were collected for mercury analysis (Appendix 7). Parasitic ticks were identified as *Ixodes uriae* (A. Heath pers. comm.).

3.5 DISCUSSION

Population surveys have suggested a major increase in numbers of Southern royal albatrosses on Campbell Island since the farming era. Dilks and Wilson's (1979) estimate of 650 pairs in the 1920s was made by extrapolating back from their 1976 count of 5300 pairs and the 1958 count of 2300 pairs (Westerskov 1963). Although farming activities early this century probably reduced albatross numbers (see Chapter 11.5) it is difficult to estimate what the population level would have been then. Using the 1958 figure for the extrapolation may be misleading if it was an underestimate, as is suggested by Westerskov's (1963) comment "nests have unquestionably been overlooked in such difficult terrain". In the 1940s Sorensen (1950a) estimated that there were 3840 pairs on the Faye Ridge by assuming there were two mated pairs per acre in an area of three square miles. He stated that "there cannot be less than 5,000 mated pairs nesting on Campbell Island each year." This points to the possibility of a population greater than 2300 pairs in the 1940s. However, Sorensen's estimates also may be questionable because no counts were conducted and his density estimates of rockhopper penguins greatly overestimated that population (Moors 1986).

All natural populations fluctuate in numbers, but it should be noted that the royal albatross is a biennial breeder with a proportion of unsuccessful birds -returning in consecutive years. After seasons of particularly poor breeding success a larger than average proportion of the population returns the next year, followed by a low population in the third year. It has been shown for wandering albatrosses that following experimental removal of eggs, the population takes at least 10 years to return to equilibrium (Tickell 1968). This may explain a low count of royals in 1958 or a high count in 1976, but in the latter case only 400 fewer pairs were counted in 1977 than 1976 (Dilks and Wilson 1979).

The equilibrium population of royal albatrosses breeding in any particular year on Campbell Island may be between 4200 and 4600, as counts in 1969 and between 1978 and 1983 all fell within this range (Taylor *et al*. 1970, Wilson and Elliott 1981, Dilks and Grindell 1983, Appendix 4). If in any one season the count of nests represents 60% of the breeding population (C. Robertson pers. comm.) the total Campbell Island population is between 7000-7700 breeding pairs.

Counts from the Col and Moubray study areas prior to 1988 can be estimated from the dots on maps for 1969 (Taylor *et al.* 1970) and 1976 (Dilks and Wilson 1979). Col albatross counts fluctuated from approximately 125 (1969) up to 210 (1976), and down to 128 (1988). Moubray results for the same three years were 185, 295 and 344.

The approximate count of 426 nests west of the 1984 sheep fence is comparable to "Paris" counts by previous authors (Appendices 4 and 5). Counts since 1969 have been between 370 and 490 except in 1977 (535) and 1978 (241).

The overall breeding success in 1988 was high, with 74% of nests having chicks in late August. This will be an overestimate because of early egg losses and late chick losses. However, it is probable that over 3000 chicks fledged on the island in 1988. Col was a less successful area than Moubray because of lower hatching success. This level of breeding success was higher than that found by Sorensen about 50% of chicks died during the first week after hatching, with implicated. (1952) disputed Sorensen's statements and analysed his nest histories to show that chick losses in the first week of one season were only 17% and up to 64% of nests (N=22) reared chicks. In 1958 a study of 101 eggs showed that 75 chicks were successfully reared (Westerskov 1963), a level of success similar to the results.

The above results are higher than found for the Northern royal albatross (*D. e. sanfordi*) at Tairoa Head, New Zealand. From 1935-1951 31% of nests (N=64) reared chicks (Richdale 1952), and from 1951-59 46% of eggs (N=48) fledged chicks (Westerskov 1963). The high losses at this locality were attributed to human interference and introduced predators.

3.6 RECOMMENDATIONS

1. Surveys should be carried out in consecutive years to obtain an idea of the size of the total population (i.e. biennial breeders plus failed breeders).

2. Meteorological staff should concentrate survey effort on the Col study area as it can easily be covered in short day-trips from Beeman Base. The Moubray study area is more time-consuming to cover thoroughly, however band records and chick banding would be useful if time and energy precluded the full survey.

3. It would be useful in occasional years to survey areas such as Paris, North Col and Moubray (Appendix 5) to obtain results that are comparable to previous authors. Counts of nests should be made in early January.

CHAPTER 4: WANDERING ALBATROSS

4.1 INTRODUCTION

The wandering albatross (*Diomedea exulans*) is a circumpolar species of the subantarctic, with a wider breeding range than the royal albatross. Only a few pairs of the New Zealand subspecies (*D. e. exulans*) nest on Campbell Island, mainly in the Moubray area. However, they are notable for their dark plumage as breeding adults (Bailey and Sorensen 1962), unlike birds from other areas which become progressively whiter with age (Harrison 1983).

The main breeding grounds close to Campbell Island are at the Auckland Islands, where there are about 13,500 pairs (Robertson 1975) and Antipodes Island, where there are about 1500-1800 pairs (Warham and Bell 1979). Concern has been expressed about population declines, mainly of the subspecies *D. e. chionoptera* in the South Atlantic and South Indian oceans, apparently a result of increased adult mortality caused by the activities of fishermen (Weimerskirch and Jouventin 1987). The small Macquarie Island population has also declined in recent years (Tomkins 1985), as has the *D. e. exulans* population at Gough Island (Williams and Imber 1982).

At Campbell Island the small population has not been studied in detail, but there have been observations made by meterological station staff since the 1940s. Robertson (1975) estimated that there were about 20 breeding pairs of wandering albatrosses on Campbell Island. The 1986-87 meteorological crew mapped out many known nest sites in relation to three coloured pegs put out in the Moubray area. This map is now housed in the Moubray Hut.

In 1987-88 we continued the monitoring of the known wandering albatross areas at Moubray. Searches for other wandering albatrosses were made only at Col during the royal albatross surveys, and while walking along the main walking routes on the island.

4.2 RESULTS

During 1988 three wandering albatross nests were found in the Moubray area, one west of the hut and the others within the royal albatross study area.

The earliest egg was found on 8 January 1988, but this nest failed. The other two pairs successfully reared chicks up to August 1988, when the chicks were banded.

From the three nests, the bands of five adults were recorded. One of these had been banded as a chick on Campbell Island in 1970, whereas the others were banded more recently as adults. Two other banded birds were identified away from nesting sites, and one of these had been banded as a chick in 1976.

4.3 DISCUSSION

During the previous year (1987), meteorological staff found four nests at Moubray and another near Cave Rock, between Mount Dumas and the head of Perseverance Harbour. Three chicks successfully fledged in January 1988. Unsuccessful pairs may have been expected to attempt breeding again in 1988, however they were not found at or near their nest sites.

Numbers of wandering albatrosses on Campbell Island have probably always been low. The records available suggest that 1-4 nests are present each year, usually in the Moubray area (Westerskov 1960, Robertson 1980, Wilson and Elliot 1981, Dilks and Grindell 1983).

CHAPTER 5: OTHER BIRDS

A few incidental bird observations are presented here where the species is unusual to Campbell Island, or there is little previous information. A complete species list with scientific names is provided in Appendix 1.

KING PENGUIN

Individual king penguins are fairly regular visitors to Campbell Island (Kinsky 1969), probably from Macquarie Island. Single juvenile king penguins were seen at Middle Bay (16 February), Monument Harbour (21 February) and Capstan Cove (3-4 May 1988).

LIGHT-MANTLED SOOTY ALBATROSS

This species is common on the island. The population is estimated at more than 1000 pairs, nesting largely on inaccessible cliffs (Sorensen 1950c). In 1987 there were two nests at Cave Rock, west of Garden Cove (at the head of Perseverance Harbour). On 25 October 1987 nest A had one fresh egg and the bird at nest B had yet to lay. On 31 December Nest A's chick was hatching and B was pipping. The first sighting of an adult in the 1988-89 season was on 3 October.

GIANT PETREL

Robertson (1980) expressed concern at a substantial reduction in giant petrel numbers, particularly at Six Foot Lake. From October 1987 to January 1988 there were at least 10 nests between Hookers and Courrejolles Peninsulas (northern part of island) and 11 nests on Folly Island (near Penguin Bay). In September 1988 (i.e. the following season) there were at least 7 nests at Complex Point (western Northwest Bay) and 35 nests at Six Foot Lake (southern coast). Therefore, discounting the different seasons, there were at least 63 breeding pairs.

CAPE PIGEON

Known as a common species around Campbell Island (Bailey and Sorensen 1962) and reported as breeding (D. Cunningham pers. comm.). Seen most months of the year, the largest flocks were about 300 at Cattle Bay on 15 November and 139 at Penguin Bay on 30 December 1987.

SOOTY SHEARWATER

Filhol (1885) noted that thousands of sooty shearwaters nested on the main island. They were exploited for food during the whaling and sealing era, and 1000 were taken from Dent Island in one season (Kerr and Judd 1978). They are still common at sea but breeding birds are unsuccessful on the main island because of predation by rats. Westerskov (1960) reported flocks of 5000 birds in 1958. In 1987-88 the most extensive burrowing found was at Cattle Bay (between Penguin and Northwest bays) and from Hookers to Courrejolles Peninsulas. The largest scattered flock seen was of more than 1000 at Northwest Bay on 24 February.

SUBANTARCTIC SHEARWATER

A little shearwater was found dead at Meteorological Base in 1970 (Kinsky 1971). Another was attracted there on 17 March 1988.

CAMPBELL ISLAND SHAG
Van Tets (1980) reported 29 nesting localities, 1300 nests and estimated a total population of 8000 shags. In December 1987, 28 nests were seen at Hookers Falls (north coast), 78 at Cattle Bay (a colony not recorded by Van Tets 1980), 14 between Penguin Bay and Cattle Bay, 17 on Folly Island, and 10 at Rocky Bay. Therefore at least 147 nests were seen, however a wide range in timing of the breeding season occurred and more pairs may have been involved at these colonies. Colonies of unknown size seen outside the breeding season were at Hookers Finger (north coast) and Shag Point (south coast). Bailey and Sorensen (1962) reported flocks offshore of 300-400 birds. Largest flocks recorded in 1988 were 90 birds near Bull Rock on 19 January, 35 at Northwest Bay on 21 January and 67 at Perseverance Harbour on 13 May.

WHITE-FACED HERON
An occasional vagrant to the island, individual white-faced herons were seen at Tucker Cove on 24 July, 31 August and 11 September 1988.

SPUR-WINGED PLOVER
Seen previously in 1945 (Bailey and Sorensen 1962), a spur-winged plover was seen at Tucker Cove several times from 30 August to 3 September 1988. It arrived after a period of strong northerlies.

SIBERIAN TATTLER
A tattler, believed to be a Siberian tattler (a new record for the island), was seen several times at Tucker Cove between 14 January and 26 April, and there were further sightings in September. It is unlikely the bird was overlooked in the intervening months as there are few suitable bays for this migrant. Either the same individual had returned, or a different bird by chance had made a landfall at Campbell Island.

TURNSTONE
This migrant was seen in summer of 1967-68 (Kinsky 1969). One was also seen and heard briefly on 11 January 1988.

WELCOME SWALLOW
Although seen once in 1946 (Bailey and Sorensen 1962) none were reported until several were seen around Cove Hostel in 1986-87 after a period of northerly winds. In 1988 one (and occasionally two) welcome swallows were seen regularly at Middle Bay (part of Northwest Bay), indicating a possible establishment.

YELLOWHAMMER
Reported three times in the 1940s and 1950s (Bailey and Sorensen 1962), yellowhammer was seen above Whale Bay on 4 May 1988.

GREENFINCH
Recorded previously in 1943 and 1944 (Bailey and Sorensen 1962), a dead greenfinch was found at Meteorological Station on 24 July 1988.

GOLDFINCH
A rare bird on the island, goldfinches were seen in 1986-87 after a period of northerlies. One was seen on at least one occasion at Cove Hostel in May 1988.

STARLING
Flocks of 100 starlings have been seen previously (Bailey and Sorensen 1962). A roost of about 30 starlings was found inland at Middle bay on 17 April 1988. The largest flocks seen were 40 birds at Antarctic Peninsula (south coast) on 31 May and 40 near Moubray (east coast) on 26 August 1988.

CHAPTER 6: SOUTHERN ELEPHANT SEAL

6.1 INTRODUCTION

The Southern elephant seal (*Mirounga leonina*) is widespread in the subantarctic with a 1985). Elephant seals in the New Zealand region belong to the population centred on Macquarie Island, where there are about 90,000 (Hindell and Burton 1987).

Although there may never have been a large population on Campbell Island, sealers wiped the species out after the island's discovery in 1810. Subsequently the seal was only a straggler to the island (Sorensen 1950b). In the 1940s Sorensen found that elephant seals were breeding and increasing in numbers. By October 1947 there were 15 harems located at 12 bays around the island, comprising 32 bulls, 194 females and 191 pups. With the arrival of males to moult in November 1944, there were over 1100 elephant seals on the island.

Since 1947 there has been a 97% reduction in the breeding population on Campbell Island (Taylor and Taylor 1989). In 1957 131 pups were counted (Bailey and Sorensen 1960) and in December 1975 Russ (1980) recorded up to 54 pups. This latter record is doubtful as only 18 pups were present in November 1975 and breeding females had departed. One year old seals arriving to moult may have been included in the December count, as they can easily be mistaken for pups. Eleven pups were born in 1984 and five in 1986 (Taylor and Taylor 1989).

6.2 AIMS

To determine the size and location of the breeding population of elephant seals in 1987-88. Outside the breeding season, to monitor the population on an opportunistic basis. This information was requested by M. Cawthron (DOC, Wellington) and R. Taylor (Ecology Division, DSIR, Nelson).

6.3 METHODS

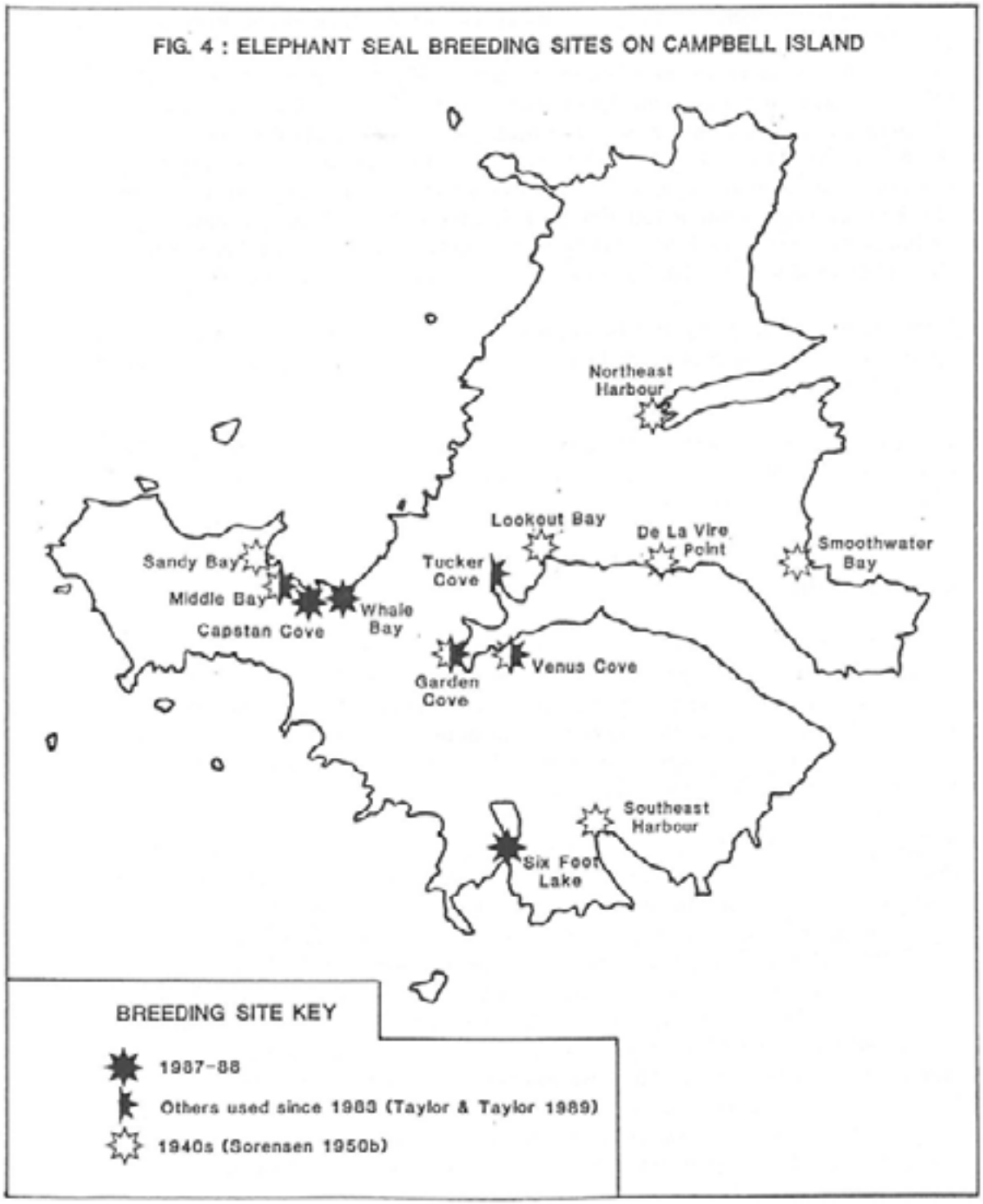
In late October-early November visits were made to all sites used in recent years for breeding by elephant seals. The number of bulls, cows and pups were recorded. In later months counts were made of bulls, subadults and young seals during all visits to Northwest Bay and on a more opportunistic basis in other areas.

6.4 RESULTS

6.4.1 Breeding Population

Former breeding sites were visited between 20-22 October 1987 and the Northwest Bay sites revisited subsequently. There were three harems comprising 3 bulls, 9 cows and 6 pups. These were at Whale Bay (2 cows, 2 pups), Capstan Cove (6 cows, 3 pups) and Six Foot Lake (1 cow, but not present when visit made, 1 pup abandoned and seemingly in poor condition) (Fig. 4). The fate of the pups is uncertain but probably only one or two at Capstan Cove survived.

FIG. 4 : ELEPHANT SEAL BREEDING SITES ON CAMPBELL ISLAND



The following season a newly born pup was seen at Whale Bay on 13 September. It was seen again five days later but had disappeared the next day. On 24 September a pup was seen at Capstan Cove, but was gone four days later. Another pup was born on 30 September and was still alive three days later when observations of the expedition ended.

6.4.2 Non-Breeding Population

The numbers of elephant seals at Northwest Bay were lowest in the breeding season, about 5-13 animals, when few non-breeding seals were present. Numbers increased through November to a peak of 88 in December (Fig. 5, Appendix 8) with the arrival of younger seals for the moult. These seals included 29 subadults and 59 small elephant seals, most of which were at Capstan Cove and Sandy Bay. At different times during late November-December there were also 16 elephant seals seen on the western coast, 23 at Rocky Bay, 16 at Perseverance Harbour and 7 at Southeast Harbour, making a total of 150. Other likely sites such as Monument and Northeast harbours were not visited, but judging from counts made there in other months the December total for the island was probably less than 200 elephant seals.

Numbers of seals at Northwest Bay decreased to less than 30 for the rest of the year, apart from a brief peak of 47 in June. Large bulls arrived in August and females in September.

Two elephant seals tagged on Macquarie Island were seen on Campbell Island in 1988. One adult (blue 1035) was seen several times in February, and a young animal (blue 640/641) was seen twice in June.

6.5 DISCUSSION

The breeding population of elephant seals at Campbell Island is very small. Allowing for pups that may have died before the survey in October 1987, there were at least 6 and probably less than 10 pups born. This is substantially less than the 191 pups found in 1947, however, at that time the number of pups born had doubled in the six years since 1941 when 75-100 pups were estimated (Sorensen 1950b). Presumably this was part of the increase after the sealing era.

At Macquarie Island elephant seal numbers may have increased beyond pre-sealing levels, although the original numbers are very hard to estimate (Hindell and Burton 1988). An over-shoot in population level could have been caused by an abundant food supply available at the end of the sealing era. The peak seal population occurred at or before the 1950s followed by a decline of more than 44% (Hindell and Burton 1987), possibly indicating that the population was returning to equilibrium (Hindell and Burton 1988). This may explain the changes that have occurred on Campbell Island. Taylor and Taylor (1989) do not consider this option in their analysis of changes in the Campbell Island population. They use the only accurate surveys of 1947, 1984 and 1986 to illustrate the 97% decline in pup production. The causes may involve a complex of ecological factors, including the effects of sea temperature and circulation changes on the food supply and increased predation by killer whales and sharks (Taylor and Taylor 1989).

FIG. 5 : ELEPHANT SEAL NUMBERS AT NORTHWEST BAY 1987–88

CHAPTER 7: HOOKER'S SEA LION

7.1 INTRODUCTION

Hooker's sea lion (*Phocarctos hookeri*) is confined to the New Zealand region. The breeding population is centred on the Auckland Islands where there are about 4000 seals (Cawthorn *et al*. 1985). Campbell Island has a small breeding population, with about 50-100 pups born annually, and fewer than 10 pups are born at the Snares Islands each year. Outside the breeding season sea lions range to Macquarie Island and the South Island of New Zealand. The total population may be 6000-7000 (Doonon and Cawthorn 1984).

Sea lions were exploited for skins and oil by sealers after the discovery of the Auckland Islands in 1806 and Campbell Island in 1810. Records of ship visits to Campbell Island during the main sealing period up to 1830 are poor (Kerr 1976), and hence the original numbers of sea lions and the impact of sealers is unknown. The evidence suggests that Macquarie and Auckland islands were much more important commercially. One report from 1815-16 was that 300 hair skins (sea lions) were taken from Campbell Island (Warneke 1982).

Although the sea lion population had been recovering from this exploitation, the recent trawling for squid around the Auckland Islands has raised concern because of incidental catches of sea lions (Doonon and Cawthorn 1984).

In the 1940s the Campbell Island population appeared largely to be composed of "many hundreds" of surplus bachelor sea lions from the Auckland Islands and no more than 20 breeding females (Bailey and Sorensen 1962). On 13 February 1958 the main concentration of sea lions was of 84 males and 5 females at Sandy Bay, and 74 males were counted there on 21 November 1975 (Russ 1980).

In contrast to the Auckland Islands, where breeding and pupping takes place in harems, Campbell Island females travel considerable distances inland to have their pups. They have been reported near the top of Mt. Honey, over 500m above sea level and 1.5km inland.

7.2 AIM

To monitor the breeding and non-breeding populations of Hooker's sea lions on Campbell Island. This information was requested by M. Cawthorn (DOC, Wellington).

7.3 METHODS

Counts of sea lions were made on an opportunistic basis but were most frequent at Sandy Bay. Records were made of pup births and sightings, and tagging of pups was conducted in March-April.

7.4 RESULTS

7.4.1 Breeding Population

The locations of sea lion pups found from December 1987 to February 1988 are shown in Fig 6 and tabulated in Table 7. Of the 34 pups found, 19 were inland at Northwest Bay. The first pup born was on 16 December. One pup near the peak of Yvon Villarceau was more than 300m above sea level and a few others elsewhere were above 200m. Most were found within 500m of the coast and less than 100m above sea level.

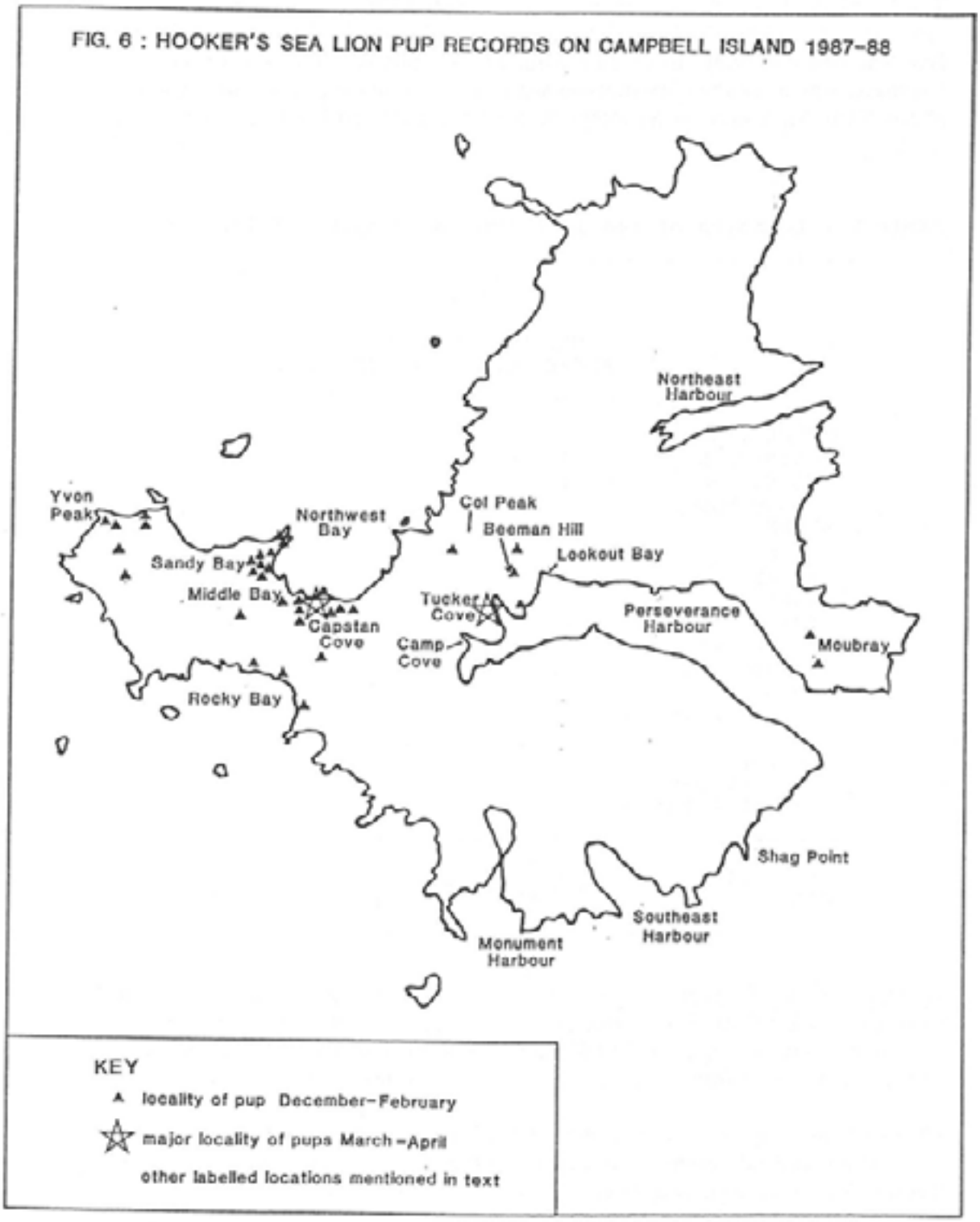
Table 7: Location of sea lion pups on Campbell Island 1987-88

Area	Number of pups			
	Dec-Feb		Mar-Apr	
	Alive	Dead	Alive	Dead
NORTHWEST BAY				
Capstan Bay	7	1	13	2
Middle Bay	1		1	2
Sandy Bay	9	1	2	
WESTERN				
Yvon	5	1		
Rocky Bay	3			
EASTERN				
Moubray	2			
PERSEVERANCE				
Venus Cove			1	
Camp Cove			1	
Tucker Cove			18	1
Col	1			
Beeman	1	2	3	
Lookout Bay			6	
Boyack Point			1	
SUB-TOTAL	29	5	46	5
TOTAL	34		51	

By March-April pups began to gather at or near the coast, particularly at Capstan Cove and Tucker Cove. Forty-three pups were tagged, a further three live and five dead pups seen, making a total of 51 pups (Table 7). The pups were apparently arriving at the coast from inland before dispersing as most were not seen after tagging.

Of the 43 pups tagged 15 were resighted, 9 of these between May and September, and one was found dead. Some were seen up to four times. Three of the pups tagged at Tucker Cove were seen away from Perseverance Harbour. One was at Northeast Harbour, 18km by sea from Tucker Cove, and the other two were at Shag Point, 11 km away from the natal area.

FIG. 6 : HOOKER'S SEA LION PUP RECORDS ON CAMPBELL ISLAND 1987–88



Small groups of pups, the majority untagged, were often seen between May and September in the main harbours. For example, 17 were seen at Shag Point on 24 May, 8 at Garden Cove on 31 August and 10 at Tucker Cove on 5 September. On all three occasions only 2 (12-25%) of these pups were tagged individuals. At the head of Northeast Harbour on 4 June there were up to 34 pups, and it appeared that only one or two were tagged (3-6%). Accurate tag ratios were rarely obtained because the animals were usually seen in the water.

7.4.2 Non-Breeding Population

Counts of Hooker's sea lions made at Sandy Bay, Middle Bay and Tucker Cove are illustrated in Fig. 7 and Appendix 9.

Males congregated at Sandy Bay thoughout the year, but large, often daily variations occurred between counts. Generally, from June to February there were 20-80 sea lions present, and the highest count of 114 was on 10 February. Counts were lower from March to May when less than 40 were present. Usually no females were present on the beach, although on one occasion there were 8, well separated from any males.

Middle Bay (Fig 7b) accumulated sand on its beach during the year and became more popular for sea lions, particularly between June and August. These were usually a few males (probably non-breeders) that had gathered a harem of females. The highest count was of 25 males and 39 females on 17 July 1988.

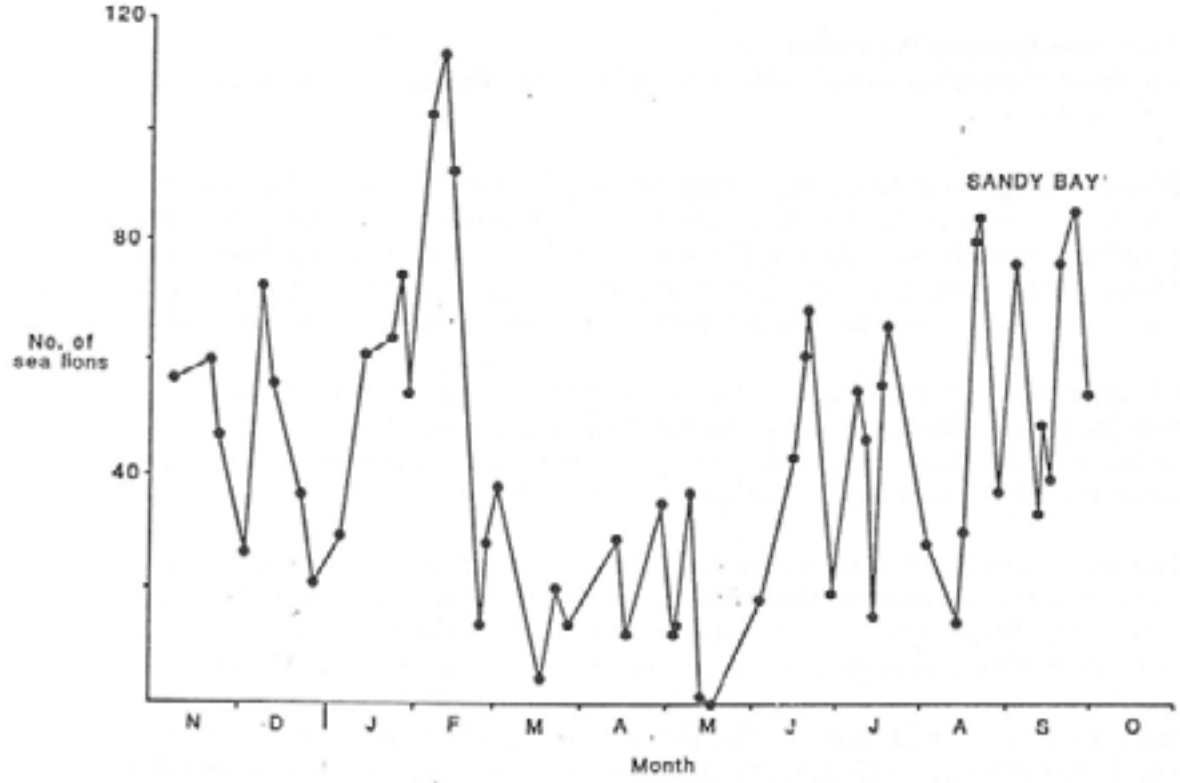
Harems also gathered at the old farm homestead area on the west side of Tucker Cove. It is not certain when this behaviour started as the cove was not visited for some time before March. On 7 March meteorological staff estimated there may have more than 100 sea lions present, but an accurate count was not made. Many of these sea lions were probably breeding animals because several pups were tagged either from the harems, or in scrub nearby. The highest count at Tucker Cove of 40 males and 27 females was on 13 April, but after mid May only a few sea lions were present.

At most other bays and harbours there were isolated sightings of small groups or individual sea lions. There were worn sea lion tracks into the scrub in most accessible parts of the shoreline, especially at Perseverance, Northeast, Southeast and Monument Harbours, and Shag Point. Highest counts in these areas were 23 at the head of Northeast Harbour on 4 June and 30 on the main beach of Southeast Harbour on 4 August. Another popular haul-out site was the sandy beach and cave beside Blue Lagoon, Penguin Bay, where up to 35 sea lions were counted.

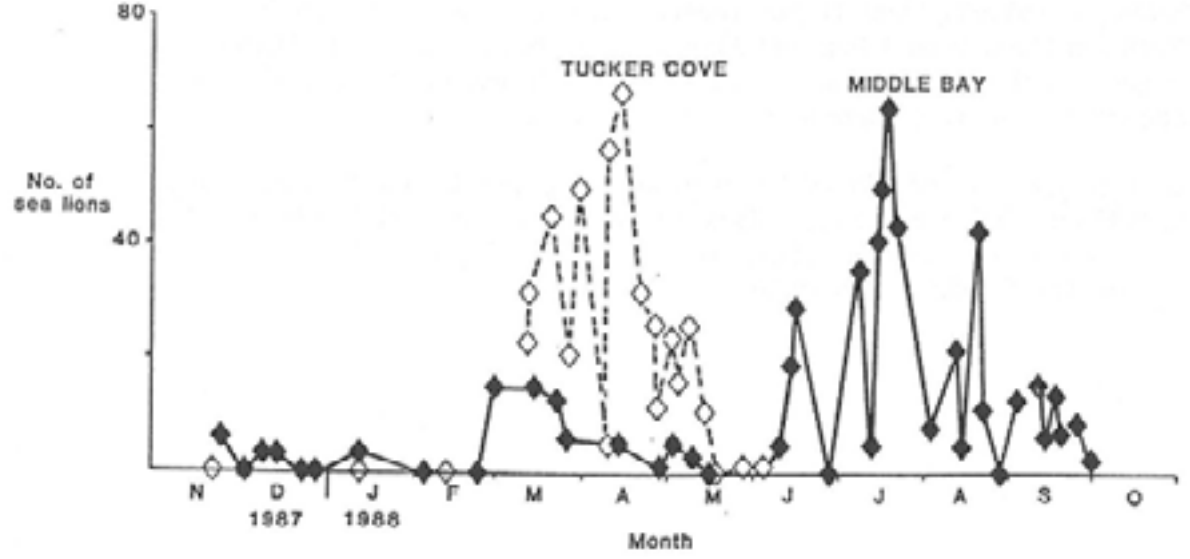
Between 1984 and 1987 39 sea lion pups were tagged on Campbell Island. One tagged in 1987 was seen several times in Perseverance Harbour in 1988. In addition 12 tagged sea lions from the Auckland Islands were recorded during this study, the eldest a four year old (M. Cawthron pers. comm.)

FIG. 7 : HOOKER'S SEA LION NUMBERS ON CAMPBELL ISLAND 1987–88

a) SANDY BAY



b) MIDDLE BAY AND TUCKER COVE



7.5 DISCUSSION

The majority of sea lion pups found early in the breeding season were at Northwest Bay. This partly reflects theamount of time we spent there looking for yellow-eyed penguin chicks. This is shown by the fact that 20 pups were found in March-April after 17 had been seen alive in preceding months, whereas 19 were seen at the coast of Tucker Cove in March-April but none in earlier months. Previous tagging of pups indicated that some born at Northwest Bay were brought over Col ridge by their mothers to the shelter of Perseverance Harbour (R. Stewart in Fraser 1986). This was not confirmed in 1988.

Other possible areas of pup production rarely visited during the breeding season included Shag Point and Monument, Southeast and Northeast Harbours.

With 51 pups known in March-April and five dead in earlier months, at least 56 were born in total. If pups seen at the far west of the island, Rocky Bay and Moubray, did not later gather at Perseverance Harbour and Northwest Bay, the total of known births would have been 67. This suggests that the estimate of 50-100 pups born annually (Cawthorn *et al.* 1985) is a reasonable one.

If pups seen in winter were locally born, the maximum tagged proportion of 25% suggests that at least 172 pups had been born on the island. This is plausible when the amount of potential breeding habitat is considered. However, in May 1981 three pups tagged on the Auckland Islands turned up on Campbell Island apparently in a cohesive .group of 36 pups (B. Graham pers. comm. to M. Cawthorn). The frequency of this type of input to the Campbell Island population is unknown.

A systematic population survey and tagging programme would be necessary to answer the questions raised here. However, the evidence suggests that there must be approximately 70-150 females and 120-200 males making a total of 200-350 sea lions on Campbell Island.

CHAPTER 8: NEW ZEALAND FUR SEAL

8.1 INTRODUCTION

New Zealand fur sealas (*Arctocephalus forsteri*) are found throughout the New Zealand region and South and Western Australia (King 1983). The species was brought close to extinction by commercial sealers during the nineteenth century but is now steadily increasing in numbers and expanding its range (Crawley and Wilson 1976).

In the early 1970s the population in the New Zealand region was estimated at 39,000 (Wilson 1981) and this was recently revised to 50,000 (Mattlin 1987). The Campbell Island contribution has been widely quoted as 2000 (e.g. Warneke 1982), although this is based on an estimate by R. Falla in 1943 (Sorensen 1969).

It is clear that Macquarie and Auckland Islands were much more important commercial sealing grounds than Campbell Island, and therefore records of the numbers of seals taken from Campbell are sketchy. Hasselbourgh apparently took 15,000 skins in 1810, the year he discovered the island, but most other expeditions reported less than 200 skins per visit (Warneke 1982). The fur seal fishery officially closed in 1894 but restricted licenses were issued to the whalers and farmers on Campbell Island in 1913-16, with 2400 seals killed in 1914 alone (Kerr and Judd 1978), and again in 1922-24, when 350 skins were taken (Sorensen 1969).

8.2 AIM

To obtain data on fur seal numbers on Campbell Island.

8.3 METHOD

Because of the amount of rocky shoreline on Campbell Island and the constraints of time, only one day was allocated to a systematic fur seal count. This was conducted at Rocky Bay on 29 December 1987. Fur seal adults and pups were counted by two people walking along the shoreline and searching in crevices and between rocks.

8.4 RESULTS

The length of Rocky Bay was surveyed on 29 December 1987 and 338 adults and 126 pups were found. Most of the pups appeared to be recently born.

Other places where fur seals were seen were Sandy Bay and Middle Bay (occasional single animals only), Borchgrevink Bay, Penguin Bay, Paris coastline, Davis Point (Perseverance Harbour) and Smoothwater Bay. The first pups seen were at Cattle Bay on 24 November 1987.

8.5 DISCUSSION

The only available population data from recent times comes from counts of seven parts of the coastline in January-February 1958 when a total of 778 fur seals was recorded (Bailey and Sorensen 1962). Assuming the "accessible" part of the south coast refers to Rocky Bay, 139 seals and 18 pups were present in 1958. Although the 1987 count was much higher than this, a comparison is not valid because the counts were made at different times of the breeding season.

Future counts at Rocky Bay conducted at a similar time to the 1987 survey, should provide an indication of population changes. Surveys in other areas would also be useful, however, much of the coastline can only be scanned by binoculars from cliff tops. Although such surveys are likely to underestimate greatly the numbers of seals amongst the rocks, they would still provide a useful index.

CHAPTER 9: LEOPARD SEAL

9.1 INTRODUCTION

Leopard seals (*Hydrurga leptonyx*) occur on the Antarctic Continent and as vagrants further north. Usually a few single animals are seen each year on Campbell Island between August and December (Bailey and Sorensen 1962). Some vagrants to Macquarie island have been tagged and then resighted at Campbell Island (Rounsevell and Eberhard 1980).

9.2 RESULTS

There were eight sightings of leopard seals in 1987-88. Five were in October-November 1987, one in July 1988 and two in September 1988. Localities were Northwest Bay, Southeast Harbour and Perseverance Harbour. Three seals were tagged and one, which was tagged at Northwest Bay on 8 November, was resighted at Southeast Harbour on 29 November.

CHAPTER 10: SOUTHERN RIGHT WHALE

10.1 INTRODUCTION

The Southern right whale (*Balaena glacialis australis*) has a circumpolar distribution in the southern hemisphere. It was considered the "right" whale to hunt because it was easily caught, floated when dead and had a high oil content (Gaskin 1972). Thousands of right whales were taken near the New Zealand coast (Cawthorn 1978) and the species was almost hunted to extinction before 1850 (Gaskin 1968). Since its protection in 1936 the population began to recover (Gaskin 1963). The southern hemisphere population has been estimated at 3000-4000 with an apparent increase of 10% per year in the 1970s (FAO 1978).

At Campbell Island two whaling stations operated between 1909 and 1916, at Northwest Bay and Northeast Harbour. Records of the number of whales taken are incomplete but 63 had been taken by 1912, including 21 in 1911 (Kerr 1976). Because of the problems of isolation and equipment loss, the whaling operations became inefficient and catches dropped (Kerr and Judd 1978). Probably fewer than 100 whales were taken in total. Consequently, Campbell Island may have been one of the last strongholds of the species in the New Zealand region (Cawthorn 1978).

Southern right whales visit Northwest Bay at Campbell Island where mating and young calves have been observed (Cawthorn 1978).

Other species of whale sighted occasionally at or near Campbell Island include killer whales (*Orcinus orca*) (Dilks and Grindell 1983), sperm whales (*Physeter macrocephalus*), humpback whales (*Megaptera novaeangliae*), fin whales (*Balaenoptera physalus*) (Bailey and Sorensen 1962), blue whales (*B. musculus*) and dolphins (Sorensen 1951).

10.2 AIMS

In 1988 it was planned to monitor numbers of Southern right whales visiting Campbell Island. This information was requested by M. Cawthorn (DOC, Wellington).

10.3 METHODS

During visits to Northwest Bay and Bull Rock in March and April 1988 sign of whales was watched for. Once they were seen at Northwest bay, visits were made about twice a week, either by the authors or meteorological staff.

Most observations were made from the whale observation shelter near sea level between Middle Bay and Capstan Cove. Other vantage points in Northwest Bay were also used in combination with penguin counts. The elevated positions of the Northwest Bay hut and the Col ridge overlooking Whale Bay were also used on occasion.

The number of whales present in the bay was determined over observation periods of up to three or four hours. These lengthy observation periods eliminated the tendency to under-estimate the number of whales under water at any one time, or over-estimate by counting the same whales more than once as they moved around.

The effort and accuracy of counts varied depending on the observer, weather conditions and the number of whales present.

Photographs of whale head callosity patterns (white warty markings) were taken of individuals close to shore. Potentially, these can be used to identify individuals in future years.

10.4 RESULTS

All whales seen in 1988 appeared to be Southern right whales.

The first sighting for the year occurred on 27 March near Bull Rock (Appendix 10). Viewing from this site was opportunistic, and the last visit for the winter was on 21 May. Ten whales were seen offshore on one occasion.

The first whales at Northwest Bay were observed on 14 April but regular sightings were not made until a month later (Fig. 8). From June to August 8-12 whales were usually present. During this peak period the mean count was 8 (S.D.=4.2 N=20). July had the highest mean count of 9.5 and the maximum count of 19 whales (Fig. 8). Two distinctively marked individuals were seen throughout the season suggesting that the 12 whales regularly counted may have been the core of the population. The whales departed over a short period between late August and early September.

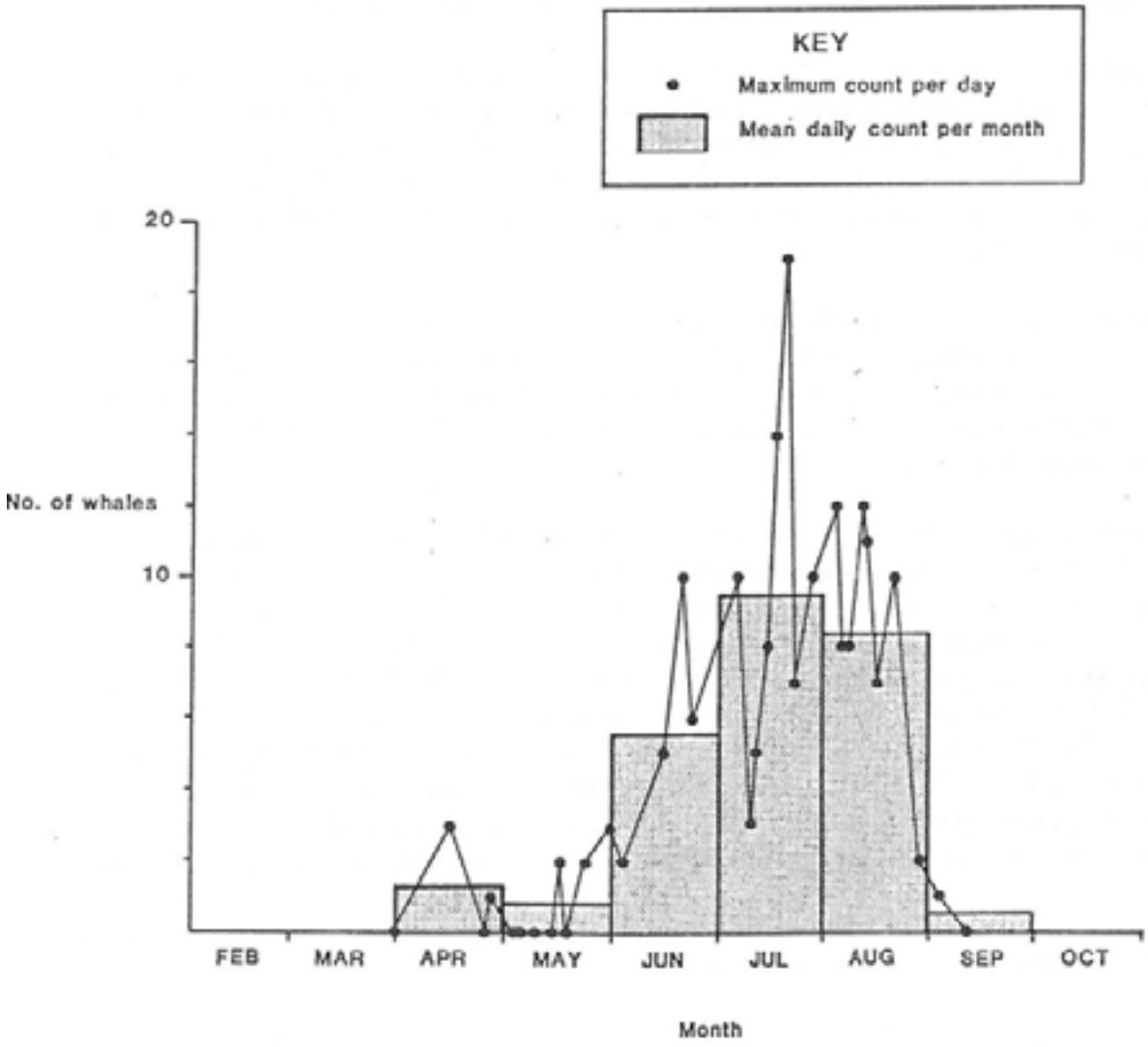
During the peak period groups of two, sometimes up to five, whales gathered and interacted by circling and rolling together, raising flippers, tails, or heads above the water, slapping tails or flippers on the surface and swimming upside down. Individuals occasionally breached (jumped) several times in succession.

Whales were also seen at the adjacent Cattle Bay but regular observations were not made there.

There were three sightings in Perseverance Harbour, but these whales did not linger for long. None were seen at Northeast, Monument or Southeast Harbours when these areas were visited in winter.

The cumulative total of whale sightings in 1988 was 210, with 175 from Northwest Bay.

FIG. 8 : NUMBERS OF SOUTHERN RIGHT WHALES AT NORTHWEST BAY 1988



10.5 DISCUSSION

The period of Southern right whale occurrence at Campbell Island in 1988 was late March to early September, with the peak of numbers in June-August. This is similar to the pattern of cumulative monthly sightings shown by Cawthorn (1978) except we sighted few whales in September and none in October. Gaskin (1968,1972) found that the peak of sightings by whalers in 1911-12 was as early as May-July. However, it is possible that the hunting efforts of the whalers early in the season would have decreased the likelihood of sightings later in the season. Also, cumulative monthly sightings rather than the maximum count per day could be misleading.

During the winter of 1987, as in 1988, the first whales seen were at Bull Rock, followed by a gradual increase in whale numbers at Northwest Bay. This suggests that whales may first visit the north of the island before gathering at the breeding grounds of Northwest Bay. This may relate to the fact that, contrary to previous beliefs, right whales travel south to the subantarctic for the winter (Cawthorn 1978).

Cawthorn (1978) assumed that most sightings of whales at Campbell Island were of different individuals and made a "highly speculative" estimate of 200 for the maximum population. The increased cumulative number of sightings per year suggested an annual increase of 2% at the island (Cawthorn 1984). This was supported by increased sightings off New Zealand and the Auckland Islands, where 75 whales were reported in 1984.

The cumulative total of 210 whale sightings in 1988 is higher than that reported for most years, which have a mean of 69 (Cawthorn 1978). However, this is dependant on the number of days of observation. Cumulative sightings of whales is the traditional way of presenting the data because many sightings are made at sea rather than from land-based sites.

A few excerpts from J. Sorensen's diary from the 1940s mention that 'upwards of 15 whales were counted at Northwest Bay, although one entry states that "several dozen" were seen on one occasion (Bailey and Sorensen 1962). The most whales seen between 1957-60 at Northwest Bay was 19 and the 12 entries for June-August (Bailey and Sorensen 1962) give a mean count of 9, compared with the 1988 mean of 8 whales. In 1983 R. Stewart used distinctive markings to identify 28 individual adult whales and two calves at Campbell Island (Fraser 1986). The maximum number seen at once at Northwest Bay was 25 in the early 1980s (Cawthorn 1984), 23 in 1987 and 19 in 1988. These figures suggest that fewer than 30 whales frequent Campbell Island's inshore waters each winter and that numbers have remained at similar levels since the 1940s.

Photographs of whales taken at Northwest Bay in winter of 1988 show that courtship and copulation were taking place (M. Cawthorn pers. comm.).

10.6 RECOMMENDATIONS

1. Meteorological station staff should be encouraged to monitor the whale population in as systematic a way as possible. Although the site has limitations because of its low elevation, the whale observation shelter is a good compromise because its proximity to Northwest Bay hut stimulates its use. Observations should be for at least three

hours duration, and should be conducted regularly throughout the whale season.

2. Because whale observations on Campbell Island are dependant on volunteers and effort cannot easily be standardised during a season or between years, future data should be analysed on the basis of maximum counts per day, or mean daily counts per month rather than cumulative sightings.

3. Photographs of head callosity patterns are a valuable tool for the identification of individuals. Film for this purpose will be supplied by M. Cawthron (DOC, Wellington).

CHAPTER 11: SHEEP

11.1 INTRODUCTION

There have been several attempts to introduce mammals to Campbell Island, including goats, pigs and rabbits, none of which established (Sorensen *1951). A* small number of cattle *(Bos taurus*) survived but were finally shot in 1984. The first sheep were brought to the island in 1890.

Farming on Campbell Island began in 1895, when 300 to 400 sheep were introduced (Kerr 1976). By 1909-10 numbers had increased to over 8500 but then decreased to about 4000 by 1931, partly as a result of sheep export and the exhaustion of the indigenous pasture from overstocking and continued burning (Meurk 1977). At the same time there was a period of climatic cooling which would not have favoured sheep production (Rudge 1986). Eventually, the farming operation became uneconomic and was abandoned in 1931 (Wilson and Orwin 1964).

In 1954 Campbell Island became a nature reserve for the protection of flora and fauna (Bell and Taylor 1970) and concern was expressed about overgrazing by sheep leading to deterioration of the vegetation (Sorensen 1954a), soil erosion and thus reduction of nesting habitat for royal albatrosses (Westerskov 1959, 1963). However, by 1961 the sheep population had declined to fewer than 1000 (Wilson and Orwin 1964), probably as a result of matted double fleecing and fleecy tails impeding copulation and thus lowering productivity (Rudge 1986).

The decline did not continue despite constant killing of sheep for food by meteorological station staff (Westerskov 1963). By 1969 the sheep had increased to 3000 (Taylor *et al* 1970), apparently as a result of the gradual evolution of fleece shedding and early sexual maturation (Rudge 1986). Scientific interest in the sheep for their genetic and agricultural values was balanced against the detrimental effects of grazing on the vegetation composition and structure (Taylor 1968, Wilson 1979). The effect of sheep on albatrosses was not clear because from 1958 to 1969 royal albatrosses had doubled in number (Taylor *et al*. 1970).

In order to evaluate the effect of sheep on the flora and fauna of Campbell Island, Ecology Division, DSIR, proposed that the sheep be removed from half the island. Consequently, in 1969 a long-term research and management programme was accepted by the Outlying Island Reserve Committee (Taylor 1980). A fence was erected across the island from Tucker Cove to the western Col coastline in 1970, and nearly 1300 sheep were eradicated from the northern half of the island (Rudge 1986).

The sheep population south of the fenceline continued to rise from 2500 in 1971 to 3500 in 1983 (Dilks and 1983). In order to decrease the impact of sheep on the island a further restriction in their range was achieved in 1984 by erection of a fence from Capstan Cove to Rocky Bay. Four thousand and thirty sheep were shot in the eastern area but a small number remained south-east of Mount Honey. In 1987 19 sheep were shot in this area but at least 9 remained (A. Fyfe pers. comm.).

The new fence-line restricted a population of about 900 sheep to the western peninsula

of the island (Orwin 1984). In 1986 110 sheep were eradicated by meteorological staff along the western Paris-Yvon Villarceau coastline, 16 at Penguin Bay and 4 at Cattle Bay to reduce disturbance to the rockhopper penguin colonies.

11.2 AIM

To estimate the sheep population west of the 1984 fenceline, as requested by L. Sanson (DOC, Invercargill).

11.3 METHODS

Sheep were counted in 11 sectors of the area west of the fence on four days between 23-30 January 1988. Counts were made by walking through the sectors and selecting vantage points to view areas with binoculars. The constraints of time and weather meant that the western sectors (mainly sectors 3 and 5, Table 9) were counted quickly and from more distant vantage points than the eastern sectors.

11.4 RESULTS

11.4.1 Population

During the survey 1105 sheep were counted. Errors are likely where sheep were hidden amongst vegetation or where movements occurred during the survey period. However, it is likely that this is an under-estimate since previous counts have accounted for only 85% of the sheep, as determined by sheep eradication (Ballance 1985).

Table 8 indicates that in the western area sheep numbers increased from 48 in 1961 to between 560-800 during the 1970s and 1980s. Since the construction of the new fence in 1984, there has been a further increase from 900 to about 1100.

Table 8: Population of sheep west of 1984 fence

	SHEEP POPULATION	
Year	"Paris"	West of Fence
1961	48	
1969	774	
1971	808	
1976	563	
1977	680	
1978	695	
1980	796	
1981	778	
1984	759	922
1988		1105

Data from Dilks and Wilson (1979), Wilson and Elliot (1981), Dilks and Grindell (1983), Orwin (1984), this study. "Paris" as shown on the map in Dilks and Wilson (1979) is similar to the area now defined by the sheep fence, although Orwin (1984) obtained two quite different figures for the sheep numbers in the two areas.

11.4.2 Distribution

Sheep favoured the southern and western parts of the area (Fig. 9, Table 9). The largest concentrations were around Yvon Villarceau Peak, Mt Paris, Rocky Bay and east of Menhir. The remaining area is predominantly *Dracophyllum* scrub, which supported a lower density of sheep.

Table 9: Distribution of sheep, January 1988

AREA	NO. OF SHEEP
1. Penguin Bay	42
2. East Yvon Villarceau	154
3. South-west Yvon	136
4. South-east Yvon	29
5. North-west Paris	41
6. North-east Paris	129
7. East Paris	138
8. Rocky Bay	128
9. East Menhir-Dumas	181
10. Cattle Bay-Sandy Bay	58
11. Inland area	69
	1105

Areas 1-11 are illustrated in Fig. 9

11.4.3 Vegetation Change

In 1988 monitoring of vegetation changes in relation to presence of sheep in different parts of Campbell Island was continued (see Chapter 14).

11.4.4 The Fence

Since 1984 the fenceline has shown some deterioration from gradual loosening of wires and damage from sea lions passing under the fence. Repairs were made in 1988, two sheep were chased back to the western side and another escapee was shot.

11.5 DISCUSSION

Sheep numbers have increased to about 1100 despite culling of 130 in 1986, and a previous assumption that food had become limiting by 1971 (Dilks and Wilson 1979). Rudge (1986) explained the increase in sheep productivity after the 1950s as being the result of climatic warming and the selection of self-shedding traits and early maturation. These factors have probably continued to operate and was clear in 1988 that the sheep were in numbers which threatened the natural vegetation and landforms of western Campbell Island.

One potential interaction that sheep have with wildlife is the trampling and disturbance at rockhopper penguin colonies at Penguin Bay, although this is now not regarded as a major problem (D. Cunningham pers. comm.). To date it appears that sheep have not

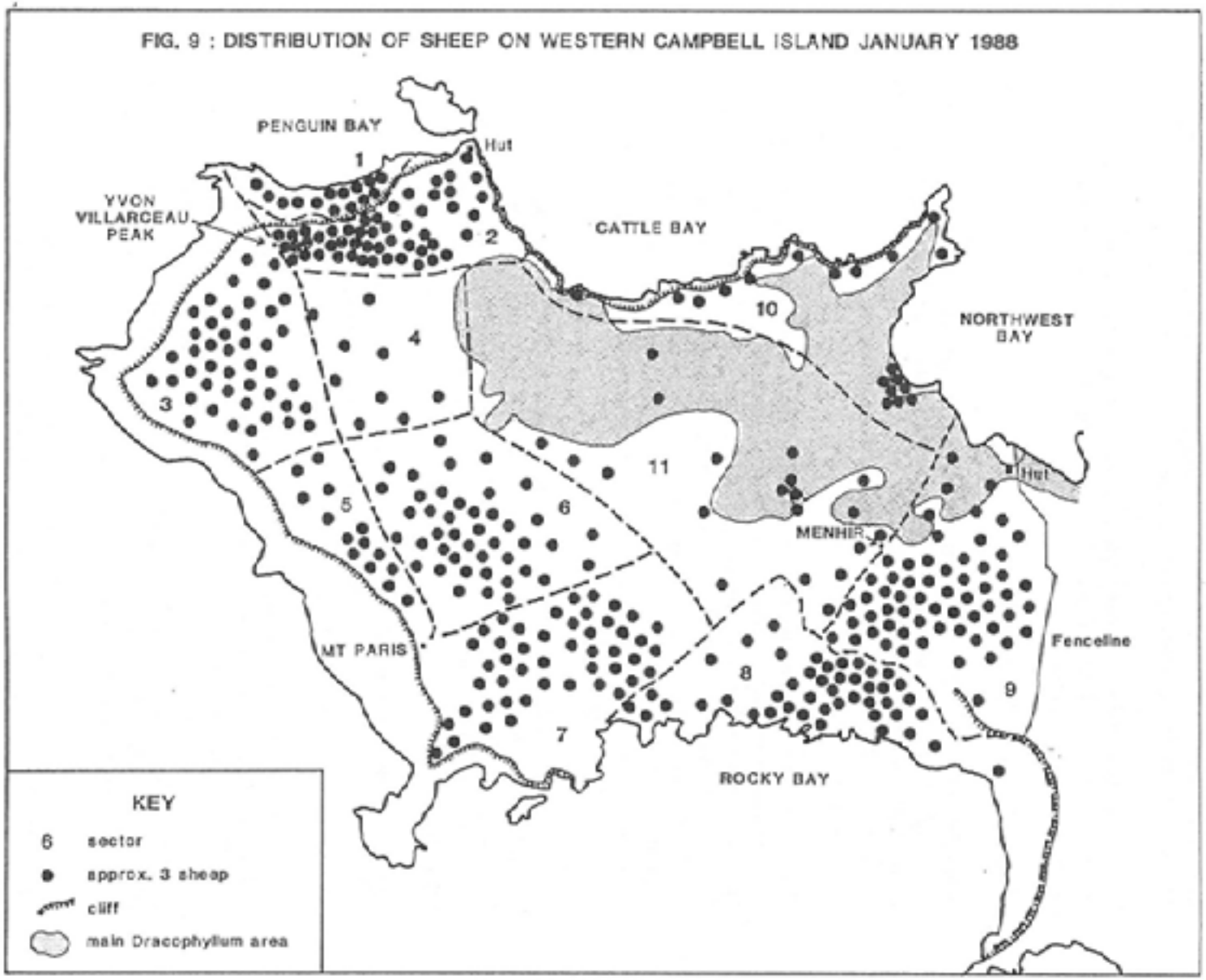


FIG. 9 : DISTRIBUTION OF SHEEP ON WESTERN CAMPBELL ISLAND JANUARY 1988
PENGUIN BAY
Hut
YVON VILLARCEAU PEAK
CATTLE BAY
NORTHWEST BAY
MENHIR
Hut
MT PARIS
Fenceline
ROCKY BAY
1
2
3
4
5
6
7
8
9
10
11
KEY
6 sector
approx. 3 sheep
cliff
main Dracophyllum area

recolonised areas below the cliffs on the Paris-Yvon Villarceau coastline. There is no apparent direct disturbance of nesting yellow-eyed penguins, but denudation of Rocky Bay has limited the potential nesting habitat, which may have led to a decline in numbers of penguins there (only 20 birds were counted there in 1988). A well maintained fence creates a barrier to yellow-eyed penguins and sea lions which breed considerable distances inland and move regularly to and from the sea. Currently there are a few places where penguins and seals get under the fence.

The fencing and removal of sheep has shown that many natural vegetation associations have the ability to recover without being overwhelmed by introduced species once grazing pressure is released.

SHEEP AND ALBATROSSES

The relationship between sheep numbers and royal albatross nesting is unclear. It has been suggested that grazing opened up the dense tussock stands making more ground available for nesting (Sorensen 1950a, Westerskov 1963). However, Westerskov (1963) also pointed out that overgrazing, burning, erosion and spread of *Bulbinella* reduced the nesting opportunities for albatrosses.

Overgrazing was noted in the 1920s by Guthrie-Smith who expressed shock at "the defilement by stock of this splendid natural Albatrosses were apparently diminishing in numbers at the time as they could not be found in areas they were known previously. Guthrie-Smith believed the causes of the decline were the degradation of the dense tussock nesting habitat, predation of adults by sheep dogs and the taking of eggs by shepherds. Even the sheep at this time were suffering the effects of overgrazing and burning of the pasture, since they had declined from 8500 to 4000 (Meurk 1977).

Sealers, whalers and farmers were also probably killing albatrosses (Atkinson and Bell 1973), for example six albatrosses were exported in 1922 along with wool and seal skins (Kerr 1976). Albatrosses were also collected to use their feet for money pouches (Kerr and Judd 1978), and as all wildlife was considered a food source, the birds were easy game.

After the departure of the shepherds in 1931 and the further decline of sheep over the next 30 years, albatrosses would have suffered less direct and indirect interference and the population began to recover.

Surveys of albatross numbers from 1958 to 1976 indicated that a substantial increase had occurred (see Chapter 3). Although inaccurate surveying and population fluctuations caused by biennial breeding may have given a false impression, it seems that the increasing sheep population had no detrimental effect on the albatross population. Also, the pattern of change in the albatross population was similar either side of the two fencelines. Possibly the sheep population had not reached pre-1931 density before being removed from most of the island.

Food supply is likely to be the main factor limiting the size of the albatross population. The quantity or quality of the nesting habitat may only become limiting in prolonged periods of high sheep density, such as occurred in the farming era.

Action is necessary to arrest the further deterioration of the western part of Campbell Island. There are three main options.

1. Eradication
A single eradication operation would be the most cost-effective option. A number of sheep could be removed to New Zealand to preserve their unique genetic qualities. Such sheep could be used in breeding programmes and genetic engineering projects for the benefit of the sheep breeding industry in New Zealand.

2. Periodic Culling
An on-going programme of culling to keep the sheep population below harmful levels is a compromise option. However, vegetation recovery is unlikely if 400 ewes are maintained, as proposed in the Management Plan for the Campbell Islands Nature Reserve (Department of Lands and Survey 1983), since this is close to the 1988 population level. The population would have to be reduced to a much lower level (e.g. less than 100 ewes) for many years for there to be any significant vegetation recovery. Regular and effective maintenance of the fence would be necessary to repair damage by sheep and sea lions.

3. Fencing Restriction
Restricting the sheep to an even smaller part of the island is probably the most expensive option since it would require another large-scale fencing operation and an on-going culling programme.

11.6 RECOMMENDATIONS

1. Eradication of sheep from Campbell Island is recommended because it is the simplest and cheapest solution to the problems that sheep have created and would be of the greatest benefit to the Nature Reserve. Progressive restriction of the range of sheep has shown that the vegetation can make a dramatic recovery. Previous fencing options have in part been compromises which have delayed the need to make a permanent decision on the fate of the island's sheep.

2. If sheep are eradicated a live sample should be returned to New Zealand for further study.

CHAPTER 12: NORWAY RAT

12.1 INTRODUCTION

Norway rats (*Rattus norvegicus*) apparently colonised Campbell Island in the mid-1800s possibly after the 'Erebus' or 'Terror' ran aground in 1840 and stores had to be offloaded onto the shores of Perseverance Harbour (Taylor 1986b). They soon became extremely numerous and a nuisance to human habitation, for example "they ate our boots, our parkas" and "the putty out of the boat!" (Sorensen 1951). They also practically eliminated small petrels and shearwaters from the island (Bailey and Sorensen 1962) and restricted Campbell Island teal and New Zealand pipits to offshore islets. Burrowing seabirds are more at threat from Norway rats than other rat species (Atkinson 1985). Consequently, rats have been described as a far greater threat to the island's status as a nature reserve than the much publicised presence of sheep (Taylor 1980).

Taylor (1986a, b) conducted a major study of Norway rats on the island from April 1984 to April 1985. He found that rats occurred at densities higher than that recorded in New Zealand and estimated a population of 100,000. They were widespread on the main island but were not found on islands further than 50 m offshore. Despite the fact that whalers used to land on Dent Island to catch mutton birds (sooty shearwater chicks) (Kerr and Judd 1978), rats are not present there and thus the island is the last refuge for the flightless Campbell Island teal.

At the time Norway rats colonised Campbell Island, this species was probably still the most common rodent aboard ships. Since the 1850s the ship rat (*Rattus rattus*) has become more common on ships (Atkinson 1985), and it is probably pure chance that this species has not reached the island as they are found on Macquarie Island.

At present rats are poisoned around the Meteorological Station, particularly when ships visit, to protect the base from infestation by local rats and colonisation by new species.

12.2 AIMS

Taylor (1986a, b) proposed that a snap-trapping line be monitored every six months to determine rat population fluctuations and arrivals of new species. An aim in 1987-88 was to set up this index line.

12.3 METHODS

A rat trap index line was established from Beeman Meteorological Station to the Col-Lyall Saddle, 2.5km to the north. This is similar in location to "line 1" of Taylor (1986a, b).

Fifty sites approximately 50m apart were marked by metal pegs and wire tunnels. One trap per site was set and tied to the tunnel or adjacent vegetation to prevent it being carried away by a rat. Traps were baited with a firm but moist mixture of peanut butter and rolled oats.

The trap line was run for three nights in April and in September, after which the traps were removed, cleaned, brushed with fish oil to prevent rusting, and stored in the laboratory at Beeman Cove Hostel.

Data recorded for each trap were the capture of a rat, trap sprung and/or bait removed. The sex and maturity of rats caught were recorded following guidelines of Cunningham and Moors (1983), as were indices of abundance and morphometric measurements.

If the index lines are run in future years, any rats that do not appear to be Norway rats should be frozen and sent to New Zealand for identification.

12.4 RESULTS

The abundance of rats on the index line in 1988 is shown in Table 10 and Appendix 11. Twice as many rats were caught in September as April. For both trapping periods combined the index was 24.7 captures/100 trap-nights.

Table 10: Abundance of rats on Col-Lyall index line 1988

	DATE	
	4-6 April	5-7 September
Rats caught	21	43
Captures and sprung traps	40	60
Trap nights	150	150
Corrected trap nights[1]	130	120
Index of abundance[2]	16.2	35.8

KEY 1: Total trap nights minus half the number of interfered traps (including captures and sprung traps, but not those uith bait removed.

2: Captures per 100 trap nights = $\frac{\text{captures x 100}}{\text{corrected trap nights}}$

The extent of trap interference including rats caught as well as traps sprung and bait removed was 37% in April and 45% in September.

The measurements of adult rats are shown in Table 11. The sex ratio of adults caught in September was almost equal, however in April only four males and 13 females were caught. There were no significant differences in measurements between the two trapping periods. Females were significantly lighter ($p<0.001$) and had shorter feet ($p<0.001$) than males.

Table 11 : Measurements of adult rats on Campbell Island, April and September 1987-88

	MEAN	S.D.	RANGE
a) MALES (N=21)			
Weight (g)	223.8	27.8	172.3-277.4
Head-body length (mm)	168.9	1.9	153.0-184.0
Tail length (mm)	153.0	11.2	125.0-167.0
Foot length (mm)	37.0	1.5	33.6-39.7
Ear length (mm)	17.6	0.8	16.4-19.5
b) FEMALES (N=31)			
Weight (g)	181.4	28.7	127.6-256.5
Head-body length (mm)	163.2	9.8	142.0-179.0
Tail length (mm)	147.4	11.2	128.0-167.0
Foot length	35.3	1.3	31.9-37.5
Ear length (mm)	17.2	0.9	14.5-19.0

12.5 DISCUSSION

Rat abundance apparently fluctuates markedly between different years on Campbell Island. In1984-85 Taylor (1986b) found indices of rat abundance on line 1 (equivalent to the index line used in this study) to be 61 in April/May 1984, 57 in August/September 1984 and 73 in march/April 1985. The overall average indices for eight index lines were 79, 87 and 56 in the respective months. The 1988 results suggest a much lower rat abundance, with indices of 16 in early April and 36 in September. In May 1989 the same index line had an intermediate figure of 43 (data from P. Hatfield).

Although 1984-85 may have been a season of maximum abundance, subsequent results still show that the Norway rat is very abundant on Campbell Island. From other Norway rat studies in New Zealand mean trapping success of 0.1-37.3 rats/100 trap nights have been recorded (Moors 1985). These figures included an index of 15 from early February 1984 at Penguin Bay, Campbell Island. At an equivalent time in 1985 at Penguin Bay (line 7), the index was 48 rats/100 trap nights (Taylor 1986b).

The mean weight of male rats caught was similar to that reported by Moors (1985) and Taylor (1986b). However female weights and body and tail lengths were smaller than in other studies. This may be a result of immature animals being included in the sample (since they were not dissected) or failure to adequately flatten out the stiffened corpses for measurement. The heaviest male caught was 277g compared with an individual of 425g caught in 1984-85 (Taylor 1986b), although rats this large are rare in the wild (Moors 1985).

12.6 RECOMMENDATIONS

Regular trapping of rats along the index line by meteorological staff would provide data on changes of abundance and identify invasions of new species. To gather comparable data, early April and early September should be the main sampling periods.

The island must be protected from invasion by other species of rodents by continuing to poison rats at the Meteorological station when vessels arrive. Protection from pests on the vessels themselves may not be as effective as it should be.

Although it would be very desirable to eradicate rats from Campbell Island, at 11,000ha the size of the island makes this task impracticable. However, eradication methods are improving and it is now possible to eradicate this species from islands as large as 170 ha (Thomas and Taylor 1988).

CHAPTER 13: FERAL CAT

13.1 INTRODUCTION

Feral cats (*Felis cattus*) are scarce on Campbell Island (Dilks 1979) possibly because of a lack of dry sites where they can shelter or raise litters (Taylor 1986b). The situation is different on Macquarie Island, where a population of 250-500 cats utilises rabbit burrows (Jones 1977). Prior to 1916, the whalers apparently did not know of cats on the island (Kerr and Judd 1978) so they may have been introduced by farmers to control rats. Sorensen noted in his diaries of the 1940s rare sightings of cat tracks, and mentions a female kitten that was brought from the Auckland Islands in 1943. This cat later had kittens (Sorensen 1942-47). Cat scats found in the 1970s mainly comprised rat and insect remains with some small birds (Dilks 1979). Although the small number of cats on Campbell Island probably do not significantly affect the remaining birdlife (Veitch 1985), calls for their eradication have been made (Dilks 1979, Taylor 1980). Cats have been successfully removed from large islands such as Little Barrier Island (2817ha), but only after several years of intensive effort (Veitch 1985).

13.2 AIM

To test the attractiveness of a commercial cat bait, as requested by L. Sanson (DOC, Invercargill).

13.3 METHODS

On 5 April 1988 10 bait stations were placed 20-30m apart in the Cave Rock area, a ridge between Camp Cove and Mount Dumas, where cat sign had been noted. Six stations had floor tiles coated with tracking spray and covered by half-metal drums. The other four were bare patches of peat. Four baits were tested; two flavours of a commercial cat bait, a dry commercial cat food and sardines. Three of the four baits were placed at each station and replaced each day.

13.4 RESULTS

The bait stations were visited each day for five days. At the covered stations only rat footprints were found and no prints were visible on the open peat sites. The bait at all sites deteriorated quickly because of rain and wind. After five days the tracking spray ran out and the experiment was abandoned.

13.5 DISCUSSION

This type of experiment should be tried in areas of high cat density and at sheltered sites. Campbell Island satisfies neither of these criteria.

Although cats probably played an important role in the demise of burrowing seabirds, flightless teal and pipits on the main island, their low numbers in comparison with rats probably make their current effect on wildlife minimal. Eradication of cats would only be of value if it was possible to remove rats as well.

CHAPTER 14: VEGETATION

14.1 INTRODUCTION

The subantarctic maritime climate has resulted in vegetation associations on Campbell Island which are subalpine and alpine in character, ranging from *Dracophyllum* dwarf-forest in sheltered harbours and gullies, snow grass tussock (*Chionochloa antarctica*) and shrub associations, to high alpine wet rush-herbfields (Meurk 1977).

Human occupation since 1810 has modified the environment through fires and introduction of exotic plants, although several attempted introductions failed. The most famous planting was of a spruce tree (Picea sp.) during or after the visit of Governor Lord Ranfurly in 1902. It represents the island's only tree and is considered an historic site (Palmer and Judd 1981). Introductions of alien species have continued to the present day around the Meteorological Station, with the establishment of lawns, chicken house and greenhouse. For instance, several introduced species were recorded in 1944 after garden soil was brought from New Zealand (Oliver and Sorensen 1951). Meurk (1977) listed 87 introduced species in the total vascular flora of 209 species.

The main human influence on the natural environment came with the establishment of farming in 1895. The farmers very quickly modified the vegetation by cutting scrub, burning tussocks and introducing pasture grasses. The sheep themselves changed the vegetation composition by grazing palatable species, particularly the *Chionochloa antarctica/Poa foliosa* grasslands and megaherbs (e.g. *Pleurophyllum* spp.), leading to the the dominance of unpalatables, such as *Poa litorosa* and *Bulbinella rossii*.

The removal of sheep from parts of the island in 1970 and 1984 allowed opportunities to study the effects of grazing pressure and the overall changes in vegetation. Photopoint series were established (Dilks and Wilson 1979, Wilson and Elliott 1981), and permanent vegetation quadrats, transects and other detailed botanical investigations begun (Given 1980, Meurk 1975, 1977, 1980, 1982, 1984, 1985).

14.2 AIMS

To continue aspects of the photographic and vegetation transect surveys, as requested by L. Sanson and A. Cox (DOC, Invercargill). By simplifying or selecting some parts of these surveys, we aimed to establish a standard monitoring programme by which future changes in the vegetation of the nature reserve could be detected.

14.3 METHODS

14.3.1 Photopoints

R. Taylor (Ecology Division, DSIR, Nelson) supplied a selection of 75 photographs from 23 photopoints to be repeated in 1988. C. Robertson (DOC, Wellington) suggested several panoramas and 94 photographs were taken at 7 photopoints, some of which

extended partial panoramas at the DSIR photopoints. At L. Sanson's suggestion, 33 photographs of slips were taken at 5 photopoints.

All photographs were taken with black and white film and colour print film. The photopoint position was also photographed from another angle in most cases to assist locating the spot in the future.

The approximate positions of the photopoints are shown in Appendix 6 and mapped on a 1:10,000 map series, copies of which are held by DOC (Wellington, Invercargill) and on Campbell Island.

Some of the original marker pegs could not be found (B, 4, 33, 34, 35M, 38, 53, 67, 78), were too short to be found easily in the future, or did not exist (e.g. Northwest Bay). These were replaced by tall wooden markers. Where a peg could not be found the positions of distinctive landmarks and vegetation were used to estimate where the original photograph had been taken from.

14.3.2. Transects

Meurk (1984) established two parallel vegetation transects on either side of the sheep fence from Northwest Bay to the cliffs above Rocky Bay. He recommended that the information from these transects be recorded again in about 1987. Six half-days were spent collecting vegetation data from 29 January to 6 February 1988.

A map of the transects and instructions (modified from Meurk 1984) are provided in Appendix 12 and 13 for the guidance of future workers. The fenceline was divided into 8 sections and 30 sampling units each side of the fence. Each sampling unit was from the fence, 2m wide and the length of the interval between fence-posts. Woody species were counted and measured and the other species were listed in descending order of importance. To limit misidentifications of species 86 samples of plants were sent to C. Meurk (Botany Division, DSIR, Christchurch) for checking.

14.3.3 Other sampling

Measurements of the spruce tree were made on 19 September 1988.

Samples of plant species collected on request from botanists via DOC (Invercargill) were *Hebe benthamii* and *Grammitis magellanica.* Samples of large driftwood were collected at the request of P. Moors (RAOU).

14.4 RESULTS

14.4.1 Vegetation Photopoints

Negatives and contact sheets of all vegetation, panorama and slip photographs are held by DOC (Invercargill). A brief comparison of the original photographs (mostly taken in 1970) revealed a few obvious trends, described below.

North of the 1970 fenceline some of the most obvious changes have occurred in sheltered areas such as near Meteorological Station and the head of Northeast Valley, where there has been substantial scrub and tussock growth. The area of the 1970 fenceline has shown a dramatic recovery of *Poa* and *Bulbinella,* replacing the grazed

sward and bare ground visible in the earlier photographs. Stands of mature *Anisotome latifolia* have appeared on the northern side of the fence where sheep have been absent for 18 years.

Between the 1984 and 1970 fencelines one area of dramatic recovery is south of Eboule peak where *Poa* tussocks are substantially larger and *Bulbinella* is less dominant than in 1977. However, another site west of Mount Honey had large *Chionochloa* tussocks present in 1970 but none in 1988, presumably a result of sheep grazing prior to 1984.

At the 1984 fenceline photographs show greater growth of *Poa* tussocks and other grasses on the east side, whereas on the west side *Bulbinella* is more obvious and sheep have grazed and trampled the strip closest to the fence.

Slips that were not present in 1970 are visible in some photographs (e.g. photopoint 33, 53, rock knob east of Col). These date from May 1982, when widespread slipping occurred around the island following a period of torrential rain (Dilks and Grindell 1983).

14.4.2 Vegetation Transects

Raw data is provided in Appendix 14.

The *Dracophyllum* dwarf-forest on the west side of Section I of the transect grew from 3.4 to 4.2 m tall from 1984 to 1988 (because of the fence extension nearby, this sampling section has sheep excluded from both sides of the fence). The edge of the forest has grown from 3.0-3.7m in height.

The total number of *Coprosmas* on the east transect (non-sheep side) increased from 12 to 28 plants in four years, whereas the western total remained about the same at 9 or 10 plants.

The foliage of many of the woody plants (*Dracophyllum, Myrsine* and *Coprosma)* were grazed on the west side so heavily that they had died in some cases. The largest plants in each sample unit grew between 1984 and 1988. For example, the tallest plants in the sampling units of Sections II-IV grew in height by 16% on the western side and 12% on the eastern side of the fence.

Table 12 summarises some changes in woody species in Sections II-V of the fenceline.

There were fewer *Poa litorosa* tussocks attaining a height of more than 50cm on the west side. The number of these plants had decreased from 89 to 71 since 1984, whereas they had increased from 84 to 100 on the ungrazed side of the fence. Most other grasses and herbs were also taller in the east than the west, where there was a tendency towards a mat of appressed plants between the taller tussocks and *Bulbinella.*

Several small plant species (e.g. *Geranium microphyllum*) were found at lower altitudes than in 1984. Some previously recorded species were not found, however this may have been due to our inability to identify them.

Table 12 : Change in numbers and size of *Dracophyllum* and *Mysine* in vegetation transects between 1984 and 1988

	WEST			EAST		
	1984	1988	% INC	1984	1988	% INC
Dracophyllum						
Section II:						
N	25	18	**-28**	29	56	**93**
MEAN (cm)	84.3	132.4	**57**	82.0	60.3	**-27**
MEAN WIDTH (cm)	76.1	99.5	**31**	72.3	43.8	**-39**
Section III-V:						
N	9	9	**0**	4	52	**1200**
MEAN (cm)	83.8	115.0	**37**	91.0	29.1	**-68**
MEAN WIDTH (cm)	85.1	100.1	**18**	105.8	23.8	**-78**
Myrsine divaricata						
Section II:						
N	28	51	**82**	47	71	**51**
MEAN (cm)	28.4	29.9	**5**	26.6	30.5	**14**
MEAN WIDTH (cm)	42.1	29.4	**-30**	32.5	29.7	**-9**
Section III-V:						
N	1	1	**0**	2	8	**300**
MEAN (cm)	25	23	**-8**	19.0	20.1	**6**
MEAN WIDTH (cm)	16	19	**19**	16.0	17.8	**11**

Two plants of the megaherb *Pleaurophyllum speciosum* found on the grazed side in 1984 had and grown and a *P. criniferum* had appeared in the intervening years. No megaherbs had been recorded from the eastern transect in 1984 but in 1988 there was a *P. speciosum*, a *Stilbocarpa polaris* and a small *Anistome latifolia* and seedlings, all near the top of the transect.

14.4.3 Spruce Tree

The measurements of the spruce tree at Camp Cove on 19 September 1988 were:

Height 7.5m (7.1m on side furthest from the stream)
Spread 11.6 x 11.2m
Diameter 0.85m (at 0.5m from base)

14.4.4 Driftwood

Three samples of driftwood were collected from the coasts of Perseverance Harbour and Northwest Bay.

A small plastic drift card was found by W. Strid on the shore of Six Foot Lake in September 1988. This had been released at sea between South Africa and Marion Island in May 1986 (pers. comm. C.B. Visser, Marine Development Directorate, Department of Environmental Affairs, Cape Town, South Africa). A similar card was found at Capstan Cove in 1987 (A. Fyfe pers. comm.).

14.5 DISCUSSION

The area released from grazing pressure in 1984 had changed in structure after four years. Plants were taller and more luxuriant. *Dracophyllum* plants taller than more than doubled in number because many of the smaller plants were only seedlings in 1984. So, although mean size of plants decreased, most individuals actually increased in size. Megaherbs have also slowly increased in prevalence.

On the grazed western side of the fence the number of *Dracophyllum* plants decreased because of death from browsing. The grassland had also decreased in stature.

Similar trends were also found by Meurk (1982) five years after the construction of the first sheep exclusion fence in 1970. He felt that the rate of recovery of the endemic flora after removal of grazing pressure indicated that much of the natural status of the island's vegetation would be regained. Unfortunately, because of a lack of time during the summer of 1987-88, the transects along the original fenceline could not be repeated.

Meurk's studies have shown an increased growth and expansion of the scrub zone on Campbell Island. This is partly a result of the release from grazing but it may also be related to climatic warming (Meurk 1982), or the fact that scrub had previously been cut and burnt during the farming era (Oliver and Sorensen 1951).

To the casual observer it is obvious that current grazing pressure in the area west of the 1984 fenceline is very high and is having a pronounced effect on the vegetation. Some areas around the peaks of Paris and Yvon-Villarceau are almost pure stands of *Bulbinella* or short swards of appressed plants such as *Scirpus aucklandicus.* Also, the severe erosion of clay soils in Rocky Bay appears to have been exacerbated by the amount of sheep tracks and heavily grazed vegetation cover. Slipping was not recorded in this area during a major slip event in 1982 (Dilks and 1983).

The spruce tree had grown substantially in the nearly five years since its previous measurement (Meurk 1984). Although individual variations in measuring may be involved because of its lack of uniformity and size, it appears that the tree has continued to accelerate in growth. It was 1.3m taller, 1.3m greater in spread and 9cm wider at breast height than in early 1984.

Two of the driftwood samples collected were identified preliminarily by R. Patel (Botany Division, DSIR, Lincoln) as *Nothofagus* beeches of species that are not found in New Zealand. The third sample apparently had a bolt hole in it and probably originated from an ocean vessel. The discovery of drift cards and driftwood confirm that these items can travel great distances under the influence of the circumpolar currents.

14.6 RECOMMENDATIONS

1. The vegetation and slip photopoint series should be repeated every five years. Panorama photographs were not as useful and need not be repeated as often, to limit costs.

   Duplicate files of large prints should be made covering the full series of photographs since 1970. These should be held by DOC and DSIR so that managers of the nature reserve and the ecologists and botanists involved with the monitoring programme have a full record of the changes that have occurred.

2. Transect studies at the 1984 fenceline should be repeated every five years, preferably by botanists (C. Meurk if possible, to allow continuity and informed analysis). The 1970 fenceline transect should also be repeated. Information that can be collected in the transect sampling units by non-botanists include the numbers and dimensions of:
   a) woody species (*Dracophyllum, Myrsine* and *Coprosma*)
   b) megaherbs (*Pleurophyllum, Stilbocarpa* and *Anisotome*).

   Some botanical knowledge and survey experience is useful if the full transect information is to be collected.

3. Grazing pressure should be reduced at the western end of the island, preferably by complete removal of sheep (see Chapter 11).

4. The potential problem of introduced plants spreading from the meteorological station and other sites of previous occupation should be addressed. DOC should consult DSIR botanists to identify the need for any control. For instance, Meurk (1984) recommended the control of *Lotus* at the old Cape Expedition camp at Tucker Cove while it is still a manageable task. Meteorological staff should also be made aware of the need to limit the possibilities of future introductions (e.g. from waste chicken food, greenhouse soil and seeds).

CHAPTER 15: HISTORIC SITES

15.1 INTRODUCTION

Historical accounts and descriptions of historic sites can be found in Kerr (1976), Kerr and Judd (1978), Judd (1980) and Palmer and Judd (1981).

N. Judd (pers. comm.) sees the task of plotting the positions of fencelines dating from the farming era as a high priority before this evidence is lost. However, the lack of time in 1987-88 to devote to this type of work means it is still a job for future expeditions.

A few previously unknown or unrecorded historic sites were found in 1987-88.

15.2 RESULTS

While visiting the shores of Northeast Harbour a 'finger-post' pointing up the harbour was found just west of Cook Point. A whaling trypot fragment (about one-third) was found wedged in rocks about 2 km along the southern shore of the harbour. On the northern shore an iron pipe (two lengths of 4m screwed together, c4cm diameter) was found running from a creek to the low water mark. This pipe seemed to be pointing in the direction of the old whaling station. Two old bottles were on the beach nearby.

At Davis Point, near the mouth of Perseverance Harbour, another finger-post was discovered. This was pointing up the harbour.

The identity and position of these sites was forwarded to N. Judd (Auckland Regional Authority) and P. Mahoney (Historic Places Trust, Wellington).

At the request of P. Mahoney a buried canister at Tucker Cove (item F of Fig.6, Judd 1980) was partially excavated. It was found to be intact and was measured, photographed and reburied.

15.3 DISCUSSION

The two newly discovered finger-posts were part of the network of posts directing potential castaways to the Government Castaway Depot at Tucker Cove, dating from about 1863 (Palmer and Judd 1981). Some of these are still in surprisingly good condition. The total number of known finger-posts now stands at six. However, the post at Sandy Bay was not noticed in 1987-88, so possibly it has fallen over or been illegally removed.

The buried canister at the Tucker Homestead site may have originally been used to render down fat of penguins or seals and was used by the farmers to keep dog-meat cool (P. Mahoney pers. comm.)

15.4 RECOMMENDATIONS

1. The formation of a museum at Beeman Cove is recommended.

   Judd (1980) and Palmer and Judd (1981) favoured the repository of artefacts on Campbell Island rather than on mainland New Zealand, but discouraged this development until all historic sites were adequately documented.

   A museum would provide a focal point for the increasing frequency of visits by tourist vessels. It is also essential for the protection of some artefacts, particularly wooden ones, before they deteriorate beyond recognition. For instance, one of the more remote finger-posts (e.g. outer Northeast Harbour) should be placed in the museum and its site marked and recorded. Other posts could be left in place to retain the integrity of the historic sites. Another example would be one of the whale pots which could be housed for display and protection. Judging from old photographs the remains of the capstan at Capstan Cove are rapidly deteriorating.

   No artefacts should be removed from the island, either officially or illegally. Any that have already been removed should be collected for display.

2. Display material of historic sites and old black and white photographs should be made available for the proposed museum or stored at the Cove Hostel in the interim. Some information in pamphlet form would be useful for the tourists and allow meteorological staff to appreciate the historic values of the island.

3. Continued study of the historic sites must be undertaken in the near future before the information is lost. N. Judd (pers. comm.) and J. Palmer have compiled a list of incomplete work or sites additional to those described in 1981. They propose a 1-2 month expedition in 1989-90 to complete this work.

   Once the historical inventory work has been completed it will be possible to formulate plans for any site preservation that is deemed necessary.

CHAPTER 16. COASTAL RESOURCES INVENTORY

16.1 INTRODUCTION

DOC is currently establishing a "Coastal Resources Inventory" which aims to document the nature of New Zealand's coastline for the benefit of coastal management. One aspect of the survey is the evaluation of human impacts on coastal areas.

16.2 AIM

To provide some information on the Campbell Island coastline.

16.3 METHODS

Guidelines from the former Coastal and Marine Directorate were used as a basis for the work.

A photographic survey was conducted at selected parts of the coastline. This survey included study areas at Penguin Bay, Sandy Bay and Perseverance Harbour, where broadly descriptive maps and profiles were drawn.

16.4 RESULTS

Photographs, maps and profiles were given to the Southland Conservancy Office, DOC, Invercargill.

16.5 DISCUSSION

Photographs of the coastline may provide a useful comparison if changes occur in the future. Most abiotic changes, however, are likely to be a result of the long-term effects of ocean and climate.

Little further analysis of the Campbell Island coastline is necessary because there are few conservation "problems" that are not already being documented or addressed (e.g. rockhopper penguin colony decline, mollymawk decline, sheep impact on vegetation).

Currently, the main human impact on the nature reserve is at the Beeman Cove Meteorological Station. Procedures such as waste disposal have gradually improved over the years. All non-perishable rubbish is now burnt or removed from the island. Food scraps are dumped in the sea 1.5km down the harbour, however, staff should be further encouraged to limit the wastage of food and feed as much scraps to the chickens as possible.

One area of concern is the "caustic drain" which twice-daily tips waste products of hydrogen production for weather balloons into Beeman Cove. This pollutes the harbour and forms a white pan on the shore at the outlet. Some improvements have recently occurred, with smaller balloons needing fewer raw materials, a double half-drum sedimentation tank and outlet extension. However, MoT should be encouraged to further improve the sedimentation of wastes or, ideally, install a new hydrogen production facility. The modern technology available would save money in the long run (through minimal raw material costs), reduce the possibilities of accidents during the current "bucket chemistry" operation, and remove the adverse impact on the environment.

Any proposals by MoT to move the caustic drain "out of sight" of visitors to the base do not address the real conservation issues and are therefore unacceptable.

CHAPTER 17: TRACK MAINTENANCE

17.1 INTRODUCTION

A system of tracks and routes exists from Beeman Meteorological Station to the six huts around the island.

Because of the soft nature of the peat soil, tracks become very muddy and incised once the vegetation is worn away. Frequent use over the years and the occasional traffic of large numbers of people from tourist ships or frigates have caused degradation in quality of some tracks. Although the tracks dry out to some extent in summer, there is little, if any, vegetation recovery. There is also a tendency for some tracks to widen as users avoid the muddiest parts.

17.2 AIM

To construct board-walks on some of the worst areas of track erosion, as requested by L. Sanson (DOC, Invercargill).

17.3 RESULTS

Building materials were moved by helicopter from the frigate "Wellington" during its visit in February.

Two bridges were constructed across Cattle Bay streams on the way to Penguin Bay from Northwest Bay.

Small stretches of board-walk totalling approximately 400m were constructed on the track from to the Col-Lyall saddle and the Northwest Bay track from Tucker Cove to the Col slip (the latter work was mainly by Meteorological staff: S. Freeman and R. Crawley). The board-walk was a simple unobtrusive design of short planks nailed to parallel runners which were laid on the track.

New coloured route marker pegs were put along several of the ridge routes to assist travel in poor conditions.

17.4 DISCUSSION and RECOMMENDATIONS

The Col-Lyall track is approximately 2.5 km long and now has over 500m protected, comprising about 250m old board-walk near the meteorological base, 80m of old “Marsden matting" and 200m of new board-walk. In hindsight all of the wood supplied in 1988 should have been used on this track since 700m (340m urgent) had been identified as needing attention. Also, longer stretches of board-walk are desirable because the construction creates extra traffic while carrying materials and uncovered track soon gets damaged. The Col-Lyall track is an important one for visitors, so further board-walking will allow this to be used in all weathers without undue damage occurring. This must be the highest priority for board-walk in the future.

The most popular track on the island for residents is the Northwest Bay track. Although 650m (270m urgent) of the 2km track had been identified as needing attention, the 200m of new boardwalk probably addresses this area enough to allow the priority areas to be worked on in the future.

The Southeast Harbour track is used less often than other tracks, however it is in great need of repair, particularly bridging work across several gullies.

The track from Camp Cove to Cave Rock is in poor condition in places but as the damage is partly a result of sea lions, boardwalk construction is not as important here as elsewhere.

Old scraps of “Marsden matting" from the Beeman Base roading makes ideal track protection. This should be collected when repairs and replacements are made and await shifting by helicopter at the next opportunity. Shifting it by hand is also possible but the weight means that enthusiasm soon wanes about five minutes from base.

CHAPTER 18. MISCELLANEOUS

Several miscellaneous tasks were undertaken in 1987-88. Most of these have already been mentioned, such as the banding of birds and recovery of old band numbers (Appendix 2) and the collection of body feathers for mercury analysis (Appendix 7).

Another task was the measurement of sea temperature at Middle Bay (Appendix 15). This was requested by P. Moors (now RAOU, Melbourne) to compare the difference of temperatures taken by Meteorological staff in the shelter of Perseverance Harbour with those of Northwest Bay and Penguin Bay. From November to February, where possible, simultaneous measurements were taken at Beeman and Middle Bay. A brief appraisal of the data shows that the pattern of sea temperature change and the individual daily temperatures are not substantially different at the two areas.

Ticks collected from seven bird species were all identified as *Ixodes uriae* (A. Heath pers. comm.) (Appendix 7d).

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APPENDICES

APPENDIX 1: Bird species list for Campbell Island

Status Key: b -breeding s -straggler
r -regular visitor * -seen 1987-88

COMMON NAME	SCIENTIFIC NAME	STATUS
king penguin	*Aptenodytes patagonicus*	s *
yellow-eyed penguin	*Megadyptes antipodes*	b *
gentoo penguin	*Pygoscelis papua*	s
rockhopper penguin	*Eudyptes c. chrysocome*	b *
macaroni penguin	*E. chrysolophus chysolophus*	s
royal penguin	*E. c. schlegeli*	r *
Fiordland crested penguin	*E. p. pachyrhynchus*	s
erect-crested penguin	*E. sclateri*	b *
Southern crested grebe	*Podiceps cristatus australis*	s
wandering albatross	*Diomedea exulans exulans*	b *
Southern royal albatross	*D. epomophora epomophora*	b *
black-browed mollymawk	*D. melanophrys melanophrys*	b *
NZ black-browed mollymawk	*D. m. impavida*	b *
grey-headed mollymawk	*D. chrysotoma*	b *
white-capped mollymawk	*D. cauta cauta*	s
light-mantled sooty albatross	*Phoebetria palpebrata*	b *
Northern giant petrel	*Macronectes hallii*	b *
Snares Cape pigeon	*Daption capense australe*	b *
white-headed petrel	*Pterodroma lessonii*	r
Auckland Island prion	*Pachyptila desolata alter*	r
narrow-billed prion	*P. belcheri*	s
fairy prion	*P. turtur*	r
grey petrel	*Procellaria cinerea*	b
white-chinned petrel	*P. aequinoctialis steadi*	b
sooty shearwater	*Puffinus griseus*	b *
short-tailed shearwater	*P. tenuirostris*	s
subantarctic little shearwater	*P. assimilis elegans*	s *
Wilson's storm petrel	*Oceanites oceanicus oceanicus*	s *?
grey-backed storm petrel	*Garrodia nereis*	b? *
black-bellied storm petrel	*Fregetta tropica*	b?
subantarctic diving petrel	*Pelecanoides urinatrix exsul*	b *
Australasian gannet	*Sula bassana serrator*	s
black shag	*Phalacrocorax carbo novaehollandiae*	s
little shag	*P. melanoleucos brevirostris*	b
Campbell Island shag	*Leucocarbo campbelli*	b *
white-faced heron	*Ardea n. novaehollandiae*	s *
white heron	*Egretta alba modesta*	s

APPENDIX 1 ctd

COMMON NAME	SCIENTIFIC NAME	STATUS
chestnut-breasted shelduck	*Tadorna tadontoides*	s
mallard	*Anas p. platyrhynchos*	b? *
grey duck	*A. s. supercilosa*	b *
Campbell Island teal	*A. aucklandica nesiotis*	b
Australasian harrier	*Circus approximans gouldi*	s
N.Z. falcon	*Falco novaeseelandiae*	s
pukeko	*Porphyrio porphyrio melanotus*	s
South Island pied oystercatcher	*Haematopus ostralegus finschi*	s
spur-winged plover	*Vanellus miles novaehollandiae*	s *
banded dotterel	*Charadnus bicinctus*	s
American black-tailed godwit	*Limosa haemastica*	s
Eastern bar-tailed godwit	*L. lapponica baueri*	s
Greenshank	*Tringa nebularia*	s
Siberian tattler	*T. brevipes*	s *
turnstone	*Arenaria i. interpres*	s *
knot	*Calidris c. canutus*	s
Southern great skua	*Stersorarius skua lonnbergi*	b *
Antarctic skua	*S. skua maccormicki*	s
Southern black-backed gull	*Larus dominicanus*	b *
red-billed gull	L. novaehollandiae scopulinus	b *
Antarctic tern	*Sterna vittata bethunei*	b *
Arctic tern	*S. paradisaea*	s?
white-fronted tern	*S. striata*	s
spine-tailed swift	*Chaetura caudacuta caudacuta*	s
skylark	*Alauda arvensis arvensis*	b?
welcome swallow	*Hirundo tahitica neoxena*	b? *
N.Z. pipit	*Anthus n. novaeseelandiae*	b
hedge sparrow	*Prunella modularis occidentalis*	b *
song thrush	*Turdus philomelos clarkei*	b
blackbird	*T. merula merula*	b *
silvereye	*Zosterops l. lateralis*	b *
yellowhammer	*Emberiza citronella caliginosa*	s *
chaffinch	*Fringilla coelebs gengleri*	b
greenfinch	*Carduelis chloris chloris*	s *
goldfinch	*C. carduelis britannica*	b? *
redpoll	*C. flammea cabaret*	b *
house sparrow	*Passer d. domesticus*	b?
starling	*Sturnus v. vulgaris*	b *

Refs: Bailey and Sorensen (1962), Kinsky (1969, 700, 71, 80), Robertson (1980, pers. comm.), Sorensen (1942-47 General Notes, 1951), Westerskov (1960), this study. Note: A flock of big white geese was reported in 1912 (Kerr and Judd 1978), but these were probably domestic geese released by farmers. There were also attempts to introduce "game and guinea fowls" (Cockayne 1903).

APPENDIX 2: Recoveries and applications of bird bands on Campbell Island 1987-88

A) Recoveries of previously banded birds

	No. of Banded Birds	No. of Records
yellow-eyed penguin	2	3
rockhopper penguin	754	2609
wandering albatross	4	9
Southern royal albatross	312	375
black-browed mollymawk	5	16
NZ black-browed mollymawk	349	391
grey-headed mollymawk	141	185
light-mantled sooty albatross	1	1
Northern giant petrel	1	1
Southern great skua	25	25
red-billed gull	1	2
TOTAL	1595	3617

B) Numbers of birds banded during 1987-88

	NO. OF BIRDS BANDED					
SPECIES	Chick	Juv.	Adult	tot	reband	TOTAL
yellow-eyed penguin	141		78	219	1	220
rockhopper penguin	164	3	174	341		341
wandering albatross	2			2		2
Southern royal albatross	354			354	45	399
black-browed mollymawk			3	3		3
NZ black-browed mollymawk	835		34	869	30	899
grey-headed mollymawk	53		33	8 6	7	93
light-mantled sooty albatross			4	4		4
Northern giant petrel			1	1		1
Southern great skua	7		19	26	1	27
red-billed gull		10	18	28		28
TOTAL	1556	13	364	1933	84	2017

APPENDIX 3: Ages of banded southern royal albatrosses recorded on Campbell Island 1987-88

SOUTHERN ROYAL ALBATROSS		
Year banded	No. seen	No. banded as chicks
1962	4	4
1963	1	
1965	6	1
1966	33	22
1967	17	14
1968	29	20
1969	5	2
1970	16	9
1971	25	14
1972	9	7
1973	1	1
1974	3	3
1975	7	4
1976	27	27
1977	43	3
1978	19	11
1979	12	11
1980	30	28
1981	11	9
1982	13	13
1983	1	1
TOTAL	312	204

APPENDIX 4: Counts of southern royal albatross breeding pairs on Campbell Island 1958-1983
Modified from Dilks and Grindell (1983)

		NO. OF PAIRS								
	Area (ha)	1958	1969	1971	1976	1977	1978	1980	1981	198
Faye	1376	465	657	-	897	772	910	794	801	692
Fizeau	1204	544	748	-	944	841	654	735	683	643
Lyall	1326	321	504	-	652	697	532	604	535	682
Moubray	787	233	569	-	694	561	593	485	567	509
North Col	604	59	148	-	230	185	156	192	167	139
South Col	466	39	59	123	139	129	94	94	90	127
Paris	1011	99	389	429	490	535	241	431	423	373
Dumas	1194	135	305	299	393	344	266	302	323	301
Honey	2300	365	897	804	814	775	696	914	846	717
Puiseux	570	18	68	54	83	67	66	44	58	60
TOTALS		2278	4344		5336	4906	4208	4575	4493	4243

APPENDIX 5: Royal albatross distribution
(Modified from Dilks and Wilson 1979)

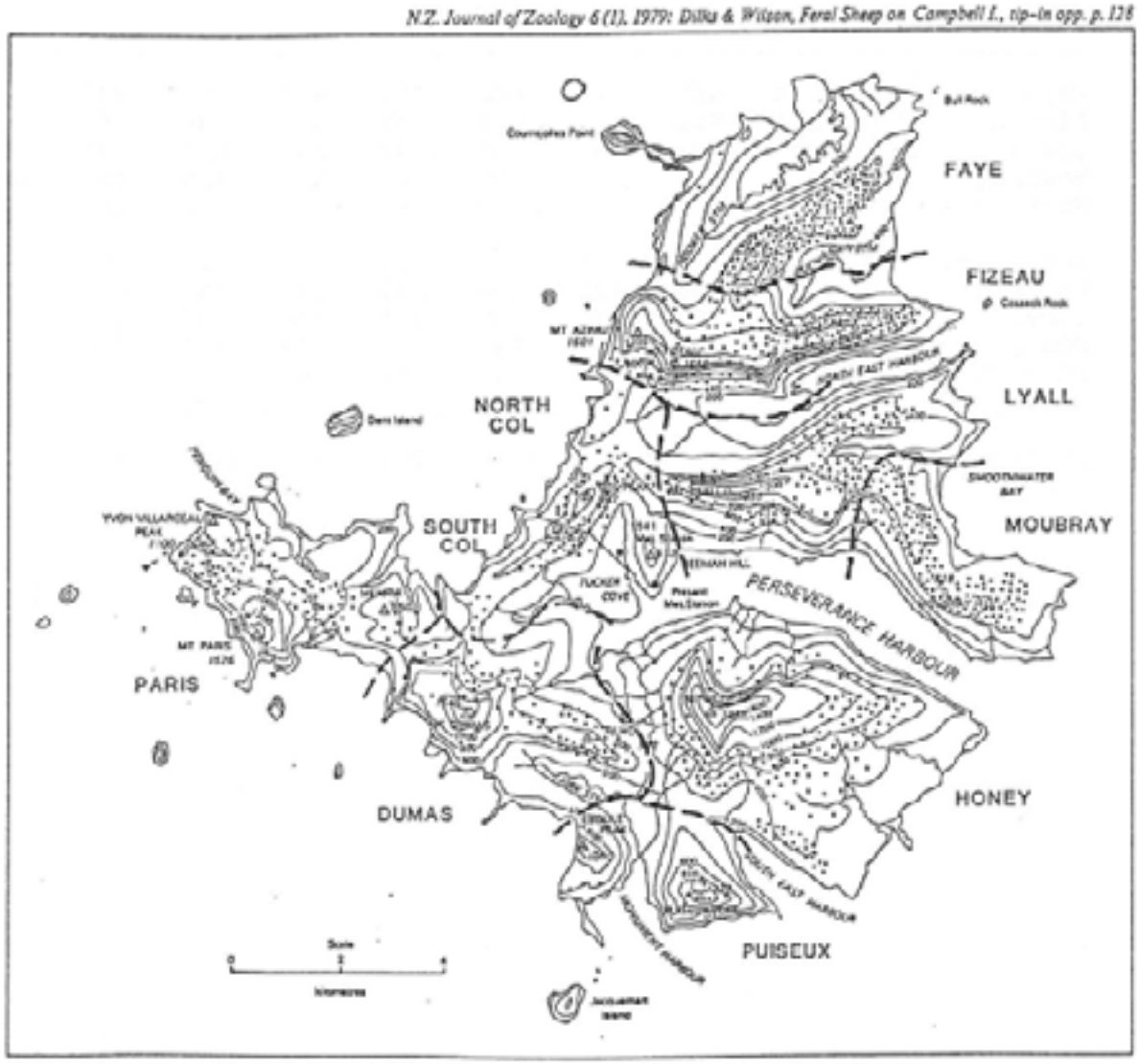
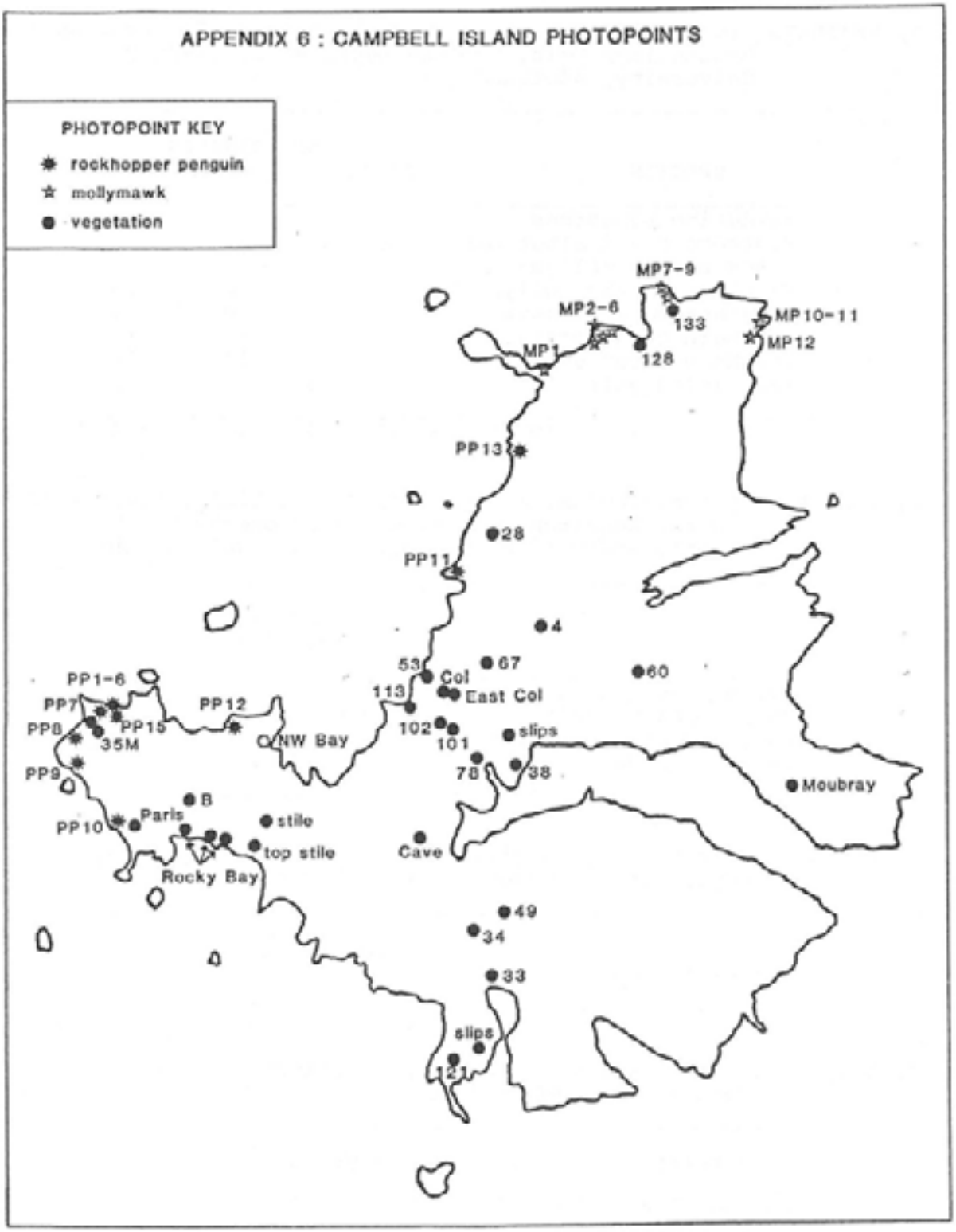


Fig. 2. Distribution of royal albatrosses on Campbell I. in 1976; one dot represents approximately five nests.

APPENDIX 6 : CAMPBELL ISLAND PHOTOPOINTS



APPENDIX 7: Miscellaneous sampling 1987-88

a) FEATHERS (for analysis of mercury content by R. Furness, Applied Ornithology Unit, Zoology Department, Glasgow University, Scotland)

	NO. SAMPLES			
	CHICK	JUV.	ADULT	TOTAL
wandering albatross	2			2
Southern royal albatross	30		23	53
black-browed mollymawk			5	5
NZ black-browed mollymawk			30	30
grey-headed mollymawk			30	30
Northern giant petrel			17	17
Southern great skua			24	24
red-billed gull		5	18	23
TOTAL	32	5	147	184

b) TISSUE (Epidemiological analyses by G.W De Lisle, Wallaceville Animal Research Centre, M.A.F., Upper Hutt. Genetic analysis by S. Triggs, DOC, Wellington)

	NO. SAMPLES	
	Pathology	Tissue
yellow-eyed penguin	1	3
rockhopper penguin	9	5
NZ black-browed mollymawk	4	4
red-billed gull		5

c) BLOOD (collected for JA Mills, genetic analyses by A. Baker, Royal Ontario Museum, Toronto, Canada)

	NO. SAMPLES
red-billed gull	23

d) TICKS (Identification by A. Heath, Wallaceville Animal Research Centre, MAF, Upper Hutt)

SPECIES	NO. SAMPLES
yellow-eyed penguin	7
rockhopper penguin	3
erect-crested penguin	1
Southern royal albatross	7
NZ black-browed mollymawk	5
grey-headed mollymawk	3
Southern great skua	1
TOTAL	27

APPENDIX 8: Counts of southern elephant seals on Campbell Island 1987-88

NORTHWEST BAY TOTAL = Sandy Bay. Middle Bay, Capstan Cove and Whale Bay
* estimated total when all four bays were not counted on visit

		No. of elephant seals							
		November							
Area	Date	9	12	15	21	24	26	28	29
SANDY BAY				1	9	4			
MIDDLE BAY			2			8		8	
CAPSTAN COVE			8	9		22	31	32	
WHALE BAY			4		11	17		19	
DE LA VIRE POINT		2							
BEEMAN BASE					2				
TUCKER COVE					2				
SOUTHEAST HARB.									7
BLUE LAGOON			2						
NORTHWEST BAY TOT.			16*	31*	51			63*	

		DECEMBER					JANUARY					
Area	Date	2	8	13	22	27	1	6	11	16	21	31
SANDY BAY		13	17	18	27	27		17	17		13	12
MIDDLE BAY		8	7	11	8	9	1	0	0	2	0	0
CAPSTAN COVE		32	33		31	27	27	22	21	13	20	7
WHALE BAY		19	28		22	15	14	8	4	3	7	7
TUCKER COVE				14	2	1	0	0	0	0	0	3
DE LA VIRE PT.		5			14			3		3		
BOYACK PT.								1				
LOOKOUT BAY								14		5		
ROCKY BAY						23						
PARIS				4								
BLUE LAGOON				5	12	6					0	
		72	85		88	78	65*	47	42	41*	40	26

		FEBRUARY			MARCH						
Area	Date	4	13	24	1	6	11	17	22	26	31
SANDY BAY		12	13	26	23	25		15	12	11	
MIDDLE BAY		0	0	0	1	0	0	0	0	0	0
CAPSTAN COVE		7	4	1	0	1	3	3	8	7	5
WHALE BAY		4		0	2	3	6		0	4	4
TUCKER COVE		5	0	0	0	0	1	2	0	2	3
GARDEN COVE								2		2	
BLUE LAGOON		0	0	0				1			
N'WEST BAY TOTAL		23	21*	27	26	29	24*	24*	20	22	20*

APPENDIX 8 ctd.

		No. of elephant seals								
		APRIL						MAY		
Area	Date	4	13	16	25	26	28	2	6	14
SANDY BAY			0	0			3	3	4	4
MIDDLE BAY			1	1			2	3	1	3
CAPSTAN COVE			7		3	4	5	5	3	1
WHALE BAY			8		5			6	9	7
TUCKER COVE			0	0	0	1	0	0	0	0
LOOKOUT BAY		1								
SOUTHEST HARB.										11
MONUMENT HARB.										2
PENGUIN BAY				1						
N'WEST BAY TOTAL			16		9*		15*	17	17	15

		JUNE				JULY			
Area	Date	3	15	20	29	11	14	17	19
SANDY BAY		11	10	19	8	2	0	0	2
MIDDLE BAY		6	4	2	3	0	1	2	5
CAPSTAN COVE		3		8	5	12	11	8	10
WHALE BAY				18	7	11	8	2	?
TUCKER COVE		0	1	0	0	0	0	0	0
DELAVIRE PT					8			5	
MOUBRAY								4	
ROCKY BAY			2						
NORTHEAST HARB.				12					
N'WEST BAY TOTAL		27*	24*	47	23	25	20	12	19*

		AUGUST				SEPTEMBER						
	Date	3	13	20	28	3	13	16	19	24	28	30
SANDY BAY		0	4	1	1	1	1	1	0	0	1	
MIDDLE BAY		0	1	0	1	0	0	0	0	0	1	2
CAPSTAN COVE		8	6	7	2	3	3	3	3	6	2	4
WHALE BAY		5	?	6	2	1	6	3	2	0	3	
SE HARBOUR									0			
BLUE LAGOON										2		
N'WEST BAY TOTAL		13	16	14	6	5	10	7	5	6	7	

APPENDIX 9: Counts of hooker's sea lions on Campbell Island 1987-88

	NO. OF SEA LIONS					
	SANDY BAY		MIDDLE BAY		TUCKER COVE	
DATE	Male	Fem.	Male	Fem.	Male	Fem.
8.11.87	57					
21.11.87	60				0	
24.11.87	45	2	2	4		
2.12.87	26		0			
8.12.87	73		3			
13.12.87	56		3			
22.12.87	36	1	0		0	
27.12.87	21		0		0	
5.01.88	29					
11.01.88	61		8		0	
23.01.88	64					
27.01.88	74	1				
29.01.88	54					
4.02.88			0		0	
6.02.88	101	2				
10.02.88	113	1				
13.02.88	93					
24.02.88	14		0			
26.02.88	26	2	0			
1.03.88	38		1	14		
7.03.88					100?	total
11.03.88					11	12
12.03.88					16	16
15.03.88			4	11		
17.03.88	4					
20.03.88					43	2
22.03.88	20		3	10		
26.03.88	13	1	2	4	11	10
31.03.88					27	23
8.04.88					44	13
9.04.88					3	2
13.04.88	29		5		40	27
16.04.88	7	5				
20.04.88					22	10
25.04.88					19	7
26.04.88					8	4
28.04.88	35		1			
2.05.88			4	2	16	8
3.05.88	7					
4.05.88	9				10	6
7.05.88					14	12
9.05.88	37		1	2	16	10
14.05.88	1				6	5
15.05.88			0			
17.05.88	0		0		0	

APPENDIX 9: ctd

	NO. OF SEA LIONS					
	SANDY BAY		MIDDLE BAY		TUCKER COVE	
DATE	Male	Fem.	Male	Fem.	Male	Fem.
27.05.88					1	
3.06.88	18		0		1	
15.06.88	43		1	4		
16.06.88					0	
19.06.88	58	3	4	15		
20.06.88	66	3	3	26		
29.06.88	19		0			
8.07.88	55		25	11		
11.07.88	46		5			
14.07.88	14	1	25	16		
15.07.88			27	23		
17.07.88	56		25	39		
19.07.88	66		43	total		
3.08.88	28		8			
13.08.88	14		11	11		
14.08.88			4	1		
15.08.88	29	1	6	8		
20.08.88	81		14	29		
21.08.88	85		4	7		
28.08.88			0			
29.08.88	37					
3.09.88	76	1	5	8		
11.09.88			13	3		
12.09.88	33					
13.09.88	41	8	3	3		
16.09.88	39		11	3		
18.09.88			7			
19.09.88	77					
24.09.88	86		3	6		
28.09.88			2			
29.09.88	50	4				
30.09.88			3			

APPENDIX 10: Southern right whale sightings 1988

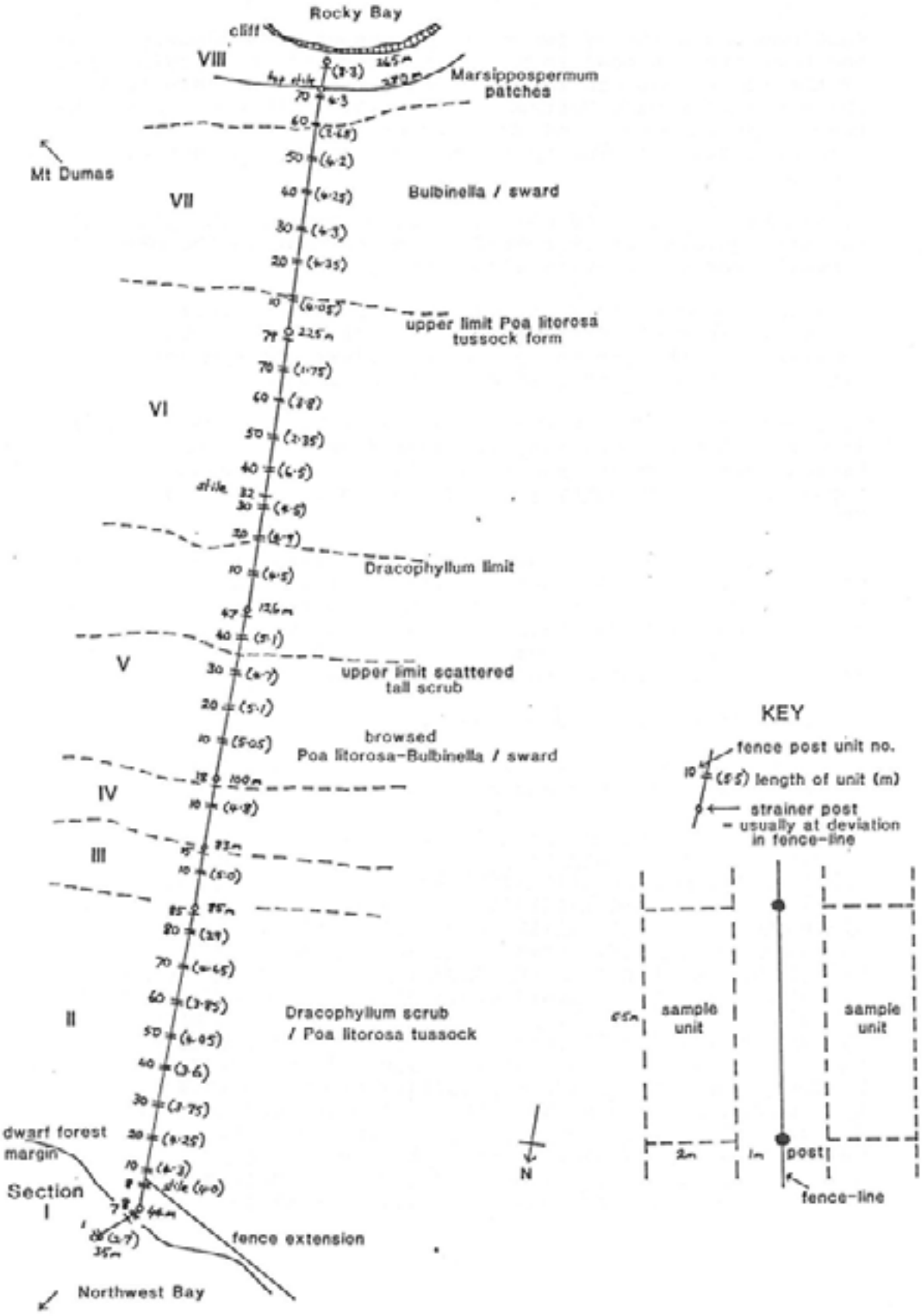
	NORTHWEST BAY		BULL ROCK		PERSEVERANCE HARBOUR
	Count	Mean	Count	Mean	
27.3.88			3		
29.3.88			2		
30.3.88			1		
31.3.88	0	**0**	2	**2**	
1.4.88			3		
6.4.88			3		
9.4.88			5		
12.4.88			0		
14.4.88	3				1
19.4.88			0		
24.4.88			0		
25.4.88	0				
26.4.88	1	**1.3**		**1.8**	
2.5.88	0				
4.5.88	0				
5.5.88			0		
9.5.88	0		2		
13.5.88			0		
14.5.88	0				
15.5.88	0				
16.5.88	2				
17.5.88	0		10		
21.5.88			0		
22.5.88	2				
29.5.88	3	**0.8**		**2.4**	
3.6.88	2				
14.6.88	5				
15.6.88	5				
19.6.88	10				
23.6.88	6	**5.6**			
1.7.88					1
6.7.88	10				
8.7.88	3				
9.7.88	5				
12.7.88	8				
14.7.88	14				
17.7.88	19				
20.7.88	7				
28.7.88	10	**9.5**			
3.8.88	12				2
4.8.88	8				
6.8.88	8				
7.8.88			0		
11.8.88	12				
15.8.88	7				
20.8.88	10				
28.8.88	2	**8.4**			
3.9.88	1				
10.9.88	0				
TOTAL SEEN	175		31		4

APPENDIX 11: Trapping of norway rats on Campbell Island, 1988.

Key: 1 = rat captured S = trap sprung B = bait removed

TRAP	4 APRIL	5 APRIL	6 APRIL	5 SEPT	6 SEPT	7 SEPT
1		B			1	
2					S	
3			B	B	1	
4			B	1		
5			B			
6		1				1
7	1	1				
8		B				
9					S	
10		1			1	1
11				1		S
12	S	S		1		
13	1			S		
14			S			
15				1		
16				1		
17				1		
18	S	S		S	1	
19	S				1	
20			S		1	1
21			B		1	1
22				B	B	
23				S	1	
24			B		1	1
25	B	S	S	S	1	
26				S	1	
27	1	1		S	S	S
28	B	S	B		B	1
29	B	1	S		1	1
30		1	1		S	S
31	1				1	B
32		B	1		1	1
33	1	1	B	1	1	1
34	1			1		
35	S	S	1	B		
36		B				
37	S	1	1		1	
38		B	1			
39			S	S	1	B
40	1	1			1	S
41	S				1	1
42			B		1	1
43						1
44						
45				1		
46				S	1	
47				B		
48						
49		S		1		
50	S	S			S	
TOTAL	7 7S 3B	9 7S 5B	5 5S 8B	10 8S 4B	21 5S 2B	12 4S 2B

APPENDIX 12 : Map of 1984 fence line transect (from Meurk 1984)



APPENDIX 13: Northwest bay vegetation transects, instructions for collection of data (modified from Meurk 1984)

Sections and units of fence-line transects are numbered from the northernmost post (not at the coast) of the original part of the fence (eastern fork of fence, not the western fork which now runs past Northwest Bay hut). Units are defined by fence-post intervals (c.4.5m) x 2m broad, lm from fence-line (see Appendix 12). The following conventions and abbreviations are used.

Plants are recorded only if half or more of the plant is in the unit quadrat or if rooted in the quadrat in the case of "trees" (where all stems are counted).

The vegetation is recorded by tiers in the order “trees”/epiphytes/shrubs/ tall tussocks-ferns-herbs etc./short herbs-ground spp. Within tiers the species are separated by - in order of cover or dominance.

Dimensions of woody species >10cm in height are given as live height x max. breadth (or stem diameter) in cm. "Seedlings” <10cm are recorded as sd=1, sds=several, >sds=many. All *Dracophyllum* seedlings are recorded as hybrids: Dr.x.

Numbers of tall (>0.5m) *Poa litorosa* tussocks are recorded, as they are for some other prominent herbaceaous species/patches/clumps etc. Tall herbs are indicated in the description, but are bracketed, eg. (Pol. v), if their cover contribution is minor. Fern patches may be given a diameter measurement (a single bracketed figure in cm).

(b) suffix = browsed by sheep.

Abbreviations used for species follow Meurk (1984) or first three letters of genus and species:

Abr.spa = Abrotanella spathulata, Abr.ros = Abrotanella rosulata, Ac.min = Acaena minor, Ac = Acaena species, Agr.cap = Agrostis capillaris(=tenuis) Ag.mag = Agrostis magellanica, Ani.lat = Anisotome latifolia, B = Bulbinella rossii, Blech = Blechnum, Cal.ant = Callitriche antarctica, Car.cor = Cardamine corymbosa, Carex = Carex appressa, Cer.fon = Cerastium fontanum (=holosteoides), Chi.cor = Chiloglottis cornuta, Clad.agg = Cladia aggregata, Col.ape = Colobanthus apetalus, Cop.cil = Coprosma ciliata, Cop.cun =Coprosma cuneata, Cor.tri = Corybas trilobus, Des.cha = Deschampsia chapmanii, Dr. l = Dracophyllum longifolium, Dr. x = Dracophyllum longifolium x scoparium cross, Epi.als = Epilobium ?alsinoides, Epi.bru = Epilobium brunnescens, Epi.con = Epilobium confertifolium, Epi.ped = Epilobium pedunculare(=linnaeoides), Fes.rub = Festuca rubra, Gent = Gentiana antarctica, Hel.bel = Helichrysum bellidioides, Ger.mic =Geranium microphyllum, Hie.bru = Hierochloe brunonis,

Hie.red = Hierochloe redolens(=fusca), Hist = Hisiopteris incisa, Hol.lan = Holcus lanatus, Hym.mul = Hymenophyllum multifidum, Hypo = Hypolepis millefolium, Jun.sch = Juncus scheuchzerioides, Lac.lep = Lachnagrostis leptostachys, Lag.pet = Lagenifera petiolata, ?Lep = Lepidozia, Lop = Lophocolea(liverwort), Luz = Luzula crinita, Lyc.f = Lycopodium fastigiatum, Lyc.v = Lycopodium varium, March = Marchantia(liverwort), Mon.fon = Montia fontana, Mon.aus = Montia australasica, Myrs = Myrsine divaricata, Ple.cri = Pleurophyllum criniferum, Ple.spe = P. speciosum, P = Poa litorosa, Poa.brev = Poa breviglumis, Poa.pra = Poa pratensis, Poa.tri = Poa cf.trivialis, Pol.v = Polystichum vestitum, Poly.jun = Polytruchum juniperinum(moss), Prat = Pratia arenaria, Ran.pin = Ranunculus pinguis, Ran.sub = Ranunculus subscaposus(=aucklandicus), Ric.coc = Riccardia cochleata, Scirp = Scirpus aucklandicus, Ste.par = Stellaria parviflora, Sti.pol = Stilbocarpa polaris, Tarax = Taraxacum magellanicum, Tel = Telaranea, Tri.spi = Trisetum spicatum, Unc = Uncinia hookeri.

APPENDIX 14: Vegetation transect results January 1988

FENCE-LINE

	WEST TRANSECT (sheep side)	EAST TRANSECT (non-sheep side)
	SECTION I: Dr. x dwarf forest	
Unit 1		
Dr. l:	1 trunk to 420x11.5	
Dr. x:	19 trunks c420x14(max) dbh to 8.5cm 8 sds (to 3cm) on moss	13 trunks c380x15(+2 dead) dbh to 8cm 4 sds (to 3cm)
Myrs:	> 17 sds (to 6.5cm)	340x70(stem),150(breadth) < half plant in quadrat >40seeds
Cop.cil:	10 x 15cm, 2 sds	
Cop.cun:		150 x 300
	30Hist(to 85cm)-Pol.v(10cm)	7Pol.v(to 41cm)
Floor:	needle litter 90%, moss 10%	needle litter 95%, moss 5%
Units 7-8	Edge of forest, 370 tall End of Section I	
	SECTION II: Open P tussock with invading Dr.x shrubs	
Unit 8	Stile	
Unit 10		
Dr.l:	196x100, 190x160, 160x20	180x70, 170x100, 190x100 190x100
Dr.x:	206x120, 190x150, sds	80x70, >sds
Myrs:	34x38, 76x58, 54x52, 52x14, 58x32, 87x127, 68x20, 34x30, 44x79, 40x15, 33x18, 29x28, 72x110, sds	36x23, 30x14, 25x33, 24x15, 24x12, 22x36, 28x22, 32x34, 18x15, 42x30, 15x15, 24x14, 20x10, 16x14, 35x20, 40x20, 18x8, 60x33, 44x44, 24x23, 63x24, 63x54, >sds
Cop.cil:	57x54, 116x30	24x26, 17x13
	3P-24B-6Hist(<100)-7Pol-Lyc.v/Ac.min	5P-B-Carex-2Hist-Pol-6Lyc.v/
	Scirp-Epi-Carex-March-Prat-Cer.fon	Scirp-March-Ac.min-moss-Cer.fon-Ger.mic
Unit 20		
Dr.l:		133x90, 165x170, 145x107, 200x136
Dr.x:	100x130	20x18(b), >sds
Myrs:	14x20(b), 14x7(b), 11x12(b), 23x14(b), 33x24(b), 16x18(b), 16x19(b), 17x14, 45x30, 23x27, 20x17	44x70, 25x22, 25x12, 18x29, 14x11, 20x28, 20x20, 14x24, 27x15, 15x13, 22x10, 12x18, 18x15, 120x136, 60x50, 17x17, 18x8, sds
Cop.cil:		17x10, sd

4P-Hist(50)-B-Pol(b)/Ac.min-Scirp-March-Ger.mic

Unit 30

Dr.l:
Dr.x: 9x19(b), 116x58(b), 94x106, 150x103, 150x125, >sds
Myrs: 29x22, 20x20, 20x6, 18x10, 12x19, 17x13, 15x15, 19x19, sds
Cop cun 65x50

4P-B-Pol-2Lyc.v/2Gent-Scirp-March-moss-Ger.mic

Unit 40

Dr.l: 210x165(b)

Dr.x: >sds
Myrs: 21x28(b), 20x19(b) 26x20(b), 17x27(b) sds

1P-Pol-B-Carex-1Lyc / 1Gent-Scirp-Unc-Epi.con-moss-lichen

Unit 50

Dr.l: 140x89, 126x155, 160x110, 14x7, >sds

Dr.x:
Myrs: 17x35, 22x32, 30x14, 11x15, 63x84, 23x28
Cop.cil: 29x37
Cop.cun:

3P-Pol-B-Hist(35)-2Lyc.v/Scirp-Unc-March-Ac.min-Ger.min-Ric.coc-moss-lichen

Unit 60

Dr.l:
Dr.x: >sds
Myrs: 15x39(b), 23x27(b)
Cop.cil: sd
Cop.cun:

6P-Pol-B-Carex-2Lyc.v/Scirp-March-moss-Unc-Prat-Ac.min-Gent-Ger.mic-lichen

1P-B-Hist(80)-Pol/Scirp-March-Ac.min-Cer.fon-Ger.mic

113x104, 75x69
82x68, 104x105, 100x60, 22x30, 20x24, sds
37x27, 22x48, 23x15, 15x35, 12x20, 13x16, 44x73, 13x24, sds

2P-B-Pol-Carex / Scirp-moss Ric.coc-Tel-?Lep-Clad.agg

84x71, 26x29, 22x22, 24x10, 20x13, 24x12, 20x10, 30x20, 20x11, 12x6
>sds
24x16, 25x30, 22x20

8P-Pol-Carex-B-Hist / Scirp-March-Prat-Luz.cri

28x19, 15x8, 16x7, 21x15, 34x23, 14x13, 15x10, 12x15, 17x16, 20x10, 17x8, 17x16, 15x14, 16x9
27x27, 133x120(>outside),>sds
57x68, 19x13, 30x55, 17x23, 27x34, 45x48, 11x7

20x24

4P-Pol-B-Carex / Scirp-March-Prat-moss-Clad.agg-Gent-Abro.spa-?Poa.brev-Epi.con-toadstool

157x145, 157x132, 145x90, >sds

28x28, 13x17, sds
12x27, sd
sds

6P-B-Pol-2Hist(12,20)/Luz.cri-Scirp-moss-March-Ac.min-Ger.min-Prat

Unit 70

Dr.l:	14x10, 17x10, 20x15, 30x10 24x13, 43x14, 15x10, 30x22, 15x14
Dr.x: sds	sds
Myrs: 20x22(b), 43x50(b), 24x23	46x45, 56x98, 70x100, 21x23, 25x22, 16x30, 13x6, sds
Cop.cil:	35x36
Cop.cun:	27x40, 42x38
5P-Pol-B-Carex/Luz.cri-Scirp-Unc-moss-Ac-Ger.mic-Lag.pet-Epi.con-Abr.spa-Cer.fon-liverwort-lichen	Pol.v(to 130cm)-5P-Hist-B/ Luz.cri-moss-Unc-Ac-March-Scirp-Ger.mic-Hel.bel

Unit 80

Dr.l: 130x125,42x49(severe b) 3 dead(b)	
Dr.x: >sds	21x13, >sds
Myrs: 13x16(b), 12x18, 40x38, 22x17, sds	37x36, 31x14, 48x33, 37x27, 57x45
Cop.cil: sd	28x57, 27x15
Cop.cun: 13x5	
Pol.v-1P-B/Unc-Scirp-moss-lichen-Ger.mic-Ac-Cer.fon-Epi.con-Lag.pet	Pol.v-4P-B/Unc-Scirp-March-Ac-moss-Cer.fon-toadstool-Ger.mic-Epi.con

Unit 85 end Section II

SECTION III

Unit 10

Dr.l: 80x60, 140x120	126x130, 23x13, 16x15, 16x10, 34x16, 18x13, 13x12, 22x15, 22x11, 13x8
Dr.x: >sds(b)	137x163, >sds
Myrs: 23x19	23x16, 36x33, 20x19, 15x17, 15x14, 22x18
Cop.cil: 15x19	20x26, 22x15, 20x21
Cop.cun: 11x18, 18x16	
Pol.v-3P-Carex-B/Luz.cri-Unc-moss-Scirp-March-Ac-Lyc.f-Hel.bel-Epi.con	3P-Pol.v-B-Carex-3Lyc-Blech/ Scirp-Unc-Luz.cri-March-Lichen-Prat-Ger.mic-Hel.bel-Gent

Unit 15 end Section III

SECTION IV

Unit 10

Dr.l: 129x120, 85x97, 157x202	70x47, 21x11, 18x14, 30x16, 20x10, 18x12, 16x8, 12x11, 10x10, 25x22, 14x14, 23x18
Dr.x: sds	>sds
Cop.cil:	22x26, 24x24, 15x33, 15x15, 20x30, 24x32, 25x45, 42x106, 25x50, 39x40, 30x30, 21x22
	sds

4P-Pol.v-B/Scirp-Unc-moss-March Hel.bel-Ger.mic-Prat-Ac

Pol.v-5P-B-Carex/Unc-moss-Scirp-March-Prat-Ger.mic

Unit 18 end Section IV

SECTION V

Unit 10

Dr.x: 154x112, 134x54, 36x60(b) >sds

20x20, 27x12, 24x17, >sds

Myrs: sds

7P(b)-Pol.v-B-1Lyc.v/Unc-Scirp-Lyc.f-Luz.cri-Ac-Hel.bel-Gent-moss-lichen-Epi.con-Cer.fon-Ger.mic-Abr.spa-Ste.par

6P-Pol.v(upto 74cm)-B/Unc-March-Scirp-moss-March-Lyc.f-Chi.cor-Ste.par-Ac-Epi.con-Ger.mic

Unit 20

Dr.x: 120x76, sds

115x135(b), 23x24, 21x15, 21x16, 26x15, 24x17, 17x14, 29x16, 20x10, 31x12, 19x10, 13x15, 17x9, 13x12, 14x9, 30x10, 18x17, 20x20, 18x14, >sds

Myrs: sd

19x17

Cop.cil:

19x12

Cop.cun:

13x6

5P-B-Pol/Scirp-March-Unc-Luz.cri-Lyc.v-Lyc.f-Hel.bel-Ger.mic-Epi.con-Lag.pet-Gent-Hie.bru?-Agr.mag

13P-Carex-B-Pol.v-Lac.lep?/Unc-scirp-March-Lyc.f-Lag.pet-Ger.mic-Prat-Hel.bel-Cer.fon-moss-lichen

Unit 30

Dr.l:

90x95

Dr.x:

18x14, 23x25, 18x18, 31x14, 28x12, sds

Myrs:

11x18

9P-B-Pol.v(b)-Carex/Scirp-March-Ac-Lyc.f-Unc-Luz.cri-Agr.mag-Poa.bre-Lac.lep-Hel.bel-Lag.pet-Ger.mic-Epi.con-Cer.fon

6P-Pol-B-Hie.red-Carex/Scirp-Unc-moss-Lyc.f-March-Ac-Hel.bel-Lag.pet-Gent-Prat-Epi.con-Ger.mic

Unit 35 end of scattered, tall scrub on this transect.

Unit 40

3P-B-Carex(b)-Hypo-(Pol)-Ple.spe (23cm diameter)/Scirp-March-Unc-1Lyc.v-Luz.cri-Agr.mag-Poa.bre-Hel.bel-Lag.pet-Epi.con-Ger.mic-Cer.fon-Abr.spa-Lag.pet-Ste.par-Ac-Jun.ant

9P-B-Hypo-Carex-Agr.cap/Scirp-March-Unc-Poa.bre-Ac-Luz.cri-lichen-Hel.bel-Cer.fon-Lag.pet-Epi.con-Ger.mic-Ste.par

Unit 47 end of Section V

SECTION VI

Unit 10 (heavily browsed sward)
3P(b)-B-Carex(b)/Agr.cap(b)-Poa.bre(b)-Scirp-March-Unc-Ac-Hel.bel-Pol.v-Lag.pet-Cer.fon-Epi.con-Ger.mic

5P-B-Pol.v-Carex-Ag.cap-1Lyc.v/Poa.bre-Unc-Ac-Luz.cri-Lag.pet-Cer.fon-Hel.bel-Ger.mic-Lyc.f

Unit 20
4P(b)-B/Agr.cap-Poa.bre-Fes.rub-Scirp-Unc-March-Ac-Pol.v-Cer.fon-Luz.cri-Epi.con-Pol.jun-Ger.mic-Abr.spa-Hel.bel

8P-B-Pol.v-Agr.cap-Carex-Poa.pra/Poa.bre-Cer.fon-Ac-Lag.pet-Ger.mic-Unc-Hel.bel

Unit 30
B-5P-Hypo/Agr.cap-Poa.bre-Hol.lan-Fes.rub/Scirp-March-Unc-Cer.fon-Hel.bel-Ac-Pol.v-Pol.jun-moss-Epi.con-Lag.pet

8P-B-Ag.cap-Poa.pra-Fes.rub/Hol.lan-Ac-Cer.fon-Ger.mic-Hel.bel-Hypo-March-Epi.con

Unit 32 Stile

Unit 40 (20% bare soil of sea lion track. Running water through unit)
B-Carex-Hypo-1P/Scirp-Tarax-March-Lag.pet-Hel.bel-Cer.fon-Ac-Ger.mic-Pol.jun-liverwort-Epi.con-Fes.rub-Poa.pra-Jun.sch

Agr.cap-5P-B-Hypo-Carex-(Pol.v)/Fes.rub-Poa.tri/Cer.fon-Hel.bel-Lag.pet-Scirp-Unc-March-Ger.mic-Ste.par-Ac-Car.cor?

Unit 50
B-(P)/Hypo-(Pol.v)-Agr.cap-Poa.tri-Fes.rub-March-Cer.fon-Lag.pet-Epi.con-Unc-Pol.jun-Scirp-Hel.bel-Ger.mic-Abr.spa

Fes.rub-Agr.cap-2P-B-Hypo/Poa.pra-Cer.fon-Lag.pet-Hel.bel-Ac-March-Pol.v-Ger.mic-Poa.tri

Unit 60
B-Hypo-P(b)/Agr.cap(b)-Poa.pra-Poa.tri/Cer.fon-Ac-Lag.pet-Hel.bel March-Tarax-Ste.par-Ger.mic-Pol.v-Car.cor?-Epi.ped-Scirp-lichen-moss

B-P-Agr.cap-Hypo/Poa.pra-Lag.pet-Cer.fon-Ste.par-March-Ac-Ger.mic-Tarax-Epi.ped-Pol.v-Car.cor?

Unit 70
B-Carex(b)-(P)/Agr.cap(b)-Poa.pra-Poa.tri-Scirp-Ac-Ger.mic-Hel.bel-Unc-Cer.fon-Jun.ant-Pol.jun-Pol.v

B-Agr.cap-Carex/Poa.pra-Poa.tri-Cer.fon-Hel.bel-Ac-Ger.mic-Pol.v-Car.cor?-Lag.pet-March

SECTION VII

Unit 10
Carex(b)-B-Poa.pra-Poa/Scirp-Abr.spa?(b)-Hel.bel-Pol.jun-Lag.pet-Cer.fon-Ger.mic-March

Poa.pra-B-P/Agr.cap-Hel.bel-Lag.pet-Pol.jun-Ac-Cer.fon-Luz.cri-Ger.mic-moss-March

Unit 20
B-Ple.cri(42cm diameter)-(P)(b)/Hel.bel-Ac-Scirp-Poa.pra-Poa.bre-Pol.v-Unc-Lyc.f-Lag.pet-Ger.mic-Car.cor?-Ste.par-moss-March-Abr.spa

B-Poa.pra-Agr.cap/Hel.bel-Scirp-Ac-Unc-Lag.pet-Cer.fon-Tarax-Abr.spa-Ger.mic-Pol.v-moss-March-Luz.cri-Ani.lat(5cm tall)

Unit 30

P(b)-B/Jun.sch-Scirp-March-Poa.pra-Cer.fon-Lag.pet-Cal.ant-Epi.bru-Poa(b)-Ger.mic-Hym.mul-Ac-Epi.ped-Hel.bel-Car.cor?-Unc-liverwort

B-P-Agr.cap-/Poa.pra-Hel.bel-Scirp-Lag.pet-Jun.sch-Cal.ant-March-Ger.mic-Ac-Cer.fon-Unc-Hym.mul-Epi.con

Unit 40

B/Scirp-March-Hel.bel-Poa(b)-Jun.sch-Lag.pet-Unc-Luz.cri-Cer.fon-moss-Epi.bru-Ger.mic-Car.cor?-Ac-Ple.spe(b)(9cm diameter)

B-P/Hel.bel-Scip-March-Unc-Luz.cri-Jun.sch-Epi.als?-Ger.mic-Abr.spa-Ac-Cer.fon-Tri.spi-moss-Pol.v-Epi.bru-Gent-Tarax-Poa.tri Sti.pol(19cm diameter) beside fence

Unit 50

B-(P)/moss-Hel.bel-March-Scirp-Jun.sch-Lag.pet-Unc-Ger.mic-Cer.fon-Tri.spi-Poa.tri-Ac-Tarax-Mon.aus-Des.cha-Epi.bru-Abr.spa

B/Scirp-Hel.bel-March-Poa.tri-Agr.cap-Jun.sch-Ac-Luz.cri-Cer.fon-Lag.pet-Ger.mic-Epi.bru-Poa-Tarax-Car.cor?-Poa.tri-Abr.spa

Unit 60

B/Scirp-March-Hel.bel-Jun.sch-Lag.pet-moss-Agr.mag?-Epi.bru-Ger.mic-Luz.cri-Cer.fon-Fes.rub Poa.tri-Abr.spa-liverwort-Mon.aus-Ani.lat(sd)

B/Hel.bel-Scirp-March-moss-Lag.pet-Epi.bru-Epi.als-Jun.sch-Luz.cri-Abr.spa-Abr.ros-Unc-Gent-Agr.mag?-Fes.rub-Cer.fon-Ger.mic-Ac-Ste.par

Unit 70

B/Poa.bre-Agr.mag?-Unc-Hel.bel-Ac-Lag.pet-Ger.mic-Epi.bru-Abr.spa-Cer.fon-Luz.cri-March-Cor.tri-Pol.v moss-Car.cor?-Ac-Epi.ped-Mon.aus-Tarax-Ste.par-Gent-Abr.ros

Agr.cap-B-Fes.rub/Hel.bel-Lag.pet-Ac-Cer.fon-moss-Ger.mic-Ran.sub-Pol.v-Epi.bru-Tri.spi-Luz.cri-Epi.als?-P-Ple.spe (35cm diam)-Unc-Tarax-Epi.con-liverwort-Car.cor?-Poa.bre

SECTION VIII

Unit 5

P-Luz.cri-Agr.mag?-Ger.mic-Ani.lat(sds)-Hel.bel-Abr.ros-Ran.pin

P-Luz.cri-Agr.mag?Ani.lat(sds)-Ran.sub-Epi.bru-Ger.mic-lichen-Abr.ros-Phyl-Ran.pin-Col.ape-B

APPENDIX 15: SEA Temperature recordings on Campbell Island 1987-88

DATE	TIME (NZST)	MIDDLE BAY	PENGUIN BAY	BEEMAN BASE
2.11.87	0730			6.5
6.11.87	1400		7.2	
9.11.87	0730	7.0		6.7
16.11.87	0730			6.7
23.11.87	0730			8.3
28.11.87	1110	7.4		8.0
30.11.87	0730			7.8
3.12.87	0830	8.2		8.6
7.12.87	1700/0730	8.2		7.6
8.12.87	1100	7.8		
12.12.87	1200/2000	7.7		7.9
14.12.87	0930/0730		7.9	8.4
15.12.87	1130/1230		7.9	8.6
17.12.87	1400	8.5		
21.12.87	0730			8.3
22.12.87	1110	8.0		9.0
24.12.87	0830		8.0	8.8
27.12.87	1230	8.2		
28.12.87	0730			8.4
1.01.88	1200/1300	8.3		8.9
4.01.88	0730			8.8
6.01.88	1050	8.0		
11.01.88	1320	8.5		
16.01.88	1100	7.8		7.9
21.01.88	1315	8.3		8.0
26.01.88	1230	9.4		9.5
31.01.88	1100	8.5		9.2
1.02.88	0730			8.6
5.02.88	1130	8.9		9.5
8.02.88	0730			8.6
10.02.88	1130/1200	9.1		11.0
15.02.88	1330	9.1		
25.02.88	1200	8.2		
1.03.88	1230	8.6		
6.03.88	1130	8.8		
7.03.88	0900			8.2
11.03.88	0900	8.8		
14.03.88	0900			8.0
16.03.88		8.4		
21.03.88	0900	8.3		8.4
26.03.88	0945	7.9		
28.03.88	0900			7.5
31.03.88	1115	8.0		
4.04.88	0900			7.5
11.04.88	0900			7.7
14.04.88	1241	8.3		
17.04.88	1300	7.9		
18.04.88	0900			7.5

APPENDIX 15: Ctd.

DATE	TIME (NZST)	MIDDLE BAY	PENGUIN BAY	BEEMAN BASE
25.04.88	0900			7.7
26.04.88	1030	8.9		
2.05.88	0900			7.7
9.05.88	1420-0900	7.3		7.5
16.05.88	1200-0900	6.6		5.9
23.05.88	0900			4.5
29.05.88	1100	7.8		
30.05.88	0900			6.1
3.06.88	1230	6.8		
6.06.88	0900			6.1
13.06.88	0900			5.5
15.06.88	1245	6.3		
19.06.88	1330	6.0		
20.06.88	0900			5.6
27.06.88	0900			5.7
4.07.88	0900			5.6
10.07.88	1145	6.4		
11.07.88	0900			6.2
18.07.88	0900			5.5
25.07.88	0900			5.7
1.08.88	0900			2.7
3.08.88		5.8		
4.08.88		6.0		
8.08.88	0900			6.4
12.08.88	1200	6.0		
15.08.88	0900			5.5
22.08.88	0900			6.1
28.08.88	1200	6.1		
29.08.88	0900			6.1
3.09.88	1500	6.3		
5.09.88	0900			6.7
14.09.88	1500	6.0		

Middle Bay recordings were from off the rocks at the eastern end of the bay. One decimal place was estimated from a thermometer of one degree accuracy.

Beeman recordings were taken by Met. staff from the wharf. The thermometer had a 0.5 degree accuracy.