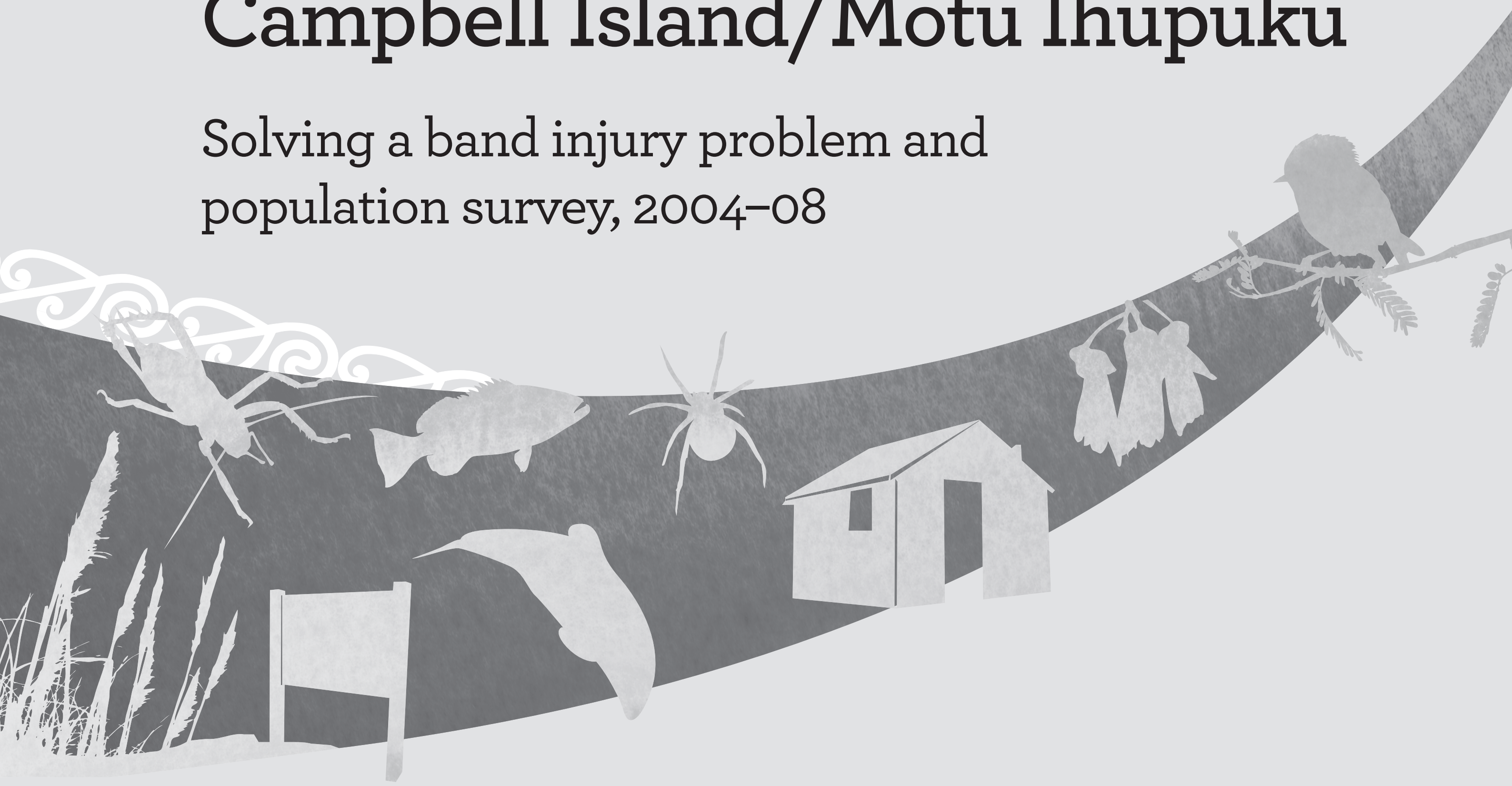
Southern royal albatross on Campbell Island/Motu Ihupuku

Solving a band injury problem and population survey, 2004–08



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Peter J. Moore, Eric J. Larsen, Matt Charteris and Moira Pryde

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Appendix 2

Southern royal albatross on Campbell Island/ Motu Ihupuku

Solving a band injury problem and population survey, 2004–08

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Abstract

Over 35 000 southern royal albatrosses (*Diomedea epomophora*; toroa) were banded on subantarctic Campbell Island/Motu Ihupuku between the 1940s and 1990s. The banding has had an unfortunate side effect, with an unacceptable number of birds being injured by their bands. To remedy this, it was decided that bands would be removed from most birds on the island. From 2004 to 2008, the island was searched annually for royal albatrosses, including in previously defined study and index count areas. Any bands found were removed and injuries were treated. During these searches, 2882 banded birds were found. Of these, 72 (2.5%) had major injuries, 8.5% had minor injuries and 12% had open bands (≥3 mm) with the potential to cause future injuries. The majority of major and minor injuries were to males because their larger legs had made closing the bands problematic. Injury rates were highest from birds banded in the 1960s and 1970s (particularly 1979), when poor banding practice combined with the tendency of the large R bands to spring open. At Col and Moubray study areas, the aim was to replace bands, and new 1.25 mm-thick stainless steel bands were trialled. R bands were found to be reliable for use on females when closed with an improved technique, but larger and springier RA bands were rejected for males because some opened > 3 mm and one re-banded bird was injured. Males at Col were subsequently marked with transponders to retain their marking history. The search for bands provided an opportunity for a census, and the composite total of 7855 nests found, or an estimated 8300–8700 breeding pairs at the beginning of the breeding season, represents a levelling in the royal albatross population on Campbell Island/Motu Ihupuku since the last census in 1995. Numbers of albatrosses in the study and index areas were stable (one area) or had declined (four areas) since the late 1990s and breeding success also decreased from 79% to 68% at Col Study Area. These data suggest conditions are currently less favourable for southern royal albatrosses.

Keywords: Southern royal albatross, *Diomedea epomophora*, band injuries, population.

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1. Introduction

The southern royal albatross (*Diomedea epomophora*; toroa) is listed by the Department of Conservation (DOC) as a threatened species which is 'at risk' because of its 'range restricted' status (Miskelly et al. 2008; Townsend et al. 2008). Over 99% of birds nest on the 11 268 ha Campbell Island/Motu Ihupuku (52°33'S, 169°08'E) in the New Zealand subantarctic (referred to as Campbell Island in the rest of this report), with 8200–8600 pairs present per year (Moore et al. 1997; Gales 1998; Birdlife International 2009). As with other great albatrosses, southern royals are slow to mature (6–12 years), breed biennially in long-term partnerships, and live for up to 40 years or more (Sorensen 1950; Westerskov 1963; Marchant & Higgins 1990; PJM unpubl. data).

Campbell Island vegetation can be broadly categorised as *Dracophyllum* shrubland (which clothes the lowlands up to about 180 m a.s.l.), tussock grasslands (including *Poa* and *Chionochloa* grasses) and megaherb fields (including *Pleurophollum* and *Bulbinella*) at mid elevation, and subalpine vegetation on the higher peaks and ridges above 350 m a.s.l. Southern royal albatrosses breed at low density in the tussock-megaherb zone, and thus occupy approximately one-third, or c. 4000 ha, of the 11 300 ha island.

The southern royal albatross population on Enderby Island (Auckland Islands; 50°30'S, 166°17'E) was extirpated by humans in the 1800s (Taylor 1971; Childerhouse et al. 2003) and the population on Campbell Island was severely depleted (by burning of vegetation, grazing, depletion of nesting habitat and direct predation of the birds) by the time the farm on the island closed in the 1930s (Oliver 1930; Guthrie-Smith 1936; Westerskov 1959; Taylor et al 1970). Sheep (*Ovies aries*) numbers peaked at 8500 in 1910. After the farm closed, the sheep and some cattle (*Bos taurus*) became feral and concern grew about the ongoing degradation of landforms, vegetation and albatross nesting habitat (Westerskov 1963). The island was formally protected as a Reserve for the Preservation of Flora and Fauna (later called a National Nature Reserve) in 1954 and a start was made on removing the introduced mammals. In order to study the effect of the sheep, they were progressively removed from portions of the island through the construction of fences in 1970 and 1984, and completely removed in 1992 (Rudge 1986; Brown 2002; Clout & Russell 2006). Cattle were eradicated in 1984 and Norway rats (*Rattus norvegicus*) in 2001 (McClelland & Tyree 2002; Clout & Russell 2006). Feral cats (*Felis catus*), which had always been scarce (Dilks 1979), apparently died out in the late 1980s (Moore 1997; Barker et al. 2005).

During the second half of the 20th Century, southern royal albatrosses re-established a small population on Enderby Island and the population on Campbell Island grew from approximately 2300 nests in 1957 (Westerskov 1963) to 7800 in 1995, with the latter count probably representing 8200–8600 nests at the start of the breeding season (Moore et al. 1997). An exception to this increasing population trend occurred at both islands during the late 1970s to early 1980s, when albatross numbers apparently stabilised or decreased (Taylor et al. 1970; Dilks & Wilson 1979; Moore et al. 1997; Childerhouse et al. 2003). While the albatross population was probably recovering from the depredations and habitat destruction that occurred during the 1895–1931 farming era on Campbell Island (Dilks & Wilson 1979), there did not appear to be a direct relationship between sheep numbers and albatross numbers, as albatross numbers increased in the presence, and absence, of sheep on different parts of the island (Dilks & Wilson 1979).

Eleven censuses of southern royal albatrosses on Campbell Island were conducted between 1957 and 1995, using 10 survey blocks (Fig. 1), and a vantage point method of counting—birds were tallied from ridge-top walking routes and vantage points (Taylor et al. 1970; Dilks & Wilson 1979). However, during the 1990s, this method appeared to become unreliable, since an unknown proportion of birds was obscured by rough terrain and thick vegetation. Increasing the survey effort tended to increase the count of nests (Moore et al. 1997). Study areas at Col and Moubray (Fig. 1) were used for breeding, banding and population studies that were carried out sporadically from the 1940s to 1990s (Sorensen 1950; Moore & Moffat 1990; Waugh et al. 1997).

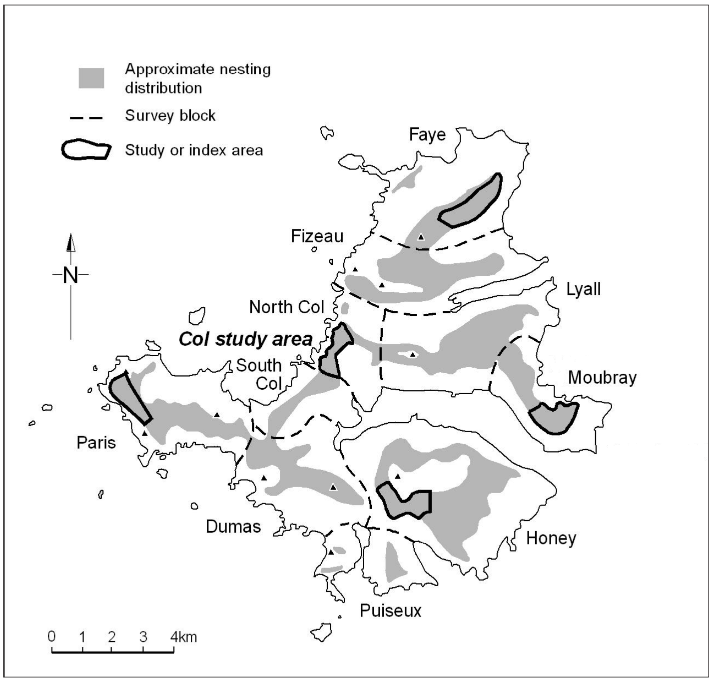

Figure 1. Southern royal albatross (*Diomedea epomophora*) survey blocks on Campbell Island/Motu Ihupuku.

Thorough searches for nests during 1987–98 within the defined boundaries of these two areas gave a much more reliable measure of population trends (Moore et al. 1997). Three sectors of Faye, Paris and Honey blocks were set up as index count sites (Fig. 1) in the late 1990s to supplement the counts at the study areas and to study population trends in different parts of the island (PJM, unpubl. data). These areas were searched by teams of three people walking in parallel sweeps approximately 15 m apart, in an attempt to encounter every nest in nesting areas.

More than 35 000 southern royal albatrosses were banded on Campbell Island between 1941 and 1998 (Moore 2003), mostly by staff of the meteorological station, who were encouraged to band albatrosses, even though they were generally not trained in bird handling and banding techniques. They banded up to 5200 birds, usually chicks, annually over the whole island (Moore 2003). The peak of banding (79% of total) was in the 1960s to 1970s. After 1987, banding was restricted to the two study areas (Col and Moubray) (Moore & Moffat 1990; Moore et al. 1997; Moore 2003). For example, six cohorts of chicks were banded at Col and Moubray in 1991–96, and all breeding adults were banded at Col in 1994–98 (PJM, unpubl. data).

Recoveries of 240 (0.68 % of the total) banded birds away from Campbell Island over the 60-year period since banding began have provided a valuable illustration of the distribution of southern royal albatrosses at sea (Robertson & Kinsky 1972; Moore & Bettany 2005). Having a proportion of the population banded has also been a potential resource for the study of the species' population dynamics. However, compared with the annual effort of banding chicks, little effort has been spent searching for banded birds once they returned to the island to breed (with the exception of some breeding studies, particularly at Col study area in the 1960s and 1990s). Consequently, only 16% of birds were seen again after they were banded (Moore 2003). Also, having banded birds spread over the large (11 300 ha) island has meant that the condition of bands on most birds was never checked.

Unfortunately, the use of untrained volunteer banders meant that many bands were applied incorrectly. Some bands were left open at banding or opened up over time (the stainless steel R band used has a large diameter (19 mm) and circumference relative to its thickness (1 mm), and this may have contributed to bands springing open with time). The resulting gap allowed band edges to embed in the legs or ankles of the affected birds.

Galls commonly formed around the imbedded bands, affecting the birds' tendons and crippling their ankles. Although band injuries had been noted in earlier years (G. Taylor, DOC, pers. comm.; Moore & Moffat 1990; Moore et al. 1997), the full extent of the problem was not highlighted until relatively recently (Moore 2003). A check of 2200 banded birds in 1994–98 found 2.5% had been injured by their bands, including 7% of birds that were banded as chicks and 0.5% that were banded as adults. It was found that six banding cohorts had 83% of injuries, with birds banded in 1979 being most affected by the problem (Moore 2003).

Once the extent of the banding problem was identified and written-up for publication (Moore 2003), the former External Relations Division of DOC instructed the former Science & Research Unit (now Science and Technical Group) and Southern Islands Area Office to come up with a plan of action to deal with the problem. This plan had to address not only the injury problems, but also the lack of capacity for continuing long-term monitoring and band maintenance of southern royal albatrosses on Campbell Island. The relatively low threat ranking of the southern royal albatross meant that a case for continuing a banding study was difficult for DOC to justify. Furthermore, the small number of overseas band returns (0.68% of the total, and usually approximately 1–2 birds per year during the 1990s to the early 2000s) was of limited value compared with distribution data that can be gained from satellite tracking, for example (Waugh et al. 2002; Moore & Taylor 2005). On Campbell Island, 66% of band recoveries, and most repeat resightings, were from the study areas at Col and Moubray (Fig. 1). Consequently, band returns from areas outside of the main study areas had little statistical value, which meant that it was not necessary to retain the island-wide spread of banded birds in order to adequately monitor population dynamics (R. Barker, University of Otago, pers. comm. 2002; Moore & Taylor 2005).

A new programme was designed to find as many banded albatrosses on Campbell Island as possible and remove their bands. Birds in the Col and Moubray study areas would also have their bands removed, but these would be replaced by new, more reliable bands or with transponders. The large size of the island and the biennial breeding pattern of the albatrosses meant that the work would require 5 years to complete. The primary motivator for band removal was one of animal welfare—to treat injured birds and prevent future injuries. Additionally, because a comprehensive five-year survey was required to find all the banded birds, it was anticipated that the re-sighting of banded birds would provide much valuable information on population size, distribution and trends (from the nest counts), and adult survival and juvenile recruitment (from the band records). This report summarises the findings from the five-year survey and band removal project (2004–2008)[1].

2. Methods

The main aim was to survey the entire breeding range of southern royal albatrosses on Campbell Island, in order to find as many banded and injured birds as possible. A secondary aim was to use the same nest surveys to illustrate distribution and population size and compare these data with previous censuses.

2.1 Survey periods and personnel

Trips to Campbell Island involved 2–3 days' travel in small charter vessels in late December, followed by 7 weeks of field work on the island. Trips were timed to coincide with the incubation period of southern royal albatrosses (eggs are laid between late November and mid December and hatch in mid February). Teams were on the island for 50–60 days in 2004 (1 January – 20 February), 2005 (1 January – 15 February), 2006 (21 December – 17 February), 2007 (31 December – 20 February) and 2008 (21 December – 9 February). Two teams of four people (sometimes five people for short periods), conducted field work during the first 4 years, and a single four-person team did the field work in the 5th field season.

[1] Note that years in this report refer to the albatross breeding season, which starts in late November; e.g. 2004 refers to the 2004/05 season).

2.2 Survey areas

For the purpose of searching for bands, the island was subdivided into 10 survey blocks based on those used in previous royal albatross censuses (e.g. Dilks & Wilson 1979; Moore et al. 1997). This provided an opportunity to repeat the counts for comparison with previous censuses, such as the most recent island-wide count of nests in 1995 (Moore et al. 1997). Because albatrosses occupy an extensive upland area (c. 4000 ha) of tussock-herb country on the island, and the largest blocks took up to a week to survey (Table 1), it was not feasible to survey the whole island multiple times each year. The proportion of birds banded or injured (Moore 2003), nest densities and historical banding rates were used to determine which survey areas should yield the greatest number of banded and injured birds. These survey blocks (South Col, North Col, Lyall, Moubray, Faye and Fizeau) are in the northern and central sectors of the island (Fig. 1) and were surveyed in the first 2 years of the study (2004 and 2005, Table 2). The southern and western sectors of the island (Paris, Dumas, Puiseux and Honey) were surveyed in the next 2 years (2006 and 2007, Table 2), and South Col, the majority of North Col, Moubray and part of Fizeau were resurveyed (making 4 years' survey in these areas). Consequently, the island–wide census of nests, created whilst searching for bands, was a composite count from 4 years of survey.

Three index count areas at Faye, Paris and Honey (Fig. 1; Appendix 1, Figs A1.1–A1.3) were re-surveyed for 3–5 years in 2004–08, including when they were surveyed as part of the larger blocks, mentioned above.

Study areas at Col and Moubray (Fig. 1; Appendix 1, Figs A1.1–A1.2) were surveyed annually for 5 years in 2004–08 to maximise the recovery of bands in these band-rich areas.

Surveys were conducted from Beeman Base or from whichever of the field huts (Sorensen, Northwest Bay, Penguin Bay, Southeast or Moubray) was closest to the block being surveyed. Fizeau was surveyed from a tent camp in 2005. Travel time varied from a minimum of 20 minutes (e.g. Northwest Bay hut to the nearest part of Dumas block) to a maximum of 1.5 hours return from the farthest corners of a block (e.g. northern Honey block to Southeast hut).

Table 1. Effort per four-person team required to survey southern royal albatross (*Diomedea epomophora*) areas on Campbell Island/Motu Ihupuku, based on fieldwork in 2004–2008 (does not include travel time to and from huts).

AREA	SURVEY EFFORT (DAYS PER 4-PERSON TEAM)				
	VISIT 1	VISIT 2	VISIT 3	VISITS 4–9 COMBINED	TOTAL
Faye	6.0	5.0			11.0
Fizeau	6.0	5.0			11.0
Lyall	6.0	4.5			10.5
Moubray	5.5	3.0			8.5
North Col	5.0	4.0			9.0
South Col	3.0	2.0			5.0
Paris	5.0	3.0			8.0
Dumas	5.0	3.0			8.0
Puiseux	2.0	1.0			3.0
Honey	7.0	5.0			12.0
Island total					**86.0**
Col study area	3.5	3.0	3.0	4.5	14.0
Moubray study area	3.0	1.5	0.5		5.0
Faye index	2.0				2.0
Paris index	2.0				2.0
Honey index	2.0				2.0
Study and index total					**25.0**

Table 2. Number of nests of southern royal albatross (*Diomedea epomophora*) found on Campbell Island/Motu Ihupuku in 2004–2008, including full and partial (in brackets) surveys of areas, and subtotals for study and index areas.

AREA	AREA (ha)	2004	2005	2006	2007	2008	MEAN OF FULL SURVEYS
Main survey blocks							
Faye	270	1285	1125	(572)	(563)	(609)	1205.0
Fizeau	344	1351	1169	(531)	(483)		1260.0
Lyall	395	998	929	(45)	(24)	(213)	963.5
Moubray	203	1064	984	1048	1030	(706)	1032.0
North Col	104	264	237	(225)	(239)	(254)	250.5
South Col	88	257	260	253	259	(82)	257.3
Paris	297			760	785	(438)	772.5
Dumas	267	(66)		609	605	(1)	607.0
Honey	562			1413	(1449)	(377)	1413.0
Puiseux	35			94	(82)		94.0
Total nests visited	**2565**	**5285**	**4704**	**5550**	**5519**	**2680**	**7854.8**
Study and index areas							
Col		207	185	182	196	214	196.8
Moubray		506	462	494	492	569	505.4
Faye		598	537	572	563	609	575.8
Paris				332	334	435	367.0
Honey				336	402	377	371.7

N.B. Data for each area is the number counted on the first visit, plus new nests from the second or subsequent visits.

2.3 Timing and visit frequency

Previous data on breeding frequency and band recovery rates were used to plan fieldwork. Because southern royal albatrosses are biennial breeders, successful birds take a year or more off between breeding attempts, whereas birds that fail at the egg or early chick stage usually return and attempt to breed in consecutive years. Birds that lose a partner may take some years to find a new partner and breed again. In an ideal monitoring situation, where an area is visited every year and multiple visits are made to the nests to find both partners of a pair, the majority of banded birds should be found in the first 2 years, and lesser numbers in following years. In 1994–98, 75% of birds that bred in the Col study area were found in the first 2 years of the 5-year study (PJM, unpubl. data). Similarly, during each breeding season monitored, the majority (approximately 70%) of banded birds present that year were found in the first two visits to each nest. Hence, visiting an area twice per year over 2 years should find about 52% of banded birds. Increasing the frequency of visits per year over a longer sequence of years improves the proportion of banded birds found.

Each survey block was visited twice per season to find breeding partners of birds found during the first visit. Visits were approximately 8 days apart (range 6–10 days), corresponding to the average incubation shift of 8 days (range 1–17 days; PJM, unpubl. data). Second visits during particular survey periods usually took less time than the first visits (Table 1) because teams were more familiar with terrain and nest distribution, or were able to use Global Positioning System (GPS) locations obtained during first visits. Also, nesting birds were marked on the chest with coloured spray paint on the first visit so that only new birds needed to be checked on subsequent visits (see section 2.6). Because of time constraints, only one visit per season was made to areas with low banded-bird encounter rates with banded birds (e.g. parts of Honey, Puiseux, Paris). Similarly, only one visit was made each season to the index count areas (except in the years the whole block was surveyed). At study areas Col and Moubray and neighbouring areas with high encounter rates with banded birds (parts of South Col and North Col), three to nine visits to individual nests were made, to increase the proportion of partners found.

2.4 Surveying

Four people walked in parallel sweeps while searching for nests—a search pattern used for previous intensive nest visit counts in albatross index areas (> 95% of nests found; PJM, unpubl. data). Nest searches were conducted from within the margin of dense scrub (Fig. 2), through the tussock-herb zone (Fig. 3) to the upper limit of nesting (Fig. 4). Depending on the terrain, weather conditions and vegetation type (i.e. the ease of locating nests), the distance between people varied between 10 m and 50 m (Figs 5 & 6). Sweeps were oriented using temporary marker poles (1.2 m-tall white PVC with a 20 cm orange strip at the top) or the GPS tracking feature (Appendix 2).

During the sweeps, team members zig-zagged slightly between the nests encountered along their path. Each nest was approached with care so as not to frighten the resident bird. Both of the bird's legs were checked carefully for bands by sight or feel. If processing time was required at the nest (e.g. to remove a band), the team generally paused to keep the sweep intact. Similarly, if a nervous or aggressive bird was found, or one with a band injury, a neighbour or the whole team could converge to help at that nest.

A set of instructions for the albatross handling and work (Appendix 2) was given to team members and a training day was held on the first day in the field.

Figure 2. Southern royal albatrosses (*Diomedea epomophora*) nesting in scrub margin at 180–200 m altitude, Moubray study area, Campbell Island/Motu Ihupuku. Moubray Hill is in the background. *Photo: Peter Moore.*

Figure 3. Southern royal albatross (*Diomedea epomophora*) nesting in mixed *Poa litorosa* tussock/*Bulbinella rossii*, c. 250 m altitude, Col study area, Campbell Island/Motu Ihupuku. *Photo: Peter Moore.*

Figure 4. Upper limit of southern royal albatross (*Diomedea epomophora*) nesting habitat at *Pleurophyllum hookeri* herbfield, c. 350 m altitude, Lyall ridge, Campbell Island/Motu Ihupuku. *Photo: Peter Moore.*

Figure 5. Searching for southern royal albatross (*Diomedea epomophora*) nests in megaherbfield, c. 220 m altitude, Moubray study area, Campbell Island/Motu Ihupuku. *Photo: Peter Moore.*

Figure 6. Surveying for southern royal albatrosses (*Diomedea epomophora*) in misty conditions on Campbell Island/Motu Ihupuku. *Photo: Malcolm Rutherford.*

2.5 Nest mapping

Each nest location was recorded using hand-held GPS units (mostly *Garmin Etrex*) and downloaded and manipulated with *Fugawi, Excel* and *ArcView*. Field maps were produced using an electronic map of Campbell Island. Waypoints of nest locations from first visits were uploaded to GPS units to help relocate nests during subsequent visits, especially those in the two main study areas, and revisits to areas of sparsely distributed nests.

The GPS positions of nests obtained during the first survey of an area provided the overall nest distribution. During second surveys of areas, only the banded birds on nests, or newly discovered nests, had GPS positions taken.

2.6 Obtaining band and nest data

Band details of nesting birds were recorded during the survey sweeps, including the band type (prefix R, RA and O), band number, state of band (closed or open), width of the band opening and quality of band (round or oval, skewed, offset, misshapen, tight) (Fig. 7). Bands were removed with 'circlip' opening pliers at all areas, and replaced with new bands at the Col and Moubray study areas only (see sections 2.9–2.11). It was not necessary to handle the birds, other than briefly shifting the leg, as they usually had a strong bond to the nest and sat tight on the egg (Fig. 8). If there was any doubt about the safety of the egg (because the adult was nervous or injured, for example), it was swapped for a dummy egg. The original egg was stored in a thermal hat and returned to the bird after the band manipulation was complete.

The chest of each bird and the ground beside its nest was sprayed with stock marker paint to indicate that the bird and nest had been checked. Marking the birds enabled adjacent observers to keep track of which nests had been visited, the orientation of subsequent sweeps, accuracy transects (explained below) and to prevent disturbance of birds on subsequent visits. Generally, the paint lasted for 2 weeks on incubating birds, but became very faint on birds that had been to sea.

Each nest was tallied and categorised according to whether the sitting bird was sprayed (for second visits), unbanded, banded, injured by a band, or the nest had failed.

Non-nesting birds that were encountered during the surveys were caught for band removal, where possible.

Figure 7. A correctly fitted R band on a southern royal albatross (*Diomedea epomophora*), Campbell Island/Motu Ihupuku, showing a typical oval shape to fit comfortably on the tarsus. A slight dent near the ankle was caused by a previous (now removed) tight band. *Photo: Peter Moore.*

Figure 8. Peter Moore removing a band from a nesting southern royal albatross (*Diomedea epomophora*) on Campbell Island/Motu Ihupuku. *Photo: Stacy Moore.*

2.7 Injuries and first aid

If an albatross had suffered injuries as a result of a leg band, the injuries were graded on a scale of 1–5 of increasing severity, from (1) where the band had indented the leg to (2) where the band had caused a blister or ridge of irritated skin, to (3) where the band had penetrated the skin of the leg, to (4) where the band had stuck into the leg and formed a gall or (5) a severe gall (Figs 9–14). The size and location of the leg injury was recorded and photographed.

Birds with the more severe injuries from embedded bands (levels 4–5) were usually removed from the nest before their bands were removed and first aid applied. Others were treated at the nest while sitting on a dummy egg. For most simple wounds, the procedure was to remove the band with circlip pliers, clean the blood away with diluted '*mediclens*' and sterile gauze swabs and apply '*betadine*' antiseptic ointment to the wound before releasing the bird. For bleeding wounds, pressure was applied with a swab until bleeding stopped and, if necessary, a silver nitrate stick or potassium permanganate crystals were used to promote clotting.

Birds with healed injuries from bands removed in previous years (Fig. 15) were also noted.

Figure 9. Dent on the leg of a southern royal albatross (*Diomedea epomophora*) on Campbell Island/Motu Ihupuku caused by a band being incorrectly shaped (injury code 1). Note the band has been slid up the leg for the photograph. *Photo: Peter Dilks.*

Figure 10. Irritation on the leg of a southern royal albatross (*Diomedea epomophora*) on Campbell Island/Motu Ihupuku probably caused by the open band (seen at right above the ankle) rotating and catching on the ridge of the tarsus and rubbing on the skin (injury code 2). *Photo: Peter Dilks*.

Figure 11. A band which has penetrated the skin on the tarsus of a southern royal albatross (*Diomedea epomophora*) on Campbell Island/ Motu Ihupuku (injury code 3). *Photo: Peter Dilks*.

Figure 12. Band embedded in the lower leg of a southern royal albatross (*Diomedea epomophora*) on Campbell Island/Motu Ihupuku, creating a small gall and crippling the foot and ankle (injury code 4). *Photo: Peter Dilks.*

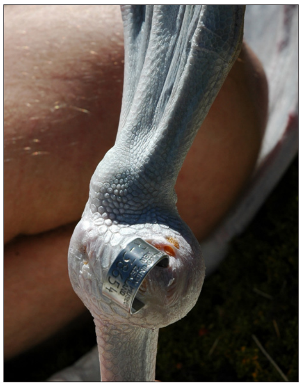

Figure 13. Band embedded and projecting from a large gall above the ankle of a southern royal albatross (*Diomedea epomophora*) on Campbell Island/Motu Ihupuku (injury code 5). *Photo: Matt Charteris*.

Figure 14. Bony growth caused by a band embedded in the leg bone of a southern royal albatross (*Diomedea epomophora*) on Campbell Island/Motu Ihupuku. *Photo: Matt Charteris.*

Figure 15. Healed injury on southern royal albatross (*Diomedea epomophora*) on Campbell Island/Motu Ihupuku showing reduced gall but with bony growth still evident beneath skin. *Photo: Peter Dilks.*

2.8 Precision and accuracy of the bird counts

Counts of birds give estimates of population size which vary from reality as a result of normal variation (precision) or bias (accuracy) (Bibby et al. 2000). The method of parallel sweeps was designed to be thorough enough to encounter most nests in an area, and careful field protocols minimised counting errors. Precision was not measured directly. Precision errors in large survey blocks included failing to tally or take a GPS point for a nest, or making two tallies or GPS points at the same nest. These probably contributed < 1% error to most counts, since areas (such as the Col and Moubray study areas) that were visited multiple times by revisiting GPS points generally had very few tally or GPS recording errors. The revisits allowed any points of confusion to be rectified and tallies adjusted. Transcription errors to computer files were minimised by comparing field tallies with the number of GPS points taken.

It was assumed that the main contributor to survey accuracy would be underestimation of nests as a result of a bias towards counting the most visible birds. Observers varied in their ability to zig-zag along their sweep, and factors such as complex terrain, vegetation height or weather affected nest visibility. To estimate survey thoroughness (underestimation of nests) of the combined team; once a survey block was completed, team members walked transect lines in directions that crossed those of the original sweeps. Every nest within 15 m either side of the line was checked for a marked bird or nest. Nests along the line were tallied and a proportion of marked/total nests calculated. Those without marks were processed and added to the total for the survey block.

A further measure of survey underestimation was gained during the second visit to an area when additional nests were encountered that had not been seen during first visits.

2.9 Col and Moubray Study Area procedures

All nests in the Col study area (Appendix 1, Fig. A1.1) were marked with numbered pegs and up to six to nine visits were made to each nest per season to find breeding partners. Breeding birds were marked with a band and/or transponder (see below). The adjacent areas of North Col (northern boundary) and South Col (southern boundary) were also searched for former study birds (from 1994 to 1998) and their nests were also marked. At least three GPS positions were taken to obtain an average location estimate. All marked nests were checked again near the end of each field period (mid-February) to record breeding success at, or near, the chick hatching stage. A final check was made the following January to estimate how many chicks had fledged. Re-growth of vegetation on and around the bowl and/or presence of egg shell fragments indicated that the egg had failed or the chick had died early in the rearing period. Skeletons near nest bowls indicated that chicks had failed late in the rearing period. Abundant grooming of the nest, nearby play nests, vegetation flushing from faeces and downy feathers indicated that a chick had fledged.

Moubray study area (Appendix 1, Fig. A1.2) was visited three times per season to find breeding partners.

2.10 New bands

After discussions with the New Zealand National Banding Scheme (R. Cossee, DOC, pers. comm.) and band manufacturers; new, thicker 1.25 mm stainless steel R and RA bands were supplied for use on Campbell Island. It was hoped that these would have less spring than the old 1 mm-thick R bands. New R bands (Fig. 7) were the same diameter (19 mm) when closed in a circle as the old bands, but were intended to be used on the smaller-legged females only. The new RA bands had a larger diameter (22 mm). Because R bands can be tight on the legs of larger-legged birds, particularly males, it was decided to re-band females with R bands and males with RA bands.

In 2004 and 2005, all existing bands on birds at Col were removed and replaced with the new bands and unmarked breeders were also banded. At the central core of Moubray (sectors 1–5, Fig. A1.5), all existing banded birds were re-banded, whereas bands were removed and not replaced on birds in the periphery (sectors a–k, Fig. A1.5).

Sex was estimated by appearance (body size and plumage) and leg size. Occasional errors occurred at the study areas when females were misidentified as males, usually by new personnel at the beginning of the survey period. These females were later re-banded with the more suitably sized R bands. Experienced band operators removed the old bands and replaced them with new bands. Careful attention was paid to ensuring the band ends butted closely together. This was obtained by using slip-joint pliers to shape the band circle into an oval (particularly important for the smaller R bands; Fig. 7) while progressively overlapping the butted ends of the band and relying on the natural spring of the band to return the band ends into the closed butted position. Any skews or uneven gaps in the butt closure were carefully corrected using the pliers at an angle to the band circle.

However, despite careful application of the new bands, early in 2006 a bird was found injured by an RA band, and bands on some other birds had opened by 3 mm or more. Subsequently, in 2006–08, all RA bands that had been applied in 2004–06 were removed when they were encountered at Col and Moubray. The practise of banding unmarked breeders at Col was also discontinued from 2006 onwards. Existing marked females at Col and central Moubray study areas continued to have their bands replaced with R bands, as these stayed closed more reliably than RA bands. Nevertheless, an improved closing technique for R bands was used from 2006 onwards. This required a greater amount of overlapping (3–4 mm) of the band ends during the final closing stages. Circlip pliers were used to pull the band ends back into the closed position after each overlap. The circlip pliers were then used for a 'spring test' of all completed bands—a correctly fitted band could be gently pulled open with the prongs of the pliers by 2–3 mm, but when released the band closed again into the correct butted position. An incorrectly fitted band stayed open by 0.5–1 mm when the pliers were released. All new R bands that had been applied in the first 2 years of the project were tested for spring and tightened if necessary.

2.11 Transponders

Trovan ID100 passive integrated transponders (PITs) were employed as an alternative marking technique to bands at Col study area. In 2004 and 2005, a sample of banded birds of both sexes had PITs implanted and their bands retained. Following on from this, in 2006–08, male banded birds at Col had their bands removed and were marked with PITs.

Installing PITs required two-person teams comprising a bird handler (with albatross handling experience), and an implant operator (with PIT or injection skills). If an egg was present, it was removed or swapped for a dummy egg before the bird was removed from the nest. The handler grasped the bird's bill with one hand and reached over the body with the other to gather in the legs, thus securing the bird in the crook of the arm. The bird was placed on a flat piece of ground near the nest, while still secured under the arm, and the neck was extended out. The implant operator separated feathers on the back of the lower neck to expose an area of skin, wetted the area down with alcohol and lifted the skin up between thumb and forefinger. A glass capsule (2.1 × 11.5 mm) containing a PIT was injected under the skin with a syringe or gun implanter (depending on operator preference). Any bleeding was checked by using a cotton wool swab to apply pressure and the needle hole was cleaned and pressed closed. Skin cement was used to seal the holes in 2006–08. An LID571 pocket reader was used to check the PIT. The egg was returned to the nest once handlers were sure no skuas (*Catharacta skua*) were present. The bird was then carefully released a few metres from the nest to allow it to walk to the nest and reposition itself over the egg. Generally, each bird was off the nest for about 2.5 minutes.

GR250 high-performance readers were used on subsequent visits to check PITs on birds sitting at the nest. The reader was slowly raised up to the bird's neck from either side and the dorsal area was 'ironed' to register an ID number, or the absence of a reading. In 2007 and 2008, all unbanded males at Col were checked for PIT readings, and birds with both bands and PIT were also checked.

3. Results

3.1 Population

Each season over the five-year study period in 2004–08, 2680–5550 nests on Campbell Island were visited to check for banded birds, making a combined total of 23 738 nests checked over the whole period (Table 2). Most survey blocks were visited at least twice per season for 2 of the 5 years, and the study areas were visited at least three times per season for 5 years. The proportion of breeding birds that were found per area increased with visit frequency (Table 3); two visits found an average of 81.0 ± 4.7 SD birds, three visits 92.2 ± 2.3 and four to nine visits 97.3 ± 1.7. Over the course of 5 years, six eggs were broken when nervous birds were visited or handled to remove bands (five) or to insert PITs (one). One egg was also chipped during re-banding of the incubating adult and this nest later failed. These confirmed failures that were caused by bird handlers represent 0.03% of total nesting attempts, 0.14% of old bands removed, 0.08% of new bands applied and 0.25% of PITs implanted.

Nests were distributed throughout the island in mid-elevation tussock-herbfields between the *Dracophyllum* scrub margin (c. 120–160 m a.s.l.) and the alpine zone (c. 320–360 m) (Figs 16, A1.1–A1.5). The majority of nests were in areas between 160 m and 320 m in elevation. Breeding birds occupied an approximate total area of 2565 ha (Table 2) at a density of 3.1 nests/ha. Distribution was uneven, with higher densities (3.7–5.1 nests/ha) in the north and east of the island (Fig. 16).

The mean counts of southern royal albatrosses during complete surveys of survey blocks yielded a composite total for Campbell Island of 7855 nests in 2004–08 (Table 2).

Table 3. Number of visits and proportions of southern royal albatross (*Diomedea epomophora*) breeding adults found in main survey blocks and study and index areas of Campbell Island/Motu Ihupuku in 2004–2008.

AREA	2004		2005		2006		2007		2008	
	VISITS	% BIRDS	VISITS	% BIRDS	VISITS	% BIRDS	VISITS	% BIRDS	VISITS	% BIRDS
Main survey blocks										
Faye	2	75.4	2	85.4						
Fizeau	2	82.5	2	83.2	2	85.7	2	69.3		
Lyall	2	82.8	2	78.8	1–2	51.3			1	50.0
Moubray	2	88.1	2	77.9	2	83.1	2	81.7	1	50.0
North Col	2–3	>76.2	2	78.4	7	95.7	4	100.0	6	98.8
South Col	2–3	>73.5	2	73.8	6	96.7	2	79.4	6	98.8
Paris					2	84.9	1–2			
Dumas	2	84.3			2	85.1	2	79.2		
Honey					1–2	55.2	1–2	77.3		
Puiseux					1	48.9	1	50.0		
Study and index areas										
Col	9	97.8	8	95.7	7	97.9	6	95.4	6	98.8
Moubray	3	>77.6	3	90.4	3	94.3	3	94.0	3	c.90.0
Faye					1	49.4	1	48.6	1	48.9
Paris									1	46.9
Honey									1	49.4

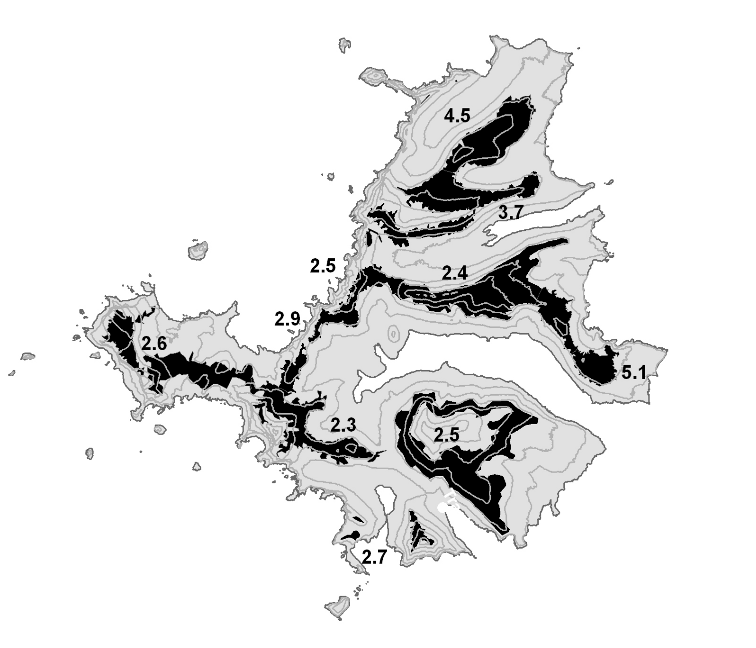

Figure 16. Southern royal albatross (*Diomedea epomophora*) nest distribution (black shading) on Campbell Island/Motu Ihupuku in 2004–08, with 80 m contours shown. Numbers indicate mean nest density (nests/ha) for each of the ten survey blocks.

Accuracy transects suggested that the sweeps of the survey blocks found an average of 99.4% of nests (SD 1.62, range 94–100%, $N = 47$ transects, 1493 nests). Similarly, < 1% of additional nests were found on second visits to survey blocks. The level of breeding success estimated at Col study area (Table 4) shows that about 6–12% of nests failed during the survey period in January–February each year. Although some failed nests were found incidentally in the surveys, they were harder to see than occupied nests and would have been underestimated. Consequently, the actual number of pairs that bred was underestimated. Allowing for the time of survey and accuracy estimate for each block and failure rates per year at Col, the total population at the beginning of the season was estimated at 8300–8700 breeding pairs (Table 5).

The previous whole of Campbell Island survey in 1995 counted about 7800 nests using a search technique of parallel sweeps (Table 5; Moore et al. 1997). Censuses of Campbell Island during the 20th Century show an overall increasing trend, although the 1950s–80s counts were vantage point counts which may have underestimated nest numbers (Moore et al. 1997). The first count in 1957 found 2278 nests, and numbers rose to a peak count of 5536 in 1975, followed by a decline to 4243 nests in 1982. Numbers subsequently increased again to 7787 nests by 1995 (Fig. 17). Numbers of nests in northern areas (Faye, Fizeau, Lyall, Moubray and North Col) and southern areas (South Col, Paris, Dumas, Honey and Puiseux) showed a similar trajectory before and after the construction of the sheep exclusion fence in 1970 (Fig. 17).

Table 4. Breeding success of southern royal albatrosses (*Diomedea epomophora*) at Col study area on Campbell Island/Motu Ihupuku in 2004–2008.

YEAR	% OF NESTS			
	FAILED BY 11 FEB*	FAILED AT EGG OR EARLY CHICK STAGE†	FAILED LATE IN CHICK REARING‡	FLEDGED A CHICK‡
2004	5.7	26.9	2.6	70.5
2005	12.0	25.5	1.9	72.6
2006	5.7	28.9	2.8	68.2
2007	>9.3	35.2	2.6	62.1
2008	5.8			
Mean 2004–08	7.7 ± 2.9	29.1 ± 4.3	2.5 ± 0.4	68.4 ± 4.5

* Egg success was checked for all nests in the study area on approximately 11 February, except for 2007 when a full round of nests was not completed.

† Estimated from the nest check on approximately 11 February (*) combined with nest sign the following season.

‡ Estimated from nest sign the following season.

Table 5. Number of southern royal albatross (*Diomedea epomophora*) nests on Campbell Island/ Motu Ihupuku in 2004–2008.

SURVEY BLOCK	1995*	1996–98 MEAN†	2004–08 MEAN‡	% CHANGE SINCE 1995	% CHANGE SINCE 1996–98
Faye	1266		1205.0	–4.8	
Fizeau	1334		1260.0	–5.5	
Lyall	1126		963.5	–14.4	
Moubray	989		1032.0	+4.3	
North Col	245		250.5	+2.2	
South Col	220		257.3	+17.0	
Paris	716		772.5	+8.0	
Dumas	522		607.0	+16.3	
Honey	1279		1413.0	+10.5	
Puiseux	90		94.0	+4.4	
TOTAL	7787		7854.8	+0.9	
Population estimate§	8250–8560		8300–8700		
Study and index areas					
Col	201†	197.3	196.4	–2.3	–0.5
Moubray	508†	541.0	505.4	–0.5	–6.6
Faye	568	631.3	575.8	+1.4	–8.8
Paris	325	440.7	367.0	+12.9	–16.7
Honey	293	420.3	371.7	+26.9	–11.6

* Ground search (nests tallied during sweeps by 2–4 people; Moore et al. 1997).

† Nest visit (intensive count by visiting nests during sweeps by 3–4 people 15 m apart; Moore et al. 1997, PJM unpubl. data).

‡ Nest visit (intensive count by visiting nests during sweeps by 3–4 people variable distance apart).

§ Population estimate—individual area counts were adjusted by the nest finding accuracy rate for that year plus an adjustment for the nest failure rate at Col study area for the corresponding time in Jan–Feb that the survey was conducted.

Estimates of nest numbers at Col and Moubray study areas since 1987 show an increasing trend through the 1990s and a levelling off or decrease in the 2000s (Fig. 18). At Moubray, nest numbers decreased by 7% from a mean of 541 in 1996–98 to 505.4 in 2004–08; and at Col, the means for the respective periods were almost unchanged at 197 and 196 (Table 5).

Index counts at Faye, Honey and Paris found 9–17% fewer nests on average in 2004–08 than in 1996–98 (Table 5, Fig. 19).

Nest counts of biennially breeding albatrosses are affected by breeding success and breeding frequency. For example, high numbers of nests at study areas in 2008 resulted from relatively poor breeding success in 2007 (62.1% fledged chicks) compared with the previous 3 years (68.2–72.6%), which caused a higher return rate of failed breeders in consecutive years. The mean breeding success in 2004–07 was lower than observed in the 1990s but similar to or higher than was recorded in earlier decades (Table 6).

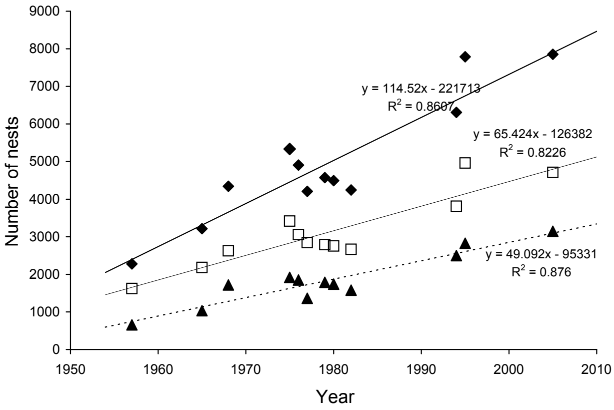

Figure 17. Number of nests of southern royal albatrosses (*Diomedea epomophora*) found at Campbell Island/Motu Ihupuku (diamonds), and northern (squares) and southern (triangles) areas of the island, 1957–2008.

Note: census data for 1957–1995 from Moore et al. (1997) and references therein. Mean counts for survey blocks were used to estimate a total count in 2004–08 (Table 2, this report).

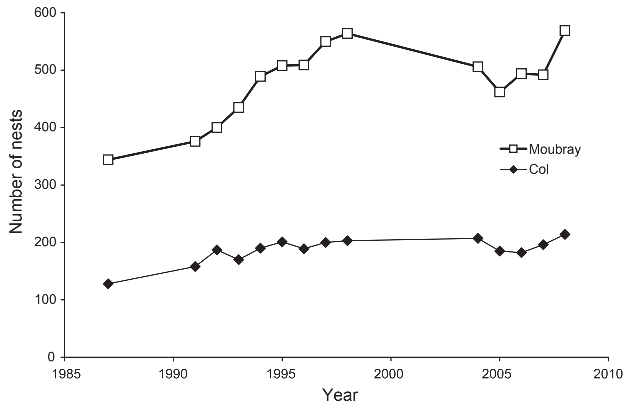

Figure 18. Numbers of nests of southern royal albatrosses (*Diomedea epomophora*) found at Col and Moubray study areas, Campbell Island/Motu Ihupuku 1987–2008.

Note: count data from 1987–1998 (Moore & Moffat 1990; Moore et al. 1997; PJM unpubl. data) and this study was obtained by searching for and visiting nests, and effort was similarly intensive in all years.

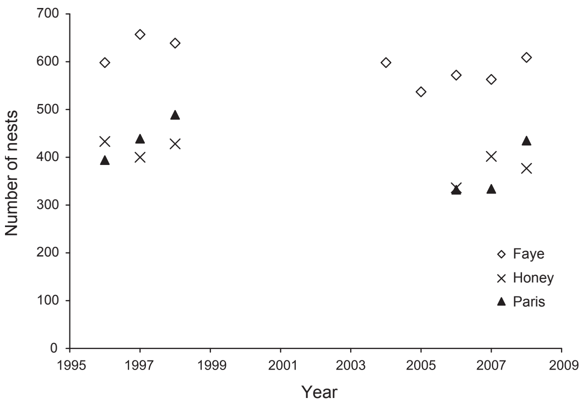

Figure 19. Numbers of nests of southern royal albatrosses (*Diomedea epomophora*) found at Faye, Honey and Paris index areas, Campbell Island/Motu Ihupuku in 1996–2008.

Note: count data from 1996–1998 (PJM, unpubl. data) and 2004–2008 (this study) was collected by teams conducting parallel sweeps and visiting nests.

Table 6. Breeding success of southern royal albatrosses (*Diomedea epomophora*) at Col and Moubray study areas on Campbell Island/Motu Ihupuku, 1940s to 2000s.

DECADE	COL			MOUBRAY		
	MEAN BREEDING SUCCESS*	SD	*n*	MEAN BREEDING SUCCESS	SD	*n*
1940s	62.5	22.8	3			
1950s	74.3		1			
1960s	62.3	11.9	5	64.1		1
1970s	60.1	1.1	2			
1980s	67.4	3.1	2	76.2		1
1990s	79.2	2.8	6	78.6	3.4	5
2000s	68.4	4.5	4			

* The proportion of monitored nests with chicks that fledged or were alive close to fledging time (last visits to nests for monitoring and/or banding varied between late August and November) (Sorensen 1950; Westerskov 1963; D. Paull & C.G. Surrey, unpubl. data 1964–67; Waugh et al. 1997; M. Crompton, unpubl. data 1969–71; R. Poole, unpubl. data 1985; Moore & Moffat 1990; Moore et al. 1997; PJM, unpubl. data 1995–96). Breeding success in 1997–2007 was estimated from nest sign the following season (PJM, unpubl. data 1997–98, this study).

3.2 Banded birds

A total of 2882 previously banded birds was found in 2004–08, or 8.2% of the 35 292 birds that were banded between the 1940s and 1990s (Table 7). The total included 2864 R bands, 9 O bands (an incorrect band size used in 1978) and 9 RA bands (a larger band trialled on males in 1998). In addition, six home-made bands and streamers made from fishing line or rope were found on birds.

Seventy-three percent of banded birds were found in the first 2 years of the project (2004–05), when the surveys concentrated on the main historical banding areas in the north and centre of the island (Faye, Fizeau, Lyall, Moubray, North Col and South Col survey blocks). These six survey blocks were the sites for 83% of the original banding and 90% of bands were found in these blocks in 2004–08 (Table 7, Fig. 20). Sixty-two percent of bands were found at Moubray and North Col combined (Table 7, Fig. 20). These survey blocks included the Moubray and Col study areas, where adults and chicks were banded between 1987 and 1998. The most recent banding at other survey blocks occurred in the mid-1980s. Consequently, and because the study areas were surveyed intensively for five consecutive years, the highest band recovery rates occurred for the Moubray and North Col blocks; i.e. 13–16% of the original cohorts from these areas were found in 2004–08 (Table 7). Also, the highest proportions (28–65%, Table 7) of breeding birds had bands in these two survey blocks in 2004, and bands were especially concentrated within the two study areas (44–72% breeders had bands at Moubray and Col study areas). South Col survey block also had high proportions of banded birds (24%), northern blocks had 5–7% of birds banded and southern blocks 1–6%. In the latter areas, searches for banded birds were relatively unproductive, and proportions of breeders with bands dropped further in consecutive years as bands were removed.

Table 7. Number and locality of previously banded southern royal albatrosses (*Diomedea epomophora*) found on Campbell Island/Motu Ihupuku in 2004–08 and proportion of banded birds now at the same areas.

AREA	NUMBER OF BIRDS BANDED IN 1940s–1990s	% OF ORIGINAL BANDS SEEN IN 2004–08 IN ALL AREAS*	% BREEDERS FOUND WITH BANDS PER AREA IN 2004–08†	NUMBER OF BANDS FOUND PER YEAR					
				2004	2005	2006	2007	2008	Total
Faye	4211	4.0	4.9	99	83	10	8	7	207
Fizeau	5876	3.5	5.3	113	73	15	3		204
Lyall	2563	2.0	6.6	116	63	2		6	187
Moubray	9411	13.3	27.6	494	340	146	103	36	1119
North Col	5470	16.2	65.4	339	214	54	33	35	675
South Col	1870	5.8	24.4	87	75	25	22	3	212
Paris	937	5.7	3.3			42	33	7	82
Dumas	1963	4.9	5.9	15		64	40	1	120
Honey	2766	1.9	1.7			27	43	4	74
Puiseux	96	0.0	1.1			1			1
Unknown	130	1.5		1					1
Total	**35292**	**8.2**		**1264**	**848**	**386**	**285**	**99**	**2882**

* Proportion of birds that were banded per area in the 1940s–90s and seen in 2004–08, including those that migrated to new areas.
† Proportion of breeders with bands during the first year of survey at each area in 2004-08.

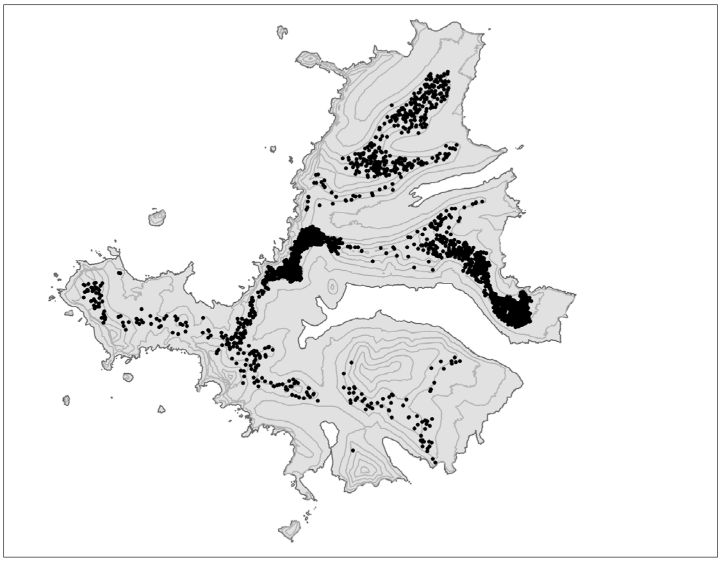

Figure 20. Distribution of previously banded southern royal albatrosses (*Diomedea epomophora*) found breeding on Campbell Island/Motu Ihupuku in 2004–08.

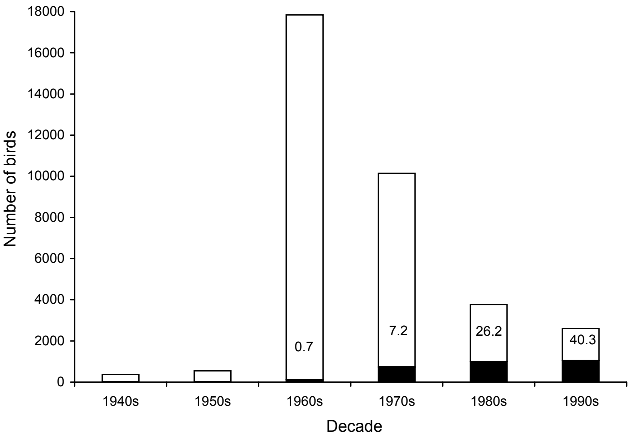

Figure 21. Number of southern royal albatrosses (*Diomedea epomophora*) banded (height of bars) per decade 1940s–90s on Campbell Island/Motu Ihupuku and proportion (black bars with percentages) of those birds that were seen in 2004–08.

Of the 35 292 birds that were originally banded on Campbell Island, 3% were banded in the 1940s–50s, 50% in the 1960s, 29% in the 1970s, 11% in the 1980s and 7% in the 1990s (Fig. 21). In contrast, recovery rates of the decade cohorts increased from 0.7 for the 1960s cohort to 40% for the 1990s cohort as the younger cohorts were more commonly found in 2004–08 (Fig. 21). The majority (81%) of the known-age birds (those banded as chicks) were 10–29 years old in 2004–08, 18% were 30–39 and 0.8% were more than 40 years old (maximum 43 years) (Table 8). The majority (93%) of birds banded as adults were originally banded less than 20 years ago, although they ranged up to 36 years since banding. One skeleton was found that was banded as an adult 39 years earlier, but the bird had been dead for an unknown period of time (Table 8).

Of the 2882 banded birds found in 2004–08, 2790 were breeders, 82 were non-breeders and 10 were dead birds or skeletons. More males than females were found (Table 9), although this may, in part, be a result of inexperienced observers tending to identify larger birds as males. Birds that were banded as adults showed a high degree of site fidelity, with approximately 80% of males and females found in the areas that they were banded in as adults (Table 9). Males that were banded as chicks showed a high degree of natal philopatry, with 76% of birds breeding in areas where they were originally banded, compared with 57% of females. Consequently, females had a greater dispersion to other parts of the island (Table 9). These measures of site fidelity are coarse however, since the survey blocks varied widely in size (35–562 ha, Table 2).

The more recent subset of chick banding from Col and Moubray study areas (both < 100 ha) showed some interesting differences between the areas. For both areas, the sex ratio of birds found in 2004–08 was skewed towards males, particularly for birds from Col (Table 10), presumably in part because males were more likely to be found in their natal area, and searches were more intensive at Col than elsewhere on the island. Of the 1987–96 cohorts of chicks banded at Col study area, 125 males returned to breed at the natal site but only 39 females

Table 8. Ages of previously banded southern royal albatrosses (*Diomedea epomophora*) found on Campbell Island/Motu Ihupuku in 2004–08.

BANDING AGE	UNKNOWN	YEARS SINCE BANDED					
		6–9	10–19	20–29	30–39	40–43	TOTAL
Unknown age	1	0	1	10	6	0	18
Chick		12	835	1155	448	19	2469
Adult		49	317	21	8	0	395
Total	**1**	**61**	**1153**	**1186**	**462**	**19**	**2882**

Table 9. Site fidelity of southern royal albatrosses (*Diomedea epomophora*) found breeding on Campbell Island/Motu Ihupuku in 2004–08.

AGE AT BANDING	SEX	% OF BIRDS FOUND BREEDING				*n*
		NATAL OR BANDING AREA*	NEIGHBOURING AREA†	OTHER PART OF ISLAND‡	UNKNOWN AREA BANDED OR FOUND	
Adult	Female	77.5	18.3	4.2	0.0	213
	Male	80.7	15.9	2.8	0.6	176
	Unknown	100.0				1
Chick	Female	56.6	27.1	16.3		1019
	Male	75.7	17.7	6.6		1252
	Unknown	40.5	54.1	5.4		111
Unknown age		38.9	27.8	22.2	11.1	18
Total		**67.6**	**21.7**	**10.6**	**0.1**	**2790**

* Twelve areas were recognised: eight main survey blocks (Faye, Fizeau, Lyall, South Col, Dumas Paris, Puiseux and Honey) plus two subdivided blocks (North Col divided into Col study area and rest of North Col, and Moubray subdivided into West Moubray and Moubray study area).

† The neighbouring contiguous area next to the original banding area.

‡ Non-contiguous areas away from the banding area.

Table 10. Natal philopatry of southern royal albatrosses (*Diomedea epomophora*) from Col and Moubray study areas, banded in 1987–96 and found breeding in different areas of Campbell Island/Motu Ihupuku in 2004–08.

NATAL AREA	SEX	% OF BIRDS FROM COL OR MOUBRAY BREEDING IN EACH AREA												NO. FOUND
		C	NC	SC	L	P	D	Pu	H	WM	M	Fi	F	
Col	Female	41.1	11.6	20.0	2.1	4.2	9.5	0	3.2	1.1	0.0	6.3	1.1	95
	Male	83.9	4.7	5.4	1.3	0.7	2.0	0	0.7	0.0	0.0	0.7	0.7	149
	Unknown	0.0	40.0	20.0	20.0	0.0	0.0	0	20.0	0.0	0.0	0.0	0.0	5
	Total	**65.9**	**8.0**	**11.2**	**2.0**	**2.0**	**4.8**	**0**	**2.0**	**0.4**	**0.0**	**2.8**	**0.8**	**252**
Moubray	Female	0.0	0.0	0.5	2.8	0.0	0.9	0	1.4	13.4	80.6	0.5	0.0	217
	Male	0.0	0.0	0.0	0.4	0.0	0.0	0	0.4	1.4	97.5	0.0	0.4	276
	Unknown	0.0	0.0	0.0	6.7	0.0	0.0	0	3.3	16.7	73.3	0.0	0.0	30
	Total	**0.0**	**0.0**	**0.2**	**1.7**	**0.0**	**0.4**	**0**	**1.0**	**7.3**	**89.1**	**0.2**	**0.2**	**523**

C = Col study area; NC = North Col (outside the Col study area), SC = South Col; L = Lyall, P = Paris; D = Dumas; Pu = Puiseux; H = Honey; WM = West Moubray; M = Moubray study area; Fi = Fizeau; F = Faye.

bred there. This is unlikely to be a result of misidentification, because the more experienced observers worked at the study areas, individuals of breeding pairs were compared for gender characteristics, and any initial identification errors were rectified during the study. The natal philopatry for males from Col study area was high at 84%, with 11% found in the three neighbouring areas and 5% elsewhere; whereas the respective proportions for females were 41%, 34% and 25% (Table 10, Fig. 22). Moubray study area birds showed stronger philopatry, with 98% of males breeding in their natal area, 1% in neighbouring West Moubray (the western half of Moubray survey block) and 1% elsewhere. Females also showed stronger philopatry than at Col, with 81%, 13% and 6% found in the three respective zones of the island.

The proportion of chicks banded at Col and Moubray study areas in 1987–96 and seen as adults in 2004–08 was 34% and 39% respectively, 12–21 years since they were banded (Table 11). The proportions found breeding were 32% and 38% respectively at the two areas. The highest proportions seen were from the 1994 cohort at each area (39% and 45%), although the more recent cohorts were still entering the breeding population. For example, only 2% of the 1996 cohort from Col was seen in 2004, at 8 years of age, but the cumulative sightings had built up to 31% by 2008 (Table 11), when the birds were 12 years of age.

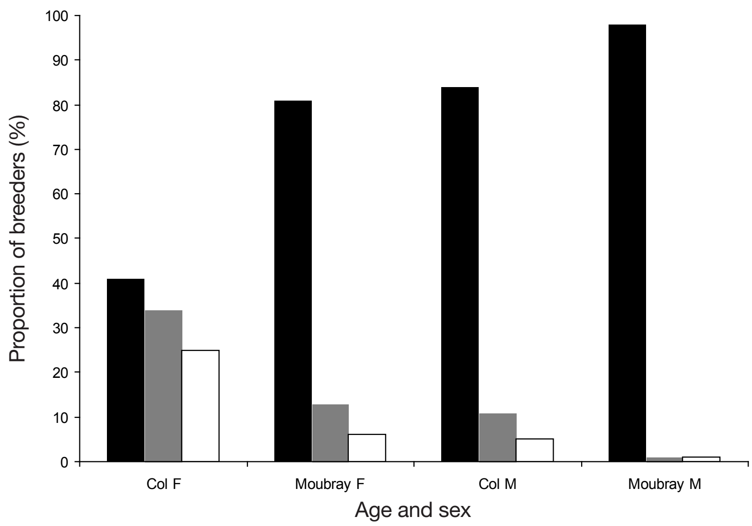

Figure 22. Southern royal albatrosses (*Diomedea epomophora*) that were banded as chicks at Col and Moubray study areas on Campbell Island/Motu Ihupuku in 1987–96 and the proportions found breeding at the natal area (dark columns), neighbouring areas (grey columns) and elsewhere (white columns) in 2004–08.

Table 11. Numbers of southern royal albatrosses (*Diomedea epomophora*) that were banded in 1987–96 as chicks on Campbell Island/Motu Ihupuku and the proportion of each cohort seen in 2004–08.

YEAR	NUMBER OF CHICKS BANDED AT COL	% SEEN IN 2004–08	NUMBER OF CHICKS BANDED AT MOUBRAY	% SEEN IN 2004–08
1987	92	29.3	262	41.2
1990	9	33.3	19	10.5
1991	127	30.7	283	39.2
1993	129	33.3	351	42.7
1994	155	38.7	159	44.7
1995	157	36.9	137	39.4
1996	157	30.6	172	25.6
Total	**826**	**33.7**	**1383**	**39.0**
Mean ± SD		33.3 ± 3.5 SD		34.8 ± 12.4 SD

N.B. Includes breeding and non-breeding records.

3.3 Band injuries and open bands

Seventy-two birds were found with major band injuries in 2004–08 (Table 12). Generally, the highest number of injuries was found during the first year of survey of each area. The majority (76%) of injuries were found in 2004–05 (Table 12), because the majority (73%) of bands were found in those years. Few injuries were found after the third year in areas that were fully surveyed in multiple years. Most injured birds were breeders, although six injured non-breeders and two injured dead birds were found (Table 12). Injured birds were distributed throughout the island, but the densest concentration was on the northern slopes of Fizeau ridge (Fig. 23). The highest numbers of major injuries were found at Fizeau and Lyall, or 44% of the total (Table 12).

Table 12. Southern royal albatrosses (*Diomedea epomophora*) with major band injuries found per year and area on Campbell Island/Motu Ihupuku in 2004–08.

SURVEY BLOCK	2004	2005	2006	2007	2008	BREEDER	NON-BREEDER	DEAD	TOTAL
Faye	2	5	0	0	0	7			7
Fizeau	12	5	1	0	–	18			18
Lyall	9	4	–	–	1	10	2	2	14
West Moubray	4	2	1	0	–	6	1		7
Moubray study area	4	1	1	0	0	5	1		6
Col study area	2	1	1	0	1	4	1		5
Other North Col	0	0	0	0	0	0	0		0
South Col	2	1	0	0	0	2	1		3
Paris	–	–	0	1	0	1			1
Dumas	1	–	4	0	–	5			5
Honey	–	–	1	5	0	6			6
Puiseux	–	–	0	0	–				0
Total	**36**	**19**	**9**	**6**	**2**	**64**	**6**	**2**	**72**

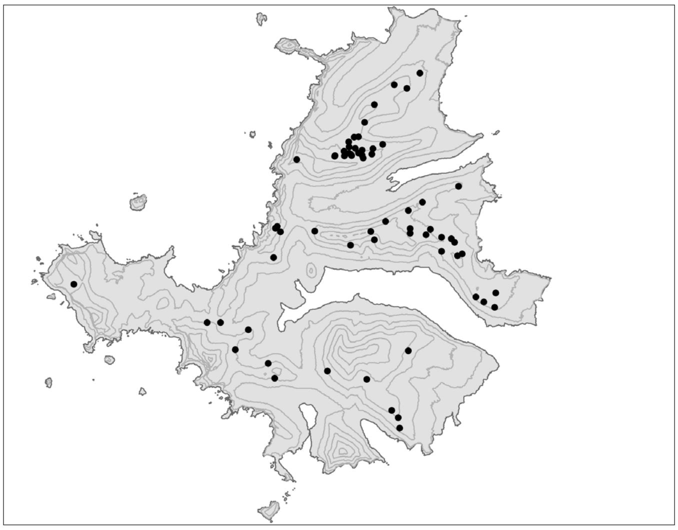

Figure 23. Distribution of breeding southern royal albatrosses (*Diomedea epomophora*) found with major injuries from leg bands on Campbell Island/Motu Ihupuku in 2004–08.

Overall, 2.5% of banded birds had major injuries (Table 13). Fizeau, Honey and Lyall had the highest proportions (7.5–8.8%) of banded birds with injuries. Less than 1% of bands had caused injuries at Col and Moubray study areas, probably because the quality of banding and efforts at band maintenance and treating of injured birds had been higher in the period 1987–1998. Areas adjacent to the study areas (South Col, North Col and West Moubray) also had below-average proportions of major injuries (0–2.4%). More males (44 individuals; 61% of the 72 birds found) had major injuries than females (19; 26%) (Table 13), and these tended to be in the major gall categories. Of the 72 major injuries, 13 birds had the skin on the banded leg pierced by a band and 59 had bands that were embedded in galls (Table 14). Major injuries came from a wide range of banding cohorts, although injury rates for birds banded in the 1960s–70s were higher (6.6–6.8%) than those for birds banded in the 1980s (1%) or 1990s (0.6%) (Table 15). This suggests that an improvement in banding technique has occurred in recent decades and/or that the chance of injury is higher for birds that carry bands for a longer period. Poor banding technique was evidently more prevalent in some years than in others—over half (51%) of major injuries came from the cohort of birds banded in 1979, 10% from those banded in 1981 and 8% from 1970.

Evidence of former injuries was found on 54 birds over the five years of survey. These birds had been re-banded or had bands removed on earlier occasions and still had hard but shrunken galls, probably resulting from pus being absorbed by the body and leaving the bony growth visible under the skin. Some appeared to be crippled, as shown by the bird in Fig. 15 not being able to bend its ankle.

Minor injuries were more common than major injuries, with 245 birds found with minor injuries, or 8.5% of the total number of banded birds (Table 13). Two-thirds of birds with minor injuries were males (162 birds; 66%; Table 13). Most (204) minor injuries were dents caused by poorly shaped or tight bands (70 % occurring in males) and 41 were irritations caused by open bands (Table 14), occurring equally in males and females. The dents or irritations were not necessarily harmful in themselves, but any projecting calluses, folds and warts offered some potential for

Table 13. Number, proportion and sex of southern royal albatrosses (*Diomedea epomophora*) with band injuries found per study area on Campbell Island/Motu Ihupuku in 2004–08.

SURVEY BLOCK OR STUDY AREA	TOTAL BANDS FOUND	MAJOR INJURY	% MAJOR INJURY	MINOR INJURY	% MINOR INJURY
Faye	207	7	3.4	36	17.4
Fizeau	204	18	8.8	26	12.7
Lyall	187	14	7.5	17	9.1
West Moubray	287	7	2.4	8	2.8
Moubray study area	832	6	0.7	19	2.3
Col study area	590	5	0.8	45	7.6
Other North Col	85	0	0.0	9	10.6
South Col	212	3	1.4	25	11.8
Paris	82	1	1.2	26	31.7
Dumas	120	5	4.2	24	20.0
Honey	74	6	8.1	9	12.2
Puiseux	1	0	0.0	1	100.0
Unknown*	1	0	0.0	0	0.0
Sex					
Female	1268	19	1.5	76	6.0
Male	1484	44	3.0	162	10.9
Unknown	130	9	6.9	7	5.4
Total	**2882**	**72**	**2.5**	**245**	**8.5**

* Band was removed from a bird but the area was not recorded.

Table 14. Number and proportion of previously banded (prior to 2004) southern royal albatrosses (*Diomedea epomophora*) with band injuries and open bands in 2004–08.

INJURY STATUS	CLOSED BAND	OPEN BAND				GRAND TOTAL	% OF TOTAL BANDS
		< 3 mm GAP	≥ 3 mm GAP	GAP NOT RECORDED	OPEN TOTAL		
Not injured	1598	722	243	2	967	2565	89
Minor injury							
Dent	98	69	36	1	106	204	7.1
Irritation	9	11	21	0	32	41	1.4
Total	**107**	**80**	**57**	**1**	**138**	**245**	**8.5**
Major injury							
Leg pierced by band	0	2	10	1	13	13	0.5
Band embedded in gall	0	3	27	29	59	59	2.0
Total	**0**	**5**	**37**	**30**	**72**	**72**	**2.5**
Grand total	**1705**	**807**	**337**	**33**	**1177**	**2882**	
% of total bands	**59.2**	**28.0**	**11.7**	**1.1**	**40.8**		

Table 15. Southern royal albatrosses (*Diomedea epomophora*) with band injuries in 2004–08 and the year or decade of banding.

YEAR BANDED	MAJOR INJURIES	TOTAL MAJOR INJURIES PER DECADE	TOTAL MINOR INJURIES PER DECADE	TOTAL BANDS FOUND FROM EACH DECADE	% MAJOR INJURIES PER DECADE	% MINOR INJURIES PER DECADE
1965	2					
1966	1					
1967	2					
1969	3	8	21	117	6.8	17.9
1970	6					
1971	2					
1974	1					
1975	2					
1979	37	48	88	729	6.6	12.1
1980	1					
1981	7					
1984	2	10	72	988	1.0	7.3
1991	1					
1993	3					
1995	1					
1996	1	6	63	1048	0.6	6.0
Unknown			1	1		
Total	**72**	**72**	**245**	**2882**	**2.5**	**8.5**

future more serious injury; e.g. by an open band catching on the projection, irritating the skin further and/or piercing the skin. Almost one third of banded birds at Paris had minor injuries, whereas < 3% of birds at Moubray study area and West Moubray survey block were recorded as having minor injuries (Table 13).

Twenty-eighty percent of old bands found in the five years of study had opened a small amount (0.5–2.5 mm), and 12% had opened a large amount (3–12 mm) (Table 14). An additional 1% of bands did not have a gap recorded, usually because the band ends of open bands were buried in the leg of a crippled bird. However, judging from the shape of the band, most of these appeared to be open by more than 3 mm. Assuming that this was the case, up to 93% of major injuries were associated with bands that were open by ≥ 3 mm, 7% were associated with bands that had gaps of < 3 mm, and no major injuries were caused by closed bands. Of the minor injuries categorised as irritations, 51% were associated with bands that were open by ≥ 3 mm, 27% with bands that had gaps of < 3 mm, and 22% with closed bands. For dents, the proportions were 18%, 34% and 48% respectively. Uninjured birds also had open bands, 9% were open by ≥ 3 mm and 28% were open by < 3 mm. These data illustrate that most of the severe injuries and half the minor irritations were caused by widely open bands. Most dents were caused by closed or nearly closed bands.

3.4 Band removal and replacement

Of the 2882 previously banded birds found in 2004–08, 1948 (68%) had their bands removed when they were found, four birds were left with their bands on because they were too nervous to handle, and 930 (32%) were initially re-banded in the Col and Moubray study areas with new R bands for females and RA bands for males (Table 16). A further 219 unbanded birds were banded with new bands at Col study area, bringing the total to 1149 birds with new bands applied.

Although the new 1.25-mm stainless steel R and RA bands were thicker than standard bands, this did not eliminate their springiness, and it was apparent in 2004 and 2005 that some bands opened a small amount in a matter of weeks. Consequently, Graeme Taylor (DOC) and PJM experimented with improving the band closure technique before the 2006 season. Up until then, the accepted technique was to use slip-joint pliers to shape the band circle while progressively overlapping the butted ends of the band. This relied on the natural spring of the band returning the band ends into the closed position. Ironically, because of the greater band thickness compared with the old 1- mm bands, the new 1.25 mm bands were more difficult to close—the band ends tended to catch on each other and spring back too far, thus requiring a lot of effort to properly reach the closed position. This meant that some apparently well-closed bands could be pulled slightly apart (1–2 mm) by hand, indicating that the natural 'resting point' of the band was in that position. This would explain why some bands opened after banding. The improved closing method used a greater amount of overlapping (3–4 mm) during the final closing stages and circlip pliers to open the band ends into the closed position after each overlap. The circlip pliers were also used for a 'spring test' of all completed bands to make sure that the resting point

Table 16. Band status of southern royal albatrosses (*Diomedea epomophora*) on Campbell Island/Motu Ihupuku in 2004–08.

BIRD STATUS	BAND STATUS	BAND RETAINED	BAND REMOVED	TOTAL
Previously banded	Not re-banded	4	1948	1952
	Re-banded with new R	436	8	444
	Re-banded with new RA	98	388	486
	Total	**538**	**2344**	**2882**
Previously unbanded	Banded with new R	133	0	133
	Banded with new RA	7	79	86
	Total	**140**	**79**	**219**
	Total R	**569**	**8**	**577**
	Total RA	**105**	**467**	**572**
	Total	**674**	**475**	**1149**

N.B. Totals do not include extra bands per individual (two previously banded birds had a band on each leg and 28 birds were re-banded twice during 2004-08, usually to give females a more appropriately sized R band).

of the band was in the closed position. In 2006, we began to test and adjust all of the bands on the recently banded or rebanded (2004–2005) birds present at the Col study area using the new technique.

Because a male was found injured by a new RA band in 2006, and RA bands were more prone to springing open than R bands, most (82%; Table 16) RA bands were subsequently removed. Consequently, by the end of the study, 81% of the previously banded birds had had their new bands removed and 19% retained a band. Most birds in the latter category were females banded with new R bands (Table 16) in the Col and Moubray study areas.

Ninety-one percent of 578 birds with new R bands and 94.5% of 599 birds with new RA bands were seen again after the bands were applied (Table 17). Three percent of birds with new R bands had minor dent injuries. Some of the injuries may have been caused by previous bands or by the new R bands not having a sufficiently oval shape to allow them to fit snugly on females with large legs. Most of the dents were of a relatively minor nature. One RA band (0.2%) that was applied in 2004 had caused a major injury by 2006. Two RA bands (0.4%) caused minor dents (or possibly the dents were retained from the previous band) (Table 17).

Birds with new bands were checked very closely when found in the study area to determine if any bands had opened since they were applied. Some very small gaps (0.5 mm) were recorded and 51% of new R bands were open < 3 mm (138 bands open by 0.5 mm, 110 by 1 mm and 21 by 2 mm) and one band (0.2%) was 4 mm open. Fifty-two percent of new RA bands were open < 3 mm (109 by 0.5 mm, 149 by 1 mm and 37 by 2 mm) and 2.7% were open by ≥ 3 mm (10 bands open by 3 mm and 5 by 4–8 mm) (Table 17). From 2006 onwards, any birds with the new R bands that were found at Col and Moubray study areas were checked for band tension and, if necessary, bands were adjusted and tightened using a better closing technique.

Table 17. Numbers and proportions of southern royal albatrosses (*Diomedea epomophora*) with open bands and injuries caused by new R and RA bands on Campbell Island/Motu Ihupuku in 2004–08.

BAND TYPE	INJURY STATUS	CLOSED BAND	OPEN BAND				GRAND TOTAL	% OF TOTAL BANDS SEEN
			< 3 mm GAP	≥ 3 mm GAP	GAP NOT RECORDED	OPEN TOTAL		
R	Not seen						52	
	Not injured	255.0	254.0	1.0		255.0	510	97.0
	Minor injury: dent	1.0	15.0			15.0	16	3.0
	Total seen	**256.0**	**269.0**	**1.0**		**270.0**	**526**	**100.0**
	% of total seen after banding	**48.7**	**51.1**	**0.2**		**51.3**		
	Grand total						**578**	
RA	Not seen						33	
	Not injured	256.0	293.0	14.0		307.0	563	99.5
	Minor injury: dent		2.0			2.0	2	0.3
	Major injury: large gall				1.0	1.0	1	0.2
	Total	**256.0**	**295.0**	**14.0**	**1.0**	**310.0**	**566**	**100.0**
	% of total seen after banding	**45.2**	**52.1**	**2.5**	**0.2**	**54.8**		
							599	

N.B. Totals include extra bands per individual (28 birds were rebanded twice during 2004–08, usually to give females a more appropriately sized R band)

Transponders (PIT) were trialled at Col study area in 2004–08 as an alternative to bands; 405 birds were implanted with PITs. Of the birds which received PITs, 19% also retained a band (Table 18). Because the use of RA bands was discontinued, previously banded males at Col were preferentially marked with PITs in order to retain their marking history. Thirteen (4%) of PITs failed to give a reading when checked for the first time subsequent to their implantation, either during the same season or in a following season. Four of these failed PITs were replaced (Table 18).

Table 18. Number of transponders implanted in southern royal albatrosses (*Diomedea epomophora*) in 2004–08, and number read or failed.

SEX	NUMBER OF BIRDS WITH TRANSPONDERS						
	IMPLANTED			CHECKED			
	BAND RETAINED	BAND REMOVED	TOTAL	READING CONFIRMED	TRANSPONDER FAILED AND NOT REPLACED	TRANSPONDER FAILED AND REPLACED	NOT SEEN
Female	58	1	59	43	2	0	14
Male	18	328	346	271	7	4	64
Total	**76**	**329**	**405**	**314**	**9**	**4**	**78**

4. Discussion

4.1 Population trends

Although the main aim of the albatross project in 2004–08 was to find as many banded and injured birds as possible, the island-wide searches created an ideal opportunity to estimate the population size.

Trends based on whole-island nest counts of southern royal albatrosses on Campbell Island suggest a substantial increase in the population occurred during the 20th Century. The number of nests increased from approximately 2300 in 1957 (Westerskov 1963) to 7800 in 1995, with the latter count probably representing 8200–8600 nests at the start of the breeding season (Moore et al. 1997). Although surveys up to the mid 1980s may have underestimated nest numbers because they were mainly carried out from ridgelines and vantage points (Moore et al. 1997), the lower stature of vegetation at that time as a result of sheep grazing (Meurk 1982) may have made this method more feasible than it is today in the absence of sheep. The albatross population was probably recovering from the depredations and habitat destruction that occurred during the 1895–1931 farming era on Campbell Island (Guthrie-Smith 1936).

The direct influence of sheep on albatrosses was not resolved, since sheep increased in numbers in the areas they were restricted to (the southern half of the island after 1970), and albatrosses increased in the presence, and absence, of sheep by 1975. Therefore, it was thought that food supply at sea was likely to be a more important determinant of albatross numbers (Dilks & Wilson 1979). In the late 1970s to early 1980s, albatrosses decreased in numbers both north and south of the sheep fence before increasing again by the 1990s. Therefore, it appears that sheep presence alone did not influence the albatross population. Higher densities of nests were found in northern rather than southern areas in 2004–08; however, since nests were relatively more numerous in the north before and after 1970, it is probable that habitat features were more favourable for nesting in these areas.

The composite count of 7855 southern royal albatross nests in 2004–08 is very similar to the number found in 1995 (Moore et al. 1997). This suggests that population growth has levelled off over the last decade, with some increases and decreases amongst survey blocks cancelling each other out. The largest decreases occurred at Lyall, Faye and Fizeau survey blocks and the largest increases at South Col, Dumas and Honey. The 1995 survey was probably the most intensive previous census and more comparable to the 2004–08 surveys because whole survey blocks were counted by observers walking in parallel sweeps. Limited accuracy tests at the study areas in 1995 suggested 95–99% of nests were found; however, the proportion of nests found was probably lower in the larger areas, such as Honey, which were more difficult to survey (Moore et al. 1997). Assuming the estimated survey accuracy of >99% in 2004–08 is correct, and adjusting the total based on the 6–12% failure rate of nests at Col in January and February each year, the composite count of 7855 nests in 2004–08 represents a population of approximately 8300–8700 nests at the start of each of the five breeding seasons monitored.

Very thorough searches for nests at Col and Moubray study areas have been conducted since 1987. These intensive counts indicate that the increase in the southern royal albatross population that had been observed for the whole island continued through the 1990s but then levelled off at Col and decreased at Moubray (by 7%) by 2004–08. Index counts at Faye, Paris and Honey commenced in 1996 to supplement the study area counts. There were 9–17% fewer nests on average in the three areas in 2004–08 than in 1996–98. Whether this change is a result of a decline in breeders, changes in breeding frequency or lower juvenile recruitment is unknown. However, the fact that breeding success was lower at Col in 2004–08 (68%) than in the 1990s (79%) indicates that the species is currently experiencing less favourable conditions. Furthermore, if

10% more breeders returned in consecutive years after nest failure in the 2000s than in the 1990s, there may be a greater decline in the total population than is apparent from the nest counts. Further analysis of banding data will help resolve these questions (MP, unpubl. data).

The small population of southern royal albatrosses on Enderby Island has followed a similar trajectory to that observed for the royal albatross population on Campbell Island. Albatrosses disappeared from Enderby Island around 1868 after a period of exploitation (Taylor 1971), but a few pairs began nesting there again in the early 1950s (Childerhouse et al. 2003). Numbers of nests gradually increased to 55 in 1995, then fluctuated annually at an average of 55.1 ± 8.9, with a peak of 69 nests in 2001 (Childerhouse et al. 2003; S. Childerhouse, L. Chilvers, DOC, pers. comm.) The count data from both islands suggest that the southern royal albatross population stopped growing in the late 1990s.

Although not as vulnerable to fishing bycatch as some wandering albatross species (Imber 1999), the southern royal albatross is accidentally killed in several fisheries (including trawling and long-lining) in New Zealand waters and other regions of the southern ocean (Murray et al. 1993; Taylor 2000; Manly et al. 2002; Robertson et al. 2003, 2004; Moore & Bettany 2005; Sullivan et al. 2006; Anon. 2008; Petersen et al. 2008; Waugh et al. 2008; Thompson 2009). Evidence of southern royal albatross interactions with long-line fisheries is frequently found on Campbell Island in the form of hooks that have been regurgitated beside nests, occasional birds found with hooks embedded in their legs or fishing line protruding from their bills, and leg bands or streamers made from fishing gear. A period of apparent decline in the southern royal albatross population in the late 1970s to early 1980s coincided with a decline in the Campbell mollymawk (*Thalassarche impavida*) population (Moore 2004) and the peak period for tuna long-line fishing in the New Zealand region (Murray et al. 1993; Klaer & Polacheck 1997; Tuck et al. 2003). Bycatch of seabirds in New Zealand waters decreased for a period after the mid 1980s (Manly et al. 2002; Robertson et al. 2004; Anon. 2008; Thompson 2009) as a result of the application of mitigation methods to prevent bycatch in the tuna fishery (Murray et al. 1993). However, seabird mortality caused by trawlers in New Zealand waters increased in 1998–2004, with an estimated 1250 albatrosses killed annually, including southern royal albatrosses (Waugh et al. 2008). The recent levelling off in the nesting population (or possible decline in the total population) of southern royal albatrosses on Campbell Island could mean that a higher level of bycatch is occurring in another part of the species' foraging range. For example, an estimated 12 southern royal albatrosses were killed by finfish trawlers in Falkland Island waters in one season (2002/03; Sullivan et al. 2006), a comparatively small part of the species' South American foraging range (Moore & Bettany 2005). There is considerable overlap in distribution between trawl and long-line fishing areas and the foraging areas of post-breeding and juvenile albatrosses off the east coast of South America, and by-catch of southern royal albatrosses has been recorded there (Schiavini et al. 1998; Moore & Bettany 2005; Jimenez et al. 2008). For example, 13 birds of this species were killed on observed long-line vessels on the Patagonian shelf and shelf break in 1999–2001 (Favero et al. 2003). If the albatross bycatch of all South American fisheries were accounted for, the annual mortality of southern royal albatrosses in these fisheries could be substantial.

Other factors that are known to affect the population of southern royal albatrosses on Campbell Island include predation by New Zealand sea lions (*Phocarctos hookeri*)—128 corpses of nesting albatrosses were found in a 230-ha area of Lyall ridge in 2004, and an unusual number of skeletons were noted in the area from earlier years (Moore et al. 2008). Undoubtedly, this influenced the 14% decrease we observed in nesting numbers at Lyall since 1995. However, the predation appeared to be the work of one individual sea lion, and once it was culled, active predation by sea lions on land was not observed subsequently during our study (Moore et al. 2008). Albatrosses ingest plastic rubbish floating on the sea surface while they scavenge for food. This has been reported as a problem for Laysan albatrosses (*Phoebastria immutabilis*) which feed their chicks large quantities of plastics, leading to health problems from full or blocked digestive tracts and, ultimately, starvation and dehydration (Auman et al. 1998). Plastic ingestion may also result in contamination by organochorines and other toxicants (Auman et al. 1998). At present, it appears that floating plastic debris is less of a problem in the Southern Ocean than has been reported in northern waters (Kock 2001). Plastics were found amongst regurgitates of indigestible matter beside many albatross nests on Campbell Island, although quantities were small, and there was no evidence to suggest that any chicks had died from plastic ingestion.

Another potential factor influencing the royal albatross population is climate change, through associated effects on food supplies, as has been found for some other albatross species (Rivalan et al. 2010). Decreased breeding success observed during our study compared with that observed in the 1990s could reflect a less-productive food supply. Climate change may also affect vegetation zonation which, in turn, may affect nesting opportunities for albatrosses. *Dracophyllum* scrub became more prevalent at low elevations on Campbell Island during the 20th Century, particularly after the farm closed in the 1930s (Wilmshurst et al. 2004). This change was thought to be mainly a result of the cessation of fires, as well as sheep grazing suppressing competing plant species, and a warmer and drier climate (Wilmshurst et al. 2004; Bestic et al. 2005). There was, however, no indication of a change in the upper elevational limit of scrub over the study period (Wilmshurst et al. 2004). We have also noted a continued thickening of scrub over the last 20 years. Open patches at the top of scrub margins have been filled in by growth and colonisation of *Dracophyllum,* hence the main scrub line appears to have moved up hill or, at least, to have become more continuous, even if the upper limit of scrub has not changed. This change has shifted the lower limit of albatross nests to a higher elevation. Very old nest sites can be found amongst dense scrub below the current lower limit of nesting distribution. Furthermore, this nesting limit is above the approximate distribution of scrub shown on the 1984 Department of Lands and Survey Campbell Island map, which further suggests that *Dracophyllum* is now more prevalent at higher elevation. The first GIS-based survey of nests in 2004–08 will allow nest distribution patterns to be more readily compared in the future.

4.2 Band recoveries

The majority (81%) of known-age birds found on Campbell Island in 2004–08 were 10–29 years old and came from cohorts banded in the mid 1970s to mid 1990s, with those banded in 1996 being the most recent cohort to start breeding. Similarly, 80% of adults were banded 10–19 years ago. This was after the peak of banding on Campbell Island which occurred in the late 1960s–early 1970s (Moore & Bettany 2005). Consequently, only 8.1% of the original 35 000 banded birds were found in 2004–08. The oldest birds were 43 years old and were from the 1965 cohort. The oldest live adult was banded 36 years ago, making it at least 42 years old if it started breeding at the earliest known age (6 years; PJM unpubl. data; ACAP 2009). The previous period of intensive band recovery (in 1994–98) found a 38-year-old bird that was banded as a chick in 1957, seven 33–36-year-olds that were banded as chicks from 1961–64 cohorts that were breeding at or near the Col study area (PJM unpubl. data). Similarly, five adults from 1961–64 were still breeding 32–34 years later in 1994–98. None of these birds were seen in 2004–08. These data suggest that few birds make it beyond 40 years of age, which makes an earlier prediction that southern royals might live to 80 years of age (Westerskov 1963) seem very unlikely. At Taiaroa Head, South Island, the northern royal albatross (*Diomedea sanfordi*) known as 'Grandma' may have lived 61+ years (Robertson 1993); however, few individuals aged 40+ have been recorded in this population (Robertson 1993, L. Perriman, DOC, pers. comm.). The oldest known-aged northern royal albatross in recent years disappeared when it was 49 (L. Perriman, DOC, pers. comm.).

Preliminary analysis of the southern royal albatross band database for two periods of intensive monitoring at the Col and Moubray study sites provided estimated mean annual rates of adult survival of 0.903 ± 0.021 (SE) in 1961–1971 and 0.935 ± 0.008 in 1994–98 (R. Barker, University of Otago, pers. comm.; ACAP 2009). At Enderby Island, mean adult survival was estimated at

0.949 ± 0.008 (1992–2000) (R. Barker, pers. comm.; ACAP 2009). These adult survival estimates are mostly lower than those found for other large albatrosses in the New Zealand region; for example, the rate was 0.946 for northern royal albatrosses in 1937–1993 (Robertson 1993), 0.957 for Antipodean wandering albatross (*Diomedea antipodensis*) in 1994–2005 (Walker & Elliott 2005), 0.970 for Gibson's albatross in 1993–95 (Walker & Elliott 1999), and 0.953 for wandering albatrosses (*D. exulans*) on Macquarie Island in 1955–2000 (Terauds et al. 2006). Now that a comprehensive search for banded southern royal albatrosses has taken place, further mark-recapture analysis of the data would provide a valuable addition to knowledge of the species' population dynamics.

Minimum survival of chicks banded in 1987–96 at Col and Moubray study areas was 34–39% and recruitment into the breeding population was 32–38%. These juvenile survival data are at the lower end of the range found for large albatrosses (Terauds et al. 2006); although, because the emphasis in our study was to find breeding birds, rather than non-breeding adolescents, this result may not be surprising.

Recruitment data for southern royal albatrosses on Campbell Island showed a bias towards banded males being found as breeders. This may, in part, reflect the higher natal philopatry of males than females at the study areas, and the greater effort to find banded birds there compared with more remote parts of the island. However, it may also reflect disproportionate mortality of females at sea. Other albatross species have shown gender differences in foraging zones and thus vulnerability to bycatch (Nel et al. 2002; Philips et al. 2004). Any resulting substantial sex bias in the breeding population could result in reduction in reproductive output of the population (Nel et al. 2002).

Males showed greater site fidelity at Moubray than at Col, and this may reflect the differing geography of the two study areas. Col lies in the centre of the island and has wide borders with three other areas, whereas Moubray is more isolated and has a narrow border along the ridge connecting it to West Moubray. Dispersion away from the study areas is likely to have been underestimated because the search effort for banded birds was not spread evenly over the island.

As expected, the number of banded birds encountered on Campbell Island decreased each year over the 2004–08 survey period, partly as a consequence of the gradual removal of bands and also because the biennial breeding pattern means that most birds are found during the first 2 years of study. Similarly, at Col study area, over a five-year period in 1994–98, 41.5% of banded breeding birds identified in the study period were first found in the first year, 34.5% in the second and 10.6%, 7.6% and 6.8% in subsequent years (PJM unpubl. data). During the first 2 years of the study, most of the successfully breeding birds were seen, and new birds seen in following years were those that had taken more than 1 year off (e.g. because of partner loss) or had migrated and recruited into the area. Also, the first 2 years' work concentrated on the areas where most historical banding occurred. Of the 35 000 birds banded on Campbell Island, 48% were banded at North Col, South Col and Moubray combined, 35% at Lyall, Fizeau and Faye and 16% at Dumas, Honey, Paris and Puiseux. This explains the low band encounter rate at the latter areas; for example, in 2006 only 134 banded birds were found at these southern and western areas.

4.3 Band injuries

The number of banded southern royal albatrosses found on Campbell Island in the 2004–08 period and their injury rates all justified the concern raised (Moore 2003) and the efforts to seek a remedy (reported in this study). The more serious injuries were found to affect 2.5% of all banded birds, which was the same proportion that was found in the 1990s (Moore 2003). Injury rates were elevated for birds banded as chicks (2.8%) compared with those banded as adults (0.8%), although this was a smaller difference than was found up to the 1990s (7% and 0.5% respectively; Moore 2003). This was because the more recent chick cohorts from the 1980s and 1990s had lower injury rates (0.6–1.0%).

In addition to the major injures found in 2004–08, 8.6% of bands caused minor injuries, 12% were open > 3 mm and another 26% of bands were open < 3 mm. We believe that there was potential for further injuries to albatrosses on Campbell Island from bands that were open, had the problem not been remedied. There appears to be a progression from the open bands irritating legs, to their causing warts and skin projections, then cutting into legs and eventually forming a debilitating leg injury. Therefore, the removal of all bands from birds outside of the study areas prevents any worsening of existing injuries and the occurrence of new injuries, and reduces the need to search for banded birds outside the study areas in the future. Apart from their effect on birds' mobility, the injuries caused by bands may also affect survival; for example, there was a link (albeit weak statistically) between high-injury years and recapture probability (Moore 2003). This may also relate to the loss of bands, for those that open up by 10 mm are more likely to fall off.

Sixty-one percent of major injuries and 66% of minor injuries were to males. The majority of minor injuries were dents or compressions of the leg caused by poorly shaped or tight bands., probably because the males' larger legs made fitting the R bands more problematic for inexperienced banders and, consequently, bands were left partially open. Even experienced banders have to shape the R band very carefully to fit it onto the larger-legged males. The result is a snug oval band with a cross-sectional shape mirroring that of the bird's tarsus.

The era of banding as many birds as possible on Campbell Island may have produced a 'ring and fling' attitude amongst some untrained banding volunteers on Campbell Island. Poor closure of bands, combined with the springiness of the large R bands, has left a legacy of injured birds. The 1979 season contributed the most band injuries, with 90 (48%) of 187 birds seen that were banded in that year having major injuries (Moore 2003). Similarly, in 2004–08, 51% of the major injuries found were amongst the cohort banded in 1979, although by the time of the 2004–08 survey, the proportion of that cohort with major injuries had decreased to 28%.

Injuries may have built up over time if bands continued to open. This may have contributed to the high injury rates observed for birds banded in the 1960s–70s (7% of banded birds found in 2004–08) compared with the 1980s–90s (0.6–1%), although the quality of the banding also improved in the latter decades because DOC projects used experienced band operators (Moore 2003).

Studies using marked animals generally assume that the marking has no effect on the animal, or, if there is an effect, it is unimportant; yet few studies have tested those assumptions (Murray & Fuller 2000). As a result, data collected may be biased and animal welfare aspects generally ignored (Murray & Fuller 2000). A growing awareness of the potential for band injuries has led to a more responsible approach to banding of threatened species in New Zealand, one which balances the advantages of banding with the welfare of the birds. Where large bands are used, such as the springy flipper bands used on penguins (e.g. yellow-eyed penguin *Megadypes antipodes*), a regular band maintenance programme is required as part of the DOC banding permit (G. Taylor, DOC, pers. comm.). Furthermore, in remote sites where regular checks are not possible, penguin bands have been removed and new banding is not permitted (G. Taylor pers. comm.; Moore & Taylor 2005). In other cases, bands have been removed in favour of transponders and transmitters (as used, for example, with some kiwi *Apteryx* spp. and kakapo *Strigops habroptilus*) to protect the birds' legs from harm. There are still major benefits for research and species management in having visible marks. However, the quality of the mark must be maintained (see Moore 2003 for discussion of banding issues). Leg injuries from bands have not been reported in the literature for other albatross banding programmes.

On remote Campbell Island it was not possible to conduct regular band maintenance on the thousands of bands that were applied to southern royal albatrosses on all parts of the island. Many of the birds that were found in the 2004–08 survey had not been seen since they were banded—up to 43 years earlier. Because of the band injury problem, DOC decided that the best course of action was to remove bands from birds outside study areas, but keep a marked population in the traditional study areas at Col and Moubray (Moore & Taylor 2005). Similarly, documentation of bands that were open, misshapen and causing minor injuries to southern royal albatrosses on Enderby Island in 2004 (J. Amey, unpubl. data), and the impracticability of ongoing maintenance, led to a decision to remove all bands from birds on this island in subsequent years (G. Taylor, L. Chilvers, DOC, pers. comm.).

4.4 New R and RA bands

While it had been hoped that the new, thicker, 1.25 mm stainless steel R and RA bands would have less spring than the old 1- mm-thick R bands, it was apparent that the traditional method of closing them still caused a proportion of them to spring open. RA bands proved to be the most unreliable, with 2.7% opening by ≥ 3 mm and one bird being injured by its band. The improved closing method developed during this study, and employment of a 'spring test' of all completed bands, provides more surety that the new R bands can be used for long-term marking of southern royal albatross on Campbell Island, albeit restricted to confined study areas for ease of future band maintenance checks. Because of the extra springiness of the new RA bands, they should only be used in areas where regular band checks can be made. The modified band closing method is now recommended for large-circumference bands in the New Zealand National Bird Banding Scheme's bird bander's manual (Melville 2011).

4.5 Transponders

Transponders (PITs) offer a long-term solution to the band injury problem amongst southern royal albatrosses on Campbell Island. However, while they allow a marked population to be retained for future study, they are not a perfect replacement for bands. Whereas bands can be applied at the nest with minimal disturbance to the birds, implanting PITs involves removal of birds from their nests which creates a lot more visible stress and increased the risk of nest abandonment and egg breakages. Good handling technique reduces the risk, however, and only one of the 405 (0.25%) procedures to implant PITs that we carried out resulted in a broken egg, compared with handling 1177 birds to install new bands that resulted in one egg (0.08%) being chipped and later failing. Albatrosses show a great range in behaviour during nest visits for either banding or PIT implanting, so the extremely nervous individuals were avoided or visited multiple times to gradually habituate them to people. At least 4% of PITs failed or, more likely, failed to implant correctly. Reasons for failed implants probably included PITs that came back out of insertion holes (before glue was used in 2006 to seal them) or needles were inadvertently pushed through the skin and back out again (e.g. for birds that struggled at the wrong moment or for thin birds with less subcutaneous fat). Improved implant technique included taking care that a good implant site was prepared, the angle of the needle was correct, the PIT could be felt under the skin (preferably as it left the needle) and the hole was pressed flat and cleaned before applying skin cement to close it.

5. Conclusions

The first island-wide search for banded southern royal albatrosses on Campbell Island in 2004–08 was designed to protect the welfare of birds that had been injured by their bands, maximise the population information benefits that could be obtained from of 60 years of banding, and maintain a marked population for future study. In total, 2882 banded birds were found; 81% were 10–29 years old, and the oldest birds were up to 43 years old. Seventy-two (2.5%) of banded birds had major injuries, a further 8.5% had minor injuries, and many others were at risk of future injury from open bands. These numbers and proportions justified the effort to remedy the problem over the five-year survey period. Most injuries resulted from banding carried out in the 1970s, and half of the injured birds had been banded in 1979. This confirmed that bands had been poorly applied in some years, particularly to the larger-legged males, although the springiness of the large R bands, which meant that some gradually opened after application, also contributed to the problem.

Removal of bands from birds over most of Campbell Island now means that banded birds are concentrated at Col and Moubray study areas. The trial of new, thicker (1.25 mm) replacement stainless steel bands at these areas had mixed success. New R bands opened a small amount after application, but an improved closing technique allowed them to be retained for use on females at the study areas. However, the larger RA bands that were trialled for males were too springy to be safe in the long term and these were replaced at Col with PITs. Our preliminary analyses show that the band records collected in 2004–08 provide valuable information on the life history and population dynamics of southern royal albatrosses. Although the banding and recovery effort has been patchy over the sixty-year banding period, the southern royal albatross band database is one of the largest and longest-running in New Zealand. Further in-depth mark-recapture analysis is recommended to fully utilise this valuable dataset.

The estimate of 7855 nests (8300–8700 breeding pairs) per year on Campbell Island in 2004–08 was similar to that estimated in 1995. However, the average number of nests in four out of five study and index areas had decreased 7–17% since the late 1990s. These data show that the population growth observed during the latter half of the 20th Century is not continuing, indicating that current conditions are less favourable for southern royal albatrosses than they were in the 1990s. Our study was the first GIS-based nest survey of albatrosses on Campbell Island, and provides a valuable baseline for future studies of distribution and population trends.

6. Recommendations

- A census of study areas (Col and Moubray) and index sites (Faye, Paris and Honey) should be conducted within 10 years of the current study. Nest counts for four consecutive years are recommended to account for fluctuations in breeding frequency that result from variations in breeding success.
- The status of bands and transponders on birds at the study areas should also be checked during this survey.
- Mark recapture analysis of existing and future records of the southern royal albatross band database is required to establish trends in adult and juvenile survival.

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Appendix 1

Study area and index area boundaries and sector counts for southern royal albatrosses (*Diomedea epomophora*) on Campbell Island/Motu Ihupuku

The Col study area northern boundary is an arbitrary line along the centre of the Lyall Plateau at the western end of Lyall ridge which meets the walking track from Beeman Base at the Col–Lyall saddle (Fig. A1.1). The boundary then follows the old track towards Azimuth (a new boardwalk constructed in early 2009 now crosses the northern corner of C and bisects area F). The nests to the north of the line are part of the main North Col survey block. The southern boundary with South Col follows the 1970 sheep fence line. Boundaries were marked with poles or used existing features in the 1990s, and GPS positions were taken in 2004 (Table A1.1). Sector counts in 1994–2008 are shown in Table A1.2.

Moubray study area boundaries were marked out in the mid 1990s to divide the upper gullies (areas 1–5) on the north and south side of the ridge from the rest of Moubray (areas A–J) (Fig. A1.2). The centre line of Moubray ridge continues out over a wide plateau southeast of Moubray Hill ('The Castle'). Generally, the pegs marking the top of areas 1–5 are at the edge of this plateau, but birds that nest on the plateau itself are included in the nearest adjacent area. GPS positions for the sector boundaries are provided in Table A1.3 and sector counts in 1994–2008 are shown in Table A1.4.

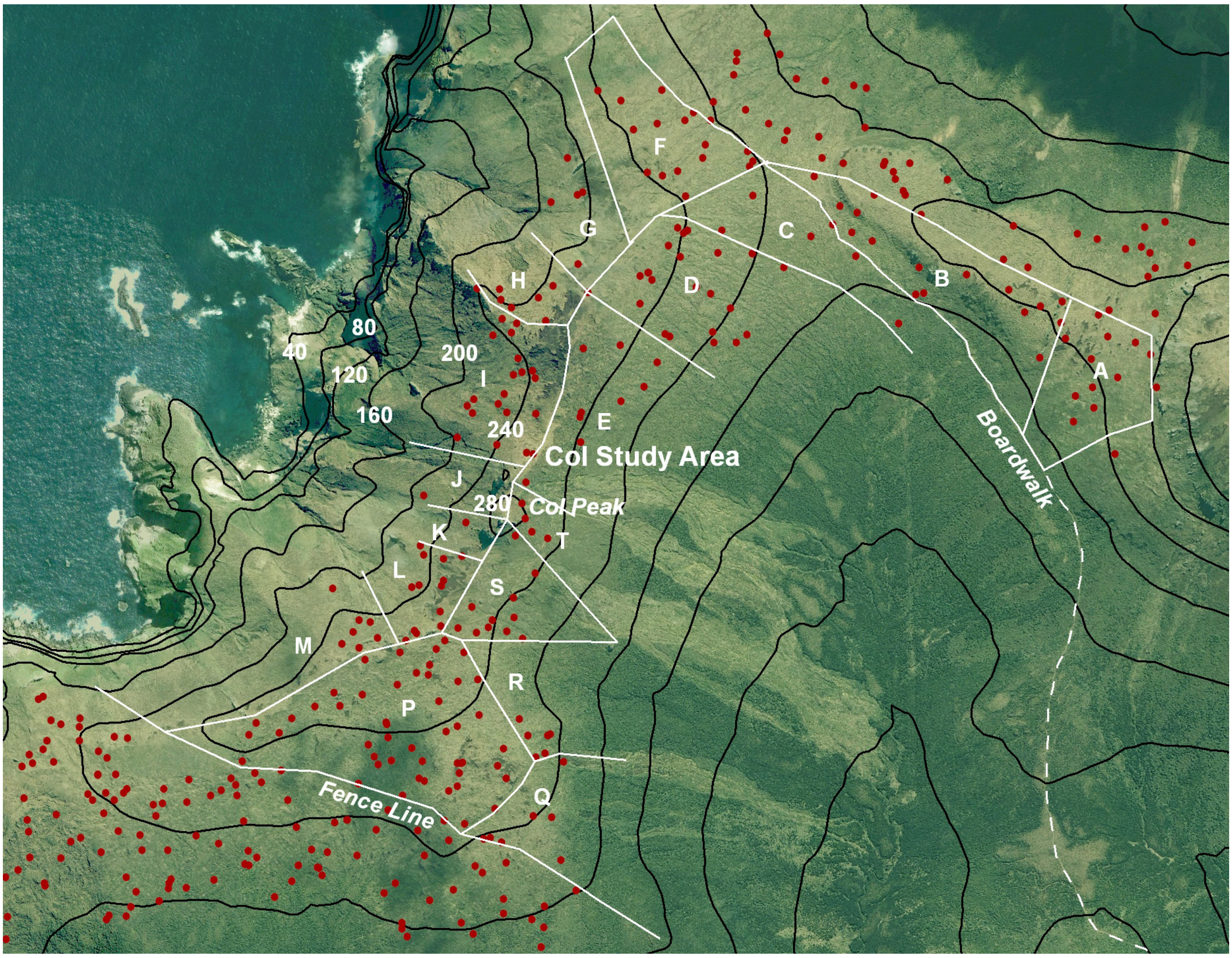

Figure A1.1. Col study area sectors (white letters) and boundaries (white lines) overlaid on 40 m contours (black lines) and satellite imagery of Campbell Island/Motu Ihupuku. Nest distribution (red dots) of southern royal albatross (*Diomedea epomophora*) in 2006 is mainly in the tussock/megaherb zone above 160–200 m. The darker-shaded vegetation below this to the right is *Dracophyllum* scrub. Note: sectors M and N were combined and there was no sector O.

Table A1.1. GPS positions of sector boundaries of Col study area.

PEG OR POSITION	UTM EAST	UTM NORTH	ELEVATION	DESCRIPTION
0	373 670	4 178 369	234	Corner knob between C, D, F and G
1	373 722	4 178 363	222	Old fence post between C and D
2	373 751	4 178 349	214	Old fence post between C and D
3	373 808	4 178 323	199	Old fence post between C and D
4	373 869	4 178 294	183	Old fence post between C and D
5	373 920	4 178 273	171	Old fence post between C and D
6	373 958	4 178 256	163	Old fence post between C and D
7	374 032	4 178 224	149	Old fence post between C and D
8	374 116	4 178 158	131	Old fence post between C and D
9	374 177	4 178 091	120	Old fence post between C and D
10	374 335	4 178 054	130	Boardwalk
11	374 299	4 178 127	137	Boardwalk
12	374 203	4 178 200	147	Boardwalk
13	374 048	4 178 327	160	Boardwalk
14	374 010	4 178 402	169	Boardwalk platform
15	373 896	4 178 482	176	Striped marker pole on old track. Note the new boardwalk in 2009 bisects area C and F uphill from this position
16	373 820	4 178 543	179	Old track marks boundary between main study area and North Col periphery
17	373 725	4 178 603	190	Old track between F and North Col
18	373 585	4 178 778	206	Old track between F and North Col
20	373 563	4 178 485	233	West end of rock near ridge crest between F and G
21	373 524	4 178 215	247	Top knob marks D/E and G/H boundaries
22	373 487	4 178 148	246	Ridge crest marks H/I boundary
23	373 406	4 178 150	227	Ridge between H and I
24	373 330	4 178 194	230	Ridge between H and I
25	373 490	4 178 103	252	Main ridge between E and I
26	373 476	4 178 017	239	Main ridge between E and I
27	373 377	4 177 834	262	Rock column north of Col peak
28	373 365	4 177 759	285	Col peak
29	373 472	4 177 813	229	Top of slip between E and T
32	373 234	4 177 531	262	Ridge junction between S, L and P
33	372 680	4 177 333	208	South Col fence post
34	372 832	4 177 262	216	South Col fence post
35	372 983	4 177 255	204	South Col fence post
36	373 215	4 177 181	196	South Col fence post
37	373 273	4 177 128	187	South Col fence post marks P/Q boundary
38	373393	4 177 228	203	Edge of bluffs mark P/Q boundary
39	373 420	4 177 274	200	Edge of bluffs mark P/Q/R corner
40	373 471	4 177 289	175	Top of slip marks Q/R boundary
41	373 578	4 177 518	156	Prominent rock marks R/S boundary
42	373 240	4 177 595	249	Main ridge between S and L
44	373 188	4 177 715	218	Balanced rock on ridge between K and L
45	373 207	4 177 788	206	Ridge below Col between J and K
46	373 244	4 177 965	200	Ridge between I and J
48	373 618	4 178 317	245	Knob on summit ridge between D and G
49	374 066	4 178 448	176	Orange peg marking centreline of plateau between Col study area and North Col periphery
50	374 245	4 178 355	183	Orange peg marking centreline of plateau
51	374 349	4 178 288	188	Orange peg marking centreline of plateau
52	374 505	4 178 214	190	Orange peg marking centreline of plateau on dyke
53	374 455	4 178 078	173	South end of dyke between A and B

Continued on next page

Table A1.1. continued from previous page.

PEG OR POSITION	UTM EAST	UTM NORTH	ELEVATION	DESCRIPTION
55	374 673	4 178 133	211	Orange peg marking centreline of plateau at edge of scree slope off Lyall ridge
58	374 675	4 177 963	228	Top marker peg marking boundary between Col study area and south-west Lyall
59	374 590	4 177 935	195	Lower marker peg on boundary of A
61	374 458	4 177 865	135	Position on boardwalk in line with boundary of A and south-west Lyall
B2	373 078	4 177 492	254	Rock knob on summit ridge between M and P
B3	373 017	4 177 470	245	Rock knob on summit ridge between M and P
B4	372 860	4 177 367	238	Rock dyke near summit ridge between M and P
B6	373 347	4 177 109	182	South Col fence post
B7	373 390	4 177 099	180	South Col fence post
B8	373 502	4 177 027	150	South Col fence post
B9	373 551	4 176 994	133	South Col fence post
B10	373 671	4 176 918	111	South Col fence post
B11	373 273	4 177 517	239	Southeast end of dyke at corner of P/R/S
B12	373 253	4 177 529	248	Other end of dyke at boundary of P/S

Table A1.2. Numbers of nests of southern royal albatrosses (*Diomedea epomophora*) in the Col study area sectors in 1994–98 and 2004–08.

SECTOR	1994	1995	1996	1997	1998	MEAN	2004	2005	2006	2007	2008	MEAN
A	9	15	5	17	8	10.8	12	11	13	12	13	12.2
B	18	10	12	13	11	12.8	15	9	11	9	17	12.2
C	12	14	9	14	13	12.4	14	10	6	10	7	9.4
D	12	19	15	13	16	15.0	18	20	15	21	22	19.2
E	20	18	19	19	17	18.6	19	13	15	20	10	15.4
F	10	12	11	9	11	10.6	9	9	7	13	17	11.0
G	5	1	3	1	3	2.6	3	1	6	3	5	3.6
H	5	10	6	6	3	6.0	6	4	5	3	6	4.8
I	19	15	18	20	23	19.0	18	23	17	17	20	19.0
J	0	3	0	2	2	1.4	2	3	2	2	1	2.0
K	3	3	0	2	5	2.6	2		2	2	1	1.75
L	7	7	7	5	7	6.6	9	9	5	7	13	8.6
M	5	7	14	4	10	8.0	10	9	8	7	7	8.2
P	41	37	43	39	46	41.2	41	39	45	42	47	42.8
Q	6	4	7	7	7	6.2	11	5	10	9	7	8.4
R	9	11	10	16	13	11.8	7	9	5	6	6	6.6
ST	9	15	9	13	8	10.8	11	11	10	13	15	12.0
NC border	14	0	19	10	18	12.2	13	11	20	19	20	16.6
SC border	0	1	2	2	4	1.8	7	12	9	12	9	9.8
Col total	190	201	188	200	203	196.4	207	185	182	196	214	196.8
Study nests	204	202	209	212	225	210.4	227	208	211	227	243	223.2

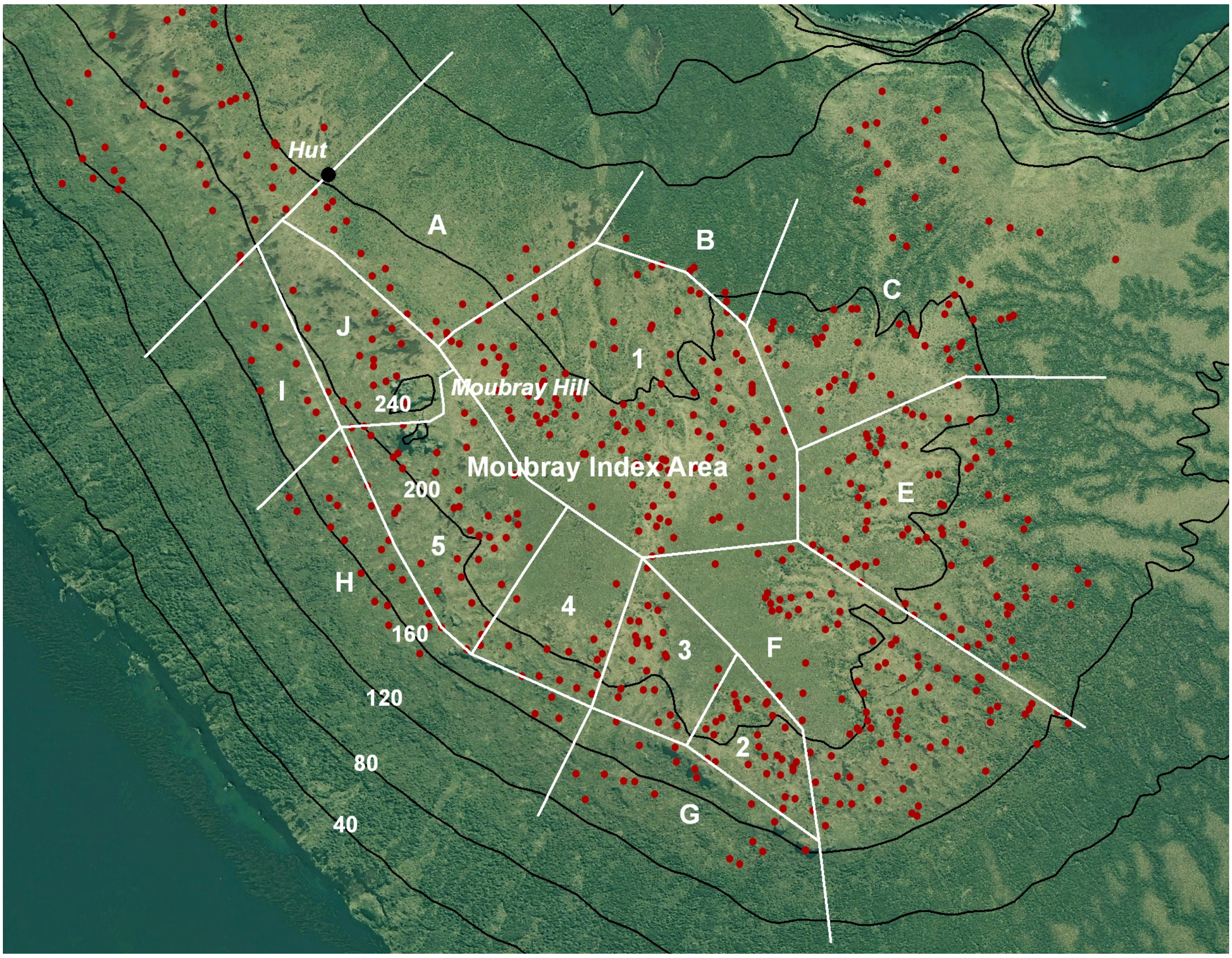

Figure A1.2. Moubray study area sectors (central core: white letters 1–5, outer zone: white letters A–J) and boundaries (white lines) overlaid on 40 m contours (black lines) and satellite imagery of Campbell Island/Motu Ihupuku. Nest distribution (red dots) of southern royal albatross (*Diomedea epomophora*) in 2006 is mainly in the tussock/megaherb zone above 160 m. The darker-shaded vegetation below this is *Dracophyllum* scrub. The area that is mostly devoid of nests within the study area is a plateau of short alpine vegetation on the ridge top (originally denoted as sector D but now shared between sectors 1–5).

Table A1.3. GPS positions of sector boundaries of Moubray study area.

PEG OR POSITION	UTM EAST	UTM NORTH	ELEVATION	DESCRIPTION
Ridge	379 983	4 176 370	215	Peg on ridge beside large rock on saddle near hut
Hut	379 907	4 176 444	188	Position 30 m northwest of hut in line with ridge marker
Peg 1a	380 148	4 176 176	215	Top corner of Area 1
Peg 1ax	380 174	4 176 198	227	Peg on edge of drop off marks the line between A and 1
Peg 1b	380 162	4 175 850	224	Top (southern) corner of 1
Peg 1c	380 699	4 176 016	215	Large wooden post in centre of plateau marks the corner of 1, C and E
Trig 214	380 621	4 176 206	214	High point defines corner of 1, C and B
Peg 1d	380 523	4 176 292	195	Peg near edge of scrub marks boundary of 1 and B
Peg 1e	380 392	4 176 334	181	Peg near edge of scrub marks corner of 1, A and B
Peg 2a	380 734	4 175 413	183	Peg above edge of bluffs marks corner of 2, F and G
Peg 2b	380 706	4 175 590	204	Peg on edge of ridge between 2 and F
Peg 2c	380 608	4 175 702	215	Peg at top of ridge between 2 and 3
Peg 2d	380 529	4 175 560	204	Peg marks bottom border of 2, 3 and G

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Table A1.3. continued from previous page.

PEG OR POSITION	UTM EAST	UTM NORTH	ELEVATION	DESCRIPTION
Peg 3a	380 451	4 175 819	221	Top of border on ridge between Area 3 and 4, about 320 m from peg 1b
Peg 3b	380 384	4 175 620	198	Peg marks corner of 3, 4, G and H
Peg 4a	380 292	4 175 850	211	Peg on ridge between 4 and 5
Peg 4b	380 199	4 175 701	200	Peg on prominent rock above bluffs marks corner of 4, 5 and H
Peg 5a	380 225	4 176 071	228	Peg at top of 5
Peg 5b	379 993	4 176 051	196	Peg on top of rock marks corner of 5, H, I and J
Peg 6a	380 081	4 175 869	184	Peg marks boundary between 5 and H
Position 6b	380 150	4 175 744	186	Position on small tussock knoll marks boundary between 5 and H
Peg E/F	380 700	4 175 875	222	Upper peg marks ridge boundary between E and F
Peg E/F lower	381 014	4 175 671	185	Lower peg marks ridge boundary between E and F
Trig 206	380 958	4 176 127	206	High point defines boundary between C and E

Table A1.4. Numbers of nests of southern royal albatrosses *(Diomedea epomophora)* in Moubray index area sectors in 1994–1998.

SECTOR	1994	1995	1996	1997	1998	MEAN	2004	2005	2006	2007	2008	MEAN
1	106	90	98	90	104		104	76	107	82	120	
2	34	22	39	15	40		25	22				
3	15	28	29	21	29		20	22	66	106	112	
4	26	10	14	20	21		21	14				
5	29	35	29	36	41		43	32	25			
A	12	23	17	24	16		20	16	24		17	
B	5	5	5	7	3		2	2	5	17	7	
C	64	74	80	91	86		62	70	54	72	65	
E	78	80	69	87	71		73	67	97	52		
F	59	83	77	93	88		78	77	59	91	175	
G	19	13	18	15	14		20	13				
H	30	22	20	28	30		18	25	34	42	45	
I	2		3	7	7		5	6				
J	10	23	10	17	14		15	20	23	30	28	
1–5 total	210	185	209	182	235	204.2	213	166	198	188	232	199.4
A–J total	279	323	299	369	329	319.8	293	296	296	304	337	305.2
Total	**489**	**508**	**508**	**551**	**564**	**524**	**506**	**462**	**494**	**492**	**569**	**504.6**

N.B. some totals were combined with adjacent sectors.

The Paris Index block is located at the western end of Campbell Island, near the Penguin Bay hut (Fig. A1.3). The block consists of two subzones (north and south) on the southwest slopes of Yvon Villarceau Peak and northwest slopes of Mount Paris. The eastern edge is approximately 30 m elevation below the ridge joining the two peaks, to include most of the birds nesting along the edge of the ridge. The southern edge is a line of plastic pegs on the slopes of Mt. Paris. The division between North and South Paris index blocks runs from the saddle down a stream course between the two peaks. GPS positions for the sector boundaries are provided in Table A1.5 and sector counts in 1994–2008 are shown in Table A1.6.

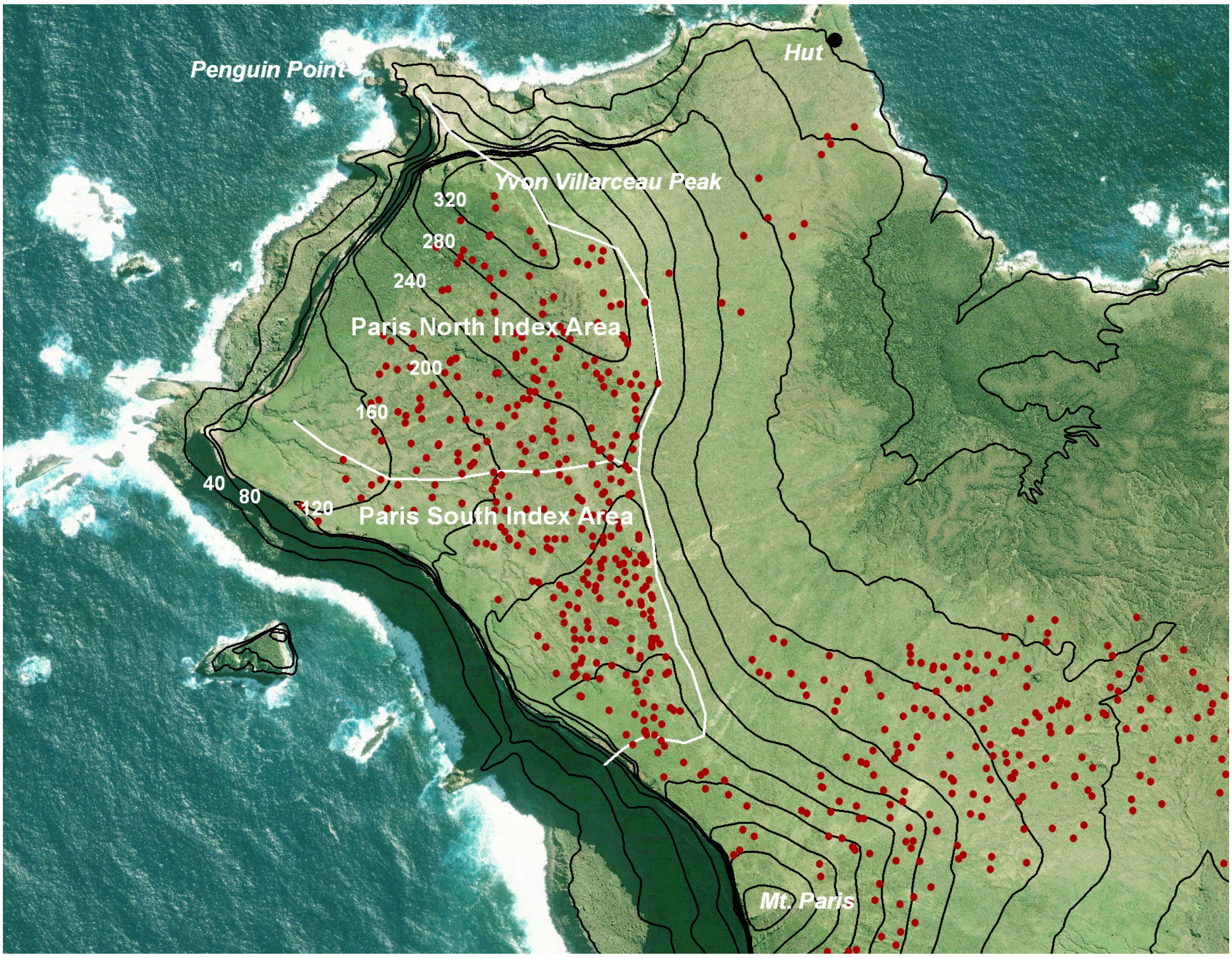

Figure A1.3. Paris index area boundaries (white lines) overlaid on 40-m contours (black lines) and satellite imagery of Campbell Island/Motu Ihupuku. Nest distribution (red dots) of southern royal albatross (*Diomedea epomophora*) in 2006 on this large slope between Yvon Villarceau Peak and Mount Paris is in the tussock/megaherb zone mainly between 160 m and 320 m elevation.

Table A1.5. GPS positions of sector boundaries of Paris index area.

PEG	UTM EAST	UTM NORTH	ELEVATION	DESCRIPTION
Peg 1	367 029	4 175 595	297	Orange plastic peg
Peg 2	366 962	4 175 606	302	Orange plastic peg
Peg 3	366 935	4 175 619	297	Orange plastic peg
Peg 4	366 889	4 175 600	300	Orange plastic peg
Peg 5	366 856	4 175 579	301	Orange plastic peg
Peg 6	367 003	4 176 402	300	Orange plastic peg
Position 7	366 829	4 176 402	244	Dividing line between zones, no peg

Table A1.6. Numbers of nests of southern royal albatrosses (*Diomedea epomophora*) in index area sectors in 1994–98 and 2004–08.

SECTOR	1996	1997	1998	MEAN	2004	2005	2006	2007	2008	MEAN
Paris north	193	207	254	218.0			149	151	191	163.7
Paris south	201	232	235	222.7			183	183	244	203.3
Paris total	394	439	489	440.7			332	334	435	367.0
Honey west	212	184	207	201.0			168	200	197	188.3
Honey east	221	216	221	219.3			168	202	180	183.3
Honey total	433	400	428	420.3			336	402	377	371.7
Faye	598	657	639	631.3	598	537	572	563	609	575.8

The Honey index block is located on the southern slopes of Mount Honey, near the Southeast Harbour hut (Fig. A1.4). The block consists of two subzones (west and east). The western border runs in a line from where the walking track comes up from Filhol saddle to the scrubline and then up to Mount Honey (see table below for UTM coordinates of marker pegs). The eastern border runs up the ridge 300 m east of Southeast Stream to a prominent wide ridge, then follows a bearing between two prominent rocks. There is no lower boundary other than that defined by the lowermost albatross nests. The upper boundary, as marked on the map, is arbitrary, the

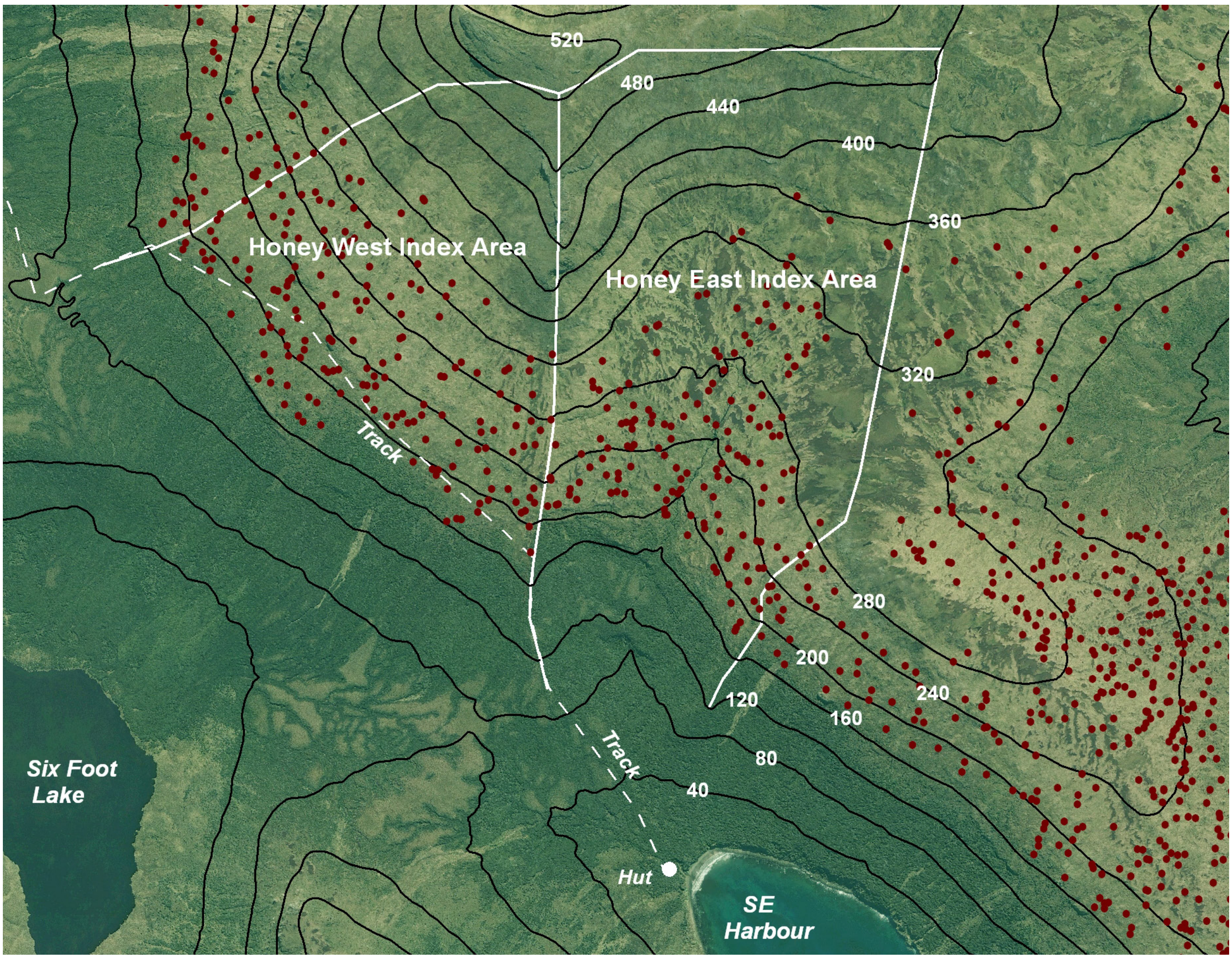

Figure A1.4. Honey index area boundaries (white lines) overlaid on 40-m contours (black lines) and satellite imagery of Campbell Island/Motu Ihupuku. Nest distribution (red dots) of southern royal albatross (*Diomedea epomophora*) in 2006 is mainly in the tussock/megaherb zone between 160 m and 360 m elevation. The darker-shaded vegetation below this is Dracophyllum scrub, the darker shades above 280 m are peat blows and above 320–350 m are alpine vegetation and rock.

intention being to include the highest nesting albatrosses. The line that divides the east from the west block is the ridgeline marked by a track marker pole indicating the turn down to Southeast Harbour. GPS positions for the boundaries are provided in Table A1.7 and sector counts in 1994–2008 are shown in Table A1.6.

The Faye index block lies to the east of the walking track between Mount Faye and Sorenson Hut (Fig. A1.5). The walking track is the western boundary and the southern boundary is a line of pegs from the track to a prominent ridge running off Mt Faye. The eastern boundary is delimited by the lower-most nests in the scrub margin. GPS positions for the boundaries are provided in Table A1.8 and nest counts in 1994–2008 are shown in Table A1.6.

Table A1.7. GPS positions of sector boundaries of Honey index area.

PEG	UTM EAST	UTM NORTH	ELEVATION	DESCRIPTION
Peg 1	376 391	4 172 400	226	Peg (grey) on eastern boundary
Peg 2	376 420	4 172 449	237	Peg (grey) on eastern boundary
Peg 4	376 774	4 173 331	357	Peg (orange) on prominent triangular rock
Peg 6	375 828	4 172 850	277	Peg on centre ridge
Position 8	376 828	4 172 837	255	Waterfall in middle of east index block
Position 9	376 617	4 172 597	316	Tall rock at edge of ridge
Peg 10	375 778	4 172 497	185	Track marker peg directing to Southeast Hut
Peg 11	375 340	4 172 882	205	Track marker peg
Peg 12	374 860	4 173 376	200	Peg on knoll above turning point in track
Peg 13	375 018	4 173 478	237	Peg on western boundary
Peg 14	375 082	4 173 523	260	Peg (grey) on western boundary
Peg 15	375 118	4 173 523	279	Peg (wooden post) on western boundary
Peg 16	375 186	4 173 590	316	Peg on western boundary
Peg 17	375 238	4 173 627	339	Peg (orange) on western boundary
Peg 18	375 283	4 173 659	358	Peg (orange) on western boundary
Peg 19	375 162	4 173 128	217	Grey peg (above track?)

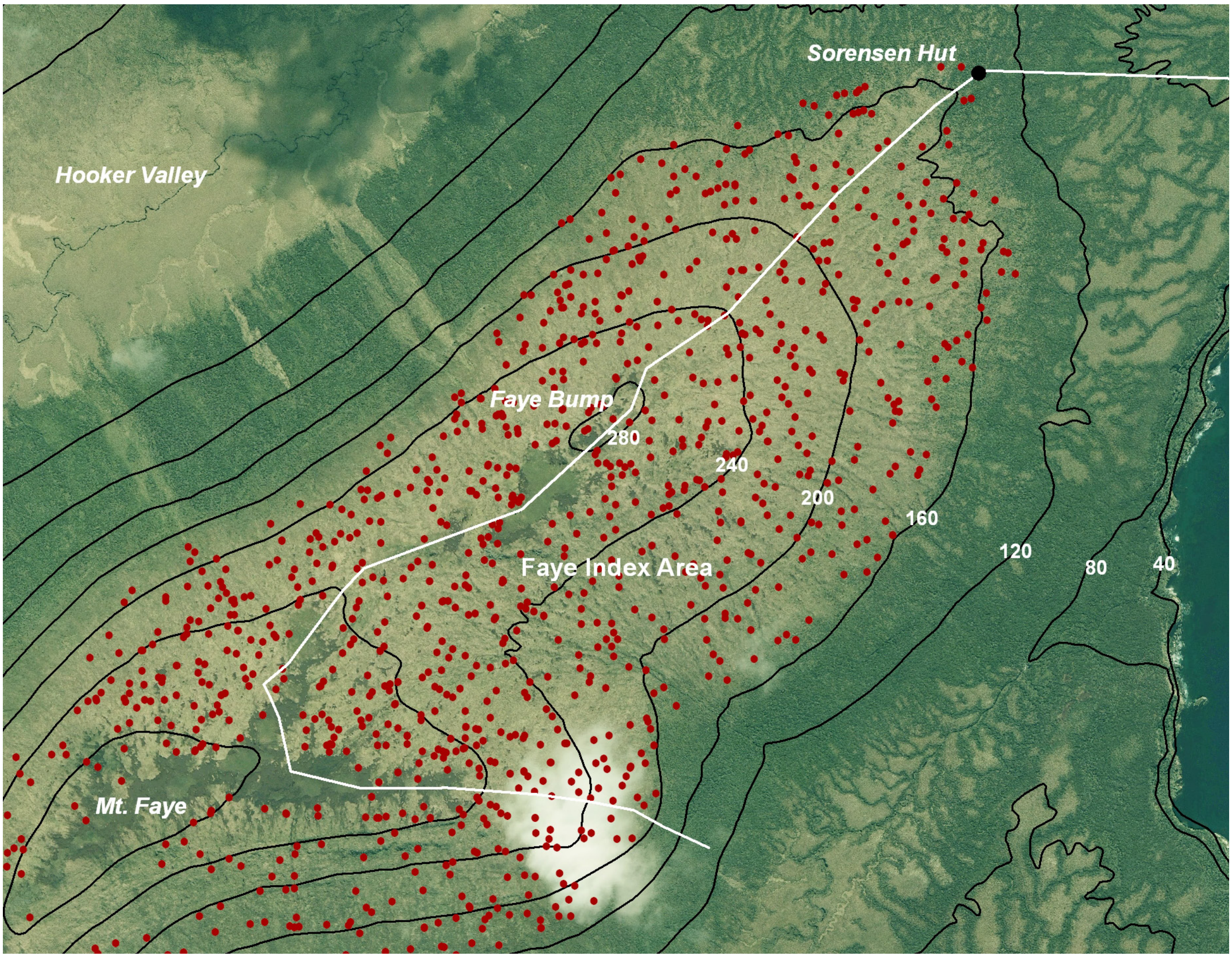

Figure A1.5. Faye index boundary (white line) overlaid on 40-m contours (black lines) and satellite imagery of Campbell Island/Motu Ihupuku. Nest distribution (red dots) of southern royal albatross (*Diomedea epomophora*) in 2006 is mainly in the tussock/megaherb zone above 160 m. The darker shaded-vegetation below this is Dracophyllum scrub. The dark areas on the Faye ridge are areas of bare peat.

Table A1.8. GPS positions of sector boundaries of Faye index area.

PEG	UTM EAST	UTM NORTH	ELEVATION	DESCRIPTION
Peg 1	376 763	4 182 391	302	South boundary
Peg 2	376 802	4 182 316	312	South boundary
Peg 3	376 827	4 182 189	317	South boundary
Position 4	377 187	4 182 153	291	South boundary—no peg
Peg 5	377 394	4 182 135	262	South boundary
Peg 6	377 519	4 182 119	239	South boundary
Peg 7	377 618	4 182 101	208	South boundary

Appendix 2

Surveying and bird handling instructions

Edited excerpts from the albatross instructions given to Campbell Island personnel in 2004–08. These are presented here to provide guidance for future albatross surveys.

A2.1 Clothing and equipment

Although some clothing and equipment is a matter of personal preference, the following items were generally carried by all personnel during albatross work in 2004–08.

- Wet weather coat and over-trousers for protection against the elements, albatross bites and ticks. Rubber boots were generally preferred because of the prevailing wet conditions.
- Peaked thermal hat to protect the face from albatross bites while checking for bands.
- Leather strap-on arm protectors to protect from albatross bites. These keep the hands free to check bands and to easily use pliers.
- Bum-bag or fishing vest to carry banding equipment and other gear needed at each nest. Day pack for spare clothing, food and water.
- Banding pliers, circlip pliers and a bag for bands collected.
- GPS for recording nest locations.
- Waterproof notebook, rubber bands to secure pages, pencils and a sharpener and a short ruler for measuring band gaps. In study areas, clip boards with plastic folders or ziplock bags were handy for carrying maps.
- Spray stock marker paint cans for marking birds and their nests.
- Dummy egg and thermal hat (kept handy to swap with real eggs, if necessary).
- Bird first aid kit to treat injured birds.
- People first aid kit, thermal banket and emergency locator beacon.
- Temporary marker poles for marking sweeps and survey sector.

A2.2 Surveying

Four people walk in parallel sweeps while searching for nests, from the margin of dense scrub through the tussock zone to the upper limit of nesting. These are essentially 'strip searches' of countryside by people walking in parallel and visiting each nest in their strip, checking for bands, and marking the birds' breast and side of the nest with a line of stock marker paint.

Depending on the terrain and vegetation type (i.e. the ease of viewing nests), the distance between searchers varies between 15 m and 50 m. The closer together searchers walk, the fewer the nests that are missed. During counts at Paris, Honey and Faye index areas carried out in 1996–98, we aimed to walk 15 m apart, usually across the slope. At the scrub margin, it was sometimes easier to zig-zag up and down into the scrub edge or up and down the more-open spurs. These approaches allowed us to find 99.2% of nests. Walking further apart in 2004/05 and 2005/06 did not apparently decrease accuracy, as the transect checks showed 99.6% of nests had been found during the first survey of each area. In other words, the majority of nests are easy to see. This means that in areas of low nest density and simple terrain, searchers can be spread more widely.

Despite what is said above, it is surprisingly easy to walk past a nest that is only a few metres away, because tussocks and hollows can obscure birds. A few things help with avoiding this:

- Keep the inter-person distance small enough to suit the nest density and terrain type—you will soon discover what works in your team.
- Zig-zag (depending on the gap between people) between nests and to look behind likely hiding places. However, don't overdo this zig-zagging, particularly if you are on the outside of the four-person sweep, as this will make it difficult for the middle two people to work out what line you are walking in; plus, you are more likely to miss nests and get confused about what sections of hillside have been covered.
- Crane your neck and scan in multiple directions, including looking back the way you came to check you got all the birds (they will be visible from some angles but not others).
- Maintain good visual and verbal contact with your neighbours. Let them know if you are going to deviate from the line, stop to deal with a difficult bird etc. Call out to make sure they see nests that may be more visible from where you are.
- Beware of tiredness—if you are exhausted you will be less likely to be vigilant; for example, tired people are less likely to look over their shoulders.
- Keep the sweep intact—it is better to wait periodically for people to catch up, rather than to allow the sweep team to become spread out. It is more effective (and more satisfying for everyone) to find an average pace for the whole team, and to have everyone process a similar number of birds.
- The outside person on each sweep periodically places poles (1.2 m-tall white PVC with a 20 cm orange strip at the top) in the ground to help delineate the sweep and orient the next sweep in the opposite direction. This helps the whole team keep to the line. On the return sweep, the marker poles are collected again. If it is misty, using the GPS track feature and walking closer together is a good alternative to marker poles.

A few tips:

- Keep a close eye on descending mist—study the country well when it is clearly visible so that you will have memories to rely on when visibility is obscured.
- Communicate well between team members during sweeps so that nests are covered efficiently. Fitter team members should bear in mind that zig-zagging onto another person's line may help speed things up, particularly if a person is dealing with a difficult bird, but if done too often it can demoralise slower walkers, as the fitter team members end up counting most of their birds.
- Make sure boundary poles are sensibly spaced out for terrain type and weather conditions.
- Complete one area (e.g. a basin) before starting another.
- Place a line of poles and mark the birds and nests well at the end of the day's work. This will make it easier to know where to start the next day and avoid confusion.

A2.3 Approaching birds on nests

A training day will need to be held on the first day of fieldwork. This is helpful for establishing teamwork, introducing new people to albatross work, and giving the old hands a refresher.

The instructions below are intended to be a reminder of good practice around birds. Our aim is to visit as many nests as possible over a short time frame, but not to cause nest failures. Albatrosses are large and may appear fairly docile at the nest, but will be stressed to varying degrees by your approach. Usually, their desire to sit tight on the egg outweighs their nervousness and there will be no problems. However, each visit by us brings a small risk of damage to the egg or the chance of nest abandonment. Also, a nervous bird may act aggressively and bite handlers. With care, you can minimise these problems. Each team and person tends to develop their own subtle differences in style with handling birds, but the basic approach should be careful and cautious.

Each nest must be approached with care, so as not to frighten the birds:

- Sleeping birds should be roused by creating some noise before they are approached.
- Approach birds slowly. When surveying a large number of nests per day, you may find you start to move in on birds too quickly, and this may eventually cause a problem.
- Approach the nest from downhill, preferably, as the birds will be less threatened when you are at their level.
- Avoid staring the bird in the eye as they may find this threatening.
- You will notice birds range in behaviour from relatively calm to nervous and flighty—take note of the bird's behaviour so you can adjust your approach.
- Slow your approach as you get closer to the nest—a slow approach usually means that the birds stay sitting tight and don't stand up.
- Although it may be tempting to approach birds at a more moderate pace so that they stand or partially stand up a bit and you get a good view of their legs to check for bands, this is not a good idea in the long run. Nervous birds are more likely to step off the nest and the subsequent stress of being herded back can make band removal impractical or risk damage to the egg.
- Pause to take a GPS record and to get your notebook ready, as this creates extra time for the bird to settle down.
- If you are carrying poles on your pack, don't lean forward over a bird as the poles will wave over its head. Either slip your pack off or carry the poles in your hands.
- Crouch down at the nest—to check for bands you need to carefully push the edge of the bird's folded wing up so that you can see its leg.
- Don't use a walking stick or pole to lift the wing for a view of the leg—this could damage the egg (if present) or even flip the bird off the nest.

A2.4 Nervous birds

If a bird looks nervous (e.g. claps its bill vigorously, stands up or starts to move off the nest):

- Stop where you are to let it settle down.
- Back off, if necessary.
- Avoid direct eye contact.
- Sit for a while. A bird will normally calm down from its initial fright and will then tolerate you approaching.
- Stoop down or crawl slowly to the bird.
- Once at the nest you may find that little trial movements with your hands towards the leg will eventually be tolerated as the bird gradually calms down further.
- Calling for help is also a good idea—your neighbour can move into position nearby or assist at the nest. Whether this approach works depends on the bird—for some it will be worse having another person come near while for others it will help deter them from leaving the nest. As always, approach cautiously.
- Rarely, a bird may run away from the nest when it sees you approaching or once you are at the nest. If this happens:
- Quickly assess the situation, e.g. how close are other nests?
- If no other nests are likely to be disturbed by your action, run around and cut the bird off.

- Slowly walk towards the bird with arms outstretched and it should turn around and return to its nest. Only herd the bird until it has got the right idea, then back off.
- You will have to leave that nest and move on, but take note of whether the bird was banded or not.

If the nest is at a windy site, a disturbed bird may fly away—it should return once you have left, but be aware of the possibility you may disturb it again returning on the next sweep—you don't want it to fly away twice.

If skuas are in the vicinity or following you around, and a bird leaves the nest, cover the egg with some leaf litter, or swap it with a dummy egg. Skuas are very quick to notice the white egg, even from a great distance, but it is also a good cue for an albatross to see its egg in the nest, so use your judgment for each case. Throwing the dummy egg on the ground away from the real nest can be a good way of diverting the skua's attention. If you use a dummy egg on the nest of an albatross that was frightened off, you may have to wait out of view for 10–20 minutes after the bird has returned to the nest before returning (carefully) to swap the eggs.

As you can imagine, preventing these situations by being cautious in the first place is the best policy.

A2.5 Aggressive birds

Some nervous birds (both males and females) react aggressively and bite. Usually your hand is the obvious target, but arms, shoulders and face can also be bitten. A number of actions may help avoid birds acting aggressively or prevent injuries:

- Wear leather arm protectors which extend along the forearm to the back of the hand. These protect you from most bites while keeping your hands and fingers free so you can check the birds' legs and work with bands.
- Distract the bird by holding your notebook near its bill while you feel for a band with your other hand.
- If you need to remove a band from an aggressive bird, wear a peaked cap and raise your jacket hood to protect your head and face from being pecked.
- Swap the egg for a dummy egg.
- As a last resort, lean your backpack against the nest in line with the shoulder of the bird to shield you from the bill while you work on the band—use your knee to hold the pack in position. Usually the bird will grab the pack with its beak and worry at it (rather than your arm). Use this method only if there is no one near enough to help you. Be careful not to put pressure on the bird, as it may damage the egg.

Best of all:

- Get someone to help. All the above single-person methods can increase the risk of problems such as a bird accidentally knocking or standing on its egg (including after the observer leaves the nest) or getting out of control while the observer is part way through removing a band. Hence a precautionary approach is best—let the bird settle, call over your neighbour so they can shield you from the bill while you work on the band (by using a bum-bag, for example).

A2.6 Change-overs at the nest

Take extra care if two birds are changing over at a nest. If the sitting bird is disturbed (and exposes the egg) the partner may try and force itself onto the nest, and a clumsier than usual change-over may result in the egg being broken. Take note of both birds' level of stress, and if they seem calm, check the sitting bird's legs for bands. Otherwise, you should leave them alone and wait until your second visit to the area (N.B. you may be able to re-visit the nest on the way back on the next sweep, as pair change-overs usually don't take very long). If the standing bird has a poorly applied band, only catch it if you know it has been relieved at the nest by its partner.

A2.7 Departing the nest

How you depart from a nest is important too:

- Stand up slowly and move away while keeping an eye on the bird's reaction. Nervous birds will occasionally hop off the nest after you have left, even if you have been careful—this won't be helped if you suddenly stand up and swing your pack or a set of poles over them!
- Keep an eye on the bird's reaction as you leave. You may have to run and cut the bird off to turn it round. Plus, it is an important part of evaluating your own methods at the nest.

A2.8 Replacing the egg with a dummy egg

If you have any doubts about working with a bird and for the safety of its egg, swap the egg with a dummy egg. As you remove the egg, keep it protected from pecking with your hand or notebook and store it safely to one side of the nest, e.g. in a thermal hat under some vegetation. As you get more experience you will find that you can work at the nest without risk to the egg, but the dummy egg should be used for nervous or aggressive birds and when you are going to handle injured birds. Bear in mind, though, that if you have to leave a nest to let a bird settle down, it may not enjoy you coming back a second time to swap the dummy for the real egg.

- Please record any egg failures that you cause

A2.9 Working at the nest

The aggressiveness of the bird, the steepness of the nest bowl and whether the bird has a band or not this will affect how you can work at the nest:

- Kneel at the nest so that you are at the bird's level.
- Be calm—if you are quiet and use gentle movements the birds will be correspondingly more relaxed.
- If you are unlucky enough to get pecked or bitten, it is best to remain calm and complete the task at hand. If you jerk or react it will only make the bird's stress levels worse.
- Protect your face—see the notes above about handling aggressive birds.
- Most birds will tolerate you gently working on their leg at the side of the nest. Try to touch the leg only briefly, as birds will not tolerate having their leg held. Once you have located the band you can then rotate and manipulate the band without touching the bird.
- Before you remove a band, record the details in your notebook (band number, state of the band etc.). If you can't rotate the band, estimate the gap by feel (see recording details).

A2.10 Removing bands

- For uninjured birds, hold the band with the fingers of one hand, slip the prongs of circlip pliers into the band circle, squeeze the pliers while keeping the prongs firmly in the band circle, then remove the band. Check that you have recorded the band number correctly and place the band in a plastic bag or a zipped pocket for the day's bands—don't keep them loose with other gear as they might get flicked out of your bumbag or backpack. Numbers on the bands are checked later against data transcribed from your field notebooks.

A few tips:

- Take the time required at each nest—don't compromise the safety of the bird/egg/chick for speed of travel.
- If in doubt, use a dummy egg.
- Keep a close eye out for skuas that could prey on eggs.
- Be aware of your level of tiredness and that of other team members to prevent mistakes being made.
- Be patient if someone is taking time to deal with a nervous bird; offer help if it is needed.
- Communicate between team members. Feel free to discuss any problems that you may have had with a bird with other team members, so the team can evaluate what went wrong and people can adjust their approach, if necessary.
- Evaluate your own performance each day. It is easy to get over confident after visiting a few hundred nests without any problems, but then you may have a close call (e.g. a bird standing on its egg, or stepping off the nest) or you may find an area that has a high proportion of very nervous birds. This is a reminder to slow down—the careful and cautious approach is the best way to go.

A2.11 Catching an injured bird

If you see a bird walking with a pronounced lurching gait caused by it standing on the toes of one of its legs, it has most likely been injured by its band. The band injury affects tendons in the leg and prevents the foot from being placed flat on the ground.

If you catch an injured bird or find one on a nest, call your team-mate over to help. Swap the egg for a dummy egg and let the bird settle. Grab the bird's bill before you secure the bird. To do this it is best to stand in front of the bird and quickly bring your hand down on the top of the bill and grasp both mandibles together (using a leather glove is a good idea, because if you get the timing wrong, the cutting edge of the bill is quite sharp). As you grab the bill, quickly crouch down and pin the bird's wings against the its side and your own body by reaching over the bird with your other hand. As you do this, reach under the bird for its legs. The bird will be quite secure now tucked under your arm and held securely by the beak with one hand and the feet with the other. Make sure the leg with the injury is on the outer side of the person holding the bird so that the person removing the band has easy access to it.

A2.12 Removing band from an injured bird

When birds have been injured by their band, it is usually projecting out from a gall, leaving sufficient space for the the prongs of the circlip pliers to be inserted. While the person holding the bird keeps a good hold of the leg, the other person should hold the band with the fingers of one hand, slip the prongs of circlip pliers into the band circle, squeeze the pliers to open the prongs. Take care to keep the prongs firmly in the band circle as you remove the band in one clean action. Most extractions should be straightforward.

If the band is more deeply buried at one end than the other, one prong of the pliers may slip out of the band opening as you attempt to extract the band. This will hurt and surprise the bird. To avoid this, hold the band firmly against one of the circlip prongs with your thumb and fingers. Lever the other end of the band out by opening the plier prongs while progressively rotating the band out of the wound. Alternatively, use slip-joint pliers to steady the band while opening the band circle with the circlips.

Occasionally you may find a band deeply buried and obscured by the gall. You may be able to gradually extract the band by inserting the circlip prongs under the visible part of the band and opening it carefully in stages within the gall. Once the band is partially open and projecting somewhat out of the gall, rotate the band round into a better position for final extraction. This action will probably cause extra pain for the bird and bleeding, so if you are not confident you can finish an extraction once you have started, it is best not to start in the first place. In general, though, it is better to have the band out and cause some short-term suffering than to leave the bird to suffer in the long term.

A2.13 Marking birds and nests

As you check birds for bands, mark the breast of each bird with a spray of stock marker—high enough up the breast that when the bird settles back down on the nest the mark is clearly visible from a distance.

- Aim the spray can nozzle fairly close to the breast and make a thick line, so that you will be able to see the mark at an angle from either side of the bird (this is important for when you do a transect check later).
- Be careful with nervous birds, as they may react to the spraying sound.
- Mark the breast more heavily on birds in areas that will be visited three times, as by the third visit the mark is very washed out.
- Note that tourists and fishing observers see our marked birds, so please do not mark the birds with big crosses or anything that looks more like graffiti than a formal mark.

Also mark the side of the nest with a line of stock marker. This is important for when you do an accuracy check and find a non-marked bird and need to know whether it is a partner that has swapped nest duty with a marked bird or a missed nest. It also helps on subsequent visits to the area as, if you come across what you think might be a nest you missed first time round, or a failed nest, you can double check the nest for its mark.

Similarly, mark any failed nests you happen to find with a spot or cross of stock marker, so that you don't assume it is a newly discovered nest on subsequent visits.