Campbell Island/Motu Ihupuku Seabird Research

Operation Endurance March 2020

Claudia Mischler

cmischler@doc.govt.nz
Department of Conservation, 15 Wairepo Road, Twizel 7901

Department of Conservation
Te Papa Atawhai

30 April 2020

Table of Contents

Summary

The March 2020 Operation Endurance trip to Campbell Island included some follow-up work from the November 2019 trip in addition to work focusing on southern royal albatross (*Diomedea epomophora*). The main aims were retrieving GLS devices, resighting bands and PIT tags, and conducting nest counts of southern royal albatross in the Col study area (and Honey index area, if time permitted). Nest counts would be used to gain insight into population trends and provide a ground count to compare to aerial photographs and satellite imagery. Aerial photographs of the Campbell (*Thalassarche impavida*) and grey-headed albatross (*T. chrysostoma*) colonies at Bull Rock and adjacent north-eastern colonies were repeated from November to determine breeding success. Sound recorders were deployed on Beeman Hill to assess abundance and distribution of petrels.

One GLS device was retrieved, 13 banded and two PIT tagged birds were resighted within the Col study area. More banded females than males were resighted. Historical data were used to examine the age range of resighted birds as well as natal philopatry and nest fidelity. Age ranges were comparable to those found during surveys between 2004-08, with known age birds ranging between 24-29 and birds banded as adults approximately 20 years ago. Natal philopatry was high with all birds having been banded within the Col study area, and nest fidelity was also high with very little movement between years. The vast available historical data allow insightful analyses even with small numbers of resighted marked birds.

A total of 104 active nests were counted within the Col study area, which was surprisingly low. The Honey index area was not surveyed due to insufficient time. When the Col nest count was adjusted using hatching success to allow comparisons to previous counts, the estimated 137 nests remained the lowest count since 1987/88. The closely related Antipodean (*Diomedea antipodensis*) and Gibson's albatrosses (*D. gibsoni*) suffered severe population declines between 2005-16, and are now at less than half of their peak populations seen in 2004; consequently, any decline in the royal population is of concern. Risk to southern royal albatross from commercial fisheries (trawl, long-line, set-net) within New Zealand has been deemed low, but is high in international waters. An up-to-date count is needed to further assess the status of the southern royal albatross population.

Aerial photographs of the southern royal albatross study and index areas could not be carried out due to the short trip duration, poor weather conditions, and mechanical difficulties with the helicopter. Using satellite imagery for nest counts is currently in progress. Aerial photographs of Campbell and grey-headed albatross were taken successfully, and breeding success calculations will be presented in a separate report.

Sound recorders on Beeman Hill were deployed for five nights, but only recorded very brief common diving petrel (*Pelecanoides urinatrix*) calls. This could be due to moon phase or the late stage of the breeding cycle when birds are generally silent.

Introduction

Campbell Island/Motu Ihupuku lies in the South Pacific Ocean approximately 700 km south of New Zealand, and is the most southern of the NZ sub-Antarctic groups (Moore & Moffat 1990). It covers over 11,000 ha, and its highest point is Mt Honey at an elevation of 569 m (Moore & Moffat 1990). Since its discovery in 1810, the island has a long history of sealing, whaling, and farming before being made a Nature Reserve in 1954 and a Marine Reserve in 2014 (Moore et al. 2012). The island was farmed from 1895 to 1931 (Moore & Moffat 1990), and the effects of sheep (*Ovis aries*) on vegetation were studied throughout the 1970s and 1980s before completely removing them from the island by 1992 (Moore et al. 2012). Cattle (*Bos taurus*) were eradicated in 1984, Norway rats (*Rattus norvegicus*) by 2001, and feral cats (*Felis catus*) disappeared in the mid-1980s (Moore et al. 2012). The island was permanently inhabited by humans during the 1940s as a look-out during World War II, followed by year-round meteorological observations until 1995 (Moore & Moffat 1990).

Southern royal albatross (*Diomedea epomophora*) are endemic to New Zealand, naturally uncommon, slow to mature (6-12 years), breed biennially, and are long-lived (Moore 2013). Campbell Island is home to over 99% of the southern royal breeding population, with the most recent census (2004-08) estimating 8,300 to 8,700 breeding pairs (Moore et al. 2012). The introduction of mammals, such as cats and rats, the degradation of the island from farming, such as burning of vegetation, grazing, and depletion of nesting habitat, and direct depredation of birds by humans greatly reduced royal albatross numbers (Moore et al. 2012). Between 1957 and 1995, eleven censuses were conducted primarily counting from vantage points (Moore et al. 2012). In the 1990s, survey methods moved away from vantage points towards sweeps to avoid missing nests in rough terrain or thick vegetation (Moore et al. 2012). Between the 1940s and 1990s, breeding, banding, and population studies were set up at Col and Moubray study areas, with regular and thorough studies from 1987 to 1998 providing a clear baseline of data (Moore et al. 2012). Three additional blocks (Faye, Paris, and Honey) were set up in the late 1990s as index count sites to supplement study area counts (Moore et al. 2012).

Over 35,000 royal albatrosses were banded on Campbell Island mostly by meteorological staff between 1941 and 1998, peaking in the 1960s and 1970s (Moore et al. 2012). Banding became restricted to the Col and Moubray study areas after 1987 (Moore et al. 2012). Large numbers of injuries were caused by incorrect banding and a tendency for the large R-band to partially spring open and embed in the birds' legs. Since there were relatively few overseas band returns, and small numbers of sightings of banded birds outside of the Col and Moubray study areas provided little statistical value, it was decided to remove bands from as many birds as possible (Moore et al. 2012). The de-banding project was however primarily due to animal welfare (Moore et al. 2012). Birds in the study areas had their bands replaced with more reliable bands (made with a thicker grade of stainless steel) or with transponders (*Trovan ID100*, passive integrated transponders (PIT)) (Moore et al. 2012). This work was completed between 2004 and 2008, and a total of 2,882 banded birds were found (Moore et al. 2012). By the end of the 2008 season, approximately 674 birds retained an appropriate band (Moore et al. 2012). A total of 405 birds had a PIT inserted, of which 314 (43 females, 271 males) had a confirmed reading on a subsequent visit (Moore et al. 2012).

In November 2019, an Operation Endurance trip to Campbell Island included seabird population monitoring (Rexer-Huber et al. 2020), and two of the November trip objectives preceded follow-up work during the March trip. These included aerial photographs of Campbell (*Thalassarche impavida*) and grey-headed (*T. chrysostoma*) albatross colonies at Bull Rock and adjacent north-eastern colonies, and use of sound recorders to identify the distribution of petrels. As summarised in Rexer-Huber (2020) and Frost (2020), the Campbell albatross population appears to fluctuate whereas grey-headed albatross showed a decline followed by a small increase. When looking at both species combined, there was an apparent decrease in the 1980s. Waugh et al. (1999) summarises breeding success over eight years (1984 to 1996, with nests checked monthly) for Campbell albatross to be 66% ± 12 (monitoring of 41-100 nests per year), and grey-headed albatross to be 40% ± 20 (monitoring of 40-94 nests per year). Since aerial photographs of mixed colonies were taken in November, it provided a unique opportunity to calculate an up-to-date breeding success by taking aerial photographs of the colonies in March when large chicks would be present on nests.

As outlined by Rexer-Huber et al. (2020), petrels on Campbell Island remain unstudied with little known about change in abundance and distribution since the eradication of rats in 2001. Sound recorders deployed at several locations in November 2019 provided invaluable information on petrel distribution and abundance (Rexer-Huber et al. 2020). Common diving petrels (*Pelecanoides urinatrix*) were recorded at Clifton Memorial near Beeman Base, and it was therefore suggested that an additional recorder be deployed on Beeman Hill. Beeman Hill reaches 187 meters above sea level, and provides a prime location overlooking Col-Lyall valley in the north, Lookout Bay on the east, Beeman Point on the south, and Tucker Cove and Stream on the west (Fig. 1).

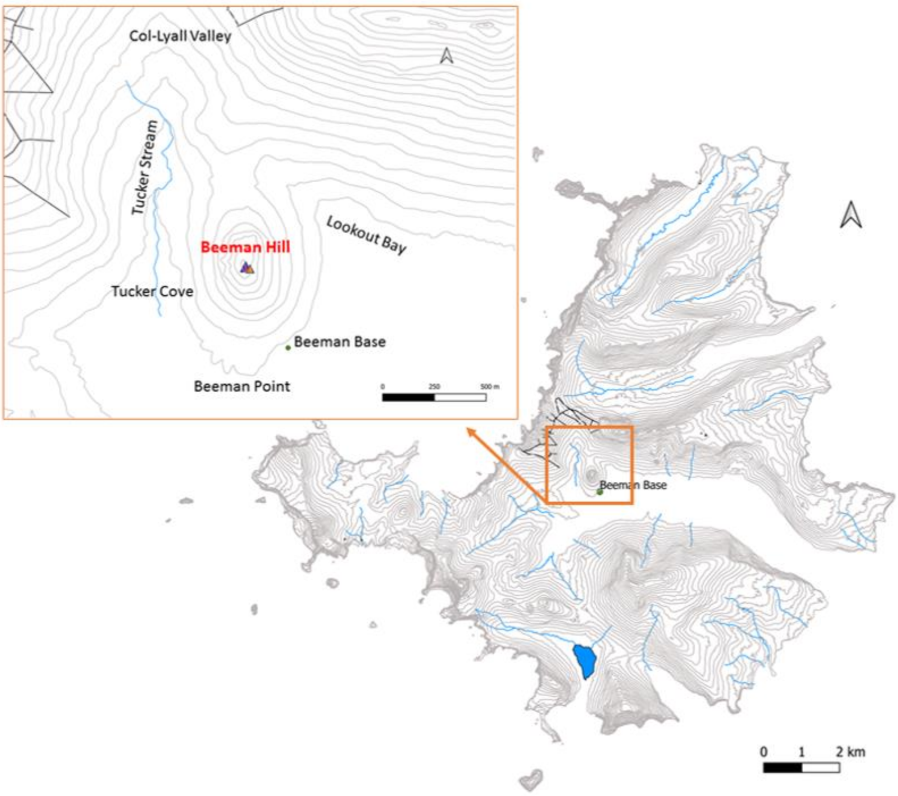

Fig. 1. Map of Campbell Island showing Beeman Base with the enlarged inset highlighting the location of sound recorders (indicated by two triangles) deployed on Beeman Hill to assess abundance and distribution of petrels.

The main objectives were:

1. To describe the at-sea distribution of southern royal albatross, through recovery of tracking devices (GLS) previously deployed (in Col study area),
2. To assess population trend of southern royal albatross through updated study and index area counts and observations, including resighting marked birds (bands and PIT tags) in the Col study area (and Honey index area, if time permits),
3. To assess the potential use of satellite images for monitoring southern royal albatross, through ground-truthing of study and index areas,
4. To assess the potential of helicopter surveys for monitoring southern royal albatross, through ground-truthing of study and index areas,
5. To assess breeding success of Campbell and grey-headed albatross through aerial photography of colonies at Bull Rock and adjacent north-eastern cliffs and comparing them to photo-point and aerial nest counts from November 2019,
6. To assess abundance and distribution of burrowing petrels by deploying sound recorders on Beeman Hill, based on suggestions from work done in November 2019.

Methods

Trip duration and timing

The March 2020 Operation Endurance trip was of short duration, departing from Bluff on Monday 9 March and returning to Lyttleton on Friday 20 March. A team was dropped off at the Auckland Islands combined with a day of work on Enderby, before arriving and being offloaded at Campbell around midday on Wednesday 11 March. The timing for the remainder of the trip on Campbell was as follows:

- 11 March: Offload and quarantine gear, set up base, deploy sound recorders on Beeman Hill
- 12 March: Nest counts, band and PIT tag resights, GLS removal of southern royal albatross at Col study area
- 13 March: Nest counts, band and PIT tag resights, GLS removal of southern royal albatross at Col study area
- 14 March: heavy rain, thick fog, strong winds – no field work possible
- 15 March: Nest counts, band and PIT tag resights, GLS removal of southern royal albatross at Col study area until 1300 hours, then heavy rain, thick fog, strong winds – no field work possible
- 16 March: Nest counts, band and PIT tag resights, GLS removal of southern royal albatross at Col study area permitted until 1400 hours, then required to go back to ship (only essential personnel allowed to stay onshore). Sound recorders removed from Beeman Hill in the morning
- 17 March: Campbell and grey-headed albatross aerial photos of colonies taken at Bull Rock and adjacent cliffs by NZDF staff.

Ship departed mid-afternoon on Tuesday 17 March for pick-up of Auckland Islands team en route to Lyttleton.

Southern royal albatross (Objectives 1 to 4)

Objectives 1 and 2, which involved removing tracking devices as well as counting nests and reading bands and PIT tags in the Col study area (Fig. 1), were done simultaneously. Methods closely followed those used in the 2004-08 population survey outlined by Moore et al. (2012). To maintain consistency, site marker and sector boundary coordinates for the Col study area and the Honey index area were obtained from Moore et al. (2012) and loaded onto two GPS units (Garmin 64st and Garmin Rino650). Maps and sector boundary descriptions available from the appendix in Moore et al. (2012) were printed and carried in the field for additional clarity.

Nest surveying was done by two people walking in parallel sweeps 10 m to 50 m apart while searching for nests within the Col study area using boundaries shown on GPS and map. The GPS tracking feature was used to maintain relatively straight sweeps and to keep a record of tracks walked (Appendix Fig. A1). Vegetation type and vantage points were used to adjust the distance of sweeps between observers. Active nests with a bird and an egg or chick were marked on the GPS. Nest contents were checked, sex of the bird was determined (using size and plumage colour), and both legs were examined for bands and tracking devices (GLS). Bands were checked for gaps. If no band was present, the back of the neck and the area towards the mantle were thoroughly scanned with a Trovan ISO Multireader for PIT tags. Birds were not removed from the nest or handled as checks for bands and PIT tags could be done without holding the bird. Nervous birds were checked as quickly as possible. Only one visit per nest was possible due to the short duration of the trip. Nests with chicks alone were marked on the GPS from 5 m away to avoid causing stress and vomiting. All loafing birds were approached and checked for bands and GLSs from a distance but not scanned for PIT tags to avoid unnecessary capture and handling.

All mapping was done on qGIS. Previous surveys have conducted nest counts during the incubation period (December to early February) whereas the current survey was done around the chick guard period. To correct for this difference in timing, hatching success data from previous Col study area studies were compiled and applied to the 2019/20 nest count. Banded and PIT tagged bird and partner histories as well as nest locations and counts from 1995-98 and 2004-08 were collated from P. Moore (pers. comm. and unpublished data, Moore et al. 2012). Nest counts from prior to 1995 and hatching success data were collated from several reports (unpublished Met Service reports, Moore & Moffat 1990, Moore et al. 1997, Waugh et al. 1997, Moore et al. 2012).

Objective 3, which involved assessing the potential use of satellite images for monitoring southern royal albatross through ground-truthing, is both still ongoing and partly linked to objective 2. Nest counts from Col study area (objective 2) provided the ground-truthing. Using satellite imagery for monitoring is in progress with Dr Peter McComb from Ocean Numerical. This requires obtaining a satellite image of the Col study area from approximately the same time period that the ground count was done, followed by counting albatross from the satellite image and comparing this to the ground count. Since this objective is still ongoing, no results or further discussions are provided here.

Objective 4, which involved assessing aerial methods for monitoring southern royal albatross through helicopter survey and ground-truth count, was not possible due to the lack of available helicopter support. The Seasprite helicopter was needed to carry out other Operation Endurance work, primarily collecting gear from outlying huts. The short duration of the trip combined with challenging weather conditions and helicopter mechanical issues greatly reduced available flying time; therefore, priority for helicopter use was given to collecting gear from huts. This resulted in insufficient time to take aerial photographs of any southern royal albatross study and index areas.

Campbell and grey-headed albatross aerial photographs (Objective 5)

Aerial photographs taken from the Seasprite helicopter of the mixed Campbell and grey-headed albatross colonies at Bull Rock and along the adjacent north-eastern coast of Campbell Island (Fig. 2) needed to be comparable to those photos taken on 18 November 2019 in order to estimate number of chicks and hence breeding success (Rexer-Huber et al. 2020, Frost 2020). A total of 14 images from the November trip clearly showing the albatross colony locations (provided by P. Frost) were printed and taken onboard the ship along with a backup digital copy on a USB flash drive. These images consisted of both overview maps showing the colony locations relative to the entire island as well as close-up photographs of cliffs identifying sub-colony locations and highlighting nests with dots (Appendix Fig. A2). GPS coordinates of locations were also shown on the images to provide additional clarity.

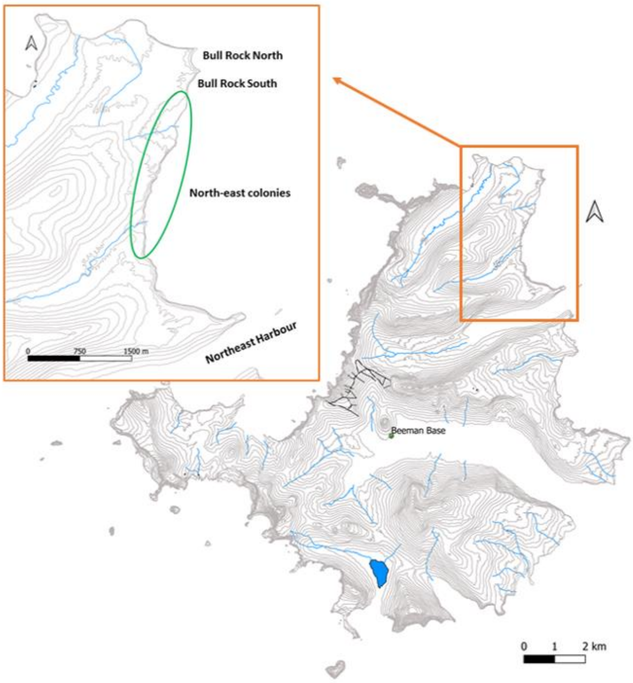

Fig. 2. Map of Campbell Island showing overall location of Campbell and grey-headed albatross colonies which were photographed during aerial survey, with enlarged inset highlighting detailed locations and colony names.

Once onboard the ship, contact was made with the appropriate staff member. Zach Taylor was part of the Seasprite flight crew, and he became the primary person for all communication concerning the aerial photographs. He was provided with the printed images and key messages regarding zoom, distance from colonies, and camera speed. Zach communicated the requests up the chain of command, and displayed the images to the rest of the flight crew by hanging them on the hanger wall.

The task of taking the photographs was then assigned to Dillon Anderson, an Army photographer. Prior to the flight, he was briefed again with the key messages regarding zoom, distance from colonies, and camera speed. Images were taken on 17 March 2020 using a Nikon D5, 24 mm focal length, f8, exposure time of 1/400 sec, and ISO-800. To avoid missing colonies, Dillon took continuous photographs of the cliffs from the north side of Northeast Harbour to Bull Rock thereby capturing all sub-colonies and any landmarks for identifying colony boundaries. The images were of incredibly great quality. Once flights were complete, all images were downloaded onto a USB flash-drive.

Images were sub-divided using outlines and boundaries from Moore & Blezard (1999). Chicks were counted using DotDotGoose (Ersts 2020). All images were also passed on to Peter Frost for counting, summarizing, and calculating breeding success using data from the November photos. A detailed summary report using counts from both observers (C. Mischler and P. Frost) will be collated separately from this report; therefore, no results or further discussions are provided here.

Petrel abundance and distribution – sound recorders on Beeman Hill (Objective 6)

Diving petrels had been recorded in November at Clifton Memorial near Beeman Base, and it was therefore suggested that an additional recorder be deployed on Beeman Hill. Two AR4 DOC Electronics sound recorders were deployed – one on the east side facing Beeman Base and Lookout Bay, and one on the west side facing Tucker Stream and Col-Lyall valley (Fig. 1). They were deployed upon arrival on the island on 11 March until departure on 16 March, recording five nights from 2200 to 0400. Due to vast amounts of weather noise, methods used by Rexer-Huber et al. (2020) were followed where every third 15-minute sound file was listened to. The night of 14 March was an exception as there was no weather noise, and all sound files from both recorders were listened to.

Results

Southern royal albatross (Objectives 1 and 2)

All breeding birds on nests and loafing birds were checked for GLS devices. Only one device was found and retrieved from a female with band number R-62545 sitting on a nest (NZTM E1338519, N4172786) with a chick on 15 March. The battery within the Biotrack device appears to have been wet. The device was sent to Graeme Taylor (Wellington) for data retrieval and analyses hence no further discussions are provided here.

All nests within the Col study area were counted, but there was insufficient time to conduct counts in the Honey index area. A total of 104 active nests were found within the Col study area, four with an egg and 100 with chicks. Since nest counts for previous surveys have been conducted during the incubation period (December to early February) whereas the current survey was done during the chick guard period, the 2019/20 count was corrected for the difference in timing. Hatching success data from previous studies in the Col study area were compiled (Table 1). The range in hatching success varied between a minimum of 64.8% and a maximum of 83.3%, with a mean of 76.4%. Nest visits in the 1964/65 to 1969/70 seasons were more frequent than in the 2004/05 to 2007/08 seasons, and hatching success was also higher. Overall, the estimated corrected range for the 2019/20 count was a minimum of 125 nests and a maximum of 161 nests, with a mean of 137 (Table 2, Fig. 3).

When using 125 nests, the minimum nest number of the estimated range, it is the lowest recorded and matches the count in 1968/69 (Table 2). It is by far the lowest since 2008/09 where the previous minimum was 128 nests in 1987/88. When using 161 nests, the maximum nest number of the estimated range, it is the fifth lowest overall. When comparing means, the estimated 137 nests is by far the lowest, particularly when comparing it to the mean of 196.8 nests from the most recent surveys conducted between 2004-08 (Table 2). When using the estimated mean of 137 nests and comparing it individually to the previously surveyed years, it is the third lowest (Fig. 3).

Table 1. Hatching success of southern royal albatross in the Col study area on Campbell Island, shown by season surveyed, number of visits to each nest, and timing of counts. Mean ± standard deviation was calculated from blocks of surveys (indicated by horizontal lines) done over consecutive seasons (apart from 1967/68 to 1969/70 as same methods were used and time gap between surveys was minimal). Data were collated from several reports (unpublished Met Service reports, Moore & Moffat 1990, Moore et al. 1997, Waugh et al. 1997, Moore et al. 2012).

Season	Hatch Success	Visits	Timing of counts	Mean ± S.D.
1964/65	78.4%	>11 visits per nest		
1965/66	82.7-84.7%		August 1964 to October 1967	
1966/67	71.0%	30 visits per nest		77.3 ± 4.6*
1967/68	74.4%			
1969/70	79.8%	49 visits per nest	November 1969 to June 1970	
1987/88	76.6%	-	January and March	
1991/92	77.8-85.4%	-	January and March**	
1992/93	77.5-88.2%	-	January and March**	
1993/94	80.9-87.3%	-	January and March**	80.0 ± 2.4*
1994/95	79.4-89.2%	-	January and March**	
1996/97	83.3-88.5%	-	January and September^	
2004/05	73.1%	-	January and September ^	
2005/06	74.5%	-	January and September ^	70.9 ± 4.3
2006/07	71.1%	-	January and September ^	
2007/08	64.8%	-	January and September ^	
Overall	**Range 64.8% – 83.3%***			**Mean 76.4 ± 5.0***

*calculated using the lowest value of each hatch success range
**some eggs still present in early March hence there is a range for hatch success
^hatch estimated by sign at nest the following year

Table 2. Number of southern royal albatross nests within the Col study area on Campbell Island, shown by month and season surveyed. Mean ± standard deviation was calculated from blocks of surveys (indicated by grey horizontal lines) done over consecutive seasons. Nest count data from 1995-98 and 2004-08 were collated from P. Moore (pers. comm. and unpublished data, Moore et al. 2012). Nest count data from prior to 1995 were collated from Moore & Moffat 1990, Moore et al. 1997, Moore et al. 2012).

Season	Month	Nests	Mean ± S.D.
1968/69	January	125	
1975/76	December	205	
1976/77	January	161	169.0 ± 32.7
1977/78	December to February	141	
1987/88	January	128	
1991/92	January	158	
1992/93	January	187	
1993/94	January	170	
1994/95	December to January	189	187.0 ± 15.8
1995/96	January	201	
1996/97	December to January	188	
1997/98	December to January*	200	
1998/99	December to January*	203	
2004/05	January to February	207	
2005/06	January to February	185	
2006/07	December to February	182	196.8 ± 13.8
2007/08	January to February	196	
2008/09	December to February	214	
2019/20	March (actual)	104	
2019/20	January (estimated)^	125-161	137

*timing of count could not be confirmed as data were difficult to obtain
^ estimated from Table 1

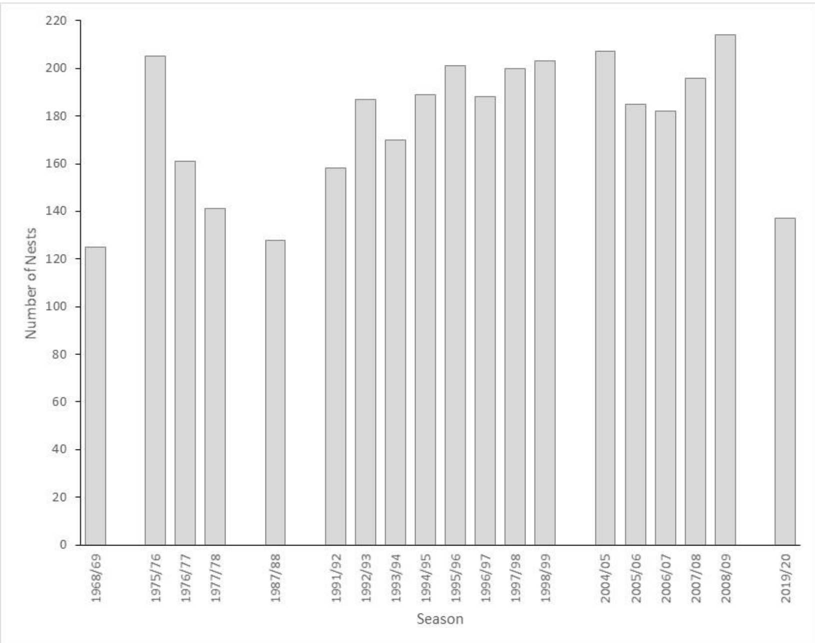

Fig. 3. Number of southern royal albatross nests within the Col study area on Campbell Island, shown by season surveyed. Nest number for 2019/20 is the mean number of nests as adjusted using hatching success data (Table 1). Nest count data from 1995-98 and 2004-08 were collated from P. Moore (pers. comm. and unpublished data, Moore et al. 2012). Nest count data from prior to 1995 were collated from Moore & Moffat 1990, Moore et al. 1997, Moore et al. 2012).

Nest locations from 2004-2008 and 2019/20 are shown in Fig 4. Only the 104 actual nests that were found are shown for 2019/20 (Fig. 4g), not the corrected estimates discussed above. The 2005/06 and 2006/07 seasons had the lowest nest count within the 2004-2008 period, with 185 and 182 nests, respectively (Table 2). When nest locations of these two low seasons (Fig. 4c, d) are compared with the higher 2004/05 and 2008/09 seasons (Fig. 4b, f), there appears to be a decrease in nest density in the southern and northern parts of the Col study area. When examining the 2019/20 nest locations, there is a large decrease in nest density along the southern side of the Col study area as well as along the western side of Col ridge (Fig. 4g).

Thirteen breeders were banded, two males and eleven females (Table 3). One of the females (R-48613) was on a nest outside of the Col study area boundary. None of the loafing birds seen were banded. All birds on nests without a band were checked for a PIT tag, and two males were identified (Table 3). No loafing birds were scanned.

The banding history, including sex, age and season at banding, of each banded and PIT tagged bird seen is outlined in Table 3 (more detailed data in Appendix Table A1). Four of the eleven females were banded as chicks, and three of the four males. The oldest female banded as a chick was 29 years old (R-62868), and the youngest were two birds banded in 1995 (R-62545 and R-48613). The oldest male banded as a chick was 25 years old (668 EC8B), and the youngest were two birds banded in 1995 (668 9B18 and RA-2458). The oldest two females were banded as breeding adults in 1996 (R-62305 and R-62130), and the oldest male in 1997 (RA-2562). Records show that all birds banded as chicks were banded within the Col study area; however, no exact locations were obtainable.

Breeding history, including season and known partner, of each banded and PIT tagged bird seen is outlined in Table 3 (more detailed data in Appendix Table A1). One female (R-48613) which was banded as a chick in 1995 had not been seen since banding. One male (RA-2458), also banded as a chick in 1995, was rebanded as a non-breeding adult in January 2006. One female (R-62868) had only one breeding season on record, and three females (R-62181, R-62363, R-62545) only had two breeding seasons on record. Two females (R-62305 and R-62130) had the maximum number of breeding seasons on record with five each. Three out of four males had three seasons each. All birds except for one female (R-62305) and one male (RA-2562) retained the same partner throughout their breeding history. One female (R-62181) bred in a previous season but her partner was not seen, and three females (R-62350, R-62106, R-62233) that had bred previously had unbanded partners in 2019/20 (Appendix Table A1).

The changes in individual nest locations from 2004-08 and 2019/20 of banded and PIT tagged birds seen are shown in Fig. 6. Nest locations from the 1996-1998 seasons could not be obtained and are therefore not shown. Of the ten females for which breeding data were available, only two (R-62181 and R-62350) moved substantially from the nest location in 2004-08 and 2019/20 (Fig. 6b). However, both remained within the Col study area. Of the three males for which breeding data were available, none made any substantial nest location movements (Fig. 6d).

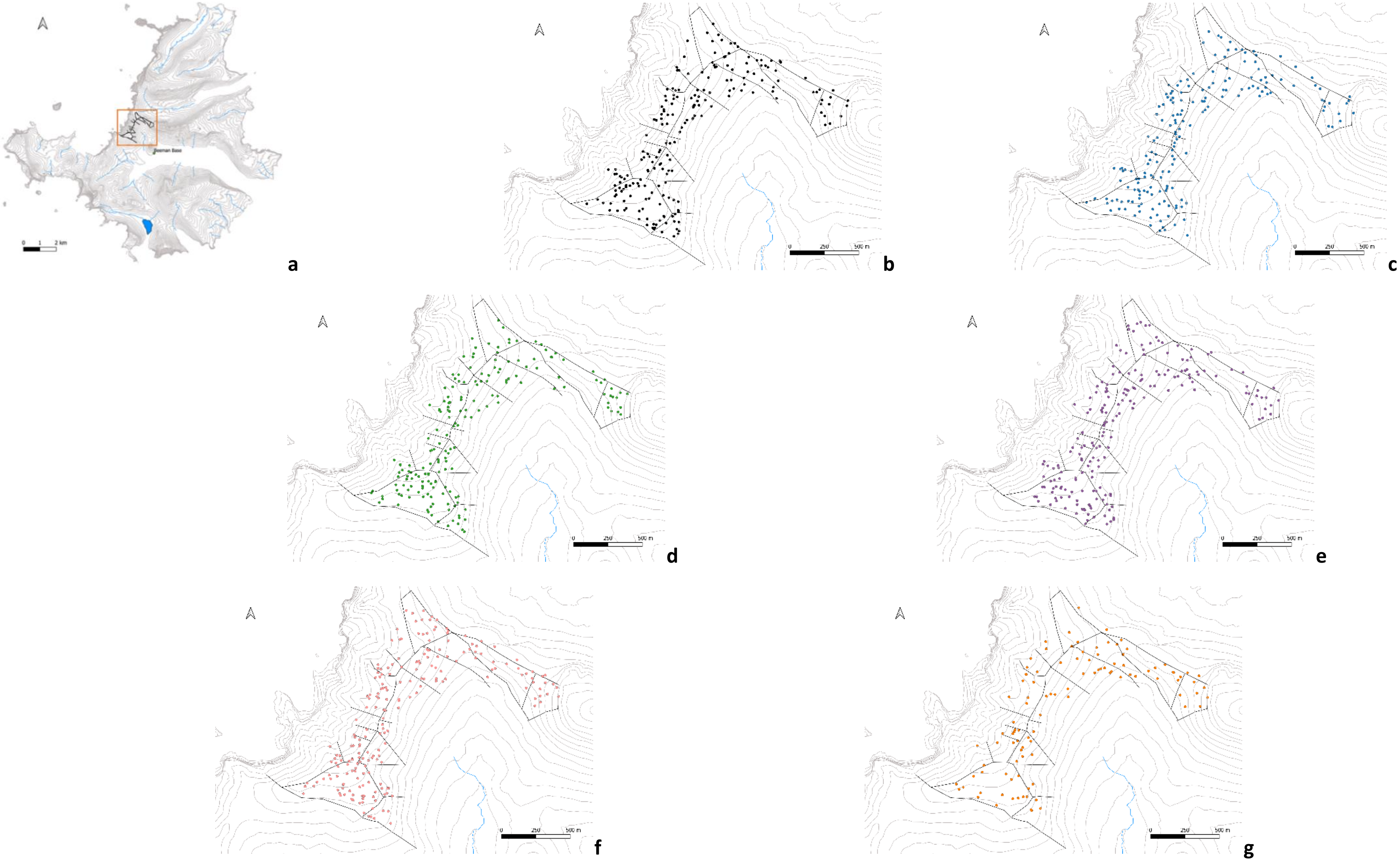

Fig. 4. Map of Campbell Island highlighting the location of the southern royal albatross Col study area (a) within the orange square. Maps b-g show southern royal albatross nest locations within the Col study area (shown as an enlarged version of the orange square seen in (a)) surveyed in December to February between 2004-08 seasons, where 2004/05 is shown in (b), 2005/06 in (c), 2006/07 in (d), 2007/08 in (e), 2008/09 in (f), and the March survey in 2019/20 shown in (g).

Petrel abundance and distribution – sound recorders on Beeman Hill (Objective 6)

The only petrel calls recorded on Beeman Hill were from diving petrels, one on the Tucker Cove side on the night of 14 March at about 2330 hours, and one on the Lookout Bay side also on the night of 14 March at about 2200 hours. Both calls were very brief, and the one on the Lookout Bay side was very faint.

Other non-petrel calls included NZ sealion (*Phocarctos hookeri*), black-backed gulls (*Larus dominicanus*), red-billed gulls (*L. novaehollandiae*), yellow-eyed penguins (*Megadyptes antipodes*), snipe (*Coenocorypha aucklandica*), ducks (*Anas* sp.), and Antarctic terns (*Sterna vittata*).

Other opportunistic observations

Two sets of plastic were found while searching for southern royal albatross nests within the Col study area (Fig. 5). One set had clearly been regurgitated as there were squid beaks attached to the plastic (Fig. 5a, b), while the other was found amongst very old bones and was therefore likely left over from a bird that had died and decomposed (Fig. 5c). The age of this dead bird could not be identified as the remains were very old. Moore et al. (2012) also mentioned finding small quantities of plastic in regurgitates. Plastics should continue to be opportunistically noted as plastic ingestion presents a problem for albatross species elsewhere around the world (Provencher et al. 2019, Phillips & Waluda 2020).

Fig. 5. Photos of plastic found within the southern royal albatross Col study area on Campbell Island. Photos (a) and (b) were in the same regurgitation. Note the presence of squid beaks in (a). Plastics in (c) were found among old bones of a decomposed bird.

Another opportunistic observation was made by M. Symons who noted that southern royal albatross chick sizes differed between sites on the island. Symons had walked to Northwest Bay via the track from Beeman Base over two consecutive days before assisting with nest counts in the Col study area. He mentioned that most southern royal albatross chicks were larger in size and alone on the nest on route to Northwest Bay whereas only two nests with chicks alone were found in the Col study area over the survey period.

Table 3. Sex, age, and season banded for each banded and PIT tagged southern royal albatross seen in or near the Col study area on Campbell Island. Every recorded breeding season and the identity of the partner of each banded or PIT tagged bird are also shown. All data were collated from P. Moore (pers. comm. and unpublished data). 'F' is female, 'M' is male, 'unb' is unbanded, 'unk' is unknown.

		Banding History		Breeding History	
Band or PIT	Sex	Age	Season	Breeding Season	Partner (ID)^
R-62348	F	Adult	2004/05	2004/05	RA-2223
				2006/07	RA-2223
				2008/09	RA-2223
R-62350	F	Chick	1993/94	2004/05	RA-2205
				2006/07	RA-2205
				2007/08	unb
R-62181	F	Adult	1998/99	1998/99*	RA-0256
				2004/05	unk
R-62305	F	Adult	1996/97	1996/97*	R-43856
				1998/99*	RA-2269
				2004/05	RA-2269
				2006/07	RA-2269
				2007/08	RA-2269
R-62868	F	Chick	1990/91	2007/08	RA-2533
R-62130	F	Adult	1996/97	1996/97*	RA-2410
				1998/99*	RA-2410
				2004/05	RA-2410
				2006/07	RA-2410
				2007/08	RA-2410
R-62363	F	Adult	2005/06	2005/06	R-62570
				2007/08	R-62570
R-62545	F	Chick	1995/96	2006/07	RA-2651
				2008/09	RA-2651
R-62106	F	Adult	2004/05	2004/05	RA-2251
				2006/07	RA-2251
				2008/09	unb
R-62233	F	Adult	2004/05	2004/05	RA-2107
				2006/07	RA-2107
				2008/09	unb
R-48613**	F	Chick	1995/96	-	-
668 EC8B	M	Chick	1994/95	2005/06	R-62412
				2006/07	R-62412
				2008/09	R-62412
RA-2562	M	Adult	1997/98	1997/98*	RA-0255
				1998/99*	RA-0255
				2005/06	R-62574
668 9B18	M	Chick	1995/96	2004/05	R-62137
				2006/07	R-62137
				2008/09	R-62137
RA-2458	M	Chick	1995/96	-	-

^Partners based on historical data as none seen during 2019/20 due to short trip duration
*Nest locations could not be obtained and are therefore not shown in Fig. 6.
**Bird was on a nest outside of Col study area (slightly south of southern fence line boundary)

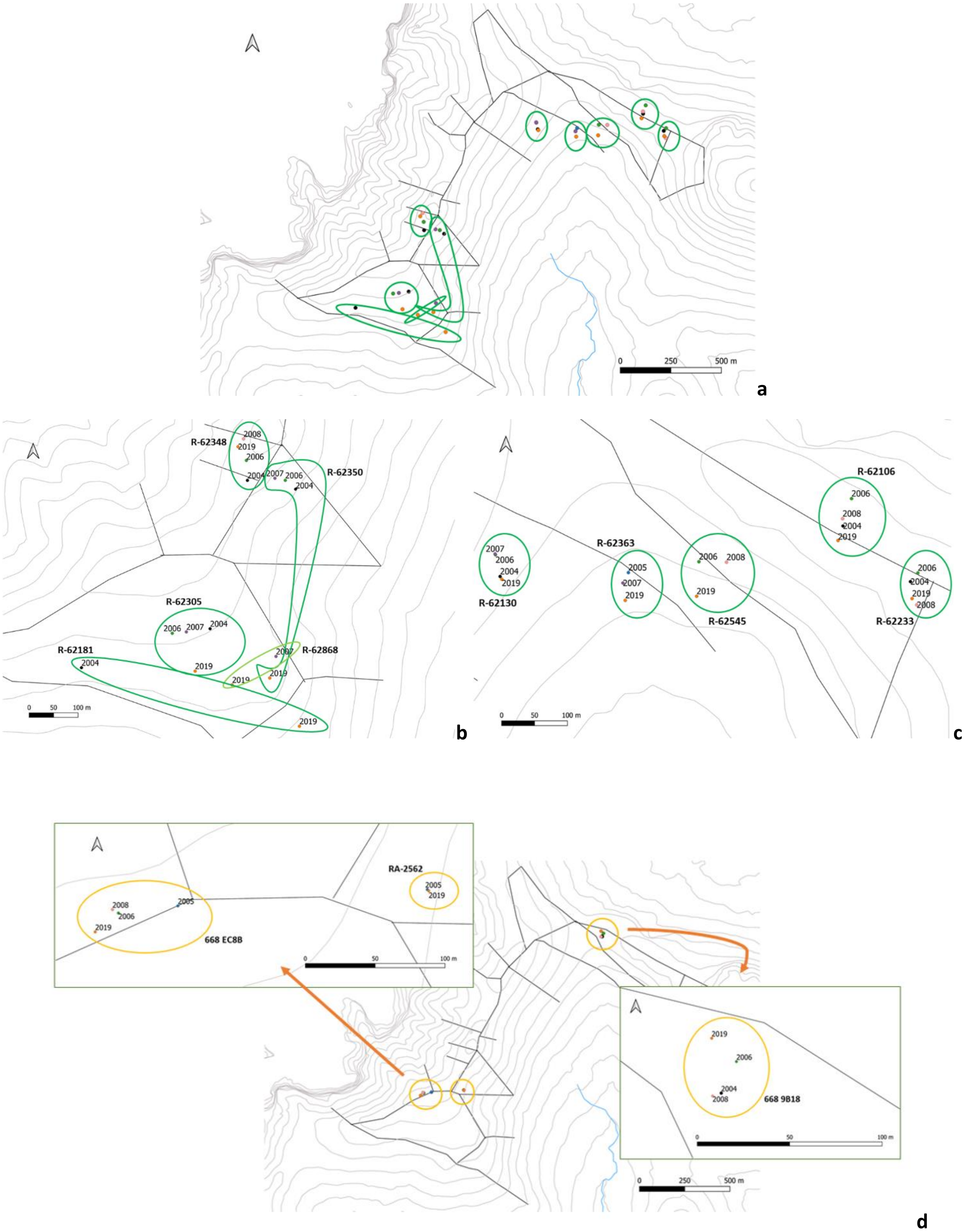

Fig. 6. Maps showing enlarged version of the southern royal albatross Col study area on Campbell Island, highlighting nest locations over several seasons (2004-08) used by banded or PIT tagged birds seen in 2019/20. Map (a) shows an overview of nest locations of banded females seen in 2019/20, with green shapes indicative of nests across seasons of one individual. Maps (b) and (c) are enlarged versions of map (a), showing specific band numbers and year of nesting location. Map (d) shows an overview of nest locations of banded and PIT tagged males seen in 2019/20, with orange shapes indicative of nests across seasons of one individual. Enlarged insets in map (d) are enlarged versions of the base map, showing specific band and PIT numbers and year of nesting location.

Discussion

Moore et al. (2012) had found a levelling in the southern royal albatross population on Campbell Island during the 2004-08 census since the last thorough count in 1995. Specifically, one index area (Col) had been stable but four (Moubray, Faye, Paris, Honey) had seen a decline. Although the current March survey was conducted only in the Col study area and nest numbers had to be adjusted for comparisons to previous years, it provides basic insight into the current population status.

Since southern royal albatross breed biennially, numbers in any given year can fluctuate based on the breeding success of the previous years (Moore et al. 2012). High numbers of nests can be indicative of a poor breeding season the previous year, with many birds that failed early coming back to try again the following year (Moore et al. 2012). Equally, higher numbers of failed breeders returning in consecutive years could give the impression of a high number of nests thereby masking a greater underlying population decline (Moore et al. 2012). Breeding biennially and having low productivity also means that it is difficult for a species like southern royal albatross to recover after decreases in population (Jiménez et al. 2014).

The decrease in nest numbers in the Col study area since the 1990s and 2004-08 (see Fig. 3) could indicate a decline in breeders, changes in breeding frequency, or low juvenile recruitment (Moore et al. 2012). Since all introduced mammals have been removed from Campbell Island since 2001, predation at breeding sites is not an issue, except for sealion predation at nests which was observed one season (Moore et al. 2012). However, albatrosses are highly vulnerable to bycatch in fisheries and at-sea threats.

Moore et al. (2012) summarized that seabird bycatch in New Zealand waters from tuna long-liners was high in the late 1970s and early 1980s, followed by implementation of mitigation measures decreasing bycatch by the late 1980s. Seabird bycatch in New Zealand by trawlers then increased between 1998 to 2004. Satellite tracking studies during incubation in 1997 and 1999 showed that southern royal albatross primarily use the southern and south-eastern shelf breaks of the Campbell Plateau and an area south of the Snares Island along an inner shelf break for foraging, feeding relatively close to their breeding site (Waugh et al. 2002). Feeding at these shelves and slopes can cause spatial overlap with fishing activities thereby increasing vulnerability to bycatch (Jiménez et al. 2014). In New Zealand, southern royal albatrosses fall into the 'negligible' risk category (categories include 'very high', 'high', 'medium', 'low', and 'negligible') based on the most recent risk assessment from commercial fisheries (Richard et al. 2020). This included trawl, longline, and set-net fisheries over a period of 2006/07 to 2016/17. In comparison, northern royal albatrosses (*Diomedea sanfordi*) are in the 'low' risk category, Antipodean albatross (*D. antipodensis*) in 'medium', and Gibson's albatross (*D. gibsoni*) in 'high' (Richard et al. 2020). Between 2002/03 and 2015/16, southern royal albatross were primarily caught in surface- and bottom-longline fisheries (Abraham & Richard 2019), and detailed data from 2017/18 showed four southern royal albatrosses caught by surface long-liners and one by a trawler (Abraham & Thompson 2018).

Outside of New Zealand, southern royal albatross travel through, and are exposed to, many international regions (Moore & Bettany 2005). Band recoveries have been obtained from New Zealand, Chile, Argentina, and Uruguay (Moore & Bettany 2005). The locations of these recoveries support tracking data findings that southern royal albatross prefer to feed over shelf breaks but do also feed over deep oceanic waters (Moore & Bettany 2005). Birds undergo a west to east circumpolar navigation, where juveniles stay near Campbell Island during the first few months of life before moving to Chile and eventually eastern South America (Moore & Bettany 2005). Eastern

South America is an important area for first 2-3 years of life as well as for failed breeders and breeders taking a year off (Moore & Bettany 2005). At 4-5 years of age, birds travel back towards Australia and eventually New Zealand, and adults older than 9 years are found in New Zealand waters during breeding (Moore & Bettany 2005).

High bycatch levels of southern royal albatross were found between 2004-11 collected on Uruguayan and Japanese pelagic longliners in Uruguayan waters (Jiménez et al. 2017). Southern royal albatrosses were primarily caught in May to August in the southwest Atlantic mainly over the shelf break and slope but also over deep oceanic water, aligning with banding recovery data (Moore & Bettany 2005, Jiménez et al. 2014). This spatial overlap with fishing activities thereby increases the vulnerability to bycatch, and threatens immature, non-breeding, and breeding birds (Jiménez et al. 2014). Sexual segregation at sea of southern royal albatross was also found, making females more likely to be caught at subtropical regions and males at subpolar (Jiménez et al. 2017). These data highlight the importance of understanding the current population status to determine whether there is a decline that could primarily be occurring in international waters, thereby making management challenging.

Two related *Diomedea* species, the Antipodean and Gibson's albatross, breeding at the Antipodes and Auckland Islands, respectively, have undergone severe population declines (Elliott & Walker 2019). The Antipodean albatrosses had an increase in numbers in the 1990s, followed by a very drastic and continuous drop since 2006 (Elliott & Walker 2019). Males are declining at 6% per annum and females at 8% per annum (Elliott & Walker 2019). Estimated nest numbers of Antipodean albatrosses reached a high in 2004 at approximately 8,100, and are now estimated at 3,100 in 2019, only 42% of the 2004 count (Elliott & Walker 2019). Declines are attributed to high female mortality, reduced breeding success, and increased recruitment age (Elliott & Walker 2019). The situation is similar for the Gibson's albatross, which had an estimated 8,700 nests in 2004 compared to 4,100 in 2018 (Rexer-Huber et al. 2019). Annual adult mortality remains higher than pre-2004 and combined with low chick production and a population half of what it used to be results in a very slow population recovery (Rexer-Huber et al. 2019). These data suggest that the period between 2005-16 may have had sub-optimal oceanic conditions that caused such vast declines in both species (Elliott & Walker 2019); however, this drop was not seen in the southern royal albatross surveys done between 2004-08 (Fig. 3). This could be due to Antipodean and Gibson's albatross feeding primarily over deep oceanic waters and deep shelf slopes (Walker et al. 1995, Nicholls et al. 2002) as opposed to southern royal albatross which prefer shallow shelf slopes and breaks and occasionally deep oceanic waters. With a large population data gap of southern royal albatross between 2004-08 to 2019/20, and a low nest count in Col during the March 2020 survey, it emphasises the need for an updated population count.

Although only 15 marked birds were seen during March, the age of banded birds seen are comparable with the age ranges observed across Campbell Island by Moore et al. (2012) during 2004-08. All known-age birds (banded as chicks) were in the age range of 24-29, with females ranging between 24-29 and males between 24-25. Moore et al. (2012) had the majority (81%) of known-age birds ranging within 10-29. For birds banded as adults, four out of seven females were banded less than 20 years ago and three were banded between 20-25 years ago. The single male was banded 22 years ago. Moore et al. (2012) had 93% of birds banded as adults less than 20 years prior to the 2004-08 survey.

Contrary to Moore et al. (2012), more banded females than males were found. This is could be due to PIT tags failing (males had bands replaced with PIT tags in the Col study area to avoid injuries) or low male survival (Moore et al. 2012). Across all of Campbell, Moore et al. (2012) found birds banded as adults had high site fidelity (80% return to banding area). For chicks banded specifically within the Col study area, 84% of males banded as chicks returned to natal site, and 41% of females banded as chicks returned to natal site during the 2004-08 surveys (Moore et al. 2012). All 15 marked birds seen in March were banded in the Col study area, either as a chick or an adult (although specific locations for chick banding were not available, they were confirmed to have been within the Col study area). Nest site fidelity of both sexes was also high with movement no more than a few hundred meters. However, this is a very small sample size and only the area within the study area was searched and hence no broad conclusions can be made. Equally, due to the short duration of the visit, partners could not be identified. However, historical breeding data for the marked birds that were seen are readily available and are invaluable. Even a small sample of 15 marked birds can provide a wealth of information in combination with long-term historical data. Future surveys will greatly benefit from access to this data by highlighting trends as climate fluctuates as well as providing insight into demographic parameters such as adult and chick survival.

The only petrel calls recorded on the two acoustic devices deployed on Beeman Hill were of common diving petrels. Rexer-Huber et al. (2020) had also reported hearing diving petrel from the headland near Beeman Base in November 2019. At other parts of the island, Rexer-Huber et al. (2020) had recorded prion (*Pachyptila* sp.; Borchgrevink Bay), white-chinned petrel (*Procellaria aequinoctialis*; Southern Switchback Ridge and above Northwest Bay), and sooty shearwater (*Puffinus griseus*) and white-headed petrel (*Pterodroma lessonii*; Southern Switchback Ridge), indicative of a slow re-colonization of Campbell Island since the eradication of rats in 2001. None of these were heard from Beeman Hill; however, this could be due to several reasons. For example, environmental variables, such as light or weather conditions, influence bird activity (Buxton et al. 2013). Activity appears to be lower on nights closer to full moon due to increased vulnerability to predators, and conditions such as strong winds or storms may make it too energetically demanding to return to land (Buxton et al. 2013). During the March visit, moonlight may have influenced bird activity and hence recordings as full moon was on 9 March and the last quarter on 16 March, coinciding with the visit from 11 to 16 March.

The low number of petrel calls recorded on Beeman Hill could also have been due to timing of the trip. It is known that acoustic activity decreases as the breeding season progresses (Brownlie et al. 2020, Arneill et al. 2020, pers. obs.). Acoustics appear to be most frequent at the start of the season primarily due to breeding birds vocalizing upon return to the colony (Marchant & Higgins 1990b, c). Non-breeding birds are also potentially present in high numbers during egg laying and hatching thereby adding to vocalizations (Brownlie et al. 2020). Birds tend to remain quiet during late incubation and chick rearing, also because they are decreasing the amount of time spent at the colony in the late phase of the breeding cycle in order to gather food for the chick (Arneill et al. 2020). There are no confirmed records of prions breeding at Campbell (Marchant & Higgins 1990c). Diving petrels would likely have nearly finished breeding by March, and leave the colony for moulting for approximately 3 months (Marchant & Higgins 1990b; Miskelly 2013; Rayner et al. 2017). White-chinned petrels would be in the chick-rearing period and would therefore likely be mostly silent, and white-headed petrels have never been confirmed to breed at Campbell (Marchant & Higgins 1990d, e; Bell 2013; Taylor 2013).

Recommendations

- Repeat whole island census of southern royal albatross. If not possible, then study and index areas should be counted. Checking for bands would also be beneficial since every nest would be approached.
- Most of the time, parallel sweeps at varying distance are required for counting nests. However, vantage points can be helpful for locating nests that are difficult to see, and judgment is required around edges of habitat. One or two people can check tussock spurs or openings below scrub lines as it is not productive to walk transects through scrub. Use judgement based on topography and vegetative cover.
- Read bands and scan for PIT tags in Col and Moubray, attempting to check both partners on a nest. This can be used for survival and recruitment calculations using vast banding histories of birds.
- Deploy sound recorders on Beeman Hill in November/December.

Acknowledgements

Thank you to the support provided by the Navy's HMNZS *Canterbury* and for making Operation Endurance possible. A big thank you to Igor Debski, Sharon Trainor, James Ware, Joseph Roberts and the Invercargill DOC team for organizing the pre-departure logistics. Thanks to Dale Chittenden for keeping things running smoothly on the ship, and a big thank you to all the Navy, Army, and Air Force staff working onboard. I'm grateful to Robbie Miller for everything he did to keep things on Campbell Island functioning so well. A huge thanks to Chris Page, Mark Symons, and Phil Clerke for helping with the southern royal albatross nest counts. Thanks to Maggie Burns, Jeff Coulter, and Chris Bennett for being part of the camp team. Thank you to Peter Frost for providing me with photos from the mollymawk work done in November, to Graeme Taylor for input and ideas, and to Kalinka Rexer-Huber and Graham Parker for sharing their wisdom and gear with me. Thank you to Peter Moore for all his help with historical data access and for edits of this report. Last but not least, I send out a very special thanks to Zach Taylor for taking charge of the mollymawk aerial photograph task and making it happen, and to Dillon Anderson for taking such amazing photos.

References

Abraham, E.R. & Y. Richard. 2019. Estimated capture of seabirds in New Zealand trawl and longline fisheries, 2002-03 to 2015-16. *New Zealand Aquatic Environment and Biodiversity Report 211*. Ministry for Primary Industries, Wellington. 99 p.

Abraham, E.R. & F.N. Thompson. 2018. Summary of observed captures during 2017-18. Prepared by Dragonfly Data Science from data held by the Ministry for Primary Industries. Available at: https://psc.dragonfly.co.nz/2019v1/released/summary.

Agreement on the Conservation of Albatrosses and Petrels (ACAP). 2009. ACAP species assessment: southern royal albatross *Diomedea epomophora*. Downloaded from http://www.acap.aq on 29 April 2020.

Arneill, G.E.; Critchley, E.J.; Wischnewski, S.; Jessopp, M.J.; Quinn, J.L. 2020. Acoustic activity across a seabird colony reflects patterns of within-colony flight rather than nest density. *Ibis 162*: 416-428.

Bell, E.A. 2013 (updated 2017). White-chinned petrel. *In* Miskelly, C.M. (ed.) *New Zealand Birds Online.* www.nzbirdsonline.org.nz

Brownlie, K.C.; Monash, R.; Geeson, J.J.; Fort, J.; Bustamante, P.; Arnould, J.P.Y. 2020. Developing a passive acoustic monitoring technique for Australia's most numerous seabird, the short-tailed shearwater (*Ardenna tenuirostris*). Emu-Austral Ornithology, DOI: 10.1080/01584197.2020.1732828

Buxton, R.T.; Major, H.L.; Jones, I.L.; Williams, J.C. 2013. Examining patterns in nocturnal seabird activity and recovery across the western Aleutian islands, Alaska, using automated acoustic recording. *The Auk 130(2)*: 331-341.

Elliott, G. & K. Walker. 2019. Antipodean wandering albatross census and population study on Antipodes Island 2019. Report to Department of Conservation. 27 p.

Ersts, P.J. 2020. DotDotGoose (version 1.5.0). American Museum of Natural History, Center for Biodiversity and Conservation. Available from https://biodiversityinformatics.amnh.org/open_source/dotdotgoose. Accessed on 1-May-2020.

Frost, P.G.H. 2020. Analysis of aerial photographs of the mixed mollymawk colonies on the north-east coast of Campbell Island. DRAFT report to Department of Conservation. Science Support Service, Whanganui.

Jiménez, S.; Domingo A.; Brazeiro, A.; Defeo, O.; Abreu, M.; Forselledo, R.; Phillips, R.A. 2017. Sexual size dimorphism, spatial segregation and sex-biased bycatch of southern and northern royal albatrosses in pelagic longline fisheries. *Antarctic Science 29(2)*: 147-154.

Jiménez, S.; Phillips, R.A.; Brazeiro, A.; Defeo, O.; Domingo, A. 2014. Bycatch of great albatrosses in pelagic longline fisheries in the southwest Atlantic: contributing factors and implications for management. *Biological Conservation 171*: 9-20.

Marchant, S.; P.J. Higgins (co-ordinating editors). 1990a. Handbook of Australian, New Zealand & Antarctic birds. Volume 1, Ratites to ducks; Part A, Ratites to petrels. Melbourne, Oxford University Press. Pages 263-264, 282-289.

Marchant, S.; P.J. Higgins (co-ordinating editors). 1990b. Handbook of Australian, New Zealand & Antarctic birds. Volume 1, Ratites to ducks; Part A, Ratites to petrels. Melbourne, Oxford University Press. Pages 263-264, 719, 724-735.

Marchant, S.; P.J. Higgins (co-ordinating editors). 1990c. Handbook of Australian, New Zealand & Antarctic birds. Volume 1, Ratites to ducks; Part A, Ratites to petrels. Melbourne, Oxford University Press. Pages 263-264, 355-356, 541-549.

Marchant, S.; P.J. Higgins (co-ordinating editors). 1990d. Handbook of Australian, New Zealand & Antarctic birds. Volume 1, Ratites to ducks; Part A, Ratites to petrels. Melbourne, Oxford University Press. Pages 263-264, 355-356, 557-566.

Marchant, S.; P.J. Higgins (co-ordinating editors). 1990e. Handbook of Australian, New Zealand & Antarctic birds. Volume 1, Ratites to ducks; Part A, Ratites to petrels. Melbourne, Oxford University Press. Pages 263-264, 355-356, 420-425.

Miskelly, C.M. 2013 (updated 2017). Common diving petrel. *In* Miskelly, C.M. (ed.) *New Zealand Birds Online.* www.nzbirdsonline.org.nz

Miskelly, C.M. 2013 (updated 2019). Fairy prion. *In* Miskelly, C.M. (ed.) *New Zealand Birds Online.* www.nzbirdsonline.org.nz

Moore, P.J. & S.M. Bettany. 2005. Band recoveries of southern royal albatrosses (*Diomedea epomophora*) from Campbell Island, 1943-2003. *Notornis 52*: 195-205.

Moore, P.J. & R. Blezard. 1999. Photographs of Campbell Island mollymawk colonies: a guide to photopoints, historical comparisons, and counting mollymawks. *Department of Conservation Technical Series 17*. Department of Conservation, Wellington. 89 p.

Moore, P.J.; Larsen, E.J.; Charteris, M.; Pryde, M. 2012. Southern royal albatross on Campbell Island/Motu Ihupuku: solving a band injury problem and population survey, 2004-08. *DOC Research and Development Series 333*. Department of Conservation, Wellington. 53 p.

Moore, P.J. & R.D. Moffat. 1990. Research and management projects on Campbell Island 1987-88. *Science and Research Internal Report 57*. Department of Conservation, Wellington. 101 p.

Moore, P.J.; Scott, J.J.; Joyce, L.J.; Peart, M. 1997. Southern royal albatross *Diomedea epomophora epomophora* census on Campbell Island, 4 January-6 February 1996, and a review of population figures. *Science and Research Series 101*. Department of Conservation, Wellington. 27 p.

Nicholls, D.G.; Robertson, C.J.R.; Prince, P.A.; Murray, M.D.; Walker, K.J.; Elliott, G.P. 2002. Foraging niches of three *Diomedea* albatrosses. *Marine Ecology Progress Series 231*: 269-277.

Phillips, R.A. & C.M. Waluda. 2020. Albatrosses and petrels at South Georgia as sentinels of marine debris input from vessels in the southwest Atlantic Ocean. *Environment International 136*: 105443.

Provencher, J.F.; Borrelle, S.B.; Bond, A.L.; Lavers, J.L.; van Franeker, J.A.; Kuehn, S.; Hammer, S.; Avery-Gomm, S.; Mallory, M.L. 2019. Recommended best practices for plastic and litter ingestion studies in marine birds: collection, processing, and reporting. *Facets 4*: 111-130.

Rayner, M.J.; Taylor, G.A.; Gaskin, C.P.; Dunphy B.J. 2017. Seasonal activity and unpredicted polar front migration of northern New Zealand Common Diving Petrels (*Pelecanoides urinatrix*). *Emu – Austral Ornithology*: http://dx.doi.org/10.1080/01584197.2017.1303332.

Rexer-Huber, K.; Elliott, G.; Thompson, D.; Walker, K.; Parker, G. 2019. Seabird populations, demography and tracking: Gibson's albatross, white-capped albatross and white-chinned petrels in the Auckland Islands 2018-19. Final report to the Conservation Services Programme, Department of Conservation. Parker Conservation, Dunedin. 19 p.

Rexer-Huber, K.; Parker, K.A.; Parker, G.C. 2020. Campbell Island seabirds: Operation Endurance November 2019. DRAFT Final report to Marine Species and Threats, Department of Conservation. Parker Conservation, Dunedin. 22 p.

Richard, Y.; Abraham, E.R.; Berkenusch, K. 2020. Assessment of the risk of commercial fisheries to New Zealand seabirds, 2006-07 to 2016-17. *New Zealand Aquatic Environment and Biodiversity Report 237*. Ministry for Primary Industries, Wellington. 57 p.

Taylor, G.A. 2013. White-headed petrel. *In* Miskelly, C.M. (ed.) *New Zealand Birds Online.* www.nzbirdsonline.org.nz

Walker, K.; Elliott, G.; Nicholls, D.; Murray, D.; Dilks, P. 1995. Satellite tracking of wandering albatross (*Diomedea exulans*) from the Auckland Islands: preliminary results. *Notornis 42*: 127-137.

Waugh, S.M.; Sagar, P.M.; Paull, D. 1997. Laying dates, breeding success and annual breeding of Southern royal albatrosses *Diomedea epomophora epomophora* at Campbell Island during 1964-69. *Emu 97*: 194-199.

Waugh, S.; Troup, C.; Filippi, D.; Weimerskirch, H. 2002. Foraging zones of southern royal albatrosses. *The Condor 104*: 662-667.

Appendix

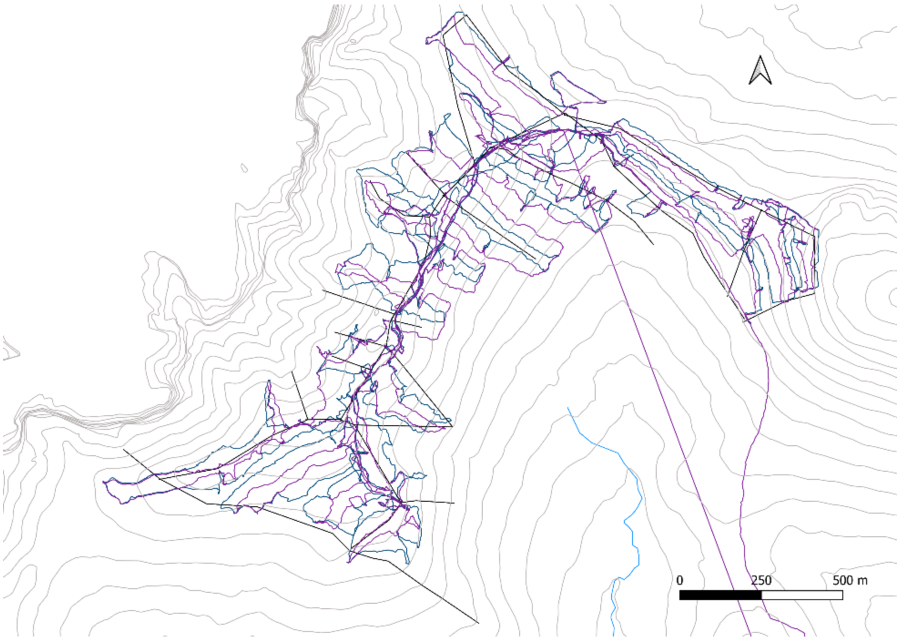

Fig. A1. Enlarged map showing southern royal albatross Col study area on Campbell Island. Blue and purple lines show tracks (as recorded by Garmin 64st and Rino650 GPS devices, respectively) walked by two observers while searching for albatross nests.

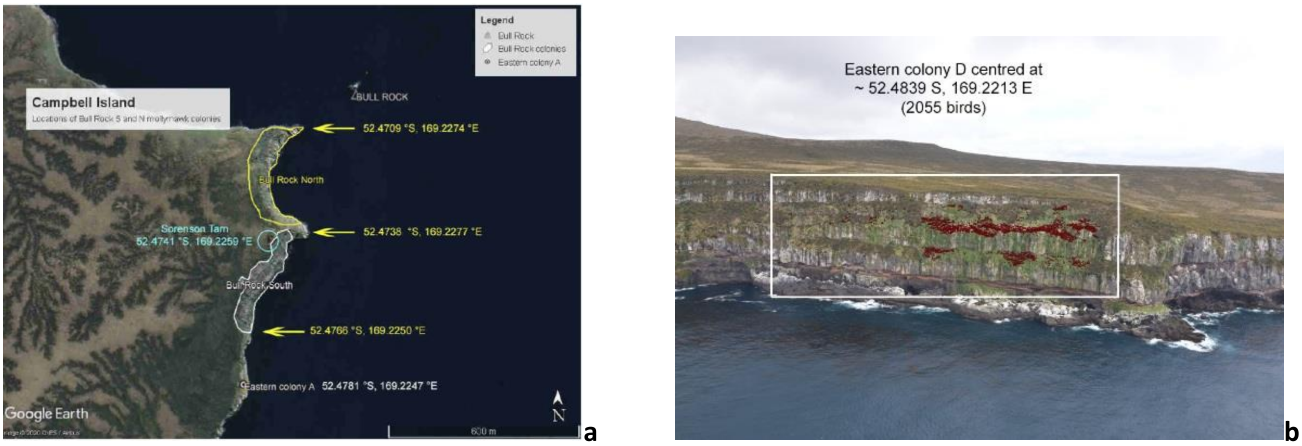

Fig. A2. Samples of maps and aerial photographs printed and provided to the NZDF staff to aid in understanding the location and task of taking aerial photographs of Campbell and grey-headed albatross colonies to use for chick counts. Map (a) provided an overview relative to the island as well as GPS locations if staff preferred to use those on the helicopter, and photo (b) provided an example and an overview of the colony on the cliff itself with landmarks and birds shown as well as GPS locations. Both (a) and (b) were provided by Peter Frost.

Table A1. Sex, age, and season banded for each banded and PIT tagged southern royal albatross seen in or near the Col study area on Campbell Island. Every recorded breeding season and the identity and history of the partner of each banded or PIT tagged bird are also shown. Any re-banding or removal of bands and PIT tag insertions are also outlined. All data were collated from P. Moore (pers. comm. and unpublished data).

		Banding History			Breeding and Partner History^		
Band or PIT	Sex	Age	Season	Previous bands	Breeding Season	Partner (ID)	Partner history and previous bands
R-62348	F	Adult	2004/05	-			Chick in 1991/92 (R-44407)
					2004/05	RA-2223	Re-banded as RA-2223 and insert PIT (668 DD06)
					2006/07	RA-2223	Band removed, PIT read
					2008/09	RA-2223	PIT read
R-62350	F	Chick	1993/94	R-45183			Chick in 1993/94 (R-45199)
			2004/05	Re-banded	2004/05	RA-2205	Re-banded as RA-2205
					2006/07	RA-2205	Band removed and insert PIT (668 B43C) but PIT failed
					2007/08	unb	
R-62181	F	Adult	1998/99	R-54382	1998/99*	RA-0256	Banded as adult
			2004/05	Re-banded	2004/05	unk	(Partner not seen)
R-62305	F	Adult	1996/97	R-48873			Chick in 1987/88 (R-43856)
			2004/05	Re-banded	1996/97*	R-43856	
					1998/99*	RA-2269	New partner banded as adult (R-54379)
					2004/05	RA-2269	Re-banded as RA-2269
					2006/07	RA-2269	Band removed and insert PIT (668 543C)
					2007/08	RA-2269	PIT read
R-62868	F	Chick	1990/91	R-44004			Chick in 1972/73 (R-25683) (Bred with R-62497 in 1994/95, 1996/97, 1998/99, 2005/06) Re-banded as RA-2533 in 2005/06
			2007/08	Re-banded	2007/08	RA-2533	Band removed and insert PIT (668 1D1B)
R-62130	F	Adult	1996/97	R-48891			Chick in 1987/88 (R-43834)
			2004/05	Re-banded	1996/97*	RA-2410	
					1998/99*	RA-2410	
					2004/05	RA-2410	Re-banded as RA-2410
					2006/07	RA-2410	Band removed and insert PIT (668 6927)
					2007/08	RA-2410	PIT read
R-62363	F	Adult	2005/06	Also insert PIT (668 82EC)			Chick in 1995/96 (R-48687)
					2005/06	R-62570	Re-banded as RA-2622
					2007/08	R-62570	Re-banded as R-62570
R-62545	F	Chick	1995/96	R-48695			Chick in 1995/96 (R-48677)
			2006/07	Re-banded	2006/07	RA-2651	Re-banded as RA-2651, band removed again and insert PIT (668 2911)
					2008/09	RA-2651	PIT read
R-62106	F	Adult	2004/05	-			Chick in 1981/82 (R-40972) (Bred with unknown in 1997/98)
					2004/05	RA-2251	Re-banded as RA-2251
					2006/07	RA-2251	Band removed and insert PIT (668 C702) but PIT failed
					2008/09	unb	

		Banding History			Breeding and Partner History^		
Band or PIT	Sex	Age	Season	Previous bands	Breeding Season	Partner (ID)	Partner history and previous bands
R-62233	F	Adult	2004/05	-	2004/05 2006/07 2008/09	RA-2107 RA-2107 unb	Banded as adult Band removed
R-48613**	F	Chick	1995/96	-	-	-	-
668 EC8B	M	Chick	1994/95 2005/06 2006/07	R-48130 Re-banded as RA-2593, insert PIT (668 EC8B) Band removed, PIT read	 2005/06 2006/07 2008/09	 R-62412 R-62412 R-62412	Chick in 1994/95 (R-45840) Re-banded as R-62412
RA-2562	M	Adult	1997/98 2005/06	R-54319 Re-banded	1997/98* 1998/99* 2005/06	RA-0255 RA-0255 R-62574	Banded as adult (R-54275) Re-banded as RA-0255 New partner banded as adult
668 9B18	M	Chick	1995/96 2004/05 2006/07	R-48597 Re-banded as RA-2412, insert PIT (668 FE6F) but PIT failed Band removed, another PIT inserted (668 9B18)	 2004/05 2006/07 2008/09	 R-62137 R-62137 R-62137	Chick in 1993/94 (R-45174) Re-banded as R-62137
RA-2458	M	Chick	1995/96 2005/06	R-48661 Re-banded (but not breeding)	-	-	-

^Partners based on historical data as none seen during 2019/20 due to short trip duration
*Nest locations could not be obtained and are therefore not shown in Fig. 6
**Bird was on a nest outside of Col study area (slightly south of southern fence line boundary)