Draft POP2023-04 Campbell Island Seabird Research Project

Photo: B. Philp

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Summary

This trip was a follow-up project from the work done on Campbell Island in March 2020 and February 2023 to primarily determine population trends for southern royal albatross (*Diomedea epomophora*). Nests were counted in two study (Col and Moubray) and three index areas (Faye, Paris, Honey) to compare to historical counts. Additional aims were to resight marked birds, band up to 200 pairs in the Col study area, deploy PTT and GLS tags, and set up remote cameras on nests to monitor breeding success. Other species work included conducting photo point counts for Campbell (*Thalassarche impavida*) and grey-headed albatross (*T. chrysostoma*) and to deploy remote cameras on grey-headed albatross nests. Accessible nest sites were searched for light-mantled sooty albatross (*Phoebetria palpebrate*), PTT trackers deployed, and remote cameras set up at nests. Opportunistic searches while traveling or within southern royal albatross study and index areas were done for Antipodean albatross (*Diomedea antipodensis antipodensis*), and any unbanded birds were marked. Opportunistic searches and counts were also done for northern giant petrels (*Macronectes halli*) and white-chinned petrels (*Procellaria aequinoctialis*).

Nest counts for southern royal albatross showed an overall decline of 32.8% since the 1990s and a 26.5% decline since the 2000s. Paris index area had the highest percent change of -46.2% since the 1990s, and Col study area had the lowest at -23.6%. A total of 35 PTT trackers were deployed on southern royal albatross in the Col study area which show birds moving north to the Chatham Rise, west to Tasmania, south towards Antarctica, and to the Patagonian Shelf east of Argentina. Thirty-four GLSs devices were also deployed. For demographics, 113 nests have both birds of the pair marked within the Col study area, and 22 cameras were set up on nests to monitor breeding success. For Campbell and grey-headed albatross photo point counts, the percent change between 2019/20 and 2023/24 showed a decline in the total number of Campbell albatross (sitting and loafing birds) of 16.1% and a decline of 27.6% of grey-headed albatross. For breeding success monitoring of grey-headed albatross, five cameras covering 28 nests were deployed. For light-mantled sooty albatross, ten PTT trackers were deployed on non-breeding birds which show most birds travelling south towards Antarctica. A total of 11 cameras covering 14 nests were set up for breeding success monitoring. For Antipodean albatross, eight birds were found on the Moubray Peninsula, of which three were previously banded as chicks in the 1990s.

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 has a long history of sealing, whaling, and farming since its discovery in 1810 (Moore et al. 2012). The island was farmed from 1895 to 1931 (Moore & Moffat 1990), with sheep (*Ovis aries*) removed from the island by 1992 and cattle (*Bos taurus*) in 1984. Norway rats (*Rattus norvegicus*) were eradicated by 2001, and feral cats (*Felis catus*) disappeared in the mid-1980s (Moore et al. 2012).

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 et al. 2012). 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 consequential 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 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 2003, Moore et al. 2012). Banding became restricted to the Col and Moubray study areas after 1987, and eventually 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)) due to a large number of leg injuries (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).

Data collected in March 2020 (Mischler 2020) and February 2023 (Mischler & Wickes 2023) were indicative of a possible drastic decline in the southern royal albatross population, and the primary purpose of the trip outlined in this report (first year of a two year project) was to build on these data. Due to the long duration of this trip (November 2023 to February 2024), several other objectives were added, including counts and monitoring of Campbell (*Thalassarche impavida*) and grey-headed (*T. chrysostoma*) albatross, tracking of light-mantled sooty albatross (*Phoebetria palpebrate*), surveys for Antipodean albatross (*Diomedea antipodensis antipodensis*) as well as incidental records of northern giant petrels (*Macronectes halli*) and white-chinned petrels (*Procellaria aequinoctialis*).

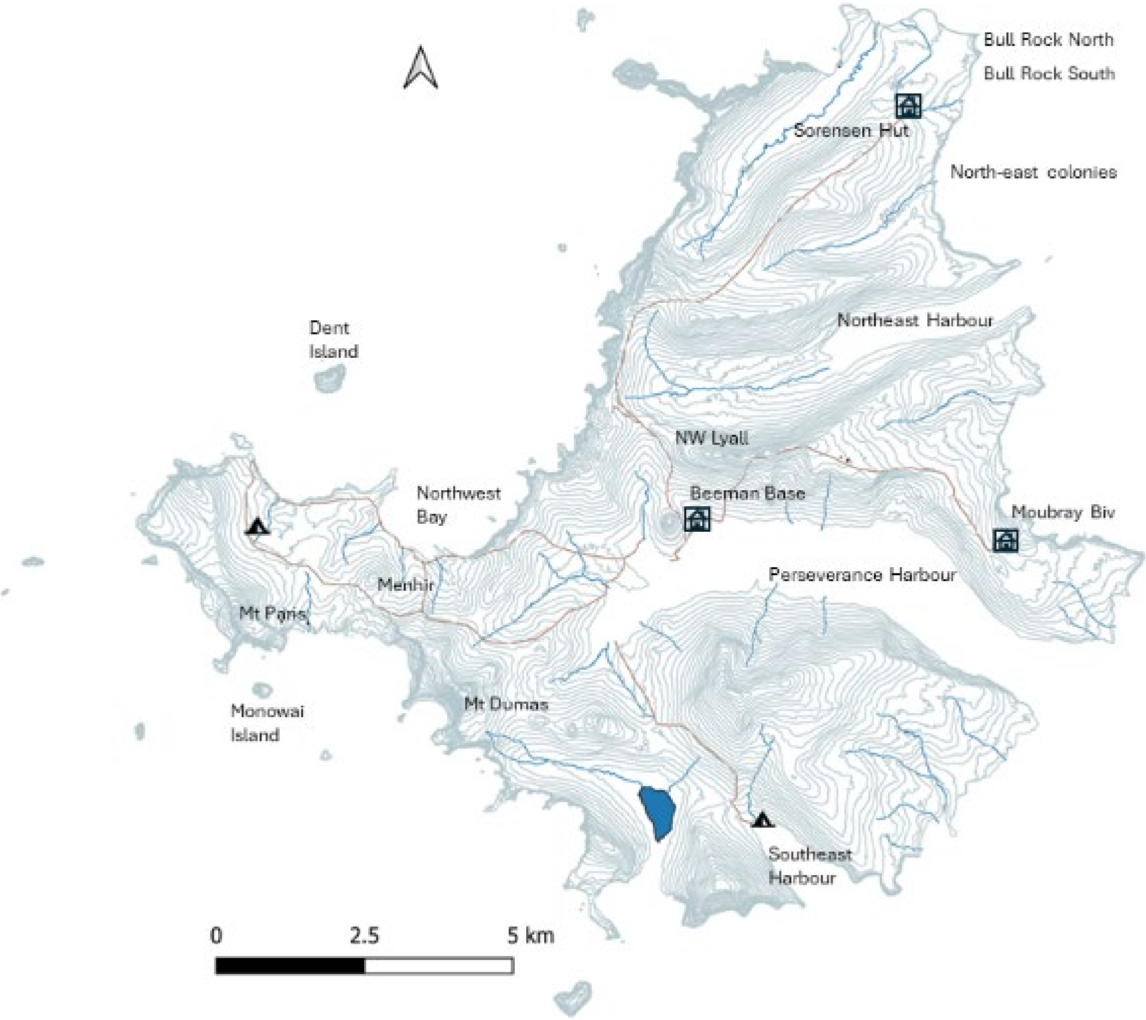

Fig. 1. Map of Campbell Island showing key locations referred to for seabird work conducted in 2023/24. Hut (house symbol) and campsite (tent symbol) locations are also indicated.

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Northern giant petrels have been largely unstudied at Campbell Island. Historically, the only whole-island census was conducted in 1996 (Wiltshire & Scofield 2000), and this was repeated by Rexer-Huber et al. (2020) which showed relatively stable numbers. Burrowing petrels also remain largely unstudied on Campbell Island, and this has been limited to grey (*Procellaria cinerea*) and white-chinned petrel surveys in 2014 and 2015 (Rexer-Huber et al. 2016). Sound recorders were deployed across the island in November 2019 to determine and detect any changes in distribution, and this showed that white-chinned petrels were recolonizing the island including in areas that were some distance away from the offshore source locations of Monowai and Dent islands (Fig. 1; Rexer-Huber et al. 2020).

The Antipodean albatross population on Antipodes Island is well studied and known to be dramatically declining, but data on Antipodean albatross on Campbell Island are scarce. Antipodean albatross were first observed breeding on Campbell in 1944 (Bailey & Sorensen 1962). Some breeding pairs were monitored, and over 200 individuals were banded between the 1940s and late 1990s, mostly on Moubray Peninsula (Fig X; Bailey & Sorensen 1962, NZNBBS 2024). Marchant & Higgins (1990) noted one pair between 1975-77 (exact location not given), and Elliott & Walker (2013) note "a few pairs". The most comprehensive data is in field notes taken by A. Tennyson during his trip in January 1993 where he summarized that 21 adults were noted in the Moubray hut book between 1986/87 to January 1993, all known to be within the Moubray area. On the 1993 trip itself, nine adults (six of which were on eggs) were noted in the same area. There was a note about an adult bird in January 1978 which was on the saddle between Paris and Menhir, and this was also noted in 1984/85 (G. Taylor, pers. comm.) There are also notes about three records which state "Dumas", and it was confirmed that there was a pair on the northeast slope of Mt Dumas in the mid-1980s which was monitored for 10-15 years (G. Taylor, pers. comm.). Besides Moubray and the above-mentioned areas, Antipodean albatross were never seen anywhere else on the island (Fig. 1).

Light-mantled sooty albatross data are also severely lacking most likely because of their inaccessible nesting location on steep coasts and cliffs. The only previous surveys on this species on Campbell Island were conducted in 1995-1997, using a mixture of vantage points for coastal areas and ground searches for accessible areas (Moore 1996, unpubl. data). Breeding success was also monitored. This was done to determine the threat of fisheries bycatch to the population and to gather baseline data (Moore 1996).

The main objectives for the 2023/24 expedition were:

1. Southern royal albatross
    a. Population counts:
        i. Count and map nests in study (Col and Moubray) and index areas (Faye, Paris, Honey) to determine trends.
    b. Demographics:
        i. Collection of resight data on known birds in the traditional study blocks and surrounding areas to inform demographic parameter estimates.
        ii. Marking of unbanded adults (aim of 200 pairs over a two-year period) within Col study area and surrounding areas to continue building the mark-resight dataset.
    c. At-sea tracking:
        i. Attach 40 GPS/PTT (platform transmitter terminal) satellite trackers to breeding adults in the study area using back-feather mounts to gain short-term high-resolution insights into distribution and fisheries risks.
        ii. Deploy 30 GLS tags to breeding adults in the study area and recover, download, and redeploy previously deployed GLS tags using colour band mounts to gain long-term low-resolution insights into distribution and fisheries risks (different individuals from GPS/PTT satellite trackers).

    d. Breeding success:
        i. Replace the existing 12 remote cameras in the study site and downloading collected over the last year to continue the breeding, phenology, and success study.
    e. Diet sample collection:
        i. Collect 6-8 new (recently moulted) back contour feathers from 20 adult males and 20 females.

2. Grey-headed albatross
    a. Population counts:
        i. Use traditional photo points to update existing population estimates.
    b. Breeding success:
        i. Install 5-10 remote cameras to study breeding biology, phenology, and success of this species.
    c. Demographics:
        i. Collection of resight data on known birds in the traditional study blocks to inform demographic parameter estimates.
        ii. Replace worn bands where necessary.

3. Light-mantled sooty albatross
    a. Population mapping:
        i. Count and map nests, particularly of accessible inland sites to identify suitable study sites.
    b. At-sea tracking:
        i. Attach 10 PTT satellite trackers to breeding adults during the chick-rearing period or non-breeding adults using back-feather or tail-mounts to gain high-resolution insights into distribution and fisheries risks.
    c. Breeding success:
        i. Install 5-10 remote cameras at an accessible site to study breeding biology, phenology, and success.

4. Antipodean albatross
    a. Population estimate:
        i. Count and map nests whenever encountered in either southern royal albatross study areas or elsewhere on the island to update the population estimate on Campbell.
    b. Genomics:
        i. Collection of blood samples of any encountered individuals to add to the ongoing Antipodean-Gibson's albatross genomics study.
        ii. Collection of morphometric and plumage measurements in conjunction with the work on Adams and Antipodes Islands.
    c. Demographics:
        i. Band (stainless steel and darvic bands) any encountered individuals to facilitate individual recognition and add to the demographic dataset.

5. Northern giant petrel
    a. Population mapping:
        i. Opportunistically count and map nests using ground searches to update population estimates from several potential study areas.

6. White-chinned petrel
    a. Population mapping:
        i. Opportunistically count and map any newly detected burrows to document recolonisation of this species.

Methods

Trip duration and timing

The trip to Campbell was 10.5 weeks total, with 9.5 weeks on the island, three days travel to the island from Bluff and five days travel return. Departure from Bluff was on 29 November 2023 on the *Evohe*, arrival on Campbell Island was on 2 December 2023, departure from Campbell was on 8 February 2024, and arrival back into Bluff was very late on 12 February 2024. The team consisted of four people – Theo Thompson, Brodie Philp, Chrissy Wickes, and Peter Moore. A five-person sealion/hoiho team was on island simultaneously, comprised of Mel Young, Janelle Wierenga, Julia Reid, Leith Thomson, and Thor Tutewhaitirangi. The team conducted work from Beeman Base, Moubray Biv, Sorensen Hut, Northwest Bay Hut, and two campsite locations (Fig. 1).

Southern royal albatross (Objective 1a-e)

For the population objective, methods followed those used in the 2004-08 population survey outlined by Moore et al. (2012) and replicated for the Col study area in 2020 by Mischler (2020). To maintain consistency, site marker and sector boundary coordinates for the two study areas (Col and Moubray) and three index areas (Faye, Paris, Honey; Fig. 2) were obtained from Moore et al. (2012) and loaded onto four GPS units (Garmin 64st). 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 four people walking in parallel sweeps apart while searching for nests within the study and index areas 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). Depending on the terrain, weather conditions, and vegetation type (i.e. the ease of locating nests), the distance between observers varied between 10 m and 50 m. Active nests with a bird and an egg 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 (all areas) and tracking devices (GLS; in Col only). Except for nervous birds, a line was sprayed across the centre of the chest of the bird using stock marker to indicate that the nest had been counted. Vegetation beside the nest was also sprayed. At the end of each survey day, accuracy checks were completed where each person walked perpendicular to their survey line and checked each nest within 15 m on either side of their line for a bird sprayed with stock marker. If birds had switched nest attendance during the day, the nest was checked for the spray mark to ensure no nests were missed. If nests had been missed, the accuracy check allowed for adjustments in numbers to be made. All mapping was done on qGIS.

For the first part of the demographics objective (resight previously marked birds), birds were checked for bands while conducting the population surveys in all study and index areas. Bands were checked for gaps and adjusted if necessary. At Col, if no band was present on male birds, 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 as checks for bands and PIT tags could be done without holding the bird. Loafing birds were captured if they had bands or GLSs. For Moubray, only one visit per nest was possible.

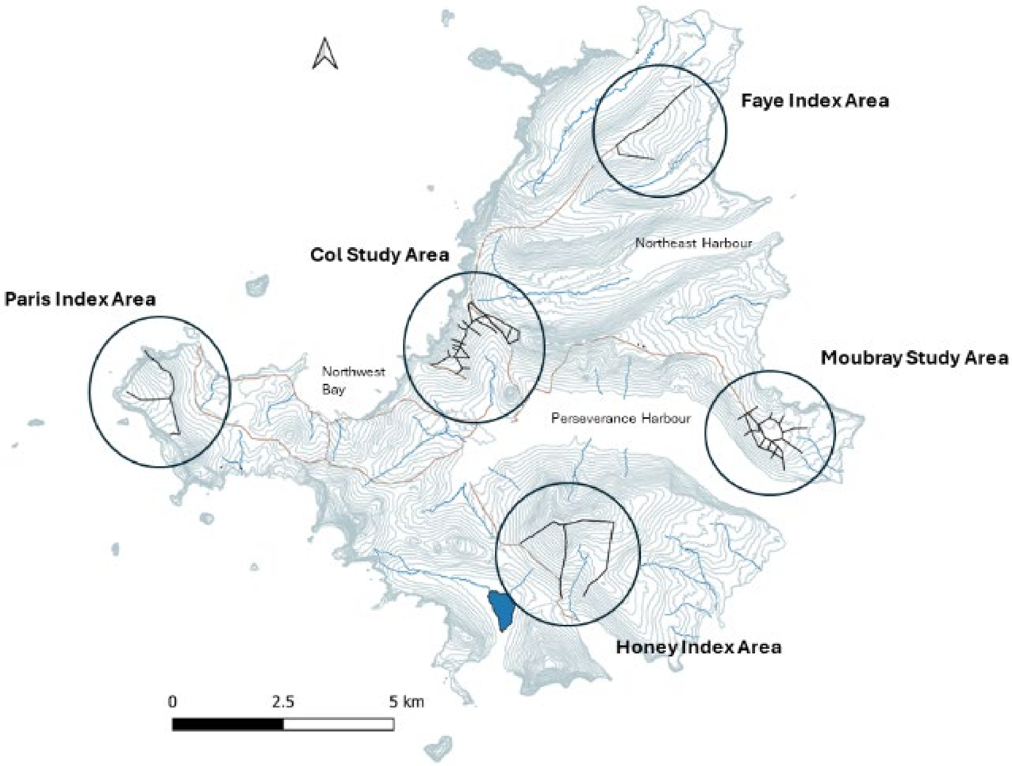

Fig. 2. Map of Campbell Island outlining the two study areas (Col and Moubray) and three index areas (Faye, Paris, Honey) used for southern royal albatross nest counts.

To meet the second part of the objective (marking of unbanded adults for a total of 200 pairs in Col), nests in the Col study area were visited several times to mark both birds of a pair. Nesting birds were generally not handled for banding, since most birds could be carefully banded while they sat on the nest. This technique requires sufficient training and experience to band the bird quickly and efficiently with the least disturbance to the bird, since the degree of difficulty varies depending on the nest site, type of bowl and behaviour of the bird. Operators worked in pairs, with the second person shielding the bander from the bird's bill with a clipboard if necessary. Since birds were more relaxed and sat more tightly on the real egg, dummy plastic eggs were only used for birds that became fidgety during banding. Exceptionally nervous birds were usually avoided on the first or second visit to allow them to get used to being approached by humans. Birds that were marked with transmitters and/or transponders were restrained. In these cases the egg was removed from the nest and placed into a thermal hat and hidden from sight from skuas. The bird was then removed from the nest by the handler with the bill and wings held tightly to allow the bander access to the legs or back. Once marking was finished, a check for skuas in the vicinity was made, the egg was placed back in the nest and the bird was placed carefully 2-3 m from the nest and allowed to return to the nest on its own. Except in areas close to the tourist boardwalk, birds that had been marked were sprayed with stock marker across the chest to indicate that those individuals had already been checked.

Most birds received a primary mark (metal band or transponder) and a secondary mark (alpha-numeric colour band). All female birds were banded on the right tarsus with an R-sized band. Two alternative metal bands were trialled on males, with 20 birds receiving RO bands and 20 RC-clip bands. The latter nests were revisited 2-3 times to ensure that there had been no damage to eggs. Once satisfied that these bands were suitable, the remainder of the males were banded with RC-clip bands except for twenty birds which were banded with an RO-sized band. Both sexes were additionally banded with an alpha-numeric darvic colour band (orange for females, blue for males; Fig. 3) on the left tarsus unless fitted with a GLS (see at-sea tracking below). A PIT tag, as an alternative primary mark, was inserted into 25 males that were marked with satellite tags. While the bird was restrained, the implant operator separated feathers on the back of the lower neck to expose an area of skin, wetted the area down with alcohol/hand sanitiser and lifted the skin up between thumb and forefinger. A PIT was injected on an angle under the skin with a syringe and the hole was pressed closed between finger and thumb. Any bleeding was checked by using a cotton wool swab. An aerosol glue was used to seal the hole.

Fig. 3. Image showing alpha-numeric darvic colour band on a female southern royal albatross. These were used to establish 200 marked breeding pairs in the Col study area on Campbell Island. (Photo: P. Moore)

The at-sea tracking objective was divided into satellite tags and GLS tags. For satellite tags, 35 tags were deployed in the Col study area with birds removed from the nest as described above. One of these fitted tags was found to be not aligned correctly, so it was removed and redeployed on a second bird. Five additional satellite tags were deployed for short periods on female royal albatross and then redeployed on light-mantled sooty albatross. The trackers were attached onto the back with Tesa tape (Fig. 4) using four "feather clumps" where a few feathers immediately over the spine were lifted away from other feathers so that Tesa tape could be placed underneath the clump and wrapped over the tracker. Progression was made down the spine, with clumps gathered up and tape put underneath it, overlapping with previous tape straps, for the length of the tracker.

Fig. 4. Image showing satellite transmitter mounted on the back of a southern royal albatross using Tesa tape in the Col study area on Campbell Island (Photo: P. Moore).

GLS tags were deployed on birds in the Col study area that did not already have a satellite tag. GLS tags were attached to plastic wraparound bands prior to deployment, with two holes drilled and a cable tie inserted through and around the GLS tag. To deploy, the plastic band was opened, wrapped around the leg of a bird sitting on its nest, and super glue applied on the outside opening. Wraparound bands for males had a diameter of 22 mm and 19 mm for females. Also, as outlined in the population objective, previously deployed GLS devices were retrieved when possible, downloaded, and redeployed if the units were still functional.

For the breeding success objective, 12 cameras previously deployed in the Col study area in February 2023 were serviced (Mischler & Wickes 2023). These deployments had used a light-weight stake for mounting the camera which were deemed unsuitable due to weather conditions causing them to fall over. This year, a total of 22 cameras (Swift Enduro Outdoor Cameras Australia with 32 GB SD cards) were deployed on southern royal albatross nests in the Col study area (Fig. 5), 12 from the previous season and ten as part of a visitor impact assessment. The latter ten were placed on nests near the boardwalk to determine the effects that visitors have on bird behaviour and nest success. The cameras viewed 27 nests (one camera viewed two nests, and four nests failed and the cameras were redeployed), all of which contained an egg. Distance from the nests varied (2-10 m) depending on terrain and vegetation but was placed far enough away from the nest to capture movement of the chick once it becomes mobile (Fig. 6). The cameras were deployed to avoid facing directly into the sunlight, and programmed to take one photograph every two hours between 0600 and 2100 hours. Gorilla Roof and Gutter silicone sealant was used around the edges of the camera and in any holes (for plugs or microphone) to prevent water seeping into the seals. Cameras were attached with wire to a wooden stake (Fig. 6) with a side stake added for stability.

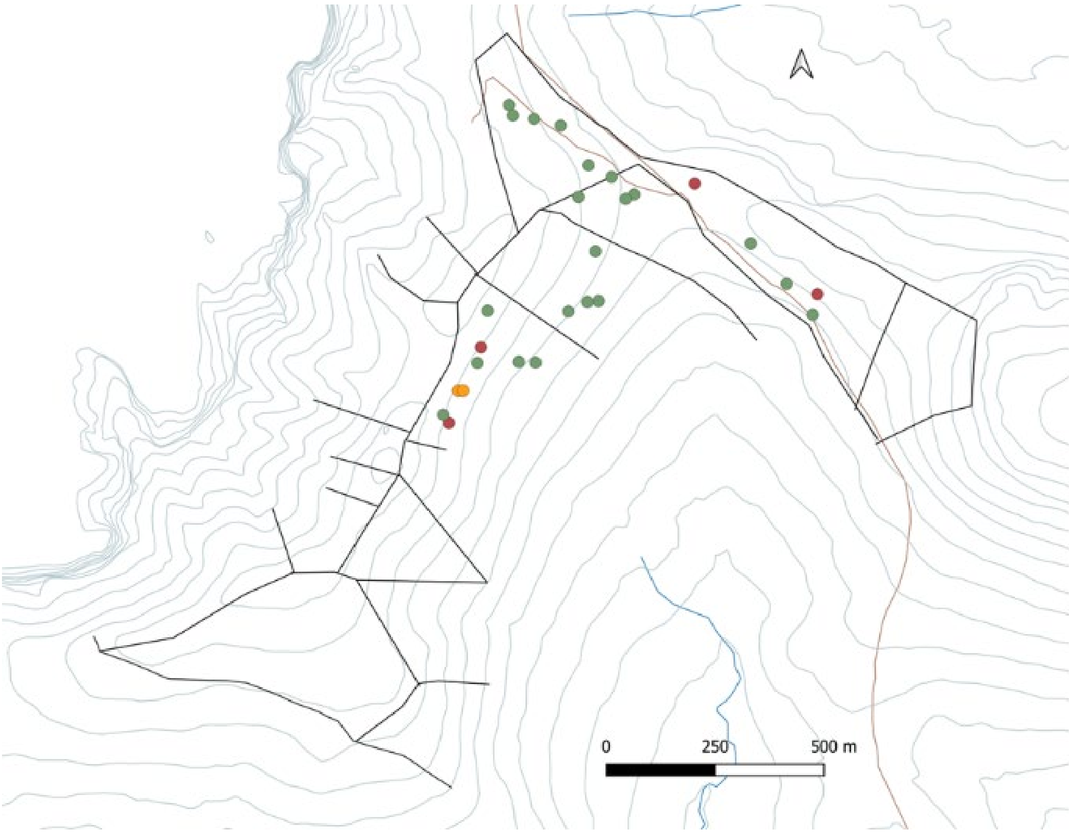

Fig. 5. Map showing nest locations of southern royal albatross in the Col study area where a camera was deployed to monitor breeding success (green). Orange indicates one camera covering two nests, and red indicates where a camera was initially set up but the nest failed and cameras were re-deployed.

For the diet sample collection, 6-8 new (recently moulted) breast feathers were collected (small feathers pulled out) from 20 adult males and 20 females. This was done by sitting quietly beside a nesting bird and snipping off the feathers. These were stored in paper envelopes and the feathers sent away for stable isotope analyses. Results will be reported on elsewhere.

Fig. 6. Image showing remote camera deployment on a southern royal albatross nest at Col study area on Campbell Island. The cameras were used to monitor breeding success data (Photo: T. Thompson)

Grey-headed albatross (Objective 2a-c)

To meet the first objective, counts from images taken at photo points (excluding C1) established by Moore (2004) were completed (Fig. 7). Rexer-Huber et al. (2020) had revisited these points in 2019 after pooling information from several reports, and this was repeated on the current trip. Photographs were taken with a Canon EOS Rebel T5 with a Canon 75-300mm zoom lens (for MP7-11) on 6 December 2023 and an Olympus EM5 mark 2 with a 10-50mm (for MP1-6, 12) and a 70-300mm zoom lens for C2 on 14 December 2023. This included an overview photo at each location and several close-up images to allow for species identification (Campbell or grey-headed albatross) and for the most accurate count of birds that appeared to be incubating an egg or brooding a chick. Nesting areas at each photo point were divided into sections which followed those outlined by Moore & Blezard (1999) and updated by Frost (2019) to allow for count comparisons. Stitching of images was not necessary as boundaries could be drawn and distinguished in adjacent individual photographs to avoid double-counting or gaps in sections. Birds were counted using DotDotGoose (v 1.7.0; Erts 2024), and classified as Campbell albatross, grey-headed albatross, or undefined (if it was not possible to distinguish the species). Within the species classification, they were classified by activity into sitting, loafing, or undefined. To determine if a bird was sitting, it had to be on a nest (of any size) and have the correct posture (sitting tightly, feet and legs not visible, the wing tips and tail sloping down). Differentiating between sitting and loafing was not always possible depending on the photograph quality (if colonies are a long distance away from the photo point) and angle (if rocks, vegetation, or birds are blocking parts of the bird) of the photograph and these birds were therefore classified as undefined.

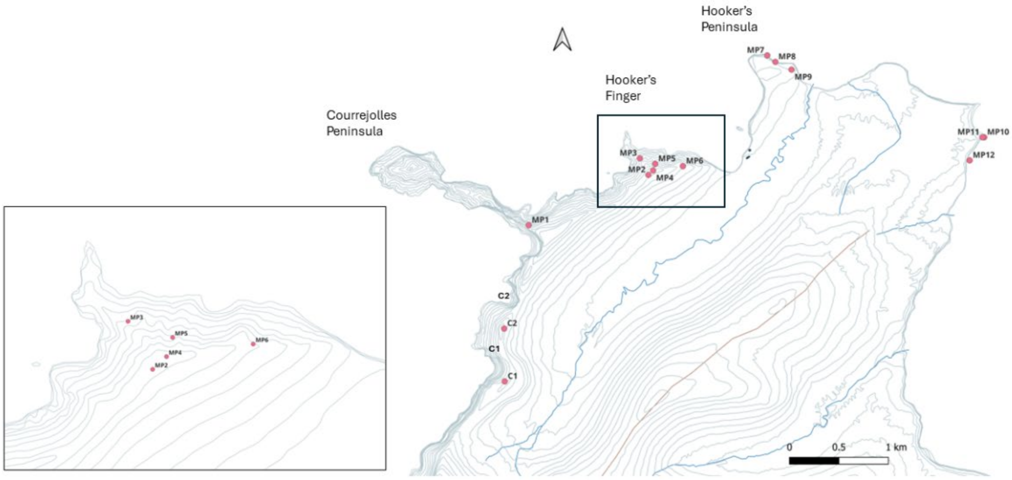

Fig. 7. Map showing photo point locations for Campbell and grey-headed albatross counts on Campbell Island. Pink dots show the actual photo point locations with blue dots indicative of access.

To combine undefined species into either Campbell or grey-headed albatross, proportions from the known species classification for specific count sections were used. For example, if 89% of birds sitting in a section were identified to be Campbell albatross, 11% were grey-headed albatross, and 284 birds were unidentified species but known to be sitting, then 253 birds were added on to Campbell sitting and 31 birds to grey-headed. The same process was done for undefined activity. These extrapolations followed those used by Frost (2019) for consistency and count comparisons.


a)

b)

Fig. 8. Images showing a) remote camera set up at grey-headed albatross nests at Bull Rock South on Campbell Island, and b) nest coverage of grey-headed albatross by one remote camera. Cameras were used to monitor breeding success data (Photos: B. Philp)

Since peak egg laying for Campbell and grey-headed albatross is assumed to be around 10 October, counting in December results in a lower number of nests as some nests will have failed. To account for these losses, Moore (2004) developed regression equations (-0.1468x + 141.39 for those colonies dominated by Campbell and -0.3144x + 189.55 for those dominated by grey-headed albatross, where x is equal to the day of year on which photographs were taken). These formulae were used to determine the final estimate of apparently nesting Campbell and grey-headed albatross.

In order to assess the proportion of nests still active with an egg or a chick, a ground survey was conducted on 6 December 2023 in four transects in the Bull Rock South colonies (see Fig. 3 in Rexer-Huber et al. (2020) for an overview of transect locations). Species were divided into Campbell and grey-headed albatross, and activity was categorized as sitting (bird sitting on an egg or chick), empty (bird sitting on a nest but with no egg or chick), and loafing (loose birds walking around in the colony or standing on an empty nest bowl). This ground survey was not used as a 'correction factor' because it only applies to one colony and does not necessarily represent what is happening at other colonies, and because of the uncertainty around what a bird on an empty nest means (i.e. it may or may not have had an egg).

For the breeding success objective, five cameras (Swift Enduro Outdoor Cameras Australia with 32 GB SD cards) were deployed on grey-headed albatross nests at Bull Rock South (Fig. 8a, 9). The cameras covered 28 nests, all of which contained an egg. Distance from the nests varied depending on where the best location for the camera was to capture the largest number of nests. A photograph was taken from behind the camera to capture and mark the nests and note nest contents for those visible within the camera photograph (Fig. 8b). Cameras were programmed to take one photograph every two hours between 0600 and 2000 hours. Gorilla Roof and Gutter silicone sealant was used around the edges of the camera and in any holes (for plugs or microphone) to prevent water seeping into the seals. Cameras were attached with wire to a wooden stake (Fig. 8a) with a side stake added for stability.

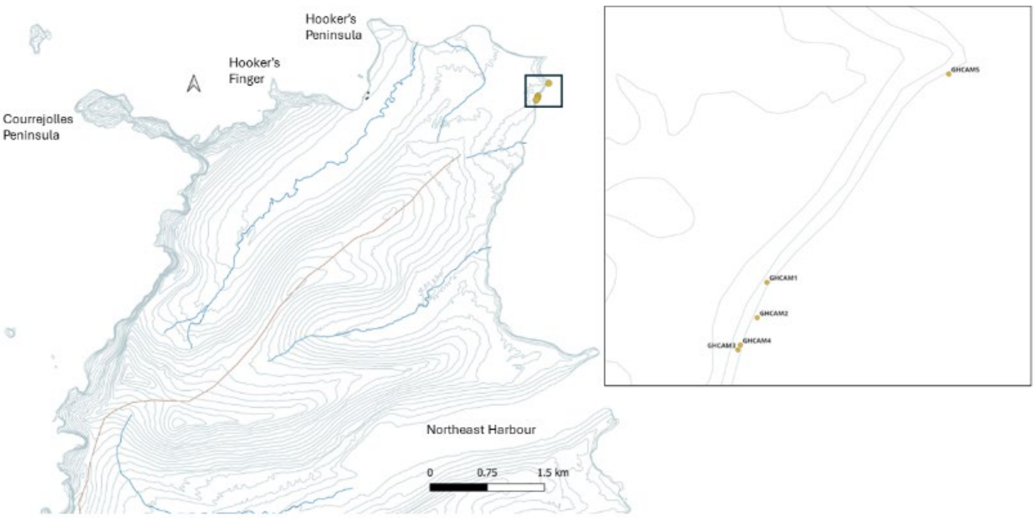

Fig. 9. Map showing locations of remote camera deployments on grey-headed albatross nests at Bull Rock South on Campbell Island. Camera is used to capture breeding success data.

For the demographics objective, all birds (both Campbell and grey-headed) which were seen during the ground survey transects at Bull Rock South were checked for bands. If incubating birds had a band, they were not removed from the nest to reduce disturbance, and the number was read while the bird was sitting. Non-breeding birds or birds walking around which had a band were captured to read the band.

Light-mantled sooty albatross (Objective 3a-c)

To meet the first objective of finding accessible nests, Moore (1996) was used as a starting point as this is the last time a comprehensive survey of light-mantled sooty albatross had been done. Breeding monitoring areas, mainly Beeman Hill and north-west Lyall ridge, that had been used by Moore (1996) were visited and searched on the ground for nests by searching steep vegetated areas or exposed rock outcrops. Flying and calling birds in an area were also used as indicators and this led to the discovery of new sites east of Lyall ridge. Scanning with binoculars is not effective in non-coastal areas as birds are hidden by vegetation and topography. Searches were conducted when time and weather permitted, with empty nest bowls initially marked but this was not continued consistently throughout all search areas.

Fig. 10. Image showing light-mantled sooty albatross with a satellite tracker attached to the back using Tesa tape and two cable ties (Photo: T. Thompson)

Ten PTT satellite trackers (of which three were experimental solar-powered units) were deployed on light-mantled sooty albatross loitering or standing near nests. No birds sitting on a nest with an egg or chick were captured to avoid abandonment due to the flighty nature of the species. Once a bird was seen on an accessible ledge, one person carrying a hand net would move slowly towards it (while crouching down), taking small breaks along the way to avoid panicking by the bird. Once the person was within reach of the bird with the hand net, they would quickly swoop the net over top of the bird. Of the three solar trackers, two were mounted on a baseplate on the tail, and one on a baseplate on the back. Of the remaining seven, one was attached onto the back with Tesa tape, three were attached onto the back with Tesa tape and two cable ties, and three were mounted onto the tail with Tesa tape and two cable ties (Fig. 10). Trackers were attached using the same “feather clumps” methods as described above for southern royal albatross. Birds were not metal banded.

For breeding success, a total of 11 cameras (Swift Enduro Outdoor Cameras Australia with 32 GB SD cards) covering 14 nests were deployed on light-mantled sooty albatross nests (nine with an adult and egg, one with an adult brooding a chick – this nest failed and the camera was moved to a nest with a post-guard chick, and four with post-guard chicks) at various locations (Fig. 11). Distance from the nests varied depending on where the best location for the camera was to capture the largest number of nests. Cameras were programmed and sealed the same way as described for the southern royal albatross. Cameras were attached with wire to a plastic waratah (*n* = 2) or a wooden stake with a side stake added for stability.

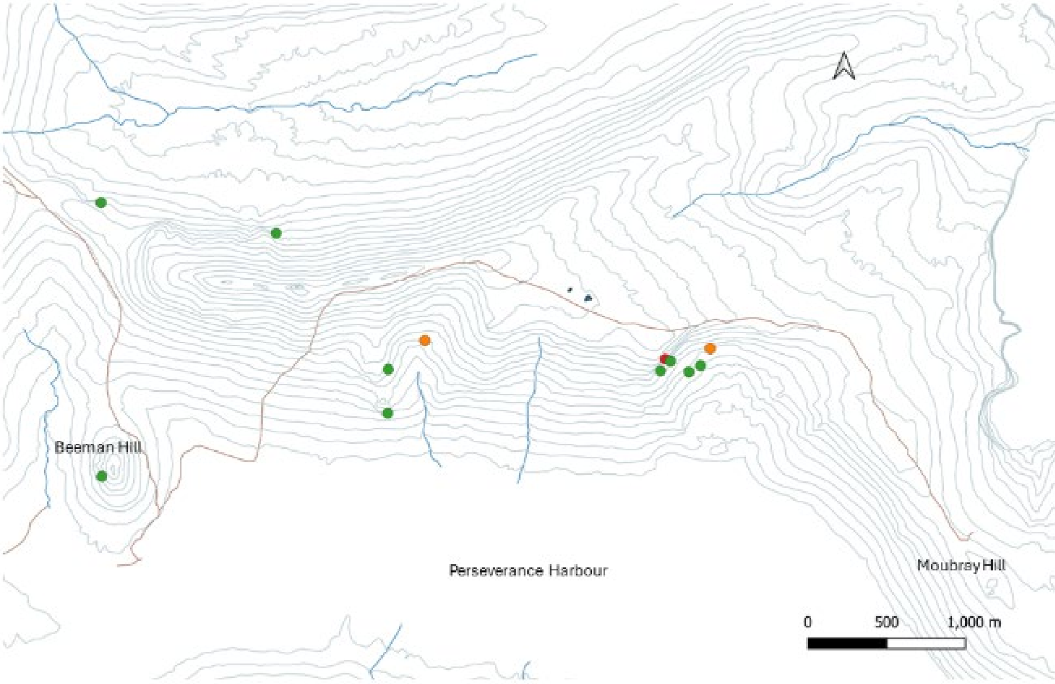

Fig. 11. Map showing light-mantled sooty albatross nest locations (green) where a remote camera was deployed to monitor breeding success on Campbell Island in 2023/24. Orange indicates one camera covering two nests, and red indicates a nest that had a camera deployed but failed and the camera was re-deployed elsewhere.

Antipodean albatross (Objective 4a-c)

The three objectives for the Antipodean albatross were all dependent upon locating birds in previously known nesting areas. Historical records for the number and locations of Antipodean albatross are very scarce and difficult to find due to data being collected haphazardly during the Meteorological Station era (1940s-1995). In 2023/24, an opportunistic search was conducted while traveling along the Lyall-Moubray ridge and counting southern royal albatross nests in the Moubray study area, where most Antipodean albatross have been found in recent decades (P. Moore, unpubl. data). Some male birds were found sitting on empty nest bowls since the timing was prior to egg laying. Once found, all bird locations were marked with a GPS point. Blood (0.2 mL) was collected from the tarsus and stored in Queen's buffer. Measurements included culmen length and culmen tip bill depth (Appendix Fig. A2). A wide selection of photographs was taken of each bird to help determine sex and GPI (Gibson Plumage Index; Appendix Fig. A3). For demographics, each bird was checked for bands. If they were previously banded, the band was checked to ensure it remained in suitable condition, and replaced if it was not. If the bird was unbanded, it was banded with a metal (R size) band on the right tarsus and a green alpha-numeric darvic band on the left tarsus.

Northern giant petrel (Objective 5a)

This objective involved opportunistic counting and mapping of nests while traveling across the island. The GPS locations of previously located nesting areas were provided to the team (K. Rexer-Huber, pers. comm.; Rexer-Huber et al. 2020) to determine if those sites remain active.

White-chinned petrel (Objective 6a)

This objective was the lowest priority, and involved opportunistically counting and mapping of any burrows found while traveling across the island for other species work. White-chinned petrel burrows generally have a very muddy and large entrance and are therefore distinguishable from other species. The GPS locations of previously located burrows were provided to the team (K. Rexer-Huber, pers. comm.; Rexer-Huber et al. 2020) to determine if those areas have undergone an increase in the number of burrows, and to determine whether any new burrows found on the island were indeed newly discovered.

Results

Southern royal albatross (Objective 1a-e)

Counts of nests for all study and index areas were conducted. All parts of Col were visited at least 2-3 times, and eastern and central parts were visited several more times to maximise the number of breeding partners encountered. Moubray and the three index count areas were visited only once. Numbers from surveys conducted between 1987/88 to 2023/24 are shown in Table 1. Nest numbers in Col and Moubray study areas in 2023/24 remain higher than they were in 1987/88, but are the lowest counts since 1991/92 (Fig. 12). Counts at Faye, Paris, and Honey index areas in 2023/24 were all the lowest compared to the rest of the survey years. When examining the percent change between the decades (Table 2, Fig. 13), there has been a decline across all years since the 1990s. Col initially remained stable between the 1990s to the 2000s but has declined at 24% since. Moubray apparently peaked in numbers in the late 1990s but decreased 24.5% since the 2000s. Paris has undergone the greatest declines across all surveys compared to the other areas, with the percent change doubling between 1990s-2000s and 2000s-2020s, and an overall decline of 46%. Faye has the second worst declines particularly between 2000s to 2020s. Honey had a relatively large decline in 1990s-2000s. Across all survey years, Paris has declined the most at 46.2%, followed by Faye (34.6%), Honey (28.4%), Moubray (27.3%), and Col (23.6%). The average across all areas between 2000s and 2020s is a 26.2% decline, and this was higher when comparing between 1990s to 2020s at 32%. Due to expected annual variation in counts caused by nesting success in the previous season (i.e. failed breeders will breed in consecutive years), counts in 2024/25 are essential for clarifying the current trend.

Table 1. Southern royal albatross nest counts completed at respective study (Col and Moubray) and index areas (Faye, Paris, Honey) in various seasons. Nest count data were collated from Moore & Moffat 1990, Moore et al. 1997, P. Moore unpubl. data 1997/98-1998/99, Moore et al. 2012).

	Study or Index area				
Season	Col	Moubray	Faye	Paris	Honey
1987/88	128	344	-	-	-
1991/92	158	376	-	-	-
1992/93	187	400	-	-	-
1993/94	170	435	-	-	-
1994/95	189	489	-	-	-
1995/96	201	508	-	-	-
1996/97	188	508	598	394	433
1997/98	200	551	657	439	400
1998/99	203	564	639	489	428
2004/05	207	506	598	-	-
2005/06	185	462	537	-	-
2006/07	182	494	572	332	336
2007/08	196	492	563	334	402
2008/09	214	569	609	435	377
2019/20	137*	-	-	-	-
2023/24	150	381	413	237	301

*adjusted nest count to Dec/Jan as actual count done in March

For the first part of the demographic objective (resight previously marked birds), 16 previously marked birds were found breeding in Col, four of which were males (one band and three transponders) and 12 females (all banded). The majority of males at Col had their bands removed and replaced with PIT tags during the 2000s (Moore et al. 2012). Scanning males for PIT tags was problematic in 2023/23 and probably contributed to fewer males being found than females. The more nervous birds did not tolerate having their neck and back “ironed” with the reader – some were consequently avoided or given a quick perfunctory scan. Successful scanning required close contact with the inner part of the circular reader and that was less often achieved if the bird was in its natural sitting position as opposed to stretching the neck forward. A trial with a wand style of PIT reader indicated a higher reading success rate with less disturbance to the birds. Four non-breeding banded females were also found at Col. The oldest female was a non-breeder banded as a chick in August 1988, the youngest female was a breeder banded as a chick in September 1996, the oldest male was a breeder banded as a chick in August 1995, and the youngest male was a breeder banded as a chick in September 1997. One intact breeding pair was found at Col – they previously bred successfully in 2005/06 and 2007/08, with the male banded as a chick in 1995/96. There were also six previously banded birds found at Moubray, of which one was a male and five females. The oldest female was banded as a chick in September 1987, and the youngest female and male were both banded as chicks in October 1997. Note that most bands were removed from males at Moubray during the 2000s (Moore et al. 2012).

Table 2. Percent change calculated between survey periods of southern royal albatross nest counts in study and index areas on Campbell Island. Weighted average was calculated using counts from seasons where all study and index areas were surveyed (*n*=7, Table 1).

	% change		
Area	1990s to 2000s	2000s to 2020s	1990s to 2020s
Col	0.2	-23.8	-23.6
Moubray	-3.7	-24.5	-27.3
Faye	-8.8	-28.3	-34.6
Paris	-16.7	-35.4	-46.2
Honey	-11.6	-19.0	-28.4
Weighted Average	**-8.9**	**-26.5**	**-32.8**

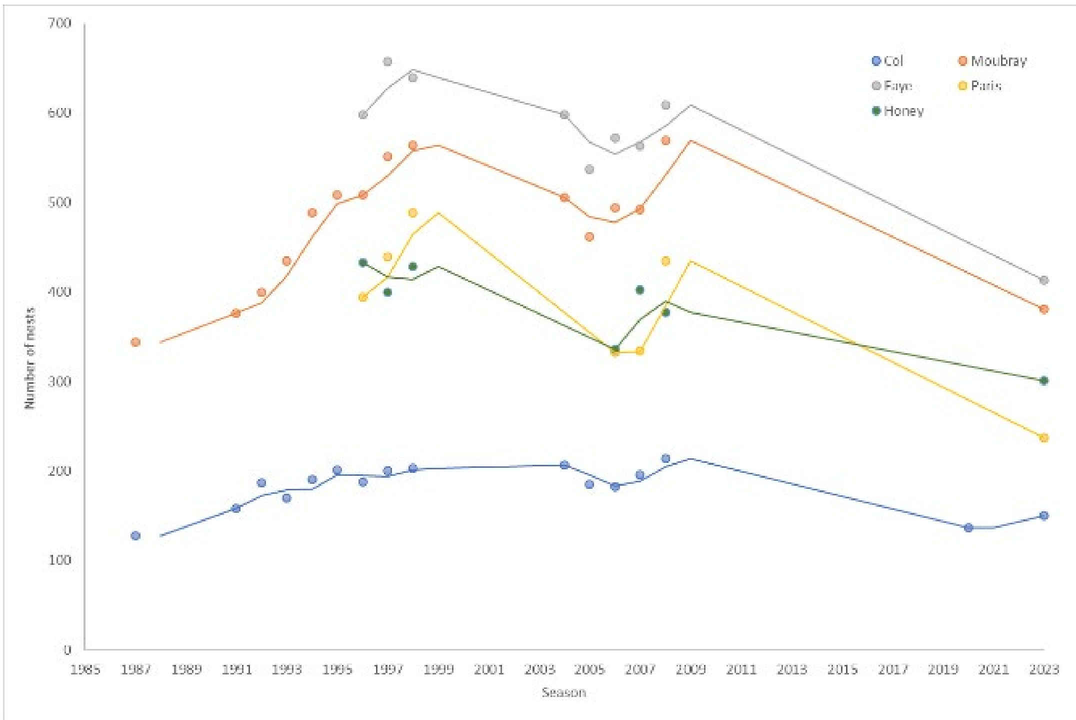

Fig. 12. Graph showing nest count data of southern royal albatross over survey seasons in study or index areas on Campbell Island. Lines are indicative of moving averages with a period of two.

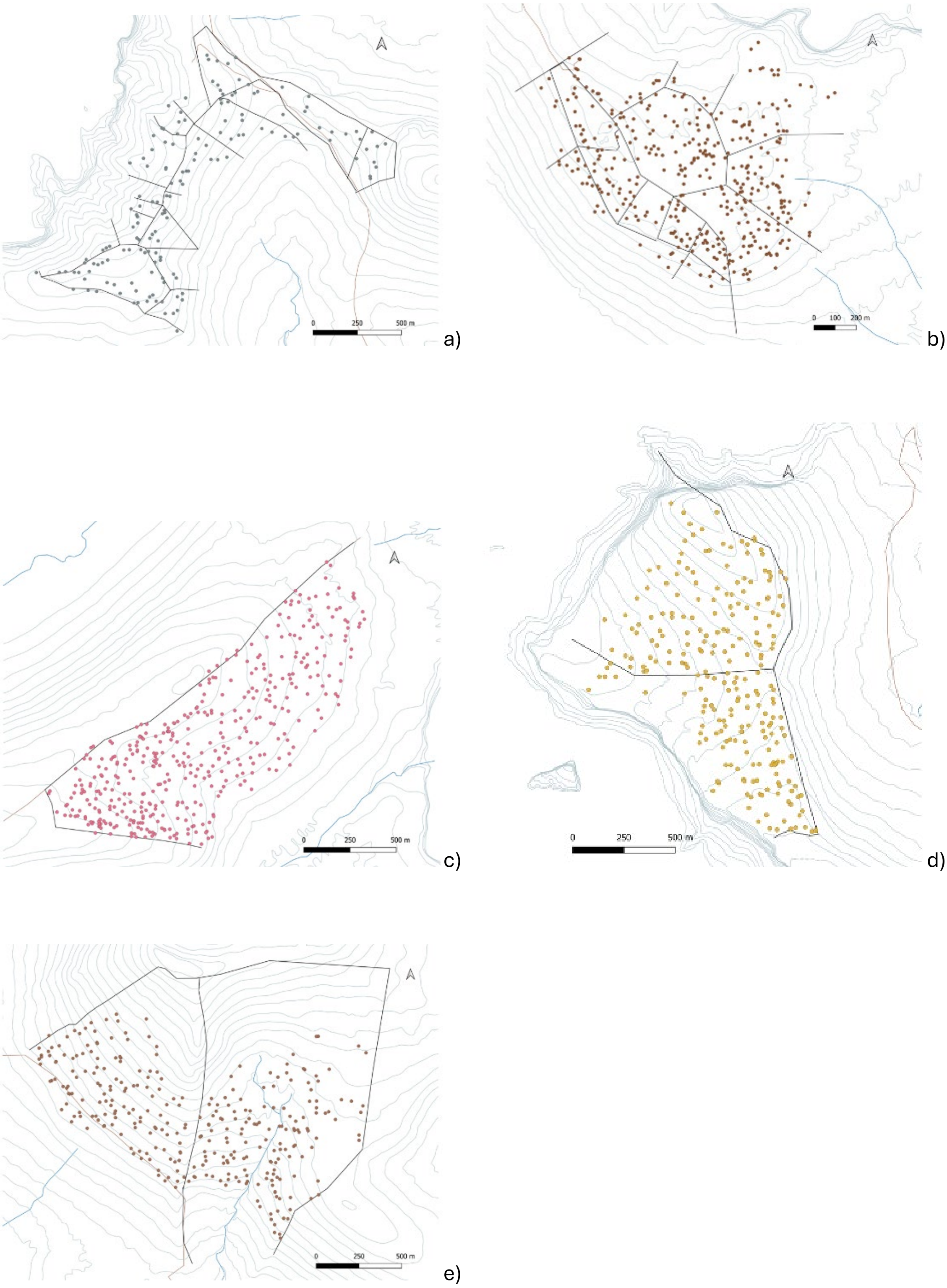

Fig. 13. Nest locations of southern royal albatross in 2023/24 in the study area of a) Col and b) Moubray, and in the index areas of c) Faye, d) Paris, and e) Honey on Campbell Island.

For the second part of the demographic objective (marking of unbanded adults for a total of 200 pairs in Col over two seasons), a total of 113 nests in Col had both partners marked, 12 nests had the female marked only (one of which failed and hence the partner could not be seen this season), and 18 nests had the male marked only (two of which failed and hence the partners could not be seen; Fig. 14)

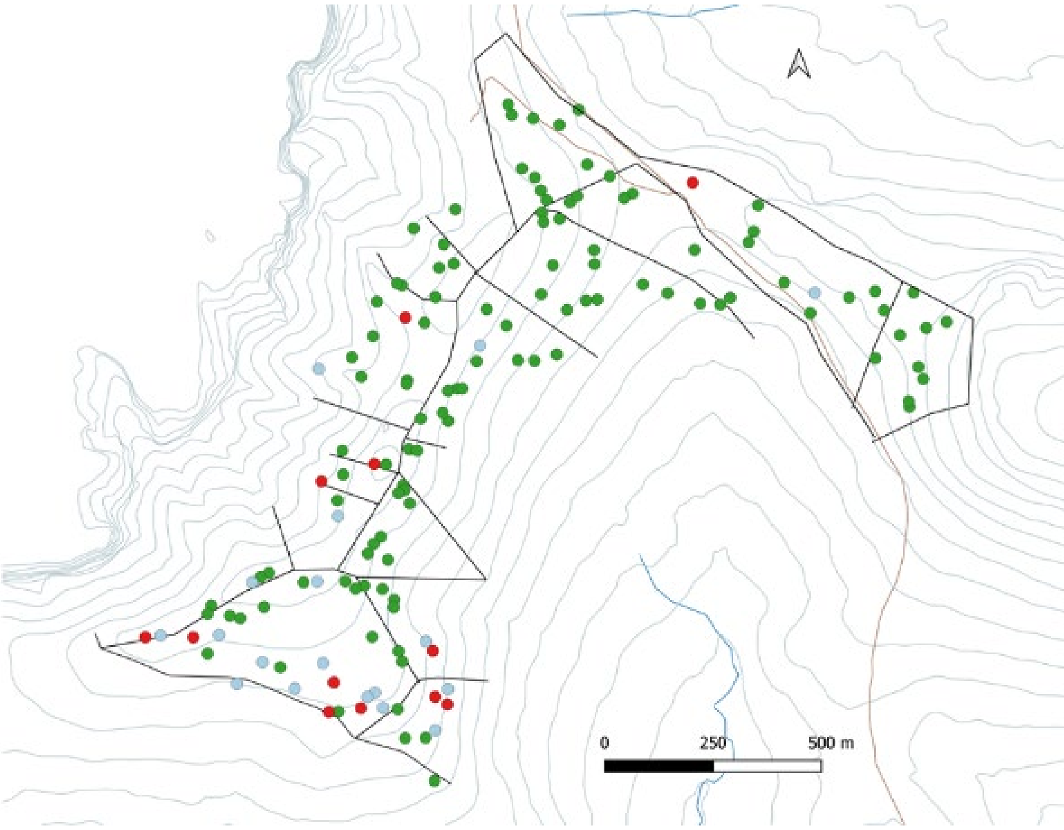

Fig. 14. Map showing nest locations (*n* = 113) of southern royal albatross in the Col study area where both partners were banded (green), only the female was banded (red), and only the male was banded (blue) on Campbell Island in 2023/24.

For the at-sea tracking objective, 15 satellite tags were deployed on females in the Col study area, 19 tags were deployed on males, and one tag was initially deployed on a male but was found to be poorly aligned and hence it was removed and redeployed on a female (overall total is deployment on 16 females and 19 males; Fig. 15). As an overview, tracks show birds moving north to the Chatham Rise, west to Tasmania, south towards Antarctica, and to the Patagonian Shelf east of Argentina (Fig. 16). The results of this will provide short-term high-resolution insight into distribution and fisheries risks assessment and will be summarized in a separate report. For GLS devices, 28 new GLSs were deployed in the Col study area of which 16 were on males and 12 on females. Additionally, three new GLSs were deployed on non-breeding female birds which were then retrieved again and redeployed on breeding female birds. Three previously deployed GLSs were retrieved, downloaded, and redeployed – all three were retrieved from males, and two were redeployed on males and one on a female. Three previously deployed GLSs were retrieved but could not be redeployed due to devices no longer functioning. Results from this will provide long-term low-resolution insight into distribution and fisheries risks assessment and will be summarized in a separate report.

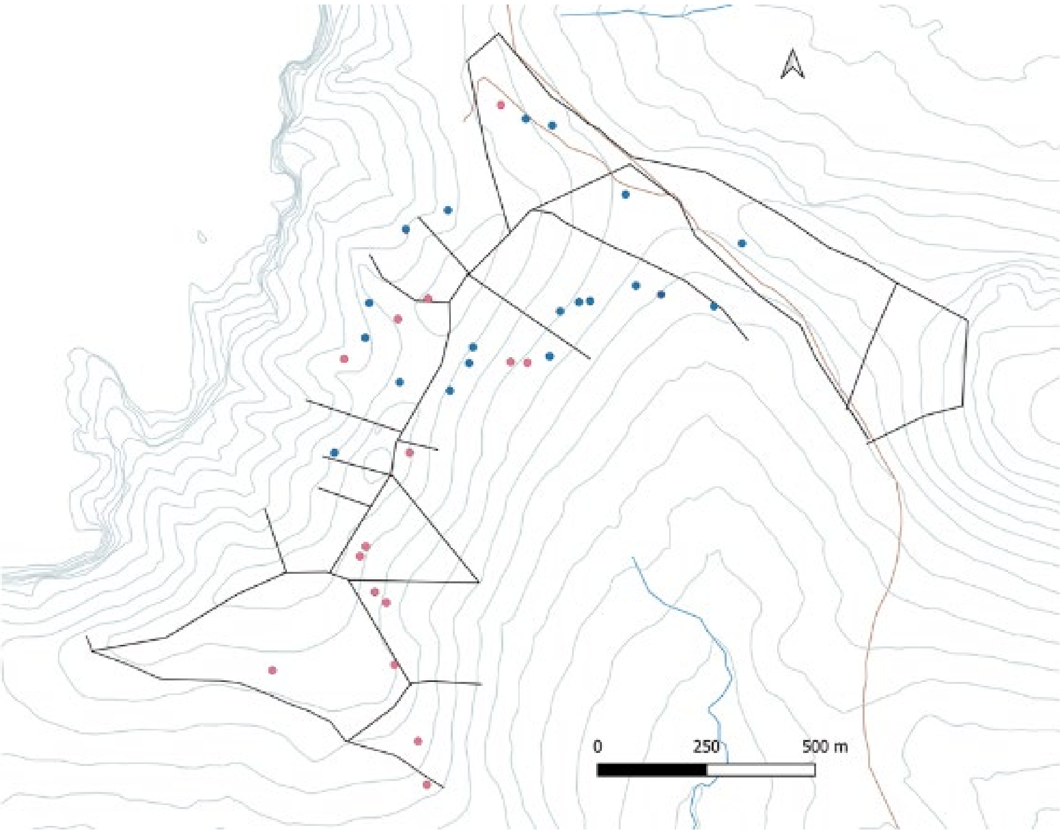

Fig. 15. Map showing nest locations of southern royal albatross at the Col study area where the male (blue) and female (pink) partner was fitted with a satellite transmitter on Campbell Island in 2023/24.

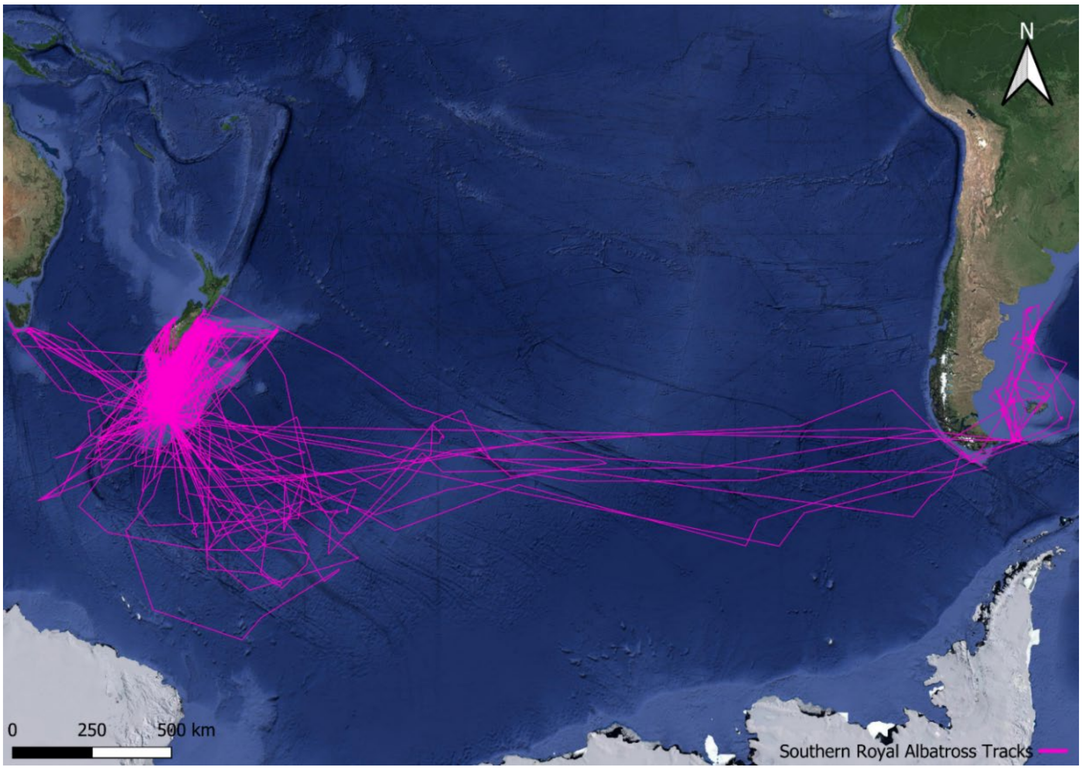

Fig. 16. Satellite tracks from devices deployed on 35 Southern royal albatross in the Col study area on Campbell Island. Tracks cover the period from deployment until 11 May 2024.

Grey-headed albatross (Objective 2a-c)

Overall counts for both Campbell and grey-headed albatross from photo points were lower than during the 2019/20 survey (Frost 2019). Table 3 has been adjusted to allow by removing counts done from aerial photographs in 2019/20 to allow for direct comparisons. It is very notable that the number of loafing birds was much higher in 2023/24 than 2019/20 for Campbell albatross in all areas except Hooker's Peninsula. For grey-headed albatross, there was an increase in the number of loafing birds for Correjolles Peninsula and Hooker's Finger only. For Courrejolles Peninsula areas, there were large unvegetated sections where birds were loafing on sheer rock. The only increase in the number of sitting birds for both Campbell and grey-headed albatross was at Courrejolles Isthmus. The combined total of sitting and loafing Campbell albatross is 17,586 in 2023/24 compared to 20,953 in 2019/20 (16.1% decline), and 4,673 in 2023/24 compared to 6,453 in 2019/20 (27.6% decline) for grey-headed albatross.

Table 3. Number of sitting and loafing Campbell and grey-headed albatross individuals from photo point counts done in 2019/20 (24 Nov 2019) and 2023/24 (6 and 14 Dec 2023). Data from 2019/20 adapted from Frost (2019) and P. Frost raw data to exclude all aerial photograph counts as well as Courrejolles Isthmus excluded an area called JDK, Bull Rock North excluded areas 1c, 16-18, Bull Rock South excluded area 10. 'Sitting' birds were assumed to be breeding birds on an egg or chick, and 'loafing' birds were non-breeding birds.

	Campbell				Grey-headed			
	Sitting		Loafing		Sitting		Loafing	
Area	2019	2023	2019	2023	2019	2023	2019	2023
Courrejolles Peninsula	7305	4180	1438	4088	3089	1844	739	1054
Courrejolles Isthmus	133	149	45	110	128	135	89	67
Hooker's Finger	1127	785	154	738	850	660	137	224
Hooker's Peninsula	347	156	109	94	303	146	192	117
Bull Rock North	3190	2335	794	856	512	305	78	24
Bull Rock South	5277	2947	1034	1148	290	76	46	21
TOTAL	**17379**	**10552**	**3574**	**7034**	**5172**	**3166**	**1281**	**1507**

When examining percent change (Table 4) between the survey years for each area, the largest decrease for sitting Campbell albatross was seen at Hooker's Peninsula. The average percent change of Campbell albatross between 2019/20 and 2023/24 was a decrease of 6.9%. The greatest decrease in sitting grey-headed albatross was seen at Bull Rock South. The average percent change of grey-headed albatross between 2019/20 and 2023/24 was a decrease of 34.0%.

Table 4. Percent change between 2019/20 and 2023/24 surveys calculated from data in Table 3 for each respective area and species. 'Total' represents the overall total percent change.

	Campbell			Grey-headed		
Area	Sitting	Loafing	Total birds	Sitting	Loafing	Total birds
Courrejolles Peninsula	-42.8	184.3	-5.4	-40.3	42.6	-24.3
Courrejolles Isthmus	123.1	144.4	45.5	5.5	-24.7	-6.9
Hooker's Finger	-30.3	379.2	18.9	-22.4	63.5	-10.4
Hooker's Peninsula	-55.0	-13.8	-45.2	-51.8	-39.1	-46.9
Bull Rock North	-26.8	7.8	-19.9	-40.4	-69.2	-44.2
Bull Rock South	-44.2	11.0	-35.1	-73.8	-54.3	-71.1
Average of percent change	**-12.7**	**118.8**	**-6.9**	**-37.2**	**-13.5**	**-34.0**
TOTAL	**-39.3**	**96.8**	**-16.1**	**-38.8**	**17.6**	**-27.6**

Using the regression formulae developed by Moore (2004) to adjust for nest failures prior to the photo point counts on 6 and 14 December 2023, the total number of nesting Campbell albatross was 11,853 and 3672 for grey-headed albatross (Fig. 17). Comparisons between surveys need to be done with caution as different methods were used during different years. When compared to the 1940s, it is a 61.8% decline for Campbell albatross and a 91.5% decline for grey-headed albatross (Frost 2019; Fig. 17). Note that the number of Campbell albatross nests in Fig. 17 was adjusted (as in Frost 2019) to 14,129 nests to hypothetically include counts from the Eastern Colonies (this was also done for the 2006-12 surveys – an average of 2276 nests was added as the count in 2004 for the Eastern Colonies had been 2257 in 1995-96 and 2295 in 2019/20; Frost 2019).

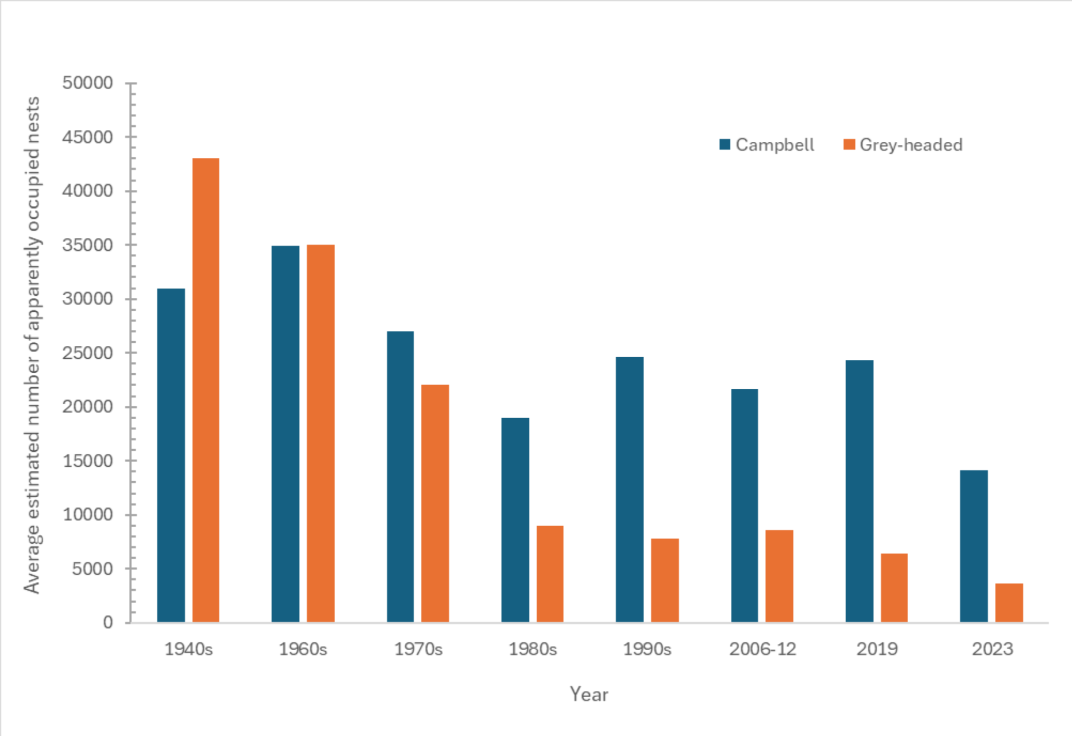

Fig. 17. Overall change in the number of Campbell and grey-headed albatross nests on Campbell Island as summarized by Frost (2019). Regression formulae have been used to adjust the total nest numbers to those expected in early October (as developed by Moore 2004). Campbell albatross numbers have been adjusted for 2006-12 and 2023 to hypothetically include Eastern Colonies. See Moore (2004), Sagar (2014), and Frost (2019) for further details. Caution is required when using this graph as different methods were used between years (i.e. aerial photographs in 2019/20).

Assessing the proportion of nests still active with an egg or a chick by ground surveys was conducted at Bull Rock South using transects outlined by Rexer-Huber et al. (2020). For Campbell albatross in 2023/24, total number of birds at Bull Rock South was 4095 of which 72% were designated as sitting which is much higher than when this is compared to the ground survey transects (Table 5) where the total % of sitting birds was 55.4%. This could indicate that only 2269 individuals were sitting in the photo views. For grey-headed albatross, the total number of birds at Bull Rock South in 2023/24 was 97 of which 78.3% were counted as sitting. This is very comparable to the ground survey transect count where 76.6% of the total number of birds were sitting. As outlined in methods, this ground survey was not used as a 'correction factor' because it only applies to one colony and does not necessarily represent what is happening at other colonies, and because of the uncertainty around what a bird on an empty nest means (i.e. it may or may not have had an egg).

Table 5. Number of birds counted while carrying out ground truthing transects (6 Dec 2023) as outlined by Rexer-Huber et al. (2020) at Bull Rock South. a) were Campbell albatross counts, and b) were grey-headed albatross counts. 'Sitting' were birds incubating an egg or guarding a chick, 'empty' were birds sitting on a nest but which did not have anything in the nest, 'loafing' were loose birds walking around in the colony or standing on nest bowls.

a)

Transect	Sitting	Empty	Loafing	Total birds on nest	Total birds	% empty of birds on nest	% loafing of all birds	% birds sitting of total birds
1	51	18	9	69	78	26.1	11.5	65.4
2	35	26	15	61	76	42.6	19.7	46.1
3	16	19	3	35	38	54.3	7.9	42.1
4	41	22	3	63	66	34.9	4.5	62.1
Total	**143**	**85**	**30**	**228**	**258**	**37.2**	**11.6**	**55.4**

b)

Transect	Sitting	Empty	Loafing	Total birds on nest	Total birds	% empty of birds on nest	% loafing of all birds	% birds sitting of total birds
1	80	20	8	100	108	20.0	7.4	74.1
2	12	2	2	14	16	14.3	12.5	75.0
3	2	1	2	3	5	33.3	40.0	40.0
4	47	6	2	53	55	11.3	3.6	85.5
Total	**141**	**29**	**14**	**170**	**184**	**17.1**	**7.6**	**76.6**

For demographics, there were 57 banded birds resighted, 13 of which were Campbell albatross and 44 grey-headed albatross. Of the Campbell albatross, five were breeding, six were on an empty nest, and two were loafing. Of the grey-headed albatross, 39 were breeding, four were on an empty nest, and one was loafing. Detailed band information is shown in Appendix A1.

Light-mantled sooty albatross (Objective 3a-i)

For the opportunistic population mapping objective, previously known nesting areas were searched and new areas were identified by using the presence of active birds. Due to time restraints, the search was restricted to Beeman Hill, Lyall ridge and Moubray areas (Fig. 18).

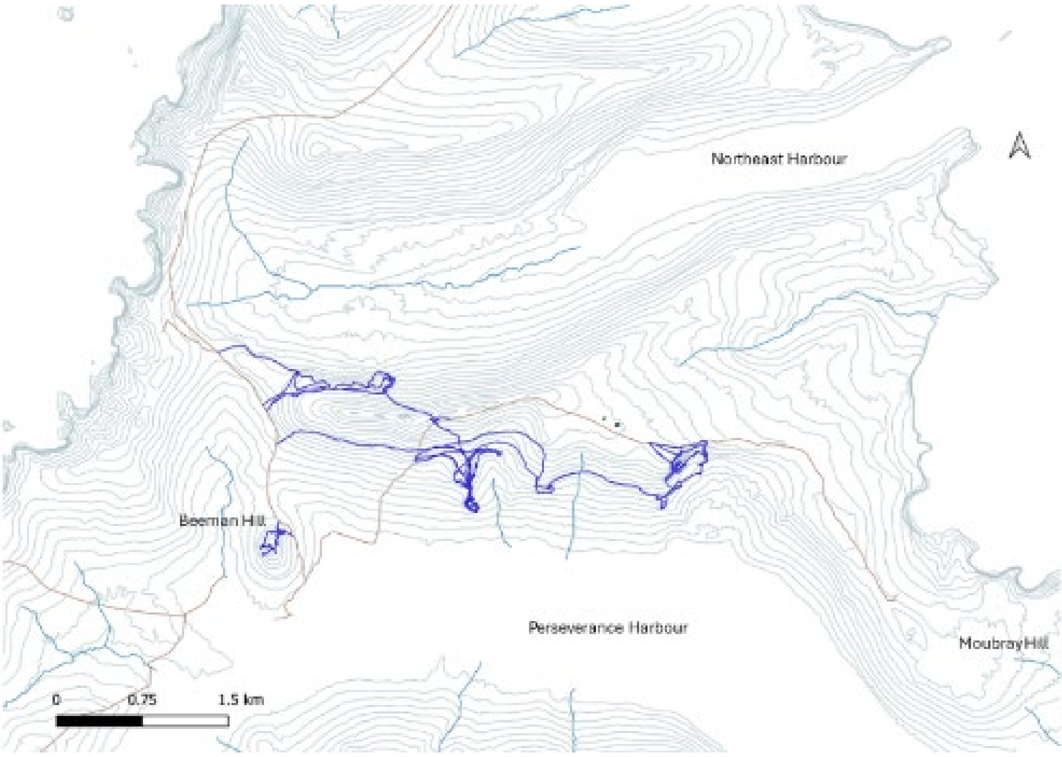

Fig. 18. Map showing track and location of where light-mantled sooty albatross nests were searched for by two observers on Campbell Island during 2023/24.

A total of 27 active and accessible nests were located and 36 old nest bowls were marked (Fig. 19). Consistency in marking old nests bowls was not maintained and this is therefore not a comprehensive count – old nest bowls are an indication of previous breeding activity, since they can remain intact for many years. Compared to the survey conducted in 1995/96 (Moore 1996), fewer active nests were found along the Lyall ridge area in 2023/24. Moore (1996) counted four occupied nests on the north side of Lyall Plateau and 12 occupied nests on the adjacent north-west Lyall Ridge. Of these 16 nests, 12 were known to have eggs (Moore 1996). In comparison, one occupied was found at Lyall Plateau and two active nests on north-west Lyall Ridge in 2023/24. On Beeman Hill, Moore (1996) found five active nests compared to one active nest in 2023/24. The habitat appeared to be much more overgrown compared with the 1990s (P. Moore, pers. obs.). The remainder of active nests (23) located in 2023/24 were located in areas not searched by Moore (1996).

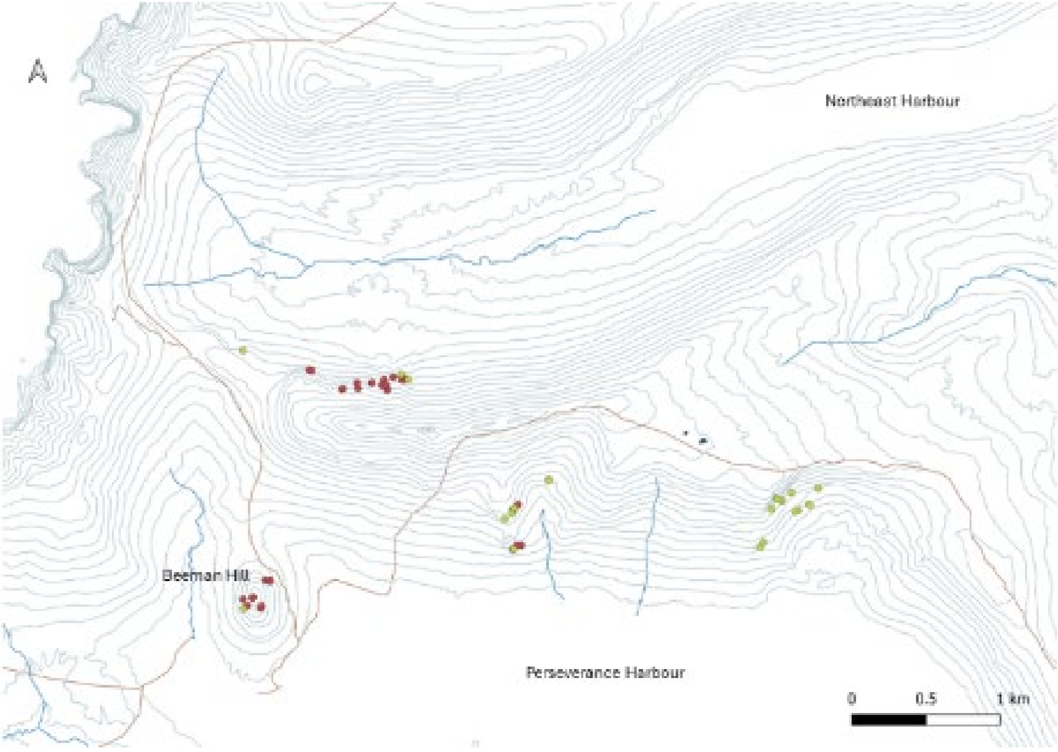

Fig. 19. Map showing light-mantled sooty albatross nests found while conducting searches on Campbell Island during 2023/24. Green indicates active nests, and red indicate old nest bowls from previous years.

The results from the ten PTT satellite trackers which were deployed on light-mantled sooty albatross will provide short-term high-resolution insight into distribution and fisheries risks assessment and will be summarized in a separate report. As an overview, most of the individuals have travelled south towards Antarctica (Fig. 20, 21).

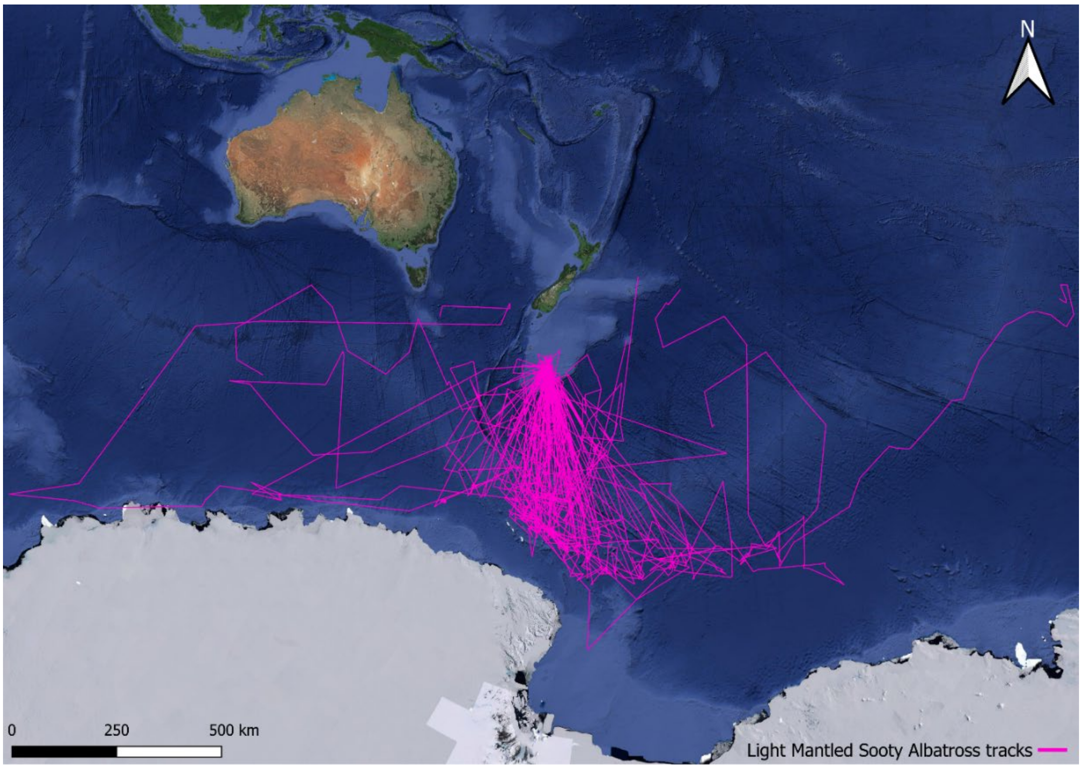

Fig 20. Satellite tracks from devices deployed on ten light-mantled sooty albatross on Campbell Island. Tracks cover the period from deployment until 11 May 2024.

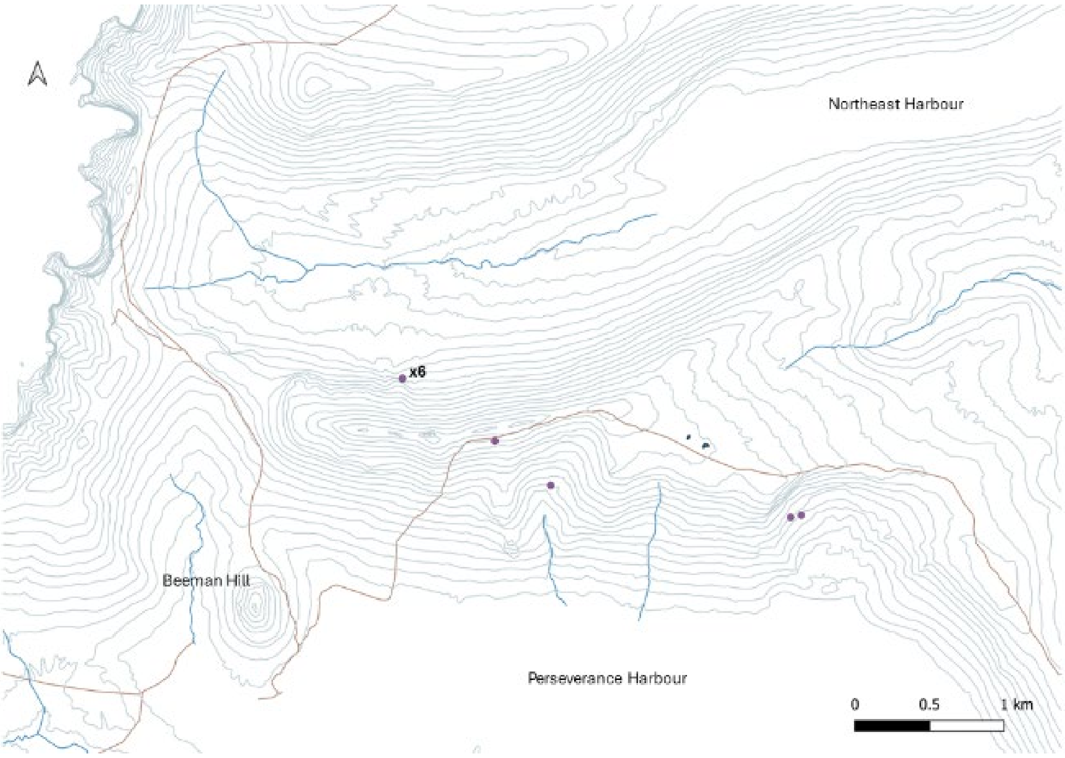

Fig. 21. Map showing light-mantled sooty albatross locations where birds were fitted with a satellite tracker on Campbell Island during 2023/24. Six trackers were deployed at one location (dot with 'x6').

Antipodean albatross (Objective 4a-c)

A total of eight Antipodean albatross were found, all of which were on the Lyall-Moubray ridge and Moubray study area (Fig. 22). Three of the birds were banded, one of which was replaced, and another had a skew that was tightened up (Table 6). All birds were found while carrying out southern royal albatross counts in or west of the Moubray study area in early January. There was a nearly fledged chick near two banded male birds that were found displaying with an unbanded female, and a few individuals were nest building. No eggs were present yet. This count is not comprehensive as no other areas outside of the royal albatross study and index areas were searched. Several unbanded flying birds were seen when traveling back to Beeman Base from Moubray, but no other birds were seen when traveling on walking routes around the island. Moubray was visited only once and therefore partners of birds were not seen.

Table 6. Antipodean albatross data collected on Campbell Island during 2023/24. 'Band' indicates a bird previously banded, 'new band' indicates a newly banded or rebanded bird (on the right tarsus), 'darvic band (green)' indicates the colour band used on the left tarsus. See Appendix Fig. A2 for details on culmen length and culmen tip bill depth measurements.

Date	Band	Original band date	New band	Darvic band (green)	Culmen length (mm)	Culmen tip bill depth (mm)
1-Jan-24	-	-	R-65453	372	151.5	44.5
1-Jan-24	-	-	R-65454	373	144	39.4
4-Jan-24	-	-	R-65455	374	157	43.5
4-Jan-24	R-54369	6-Jan-99 (chick)	R-65456	375	145.5	42.2
4-Jan-24	-	-	R-65457	376	149.4	40.5
5-Jan-24	-	-	R-65458	377	151.8	40
5-Jan-24	R-45527	mid-1990s*	-	378	144.9	40.6
5-Jan-24	R-44098	1-Sept-92 (chick)	-	379	148	41.3

*no records were found of this bird but likely banded in the mid-1990s.

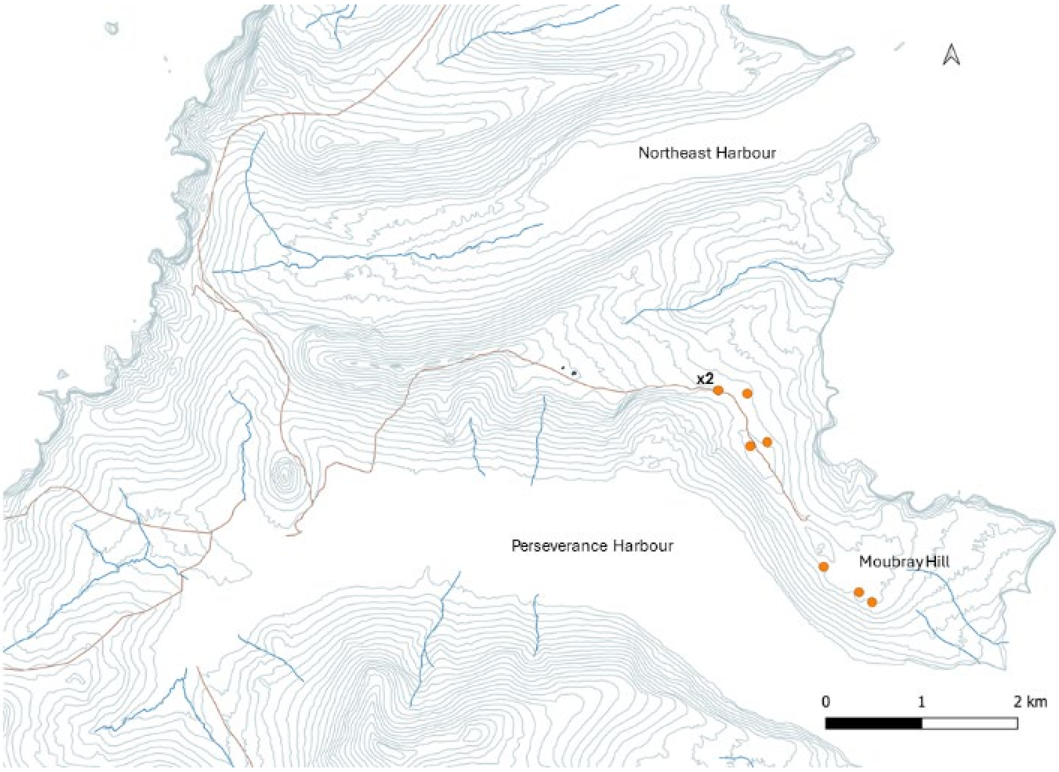

Fig. 22. Map showing locations of Antipodean albatross found on Campbell Island in 2023/24. Two birds were found at one location (dot with ‘x2’).

Northern giant petrel (Objective 5a)

Since it was an opportunistic survey, no comprehensive nest counts were conducted. There were chicks at some of the previously located nesting areas but not all areas were visited. It is therefore not possible to provide a clear update on population estimates. Thirteen approximate locations of where chicks were found are shown in Fig. 23.

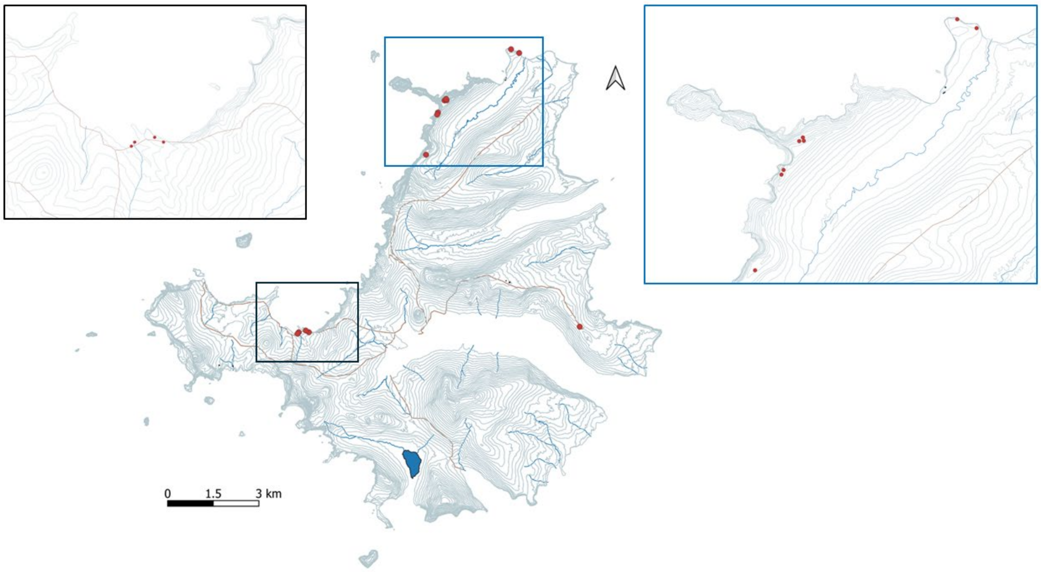

Fig. 23. Map showing approximate locations of northern giant petrel chicks opportunistically found on Campbell Island in 2023/24.

White-chinned petrel (Objective 6a)

Recent activity was noted in the southwest corner of the Southern royal albatross index plot of Paris on 21 January 2024 in previously marked burrows. No other burrows were opportunistically located while traveling across the island, and previous locations were not visited.

Other key opportunistic observations and tasks

Plastics and fishing equipment were opportunistically collected as seen while working and traveling across the island. This was done because plastic ingestion presents a problem for albatross species elsewhere around the world (Provencher et al. 2019, Phillips & Waluda 2020). Both Mischler (2020) and Moore et al. (2012) found small quantities of plastic in regurgitates on Campbell Island. The amount of plastic and fishing equipment which was collected is of great concern (Fig. 24).


a)


b)


c)

Fig. 24. Photos showing opportunistic collections of a) plastic pieces, b) plastic bottle lids, and c) fishing equipment while working and traveling on Campbell Island. All items were presumed to be from southern royal albatross since most were found amongst regurgitated material near nests.

Due to the looming threat of the HPAI (highly pathogenic avian influenza) virus arriving in the New Zealand sub-Antarctic islands, sampling of as many different bird species as possible was encouraged by the Department of Conservation (DOC) and the Ministry of Primary Industries (MPI). This involved swabbing of both the oral cavity and the cloaca, and keeping the samples as cold as possible. The appropriate personal protective equipment needed to be worn (i.e. gloves, goggles, mask) and hands needed to be sanitized post-sampling. The team screened 17 southern royal albatross, 13 northern giant petrels, four light-mantled sooty albatross, 18 skua, three red-billed gulls, three Antarctic terns, one black-backed gull, 11 eastern rock hopper penguins, and one erect crested penguin. These samples provide excellent baseline data for future detections of the virus.

Discussion

Nest numbers of southern royal albatrosses had been increasing overall during the 20th century, probably recovering from depredations and habitat destruction during the 1895-1931 farming era on Campbell Island (Guthrie-Smith 1936, Moore et al. 2012). The first coarse island-wide survey found 2278 nests in 1957 (Westerskov 1963), numbers fluctuating from 3216-5336 through the 1960s-1980s (Moore et al. 1997 and references therein) to 6308-7787 in 1994/95 and 1995/96. Early counts were probably underestimates due to the effort and methodology not being standardized. The last comprehensive population survey of southern royal albatross on Campbell Island was conducted between 2004/05-2008/09 with a composite count of 7855 nests representing 8300-8700 nests once survey accuracy and nest failure was taken into account (Moore et al. 2012). It was suggested from the island-wide counts that there had been a levelling in the population since the 2000s estimate was similar to 1995/96 (Moore et al. 1997, 2012). However, in areas where counts of comparable effort were made, one study area had remained stable (Col), and the second study area (Moubray) and three index areas (Faye, Paris, Honey) had all declined by 4-17% (Moore et al. 2012). A nest count done in March 2020 of the Col study area indicated the possibility of a more severe decline (Mischler 2020). The actual March 2020 count for Col was 104 nests, and this was adjusted to a January estimate of 137 nests based on expected nest failure by March, compared to an average nest number of 197 at Col between 2004-08 (Mischler 2020). Another count of Col was attempted in February 2023; however, the short duration of the trip did not allow for a full count (Mischler & Wickes 2023). Overlaying of the track surveyed in 2023 and comparing it to nest locations in Col in 2020 and 2004-08 showed similar nest numbers to 2020 thereby continuing to support the dramatic suspected decline (Mischler & Wickes 2023). Since southern royal albatross are biennial breeders, it was alarming that both cohorts appeared to be undergoing the same decline (as 2019/20 represented one cohort and 2022/23 another). To fully understand the population trend across Campbell Island, it was highly critical that the other four survey areas be counted.

The decrease in southern royal albatross nest numbers since the 1990s and 2004-08 across all of Campbell Island is very concerning. Repeating the nest counts across all 5 areas for another season (2024/25) will be important to capture the second cohort of breeders. As discussed in Mischler (2020), the decline could be indicative of a decline in breeders, changes in breeding frequency, or low juvenile recruitment. Albatross are highly vulnerable to bycatch in fisheries, at-sea threats, and changes in food supply due to climatic conditions (Cleeland et al. 2021, Patrick et al. 2020). Southern royal albatross feed on the southern and south-eastern shelf breaks of the Campell Plateau and an area south of the Snares Island along an inner shelf break which may cause overlap with fishing activities (Waugh et al. 2002, Jiménez et al. 2014). Between 2006/07 to 2016/17, southern royal albatross had been placed in the 'negligible' risk category (Richard et al. 2020) with most birds caught in surface- and bottom-longline fisheries between 2002/03 and 2015/16 (Abraham & Richard 2019). However, based on the most recent update to the risk assessment from commercial fisheries, southern royal albatross are now considered to be one of the top at-risk species (Edwards et al. 2023). The highest risk fishery group is 'Squid' followed by 'Large freezer' which equates to the highest threats from bottom longline and trawl fishing (Edwards et al. 2023). Annual data from 2016/17 to 2020/21 has shown an increase in trawl fishery bycatch with six southern royal albatross caught in 2020/21 (MPI 2024).

Outside of New Zealand, shelf breaks and deep oceanic waters are the preferred feeding grounds for southern royal albatross (Moore & Bettany 2005). Young birds (2-3 years old) and non-breeders use areas near Chile and eastern South America with older birds (4+ years) traveling back to New Zealand via Australia (Moore & Bettany 2005). All ages are vulnerable to bycatch in pelagic longliners in the southwest Atlantic, and females are more likely to be caught in subtropical regions and males at subpolar regions due to sexual segregation at sea (Jiménez et al. 2014). Satellite tracking and GLS data from the current study will provide useful information in determining overlap with fisheries within and outside of New Zealand and identifying potential threats.

As discussed in Mischler (2020), two related *Diomedea* species, the Antipodean and Gibson's (*D. antipodensis gibsoni*) albatross, have undergone severe population declines since 2006. High adult mortality, reduced breeding success, and increased recruitment age are attributed to the decline (Elliott & Walker 2019). Antipodean and Gibson's albatross feed primarily over deep oceanic waters and deep shelf slopes as opposed to southern royal albatross which feed over shallow shelf slopes and breaks and occasionally deep oceanic waters (Walker et al. 1995, Nicholls et al. 2002). For the southern royal albatross, it is also not possible to specifically determine when the decline started due to a large gap in nest counts between 2008/09 and 2019/20. Re-establishing a banded population for mark-recapture studies and using the remote cameras to gather breeding success data as has been done in the current study will provide insight into mortality, recruitment, and overall breeding success thereby improving the overall understanding of the dynamics of the population.

Photo point counts are challenging as there are many sources of error and bias. These include but are not limited to different timings of surveys in relation to the breeding cycle of the birds, variation in interpretation of each bird's activity, camera type, etc (Moore & Blezard 1999, Moore 2004, Frost 2019). One of the key points here is the timing of the photographs. Nests are nearly fully occupied in October when laying is complete, and the colonies remain busy in November as failed breeders continue to sit tightly on failed nests (G. Taylor, pers. comm.). Occupancy in colonies begins to decline in December when failed breeders have finished with pair bonding behaviour before departing to sea (G. Taylor, pers. comm.). With surveys completed in early December, the colonies will have started to appear less populated than would have been the case in October or November. To mitigate this issue, the coefficient calculation was applied to present a more accurate number of breeding birds. It is, however, important to note that the breeding success used to determine the coefficient calculations may have been vastly different from the breeding success in any given year and may therefore not be truly representative of nest numbers. Ideally photo point counts should be completed as close to the mid-October period as possible (Moore 2004, Sagar 2014).

Both Campbell and grey-headed albatross populations at Campbell Island have generally decreased over time (Waugh et al. 1999; Moore 2004; Rexer-Huber et al. 2020; Frost 2019). Campbell albatross numbers appeared to fluctuate over time whereas grey-headed albatross numbers underwent a long-term decrease between the 1940s to 1997 attributed to change in food conditions due to rising sea-surface temperatures or fisheries bycatch in international waters (Waugh et al. 1999; Moore 2004; Rexer-Huber et al. 2020). Campbell albatross have undergone varying trends between 1940s to 1997, but saw a decline between the 1990s and 2006-12 (Sagar 2014). Frost (2019) suggested that Campbell albatross were relatively stable since the 1990s but 20-30% below the numbers in the 1940s and 1960s. For grey-headed albatross, Moore (2004) had suggested that the population decreased by 82-88% over 55 years (1940s to 1997) in some colonies, but Sagar (2014) suggested that the declines stopped and that there was an increase in breeding pairs from 1990s to 2006-12. Frost (2019) suggested a 18-25% decline over the past 25 years. The ongoing high percent declines of 51.3% and 42.9% for Campbell and grey-headed albatross, respectively, compared to 2019 is a real concern. For grey-headed albatross breeding at South Georgia, there was an annual rate of decline of 5% and an overall decline of 43% between 2003 and 2014 (Poncet et al. 2017). Numbers appeared stable at Diego Ramirez between 2002 and 2011 (Robertson et al. 2014) and at Marion Island between 2001 and 2008 but declined at Prince Edward Island (Ryan et al. 2009). The decline at the South Georgia populations was attributed to fisheries bycatch threat during the non-breeding season while foraging at oceanic frontal zones (Poncet et al. 2017). It is not possible to compare Campbell albatross to other areas because they only breed on Campbell Island, but the closely related black-browed albatross (*Thalassarche melanophris*), the overall decline was 19% and 1.9% annually at South Georgia also attributed to fisheries bycatch (Poncet et al. 2017). Within New Zealand, only one grey-headed albatross has been reported as bycatch in surface longlining and one in trawling between 2002/03 and 2020/21 (MPI 2024). For Campbell albatross in New Zealand, 21 were reported as bycatch in trawlers, 48 in surface longliners, and three in bottom longliners between 2002/03 and 2020/21 (MPI 2024).

Recommendations

- Deploy tracking devices on birds breeding in the Paris index area. This area is experiencing the largest decline in nest numbers and it would therefore be helpful to determine if they forage in different areas than the birds at Col.
- Continue the capture-mark-recapture work for at least another year, but preferably annually to better understand the drivers of the population decline.
- Repeat the count efforts for southern royal, Campbell, and grey-headed albatross next year to account for the second cohort of breeders as well as annual variability, and then at least every 5 years, if not more regularly to keep a closer eye on the population
- Deploy tracking devices on Campbell albatross and grey-headed albatross to better understand what is causing the population declines.
- Re-start the capture-mark-recapture banding study on Campbell and grey-headed albatross to understand the drivers of the population declines.
- When traveling around the island for southern royal albatross study and index plot counts, spend a day or two in the given areas to focus solely on northern giant petrel counts and searching for white-chinned petrel burrows (following methods used by Rexer-Huber et al. 2020). This should include revisiting previously located sites for both species.

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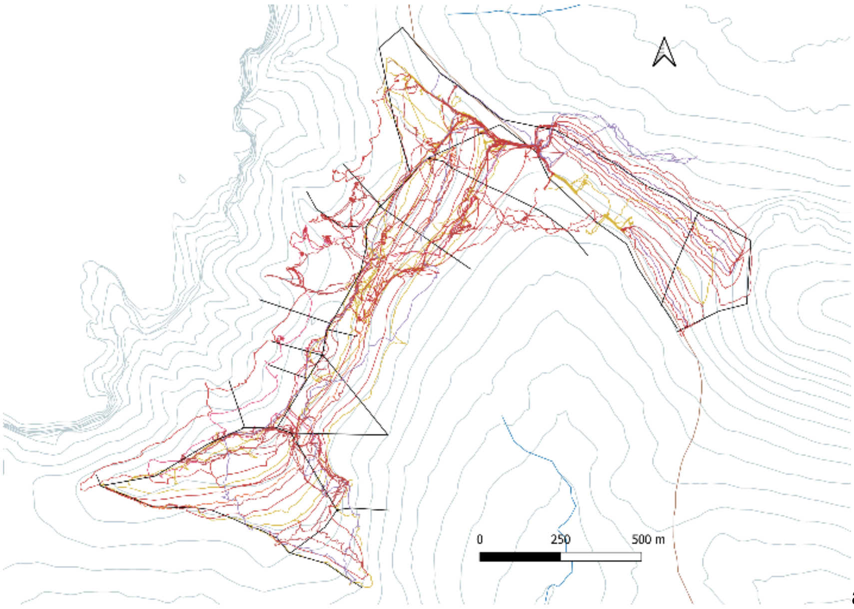
Appendix



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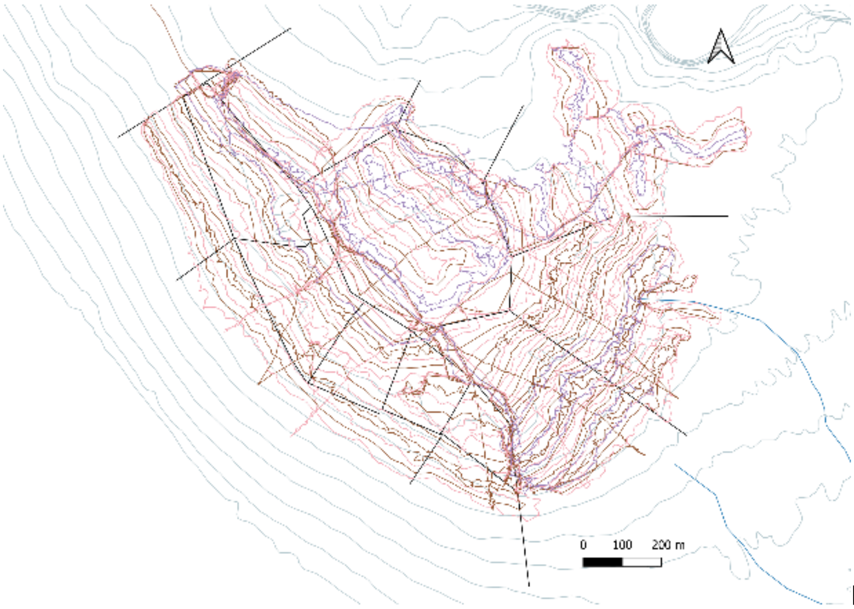

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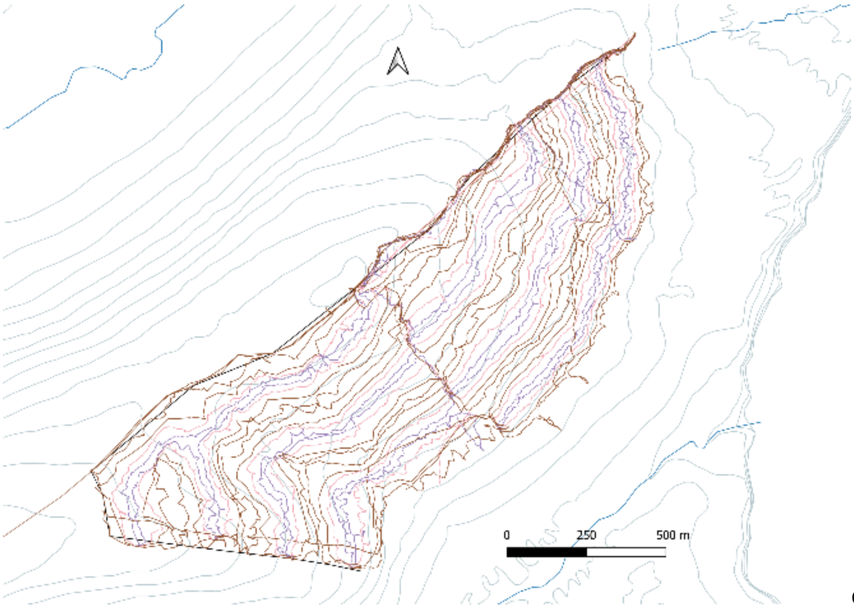

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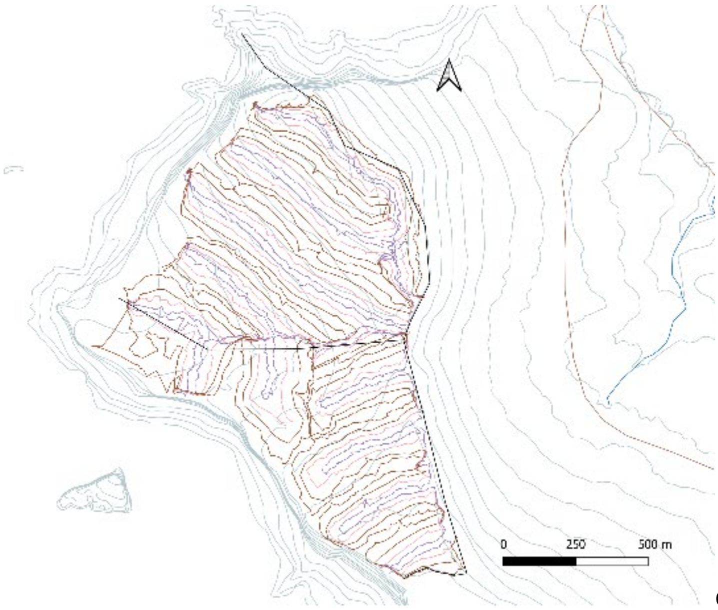

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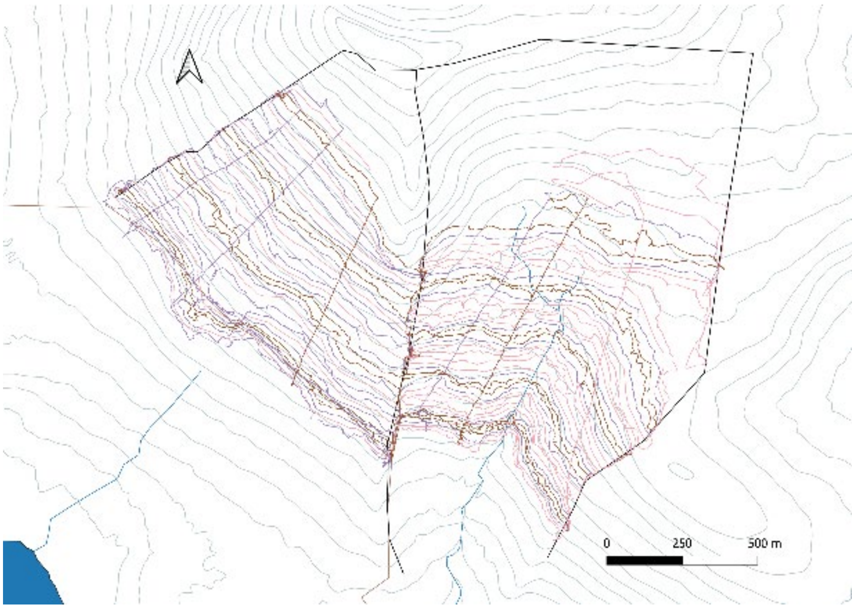

e)

Fig. A1. Enlarged map showing tracks walked by four observers while searching for southern royal albatross nests on Campbell Island in a) Col study area, b) Moubray study area, c) Faye index area, d) Paris index area, and e) Honey index area.

Table A1. Banding information, history, and partner data of previously banded southern royal albatross on Campbell Island. Under 'Breeding & banding history', BS - bred successfully, BF - bred but failed, BU - bred with unknown.

Current Band or PIT	Previous band	Date seen	Site	Sex	Original band date	Age at first mark	Band age	Breeding & banding history	Previous partner	Partner notes
668DBF6	R-45826	12/12/2023	Col	Male	19/08/1995	Chick	29	BS 2004, BS 2006, BU 2008; R-45826, rebanded RA-2144, new PIT 2006 when band removed, PIT read 2008	R-62202	
R-54184		4/01/2024	Moubray	Male	4/10/1997	Chick	27	Has not been seen since first banding as chick		
R-62136	R-45150	10/12/2023	Col	Female	5/08/1994	Chick	30	BS 2004 (10-year-old), BS 2006, BU 2008; R-45150, rebanded R-62136 in 2004	668 E203	Was RA-2245, new transponder
R-62138	R-54406	9/01/2024	Col	Female	20/01/1999	Adult	25	BU 1998, BS 2004, 2006, BU 2008; R-54406 rebanded in 2004	RA-2326	Replaced with transponder
R-62158		25/01/2024	Col	Female	7/01/2005	Adult	19	BF 2004, BS 2006, BU 2008	RA-2429	Replaced with transponder
R-62240		10/01/2024	Col	Female	15/01/2005	Adult	19	BS 2004, 2006, BU 2008	RA-2145	Replaced with transponder
R-62242		25/01/2024	Col	Female	7/01/2005	Adult	19	BS 2004, 2006, BU 2008	RA-2283	Replaced with transponder
R-62267		3/02/2024	Col	Female	14/01/1996	Adult	28	BS 1995, 1997, BF 2004, BS 2005, BF 2007, BU 2008; R-48514 rebanded in 2004	RA-2266, RA-2203	Replaced with transponder
R-62280	R-43676	2/01/2024	Moubray	Female	2/09/1987	Chick	37	BU 1995, 1997, 2004, 2006, 2008; R-43676, banded as a chick in 1987 east of Moubray Castle, rebanded 2004		

Current Band or PIT	Previous band	Date seen	Site	Sex	Original band date	Age at first mark	Band age	Breeding & banding history	Previous partner	Partner notes
R-62302		11/12/2023	Col	Female	25/01/2005	Adult	19	BF 2004, BS 2006, BU 2008	668E3D3	Was RA-2263, new PIT in 2006, read in 2008
R-62349		16/12/2023	Col	Female	25/01/2005	Adult	19	BS 2004, BS 2007	RA-2449	No transponder, band was removed
R-62363		12/12/2023	Col	Female	3/01/2006	Adult	18	BS 2005, BS 2007,	R-62570	No transponder
R-62364	R-54355	28/12/2023	Col	Female	1/01/1999	Adult	25	BU 1998, BS 2005, BF 2007, BU 2008; R-54355, rebanded R-62364 in 2005	668D07F	Was RA-2544, new transponder
R-62398		3/2/2024	Col	Female	5/01/2006	Adult	18	BS 2005, 2007	RA-2600	
R-62409		10/01/2024	Col	Female	9/01/2006	Adult	18	BF 2005, 2006, 2007	RA-2363	Replaced with transponder
R-62417	R-54253	16/12/2023	Col	Female	6/01/1998	Adult	26	BS 1997, BF 2005, BF 2006, BF 2007; R-54253, rebanded R-62417 in 2005	6681154	Replaced with transponder
R-62442	R-45523	4/01/2024	Moubray	Female	7/09/1994	Chick	30	BU 2004, R-45523, rebanded in 2004		
R-62525	R-44721	4/01/2024	Moubray	Female	30/08/1992	Chick	32	BU 2005, 2006, 2008; R-44721, rebanded in 2005		
R-62570	R-48468	16/12/2023	Col	Male	30/09/1996	Chick	28	BS 2005 (bred as 9-year-old), BS 2007; R-48468, rebanded RA-2622 in 2005, rebanded R-62570 in 2007	R-62363	
R-62581	R-48836	3/01/2024	Moubray	Female	3/10/1996	Chick	28	BU 2005, 2008; R-48836, rebanded in 2005		

Current Band or PIT	Previous band	Date seen	Site	Sex	Original band date	Age at first mark	Band age	Breeding & banding history	Previous partner	Partner notes
R-62590	R-43860	16/12/2023	Col	Female	31/08/1988	Chick	36	BS 1995 (8-year-old), BS 1997, BS 2006, BU 2008 (21-year-old); R-43860, rebanded R-62590 in 2006	668D256	Was R-48472, new transponder
R-62718	R-54139	3/01/2024	Moubray	Female	3/10/1997	Chick	27	BU 2006; R-54139, rebanded 2006		
R-62851		10/01/2024	Col	Female	30/09/1996	Chick	28	BF 2007, BU 2008	R-49052	Replaced with transponder
R-62921	R-48667	16/12/2023	Col	Female	30/09/1996	Chick	28	BU 2008, probably first breeding year as 12-year-old; R-48667 was rebanded as R-62921	UB	No transponder
RC-0201	000668E018	12/01/2024	Col	Male	1/10/1996	Chick	28	BS 2004, 2007; R-48731 banded as chick in 1995 season, rebanded RA-2276 in 2004, band removed and PIT added in 2007	R-62864	
RC-0205	000668AA31	24/01/2024	Col	Male	29/09/1997	Chick	27	BF 2006, BU 2008; R-48379 banded as chick in 1996 season, rebanded RA-2699 in 2006, band removed in 2008 and transponder inserted	UB	

Table A2. Banding information for Campbell and grey-headed albatross resighted at Bull Rock South on Campbell Island. BN – breeder on nest, EN – bird on an empty nest.

Prefix	Band Number	Breeder/Loafer	Species	Date
M	61663	EN	Grey-headed albatross	6/12/2023
M	49393	EN	Grey-headed albatross	6/12/2023
M	62061	EN	Grey-headed albatross	6/12/2023
M	89433	BN	Campbell albatross	6/12/2023
M	90286	BN	Grey-headed albatross	6/12/2023
M	49387	BN	Grey-headed albatross	6/12/2023
M	58570	BN	Grey-headed albatross	6/12/2023
M	89391	BN	Grey-headed albatross	6/12/2023
M	89449	BN	Grey-headed albatross	6/12/2023
M	49656	BN	Grey-headed albatross	6/12/2023
M	61705	BN	Grey-headed albatross	6/12/2023
M	49645	BN	Grey-headed albatross	6/12/2023
M	48377	BN	Grey-headed albatross	6/12/2023
M	90292	BN	Grey-headed albatross	6/12/2023
M	90546	BN	Grey-headed albatross	6/12/2023
M	61722	BN	Grey-headed albatross	6/12/2023
M	66382	EN	Campbell albatross	6/12/2023
M	62079	BN	Grey-headed albatross	6/12/2023
M	89513	BN	Grey-headed albatross	6/12/2023
M	89423	BN	Grey-headed albatross	6/12/2023
M	49753	BN	Grey-headed albatross	6/12/2023
M	65376	BN	Campbell albatross	6/12/2023
M	65704	BN	Campbell albatross	6/12/2023
M	48829	EN	Campbell albatross	6/12/2023
M	66237	EN	Campbell albatross	6/12/2023
M	66267	EN	Campbell albatross	6/12/2023
M	90406	BN	Grey-headed albatross	6/12/2023
M	49358	BN	Grey-headed albatross	6/12/2023
M	61969	EN	Campbell albatross	6/12/2023
M	58537	BN	Grey-headed albatross	6/12/2023
M	89474	EN	Grey-headed albatross	6/12/2023
M	90283	BN	Grey-headed albatross	6/12/2023
M	61757	BN	Grey-headed albatross	6/12/2023
M	49353	BN	Grey-headed albatross	6/12/2023
M	90180	BN	Grey-headed albatross	6/12/2023
M	89561	BN	Grey-headed albatross	6/12/2023
M	62056	BN	Grey-headed albatross	6/12/2023
M	61761	BN	Grey-headed albatross	6/12/2023
M	90182	BN	Grey-headed albatross	6/12/2023
M	90440	BN	Grey-headed albatross	6/12/2023
Prefix	Band Number	Breeder/Loafer	Species	Date

M	64731	BN	Grey-headed albatross	6/12/2023
M	90534	BN	Grey-headed albatross	6/12/2023
M	62059	BN	Grey-headed albatross	6/12/2023
M	58500	BN	Grey-headed albatross	6/12/2023
M	64695	BN	Campbell albatross	6/12/2023
M	61215	Loafer	Campbell albatross	6/12/2023
M	64651	EN	Campbell albatross	6/12/2023
M	61392	Loafer	Campbell albatross	6/12/2023
M	49891	BN	Campbell albatross	6/12/2023
M	89394	BN	Grey-headed albatross	6/12/2023
M	61880	BN	Grey-headed albatross	6/12/2023
M	82589	Loafer	Grey-headed albatross	6/12/2023
M	90493	BN	Grey-headed albatross	6/12/2023
M	90276	BN	Grey-headed albatross	6/12/2023
M	89473	BN	Grey-headed albatross	6/12/2023
M	90277	BN	Grey-headed albatross	6/12/2023
M	89395	BN	Grey-headed albatross	6/12/2023

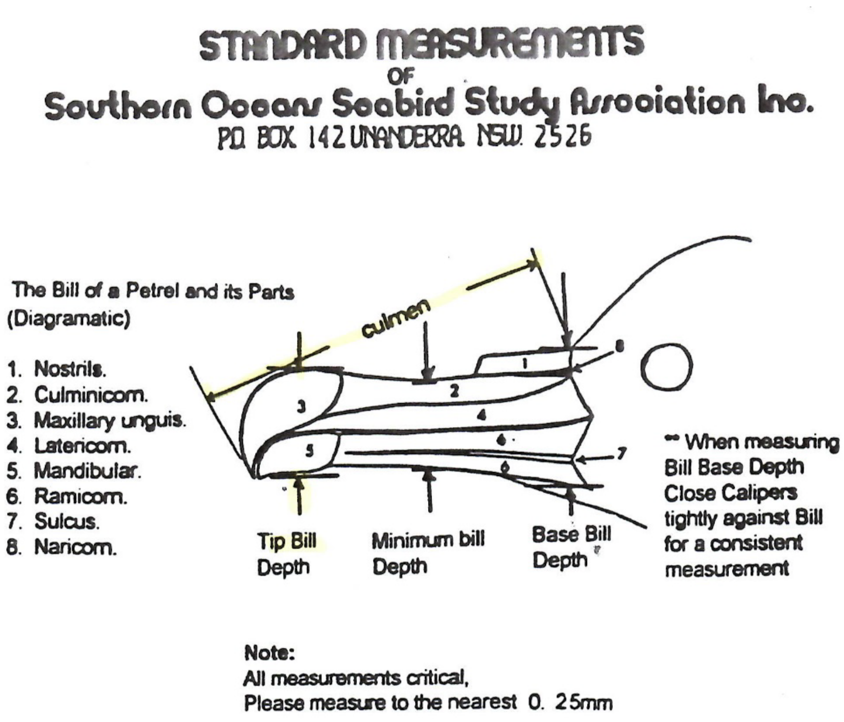

Fig. A2. Image showing standard bill measurements as was used for Antipodean albatross on Campbell Island during 2023/24.

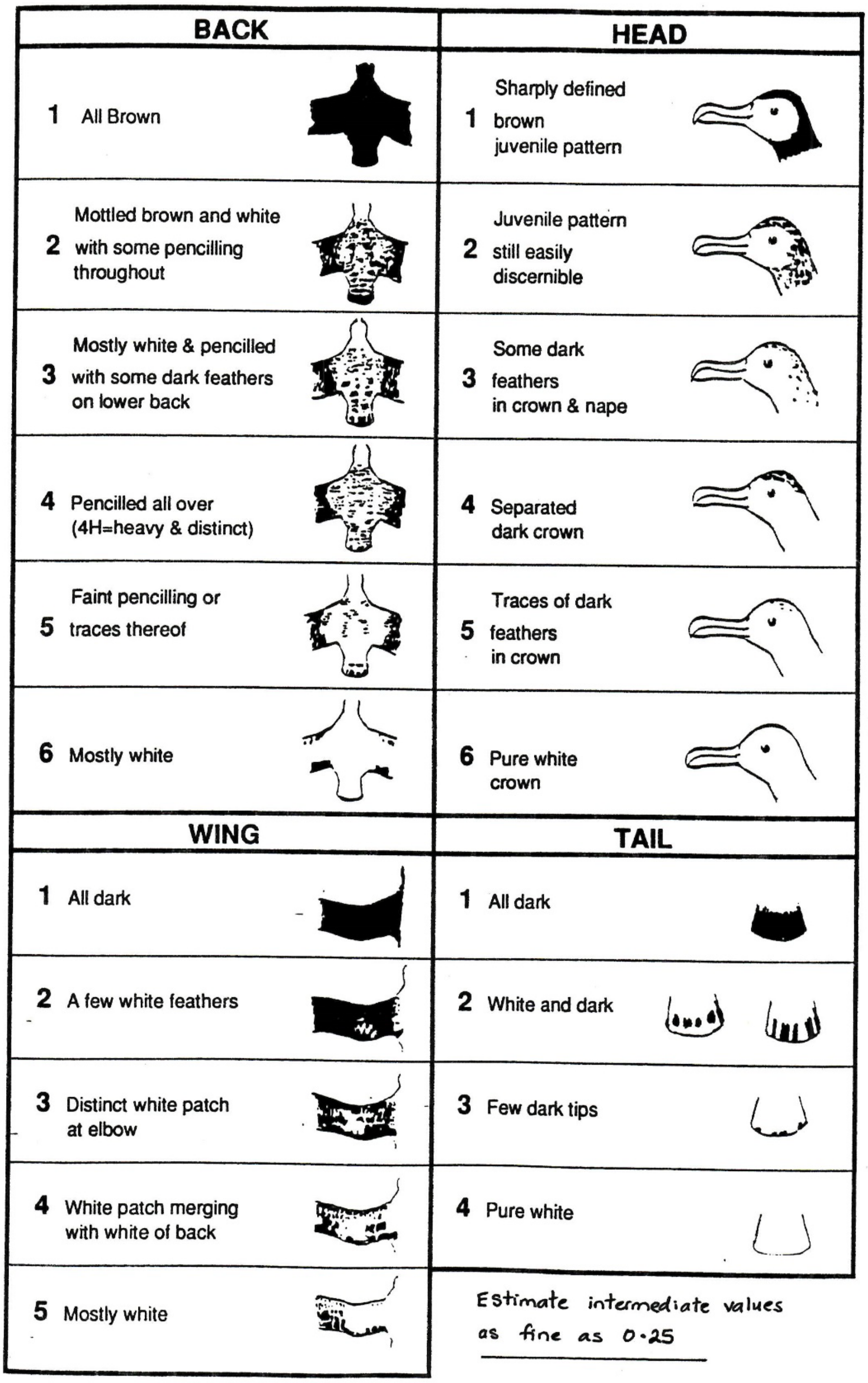

Fig.A.1 Gibson Plumage Index Standard (Gibson Code) for describing *D.exulans* plumage.

Fig. A3. Gibson plumage index standard (Gibson Code) for describing plumage.