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Aerial survey for Gibson's albatross on Adams Island, 2016

Final Report prepared for New Zealand Department of Conservation

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Assessment of aerial census techniques to robustly estimate the total population size of Gibson's albatross on Adams Island

1. Introduction

The biennially breeding Gibson's albatross (*Diomedea gibsoni*), listed as Vulnerable on the IUCN Red List (Birdlife International 2012) and Nationally Critical on the New Zealand Threat Classification system (Robertson et al. 2012), is a large seabird endemic to the sub Antarctic Auckland Islands group. Approximately 95% of the global breeding population of Gibson's wandering albatross breed on Adams Island (50°53'S, 166°10'E), the southern-most island in the Auckland Islands group (Elliott et al. 2016). The remaining birds occur on Disappointment Island and the southern parts of the main Auckland Island.

The remote and rugged Adams Island is roughly 20 km long and seven kilometres wide with a total area of approximately 101 km² (Walker and Elliott 1999). It is mountainous with a 600 m high range running east-west along its length (Walker and Elliott 1999) and high coastal cliffs in places (Cooper 2013). The island has a narrow band of coastal forest (including Southern Rātā *Metrosideros umbellate*) and scrub, with tussock then bare fellfield above (Walker and Elliott 1999; Cooper 2013). Gibson's albatross nest on most ridges off the main range although there are two large concentrations of nesting birds on the southern slopes of the island i.e. "Amherst–Astrolabe colony" and "Fly Basin colony" (Walker and Elliott 1999).

Since 1991, an annual long-term research program on Gibson's albatross on Adams Island has shown declines in adult survival, productivity and recruitment although there has recently been a small increase in recruitment, nesting success and survival from low points recorded in 2006 (Elliott and Walker 2014). The annual counts of the number of active albatross nests in three areas (representative of low, medium and high density nesting habitat) provide data to estimate annual population size and trends (Walker and Elliott 1999; Elliott and Walker 2005). These three areas comprise approximately 10% of all the nests on Adams Island (Elliott and Walker 2005). Counts are undertaken as soon after completion of egg-laying as possible (most eggs are laid between 26 December and 25 January, ACAP 2012) and usually in late January to early February (Walker and Elliott 1999; Elliott and Walker 2014). The total number of pairs has been estimated by multiplying the proportional change in the number of nests in the three regularly counted blocks by the average number of nests counted in a comprehensive on-ground island-wide census undertaken in 1997 (Walker and Elliott 1999). The long-term monitoring on Adams Island recorded a rapid population decline between 2005 and 2008 when the size of the breeding population dropped more than 40%. Since then, the population recovery has been slow from the 2006 low of 2,816 annual breeding pairs to the most recent reported estimate of 4,340 breeding pairs on the Auckland Islands in 2014 (Elliott and Walker 2014).

The remoteness of the Gibson's albatross breeding population on Adams Island means that it is logistically difficult to undertake regular on-ground site visits to census the entire albatross population. The albatross are widespread across the rugged, topographically challenging island and so obtaining whole island population size estimates using on-ground census methods requires a substantial effort and significant time. In the Auckland Islands (Baker et al. 2015) and elsewhere (e.g. Arata et al. 2003; Robertson et al. 2008, Wolfaardt and Phillips 2011), aerial survey has been used for counts of a range of species and has been shown to permit rapid coverage of large areas of land as well as areas that are difficult to access on the ground (Magrath et al. 2010). In 2014 and 2015 exploratory aerial census work was conducted at the Auckland Islands with a particular focus on preliminary aerial surveys of Adams Island (Baker and Jensz 2014; Baker et al. 2015). These studies identified issues of efficient aerial coverage and the need to develop camera/lens/flight height combinations that would provide sufficient photographic resolution to permit nesting birds to be identified.

The objective of this report is to refine recommendations for robustly estimating the total population size of Gibson's albatross at Adams Island, building on the preliminary work undertaken in 2015 (Baker et al. 2015). We report on the analysis of further aerial census work conducted at Adams Island in January 2016, and in particular the use of a vertically oriented camera, GPS linked, and suitable for use on rotary winged platforms, and the effectiveness of a partial aerial survey of Adams Island in estimating the number of breeding pairs of Gibson's albatross present in defined areas.

2. Methods

2.1 Aerial photography

On 17 January 2016 we took a series of photographs of Gibson's albatross colonies on Adams Island, Auckland Islands Archipelago, as time and weather permitted. The photos were taken as a series of transects designed to provide full photographic coverage of an area adjacent to and including a long term mark-recapture study site on the south of the island, as described by Walker & Elliot (1999) and shown in Figure 1. The area surveyed overlapped an area that was ground-counted at the time of the photography, which allowed ground truthing and comparison with ground survey methods.

The aircraft used for the survey was a single-engined Squirrel AS350B3 helicopter, piloted by Mark Deaker (Southern Lakes Helicopters). On board was one passenger, Barry Baker, who was the photographer and coordinator for the project. We flew a series of transects (Table 1) spaced at 70 m centres that ran across the terrain from east to west, and used the aerial guidance system TracMap Flight Pro (http://www.tracmap.com/aviation/products/aviation-tm386-flight-pro) to define and accurately fly the series of transects. The transects were set up to ensure that the 70m centre lines would provide an overlap tolerance of at least 50% (20 m) side overlap (between flying tracks) and 75% (20 m) frontal overlap (with respect to the flight direction), and maintaining as much as possible a constant height over the terrain under the following flight and photographic specifications:

- Flight height 500 ft agl;
- Ground speed 40 knots, as assessed using the on-board radar altimeter;
- Camera and lens: a full-frame Digital Single Lens Reflex Camera (Nikon D800) and 50 mm lens (Nikon 50mm f1.8)
- Photo frame rate: 2 second intervals

The camera was vertically-mounted in a purpose-built camera mount that was fitted in a weatherproof pod suspended underneath the aircraft, and manually controlled from the helicopter. Shutter speeds were set at 1/1000 s or faster to minimise the effect of vibration on image quality. To assist with spatial resolution of each photo, a Garmin GPSmap 60CSx GPS was connected to the cameras, ensuring a latitude and longitude stamp was recorded with the EXIF metadata for each photograph. All photographs were saved as Raw NEF files and subsequently converted to fine JPG format files. The combination of flight height, ground speed, photo frame rate and focal length was derived from an earlier trial of lens/flight height combinations designed to ensure complete ground coverage (adequate overlap between transects) in Te Anau, New Zealand.

Weather conditions at Adams Islands can vary considerably throughout the day and change rapidly. We aimed to fly when we thought cloud cover would be absent or minimal, and based our assessment on real-time weather reports from field researchers based on Adams Island, and the crew of support vessel *Tiama* which was based in Carnley Harbour. Nonetheless, we were not able to photograph all areas as and when planned because weather conditions changed either while we were in transit from Enderby Island, or during the flights themselves. This meant that we were prepared to abandon runs occasionally, and re-fly these areas later. We were able to complete photographic coverage of the study area over a four-hour period on 17 January 2016 between 1100 and 1500 hours NZ Summer Time. The entire study site required a total of 35 transects to ensure adequate coverage. The entire set of photos was subsequently replicated to ensure that complete back-up sets existed both on portable hard drives and in at least three different locations. A full collection of photographs has been submitted to the Department of Conservation, and an archival set of photos has also been retained by Latitude 42.

2.2 Ground counting

Ground counting of all albatrosses nesting in the Adams Island mark-recapture study were undertaken between between 24 January - 5 February 2016 and are reported upon by Elliott et al. (2016). Briefly, counts were carried out just after the completion of laying, using a strip search method where two observers walked back and forth across the area to be counted, each within a strip about 25 m wide and displayed on a GPS map, and counted all the nests with eggs in their strip. Every bird on a nest was checked for the presence of an egg, and each nest found with an egg was marked with spray paint, counted and the nest-site location recorded using a hand-held GPS. All non-breeding birds on the ground were also counted. Once the whole block had been counted, the accuracy of the census was checked by walking straight transects at right angles to the strips, checking all nests within 10-15 m of the transect for paint marks indicating the nest has been counted.

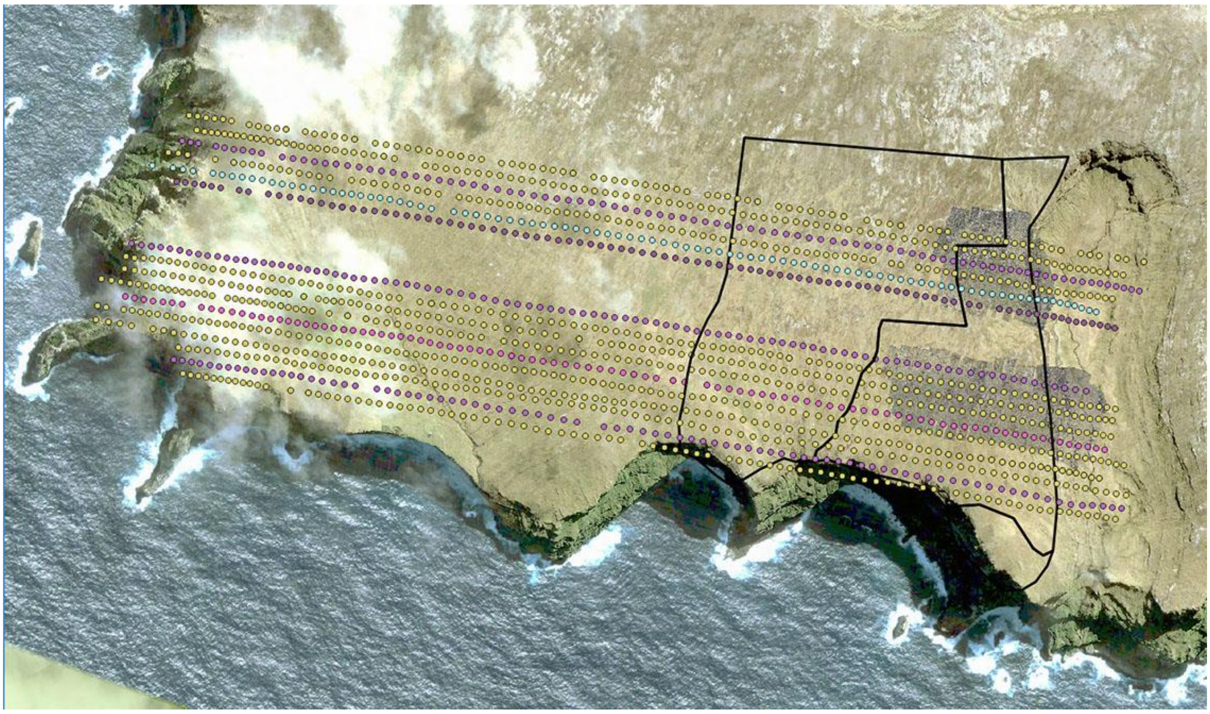

Figure 1. The area on Adams Island that was overflown and photographed in January 2015. which incorporates two study blocks used for fine-scale demographic studies undertaken by Walker and Elliott (1999) – outlined by the solid lines. The coloured circles indicate the transects flown. Only a subset of photos was subsequently analysed as part of this study, and these formed three maps taken from the two shaded areas located within the demographic study site.

2.3 Analysis of photographs and mapping

High definition photographs were labelled by transect number and selectively stitched manually to check overlap, the existence of EXIF metadata data, and image quality. Three areas within the demographic study site were randomly chosen for analysis, and between 80 and 100 photos covering each area were selected for analysis. Only images with spatial references included in their EXIF data (Latitude and Longitude as a minimum) were selected. These were uploaded to an Internet-based online geo-referencing interface *Maps Made Easy* (https://www.mapsmadeeasy.com/) for stitching and geo-referencing. *Maps Made Easy* allows users to upload suitable aerial images, stitches the images together and provides outputs in several formats including GeoTIFF, JPEG and KMZ (plus several other formats including 3D models). The various outputs can be used in software such as ADOBE PHOTOSHOP to undertake counts, or used in conjunction with GIS programs (ESRI, QGIS or Manifold) for counting as well as spatially locating birds and or nests.

High-resolution maps were produced by *Maps Made Easy* for each of the three selected areas and provided as large TIF and JPEG files. The mapped areas had irregular edges because spatial data for the map margins were incomplete, a standard issue with producing maps in this way. The TIFF files were initially imported into the image editing software package ADOBE PHOTOSHOP (http://www.adobe.com/). Counts of all Gibson's albatrosses on each map were then made by first quickly assessing each image to identify likely birds, and then magnifying the image to view birds and using the paintbrush tool in PHOTOSHOP to mark each bird with a small red-coloured circle as they were counted (Figure 2, left panel). Each bird located was also given a unique number which was also marked on the map. Maps were then imported into the GIS software program QGIS and each identified bird spatially located (latitude, longitude) and recorded on a spreadsheet. Each map was then trimmed to remove the irregular edges, and saved as a JPEG files. Trimmed maps and the spatial data for each bird were then compared against nest site data collected on-ground when the detailed census was undertaken to determine the accuracy of the aerial counts. Nests identified in ground counts were marked on the map by a solid blue circle (Figure 2, right panel).

Each single bird was assumed to represent a breeding pair. While most birds were alone at nest sites, we also recorded instances when two birds were sitting close together and assumed to both be members of a nesting pair. In this situation, both birds were counted, and the number of pairs recorded. The number of pairs was subsequently deducted from the total number of birds to derive an estimate of annual breeding pairs.

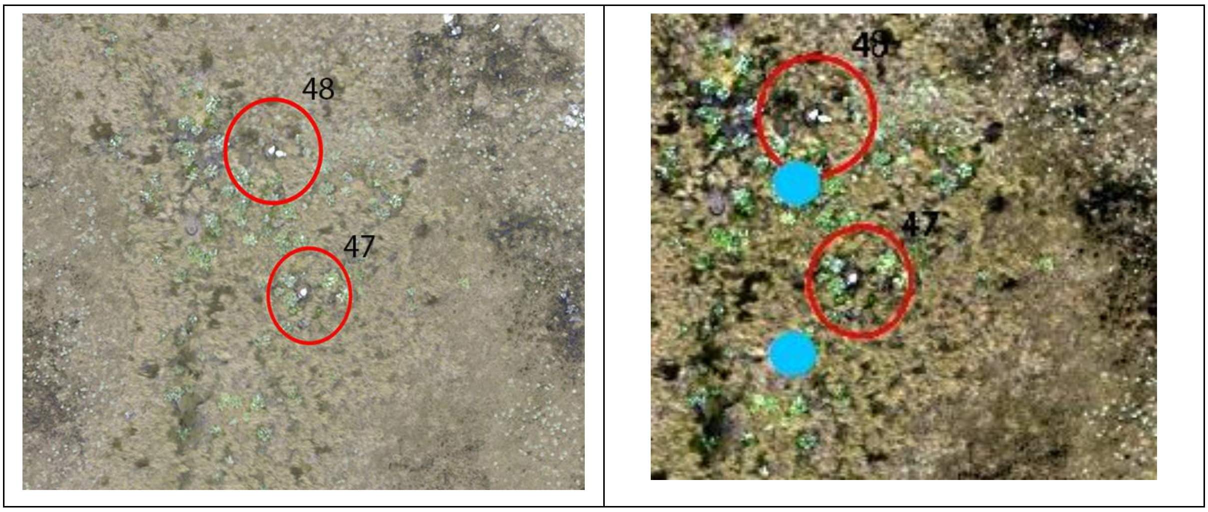

Figure 2. Left panel – section of a high resolution map generated from the aerial photographs showing the convention used to identify Gibson's albatross nesting birds in the initial analysis – a red circle and unique site number. **Right panel** – Nests identified in ground counts were subsequently marked on the map by a solid blue circle to assess the efficiency of the aerial count. Generally there was close alignment between aerial and ground counts, and the slight differences evident here are due to datum and projection differences.

3. RESULTS

The TracMap Flight Pro flight plan established a total of 35 transects to cover the survey area at the specified transect width of 70 m centres. Unfortunately, data from four of the transects were lost because of a corrupt memory card, leaving a gap in the planned coverage of the area. An attempt to re-fly these four transects subsequently was unsuccessful because inclement weather restricted visibility over the study area.

The photography obtained provided high-resolution images with extensive overlap between transects, thus providing complete coverage of all areas overflown, except for the four transects (c. 10% of surveyed area) lost because of the card-corruption issue. Initial inspection showed that birds were clearly visible (fit for the purpose of counting individuals) and EXIF metadata suitable for mapping purposes available.

Table 1. Aerial counts of Gibson's albatross ashore on Adams Island on 17 January 2016, taken from three maps developed from aerial photos using the Internet-based online geo-referencing interface *Maps Made Easy*, together with the results of ground-truthing.

Category	Aerial assessment	Ground truthing	
	Bird on nest	Correct	No nest
Bird on nest	**129**	**95**	**34**
Possible bird	**3**	**0**	**3**
Totals	**132**	**95**	**37**

In our aerial assessment we counted a total of 129 birds ashore on the three maps (Table 1). Ground-truthing showed that only 95 (74%) of these birds at the time of the aerial count, or subsequently, were nesting (nest associated with an egg). The other 34 birds (26%) were therefore loafing at the time of the aerial count (Table 1). The resolution of the images was substantially improved over that obtained in aerial photography in 2015 (Baker et al. 2015), leading to very little uncertainty separating nesting albatrosses from the large number of white rocks that are present at this site. There was only three white objects located on the maps for which identification was uncertain – the assessment of three observers was that this object was most likely not a bird, which was subsequently confirmed by ground-truthing.

Since the aerial photographs did not cover the whole of the demographic study area or Astrolabe Basin census block we did not attempt to estimate the number of birds in the study area or census block from the photos.

4 Discussion

Vertical mounting of the camera, in combination with a flight height of 500 ft and precision of transect coverage, greatly improved the resolution of the photographic images over that obtained in our 2015 trial (Baker et al. 2015), permitting the production of high resolution maps suitable for counting Gibson's albatross colonies on Adam's Island. The counts conducted on the three blocks for which we produced maps indicated that 26% of the birds ashore did not go on to subsequently lay an egg, and therefore be considered as representing an 'annual breeding pair'. This figure would be useful for correcting future counts from aerial photography of albatross colonies on Adams Island taken at a similar time of year. It should be noted, however, that the proportion of non-breeding birds ashore will vary from time to time, subject to weather conditions (G. Elliott and K. Walker, unpublished). However, it is likely that future aerial surveys of other parts of Adams Island will need to be carried out under similar weather conditions to those experienced during our counts this year, which may go some way to reduce the variance around the presence of loafers.

It should also be noted that the aerial photographs were taken at a time when only about 89% of the eggs had been laid (Walker and Elliott 1999) and therefore photos taken in mid-January do not provide a complete assessment of the number of annual breeding pairs (nests). Future aerial counts would need to be corrected for this, and use of data from the annual on-ground monitoring program would be valuable for this purpose.

5. Recommendations for future work

Accurate estimation of population size is critical for determining conservation status, and for identifying the key factors influencing changes in population size and demography of albatrosses. While a ground count of all of Adams Island has been undertaken previously, access to much of the island is difficult on foot, and habitat is likely to more comprehensively counted from the air (Walker and Elliott 2015). Adams Island is also a restricted access site. For these reasons it is recommended that if the population size of Gibson's albatross is to be re-estimated, a mix of on-ground and aerial techniques would be appropriate. The work described in this report leads us to believe that a suitable methodology to undertake an aerial count in the Auckland Islands is now available using photography.

Based on our field work on Adams and Disappointment Islands, we recommend the following approach for conducting aerial photographic surveys of Gibson's wandering albatross.

1. Helicopters are the only feasible aerial platform available at this stage. The remoteness of the site, lack of an airport within the Auckland Islands and frequently changing weather conditions over Adams Island precludes the efficient use of fixed wing aircraft for this purpose.
2. The use of a series of transects to provide spatial coverage of target areas is recommended. Photography should be undertaken using a digital camera vertically-mounted underneath the aircraft. All photographs taken should be geo-referenced using suitable GPS equipment.
3. Development of high-resolution maps generated from suitable geo-referenced photos will permit counting of most birds ashore.
4. Photography needs to be supported by ground-truthing to develop meaningful correction factors that account for loafers/non breeders in colonies. Maintaining and potentially expanding the existing Amherst – Astrolabe census block, as suggested by Walker and Elliott (2015) is recommended for this purpose. Use of fine-scale 'close-up' photographs taken with a large telephoto lens, as now routinely occurs in photographic surveys of white-capped albatross (Baker et al. 2014) would also be appropriate for this purpose.
5. Ideally, aerial surveys should not be conducted until egg laying is complete (c 25 January), although logistical constraints may mean there is a need for some flexibility around this date. Again, correction factors could be developed to correct for this bias using data collected from the long-term Amherst – Astrolabe monitoring sites.
6. The ever-changing nature of the weather on Adams Island is such that it may not be possible to fly all areas targeted for aerial survey in one breeding season, particularly if the project is to rely on the presence of a helicopter in the Auckland Islands for other work e.g. sea lion research. We recommend a survey schedule is drawn up that would plan to have all the island surveyed over three or four years, with flexibility built in so that advantage can be taken of good weather conditions when they arise.
7. An alternative approach to the use of aerial photography to rapidly assess population size of great albatrosses was trialled on Enderby Island in January 2017. This involved the use of a helicopter to fly transects at 200m centres, with birds being counted within a defined transect strip., and aerial photography confined to taking close-up photos of nesting birds to improve estimates of the proportion of loafing birds within colonies. This work will be reported upon separately (B.Baker, C.Muller and R.French, unpublished data).

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Annex 1

Aerial count of Gibson's albatross ashore on 17 January 2016 and the results of the ground truthing.

				Aerial assessment	Ground truthing
Map	**Bird ID**	**lat**	**long**	**Bird on nest**	**Correct**
1	6	-50.9006	165.9964	yes	yes
1	8	-50.9010	165.9971	possible bird	no nest
1	9	-50.9020	165.9968	yes	yes
1	10	-50.9022	165.9964	yes	yes
1	11	-50.9022	165.9970	yes	no nest
1	12	-50.9024	165.9968	yes	yes
1	13	-50.9023	165.9965	yes	yes
1	14	-50.9026	165.9979	yes	no nest
1	15	-50.9018	165.9974	yes	no nest
1	16	-50.9014	165.9977	yes	yes
1	17	-50.9011	165.9981	yes	yes
1	18	-50.9005	165.9981	yes	yes
1	19	-50.9032	166.0004	yes	no nest
1	20	-50.9031	166.0004	possible bird	no nest
1	21	-50.9030	166.0005	yes	yes
1	22	-50.9027	166.0006	yes	no nest
1	23	-50.9026	165.9998	yes	yes
1	24	-50.9020	165.9988	yes	yes
1	25	-50.9014	165.9988	yes	yes
1	26	-50.9014	165.9991	yes	yes
1	30	-50.9013	166.0008	yes	yes
1	31	-50.9012	166.0010	yes	no nest
1	32	-50.9017	166.0009	yes	yes
1	33	-50.9015	166.0010	yes	yes
1	34	-50.9028	166.0008	yes	yes
1	35	-50.9026	166.0009	yes	yes
1	36	-50.9030	166.0011	yes	yes
1	37	-50.9027	166.0012	yes	no nest
	38	-50.9025	166.0016	yes	yes
1	39	-50.9027	166.0013	yes	no nest
1	40	-50.9033	166.0011	yes	yes
1	44	-50.9036	166.0027	yes	yes
1	45	-50.9034	166.0019	yes	yes
1	46	-50.9028	166.0027	yes	yes
1	47	-50.9025	166.0025	yes	yes
1	48	-50.9023	166.0024	yes	yes
1	49	-50.9019	166.0023	yes	yes

				Aerial assessment	Ground truthing
Map	Bird ID	lat	long	Bird on nest	Correct
1	50	-50.9017	166.0021	yes	yes
1	51	-50.9014	166.0013	yes	no nest
1	52	-50.9015	166.0025	yes	no nest
1	53	-50.9015	166.0027	yes	yes
1	58	-50.9015	166.0035	yes	yes
1	59	-50.9017	166.0035	yes	yes
1	60	-50.9019	166.0040	yes	no nest
1	61	-50.9023	166.0034	yes	no nest
1	62	-50.9023	166.0031	yes	yes
1	63	-50.9029	166.0030	yes	no nest
1	64	-50.9027	166.0037	yes	no nest
1	65	-50.9030	166.0038	yes	yes
1	66	-50.9036	166.0032	yes	no nest
1	67	-50.9037	166.0031	yes	no nest
1	70	-50.9038	166.0037	yes	no nest
1	72	-50.9036	166.0038	yes	yes
1	73	-50.9035	166.0037	yes	no nest
1	76	-50.9039	166.0041	yes	yes
1	77	-50.9037	166.0041	yes	yes
1	78	-50.9035	166.0042	yes	yes
1	84	-50.9028	166.0047	yes	yes
1	85	-50.9027	166.0048	yes	yes
1	86	-50.9027	166.0042	yes	yes
1	87	-50.9024	166.0042	yes	yes
1	88	-50.9026	166.0049	yes	yes
1	89	-50.9020	166.0043	yes	yes
1	90	-50.9020	166.0046	yes	yes
1	91	-50.9023	166.0044	yes	no nest
1	92	-50.9024	166.0048	yes	no nest
1	94	-50.9026	166.0047	possible bird	no nest
1	96	-50.9014	166.0043	yes	yes
2	5	-50.8957	165.9998	yes	yes
2	6	-50.8949	166.0001	yes	no nest
2	7	-50.8957	166.0008	yes	yes
2	8	-50.8964	166.0015	yes	yes
2	9	-50.8963	166.0013	yes	no nest
2	10	-50.8950	166.0017	yes	yes
2	11	-50.8966	166.0021	yes	yes
2	12	-50.8967	166.0016	yes	yes
2	13	-50.8970	166.0018	yes	yes
2	14	-50.8968	166.0030	yes	yes
2	15	-50.8972	166.0026	yes	yes
2	16	-50.8973	166.0029	yes	yes

				Aerial assessment	Ground truthing
Map	**Bird ID**	**lat**	**long**	**Bird on nest**	**Correct**
2	17	-50.8972	166.0029	yes	yes
2	18	-50.8971	166.0027	yes	yes
2	19	-50.8968	166.0036	yes	no nest
2	25	-50.8966	166.0038	yes	no nest
2	26	-50.8953	166.0036	yes	yes
3	2	-50.9004	165.9981	yes	yes
3	3	-50.9002	165.9982	yes	yes
3	4	-50.9006	165.9978	yes	yes
3	5	-50.9002	165.9973	yes	yes
3	6	-50.9005	165.9972	yes	yes
3	8	-50.9005	165.9967	yes	no nest
3	9	-50.9000	165.9972	yes	yes
3	10	-50.8996	165.9974	yes	yes
3	14	-50.8993	165.9979	yes	yes
3	15	-50.8990	165.9979	yes	no nest
3	16	-50.8995	165.9978	yes	yes
3	21	-50.8999	165.9986	yes	yes
3	22	-50.8999	165.9988	yes	no nest
3	23	-50.8994	165.9987	yes	no nest
3	24	-50.8993	165.9982	yes	no nest
3	25	-50.8992	165.9984	yes	yes
3	26	-50.9009	166.0006	yes	yes
3	27	-50.9006	166.0004	yes	yes
3	28	-50.9002	166.0006	yes	yes
3	29	-50.8999	166.0004	yes	no nest
3	30	-50.8995	166.0002	yes	yes
3	31	-50.9002	166.0015	yes	no nest
3	32	-50.9008	166.0008	yes	no nest
3	34	-50.9012	166.0007	yes	yes
3	37	-50.9011	166.0023	yes	yes
3	39	-50.9014	166.0025	yes	yes
3	40	-50.9008	166.0026	yes	yes
3	41	-50.9009	166.0026	yes	yes
3	43	-50.9015	166.0033	yes	yes
3	45	-50.9010	166.0035	yes	yes
3	46	-50.9006	166.0035	yes	yes
3	47	-50.9002	166.0036	yes	yes
3	48	-50.9001	166.0035	yes	yes
3	49	-50.9005	166.0028	yes	no nest
3	50	-50.8998	166.0031	yes	yes
3	52	-50.9004	166.0044	yes	yes
3	53	-50.9005	166.0043	yes	yes
3	54	-50.9009	166.0037	yes	yes

				Aerial assessment	Ground truthing
Map	**Bird ID**	**lat**	**long**	**Bird on nest**	**Correct**
3	55	-50.9009	166.0040	yes	yes
3	56	-50.9008	166.0044	yes	yes
3	57	-50.9014	166.0041	yes	yes
3	58	-50.9019	166.0048	yes	yes
3	59	-50.9014	166.0046	yes	yes
3	61	-50.9007	166.0019	yes	no nest
3	62	-50.8996	166.0020	yes	yes
3	63	-50.9003	166.0026	yes	yes
3	64	-50.9003	166.0025	yes	yes
		bird on nest		129	95
		no nest			34
		possible bird		3	3
Totals				**132**	**132**