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White-capped albatross aerial survey 2014

Draft Final Report

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Executive Summary

White-capped albatrosses *Thalassarche steadi* are endemic to New Zealand, breeding on Disappointment Island, Adams Island and Auckland Island in the Auckland Island group, and Bollons Island (50-100 pairs) in the Antipodes Island Group. Population estimates suggest most (95%) of the global population breeds on Disappointment Island, an area where access is restricted to maintain environmental values at the site. Virtually all aspects of the biology and ecology of white-capped albatrosses are poorly known and although approximate population sizes have developed there have been no well-documented population estimates for any of the colonies until this study.

Between 2006/07 and 2013/14 (hereinafter 2006 and 2013, respectively) we undertook repeated population censuses of the white-capped albatrosses breeding in the Auckland Islands using aerial photography. These population censuses were carried out in either December or January each year to estimate population size and track population trends.

In 2013 we estimated that there were 89,552 (95%CI 88,953 — 90,151), 5,542 (5,393 — 5,691) and 184 (157— 211) annual breeding pairs at Disappointment Island, South West Cape and Adams Island, respectively, based on the raw counts, giving a total for these sites of 95,278 (94,661 — 95,895) breeding pairs.

To assess population trend in total counts we used an appropriate Generalised Linear Model where the response was specified as an over dispersed Poisson distribution and the link was logarithmic. To allow for possible non-linear trend effects we used regression splines with a single knot at 2010. We also assessed trend using software program TRIM (TRends and Indices for Monitoring Data), the standard tool used by the Agreement for the Conservation of Albatrosses and Petrels (ACAP).

Evidence from a series of 'close-up' photographs taken each year (2007-2013) indicates that the number of non-breeding birds present in the colonies differed somewhat between December and January. The proportion was very low in December counts (1-2% of birds present), but higher in the January counts (14% of birds present). Estimated annual counts for all three breeding sites in the Auckland Islands were adjusted to account for the presence of non-breeding birds, giving adjusted estimates of annual breeding pairs of 116 025, 90 036, 96 118, 73 838, 76 119, 92 692, 102 273 and 74 031 for each year from 2006 to 2013 inclusive. These adjusted figures were used as inputs into models used for assessment of population trend.

Trend analysis for all sites combined using regression splines showed no clear evidence for systematic monotonic decline over the 8 years of the study. This is particularly so if the count for 2006 is excluded. Given this we do not have sufficient evidence to reject the null hypothesis of no systematic trend in the total population. The population size estimates computed from the TRIM model indicate an average growth rate of -3.16% per year ($\lambda = 0.9684 \pm 0.001$; assessed by TRIM as moderate decline. We note, however, that a simple linear trend analysis, as performed by TRIM is not well suited to a data set with high inter-annual variability. Trend analysis using regression splines is more appropriate to such data sets, and the TRIM analysis is only presented because it is currently used by ACAP to assess population trends in albatross populations.

In a global review of fisheries-related mortality of shy and white-capped albatrosses it was estimated that 8,000 white-capped albatrosses were killed each year as a result of interactions with trawl and longline fisheries in the Southern Ocean. This level of mortality highlights the need to continue to acquire accurate population estimates and trends for white-capped albatross populations to assess the impact of fisheries operations on this species. Although annual counts over the last eight years indicate the population is stable, ongoing population monitoring is recommended to clarify if current levels of fishing mortality remain sustainable.

1. Introduction

White-capped albatrosses *Thalassarche steadi* are endemic to New Zealand, breeding on Disappointment Island (72 000 pairs), Adams Island (100 pairs) and Auckland Island (3 000 pairs) in the Auckland Island group, and Bollons Island (50-100 pairs) in the Antipodes Island Group (Gales, 1998). The population estimates of Gales (1998) suggest most (95%) of the global population breeds on Disappointment Island, an area where access is restricted to maintain environmental values at the site

Virtually all aspects of the biology and ecology of white-capped albatrosses are poorly known and although approximate population sizes are given above there were, until this study was commissioned, no well-documented population estimates for any of the colonies (Taylor 2000). Ground and aerial photographs were undertaken of Disappointment Island colony in 1972, 1981, 1985, 1990 and 1993 by others (Taylor, 2000) but no reports or papers have been produced from these surveys. In 2006 we commenced annual population censuses of white-capped albatrosses breeding on the Auckland Islands using aerial photography years to estimate population size and track population trends (Baker et al, 2013).

This project was developed to build on the recent population census work. Specifically, the objectives of the project were to:

1. estimate the breeding population size of white-capped albatross at the Auckland Islands during the 2011 and 2012 breeding seasons; and
2. determine the population trend of white-capped albatross at the Auckland Island.

We were also tasked with

3. taking aerial photographs suitable for estimating the New Zealand sea lion pup production at Sandy Bay, Enderby Island and Dundas Island; and
4. providing aerial (helicopter) support for other researchers (Investigation 4522) to access Dundas Island from Enderby Island.

Here we report on the results of counts undertaken in January 2014 (Items 1 & 2 above). This report also consolidates data from counts undertaken in earlier years to provide a complete picture of the surveys undertaken. We have previously reported on Items 3 and 4 (Baker and Jensz, 2014).

2. Methods

The Site

The Auckland Islands (50^0 44'S, 166^0 06'E) lie 460 km south of New Zealand's South Island, and comprise the largest island group in the New Zealand sub Antarctic. The archipelago consists of four larger islands (Auckland, Enderby, Adams and Disappointment Islands, together with a set of smaller islands (Peat 2006). Within the archipelago, white-capped albatross breed mainly on Disappointment Island, located to the west of the main Auckland Island, with smaller colonies situated on the South West Cape of Auckland Island and on the southwest coast of Adams Island (Tickell 2000). Disappointment Is. is 4 km long by up to 1 km wide, and is covered in *Poa* grassland and giant herbs, with scattered areas of shrubland and fellfield around the top of the island (Peat 2006). The island rises steeply from the sea to a plateau, with white-capped albatrosses breeding extensively on the slopes but avoiding the plateau. Birds breeding at the colonies on South West Cape and Adams Island also confine nesting to steep, tussock-covered slopes.

Field Work

Field work for previous years (2006-2012) has been previously described in Baker et al 2013b). Every year from 2006/07 (hereinafter 2006) to 2013/14 (2013) we chartered a helicopter from Southern Lakes Helicopters Company to conduct a return flight to the Auckland Islands group. The aircraft, a single-engined Squirrel AS350B3, was piloted by either Chris Green, Richard Hayes or Mark Deaker (Southern Lakes Helicopters Company). On board was Barry Baker (photographer and project coordinator), a back-up photographer, a flight logistics manager and a Department of Conservation representative.

From 2006 to 2010 flights were conducted in December to coincide with the early incubation period of the breeding cycle. At this time it was anticipated that birds would have just completed egg laying (M. Double unpublished; P. Sagar unpublished), and hence most birds that attempted to breed would still be attending active nests. The dates of our previous visits to the Auckland Islands were 16 December 2006, 13 December 2007, 14 December 2008, 3 December 2009 and 15 December 2010. For logistical reasons the flights for the 2011, 2012 and 2013 counts were undertaken on 11 January 2012, 14 January 2013 and 20 January 2014, respectively. This timing was not ideal with respect to the breeding cycle of white-capped albatross, as although hatching would not have commenced, some nests could be expected to have failed and those breeding birds may have abandoned their breeding sites.

For all flights we selected a weather window for the operation that predicted clear flying conditions with minimal low-level cloud. At the time of the 20 January 2014 flight the weather around the Auckland Islands was overcast, with winds gusting to 40 knots, and a cloud base of 1500 metres. We were able to obtain clear photographs of all colonies during two photographic circuits of the island. Weather conditions during all flights are shown below:

Date	Weather conditions encountered during photographic survey
16/12/2006	calm and fine, no cloud
13/12/2007	calm and fine, minimal cloud
14/12/2008	calm and overcast, cloud base over 1,200 metres. On a couple of occasions light showers encountered
3/12/2009	calm but overcast, cloud base 600 metres. Light showers and sea fog encountered during flight over Disappointment Island, obstructing visibility of the top of the island on occasions.
15/12/2010	calm and fine, minimal cloud
11/01/2012	calm and fine, minimal cloud
14/01/2013	calm and fine, minimal cloud
20/01/2014	Wind gusting to 40 knots, overcast, cloud base 1500 metres

Photography was timed to occur between 1100 to 1600 NZDT. Although there is little information on the behaviour of breeding white-capped albatrosses, information from the closely-related shy albatross *Thalassarche cauta* indicates that during the early incubation period the ratio of incubating to loafing birds is high as most loafers are at sea during the middle of the day (B. Baker unpublished). This assumption has subsequently been confirmed by observations at the South West Cape colony in December (Paul Sagar and David Thompson, unpublished), although the number of loafers was higher during January counts, based on photographic evidence (see below).

In January 2014 we left Enderby Island (Auckland Islands) at c.1300 NZDT with the door on the port side of the helicopter removed, and approached Disappointment Island at c.1310 NZDT. We conducted two circuits to provide the images that were used to count the breeding birds on the island, which were taken using a photo-extension of 70 mm. Additional photographs using maximum photo-extension (200 mm or 300mm) to assist in determining the proportion of empty nests and non-breeding birds in the colonies were also taken. The survey of Disappointment Island was completed by c.1438 NZDT and we proceeded to the smaller white-capped albatross colonies at South-West Cape on Auckland Island and Adams Island which we also photographed. These were photographed between 1450—1520 NZDT. After photographing these two smaller colonies, the helicopter returned to Enderby Island.

For the photography, two photographers were positioned on the port side of the aircraft to permit each to take photographs of the island simultaneously. All photographs were taken through the open port side of the aircraft using Nikon D300 or D800 digital cameras and image-stabilised Nikkor 70—200 mm F2.8 and 18—200 mm zoom lenses, or a 300 mm F2.8 telephoto lens. Shutter speeds were set at 1/1000 s or faster to minimise camera shake, and every effort made to ensure that the photographs were taken perpendicular to the land surface. The focal length of the zoom lens was not adjusted within each pass sequence over the island. From the circuits of the island we produced a complete series of overlapping images that covered the entire area of the island where albatrosses were nesting. The two photographers took approximately 3,000 digital photographs each during the survey flight. All photographs of the colony were saved as fine JPG format files. The survey photographs of Disappointment Island were taken at an altitude of about 400 metres, well above the minimum limit of 300 m recommended by DOC. Most photographs were taken with the zoom lens set at a focal length of 70 mm. The close-ups were taken with the zoom lens set at 200 mm or using the 300 mm telephoto lens. The entire sets of photographs were subsequently replicated to ensure that four complete back-up sets existed both on portable hard drives and in at least three different locations. A full collection of photographs will also be submitted to the Department of Conservation on the completion of the contract.

Counting protocol

We used protocols previously developed for aerial censuses of Chilean albatross colonies (Arata et al, 2003; Robertson *et al*. 2007) and refined in our survey of the Auckland Islands in 2006. Briefly, 30 photographic montages of Disappointment Island (Figures 1—3), 8 of South West Cape and 1 of Adams Island were constructed from overlapping photographs using the image editing software package ADOBE PHOTOSHOP (http://www.adobe.com/). The boundary of the photographic montages for Disappointment Island generally followed those selected in previous flights (Baker et al. 2013) although slight differences between years were inevitable due to different photographic angles. Photomontages were made only of the slope habitats of Disappointment island, South West Cape and Adams Island because an earlier site visit revealed that this was the habitat preferred by white-capped albatrosses — Gibson's albatross *Diomedea antipodensis gibsoni* nests only on the plateau at Disappointment and Adams Islands and the two species do not form mixed breeding colonies (Mike Double unpublished). Counts of all white-capped albatrosses on each montage were then made by magnifying the image to view birds and using the paintbrush tool in PHOTOSHOP to mark each bird with a coloured circle as they were counted (Figures 4 and 5). To assist with counting we used MOUSECOUNT software (http://www.kittyfeet.com/mousecount.htm) and a hand held click counter. Once all birds had been counted on a photo-montage, the file was saved to provide an archival record of the count. Each single bird was assumed to represent a breeding pair. While most birds were alone at nest sites, we also counted instances when two birds were sitting close together (i.e. inside the pecking distance that defines the minimum distance between nests) 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.

Counts of photo montages in all years except 2006 were undertaken by one observer only. Previously we undertook multiple counts of photomontages from the December 2006 census to estimate counter variability associated with miscounting and misidentifying white spots on the ground as birds. These count data were statistically modelled by Poisson regression, a special case of a Generalised Linear Model (McCullagh and Nelder, 1989), with observer and area as fixed effects. After allowing for both mean observer and mean area differences, there was no evidence to suggest that our model and data were incompatible, based upon regression diagnostics and model checking. There was also no evidence of a difference between observers and hence an observer bias. We have no reason to believe that data collected subsequently should have different distributional properties to our 2006 data and so we assume the current data are also compatible with a Poisson model. Thus we present raw counts only and assume the standard deviation is estimated as the square root of the count, a property of the Poisson model.

Ground counts

Ground counts were undertaken at SW Cape in 2007 and 2008 and on Disappointment Island in 2008. All ground-truthing activities were undertaken within a week of the 2007 and 2008 aerial counts.

At Disappointment Is counts of occupied nests were undertaken by two observers to determine the proportion of nests containing eggs. All occupied nests encountered 1 m either side of a randomly placed transect were inspected and the presence of eggs recorded. These counts were undertaken on 9 December 2008 between 12.00 and 12.30 NZDT.

At South West Cape counts were conducted by three observers who independently recorded the number of birds sitting or standing on nests, the number of pairs (partners accompanying an incubating bird), and the number of non-breeding birds present in four well defined areas of the colony. Counts were made every hour between 10.30 to 16.30 NZDT.

Trend Analysis

To assess population trend in total counts we used an appropriate Generalised Linear Model (Nelder and McCullough) where the response was specified as an over dispersed Poisson distribution and the link was logarithmic. To allow for possible non-linear trend effects we used regression splines with a single knot at 2010.

Trend analyses were also run using software program TRIM (TRends and Indices for Monitoring Data; Pannekoek and van Strien, 1996). TRIM is a freeware program, developed by Statistics Netherlands and is the standard tool used by the Agreement for the Conservation of Albatrosses and Petrels (ACAP) to analyse trends. We used the linear trend model with stepwise selection of change points (missing values removed) with serial correlation taken into account but not overdispersion. Following Delord et al (2008), we analysed overall population trends for each species by combining the time-series with missing observations, and made a log-linear regression model with Poisson error terms. To obtain the overall estimated breeding numbers on the monitored sites for each species, we used the population size estimates together with their standard errors obtained from the TRIM analysis. Because we were interested in identifying the changes in population trends across years, we started the analysis with a model with change points at each time-point, and used the stepwise selection procedure to identify change points with significant changes in slope based on Wald tests with a significance-level threshold value of 0.01 (Pannekoek and van Strien, 1996). We took into account over-dispersion and serial correlation since they can have important effects on standard errors, although they have usually only a small effect on the estimates of parameters (Pannekoek and van Strien, 1996). No covariate was used. Annual population rates of changes were calculated, for each species, using the relationship:

$$r = \ln \lambda = \ln Nt\text{-}1 / Nt$$

where Nt and N t+1 are the number of pairs breeding in year t and t + 1 respectively (taken to be the number of breeding birds counted in year t and t + 1) and λ the population growth rate (Caughley, 1980). It was assumed that all the nesting birds were detected. N t+1, Nt and λ were given by TRIM. All population size estimates are presented ±1 SE or ± 95% confidence intervals.

TRIM classifies trends by converting the multiplicative overall slope estimate in TRIM into one of the six categories shown below. The category depends on the overall slope as well as its 95% confidence interval.

Strong increase - increase significantly more than 5% per year (5% would mean a doubling in abundance within 15 years). Criterion: lower limit of confidence interval > 1.05.

Moderate increase - significant increase, but not significantly more than 5% per year. Criterion: 1.00 < lower limit of confidence interval < 1.05.

Stable - no significant increase or decline, and it is certain that trends are less than 5% per year. Criterion: confidence interval encloses 1.00 but lower limit > 0.95 and upper limit < 1.05.

Uncertain - no significant increase or decline, but not certain if trends are less than 5% per year. Criterion: confidence interval encloses 1.00 but lower limit < 0.95 or upper limit > 1.05.

Moderate decline - significant decline, but not significantly more than 5% per year. Criterion: 0.95 < upper limit of confidence interval < 1.00.

Steep decline - decline significantly more than 5% per year (5% would mean a halving in abundance within 15 years). Criterion: upper limit of confidence interval < 0.95.

3. Results

3.1 Aerial counts

In 2013 we estimated the total count of nesting white-capped albatrosses to be 92,321 (95%CI 91,713 — 92,929) for Disappointment Island (Table 1); 5,756 (5,604 — 5,908) for South West Cape, Auckland Island (Table 2); and 186 (159— 213) for Adams Island (Table 3). Of these, 2,769 (2,664— 2,874), 214 (185— 243) and 9 (3—15) birds were assessed as being the partners of incubating birds at Disappointment Island, South West Cape and Adams Island, respectively. Therefore, we estimate that there were 89,552 (95%CI 88,953 — 90,151), 5,542 (5,393 — 5,691) and 184 (157— 211) annual breeding pairs at Disappointment Island, South West Cape and Adams Island, respectively, in 2013, based on the raw counts, giving a total for these sites of 95,278 (94,661 — 95,895) breeding pairs (Table 4).

Analysis of 30 close-up photographs randomly selected showed that in 2013 most (860 of 1,107, or 77.7%) of the birds visible in the photographs were sitting on nests (Table 5). Two hundred and forty seven birds (22.3%) were clearly not associated with a nest, and we were unclear of the status of a further 24 birds. Across four years of close-up counts for years 2007-2010, 3,939 of the 3,993 visible birds (99%) were sitting on nests, while 54 birds (1%) were not associated with nests (Table 6). Across three years of close-up counts for years 2011-2013, 2,963 of the 3,456 visible birds (86%) were sitting on nests, while 493 birds (14%) were not associated with nests (Table 6). The proportion of non-breeding birds during the last three years ranged from 7-22%.

These results indicate that when counts were carried out in 2006-2010 (December, early incubation) there were few non-breeding birds in the colony, but in 2011-2013 (January, late incubation period) more non-breeders were present. These differences were taken into account when assessing population trends (see Section 3.3 below).

Also apparent in the close-up photographs were a large number of empty nests. For the seven years 2007 to 2013 we counted a total of 2,777 empty nest pedestals compared with 6,902 occupied nests in the randomly selected close-ups each year (29% unoccupied).

3.2 Ground counts

Ground counts of nests inspected on the ground on Disappointment Island on 9 December 2008 showed that 447 occupied nests (93.5%) contained eggs and 31 (6.5%) were empty.

At SW Cape ground counts in 2007 and 2008 confirmed the impression provided by the close-up photos that few non-breeding birds are generally present in the colony during December counts at the time of day that the aerial photography was undertaken. From 84 observations, ≤ 2% of birds present were non-breeders on 86% of observations, and ≤ 5% on 97% of the total observations. The maximum number of non-breeders present at any one time was 10%.

3.3 Trend Analysis

Count data over eight years show strong inter-annual fluctuations, a characteristic we have observed for many other seabird species (e.g. Baker and Holdsworth 2013). This variability would encompass counting error, the presence of non-breeding birds during counts, environmental stochasticity and other unknown variables that are not easily quantified.

Estimated annual counts for all three breeding sites in the Auckland Islands (Table 4) were adjusted to account for the presence of non-breeding birds (Table 6), giving adjusted estimates of annual breeding pairs of 116 025, 90 036, 96 118, 73 838, 76 119, 92 692, 102 273 and 74 031 for each year from 2006 to 2013 inclusive. These adjusted figures were used as inputs into models used for assessment of population trend.

Trend analysis for all sites combined using regression splines showed no clear evidence for systematic monotonic decline over the 8 years of the study. This is particularly so if the count for 2006 is excluded. Given this we do not have sufficient evidence to reject the null hypothesis of no systematic trend in the total population (Figure 4).

Using TRIM for all sites combined and analysing eight years of data (2006 to 2013 breeding seasons), the stepwise procedure stepwise procedure for selection of change points indicated significant change points in all years ($p < 0.01$ for Wald tests). The population size estimates computed from the model indicate an average growth rate of -3.16% per year (λ = 0.9684 ± 0.001; assessed by TRIM as moderate decline.

4. Discussion

Comparison of Annual Photographic Counts

The counts of nesting white-capped albatross, corrected for the presence of non-breeding birds, over the last eight years have ranged from a high of 116,025 annual breeding pairs in 2006 to a low of 73,838 in 2009. The observed strong inter-annual fluctuations is a characteristic we have observed for many other seabird species (e.g. Baker and Holdsworth 2013), and would encompass counting error, the presence of non-breeding birds during counts, environmental stochasticity and other unknown variables that are not easily quantified. Despite the strong inter-annual fluctuations, the data are useful for tracking change in the white-capped albatross since they have been collected at roughly the same time of the breeding cycle (incubation), allowing inferences about long-term trends to be made. This information should provide a statistical basis for making decisions pertaining to management of these populations.

Francis (2011) conducted a population viability analysis for the white-capped albatross and assessed the early (2006 to 2009) count data presented here. He concluded that the status of the population was uncertain, particularly if the counts are to be interpreted as counts of breeding pairs. While noting our photographic surveys suggested the adult population declined at about 9.8% per year between 2006 and 2009, he believed that the 2006 estimate to be imprecise, and too high to be consistent with either bycatch estimates or adult survival rates estimated from mark-recapture data (Francis 2011). In particular, he expressed concern that the 2006 count could have included a higher proportion of non-breeders (loafers) than was generally indicated by the close up counts, in part because one close-up photo indicated that 50% of birds present were loafers (subsequently identified as an error in reporting), but also, it appears, because the count in that year concluded later in the day (1700 NZDT) when some non-breeding birds would be returning to the colony after foraging at sea. Francis (2011) also noted that the Poisson confidence limits underestimate total uncertainty because they do not include any uncertainty in the proportion of non-breeding birds.

We are confident that the observed differences in counts are real and not an artefact of technique, although the timing of the counts over the last three years (2011-2013) differed by one month from all previous counts. Although the 2006 count concluded at 1700 NZDT, this is still comparatively early in that day in December in the sub-Antarctic and we would expect few non-breeding birds to be in the colony at that time. The confidence intervals in the estimates have always been clearly stated to refer to counter error and nothing else. Any bias that exists around the counts due to the presence of loafers should be consistent across all years when counts are undertaken at the same time of year, as our close-up date indicates.

In all other aspects, the methods employed and the personnel we used for the photography, construction of photo montages and counting were essentially identical for all years. It is also clear from an analysis of the close-up photos photographs taken in all but the first year of the study that there were a number of visibly unoccupied nest pedestals across the two larger colonies. Such a high proportion (0.30) of empty to occupied nests is usually not apparent in colonies of the medium to small albatrosses until later in the breeding season. Also apparent is an increase in the number of non-breeding birds present in the colony in counts taken later in the breeding season (January), which was evident from the 'close-up' photos and on-ground observations (David Thompson unpublished).

There are a couple of possible explanations for the differences observed between the years. White-capped albatrosses are now considered to be biennial breeders, as recent research has indicated (Paul Sagar and David Thompson unpublished). As such, we would expect to see larger inter-annual fluctuations in counts than that typically observed with annual breeding species where populations are stable. Breeding may have commenced earlier in some years, placing our counts at a time after significant early nest failure may have occurred. Certainly, it needs to be remembered that counts over the last two years (2011 and 2012) have been made a month later than in the first five years of counts. While we have taken into account the presence of more loafers in the colony in the last 2 years, we would also expect numbers later in the season to be lower than those recorded at the end of egg laying (December) as some pairs would have failed and ceased attending the colony.

It is also possible that the difference between years may represent normal inter-annual variation in breeding, with reduced resource availability in later years causing many birds to not breed in those years. A further possibility — that we are observing a population decline — seems unlikely with the evidence that trend analysis showed no evidence for systematic monotonic decline over the seven years of the study.

Sources of Error in Photographic Census

Ground-truthing has been used in other photographic censuses of albatross colonies to estimate the bias associated with birds loafing in colonies, birds sitting on nests without an egg, and to identify areas where nests may be obscured from the air by topographical features (Robertson et al. 2007). The information gained from ground surveys can then be used to estimate the total number of breeding pairs from the total number of birds counted. Unfortunately, ground-truthing at Disappointment Island has only been possible in 2008 because of logistics and access restrictions, and this situation is unlikely to change in the foreseeable future.

There are several likely sources of bias and identifiable components of variability in using aerial survey techniques, some of which can be addressed with ground truthing, and some of which cannot.

(1) The total number of active nests will be overestimated due to the presence of loafing birds and birds sitting on nests without eggs. For black-browed albatross colonies in Chile, Robertson et al (2007) estimated that nearly 12% of birds attending a colony fell into one of these two categories. Simultaneous ground-truthing revealed that 5% of the birds photographed were loafing in the colony and a further 7% were sitting on empty nests. The size of these errors would differ depending on the time of day and stage of breeding that surveys were conducted.

    Evidence from the close-up photographs across seven years indicates that the number of loafing white-capped albatrosses at Disappointment Island is very low early in the incubation period (<2% for all December counts), but higher later in the breeding season (7%, 15% and 22.3% for January counts in 2011, 2012 and 2013, respectively).

(2) Differences between observer counts will generate variability in the total count, as will misidentification of birds in mixed species colonies. Fortunately, our analyses suggest that the error associated with our counts was no larger than the intrinsic error expected in count data, and there were no other species nesting amongst the white-capped albatross colonies.

(3) Poor stitching of the photographs will generate variability in counts. Omission or double-counting of albatrosses near stitch lines due to parallax has been considered a problem in other studies (Robertson et al. 2007). For the counts at all breeding sites in the Auckland Islands the nature of the terrain was such that we were confident that on most stitch lines errors such as this did not occur. The only occasions where error may have occurred would have been due to the accuracy of the lines drawn on the stitched images to indicate which side of a ridge to count the birds. The birds on the other side of the ridge were counted on the following image where a corresponding ridge line was drawn. On most images the ridge lines were easily defined and we were confident that birds were not missed or double counted. However on a couple of occasions it was difficult to draw these lines as there were no clear topographical features that permitted the edge of ridge lines to be defined easily and difficult to identify individual birds. When this occurred, a count of birds close to ridge lines suggested that any error would not have exceeded two hundred birds in total across all stitched images in any year.

(4) Ground-truthing may permit identification of 'detection error' in areas where nests may be obscured from the air by topographical features such as jumbled rock substrate, but this is unlikely to have been a problem for the Auckland Island sites. Note however, that in some cases where site topography is rough, it is possible to miss small colonies in ground counts that may be readily observed from the air (Robertson et al 2007; G. Robertson unpublished).

While ground-truthing may improve the accuracy of population estimates derived from aerial surveys, it needs to be recognised that the timing of aerial and on-ground counts needs to synchronous if meaningful correction factors are to be developed. In any albatross colony, nests fail regularly after laying as eggs are broken or become buried in the mud-nest pedestals. In the closely related shy albatross, some birds may continue to attend nests for some time after eggs are lost or broken. However, as the time-lag between an aerial and on-ground count increases, the relativity between estimates derived from both counts is likely to decrease. Access to many sub Antarctic islands is often difficult for both logistic and financial reasons, and the uncertainty associated with access may provide a valid reason to solely rely on aerial counts for estimating population size at sites where it is feasible to do so. As advocated by Robertson et al (2007) and used by Arata et al. (2003) and in this study, the use of larger scale digital photographs and subsequent magnification on the computer screen to enhance the images of individual birds, can provide improved information on posture and behaviour that may enable nesting and loafing birds to be separated. Elimination of ground truthing has further benefits in reducing disturbance at nesting colonies, and efforts to develop survey techniques that will minimise disturbance to nesting birds should be encouraged.

Conservation implications

The remoteness of breeding sites and difficulty of access has previously constrained development of a comprehensive estimate for size of the breeding population of white-capped albatross (Taylor 2000; Croxall and Gales 1998). While attempts have been made at times over the last 20 years to conduct counts at Disappointment Is and South West Cape, where the bulk of the global population breeds, details of these have never been published and it is difficult to assess the methodology used, the time of year counts were made, the completeness of the counts, and any population trend beyond the data we have collected.

With only the reputedly small colony on Bollons Island (Gales 1998; Tennyson et al, 1998; Robertson 1975) not counted in this study, our estimates represent the first reliable population estimate for this species. These estimates indicate that global population is currently c.110,000 annual breeding pairs, which is much larger than previously thought. This may be the result of sustained population growth since the 1970s, or simply reflect inaccuracy of the earlier counts in a population that is stable.

The population size estimates computed from the TRIM model indicate an average growth rate of - 3.16% per year ($\lambda = 0.9684 \pm 0.001$); assessed by TRIM as moderate decline. We note, however, that a simple linear trend analysis, as performed by TRIM is not well suited to a data set with high inter-annual variability. Trend analysis using regression splines is more appropriate to such data sets, and showed no evidence for systematic monotonic decline over the 8 years of the study, therefore providing support to the null hypotheses of no trend (stability) in the total population.

In a global review of fisheries-related mortality of shy and white-capped albatrosses Baker et al. (2007a) estimated that 8,000 white-capped albatrosses were killed each year as a result of interactions with trawl and longline fisheries in the Southern Ocean. This level of mortality highlights the need to continue to acquire accurate population estimates and trends for white-capped albatross populations to assess the impact of fisheries operations on this species. The lower numbers observed each year since the 2006 count may be indicative of a population decline, and further counts for at least another year are recommended to indicate if the population is stable or declining and if the current level of fishing mortality is sustainable.

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Table 1. Counts of nesting white-capped albatrosses, made from photomontages of Disappointment Island, Auckland Island, 20 January 2014.

Area	Counts		
	Total birds	Pairs	Occupied nests
1	608	13	595
2	2,562	76	2,486
3	773	24	749
4	84	3	81
5	1,327	36	1,291
6	17,157	437	16,720
7	2,400	64	2,336
8	981	23	958
9	1,573	61	1,512
10	217	9	208
11	768	22	746
12	8,415	204	8,211
13	1,604	79	1,525
14	7,476	194	7,282
15	13,666	380	13,286
16	10,967	379	10,588
17	16,195	606	15,589
18	1,100	31	1,069
Castaway a	46	0	46
Castaway b	4,402	128	4,274
TOTAL	**92,321**	**2,769**	**89,552**
SE	303.84	52.62	299.25

Table 2. Counts of nesting white-capped albatrosses, made from photomontages of South West Cape, Auckland Island, 20 January 2014.

Area	Counts		
	Total birds	Pairs	Occupied nests
1	2,469	85	2,384
2	464	17	447
3	947	41	906
4	206	11	195
5	21	1	20
6	84	2	82
7	40	0	40
8	48	3	45
9	640	25	615
10	837	29	808
TOTAL	**5,756**	**214**	**5,542**
SE	75.87	14.63	74.44

Table 3. Counts of nesting white-capped albatrosses, made from a photomontage of the Adams Island colony, 20 January 2014.

Area	Counts		
	Total birds	Pairs	Occupied nests
1	7	0	7
2	186	9	177
TOTAL	**193**	**9**	**184**
SE	13.89	3.0	13.56

Table 4. Annual breeding pairs of white-capped albatrosses in the Auckland Islands in December 2006-2010 and January 2012-2014, with 95% Confidence Intervals.

	Adams Island			Disappointment Island			SW Cape, Auckand Island			Total		
Year	Count	CIL	CIU	Count	CIL	CIU	Count	CIL	CIU	Count	CIL	CIU
2006	no data			110,649	110,040	111,258	6,548	6,400	6,695	117,197	116,570	117,823
2007	79	61	97	86,080	85,493	86,667	4,786	4,648	4,924	90,945	90,342	91,548
2008	131	108	154	91,694	91,088	92,300	5,264	5,119	5,409	97,089	96,466	97,712
2009	132	109	155	70,569	70,038	71,100	4,161	4,032	4,290	74,862	74,315	75,409
2010	117	95	139	72,635	72,096	73,174	4,370	4,238	4,502	77,122	76,567	77,677
2011	178	151	205	93,752	93,140	94,364	5,846	4,693	5,999	99,776	99,144	100,408
2012	215	186	244	111,312	110,645	111,979	6,571	6,409	6,733	118,098	117,411	118,785
2013	184	157	211	89,552	88,953	90,151	5,542	5,393	5,691	95,278	94,661	95,895

Table 5. Counts of 30 randomly selected close-up photographs taken at the Disappointment Island colony, 14 January 2012.

Photo ID	On Nest	Not sure	Not on nest	Pairs	Empty nests
1	40	0	3	3	24
2	67	0	6	4	33
3	14	0	5	2	6
4	34	1	5	1	31
5	13	1	9	0	14
6	37	0	2	1	16
7	12	0	4	2	13
8	9	0	11	1	10
9	13	2	11	0	19
10	25	0	7	0	14
11	63	1	13	2	18
12	26	0	1	0	4
13	37	1	8	0	14
14	21	0	8	0	14
15	58	6	20	2	13
16	8	0	3	0	11
17	12	0	9	0	25
18	34	2	7	3	11
19	10	1	12	0	19
20	45	1	5	2	10
21	81	1	18	3	22
22	31	1	17	0	22
23	41	0	8	1	22
24	25	0	5	1	20
25	17	1	4	0	14
26	23	0	7	0	28
27	22	0	12	0	21
28	14	1	9	0	9
29	16	0	8	0	15
30	12	4	10	1	12
Totals	860	24	247	29	504

Table 6. Summary of counts of randomly selected close-up photographs taken each year at Disappointment Island in December 2007-2010 and January 2012-2014.

Year	On Nest	Not sure	Not on nest	Pairs	Total Birds - breeding status known	Empty nests	Total nests
2007	805	21	4	5	809	326	1,131
2008	1,590	20	29	22	1,619	438	2,028
2009	937	23	13	5	950	633	1,570
2010	607	16	8	2	615	343	950
2011	1,007	31	77	19	1,084	291	1,298
2012	1,096	63	169	17	1,265	n/a	663
2013	860	24	247	29	1,107	504	1,364
Totals	**6,469**	**166**	**494**	**82**	**7,449**	**2,777**	**9,679**

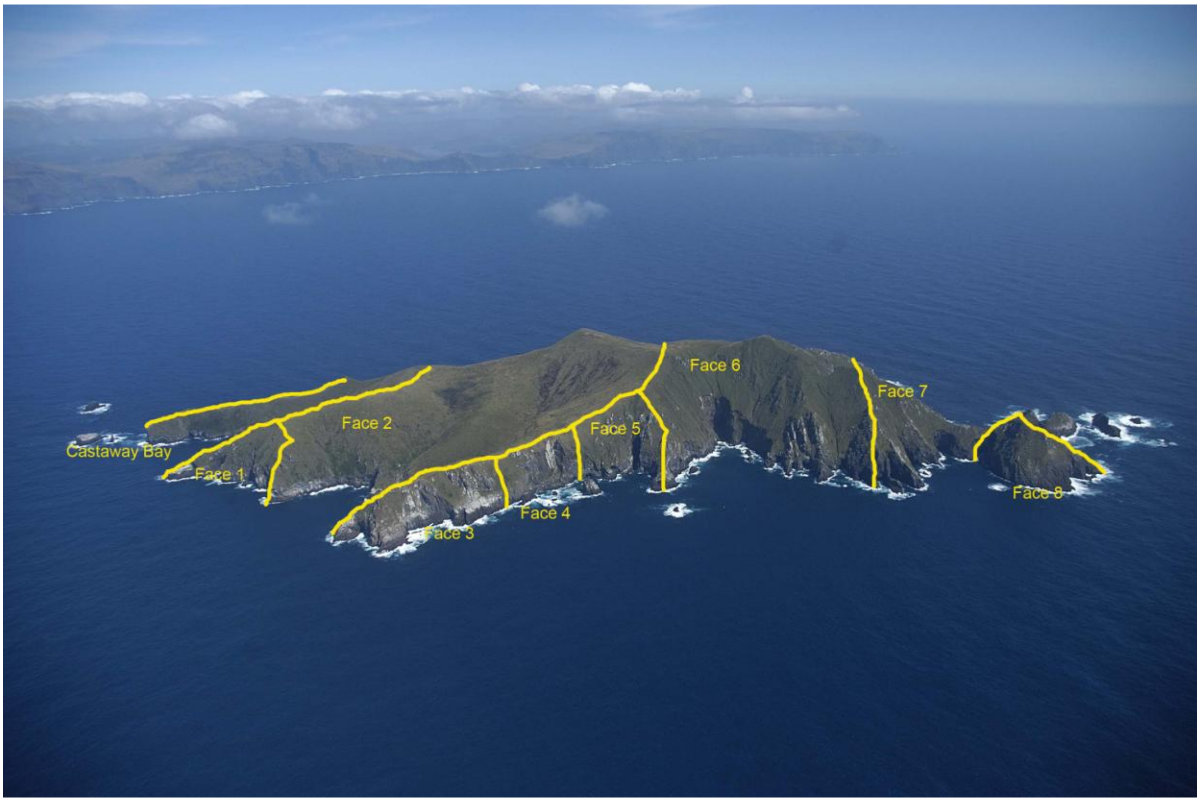

Figure 1. Boundary of photographic montages 1 to 8 and Castaway Bay, Disappointment Island

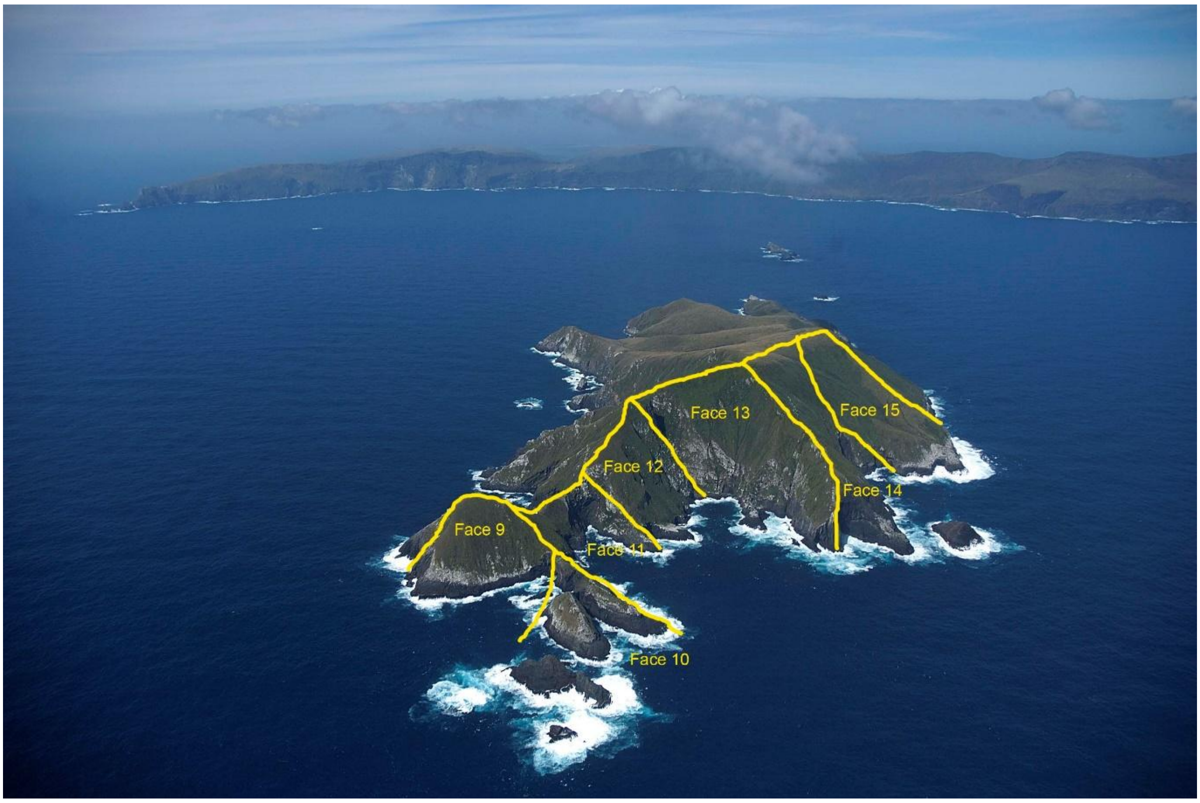

Figure 2. Boundary of photographic montages 9 to 15, Disappointment Island

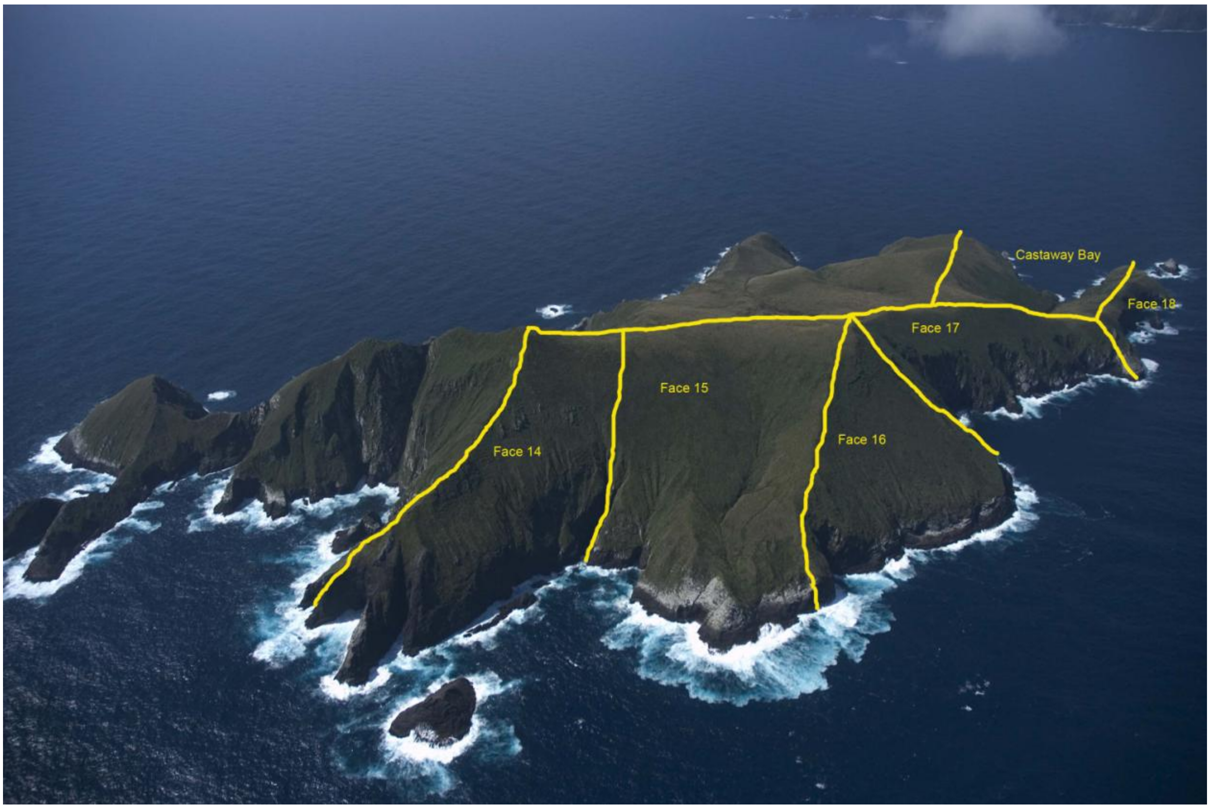

Figure 3. Boundary of photographic montages 14 to 18 and Castaway Bay, Disappointment Is.

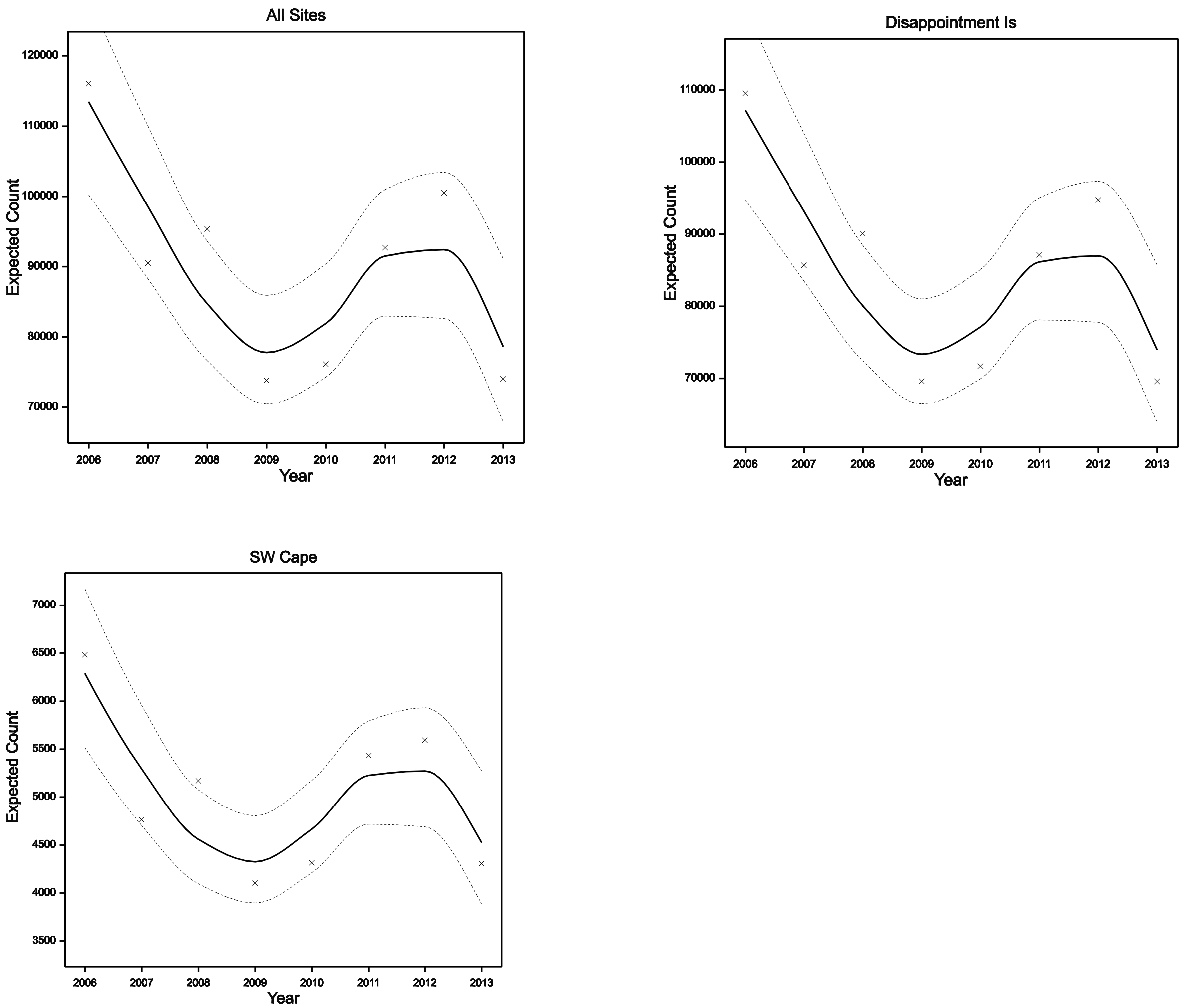

Figure 4. **Data points (total counts as adjusted for the presence of non-breeding birds), regression trend line with associated 85% confidence intervals for annual breeding pairs of white-capped albatross at three sites in the Auckland Islands. Non-overlap of the 85% CI between any two points infers significance at P=0.05. Note that scale differs on the Y axis.**