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White-capped albatross population estimate — 2011/12 and 2012/13

Milestone 2 — Analysis of 2011/12 & 2012/13 data

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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.

Between 2006/07 and 2010/11 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 December each year to estimate population size and track population trends.

We have now undertaken two additional counts at the Auckland Islands: on 11 January 2012 and 14 January 2013 (2011/12 breeding seasons, respectively).

In 2011/12 we estimated the total count of nesting white-capped albatrosses to be 93,752 (95%CI 93,140 — 94,364), 5,846 (5,604 — 5,999) and 178 (151— 205) annual breeding pairs at Disappointment Island, South West Cape and Adams Island, respectively, giving a total for these sites of 99,776 (99,144—100,408) breeding pairs.

In 2012/13 we estimated the total count of nesting white-capped albatrosses to be 93,752 (95%CI 93,140 — 94,364), 5,846 (5,604 — 5,999) and 178 (151— 205) annual breeding pairs at Disappointment Island, South West Cape and Adams Island, respectively, giving a total for these sites of 99,776 (99,144—100,408) breeding pairs.

The counts of nesting white-capped albatross over the last five years have been significantly lower than the counts taken in 2006/07, when a total of 117,197 annual breeding pairs were present in the Auckland Islands. These differences in counts may represent normal inter-annual variation in breeding rather than indicating a decline in numbers. However, 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 six years indicate the population may be in decline, further counts are recommended to clarify if this apparent trend is real, and if current levels of fishing mortality are sustainable. Analysis of data to be collected in January 2013 will assist in this regard.

Milestone

White-capped albatross — gather data to estimate population size and trend on Disappointment Island.

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 2006/07 we commenced annual population censuses of white-capped albatrosses breeding on the Auckland Islands using aerial photography. These population censuses have now been conducted over seven years to estimate population size and track population trends. Previous reports on the first five years of the study have been provided for surveys in 2006/07, 2007/08, 2008/09, 2009/10 and 2010/11 (Baker et al. 2007b, 2008, 2009, 2010, 2011).

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 2011/12 and 2012/13 breeding seasons; and
2. determine the population trend of white-capped albatross at the Auckland Island.

Here we report on the results of counts undertaken in January 2012 and 2013. This report also consolidates data from counts undertaken in earlier years to provide a complete picture of the surveys undertaken.

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 (2006-2009) has been previously described in Baker et al (2007b, 2008, 2009, 2010, 2011). Every year from 2006/07 (heinafter 2006) to 2012 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 and 3 December 2009 (Baker et al 2007b, 2008, 2009, 2010, 2011). For logistical reasons the flights for the 2011 and 2012 counts were undertaken on 11 January 2012 and 14 January 2013, 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 11 January 2012 flight the weather around the Auckland Islands was calm and clear. 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

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 at this time 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 (Paul Sagar and David Thompson, unpublished).

In both 2011 and 2012 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.1315 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.1430 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 1530—1550 NZDT. After photographing these two smaller colonies, the helicopter landed near South-West Cape for a scheduled break before returning 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 six 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 (Baker et al 2007b). 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. 2007b, 2008, 2009, 2010, 2011) 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

Trend analyses were 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 analysised 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:

$$r = \ln \lambda = \ln N_{t-1} / N_t$$

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 2011 we estimated the total count of nesting white-capped albatrosses to be 95,061 (95%CI 94,444 — 95,678) for Disappointment Island (Table 1); 5,936 (5,782 — 6,090) for South West Cape, Auckland Island (Table 3); and 186 (159— 213) for Adams Island (Table 5). Of these, 1,309 (1,237— 1,381), 90 (71— 109) and 8 (2—14) 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 93,752 (95%CI 93,140 — 94,364), 5,846 (5,693 — 5,999) and 178 (151 — 205) annual breeding pairs at Disappointment Island, South West Cape and Adams Island, respectively, in 2011, giving a total for these sites of 99,776 (99,144 — 100,408) breeding pairs (Table 7).

In 2012 we estimated the total count of nesting white-capped albatrosses to be 115,047 (95%CI 114,369 — 115,725) for Disappointment Island (Table 2); 6,614 (6,451 — 6,777) for South West Cape, Auckland Island (Table 4); and 221 (191— 251) for Adams Island (Table 6). Of these, 3,735 (3,613—3,857), 371 (332— 410) and 6 (1—11) 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 110,778 (95%CI 110,112 — 111,444), 6,571 (6,409 — 6,733) and 215 (186 — 244) annual breeding pairs at Disappointment Island, South West Cape and Adams Island, respectively, in 2012, giving a total for these sites of 117,564 (116,878 — 118,250) breeding pairs (Table 7).

Analysis of 15 close-up photographs randomly selected showed that in 2011 most (1,007 of 1,115, or 90%) of the birds visible in the photographs were sitting on nests (Table 8). Seventy seven birds (7%) were clearly not associated with a nest, although we were unclear of the status of a further 31 birds. Analysis of 20 close-up photographs randomly selected for 2012 showed that fewer (663 of 810, or 82%) of the birds visible in the photographs were sitting on nests (Table 9). One hundred and sixteen birds (14%) were clearly not associated with a nest, although we were unclear of the status of a further 31 birds. Excluding the birds of uncertain status for both years, 7% and 15% of birds in 2011 and 2012 were clearly not associated with a nest and consequently considered to be floaters (Table 10). 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 80 birds (1%) were not associated with nests (Table 10).

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 and 2012 (January, late incubation period) more non-breeders were present. This difference was taken into account when assessing population trends.

Also apparent in the close-up photographs were a large number of empty nests. For the five years 2007 to 2011 we counted a total of 2.031 empty nest pedestals compared with 4,946 occupied nests in the 15 randomly selected close-ups each year (29% unoccupied). Counts of empty nest pedestals in 2012 were not available at the time this report was written.

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 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

Estimated annual counts for all three breeding sites in the Auckland Islands (Table 7) were adjusted to account for the presence of non-breeding birds (Table 10), giving adjusted estimates of annual breeding pairs of 116 025, 90 036, 96 118, 73 838, 76 119, 92 792 and 99 929 for each year from 2006 to 2012 inclusive. These adjusted figures were used as inputs into the TRIM model for assessment of population trend.

For all sites combined, using seven years of data (2006 to 2012 breeding seasons), the 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 -2.19% per year ($\lambda = 0.9781 \pm 0.001$; assessed by TRIM as moderate decline.

It needs to be remembered that counts over the last two years (2011/12 and 2012/13 have been made a month later than in the first five years of counts. While we have taken into account the presence of more floaters 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.

4. Discussion

Comparison of Annual Photographic Counts

The counts of nesting white-capped albatross over the last five years have been significantly lower than the counts taken in 2006/07, when a total of 117,197 annual breeding pairs were present in the Auckland Islands (Table 4). The estimated differences ranged from 17,421 to 42,355 fewer annual breeding pairs. We are confident that the observed differences are real and not an artefact of technique, although the timing of the count in 2011/12 differed was one month later than all earlier counts. 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 (0.29) of empty to occupied nests is usually not apparent in colonies of the medium to small albatrosses until later in the breeding season.

There are a couple of possible explanations for the differences observed between the years. Breeding may have commenced earlier in the last five years, placing our counts at a time after significant early nest failure may have occurred. It is also possible that the difference 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 third possibility is that we are observing a population decline, although we are reluctant to make this judgement until we have a few more years' data. White-capped albatrosses are now considered to be biennial breeders, as recent research by NIWA 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. It is necessary to quantify with precision the inter-annual variability before it can be confidently concluded that a long term change is occurring; this will likely require at least another years data.

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 four years indicates that the number of loafing white-capped albatrosses at Disappointment Island is similar or less than that observed for black-browed albatrosses. Our analysis indicated that most (94%) of the birds present were clearly associated with nests and unlikely to be loafing. Of the remaining birds, we were unable to determine the breeding status of 2% (i.e. it was unclear if birds were associated with a nest and hence non-breeders); or birds were either apparently non-breeding birds (3%) or the partners of other birds associated with nests (1%).

(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 two images 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 it was difficult to identify individual birds. For these two ridge lines, a count of birds close to ridge lines suggests 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.

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 was c.117,000 annual breeding pairs in 2006, 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.

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 2006/07 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, 11 January 2012.

Area	Counts		
	Total birds	Pairs	Occupied nests
1	725	14	711
2	2,678	60	2,618
3	694	6	688
4	170	2	168
5	1,501	16	1,485
6	20,429	254	20,175
7	2,259	35	2,224
8	1,129	20	1,109
9	1,285	14	1,271
10	213	2	211
11	633	2	631
12	2,638	18	2,620
13	6,209	79	6,130
14	8,119	86	8,033
15	12,951	163	12,788
16	11,624	133	11,491
17	15,628	299	15,329
18	1,423	28	1,395
Castaway a	35	0	35
Castaway b	4,718	78	4,640
TOTAL	**95,061**	**1,309**	**93,752**
SE	308.32	36.18	306.19

Table 2. Counts of nesting white-capped albatrosses, made from photomontages of Disappointment Island, Auckland Island, 14 January 2013.

Area	Counts		
	Total birds	Pairs	Occupied nests
1	922	29	893
2	3,195	110	2,995
3	811	26	785
4	220	8	212
5	1,816	67	1,749
6	22,641	761	22,146
7	2,783	101	2,672
8	1,187	47	1,140
9	1,587	51	1,536
10	182	6	176
11	677	22	655
12	4,816	158	4,668
13	7,534	245	7,289
14	9,487	261	9,216
15	14,524	418	14,106
16	13,913	505	13,408
17	21,395	667	20,028
18	1,547	63	1,484
Castaway a	45	2	43
Castaway b	5,765	188	5,577
TOTAL	**115,047**	**3,735**	**110,778**
SE	339.19	61.11	332.83

Table 3. Counts of nesting white-capped albatrosses, made from photomontages of South West Cape, Auckland Island, 11 January 2012.

Area	Counts		
	Total birds	Pairs	Occupied nests
1	2,378	46	2,332
2	446	6	440
3	979	8	971
4	173	1	172
5	108	1	107
6	57	1	56
7	98	1	97
8	415	5	410
9	690	12	678
10	592	9	583
TOTAL	**5,936**	**90**	**5,846**
SE	77.05	9.49	76.46

Table 4 Counts of nesting white-capped albatrosses, made from photomontages of South West Cape, Auckland Island, 14 January 2013.

Area	Counts		
	Total birds	Pairs	Occupied nests
1	2,496	82	2,414
2	666	19	647
3	1,076	36	1,040
4	6	170	164
5	18	0	18
6	111	4	107
7	50	1	49
8	71	7	64
9	600	12	588
10	1,520	40	1,480
TOTAL	**6,614**	**371**	**6,571**
SE	81.33	19.26	81.06

Table 5. Counts of nesting white-capped albatrosses, made from a photomontage of the Adams Island colony, 11 January 2012.

Area	Counts		
	Total birds	Pairs	Occupied nests
1	186	8	178
TOTAL	**186**	**8**	**178**
SE	13.64	2.83	13.34

Table 6. Counts of nesting white-capped albatrosses, made from a photomontage of the Adams Island colony, 14 January 2013.

Area	Counts		
	Total birds	Pairs	Occupied nests
1	221	6	215
TOTAL	**221**	**6**	**215**
SE	14.87	2.45	14.66

Table 7. **Annual breeding pairs of white-capped albatrosses in the Auckland Islands in December 2006-2010 and January 2012 and 2013, 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	110,778	110,112	111,444	6,571	6,409	6,733	117,564	116,878	118,250

Table 8. Counts of 15 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	68	3	3	1	30
2	73	2	2	0	28
3	31	0	0	0	29
4	70	0	4	0	6
5	65	0	6	2	28
6	45	0	10	1	12
7	62	5	4	2	24
8	64	9	5	2	35
9	60	1	8	1	14
10	114	5	6	3	8
11	113	2	10	0	15
12	63	3	10	3	8
13	87	0	4	1	25
14	49	1	3	1	22
15	43	0	2	2	7
Totals	1,007	31	77	19	291

Table 9. Counts of 20 randomly selected close-up photographs taken at the Disappointment Island colony, 14 January 2013.

Photo ID	On Nest	Not sure	Not on nest
1	33	0	2
2	24	0	2
3	46	0	1
4	49	0	7
5	27	1	4
6	9	0	2
7	5	1	2
8	12	0	2
9	13	0	7
10	40	0	3
11	11	0	2
12	8	0	5
13	32	3	9
14	26	0	9
15	49	0	7
16	94	7	14
17	24	0	7
18	53	12	10
19	52	7	16
20	56	0	5
Totals	663	32	116

Table 10. Summary of counts of 15 randomly selected close-up photographs taken each year at Disappointment Island in December 2007 to 2010 and January 2012 and 2013.

Year	On Nest	Not sure	Not on nest	Pairs	Total Birds	Empty nests	Total nests
2007-08	805	21	4	5	830	326	1,131
2008-09	1,590	20	92	22	1,639	438	2,028
2009-10	937	23	13	5	973	633	1,570
2010-11	607	16	8	2	631	343	950
2011-12	1,007	31	77	19	1,115	291	1,298
2012-13	663	31	116		810		
Totals	**4,946**	**111**	**131**	**53**	**5,241**	**2,031**	**6,977**

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

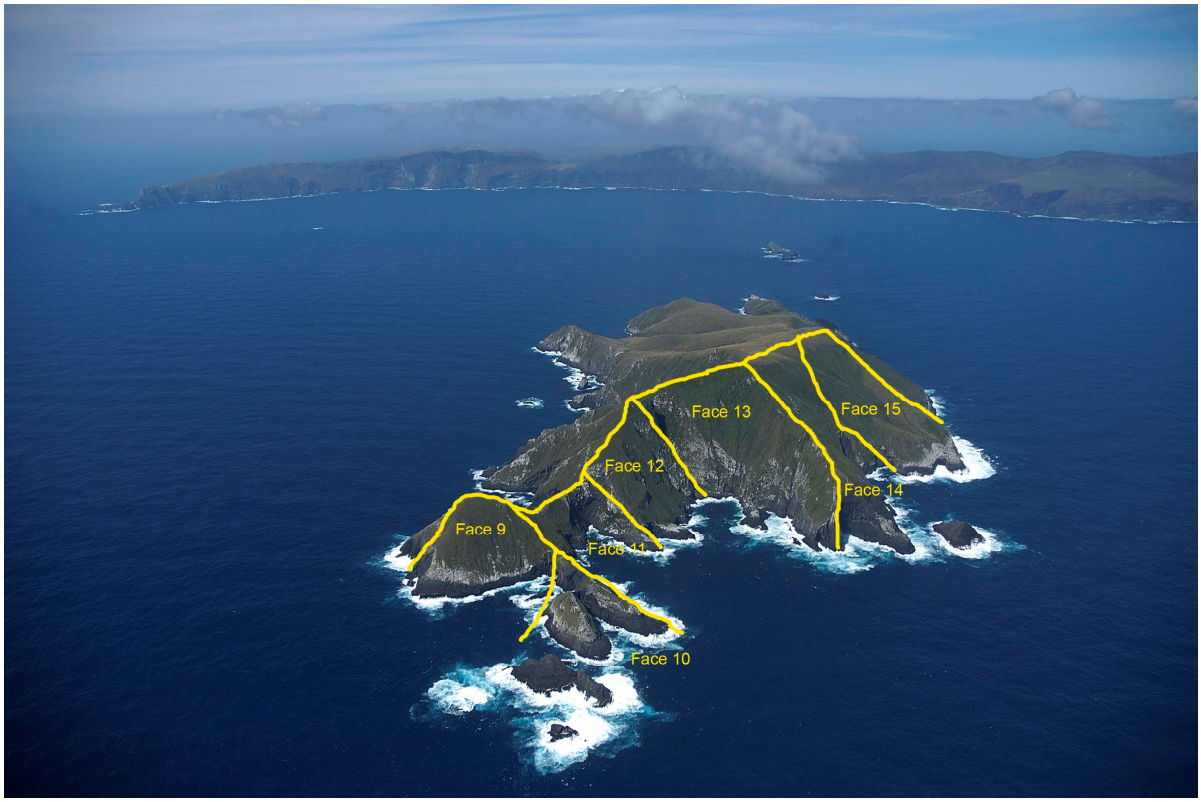

Figure 2. Boundary of photographic montages 9 to 15, Disappointment Island

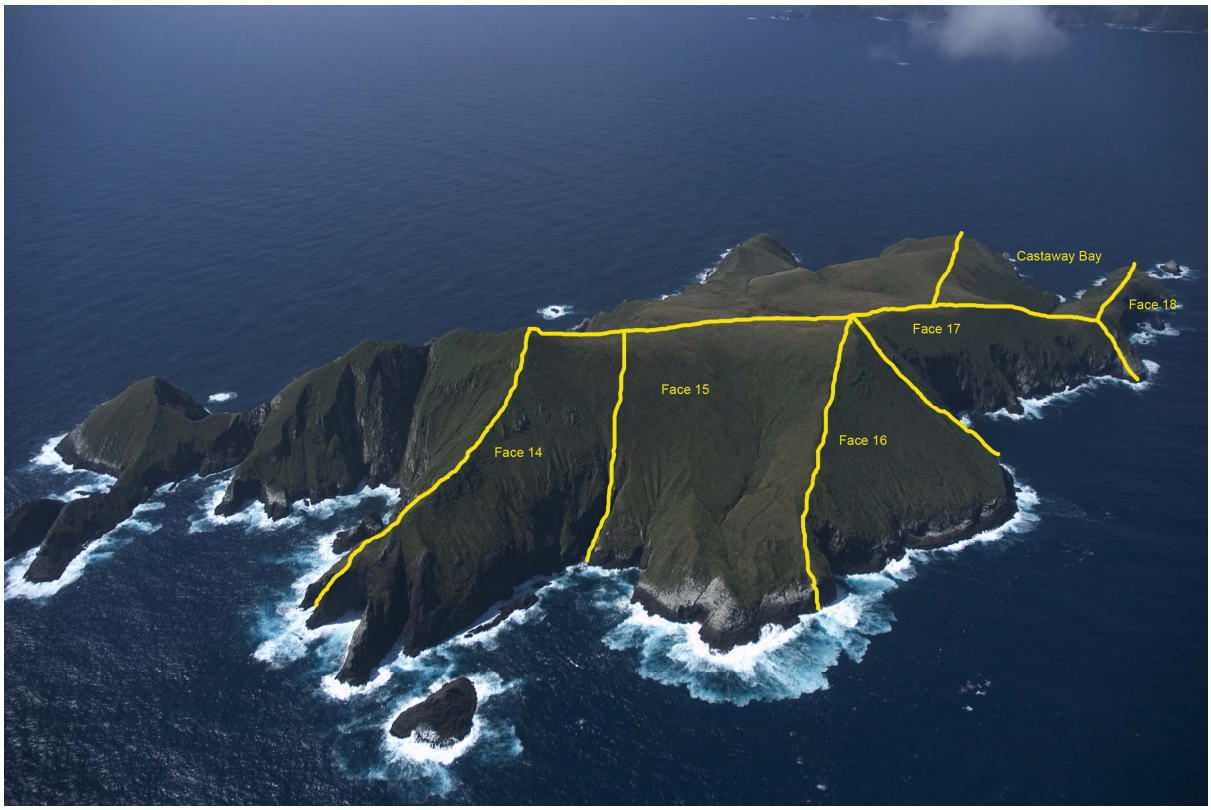

Figure 3. Boundary of photographic montages 14 to 18 and Castaway Bay, Disappointment Is.