Notornis, 2011, Vol. 58: 57-63
0029-4470 © The Ornithological Society of New Zealand, Inc.

Population size, breeding frequency and survival of Salvin's albatrosses (*Thalassarche salvini*) at the Western Chain, The Snares, New Zealand

P.M. SAGAR*
National Institute of Water & Atmospheric Research, P.O. Box 8602, Christchurch, New Zealand

M.R. CHARTERIS
177 Beach Road, Charleston, New Zealand

J.W.A. CARROLL
Foreshore Road, Colac Bay, RD 1 Riverton, New Zealand

R.P. SCOFIELD
Canterbury Museum, Rolleston Avenue, Christchurch, New Zealand

Abstract We investigated the population size and annual survival of Salvin's albatrosses (*Thalassarche salvini*) breeding at the Western Chain, The Snares, New Zealand. A count of breeding pairs during incubation resulted in totals of 1100-1200 breeding annually on Toru and Rima Islets in the 3 years 2008-2010; none was seen breeding on Tahi, Rua or Wha Islets.The majority of adults bred annually. Based on banding and recapture the annual survival probability of breeding birds was estimated to be 0.967 while that of known-age birds banded as chicks in Feb 1986 was estimated at 0.939. A bird banded as a chick on the Bounty Is in 1985 was found breeding on Toru Islet of the Western Chain in the 3 years 2008-2010. This is the first record of a banded Salvin's albatross breeding away from its natal island.

Sagar, P.M.; Charteris, M.R.; Carroll, J.W.A.; Scofield, R.P. 2011. Population size, breeding frequency and survival of Salvin's albatrosses (*Thalassarche salvini*) at the Western Chain, The Snares, New Zealand. *Notornis 58(2):* 57-63.

Keywords Salvin's albatross; *Thalassarche salvini*; population size; survival; The Snares

INTRODUCTION

Since commercial fishing operations were recognised ~20 years ago as one of the major factors influencing albatross populations (Bartle 1991; Brothers 1991; Gales 1998; Croxall & Gales 1998) much effort has gone into assessing population sizes and trends of the 14-24 albatross taxa (Croxall & Gales 1998; Brooke 2004; Gill *et al*. 2010). For example, an increase in the black-browed albatross (*Thalassarche melanophris*) population at South Georgia during the 1980s was possibly a result of increased scavenging opportunities provided by trawlers, but more recent declines in population were thought to result from the development of a new longline fishery for Patagonian toothfish (*Dissostichus eleginoides*; Croxall *et al.* 1998; Prince *et al.* 1998) and potential changes in krill (*Euphausia* spp.) abundance (Arnold *et al.* 2006).

In the New Zealand region, population decreases have been reported for Campbell (*T. impavida*) and grey-headed (*T. chrysostoma*) albatrosses at Campbell I (Moore & Moffat 1990), although the breeding population of Campbell albatross has probably

Received 4 May 2011; accepted 4 Jul 2011
*Correspondence: *p.sagar@niwa.co.nz*

increased since 1990 (Waugh *et al.* 1999; Moore 2004). Moore (2004) noted that the large decrease of Campbell albatrosses during the late 1960s to early 1980s coincided with the peak in long-line fishing of southern bluefin tuna (*Thunnus maccoyii*) within the New Zealand region while environmental change affecting the food supply was proposed as the most likely explanation for the continuing decline of grey-headed albatrosses. In contrast, the breeding population of Buller's albatrosses (*T. bulleri*) at The Snares increased markedly from at least 1969 to 2002 (Sagar & Stahl 2005). Annual adult survival of Buller's albatrosses breeding at The Snares was about 2.5% lower during 1969-1991 than during the period 1992-1997, with the increase in survival during the 1990s contemporaneous with both a decrease in pelagic long-lining effort in southern New Zealand waters and the use of mitigation measures by those fishing vessels (Sagar *et al.* 2000).

Several species of albatross have been reported in the bycatch of fisheries within the New Zealand Exclusive Economic Zone (*e.g.*, Robertson *et al.* 2004), but the impacts on the population size or even basic breeding biology are unknown for some species. However, the occurrence of white-capped (*T. steadi*), Salvin's (*T. salvini*), and Chatham (*T. eremita*) albatrosses in fisheries bycatch within the New Zealand Exclusive Economic Zone (*e.g.,* Robertson *et al*. 2004) has resulted in recent assessments of population size and trends of these species. Here, we report the results of one such study, which investigated the numbers of breeding pairs, breeding frequency and annual survival of adult Salvin's albatrosses at the Western Chain, The Snares, New Zealand, during the period 2008 to 2010. Previous information about this population of albatrosses is available from occasional visits to the islets made in 1972 (Fleming & Baker 1973), 1976 (Sagar 1977), 1984-85 and 1985-86 (Miskelly 1984, 1997), and 1995 (Clark 1996). We use information from these sources to assess any changes in population size. In addition, we used recapture data from birds banded as chicks in Jan 1986 and breeding adults in Oct 1995 to extend the period of assessment of annual survival. Overall, these results provide important new information about the size and trend of this population of Salvin's albatrosses, plus the 1st estimates of annual survival in this species.

METHODS

The Western Chain (48° 02'S, 166° 29'E) is a small group of rocky islets about 7 km south-west of The Snares. The group consists of 5 islets which rise steeply out of deep water to heights of about 80 m a.s.l, and a number of rock stacks (Fleming & Baker 1973), all of which are largely devoid of vegetation (Miskelly *et al.* 2001). Eleven species of birds have been reported breeding on the islets (Miskelly 1997), the most numerous being Salvin's albatross, Snares penguin (*Eudyptes robustus*), Cape petrel (*Daption capense australe*) and fulmar prion (*Pachyptila crassirostris*) (Miskelly *et al*. 2001). Day visits to the islets by researchers have been reported by Stead (1948), Dawson (1964), Fleming & Baker (1973), Sagar (1977) and Miskelly (1984, 1997). The 1st researchers camped overnight on Toru Islet from 30 Sep to 6 Oct and Rima Islet from 9 to 18 Nov 1995, when their prime interest was to study the breeding of Salvin's albatross (Clark 1996).

Salvin's albatrosses breed on just 2 islets, Toru and Rima, of the Western Chain, The Snares. Clark (1996) estimated that the average date of the start of laying was 27 Aug and that laying was completed by the 1st week of Oct. Therefore, our visits were timed to occur during the 1st half of Oct, when the maximum numbers of breeding pairs (represented by an incubating bird) were present.

Counts

The counts of incubating birds on Toru Islet were completed on 6-7 Oct 2008, 2 Oct 2009 and 28-29 Sep 2010 and on Rima Islet on 16 Oct 2008 and 30 Sep 2009; sea conditions were unsuitable for landing on Rima Islet during the 2010 visit. All counts were completed by Matt Charteris (MC) and Jeremy Carroll (JC). The same counting procedure was used each year and involved the observers systematically searching the entire area of each islet for Salvin's albatross nests and recording whether an adult and an egg were present. Nests with an abandoned egg or freshly broken egg shell present were recorded separately. As each nest was recorded it was sprayed with stock marker to avoid duplicate counting and to allow for checks to be made of the accuracy of the systematic survey.

Breeding frequency and survival

MC and JC camped on Toru during the periods 6-13 Oct 2008, 1-6 Oct 2009 and 27-30 Sep 2010. In addition, day visits were made on 29 Sep, 7 Oct and 14 Oct 2009 and 7, 8 and 13 Oct 2010. On 7 Oct 2008 a study area with clearly defined topographic boundaries was established; this centred on the study area established by Jacinda Amey and Gus McAllister in Oct 1995 (J. Amey, *pers. comm.*). Nests within this study colony were numbered and checks were made of incubating birds and nest contents each day that the team was ashore. Within this study area breeding Salvin's albatrosses were banded and recaptured during each visit to the island. Birds were captured by hand at the nest and fitted with a uniquely numbered stainless steel band before being released and returned to the nest. In addition, on each visit an attempt was made to recapture as many banded non-breeding birds (*i.e.,* not associated with eggs) as possible.

Table 1. Numbers of Salvin's albatross pairs breeding on Toru and Rima Islets, Western Chain, The Snares, 2008-2010. Failed nests are those assessed to contain fresh egg fragments. No count was made on Rima Islet in 2010.

Islet	Date	Adult + egg	Failed nest	Total
Toru	6-7 Oct 2008	828	70	898
	2 Oct 2009	783	51	834
	28-29 Sep 2010	780	49	829
Rima	19 Oct 2006	279	18	297
	30 Sep 2009	265	17	282

Analysis and model selection

As we had a small sample of recoveries we used the joint recapture/recovery model of Burnham (1993) to estimate survival probabilities. This model is parameterised with 4 different probabilities; S_i: the probability that a banded individual survives from year i to year $i + 1$ (here referred to as survival probability), F_i: the probability that a banded individual does not emigrate permanently from the study area from year i to year $i + 1$ (here defined as fidelity probability), p_i: the probability that a banded individual that is alive and in the study area at i is seen at $i + 1$ (the resighting probability), r_i: the probability that a banded individual that has died between year i and $i + 1$ is found and its band reported to the Banding Office (the recovery probability). The most general model included separate survival (S), fidelity (F) and recovery (r) parameters for each year (t), and age class (a). Two age classes were considered: birds banded as chicks in the nest during Jan 1986 and birds banded as adults in subsequent years. For both age classes separate resighting (p) parameters were calculated for each year (t).

To make inferences from the data we *a priori* formulated different models, each representing a hypothesis about survival and other mathematically necessary but biologically unimportant parameters (nuisance parameters). These models were fitted using Program MARK (White & Burnham 1999). To evaluate the fit of our set of models to the data we used a parametric bootstrap Goodness-of-Fit (GOF) test on the most general model (*i.e.*, the model with the most parameters). If the structure of the general model adequately fit the data, then subsequent models that are constraints of the general model can be derived (White *et al*. 2001). These bootstrap simulations also provide an estimate of the dispersion parameter ($\hat{c}$), calculated as the observed deviance divided by the average of the simulated deviances ($\hat{c}$ =1) if the model fits perfectly. The models were ranked according to the small sample-size adjusted Akaike's information criterion (*AICc;* Burnham & Anderson 1998). To reduce the list of reasonable models, we conducted modelling in 2 steps (Lebreton *et al*. 1992). First, we looked for a model that minimised the influence of the nuisance parameters (F, p, r) in the most parsimonious way. The survival part of the model was kept as the most complex structure in this step. Second, we assessed different models for survival while always retaining the most parsimonious structure of the nuisance parameters. Although survival of adults was estimable using the Burnham model, the survival of birds banded as a chick (in Jan 1986) was inestimable because of a lack of recovery data for this cohort in the 1st few years after banding. For this reason the recapture/recovery data for the chick cohort were modelled separately using the simple Cormack-Jolly-Seber (C-J-S) model in Program MARK.

To estimate longevity and expectation of further life we used our estimates of survival from MARK and the calculations in Seber (1982). Expectation of further life was calculated using the formula: $-1/\ln(S_i)$.

RESULTS

Population size

Totals of 1195 and 1116 breeding pairs were counted on Toru and Rima Islets during Oct 2008 and Sep-Oct 2009, respectively (Table 1); these totals include up to 5 birds on nests on rock stacks off Toru Islet. No count was made on Rima during 2010, but the total of 829 pairs counted on Toru was similar to the 834 counted during 2009 (Table 1). A landing was made on Wha Islet on 7 Oct 2009 and no breeding albatrosses were found despite a comprehensive search. Likewise, no breeding albatrosses were observed through binoculars on Tahi and Rua Islets.

An indication of the daily failure rate of incubating birds was estimated over a 16-day period in 2010. In a study area with clearly defined topographical boundaries the numbers of incubating birds declined from 165 on 28 Sep, to 164 on 29 Sep, 161 on 30 Sep, 152 on 7 Oct and 146 on 13 Oct. This represented an average decline of 1.2 breeding birds/day or 0.7%/day.

Breeding timetable

On 13 Oct 2008, a chick had broken through the eggshell and was heard peeping. This was the only indication of the start of hatching on all of our visits.

Breeding frequency

Of 71 banded birds where breeding status (*i.e.*, incubating or on an empty nest) was recorded

Table 2. Capture-recapture data for Salvin's albatrosses banded on Toru Islet, Western Chain, The Snares; 1986, 1995 and 2008-2010.

Year	No. banded	Year of recapture				Not recaptured
		1995	2008	2009	2010	
1986	71	5	11	16	13	52
1995	123	-	25	26	23	89
2008	71	-	-	59	52	4
2009	40	-	-	-	28	12

Table 3. *AICc* values for the top 2 Burnham recovery/recapture models for Salvin's albatrosses on the Western Chain, The Snares, 2008-2010.

Model	*QAICc*	*QAICc*	Weight	Likelihood	No. parameters	*Q* Deviance
S(g) p(t) r(.) F(.)	597.823	0	0.706	1	7	39.363
S(g) p(t) r(.) F(g)	599.573	1.75	0.294	0.4167	8	39.058

in each year from 2008 to 2010, 51 (71.8%) were recorded breeding in all 3 years, 15 (19.7%) bred in 2 years, and 6 (8.5%) in 1 year. Of 68 banded birds recorded incubating in 2008, 60 (88.2%) were also recorded incubating an egg in 2009. Likewise, of 94 birds recorded as incubating in 2009, 78 (83.0%) were incubating an egg in 2010.

Survival

The numbers of birds banded and recaptured alive each year are summarised in Table 2. One thousand bootstrap simulations indicated no obvious lack of fit of the general Burnham model ($P = 0.09$) with only minor over-dispersion ($\hat{c}$ =1.145). Of the 256 possible models run only 2 recapture/recovery models had an *AICc* < 10 (Table 3). One thousand bootstrap simulations of the simple C-J-S model (Table 4) indicated no obvious lack of fit of the general Burnham model ($P = 0.05$) with some over-dispersion ($\hat{c}$ =2.160). Deviances reported in Table 4 are calculated using the new $\hat{c}$.

Results indicate that the survival (*S*) of adults was 0.967 (SE = 0.0132) and the apparent survival of the 1986 cohort of chicks (Φ) was 0.939 (SE = 0.0086). Probabilities of recapture, recovery and fidelity are given in Table 5.

Survival and longevity

With an annual adult survival rate of 0.967, a breeding Salvin's albatross would have, on average, a reproductive life-span of 29.8 years. Similarly, a fledgling, having survived the 1st year of life and with a subsequent survival rate of 0.939 would have an average life span of 15.9 years, with the oldest birds surviving over 25 years.

Movement

In all 3 years from 2008-2010, a bird banded O-19270 was recorded breeding on Toru Islet. This bird was 1 of 890 banded in Mar 1985 as a chick in the nest on Proclamation, Depot and Funnel Is, Bounty Is (47° 50'S 179° 00E), 930 km east of the Western Chain, The Snares.

DISCUSSION

Our results provide the 1st estimates of total population size, survival, and breeding frequency and the 1st information about dispersal from their natal site of Salvin's albatrosses at the Western Chain, The Snares.

Previously, counts of eggs and chicks of Salvin's albatrosses at the Western Chain have been completed later in the breeding cycle or on either Toru or Rima Islets, but not both. The 1st count was reported by Sagar (1977), who found 135 chicks and 9 eggs on Rima Islet on 9 Nov 1977. Subsequently, Miskelly (1984) counted 435 chicks on Toru and 150 chicks on Rima during Feb 1984 and suggested that the total population was fewer than 650 pairs. However, Clark (1996) reported 1021 nests with eggs on Toru on 5 Oct 1995, but by the 1st week of Nov only about 507 chicks survived, indicating that high mortality had occurred. In addition, Clark (1996) reported 189 nests with either an egg or a chick on Rima on 8 Nov 1995. Given high mortality of eggs and chicks within a month and the variations in timing and coverage of counts it is not possible to determine the trend of the population. However, our counts over the 3 years from 2008 to 2010 indicate that the number of Salvin's albatrosses at the Western

Table 4. *AICc* values for the all C-J-S models for the 1986 cohort of Salvin's albatross chicks banded on Toru Islet, Western Chain, The Snares.

Model	*AICc*	Delta *AICc*	*AICc* weights	Model likelihood	Number parameters	Deviance
Φ(.) p(t)	175.567	0	0.568	1	5	13.537
Φ(t) p(t)	177.567	2.000	0.209	0.3678	7	10.977
Φ(t) p(.)	206.143	30.576	0	0	5	44.113
Φ(.) p(.)	211.909	36.342	0	0	2	56.378

Table 5. Probability of live recapture, reporting of dead recovery and fidelity for the *S(g) p(t) r(.) F(.)* Burnham model and the C-J-S model of Salvin's albatross adult and chick cohorts, at the Western Chain, The Snares.

Probability	Estimate	*SE*	Lower 95% *CI*	Upper 95% *CI*
Recapture of chicks in 1995	0.122	0.056	0.047	0.280
Recapture of adults in 2008	0.671	0.072	0.517	0.796
Recapture of chicks in 2008	0.122	0.077	0.033	0.362
Recapture of adults in 2009	0.880	0.035	0.791	0.934
Recapture of chicks in 2009	0.628	0.174	0.281	0.879
Recapture of adults in 2010	0.818	0.043	0.718	0.888
Recapture of chicks in 2010	0.936	0.091	0.426	0.996
Bird recovered dead	0.066	0.040	0.019	0.204
Bird remains in study area and is available for live recapture given it is alive (fidelity)	0.939	0.009	0.918	0.955

Chain was relatively stable, at 1100-1200 breeding pairs annually.

Elsewhere, Robertson & van Tets (1982) estimated 76,000 breeding pairs of Salvin's albatrosses in 1978 at the Bounty Is, although only 30,752 pairs were estimated to breed there in 1997 (Taylor 2000). However, during these expeditions different base maps were used for calculating island areas, and so different estimates of the area suitable for nesting were used, which confounds comparisons between the 2 population estimates (Taylor 2000).

Our estimates of breeding frequency indicate that the majority of adult Salvin's albatrosses are annual breeders. This is typical of most *Thalassarche* albatrosses (Warham 1990); however, in the grey-headed albatross (*T. chrysostoma*) most pairs are biennial breeders although some pairs breed annually (Tickell & Pinder 1967).

With an estimated adult survival probability of 0.967, the survival rate of Salvin's albatrosses is among the highest recorded among any species of annual-breeding albatrosses. For example, within the New Zealand region the overall annual survival rate of adult Buller's albatrosses at The Snares over the period 1961-1997 was 0.934 (Sagar *et al.* 2000) and that of Campbell albatrosses at Campbell I over the period 1984-1995 was 0.945 (Waugh *et al.* 1999). In a study of the relative influence of fisheries and climate on the demography of 4 albatross species breeding on sub-Antarctic islands in the Indian Ocean, Rolland *et al.* (2010) found that adult survival of most species was not affected by climatic variations, but was negatively affected by tuna longlining effort in 3 species. In these 3 species annual survival probabilities declined by 0.001 to 0.050, with wandering albatross the least affected species because fishing effort was low in their foraging area (Rolland *et al.* 2010).

Because of the time elapsed between banding (1986; Miskelly 1997) and 1st recapture effort (1995; Clark 1996) we could not estimate the mortality of the 1986 cohort of chicks in their 1st year. Our estimate of survival probability of this cohort as adults (0.939) is 0.028 less than the estimate for birds banded as breeding adults of unknown age. Breeding adult albatrosses are highly faithful to their nesting colony year after year, however, younger birds are more likely to disperse before making their 1st breeding attempt (Gauthier *et al.* 2010), and so this may account for the lower estimate of survival probability.

Our recapture of a bird banded as a chick at the Bounty Is is the 2nd reported movement of a banded Salvin's albatross away from its natal island, and the 1st to be recorded breeding. Previously, a banded bird from the same cohort as the bird recaptured on Toru Islet has been reported ashore at The Pyramid, Chatham Is (Miskelly *et al*. 2006), but this latter bird has not been recorded as breeding. The lack of information about movements of banded birds between breeding colonies is not surprising given the relatively low rate of banding and recapture effort that have been made in these remote and difficult of access breeding locations. For example, molecular data from a study of Buller's albatrosses suggested migration of birds between The Snares and the Solander Is (van Bekkum *et al.* 2006), but despite extensive banding and recapture effort at both breeding islands over several years no banded birds had been detected breeding away from their natal island. Also, in long-lived seabirds, fidelity to the natal site (philopatry) is generally high; for example, in a capture-recapture analysis of a 36-year data set of 3 wandering albatross (*Diomedea exulans*) breeding colonies on Ile de Possession, Crozet Is, philopatry ranged from 0.70 to 0.92 (Gauthier *et al.* 2010). However, wandering albatrosses do move between island groups: 18 wandering albatross chicks banded on Possession I subsequently bred on Marion I, 1,068 km away and 1 fledging from Marion I bred on Possession I (Cooper & Weimerskirch 2003). Consequently, Cooper & Weimerskirch (2003) concluded that the 2 island groups formed a metapopulation that should be conserved as a single unit. Further banding and recapture effort at the Western Chain and Bounty Is may provide further information about the rate of interchange of Salvin's albatrosses between the 2 island groups.

ACKNOWLEDGEMENTS

Completion of the field work would not have been possible without the support and expert seamanship of Henk Haazen (skipper), Steve Parsons and crew of *R/V Tiama*. Thanks to Pete McClelland, Gilly Adam and Sharon Trainor, Southland Conservancy, Department of Conservation for permitting the study and their support. Our study benefitted from the banding efforts of Chris Robertson, Colin Miskelly, Jacinda Amey and Gus McAllister; thanks to Graeme Taylor for making the early banding information available for our analysis. This study was funded by the New Zealand Ministry of Fisheries, under contract PRO200601. Finally, we thank Colin Miskelly and an anonymous reviewer for their comments that improved an earlier version of the paper.

LITERATURE CITED

Arnold, J.M.; Brault, S.; Croxall, J.P. 2006. Albatross populations in peril: a population trajectory for black-browed albatrosses at South Georgia. *Ecological Applications 16*: 419-432.

Bartle, J.A. 1991. Incidental capture of seabirds in the New Zealand subantarctic squid trawl fishery, 1990. *Bird Conservation International 1*: 341-359.

Brooke, M.L. 2004. *Albatrosses and petrels across the world*. Oxford: Oxford University Press.

Brothers, N.P. 1991. Albatross mortality and associated bait loss in the Japanese longline fishery in the Southern Ocean. *Biological Conservation 55*: 255-268.

Burnham, K.P. 1993. A theory for combined analysis of ring recovery and recapture data. Pages 199-213. *In*: Lebreton, J-D.; North, P.M. (eds). *Marked individuals in the study of bird population.* Basel, Switzerland: Birkhauser Verlag.

Burnham, K.P.; Anderson, D.R. 1998. *Model selection and inference: a practical information-theoretic approach*. New York: Springer-Verlag. 353 p.

Clark, G. 1996. The '*Totorore*` expedition to the Snares Western Chain; September 1995 to December 1995. Report to Department of Conservation, Invercargill.

Cooper, J.; Weimerskirch, H. 2003. Exchange of wandering albatross *Diomedea exulans* between Prince Edward and Crozet Islands. *African Journal of Marine Science 25*: 519-523.

Croxall, J.P.; Gales, R. 1998. Assessments of the conservation status of albatrosses. Pp. 46-65. *In*: Robertson, G; Gales, R. (eds) *Albatross biology and conservation*. Sydney: Surry Beatty.

Croxall, J.P.; Prince, P.A.; Rothery, P.; Wood, A.G. 1998. population changes in albatrosses at South Georgia. Pp. 69-83. *In*: Robertson, G; Gales, R. (eds) *Albatross biology and conservation*. Sydney: Surry Beatty.

Dawson, E.W. 1964. Antarctic oceanography 1963-64. *Antarctic 3*: 430-432.

Fleming, C.A.; Baker, A.N. 1973. The Snares Western Chain. *Notornis 20*: 37-45.

Gales, R. 1998. Albatross populations: status and threats. Pp. 20-45. *In*: Robertson, G; Gales, R. (eds) *Albatross biology and conservation*. Sydney: Surry Beatty.

Gauthier, G.; Milot, E.; Weimerskirch, H. 2010. Small-scale dispersal and survival in a long-lived seabird, the wandering albatross. *Journal of Animal Ecology 79*: 879-887.

Gill, B.J. (Convener) 2010. *Checklist of the birds of New Zealand, Norfolk and Macquarie Islands, and the Ross dependency, Antarctica*. Wellington: Te Papa Press and Ornithological Society of New Zealand.

Lebreton, J-D.; Burnham, K.P.; Clobert, J.; Anderson, D.R. 1992. Modelling survival and testing biological hypotheses using marked animals: a unified approach with case studies. *Ecological Monographs 62*: 67-118.

Miskelly, C.M. 1984. Birds of the Western Chain, Snares islands, 1983-84. *Notornis 31*: 209-223.

Miskelly, C.M. 1997. Biological notes on the Western Chain, Snares Islands, 1984-85 and 1985-86. *Conservation advisory science notes no. 144*. Wellington: Department of Conservation.

Miskelly, C.M.; Bester, A.J.; Bell, M. 2006. Additions to the Chatham Islands' bird list, with further records of vagrant and colonising bird species. *Notornis 53*: 215-230.

Miskelly, C.M.; Sagar, P.M.; Tennyson, A.J.D.; Scofield, R.P. 2001. Birds of the Snares Islands, New Zealand. *Notornis 48*: 1-40.

Moore, P.J. 2004. Abundance and population trends of mollymawks on Campbell Island. *Science for Conservation 242*. Wellington: Department of Conservation.

Moore, P.J.; Moffat, R.D. 1990. Mollymawks on Campbell Island. *Science and Research Division internal report no. 59*. Wellington: Department of Conservation.

Prince, P.A.; Croxall, J.P.; Trathan, P.N.; Wood, A.G. 1998. The pelagic distribution of South Georgia albatrosses and their relationships with fisheries. Pp. 137-167 *In*: Robertson, G; Gales, R. (eds) *Albatross biology and conservation*. Sydney: Surry Beatty.

Robertson, C.J.R.; Bell, E.; Scofield, P. 2004. Autopsy report for seabirds killed and returned from New Zealand fisheries, 1 October 2000 to 30 September 2001. *New Zealand Department of Conservation internal series no. 155*. Wellington: Department of Conservation.

Robertson, C.J.R.; van Tets, G.F. 1982. The status of birds at the Bounty Islands. *Notornis 29*: 311-336.

Rolland, V.; Weimerskirch, H.; Barbraud, C. 2010. Relative influence of fisheries and climate on the demography of four albatross species. *Global Change Biology 16*: 1910-1922.

Sagar, P.M. 1977. Birds of the Western Chain, Snares Islands, New Zealand. *Notornis 24*: 178-183.

Sagar, P.M.; Molloy, J.; Weimerskirch, H.; Warham, J. 2000. Temporal and age-related changes in the survival rates of southern Buller's albatrosses (*Thalassarche bulleri bulleri*) at The Snares, New Zealand, 1948 to 1997. *Auk 117*: 699-708.

Sagar, P.M.; Stahl, J.C. 2005. Increases in the numbers of breeding pairs in two populations of Buller's albatross (*Thalassarche bulleri bulleri*). *Emu 105*: 49-55.

Seber, G.A.F. 1982. *The estimation of animal abundance and related parameters. 2nd ed.* London: Griffin.

Stead, E.F. 1948. Bird life on The Snares. *New Zealand Bird Notes 3*: 70-80.

Taylor, G.A. 2000. Action plan for seabird conservation in New Zealand. Part A: threatened seabirds. *Threatened species occasional publication no. 16*. Wellington: Department of Conservation.

Tickell, W.L.N.; Pinder, R. 1967. Breeding frequency in the albatrosses *Diomedea melanophris* and *D. chrysostoma*. *Nature 213*: 315-316.

Van Bekkum, M.; Sagar, P.M.; Stahl, J.C.; Chambers, G.K. 2006. Natal philopatry does not lead to population differentiation in Buller's albatross (*Thalassarche bulleri bulleri*). *Molecular Ecology 15*: 73-79.

Warham, J. 1990. *The petrels – their ecology and breeding systems*. London: Academic Press.

Waugh, S.M.; Weimerskirch, H.; Moore, P.J.; Sagar, P.M. 1999. Population dynamics of black-browed and grey-headed albatrosses *Diomedea melanophrys* and *D. chrysostoma* at Campbell Island, New Zealand. *Ibis 141*: 216-225.

White, G.C.; Burnham, K.P.; Anderson, D.R. 2001. Advanced features of program MARK. Pp. 368–377 *In* R. Field, R.J. Warren, H. Okarma, and P.R. Sievert (eds). *Wildlife, land, and people: priorities for the 21st century*. Proceedings of Second International Wildlife Management Congress. Bethesda, Maryland: Wildlife Society.

White, G.C.; Burnham, K.P. 1999. Program MARK: survival estimation from populations of marked animals. *Bird Study 46 (Supplement)*: 120-138.