Notornis, 2018, Vol. 65: 196–201
0029-4470 © The Ornithological Society of New Zealand Inc.

An estimate of the Hutton's shearwater (*Puffinus huttoni*) population in the Kaikōura region using colour-marking in 2002 and 2014

LINDSAY K. ROWE*
Hutton's Shearwater Charitable Trust, PO Box 58, Kaikōura 7300, New Zealand

R. PAUL SCOFIELD
Canterbury Museum, Rolleston Avenue, Christchurch 8013, New Zealand

GRAEME A. TAYLOR
Department of Conservation, PO Box 10420, Wellington 6143, New Zealand

RICHARD J. BARKER
Department of Mathematics and Statistics, University of Otago, PO Box 56, Dunedin 9016, New Zealand

Abstract: In September 2002 and 2014 respectively, 2,077 and 1,704 prospecting Hutton's shearwaters were colour-marked on the ventral plumage at their breeding grounds at Kōwhai River, Seaward Kaikōura Ranges, New Zealand. Large numbers (425,516 in 2002, and 106,900 in 2014) of marked and unmarked birds were then counted from small boats off the Kaikōura coast between Haumuri Bluff and Ohau Point. A hypergeometric sampling model was fitted these counts, leading to population estimates of $\hat{N}$ = 459,290 (95% CI = 434,306-484,733) birds in 2002 and $\hat{N}$ = 590,407 (95% CI = 543,992–642,697) individuals in 2014. These estimates include both breeding and non-breeding birds and indicate that between 2002 and 2014 the population trend was about +2% per year.

Rowe, L.K.; Scofield, R.P.; Taylor, G.A.; Barker, R.J. 2018. An estimate of the Hutton's shearwater (*Puffinus huttoni*) population in the Kaikōura region using colour-marking in 2002 and 2014. *Notornis 65*(*4*): 196-201.

Keywords: Hutton's shearwater, mark-recapture, population estimates, *Puffinus huttoni*

INTRODUCTION

Hutton's shearwater (*Puffinus huttoni*; Mathews 1912) is currently classified by BirdLife International (2018) as "Endangered", and as "Threatened – Nationally Vulnerable" under the New Zealand Threat Classification system (Robertson *et al*. 2017). It is a small black-and-white shearwater (length 36–38 cm, weight 365 gm; Marchant & Higgins 1990) whose breeding grounds were unknown to the scientific community until 1965. Anecdotal reports from Maori, musterers, hunters, and Kaikōura locals indicated there were "muttonbirds" nesting in burrows high in the Seaward Kaikōura Ranges. Following up on these reports, Harrow (1965) confirmed breeding colonies of Hutton's shearwater in the headwaters of the Kōwhai River, between 1,200 and 1,800 m a.s.l. Extensive searching led to the discovery of nine further colonies, but only two (Kōwhai River and Shearwater Stream) remain today (Marchant & Higgins 1990; Cuthbert 2001; Sommer *et al*. 2009).

The reasons for the population decline of the Hutton's shearwater in the 20th century are not definitive. Deer, goats, and chamois have been observed breaking through the shallow friable soils into burrows and nest chambers (Harrow 1976). Stoats, although present in the Kōwhai colony, were not considered to occur in sufficient numbers to be a threat to the remaining colonies (Cuthbert & Davis 2002a). Cuthbert (2001, 2002) noted accessibility for, and evidence of, feral pigs in the colonies that had recently become extinct, and the relative inaccessibility to pigs to the Kōwhai River

Received 11 June 2018; accepted 27 August 2018
*Correspondence: *lindsay.jan.rowe@xtra.co.nz*

and Shearwater Stream colonies. Thus, Cuthbert (2001, 2002) concluded that predation and habitat destruction by feral pigs were likely the main causes of the population decline.

Another major threat to the continued existence of the Hutton's shearwater colonies is devastation by natural processes such as snow avalanches or debris avalanches/rock falls. Sherley (1992) reported that during his study two entire colonies had slipped away, and that erosion could cover burrows with alluvium. However, recent magnitude 5.7 (April 2015) and 6.2 (February 2016) earthquakes, about 50 km deep centred near St Arnaud 50 km to the northwest, did not produce any obvious landsliding in the Kōwhai River (LKR *pers. obs.*).

To understand the current status of Hutton's shearwater and its vulnerability to catastrophic events, information on population size is needed. Several population estimates have been made since the mid-1980s. Sherley (1992) calculated the number of breeding pairs from burrow counts at quadrats in 17 of the 36 defined sub-colonies in the Kōwhai River and Shearwater Stream. He estimated a maximum of 134,400 breeding pairs less an unknown number of non-breeding pairs and unmated birds in active burrows. Correction factors for the total number of the burrows occupied by breeding pairs in the Kōwhai colony have been applied to Sherley's estimate to arrive at 94,000 breeding pairs (Taylor 2000). Later estimates gave a combined total of 106,000 breeding pairs (Shearwater Stream 8,000 and Kōwhai River 98,000 pairs; Cuthbert & Davis 2002b; Sommer *et al.* 2009). These studies focussed on breeding pairs and did not account for non-breeding birds at Kaikōura or young birds still in Australian waters (Waugh *et al*. 2013). More than half of a seabird population can be made up of non-breeding individuals (Warham 1996). Little is known about population trends, but a 20-year assessment, again based on burrow occupancy and breeding success, suggested the population at the Kōwhai River is increasing (Sommer *et al*. 2009).

Taylor (2000) recommended an assessment be made of Hutton's shearwater population using a non-traditional approach whereby a sample of the population at the breeding colony is colour-marked, and counts conducted at sea to obtain the ratio of marked and unmarked birds. This would allow for an estimate of the total population present in the Kaikōura region at that time, and the process should be repeated every 10 years to assess trends. Here, we present a study comparing estimates of the Hutton's shearwater population at Kaikōura made using this colour-marking technique in 2002 and 2014.

METHODS

Hutton's shearwaters return to the Kaikōura region from Australian waters in late-August (Harrow 1976; Marchant & Higgins 1990). By mid-September it is assumed that most birds have returned to New Zealand seas. In most seasons, a deep snow layer over the high altitude colonies prevents adults reaching their burrows in early spring. Therefore, large numbers of birds are found sitting on the surface at night and this is a mixture of breeding age and immature birds. The key advantage of sampling under snow conditions is ease of capture of birds off the surface. Another benefit is reduced damage to underlying burrows due to the deep snow cushioning the soft, friable, heavily burrowed ground. The technique works as it is not biased towards capturing mainly immatures on the surface as might happen later in the breeding season.

Tests of different types of colour-markers applied to the body plumage of Hutton's shearwaters were carried out by the Department of Conservation in September 2001. Water-based markers (e.g. Raddle™, Donaghys Limited) were considered too ephemeral as they washed off very easily, or faded rapidly on birds digging in snow or soils. Enamel spray paint had been used on black-browed albatross (*Thalassarche melanophris*) in the Falkland Islands (Thompson & Rothery 1991) and on shy albatross (*T. cauta*) in Australia with no discernible effect on these birds (Brothers *et al.* 1997). Following correspondence with overseas researchers who have used these products on seabirds we chose Dulux Spraykote (now Spraypak) Quick Dry™ enamel spray-paint. This paint is easy to apply, durable, and highly visible, but was expected to wear off the birds over a few weeks through repeated washing, diving, moving around in snow, and digging of burrows. The spray paint provides a surface coating on the outer feather layers only. Colour-marking followed the procedures listed in the New Zealand Bird Banding Manual (Melville 2011).

In 2002, the breast, belly, and underwings were marked; in 2014 the breast, belly, and under-tail coverts were marked as previous experience indicated little benefit in marking under the wings. Eight weeks after the marker was applied at the Kōwhai River capture site (10–12 November 2014), very few birds showed any discernible tinges of pink spray paint (LKR *pers. obs.*).

Field parties visited the Kōwhai River Hutton's shearwater colony (42°15′30″ S, 173°36′15″ E) between 16–20 September 2002 and 15–17 September 2014 (Table 1).

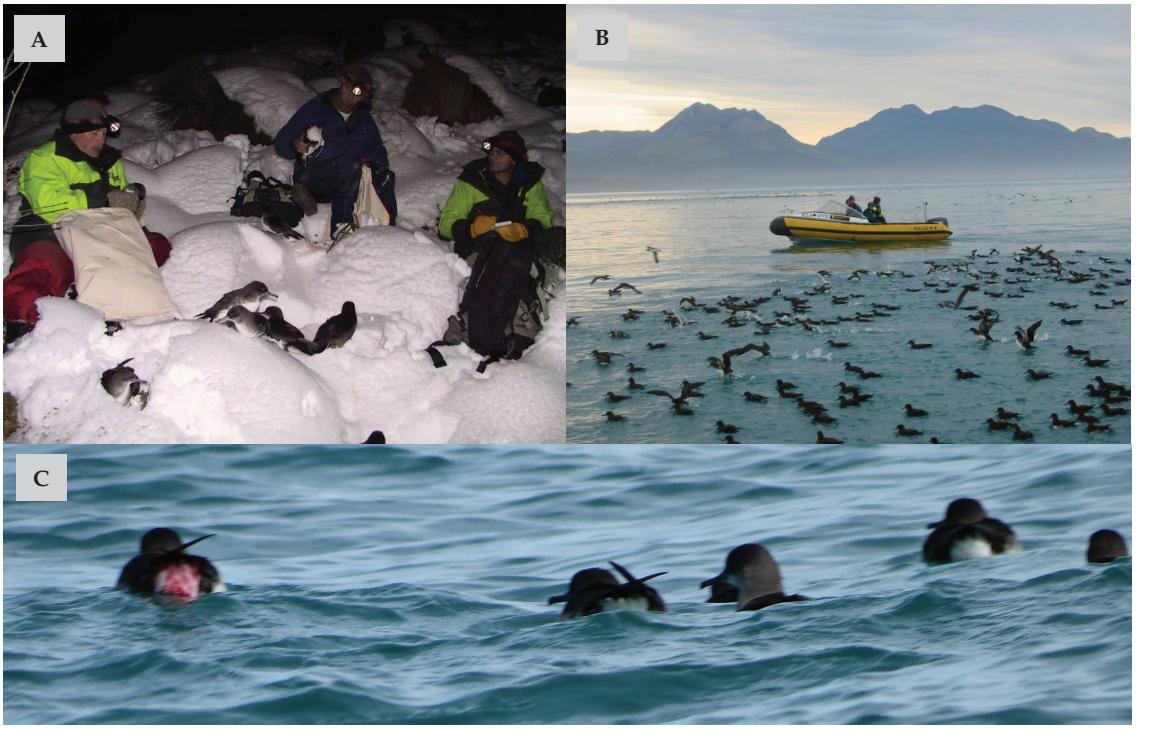

Figure 1. a) Field party, on the snow surface, collecting Hutton's shearwaters for marking in 2002 (Photo: Department of Conservation); b) Survey boat passing through a raft of Hutton's shearwater with observers searching for marked and unmarked birds (Photo: G. Taylor); c) Colour marked Hutton's shearwater on the water (Photo L. Rowe).

Birds return to the colony after dark at which time they were picked off the snow surface and placed in bird bags (Fig. 1a). They were held by one of the team who covered the head to prevent marker drift, marked by another member, and released. Accurate counts of birds marked with spray-paint were kept by field parties.

Immediately after the completion of the marking operation at the colony, observers started checking rafts of Hutton's shearwaters at sea using boat-based observations to count the birds on a daily basis. Multiple, large flocks of shearwaters (thousands of birds) were found each day between the Haumuri Bluffs to the south and Ohau Point to the north, and within 2 km of the shoreline. Up to four small boats on any given day were deployed and cruised slowly alongside or through the rafts (Fig. 1b). Observers on each boat looking out at different directions counted the numbers of unmarked and marked birds in a block and relayed these to a recorder (e.g. 200/0, 100/1, 86/0, 12/0, 130/1, etc.). Birds were counted as they flew off the water as the boat approached. Birds were only added to counts if the breast and belly could be clearly seen and, in 2014, if the under-tail coverts could be seen on birds swimming away from the boats (Fig. 1c).

The data were compiled into daily counts, and inference was carried out using a mark-resight model described as:

$$L(N|M,m,u) = \prod_{i=1}^{days} \frac{\binom{M}{m_i}\binom{N-M}{u_i}}{\binom{N}{m_i+u_i}}.$$

where $L(.)$ denotes the likelihood function and N is the unknown population size. M = number of birds marked over the total number of days at the Kōwhai River. A series of counts (resighting sessions) were carried out over a number of days (*days*) indexed by $i = 1, \ldots days$, and the number of marked (denoted by m_i) and unmarked (denoted by u_i) birds was recorded. The resighting data were modelled as D independent draws of marked and unmarked birds from the population sampled without replacement. Data were regarded as replaced between days. This leads to the likelihood function proportional to the product of D hypergeometric distributions each with a common value for abundance. Approximate 95% confidence intervals were found by inverting a likelihood ratio test for $N = N_0$ where N_0 is the abundance under the null hypothesis.

Table 1. Summary of Hutton's shearwaters marked at the Kōwhai River colony and counted at sea.

	2002	2014
Dates sampled	16–20 September (4 nights)	15–17 September (2 nights)
Number of birds marked	2,077	1,704
Dates counted at sea	21–30 September (10 days)	17–20 September (4 days)
Number of unmarked birds counted at sea	425,516	106,900

RESULTS

The smaller numbers of birds marked and counted in 2014 were the result of bad weather curtailing the marking programme after 2 nights and gale force winds limiting the at-sea observations to 4 days from the planned 10 days (Table 1). In 2002 the estimated population size of Hutton's shearwaters was $\hat{N}$ = 459,290 (SE = 12,864; 95% confidence interval = 434,306–484,733). The estimated population size in 2014 was $\hat{N}$ = 590,407 (SE 26,678; 95% confidence interval = 543,992–642,697. As these confidence intervals do not overlap the inference is that the population of Hutton's shearwaters off Kaikōura in late September increased between 2002 and 2014. The estimated change in number of 131,117 birds, or 28.5%, corresponds to compounded annual growth of 2% per year.

DISCUSSION

Previous population estimates of Hutton's shearwater were 94,000 (Taylor 2000) and 106,000 (Cuthbert & Davis 2002b) breeding pairs. If, as has been suggested by Warham (1996), that more than half of a seabird population can be made up of non-breeding individuals, then there could be >400,000 birds in the Kaikōura population; this does not take into account the number of young birds still in Australian waters and yet to return. Our 2002 population estimate from our colour-marked bird modelling is about 460,000 birds, only 15% greater than that based on burrow counts which is very dependent on how close Warham's (1996) generalised estimate of non-breeders is for Hutton's shearwater.

Sommer *et al.* (2009) suggested there was an annual population increase of 1.7% in the 20 years to 2007 which was also consistent with population modelling (Cuthbert & Davis 2002b). If that increase is applicable through to 2014, and it is compounded over the period 2002–2014, there would be a population increase of 22.4% between counts; that is remarkably close to the increase measured here of 28.5% from our 2002 and 2014 colour marking exercises.

The population estimates for birds found off the Kaikōura coast in this study were much higher than estimates based on burrow counts, e.g. 106,000 pairs (Cuthbert & Davis 2002b). We suggest one of three reasons for this.

1) Our assumptions that (i) counts were independent and (ii) could be treated as sampling without replacement within a resampling session were violated. For example, there may have been inadvertent double counting of birds within a resighting session.
2) The non-breeding population approximates the breeding population as suggested by Warham (1996).
3) The estimates of burrowed surface area in Cuthbert & Davis (2002b) and Sommer *et al.* (2009) are inaccurate.

This study is unable to suggest which of these three scenarios is most likely and indeed all three may well be interacting to produce these results. We have some confidence that the shearwater flocks at sea mix randomly each day. In 2001, VHF radio-transmitters were attached to ten individual Hutton's shearwaters caught near the research hut to look at the flight paths the birds used to access the colony. These birds were checked for at sea each day near the Kaikōura Peninsula. The presence of individually radio-tagged birds at-sea changed daily. Also, most tagged birds went well beyond the VHF receiver range near Kaikōura (up to 20 km distance), only returning near land at dusk. From this we assumed that colour-marked birds would be mixing at random with unmarked birds from the entire species population each day rather than clustering into colony-specific flocks (GAT *unpubl. data*). The technique also works as it is not biased towards capturing mainly immatures on the surface as might happen later in the breeding season.

Thus, as long as this methodology and method of analysis is repeated, we consider this a scientifically and statistically robust method of estimating the population. By this we mean that we should be able to infer estimates of the population change, even if there is bias in our absolute abundance estimates. The increase we have estimated between 2002 and 2014 of 2% per year is in line with the increase in the breeding population in the Kōwhai colony between

1997 and 2008 (Sommer *et al*. 2009).

The methods adopted in this study allowed us to assess the total population of Hutton's shearwater in the Kaikōura region. The increase in total population is similar to the increase in breeding numbers (1.7% year^{-1}; Sommer *et al*. 2009). Therefore, the non-breeding and breeding populations are increasing at a similar rate. Prior to this study, there was concern as to whether stoat predation may be affecting different parts of the population disproportionately, depending on their onshore behaviour. Whereas Cuthbert and Davis (2002a) found that only 0.25% of breeding adults were killed by stoats each year, there was less certainty about impacts on other age groups. Birds in burrow chambers are not as easy for stoats to access and kill as birds sitting on the surface. Breeding birds therefore have some advantages within the nest and spending very limited time on the colony surface once the snow has melted. Pre-breeders by comparison spend large amounts of time at night sitting around calling, displaying, or sleeping on the ground and are considered at greater risk to stoat predation. Therefore, we wanted to determine the size of the total population, not just the birds occupying burrows to see if the non-breeding pool was being reduced by stoats. This does not appear to be the case and the observation that the population is growing supports Cuthbert's (2001) conclusion that stoats do not have an adverse impact on Hutton's shearwaters.

Utility of these data on estimating the impact of the 2016 Kaikōura Earthquake

The November 2016 magnitude 7.8 earthquake centred near Kaikōura was the largest earthquake in this region in over hundred years (United States Geological Survey 2016). It affected the northern half of the South Island and caused massive landslides and rockfalls within the Hutton's shearwater breeding colonies (M. Morrissey, Department of Conservation, *pers. comm*. 2016). The timing of the earthquake (at 0002 h, 14 November 2016 NZDT) coincided with the peak laying period for these shearwaters (Cuthbert 2001). We consider our population estimates of great value in assessing the impact of the November 2016 earthquake on Hutton's shearwater. A repeat colour-marking total population estimate is scheduled for September 2018.

ACKNOWLEDGEMENTS

This project would not have been possible without funding from: Ron and Edna Greenwood Environmental Trust; The Lion Foundation; Foodstuffs Community Trust; Mr G. Harrow. Personnel and boat resources were provided by the Department of Conservation, Canterbury Museum, and the University of Canterbury. In addition, many individuals (members of the Ornithological Society of New Zealand, the Hutton's Shearwater Charitable Trust, Forest & Bird, and local residents) gave their time, especially on the boats and up the Kōwhai River, and their contributions are especially appreciated. The Department of Conservation Animal Ethics Committee and National Bird Banding Officer approved the use of the plumage spray-paints in 2002 and 2014. We also appreciate the efforts of the reviewers that have helped improve this paper.

LITERATURE CITED

BirdLife International. 2018. Species factsheet: *Puffinus huttoni*. Downloaded from http://www.birdlife.org on 15 February 2018.

Brothers, N.P.; Reid, T.A.; Gales, R.P. 1997. At-sea distribution of shy albatrosses *Diomedea cauta cauta* derived from records of band recoveries and colour-marked birds. *Emu 97*: 231–239.

Cuthbert, R.J. 2001. Conservation and ecology of Hutton's shearwater (*Puffinus huttoni*). *Conservation Advisory Science Notes No. 335*. Department of Conservation. Wellington. 35pp.

Cuthbert, R.J. 2002. The role of introduced mammals and inverse density-dependent predation in the conservation of Hutton's shearwater. *Biological Conservation 108*: 69–78.

Cuthbert, R.; Davis, L.S. 2002a. The impact of predation by introduced stoats on Hutton's shearwaters, New Zealand. *Biological Conservation 108*: 79–82.

Cuthbert, R.; Davis, L.S. 2002b. Adult survival and productivity of Hutton's shearwaters. *Ibis 144*: 423–432.

Harrow, G. 1965. Preliminary report on discovery of nesting site of Hutton's shearwater. *Notornis 12*: 59–65.

Harrow, G. 1976. Some observations of Hutton's shearwater. *Notornis 23:* 269–288.

Marchant, S.; Higgins, P.J. (*eds*). 1990. *Handbook of Australian, New Zealand and Antarctic birds. Vol. 1 Ratites to ducks*: 655–662. Melbourne: Oxford University Press.

Matthews, G.M. 1912. Puffinus reinholdi huttoni. *The birds of Australia.* Vol. 2: 47. London: Witherby.

Melville, D.S. 2011. *New Zealand National Bird Banding Scheme: bird bander's manual.* Department of Conservation, Wellington. 133pp.

Robertson, H.A.; Baird, K.; Dowding, J.E.; Elliot, G.P.; Hitchmough, R.A.; Miskelly, C.M.; McArthur, N.; O'Donnell, C.F.J.; Sagar, P.M.; Scofield, R.P.; Taylor, G.A. 2017. Conservation status of New Zealand birds. *New Zealand threat*

classification Series No. 19. Wellington Department of Conservation. 23pp.

Sherley, G.H. 1992. Monitoring Hutton's shearwater 1986–1989. *Notornis 39*: 249–261.

Sommer, E.; Bell, M.; Bradfield, P.; Dunlop, K.; Gaze, P.; Harrow, G.; McGahan, P.; Morrissey, M.; Walford, D.; Cuthbert, R. 2009. Population trends, breeding success and predation rates of Hutton's shearwater (*Puffinus huttoni*): a 20 year assessment. *Notornis 56:* 144–153.

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.

Thompson, K.R.; Rothery, P. 1991. A census of the black-browed albatross *Diomedea melanophrys* population on Steeple Jason Island, Falkland Islands. *Biological Conservation 56*: 39–48.

United States Geological Survey. 2016. https://earthquake.usgs.gov/earthquakes/eventpage us1000778i#executive. (Retrieved 2 March 2018).

Warham, J. 1996. *The behaviour, population biology and physiology of the petrels.* Academic Press, London.

Waugh, S.M.; Tennyson, A.J.D.; Taylor, G.A. Wilson, K.J. 2013. Population sizes of shearwaters (*Puffinus* spp.) breeding in New Zealand, with recommendations for monitoring. *Tuhinga 24*: 159–204.