

Snares crested penguins *Eudyptes robustus* population estimates 2000–2013

Johanna A. Hiscock¹ and B. Louise Chilvers^{2*}

¹Southern Islands, Department of Conservation, PO Box 743, Invercargill 9840

²Wildbase, Institute of Veterinary, Animal and Biomedical Sciences, Massey University, Private Bag 1112, Palmerston North 4442

*Author for correspondence: (Email: b.l.chilvers@massey.ac.nz)

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Abstract: New Zealand (NZ) is an internationally significant area for penguins. All NZ penguin species are listed in ‘at risk’ threat categories. The naturally uncommon Snares crested penguins (*Eudyptes robustus*), which are restricted to NZ subantarctic islands, are highly susceptible to localised stochastic events and human activities. There has been uncertainty about population size and trends for Snares crested penguins. We surveyed the nest abundance and distribution of Snares crested penguins on Northeast (NE) and Broughton Islands, Snares Island group, from late September to early October in 2008, 2010 and 2013 and compared results with a survey from 2000. Counts of all nests (nests with eggs and total observed nests) within all colonies around the islands were undertaken. In 2008, 19 845 ± 29 nests with eggs and 24 666 ± 38 total nests were counted from 111 colonies. In 2010, 25 525 ± 21 nests with eggs and 30 672 ± 26 total nests from 117 colonies were counted while in 2013, 25 149 ± 39 nests with eggs and 29 009 ± 45 total nests from 119 colonies were counted. Penguin nest numbers at the Snares appear to be stable overall when compared with the 2000 survey, which gave 28 396 nests with eggs (direct counts) and 30 607 total nests from 112 colonies. However, 2008 appears to be a year with considerably lower numbers of nests compared with other years. This apparently stable population is in contrast to most other crested penguins in the world. Given the extremely restricted distribution of Snares crested penguins and potential for a rapid catastrophic decline, we recommend surveys be continued at regular intervals in order to detect a significant decline and allow management measures to be implemented if needed.

Keywords: abundance; long-term monitoring; nest counts; New Zealand subantarctic islands; Snares Islands

Introduction

The majority of crested penguin (*Eudyptes* spp.) populations around the world are currently in decline (Cunningham & Moors 1994; Hilton et al. 2006; Birdlife International 2010; Hiscock & Chilvers 2014). New Zealand is an internationally significant area for breeding seabirds, particularly penguins, with six species present, four being endemic (Marchant & Higgins 1990). All NZ penguin species are listed under the NZ threat classification (Townsend et al. 2008) in ‘at risk’ categories, due to being naturally uncommon, having restricted natural distributions or small and declining populations (Robertson et al. 2012). Erect-crested (*E. sclateri*) and Snares crested penguins (*E. robustus*) are both naturally uncommon species with distributions restricted to the NZ subantarctic islands. Fishing bycatch/competition, geological exploration, tourism, pollution (oil, fuel, rubbish) and introduced predators are all factors affecting penguin species (Doole 1998). Small restricted populations are highly susceptible to localised stochastic events and human activities (Kendall & Wittmann 2010). If these populations are impacted by negative external factors, these species could quickly become endangered or extinct.

The Snares crested penguin is only known to breed on four islands in the Snares group (48°S, 166°35'E; Fig. 1). They are a medium-sized crested penguin with body length of 50 to 60 cm and average mass of 2.8 kg for females and 3.4 kg for males (Marchant & Higgins 1990). The breeding period of Snares crested penguins is well defined, with adults arriving in the first three weeks of September, the males arriving approximately a week before the females (Warham 1974). Nests are generally scooped out hollows lined with mud or

peat mixed with twigs, stones and bones. Two eggs are laid on average 4.5 days apart in late September/early October. For the first 2 weeks after egg laying, both males and females remain at the nest, although the females predominantly incubate the egg during this time (Warham 1974). After the first 2 weeks, males leave to forage for approximately 2 weeks while the females continue incubating (Amey et al. 2001, unpubl. report, see Appendix S1; hereafter the 2001 Amey Report). They then swap, allowing females to forage for about a week while males incubate, with females returning to coincide with egg hatching (Mattern 2007).

With only two previous breeding population estimates for Snares crested penguins, there has been uncertainty about population size and long-term trend. In 1985/86 the total breeding population of Snares crested penguins was estimated at 23 250 pairs based on counts of chicks and 73% breeding success per pair (Johns & Miskelly 1986). The 2001 Amey Report (Appendix S1) undertook a full census of NE Island for Snares crested penguins in October 2000. Direct counts of 25 870 breeding nests and 23 659 nests with eggs were recorded for NE Island. An estimate (not count) of 4737 nests was made for Broughton Island, giving a total for the two main Snares Islands of 30 607 nests or 28 396 nests with eggs.

The purpose of this study was to monitor variability in Snares crested penguin colonies and obtain accurate population estimates for the two main breeding islands (NE and Broughton Islands; 99% of the estimated population; Appendix S1) from 2008 to 2013. We then compared our 2008–2013 data with findings from previous surveys to clarify the overall population trend.

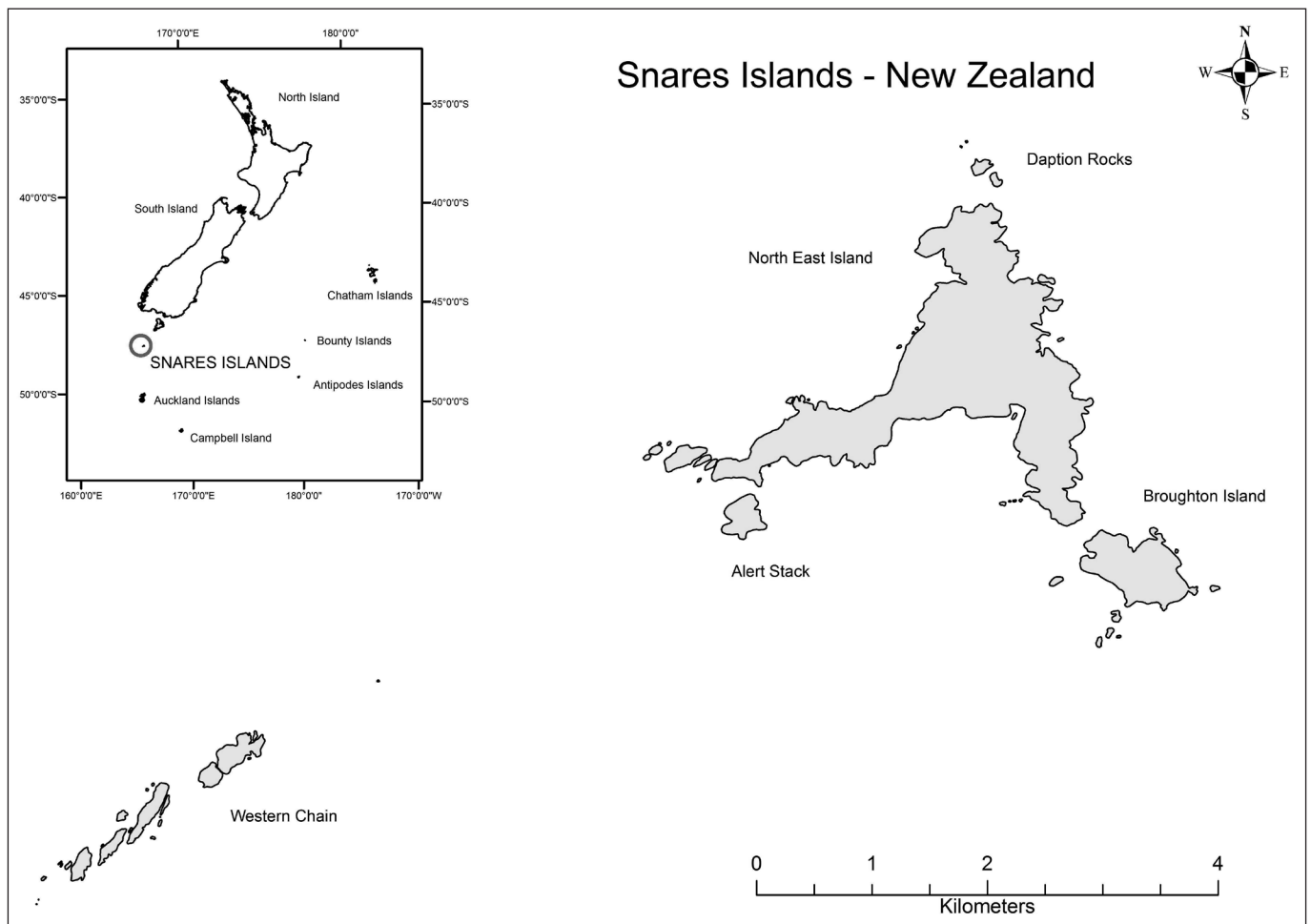


Figure 1. Map of the Snares Islands groups, showing their location in relation to the South Island of New Zealand and the other subantarctic islands.

Material and Methods

The Snares are the closest subantarctic group to mainland NZ (48°S, 166°E; 100km south of Stewart Island), with Snares crested penguins breeding on four of its islands, NE (280 ha) and Broughton Islands (48 ha; Fig. 1), and Rima and Toru Islands on the western chain islands, four kilometres SW of NE Island (not shown on map). The Snares crested penguin colonies are sited on bare rock, in open areas surrounded by tussock grass or forest, or under a canopy of *Olearia lyallii*, *Brachyglottis stewartiae* or *Hebe elliptica*. Ground count surveys of NE and Broughton Islands were undertaken between 1 October and 15 October 2008, 30 September and 9 October 2010, and 30 September and 12 October 2013 to coincide with the end of the egg laying period, when the maximum number of pairs attempting to breed would be present (Appendix S1). Ground counts were not undertaken on Rima or Toru Islands because peak laying on these islands is approximately six weeks after NE and Broughton Islands (Miskelly et al. 2001).

Counts were made of: 1) 'egg' nests, defined as where an egg/s were seen, or a bird or bird pair were in an incubating position; or 2) empty nests, being nests that were 'an obvious this year's nest mound/scrape with or without birds' (Amey Report, Appendix S1). This division was made because a bird/pair incubating an egg are obviously breeding, whereas an

empty nest may belong to birds not capable of breeding but trying to breed (i.e. old or infertile, but still building nests, or young birds prospecting for a nest and mate). In some cases, empty nests may also be early failed breeders still present in the colony or late breeders.

Two methods of counting were used to ground count all nests. The majority of colonies (c. 80%) were 'tally' counted with two people visually counting nests, registering nests with an egg and empty nests on separate tally counters, and the counts averaged. Approximately 25 colonies were 'paint' counted because of the difficulty of counting the colonies due to high vegetation cover and large size of the colony. Every nest visited in these colonies was counted on the tally counters (as above) and marked with a paint mark beside the nest. Ten per cent of these colonies were then resampled, checking all nests for paint marks. After the recount, the total count was adjusted for nests not painted or those painted twice. Any colony larger than 100 nests, regardless of whether they were tally or paint counted, was divided into small, easy-to-count areas by painting lines with rattle stock marker aerosols ('Telltall', FIL, Mount Maunganui, NZ). The rattle was water soluble and was not visible a week after application on most surfaces.

Colonies in 2008 were originally located using GPS locations from the 2000 survey (see Appendix S1) and these GPS locations were updated during each consecutive survey

because 1) more accurate locations could be obtained due to improved GPS technology, 2) colonies moved locations, 3) new colonies were established or 4) colonies were abandoned.

As outlined in the 2001 Amey Report (Appendix S1), we defined a colony as ‘an area the penguins treat as one nesting area, where birds move between or hang around between areas, but not including penguin paths or through traffic’. This definition fitted better than using an arbitrary distance, e.g. 20 m, to separate colonies, as some colonies were quite close together but still distinct, while others were separated by a physical barrier, e.g. rock outcrop or wet area, but were essentially one colony. Colony names and numbering system were continued on from the 2001 Amey Report (Appendix S1). Colonies were numbered sequentially when found and were grouped by the catchment and landing site from which the colony was accessed. If the separation of a smaller colony from a larger colony was distinct but the vegetation and environment suggested it was a remnant of a nearby colony, or if the smaller colony was very close, it was considered a sub-colony and numbered accordingly with the established colony number and a suffix. If the new colony was distinct from any current or historical colonies it was allocated an entirely new number.

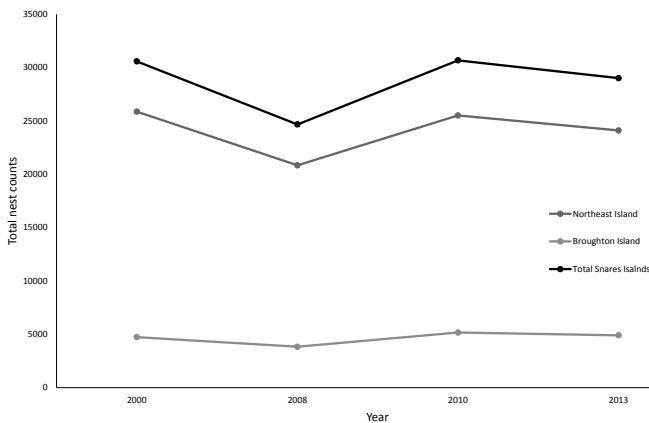


Figure 2. Total nest counts of Snares crested penguins from Northeast and Broughton Islands, and The Snares combined from 2000 to 2013.

Results

On Broughton Island, 30 colonies were counted in 2008, 29 colonies in 2010 and 28 colonies in 2013. Many of these colonies split between years and were counted as sub-colonies. The Broughton Island total nest counts showed no overall trend and changed substantially only between 2008 and 2010, with 25% more nests found in direct counts in 2010 (Table 1, Fig. 2). There were 6% fewer nests counted in 2013 than 2010, though this change was predominately caused by higher numbers of empty nests in 2010 than in 2013 (Table 1, Fig. 2).

On NE Island, 111 colonies were counted in 2008, 117 in 2010, and 119 in 2013; these colony numbers were very similar to the 112 colonies counted in 2000. Between the 2000 and 2013 nest counts, 12 colonies were lost, while 19 new colonies were formed. There were many changes within colonies, with colonies expanding and contracting in size. NE Island total nest direct counts showed no overall trend, but in 2008 there were 19% fewer nests counted than in 2000 and 18% more nests counted in 2010 than in 2008 (Table 1, Fig. 2).

Overall, the Snares crested penguins total nest direct counts between 2000 and 2013 were stable, although all nest counts were lower in 2008 (Table 1, Fig. 2). There was a slight decrease in numbers of nests with eggs across the 13 years of this research (Table 1, Fig. 2).

Discussion

The purpose of this research was to monitor Snares crested penguins breeding population size for the two main breeding islands (NE and Broughton Islands) from 2008 to 2013. The quantitative estimate we obtained indicates an overall stable population between 2000 and 2013, but with an anomalous year with a substantial drop in numbers in 2008. Although it is difficult to compare population estimates from this study with previous studies that counted chicks and not nests (Johns & Miskelly 1986; Tennyson 1987), these studies also report the relative stability of breeding numbers for Snares crested penguins. There are no survey data to determine whether the breeding population has been higher or lower historically and the only way to assess this would be through genetic analysis (Collins et al. 2014; Robertson 2015).

Table 1. Total nest counts of nests with eggs and empty nests of Snares crested penguins from Northeast and Broughton Islands, and The Snares combined from 2000, 2008, 2010 and 2013.

	2000*	2008	2010	2013
Broughton Island				
Nests with eggs		3 375 ± 20.3	4 358 ± 4.3	4 433 ± 29.8
Empty nests		457 ± 8.0	805 ± 5.1	472 ± 7.8
Total		3 832 ± 21.8	5 163 ± 6.7	4 904 ± 30.8
Northeast Island				
Nest with eggs	23 659	16 470 ± 20.7	21 167 ± 20.6	20 716 ± 25.7
Empty nests	2 211	4 364 ± 23.4	4 342 ± 14.7	3 389 ± 19.7
Total	25 870	20 834 ± 31.2	25 509 ± 25.3	24 105 ± 32.4
Snares Islands				
Northeast Island	25 870	20 834 ± 31.2	25 509 ± 25.3	24 105 ± 32.4
Broughton Island	4 737	3 832 ± 21.8	5 163 ± 6.7	4 904 ± 30.8
Egg nest only total	28 416	19 845 ± 29.0	25 525 ± 21.0	25 149 ± 39.4
Total	30 577	24 666 ± 38.1	30 672 ± 26.2	29 009 ± 44.7

* 2001 Amey Report (Appendix S1), Table 4 direct count data – Broughton Island data are estimates not counts.

When making comparison between this study and that of the 2001 Amey Report (Appendix S1) it must be noted that the Report presented results from direct counts and ‘corrected’ counts. To obtain corrected counts, several colonies were monitored from the beginning to the end of the two-week sampling period and the numbers of new or failed nests were compared with the original count undertaken on 9 October 2000. From this, a correction factor was added to those colonies counted after 9 October. This correction monitoring or calculation was undertaken in 2008, but similarly to the 2001 Amey Report (Appendix S1), gave negligible differences compared with direct counts, so was not undertaken in 2010 or 2013.

This research confirms the assumption of the 2001 Amey Report (Appendix S1) that the Broughton Island population makes up approximately 20% of the Snares crested penguin breeding population (16% of total nest counts in 2008, and 17% in both 2010 and 2013, Table 1). Therefore, it should be surveyed when NE island is being surveyed because it does comprise an important proportion of the population.

It is not known why the number of nesting Snares crested penguins reduced in 2008; however, given the return to previous numbers within two years, it is likely to have been caused by fewer birds returning to breed that year, rather than a decrease of individuals in the population. A strong El Niño season in 2007 may have resulted in a later onset of the spring bloom and subsequent reduction in oceanic productivity, which could account for the decrease in nests in 2008. Similar breeding declines were seen in other pelagic bird populations in NZ and were attributed to the strong 2007 El Niño season (Graeme Taylor, Department of Conservation, pers. comm.). Penguins are generally thought to be sensitive to climate change (Barbraud & Weimerskirch 2001; Jenouvrier et al. 2005; Trathan et al. 2006; Boersma 2008; Ainley et al. 2010). The decline in rockhopper penguins on Campbell Island/Motu Ihupuku is thought to be due to increases in sea temperature leading to changes in food distribution and abundance (Cunningham & Moors 1994; Morrison et al. 2015). The frequency of years with El Niño conditions has increased in the past decades and could continue to have a negative impact on the Snares population, particularly if several El Niño events occurred in short succession (Cai et al. 2014). This could have a long-term effect on the population, by decreasing the recruitment of birds into the breeding populations.

Overall, the findings that Snares crested penguin populations appear to be stable is in contrast to most other crested penguins in the world. For example, the population of western rockhopper penguins (*E. chrysocome*) on the Falkland Islands in the South Atlantic Ocean was estimated at approximately 3 million breeding pairs in the early 1930s, but had declined to approximately 275 000 pairs by the 2000/01 breeding season (Pütz et al. 2002). Likewise, the population of northern rockhopper penguins (*E. moseleyi*) breeding on Amsterdam Island in the Indian Ocean declined at a rate of 2.7% per year between 1971 and 1993, decreasing from 58 000 pairs to 24 890 pairs (Guinard et al. 1998). A similar trend has also been observed in NZ, with numbers of eastern rockhopper penguins breeding on Campbell Island/Motu Ihupuku declining from an estimated 1.6 million pairs in the early 1940s to 103 100 pairs in 1984–87 (Cunningham & Moors 1994). Erect-crested and eastern rockhopper penguins at the Antipodes Islands have shown a 23% decline in the number of penguin nests between 1995 and 2011 (Hiscock & Chilvers 2013).

In the long term, the greatest threat to Snares crested penguins is the small size of the island group on which they breed (328 ha), making them vulnerable to disastrous stochastic events such as tsunamis, earthquakes or oil spills (Taylor 2000; BirdLife International 2010). On NE Island, which holds around 85% of the world’s population, Snares crested penguins use only a few landing sites along the east coast (Fig. 1). The loss of these sites due to earthquake movements or landslides would have a devastating effect on the species. Similarly, an oil spill within the vicinity of the landing sites would have severe consequences, especially during the height of the breeding season, or during moulting. Ruoppolo et al. (2012) gives an account of how thousands of moulting northern rockhopper penguins were killed on Nightingale Island at Tristan da Cunha in the Atlantic Ocean due to an oil spill from a grounded ship. Tristan da Cunha was a stronghold for the endangered northern rockhopper species with an estimated 25 000 breeding pairs (BirdLife International 2012).

Future census

Given the restricted distribution of Snares crested penguins and therefore their susceptibility to stochastic events, we recommend a survey be undertaken every 5 years for this species, with a survey repeated within 2 years if a substantial decrease, as seen in 2008, is observed. Future censuses should be carried out at a similar time in the year to coincide with the end of the egg laying period (99.5% of nests had been laid by 6 October 2000; Amey Report, Appendix S1), when the maximum number of breeding pairs are in the colony. The surveys should not be undertaken after chicks have hatched, as the number of failed nests would be higher than when carried out at the egg stage due to the predation of chicks by skua (*Stercorarius antarcticus*). Also, by 16 October, locating and counting penguin colonies becomes more difficult (Amey Report, Appendix S1). The colonies became very quiet because 80% of male penguins had departed for sea, leaving the female bird incubating and it is possible to pass close without hearing the colony (Amey Report, Appendix S1). Similarly, single females are easily scared from nests leaving eggs vulnerable to predation and making counting more difficult.

A separate census of the Western chain penguin population is recommended, but given it is likely to be less than 2% of the entire population and the six week delay in the breeding cycle of these birds, it is not as high a priority as NE and Broughton Islands. However, because of this six week delay in breeding, there may be interesting comparisons to be made between these small populations and the main population. A difference in breeding timing may indicate different foraging patterns and therefore a differing susceptibility to environmental changes. Aerial photography survey may be possible on these treeless islands, but would ideally be ground truthed to confirm timing of breeding.

Conclusions

The findings of this study indicate that the population of Snares crested penguins appears to have been stable between 2000 and 2013, but with a reduction in animals breeding in 2008. The survey method outlined in this paper and in the 2001 Amey Report provides baseline information, general colony locations and a methodology for monitoring this small, geographically restricted, threatened seabird species. Given the dynamic nature of the colonies across both NE and Broughton islands,

whole island censuses are recommended during each survey. However, if time is restricted, efforts should be concentrated on NE Island. A monitoring programme carried out every 5 years, with more frequent surveys if nesting numbers are abnormally low (as for 2008), should ensure any long-term population trends will be observed, supporting the need for mitigation strategies.

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Supplementary Material

Additional supporting information may be found in the online version of this article:

Appendix S1. Amey et al. (2001). Snares Penguin Survey Report.

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