A Census of the Atlantic Puffins *Fratercula arctica* breeding on Orkney in 2016

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Abstract

Atlantic Puffins *Fratercula arctica* were counted at all known colonies in Orkney (excluding Sule Skerry) during the 2016 breeding season. Counts of individuals (IND) were made during pre-laying and incubation at all 20 sites and at six sites where burrows where physically accessible. In 2016 the Atlantic Puffin population of Orkney was estimated to be 6,675 breeding pairs (based on the counts of apparently occupied burrows [AOB] where available, and assuming that one individual represented one breeding pair for the other sites). AOB counts were higher than the IND counts at all six colonies where both methods were used. Previous Orkney Atlantic Puffin population estimates of breeding pairs were mostly based on counts of individuals on land (INDL) made during late incubation and chick rearing. While caution must be used when comparing INDL counts between years the results suggest a decline in line with studies of other Northern Isles colonies.

Introduction

The Atlantic Puffin *Fratercula arctica* (hereafter 'Puffin') is a rocky crevice and burrow nesting seabird, whose range is restricted to the cold waters of the North Atlantic (Harris & Wanless 2011). Due to the Puffins' nesting habits, often in remote or inaccessible locations, accurately determining their population size is difficult. Since 2016 the species has been placed on the International Union for Conservation of Nature (IUCN) list of species vulnerable to global extinction (BirdLife International 2016), and has been classified as a red-listed Bird of Conservation Concern in the UK (Eaton *et al*. 2015). Current threats to Puffin populations include introduced predators such as cats and rats; environmental pollution; and declining sandeel *Ammodytes sp* stocks due to competition with industrial fisheries (Harris & Wanless 2011) and as a result of climate change (summarised by Heath *et al*. 2009). National seabird counts are important for assessing the status of the UK's internationally important seabirds, identifying large-scale changes in their populations and assisting in informing of marine planning.

The Seabird 2000 census (1998–2002; Mitchell *et al*. 2004) estimated the Puffin population in the UK and Ireland to be 580,700 breeding pairs, approximately 10% of the world population, of which 61,758 pairs bred on Orkney. Excluding

Sule Skerry, which held 96% of the Orkney population, the Seabird 2000 count for Puffins on Orkney was 3% lower than the first national seabird census, Operation Seafarer, in 1969–1970 (Cramp *et al*. 1974) and 11% higher than the Seabird Colony Register census in 1985–1988 (Lloyd *et al*. 1991). Since the Seabird 2000 survey, only sporadic counts have been made of Puffins in Orkney, at a small number of sites. This paper reports on a single-season survey of all known Orkney colonies, except Sule Skerry.

Methods

A census of Puffins on Orkney was carried out using standard methods (Walsh *et al*. 1995) between 17 April and 10 June 2016. The census coincided with pre-laying and incubation periods, with the first sign of chick hatching (two empty eggshells) on 10 June on Eynhallow (Figure 1). Apart from the extremely remote Sule Skerry, all colonies censused in the Seabird Colony Register (1985–1988) and Seabird 2000 were visited in 2016 (Figure 1). Two census methods were used (Table 1): Counts of individuals (IND) on land (INDL), at sea (INDS) and in the air around the colony (INDA) were made at all sites; and where burrows were accessible, apparently occupied burrows (AOB) were also counted. No counts were made at sites that recorded no Puffins in the previous two censuses (Sanday, Eday, Green Holm and Stronsay, locations in Figure 1).

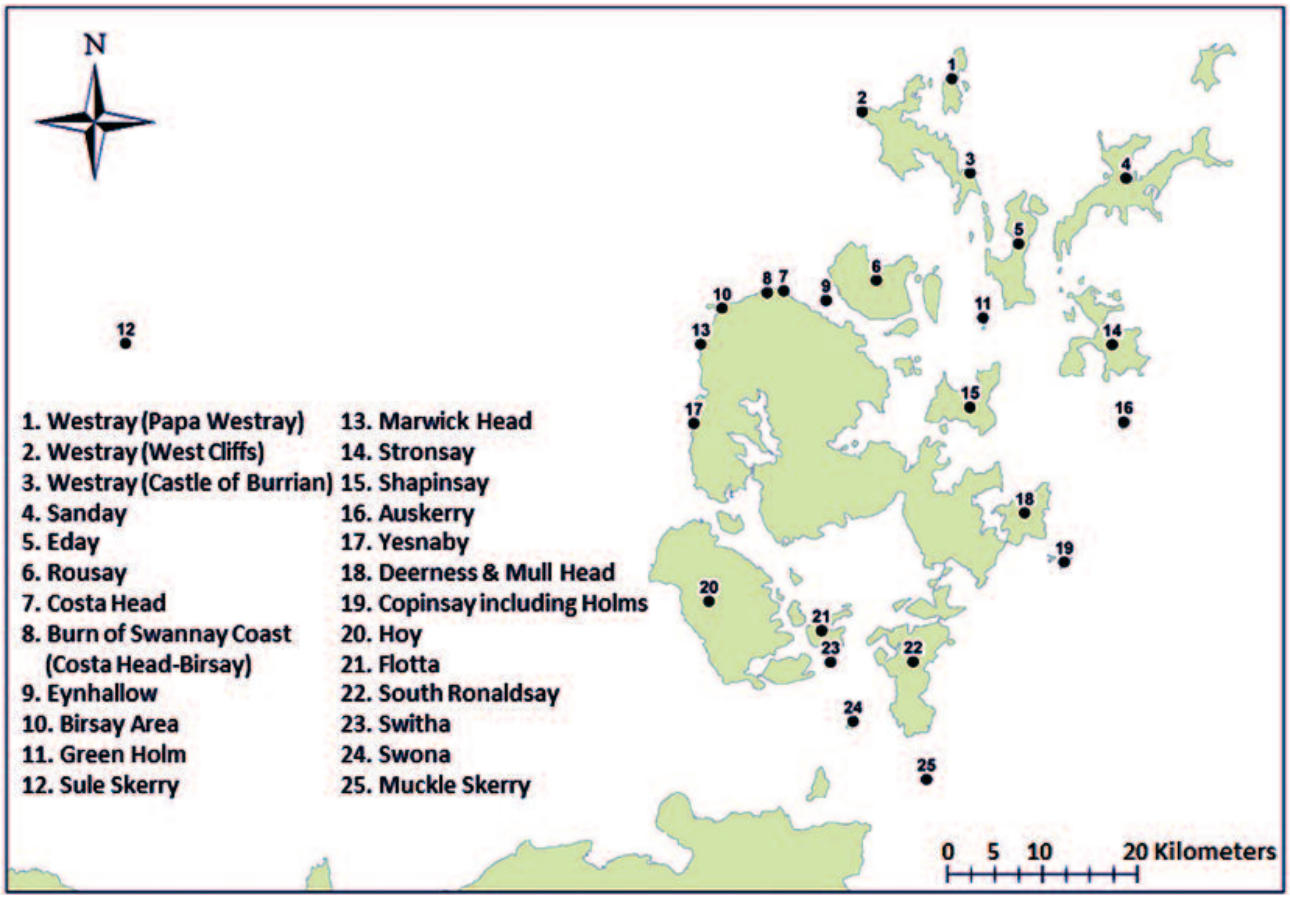

Figure 1. Location of sites censused for Atlantic Puffins *Fratercula arctica* in Orkney during 2016, with the addition of Sule Skerry and sites with no Puffins recorded in the previous two censuses (Sanday, Eday, Green Holm and Stronsay) - classified as historic sites.

Table 1. Survey method, dates, approximate time and number of Atlantic Puffin *Fratercula arctica* counted on land (INDL), floating on the sea (INDS) and flying (INDA) around the colonies and, where counted, apparently occupied burrows (AOB) during the 2016 census. A count of each unit represents one breeding pair.

Map ID	Site	Date	Approx. Time (BST)	INDL	INDS	INDA	AOB
1	Papa Westray	14 May	09.00–10.00	26	6	2	
2	West Cliffs	23 May	09.00–15.00	167	64	51	
3	Castle of Burrian	09 June	20.00–21.00	271	1,263	240	
6	Rousay	11–13 May	10.00–16.00	9	46	5	
7	Costa Head	14 May	16.00–18.00	4	1	0	
8	Costa Head-Birsay	25 May	10.00–15.00	0	15	1	
9	Eynhallow	10 June	10.00–13.00	8	91	0	112
10	Birsay Area	24 April	09.00–10.00	20	17	1	
13	Marwick Head	08 May	19.00–20.00	5	7	0	
15	Shapinsay	09 May	10.00–13.00	0	2	0	
16	Auskerry	30–31 May	09.00–21.00	0	210	2	223
17	Yesnaby	29 April	13.00–15.00	1	17	0	
18	Deerness and Mull Head	21–23 April	08.00–11.00	2	4	0	
19	Copinsay including Holms	4–6 May	08.00–20.00	184	417	0	493
20	Hoy	22 May	11.00–14.00	0	c. 3,000	0	
21	Flotta	25 May	09.00–12.00	0	5	0	
22	South Ronaldsay	10 May	11.00–16.00	13	61	1	
23	Switha	12 May	10.00–14.00	1	70	0	56
24	Swona	26 May	10.00–15.00	13	182	16	289
25	Muckle Skerry	17–18 June	09.00–20.00	313	840	129	1,984
Total				**1,037**	**6,318**	**448**	**3,157**

Burrow counts of a colony are the more accurate method of estimating Puffin populations where birds are accessible (Harris & Wanless 2011; Walsh *et al.*, 1995). IND counts can lead to under or overestimating the population as numbers can vary in a single day and between days (Brooke 1972; Harris 1976; Calvert & Robertson 2002). Although, when carried out frequently following a standardised repeatable approach, such counts can be used to indicate population changes over a lengthy timespan when changes are large (Miles *et al*. 2015). However, IND counts are often the only method possible given logistical and accessibility constraints.

Counts of Individuals (IND): Three observers (RDH, FLB, GB) participated in the IND census method, which was carried out at all colonies (n = 20). To help ensure count accuracy and consistency between observers, paired observers simultaneously counted a selection of colonies at the start of the season and cross-checked their counts. Binoculars (8 x magnification) were used for most counts; however, a telescope (20 x magnification) was used on Hoy and parts of mainland Orkney where cliffs had to be observed from a distance. Puffins on land, flying or wheeling around the colony, or floating on the sea within 200 m of the shore were counted and recorded separately. For Orkney, Seabird 2000 observers generally collected 'birds on land' data, with sea or flying counts of birds on the sea or in flight only being used where no land count was available (following Walsh *et al*. 1995). One bird on land is taken as being equivalent to one breeding pair (Mitchell

et al. 2004). IND counts are recommended to be undertaken before June as immature Puffins start attending the colony around that time (Walsh *et al*. 1995). The majority of 2016 counts were made before June, but due to time constraints this was not possible for four colonies (Table 1). Walsh *et al*. (1995), recommend counting in the 'evening' when the INDL at the colony are usually highest. Counts were carried out in the evening where possible, but logistic constraints prevented this at most sites (Table 1). Counting ceased if visibility became poor (< 200 m) due to fog, during persistent rain and if wind was Beaufort scale 4 or above.

Repeat IND counts were made in some sections of sites where many birds occurred. We report the highest count. The extensive cliffs on Hoy were not surveyed as part of Seabird 2000 but a Seabird Condition Monitoring count was made in June 2004 (Scottish Natural Heritage, unpubl. data) to which we compared our counts.

Apparently Occupied Burrows (AOB): AOB counts were made at Auskerry, Copinsay & the Holms, Eynhallow, Muckle Skerry, Switha and Swona (Figure 1). We searched the whole of each colony and counted all AOBs. AOBs were defined as burrows showing signs of fresh digging, regular use, having neatly shortened grass at the edge of the burrow entrance, having fresh white guano at the entrance of the burrow or spray along a flight-line where birds enter/exit from the cliff edge.

Two observers (RDH, FLB) undertook the AOB counts. At the start of counting we checked a sub-sample of burrows to ensure we were correctly identifying them as Puffin rather than European Rabbit *Oryctolagus cuninculus* burrows by reaching into the burrows to confirm the presence of a Puffin. If there were good external signs and the end of the burrow could not be reached, the burrow was recorded as active. European Rabbit burrows generally have a larger entrance hole, show more substantial digging and often have distinctive droppings in the area. Manx Shearwaters *Puffinus puffinus* have similar burrows to Puffins, but are not known to breed on any of the islands where burrow counts were made. Multiple Puffin pairs can share burrow entrances to nests (Harris & Wanless 1998); however, this is less likely to occur in relatively low-density colonies such as on Orkney and we found no evidence of this during our checks, so did not consider this in our counts.

Results and Discussion

Combining AOB counts (six sites), with IND counts where AOB could not be carried out (14 sites) Orkney's total breeding population was estimated to be 6,675 pairs. This total assumes one IND was equivalent to one breeding pair. When comparing our AOB to IND counts (Table 1), AOB were strongly correlated to IND (land + air + sea; $r_p = 0.98$, df = 5, $P < 0.001$). IND counts had a mean of 87 (range 0–313) and for AOB 526 (range 56–1,964) where both methods were used, highlighting that IND counts are likely to underestimate colony numbers. We observed no INDL during counts at Auskerry, but AOB inspections revealed 223 active breeding pairs.

Comparisons cannot be made directly between years due to counts being conducted in different months. However, we have attempted to broadly compare

the results to demonstrate any indication of population changes. Previous population estimates of Puffins on Orkney were based on IND counts and a comparison of counts using this method suggests a decline 55% from 2,452 to 1,106 pairs using the IND counts (2000–2016), when excluding the highly variable Hoy counts. Since the Seabird Colony Register census, the estimated population has declined 13%, from 1,250 to 1,106 pairs.

A small number of Puffins breed among boulders on Muckle Skerry in a small mixed seabird species area. Despite extensive searching, some burrows will have been missed. It was difficult to survey Swona for AOBs as many of the Puffins nest in crumbly shale rock crevices and burrows on the cliff edges. This rock type makes safe access difficult therefore some burrows may also have been missed. Despite extensive searching, no AOBs were found on the Horse of Copinsay (58°54'N, 02°39'W). We observed no Puffins at the Bay of Skaill (59°02'N, 03°21'W) or in the north-eastern area of Shapinsay, despite birds being previously recorded as breeding, or present in historic counts, i.e. sites where Puffins have not been recorded in the previous two censuses (see Figure 1). When counting from the cliff-tops of Hoy we recorded an IND count of 89, however we observed a greater number of IND during an opportunistic count from a boat later in the season where we recorded c. 3000 and so have reported the higher figure here.

Accurate population counts of seabirds are an important basis for conservation decisions and impact assessments. This census increases our knowledge of the current population of Puffins breeding on Orkney. It is the first with the majority of the counts completed before the arrival of non-breeding birds to the colonies which typically occurs in June. We estimated the Orkney Puffin population (excluding Sule Skerry) to be 6,675 breeding pairs in 2016 using a combination of counts of individuals on land and apparently occupied burrows where these were available. The AOB count is the most accurate method of counting Puffins where breeding sites are accessible, especially at the larger sites where IND counts are all but impossible (Brooke 1972; Flegg 1972; Harris 1976; Harris & Murray 1981; Anker-Nilssen & Røstad 1993) and our census derives 47% of the Orkney population estimate from AOB counts compared to 0.4% in Seabird 2000 and 0.6% in the Seabird Colony Register.

The high steep cliffs of Hoy where Puffins breed in rocky crevices, many of which are not visible from land, mean our counts there are likely to be an underestimate. When counting Puffins on Hoy we recorded an IND of 89, which is closer to the previous 2004 count (417). However, from a boat in close proximity to Hoy and flying into the cliffs we recorded approximately 3,000 Puffins, which is approaching the Seabird Colony Register figure (6,726). The difference in these counts demonstrates the difficulty and variability of counting Puffins, and therefore how IND counts will likely underestimate assessments of Puffin populations. We recommend that a boat be used for future counts at this location, in conjunction with land-based surveys in more accessible areas.

The majority of the Seabird 2000 and Seabird Colony Register IND censuses were carried out in June, outside of the recommended counting period, so attendance of non-breeding birds could have inflated those counts. In addition, IND counts are known to vary substantially even over relatively short time periods, therefore any comparisons can only be considered as indicative. Therefore, caution must be exercised when interpreting percentage differences indicated by comparing IND counts between censuses (Table 2).

Our census also recorded many Puffins on the sea as opposed to on land. Calvert & Robert (2002) found that individual Puffins attended the colony for longer when overall colony attendance was higher. It may be that birds are gathering on the sea for safety in numbers where the population size is smaller to avoid the risks associated with being on land. If this changing behaviour indicates a decline in the population, it is increasingly important to count and record the number of birds on land, sea and flying separately in the future to reflect this.

Table 2. A comparison of Atlantic Puffin *Fratercula arctica* population counts on Orkney 1998–2004 (Seabird 2000), and the 2016 IND counts. Note that Seabird 2000 Puffins were counted in June with the exception of Copinsay, Copinsay Holms and Yesnaby which were counted in May and that all counts are IND in 2000 except AOB counts in part of Shapinsay (12) and Auskerry (1). [1]Hoy was counted in 2004. - = not counted.

Map ID	Site	1985–1988	1998–2002	2016	Difference 1998–2002 and 2016
1	Papa Westray	7	34	26	–24%
2	West Cliffs	178	278	167	–40%
3	Castle of Burrian	224	250	271	8%
4	Sanday	1	-	-	-
5	Eday	5	-	-	-
6	Rousay	122	53	9	–83%
7	Costa Head	11	-	4	-
8	Costa Head-Birsay	16	-	0	-
9	Eynhallow	62	4	8	100%
10	Birsay Area	-	94	20	–79%
11	Green Holm	17	-	-	-
13	Marwick Head	29	30	5	–83%
14	Stronsay	10	-	-	-
15	Shapinsay	1	24	0	–100%
16	Auskerry	80	187	0	–100%
17	Yesnaby	-	15	1	–93%
18	Deerness & Mull Head	-	20	2	–90%
19	Copinsay including Holms	35	350	184	–47%
20	Hoy	6,726	417[1]	c. 3,000	86%
21	Flotta	16	-	0	-
22	South Ronaldsay	21	44	13	–70%
23	Switha	44	250	70	–72%
24	Swona	90	299	13	–96%
25	Muckle Skerry	281	520	313	–40%
Total		**7,976**	**2,869**	**4,106**	

Notwithstanding the limitations associated with comparing the IND data, the evidence broadly points in the direction of declines since the previous census. Although not counted here, Sule Skerry, the largest local population, was estimated to be 34,348 breeding pairs in 2005, 19% down on the previous 1986 count (42,456), comparing AOB counts from quadrats (Blackburn *et al*. 2007). The suggested declines of this census and the Sule Skerry decline are in line with other declines in the Northern Isles (Mitchell *et al*. 2004; Nisbet & Denton 2017; Owen *et al*. 2018; Parnaby *et al*. 2017; Miles *et al*. 2015).

There are likely to be multiple causes for the observed Puffin declines which could include climate change, changing fisheries practices and pollution (Mitchell *et al*. 2004, Carroll *et al*. 2017), as well as reduced recruitment of immatures into breeding colonies (Miles *et al*. 2015). The impact of climate change on food availability, especially Lesser Sandeels *Ammodytes marinus*, one of the main Puffin food sources (Miles *et al*. 2015), is particularly likely to affect Puffins, and other seabirds, in the Northern Isles (Frederiksen *et al*. 2013). A specific local threat on Orkney may be the predation by non-native Stoats *Mustela erminea* which have appeared on Orkney. Furthermore, possible interactions with future renewable energy devices may also affect the population (Furness *et al*. 2012). Re-survey of the colonies counted here, particularly using the AOB method will be the best way to monitor changes in Orkney's Puffin population in the future.

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