Storm Petrel Census of the Treshnish Isles 2018-2019

Robin M. Ward

TRESHNISH ISLES AUK RINGING GROUP

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1. Summary

1.1.1. In 1996, a survey of the numbers of Storm Petrel breeding on the Treshnish Isles provided the first realistic population estimate for the archipelago, 5,040 apparently occupied sites (Gilbert *et al.* 1998a). This report describes the findings of a second census on the Treshnish Isles using playback which in 2018-2019 found a breeding population of Storm Petrels estimated on five of the seven islands known to support colonies at 10,228 (8,707 – 12,346 at 95% CI) apparently occupied sites. For the two islands not surveyed in 2018-2019, Cairn na Burgh Beg and Bac Beag, their population of Storm Petrel constituted less than 1.49% of the estimated population of the Treshnish Isles in 1996 (Gilbert *et al.* 1998a).

2. Introduction

2.1 Population status

2.1.1. The colonies of breeding Storm Petrel *Hydrobates pelagicus* on the Treshnish Isles, south-west Scotland (56º29'N 06º25'W) are one of the features noted in the islands' designation as a Special Protection Area in 1994 under the EC Wild Birds Directive. The Treshnish Isles (56º29'N 06º25'W) are a group of eight terraced Tertiary basalt islands (c.128 ha), together with 3 smaller vegetated islets and numerous skerries, situated at its closest 3 km west of Mull, N.W. Scotland (Figure 2-1). Seven of the eight islands support colonies of breeding Storm Petrel (Gilbert *et al.* 1998a). Very few if any breeding birds of this species are considered to occupy the other island and islets, as little or no suitable habitat exists.

2.1.2. In 1996, a comprehensive survey of the numbers of Storm Petrel breeding on the Treshnish Isles provided the first realistic population estimate for the island (Gilbert *et al.* 1998a). This first survey found a population of Storm Petrel on the Treshnish Isles of 5,040 apparently occupied sites (AOS). Prior to this survey, the population had been estimated at around 2,000 pairs with the majority reputedly on Lunga (Pritchard *et al.* 1992), though the source of this figure is unknown.

2.1.3. In 2018 and 2019, a second comprehensive survey of the numbers of Storm Petrel breeding on the Treshnish Isles was conducted. The aim of the survey was to provide an estimate of the numbers of breeding pairs of Storm Petrel on the Treshnish Isles. This report describes the findings of the survey.

2.2 Censusing difficulties

2.2.1. Storm Petrels are a notoriously difficult breeding seabird to census owing to their nocturnal and cavity-nesting habits. The species breeds in a variety of habitats that includes cavities among boulder beaches, loose rock and dry-stone walls, cracks in rock and ledges in caves. The nest sites are typically impossible to detect visually with no discernible entrance. Current guidance on seabird counting and monitoring techniques relevant to British and Irish colonies, recommends either of two methods for censusing Storm Petrel (Gilbert *et al.* 1998b). Breeding colonies can be surveyed by counting incubating adults by eliciting calls using diurnal playback methods either in the form of a complete census or sample survey. The conducting of a complete census has the advantage of being more accurate than sample surveys as Storm Petrel distribution within areas of apparently suitable habitat can be highly variable (Gilbert *et al.* 1998b).

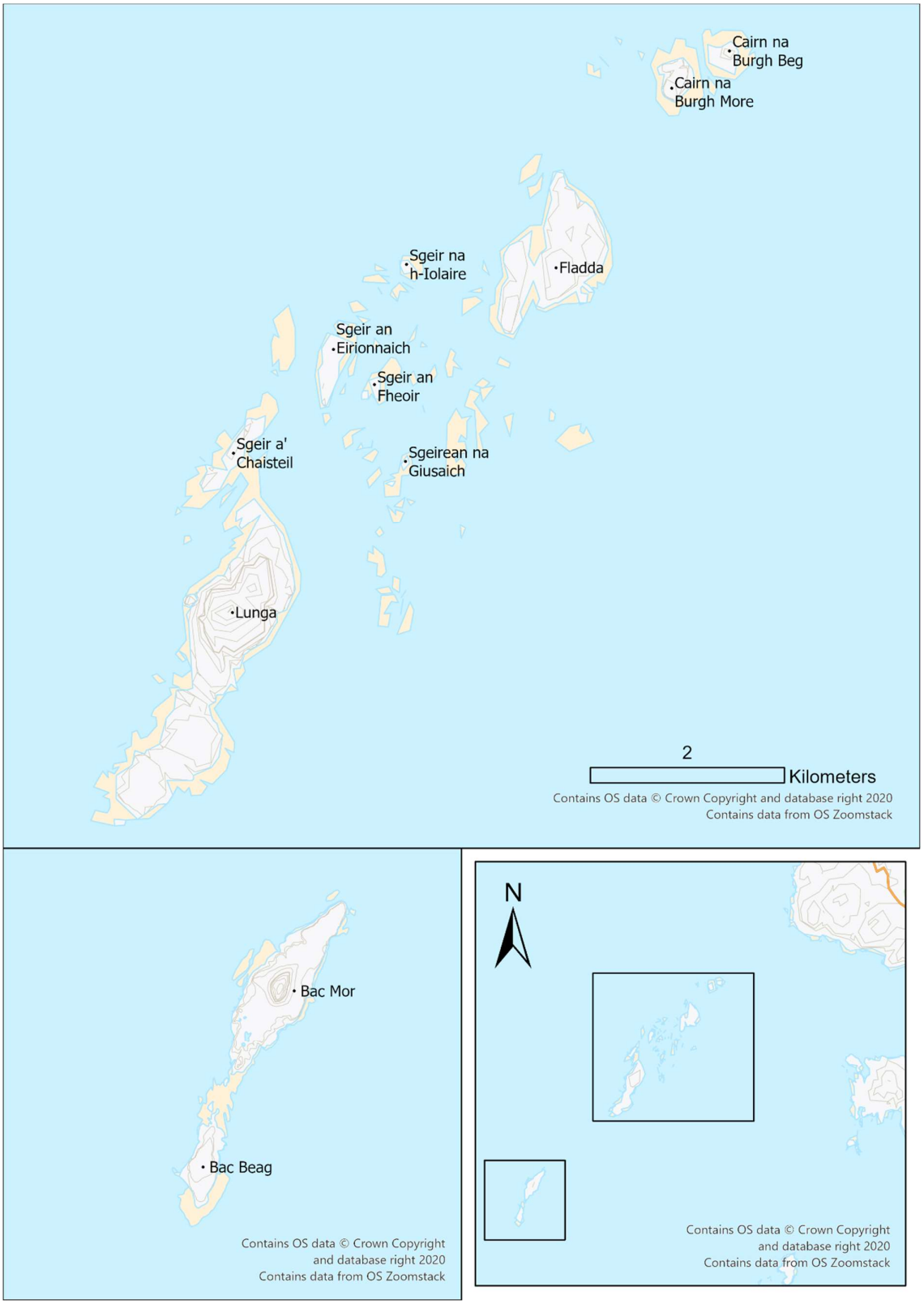

Figure 2-1 The Treshnish Isles, Argyll, S.W. Scotland

2.2.2. In Britain and Ireland, the systematic application of playback during the Seabird 2000 census (mostly conducted in 1998–2002) gave the first national population estimates for Storm Petrel (Mitchell *et al.* 2004). The methods used to census Storm Petrel during Seabird 2000 followed those of Gilbert *et al.* (1998b) with the recording used for diurnal playback being of the male's "purr" song. What has however since come to light, is that the original recordings used contained warning calls that it is now known do not elicit accurate responses (D. Burnell pers comm., Bolton *et al.* 2017).

2.3 Current census methods

2.3.1. The survey of Storm Petrels on Treshnish Isles in 2018 and 2019, was conducted as part of the *Seabirds Count*, the fourth census of all breeding seabirds in Britain and Ireland, following on from Operation Seafarer (1969/70), the Seabird Colony Register (SCR; 1985-88) and Seabird 2000 (1998-2002). Storm Petrel breeding colonies were for the *Seabirds Count*, either sampled or a complete census conducted using methods taken from Gilbert *et al.* (1998b) that count incubating adults by eliciting calls using taped calls during day-light hours.

2.3.2. For the reasons discussed above (section 2.2.1), a complete census of Storm Petrel on the Treshnish Isles in 1996 and 2018-19 were conducted using diurnal playback. The playback census method used was as recommended by Gilbert *et al.* (1998b).

2.4 Response probabilities

2.4.1. Diurnal playback as a method of censusing Storm Petrels will not detect every pair of breeding birds in a single visit (Gilbert *et al.* 1998a). Playback at a nesting cavity may fail to elicit a response because there may be no adult present in the nesting cavity or the adult may fail to respond if present. It is therefore necessary to obtain a correction factor based on response probabilities in order to calculate the total population. Response rates are however variable between colonies and years, requiring calibration plots with daily visits for around one week to determine colony/year-specific response rates (Mitchell *et al.* 2004). Calculations for estimating a colony's population size (number of Apparently Occupied Sites, AOSs, which is the prescribed count unit for Storm Petrel) involve multiplying the number of responses elicited from playback within a survey area by the reciprocal of the response rate. This correction factor accounts for unresponsive birds.

2.4.2. To increase the probability of obtaining responses to playback, the survey takes place at the peak of nest attendance which is during the incubation period, which in Britain and Ireland is early to mid-July (Walsh *et al.* 1995).

3. Study area

3.1.1. The Treshnish Isles is a group of eight terraced, Tertiary basalt islands (c.128 ha), together with three smaller vegetated islets and numerous skerries, situated at its closest 3 km west of Mull, N.W. Scotland (56º29'N 06º25'W). The Isles have been uninhabited by humans since 1834 and livestock since the 1980's. The survey of Storm Petrels was undertaken on five of the largest islands of the Treshnish Isles; Lunga (59.9 ha in extent; ha above Mean High Water Spring tide), Fladda (20.6 ha), Bac Mor (Dutchman's Cap; 24.7 ha), Cairn na Burgh Mor (3.6 ha), Sgeir a' Chaisteil (3.7 ha). Poor weather conditions during the remainder of the time available to survey, prevented access to the other two islands in the Treshnish group which are known to have held breeding Storm Petrels, Cairn na Burgh Beg and Bac Beag.

4. Methods

4.1 Survey timing and locations

4.1.1. Fieldwork was carried out between:
- 16th– 27th July 2018
- 21st – 28th July 2019.

4.1.2. The year in which a complete census of Storm Petrel was conducted for each of the islands surveyed was:
- 2018: Lunga, Fladda and Sgeir a' Chaisteil
- 2019: Bac Mor (Dutchman's Cap) and Cairn na Burgh Mor

4.2 Correction for non-response to playback

4.2.1. To estimate a response probability sample calibration, trial plots representative of habitats occupied by Storm Petrel on the Treshnish Isles were chosen on Lunga where playback was repeated during the day on at least 7 days. The time of day of playback was varied. The nesting cavities of breeding Storm Petrel on Lunga cannot easily be inspected without potentially damaging the cavities, so the sample calibration was 'blind'.

4.2.2. Plots of wall, ruined dwellings and boulder beach habitats were chosen on Lunga as sites where playback was repeated during the day for at least seven days in 2018. Six sample plots of each of the three habitats were used for the calibration trial. The calibration trial plots of boulder beach habitat were re-surveyed in 2019 in order to calculate a response probability for the complete census of Storm Petrel on Bac Mor and Cairn na Burgh Mor. This was necessary because the response rate has been found to differ significantly among years within a colony (Soanes and Thomas 2012).

4.2.3. The methods used to survey the calibration trial plots followed those of Gilbert *et al.* (1998b) for dry-stone walls and boulder beach habitats. Throughout the dry-stone wall surveys, 10 second playbacks were made every 1 metre of wall. For boulder beach surveys, 5x5 metre plots were staked out above the high-tide line, with playbacks made every 1 metre within each plot. All responses were noted and approximate nest chamber locations were marked with tape and numbered. Subsequent visits followed the above methodology, with all responses noted and new nest chambers marked and numbered. The Storm Petrel male's "purr" song was used in all playback surveys, the recording being from Shetland https://www.xeno-canto.org/46091 (Recordist: Dougie Preston), the nearest locality to the Treshnish Isles available on Xeno-canto (https://www.xeno-canto.org/species/Hydrobates-pelagicus), the source material as advised by *Seabird Count* D. Burnell pers. comm.). The recording was played using a Neocore Wave A1 Portable Bluetooth Speaker (10 WATTS [2x5W stereo], Subwoofer).

4.2.4. The estimation of the number of AOS within the calibration trial plot was calculated using the du Feu mark-recapture method which makes full use of data on the number of nest cavities from which responses are repeatedly obtained during the

trial (du Feu *et al.* 1983, Soanes *et al.* 2012). The du Feu mark-recapture method was run within *ShinySeabirds*[1].

4.2.5. For each estimate of the number of AOSs within the calibration plots sampling a habitat, the mean daily response rate across all calibration surveys was calculated together with its standard error (S.E.) and 95% confidence intervals (±1.96 S.E.).

4.2.6. For each habitat type, the reciprocal of the mean daily response rates provides the correction factor with which to derive a whole island population estimate for that habitat on multiplication with the number of responses from the single visit playback survey of a whole island survey. The 95% confidence intervals calculated for the daily response rate assumes the variation to be normally distributed, which can be expected not to be the case. Therefore, for each habitat type, reciprocals of 999 bootstrapped replicates of the calibration response rate were multiplied by the number of whole-island responses from that habitat, ranked and the 2.5th and 97.5th percentile values taken.

4.3 Whole island surveys

4.3.1. All potential Storm Petrel breeding habitat on five of the seven islands known to support colonies of Storm Petrel on the Treshnish Isles (Lunga, Fladda, Bac Mor, Cairn na Burgh Mor, Sgeir a' Chaisteil) were surveyed once during daylight hours using the same method of call playback as for the calibration trial. The same recording and playback equipment were used as for the calibration trial. The response was noted.

4.3.2. The number of occupied nesting cavities in each of the available breeding habitats on an island was estimated from the number of nesting cavities a response was elicited, multiplied by the correction factor for the respective habitat as calculated using the du Feu mark-recapture method (section 4.2). The population estimates for each habitat occupied by breeding Storm Petrel were summated to provide population estimates for the islands individually and in-combination. 95% confidence intervals were estimated using a bootstrapping procedure for the population estimates of the islands individually, and when summated.

4.3.3. In calculating the confidence intervals for the total population estimate of an island with more than one breeding habitat, initially reciprocals of 999 bootstrapped replicates of the calibration response rates for each habitat (calculated using the du Feu mark-recapture method run within *ShinySeabirds*) were respectively multiplied by the number of whole-island responses from that habitat. The resultant values were then randomly grouped and summated to provide total population estimates of the island which were subsequently ranked and the 2.5th and 97.5th percentile values taken.

4.3.4. Similarly, in calculating the confidence intervals for the total population estimate of the five islands surveyed, initially reciprocals of 999 bootstrapped replicates of the calibration response rates for each habitat (calculated using the du Feu mark-

[1] *ShinySeabirds* is a web interface tool that provides advice and recommendations on survey methods for the census of the species of nocturnal Procellariiformes found in the UK (European Storm Petrel *Hydrobates pelagicus*, Leach's Storm Petrel *Oceanodroma leucorrhoa*, and Manx Shearwater *Puffinus puffinus*). It includes a series of shiny apps that provide a coding-free way of computing parameters necessary for making final population estimates, beginning from calculating response rates from playback surveys (Bolton *et al.* 2019).

recapture method run within *ShinySeabirds*) were respectively multiplied by the number of whole-island responses from that habitat. The resultant values were then randomly grouped and summated to provide total population estimates of the five islands which were subsequently ranked and the 2.5th and 97.5th percentile values taken.

5. Results

5.1 Calibration trial

5.1.1. Table 1 presents the number of nest cavities detected in the calibration trial plots as occupied by Storm Petrel for each of the three breeding habitats, together with the estimated population and respective calculated response rate statistics. The number of responses recorded each visit of the calibration trial for each habitat are presented in Appendix A.

Table 1 Results of the calibration trials for each breeding habitat of Storm Petrel, the estimated population of the summated plots and respective calculated response rate

Habitat	Survey Year	No. of visits	No. of plots / houses	No. of occupied nest cavities	Estimated population (using du Feu *et al.* 1983)	Response rate (3 s.f.)		
						Mean	S.E.	95% C.I.
Wall	2018	7	6	61	64	0.438	0.030	0.058
Boulder Beach	2018	9	6	72	76	0.332	0.032	0.063
	2019	7	6	36	40	0.318	0.052	0.101
Ruined dwellings	2018	7	8	38	40	0.439	0.034	0.067

5.1.2. The reciprocal of the mean daily response rates calculated from the calibration trials for each of the three breeding habitats of Storm Petrel are presented in Table 2. These correction factors when multiplied with the number of responses elicited from a diurnal playback survey of the habitat of an island, gives an all-island estimate of breeding pairs supported by the habitat.

Table 2 Correction factor by habitat used in multiplying responses elicited from diurnal playback surveys on the Treshnish Isles (2018-2019) to derive population estimates of breeding Storm Petrel

Habitat	Survey Year	Correction factor (1 / mean daily response rate)
Wall	2018	2.285714

Habitat	Survey Year	Correction factor (1 / mean daily response rate)
Boulder Beach	2018	3.013216
	2019	3.146067
Ruined dwellings	2018	2.276422

5.2 Whole island surveys

Lunga

5.2.1. Between 16–27th July 2018 on Lunga, 937 responses from Storm Petrels were elicited from playback when surveying all boulder habitat, 155 responses from all existing wall habitat and 32 responses from the ruined dwellings of the Village in the north east of the island. An all-island estimate of breeding pairs (AOS) supported by each habitat is presented in Table 3 when applying the habitat specific correction factors to the number of responses obtained from Lunga. On summation of these estimates, the total population of Storm Petrels on Lunga was estimated in 2018 as 3,251 breeding pairs (AOS), with 95% confidence intervals when estimated using a bootstrapping procedure of 2,735 – 3,907 pairs (Table 4).

Sgeir a' Chaisteil

5.2.2. Between 16–27th July 2018 on Sgeir a' Chaisteil, 87 responses from Storm Petrels were elicited from playback when surveying all boulder habitat. An all-island estimate of breeding pairs (AOS) supported by this habitat is derived when applying the boulder habitat specific correction factor to the number of responses obtained from Sgeir a' Chaisteil. The total population of Storm Petrels on Sgeir a' Chaisteil was estimated in 2018 as 262 breeding pairs (AOS), with 95% confidence intervals when estimated using a bootstrapping procedure of 220 - 313 pairs (Table 4).

Fladda

5.2.3. Between 24-25th July 2018 on Fladda, 1,698 responses from Storm Petrels were elicited from playback when surveying all boulder habitat and 15 responses from all existing wall habitat. An all-island estimate of breeding pairs (AOS) supported by each habitat is presented in Table 3 when applying the habitat specific correction factors to the number of responses obtained from Fladda. On summation of these estimates, the total population of Storm Petrels on Fladda was estimated in 2018 as 5,151 breeding pairs (AOS), with 95% confidence intervals when estimated using a bootstrapping procedure of 4,217 – 6,324 pairs (Table 4).

Cairn na Burgh Mor

5.2.4. On 27th July 2019 on Cairn na Burgh Mor, 388 responses from Storm Petrels were elicited from playback when surveying all boulder habitat and 1 responses from all existing wall habitat. An all-island estimate of breeding pairs (AOS) supported by each habitat is presented in Table 3 when applying the habitat specific correction factors to the number of responses obtained from Cairn na Burgh Mor. On summation of these estimates, the total population of Storm Petrels on Cairn na Burgh Mor was estimated in 2019 as 1,223 breeding pairs (AOS), with 95%

confidence intervals when estimated using a bootstrapping procedure of 887 – 1,918 pairs (Table 4).

Bac Mor

5.2.5. On 28th July 2019 on Bac Mor, 119 responses from Storm Petrels were elicited from playback when surveying all boulder habitat. An all-island estimate of breeding pairs (AOS) supported by this habitat is derived when applying the boulder habitat specific correction factor to the number of responses obtained from Bac Mor. The total population of Storm Petrels on Bac Mor was estimated in 2019 as 374 breeding pairs (AOS), with 95% confidence intervals when estimated using a bootstrapping procedure of 290 - 513 pairs (Table 4).

Treshnish Isles

5.2.6. The total population of Storm Petrels on the Treshnish Isles for five of the seven islands known to support colonies was estimated in 2018/19 as 10,261 breeding pairs (AOS), with 95% confidence intervals when estimated using a bootstrapping procedure of 8,737 – 12,375 pairs (Table 4).

Table 3 Breeding population estimates of Storm Petrels by habitat for individual islands of the Treshnish Isles (2018-2019), with 95% confidence intervals when estimated using a bootstrapping procedure

Island	Habitat (survey year)	No. of responses elicited	Habitat specific correction factor	Estimated population of breeding pairs (AOS)* (95% C.I. estimated using a bootstrapping procedure)
Lunga	Wall	155	2.285714	354 (317-401)
	Boulders (2018)	937	3.013216	2,823 (2,364-3,392)
	Ruined dwellings	32	2.276423	73 (65 – 85)
Sgeir a' Chaisteil	Boulders (2018)	87	3.013216	262 (220-313)
Fladda	Wall	15	2.285714	34 (31-40)
	Boulders (2018)	1,698	3.013216	5,116 (4,316-6114)
Cairn na Burgh Mor	Wall	1	2.285714	2 (2-3)
	Boulders (2019)	388	3.146067	1,221 (945-1,698)
Bac Mor	Boulders (2019)	119	3.146067	374 (290-513)

* to zero decimal places

Table 4 Population estimates of Storm Petrels breeding on the Treshnish Isles in 2018-2019

Island	Survey Year	Estimated population of breeding pairs (AOS) (95% C.I. estimated using a bootstrapping procedure)
Lunga	2018	3,251 (2,735 – 3,907)
Sgeir a' Chaisteil	2018	262 (220 - 313)
Fladda	2018	5,151 (4,217 – 6,324)
Cairn na Burgh Mor	2019	1,223 (887 – 1,918)
Bac Mor	2019	374 (290 - 513)
Total population of Treshnish Isles (excluding Cairn na Burgh Beg and Bac Beag)	2018/2019	10,261* (8,737 – 12,375)

*summation of the total populations of the individual populations as whole numbers i.e. to zero decimal places.

6. Discussion

6.1.1. An estimated 10,261 breeding pairs of Storm Petrels counted in 2018/19 shows an increase of 104% from the numbers recorded on Treshnish Isles in 1996 (Table 5). The magnitude of this difference between the two population estimates may actually be greater as two of the seven islands known to support colonies in 1996, were not surveyed in 2018-2019. However, this additional change is likely to be small as for the two islands not surveyed in 2018-2019, Cairn na Burgh Beg and Bac Beag, their population of breeding Storm Petrel, 22 and 53 pairs, constituted less than 1.49% of the estimated population of the Treshnish Isles in 1996 (Gilbert *et al.* 1998a).

6.1.2. Since the first comprehensive estimate of Storm Petrel population size was obtained during the Seabird 2000 Census, little information exists on population trends (JNCC 2020a). Re-surveys of Mousa (Shetland), the largest UK colony at the time of the Seabird 2000 census at 5,410 pairs in 1996 (22% of the UK population), have indicated a substantial increase to 11,781 pairs in 2008 (118%; Bolton *et al.* 2010) followed by 12.8% decline to 10,778 pairs in 2015. The population size quantified by this second re-survey of Mousa, still represents a substantial increase from that in 1996, and of a comparable increase at 99%, to that recorded by the current study's re-survey of the Treshnish Isles in 2018-2019 (a 104% increase from 1996). Elsewhere, re-surveys have indicated declines of approximately 50% at Priest Island, Ross and Cromarty, West Scotland, between 2001 and 2012 (Insley *et al.* 2014), and 22% at Skokholm, Pembrokeshire, Wales,

between 2001 and 2012 (Mitchell *et al.* 2004, Wood *et al.* 2017). However, differences in survey methodology and analysis between the two surveys has led Wood *et al.* (2017) to conclude that the colony had probably remained stable between 2001 and 2016 from several re-surveys of a sub-colony.

6.1.3. For Storm Petrel alone, the estimated breeding population of 10,261 pairs on the Treshnish Isles represents approximately 2.1% of the World population, and therefore qualifying as of international importance using a threshold of 4,900 pairs (Mitchell *et al.* 2004) i.e. 1% of the world population. When the estimated breeding population of Storm Petrel is taken together with that of the other populations of breeding seabird species that were surveyed in 2018 and 2019 (TIARG 2018, 2019), the Treshnish Isles also exceeds international importance threshold for its total assemblage (over 20,000 breeding seabirds; JNCC 2020b).

Table 5 Population estimates of Storm Petrels breeding on the Treshnish Isles in 1996 and 2018-2019

Island	**Estimated population of breeding pairs (AOS)**	
	1996 (Gilbert *et al.* 1998a)	**2018/2019**
Lunga	922	3,251
Sgeir a' Chaisteil	86	262
Fladda	3,119	5,151
Cairn na Burgh Mor	644	1,223
Cairn na Burgh Beg	22	Not surveyed
Bac Mor	194	374
Bac Beag	53	Not surveyed
Total population of Treshnish Isles	5,040	10,261*

*summation of the total populations of the individual populations as whole numbers i.e. to zero decimal places.

7. Acknowledgements

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Appendix A

A.1 Responses recorded from Storm Petrel plots surveyed in the calibration trial on the Boulder beach, Lunga, in 2018

Plot	Sub-site	Date of visit (July)								
		16	**17**	**18**	**19**	**20**	**22**	**23**	**24**	**25**
1	1	1	0	0	0	0	0	0	0	0
2	1	1	0	0	1	1	0	1	0	1
3	1	1	0	0	0	0	0	0	0	0
3	2	0	0	0	1	0	1	0	1	1
4	1	1	0	0	1	1	0	0	0	0
4	2	1	0	0	1	1	0	0	1	1
4	3	1	0	0	0	0	0	0	0	0
4	4	1	1	0	0	0	0	0	0	0
4	5	1	1	1	1	0	0	0	1	0
4	6	1	0	1	1	0	0	0	0	0
4	7	1	0	0	1	0	0	0	1	0
4	8	1	0	1	1	1	0	0	0	0
4	9	1	1	1	1	0	1	0	1	1
4	10	1	1	1	1	1	0	0	0	1
4	11	1	1	1	1	0	0	0	0	0
4	12	1	0	0	0	0	0	0	0	0
4	13	0	1	0	0	0	0	0	0	0
4	14	0	1	0	0	0	0	0	1	0
4	15	0	1	0	0	0	1	0	0	0
4	16	0	0	1	0	0	0	0	1	0
4	17	0	0	1	0	0	0	0	0	0
4	18	0	0	1	0	1	1	0	0	0
4	19	0	0	1	1	1	0	0	0	1
4	20	0	0	0	1	1	0	0	0	0
4	21	0	0	0	1	0	0	0	1	0
4	22	0	0	0	1	0	1	0	0	0
4	23	0	0	0	1	0	0	0	1	1
4	24	0	0	0	1	0	0	0	1	0
4	25	0	0	0	0	1	1	0	1	1
4	26	0	0	0	0	0	1	0	0	0
4	27	0	0	0	0	0	0	1	0	0
4	28	0	0	0	0	0	0	0	1	0
5	1	1	0	0	0	1	1	0	1	0
5	2	1	1	0	1	0	0	0	0	1
5	3	1	0	0	0	0	0	0	0	0
5	4	1	0	1	1	0	1	1	0	0
5	5	1	0	1	1	1	0	0	1	0
5	6	1	1	0	1	0	0	0	0	0

Plot	Sub-site	Date of visit (July)								
		16	**17**	**18**	**19**	**20**	**22**	**23**	**24**	**25**
5	7	1	0	0	1	1	1	0	0	1
5	8	1	0	0	1	1	1	0	0	0
5	9	1	1	1	1	0	1	0	1	0
5	10	1	1	1	1	0	1	0	1	1
5	11	1	0	0	0	0	0	0	0	1
5	12	1	0	0	1	1	0	0	0	0
5	13	0	1	0	0	1	0	0	0	1
5	14	0	1	0	1	0	0	0	0	0
5	15	0	1	0	1	1	1	1	1	0
5	16	0	0	0	1	0	0	0	1	1
5	17	0	0	0	1	0	0	0	0	1
5	18	0	0	0	1	0	1	0	0	0
5	19	0	0	0	1	0	1	0	0	0
5	20	0	0	0	1	1	1	0	1	1
5	21	0	0	0	0	1	1	0	0	0
5	22	0	0	0	0	0	1	0	0	0
6	1	1	1	1	1	0	1	1	1	1
6	2	1	1	1	1	0	0	0	0	0
6	3	1	0	1	0	0	0	1	0	0
6	4	1	1	1	0	0	0	0	0	1
6	5	1	0	1	1	1	0	1	0	1
6	6	1	0	1	1	0	0	0	0	0
6	7	1	1	1	0	1	1	1	1	0
6	8	1	1	0	0	0	0	1	0	0
6	9	0	1	1	0	1	0	1	0	0
6	10a	0	1	0	1	0	0	1	0	1
6	11	0	0	1	0	0	0	1	0	0
6	12	0	0	1	1	0	0	0	0	0
6	10b	0	0	1	0	0	0	0	0	0
6	13	0	0	0	0	0	1	1	1	1
6	14	0	0	0	0	0	1	1	1	1
6	15	0	0	0	0	0	0	1	0	0
6	16	0	0	0	0	0	1	0	0	0
6	17	0	0	0	0	0	0	0	1	0
Total Responses		**35**	**22**	**25**	**39**	**21**	**24**	**15**	**24**	**22**

* 1 = responses, 0 = no response

A.2 Responses recorded from Storm Petrel plots surveyed in the calibration trial of Walls, Lunga, in 2018

Plot	Sub-site	Date of visit (July)						
		16	17	18	19	20	22	23
1	1	1	1	1	0	1	0	1
1	2	1	1	1	0	1	1	0
1	3	1	0	0	1	1	0	0
1	4	1	0	0	0	0	0	0
1	5	1	0	0	0	1	0	0
1	6	1	0	0	1	1	0	0
1	7	0	1	1	1	0	0	0
1	8	0	1	1	1	0	0	0
1	9	0	1	0	0	0	0	0
1	10	0	0	1	1	1	1	0
1	11	0	0	1	1	1	0	0
1	12	0	0	1	1	1	0	0
1	13	0	0	1	1	0	0	0
1	14	0	0	0	1	1	0	0
1	15	0	0	0	0	0	1	1
1	16	0	0	0	0	0	1	0
2	1	1	0	0	1	0	0	0
2	2	1	0	1	1	1	0	0
2	3	1	1	0	1	1	1	1
2	4	1	1	1	1	0	0	1
2	5	0	1	1	0	0	0	0
2	6	0	1	0	0	0	0	1
2	7	0	0	1	1	0	0	0
3	1	1	1	1	1	1	1	1
3	2	1	1	1	0	0	1	1
3	3	1	1	1	0	0	0	0
3	4	1	1	1	0	0	0	1
3	5	1	1	1	1	1	1	1
3	6	1	1	1	0	0	1	1
3	7	1	1	0	1	1	1	0
3	8	1	0	0	1	0	1	0
3	9	1	1	0	0	1	0	0
3	10	0	1	1	0	0	0	0
3	11	0	1	1	1	1	0	0
3	12	0	1	0	1	1	0	1
3	13	0	0	1	1	1	1	1
3	14	0	0	1	0	1	1	1
3	15	0	0	1	0	0	0	0
3	16	0	0	1	0	0	0	0
3	17	0	0	1	1	0	1	0
3	18	0	0	1	0	0	1	0
3	19	0	0	0	1	0	0	1
3	20	0	0	0	1	1	0	0
4	1	1	0	1	1	1	0	1
4	2	1	0	1	0	1	0	1
4	3	1	0	0	1	1	0	0

Plot	Sub-site	Date of visit (July)						
		16	17	18	19	20	22	23
4	4	1	1	1	1	0	1	1
4	5	1	1	1	0	0	1	1
4	6	1	0	1	0	1	0	0
4	7	1	0	0	0	0	0	0
4	8	1	1	0	0	0	1	0
4	9	1	0	0	0	0	0	0
4	10	1	1	0	0	0	0	0
4	11	1	1	1	1	0	0	1
4	12	1	1	0	0	1	0	0
4	13	0	1	1	1	0	0	1
4	14	0	1	0	1	0	1	0
4	15	0	1	0	0	1	0	0
4	16	0	0	0	0	0	0	0
4	17	0	0	0	0	0	0	0
4	19	0	0	0	1	1	0	0
4	20	0	0	0	1	1	1	1
4	21	0	0	0	0	1	1	0
Total Responses		**31**	**29**	**33**	**32**	**29**	**21**	**21**

* 1 = responses, 0 = no response

A.3 Responses recorded from Storm Petrel plots surveyed in the calibration trial of remanent dwellings, Lunga, in 2018

Plot	Sub-site	Date of visit (July)						
		Day 1	21	22	23	24	25	27
Bothy	1	1	1	1	1	1	0	1
Bothy	2	0	1	1	1	1	0	0
Bothy	3	0	1	1	0	0	0	0
Bothy	4	0	0	0	1	1	0	0
Fallen House	1	1	1	1	0	0	1	0
Fallen House	2	1	1	0	1	1	0	1
Fallen House	3	1	0	0	1	1	1	1
Fallen House	4	1	0	0	1	0	0	0
Fallen House	5	1	0	0	0	0	0	0
Fallen House	6	1	1	1	1	1	1	0
Fallen House	7	1	0	0	0	0	0	0
Fallen House	8	1	1	1	1	0	1	1
Fallen House	9	1	1	1	0	0	1	0
Fallen House	10	1	1	1	0	0	0	0
Fallen House	11	1	1	1	0	0	1	0
Fallen House	12	1	0	1	0	1	1	0
Fallen House	13	1	1	1	1	0	0	1
Fallen House	14	0	1	1	1	0	1	0
Fallen House	15	0	1	1	1	0	0	1
Fallen House	16	0	1	1	1	1	1	0
Fallen House	17	0	0	0	1	1	1	1
Fallen House	18	0	0	0	0	1	1	1

Plot	Sub-site	Date of visit (July)						
		Day 1	**21**	**22**	**23**	**24**	**25**	**27**
Fallen House	19	0	0	0	0	0	1	1
No. 4	1	1	0	0	0	0	0	0
No. 4	2	0	0	1	1	0	0	1
No. 4	3	0	0	1	1	0	0	0
No. 4	4	0	0	0	0	0	1	1
No.5	1	1	0	0	1	1	0	1
No.5	2	1	0	0	1	1	0	0
No.5	3	1	1	1	1	1	0	0
No.5	4	1	0	0	0	0	0	0
No.6	1	0	1	1	0	0	0	0
No. 8	1	1	1	1	0	0	1	0
No. 8	2	1	0	0	0	0	0	0
No. 8	3	1	0	0	0	0	0	0
No. 8	4	1	1	1	1	0	0	0
No. 8	5	0	0	0	0	1	1	0
No. 8	6	0	0	0	0	1	1	0
Total Responses		**23**	**18**	**20**	**19**	**15**	**16**	**12**

* 1 = responses, 0 = no response

A.4 Responses recorded from Storm Petrel plots surveyed in the calibration trial of the Boulder Beach, Lunga, in 2019

Plot	Sub-site	Date of visit (July)						
		21	**22**	**23**	**24**	**25**	**26**	**27**
1		0	0	0	0	0	0	0
2		0	0	0	0	0	0	0
3		0	0	1	1	0	0	0
4	1	1	1	1	1	1	0	1
4	2	1	1	1	0	0	0	1
4	3	1	1	0	1	1	1	0
4	4	1	1	0	0	0	0	0
4	5	1	1	0	0	1	1	0
4	6	1	1	0	0	0	0	1
4	7	0	1	0	0	1	0	0
4	8	0	1	0	0	1	0	1
4	9	0	1	1	0	0	0	0
4	10	0	0	1	0	0	0	0
4	11	0	0	1	0	0	0	0
4	12	0	0	1	1	1	0	1
4	13	0	0	1	0	0	0	1
4	14	0	0	1	1	0	0	0
4	15	0	0	0	1	1	1	0
4	16	0	0	0	1	0	0	0
4	17	0	0	0	0	1	0	0
4	18	0	0	0	0	1	0	0
5	1	1	0	1	0	0	0	0
5	2	1	0	0	0	0	0	0
5	3	1	0	0	0	0	0	0

Plot	Sub-site	Date of visit (July)						
		21	22	23	24	25	26	27
5	4	1	1	0	0	0	0	0
5	5	1	0	1	1	0	0	0
5	6	1	0	0	0	0	0	0
5	7	1	0	7	1	0	0	0
5	8	1	0	0	0	1	0	0
5	9	1	0	0	0	1	0	0
5	10	0	0	0	0	1	0	1
6	1	1	0	0	0	0	1	0
6	2	1	0	1	1	0	1	0
6	3	0	0	1	1	0	0	0
6	4	0	0	1	1	1	0	0
6	5	0	0	0	1	0	0	1
6	6	0	0	0	1	0	0	0
6	7	0	0	0	0	1	0	0
Total Responses		**17**	**10**	**21**	**14**	**14**	**5**	**8**

* 1 = responses, 0 = no response

* Grid references of the

A.5 Locations of Storm Petrel plots surveyed in the calibration trial of the Boulder Beach, Lunga, in 2018 and 2019

Plot	Grid references
1	NM 28102 42491
2	NM 28098 42484
3	NM 28104 42478
4	NM 28120 42465
5	NM 28126 42462
6	NM 28133 42458

A.6 Sketch Plan of Village at Lunga's north end showing the locations of Storm Petrel plots surveyed in the calibration trial of the remanent dwellings in 2018

(not drawn to scale)