A pilot study of the phenology and breeding success of Leach's Storm-petrel *Oceanodroma leucorhoa* on St Kilda, Western Isles

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Abstract
From June to September 2007, 27 occupied Leach's Storm-petrel *Oceanodroma leucorhoa* burrows on St Kilda were investigated by endoscope to estimate phenology and breeding success. From 17 burrows that could be followed to chick development, a minimum productivity of 0.59 young per egg laid was estimated, similar to other published figures of breeding success from the northwest Atlantic. Similar life cycle timings to those of Leach's Storm-petrels in the northwest Atlantic were revealed, with egg laying in late May to mid June, hatching in mid to late July and fledging from mid September onwards. Implications for conservation and monitoring are discussed, and guidance for future studies suggested.

Introduction
The St Kilda archipelago (57°49'N, 08°35'W), 66 km west of the Western Isles, holds a population of around 45,000 pairs of Leach's Storm-petrels *Oceanodroma leucorhoa* which represents 94% of the British and Irish population (Mitchell 2004). Recent work in the northwest Atlantic by Huntington *et al*. (1996) and A. Hedd (unpubl.) has been carried out on the breeding biology of Leach's Storm-petrel, but little is known about their breeding habits within Britain, and little has been published since that of Ainslie & Atkinson (1937) on the Flannan Isles and North Rona, apart from some exploratory work on Gruney, Shetland in the 1990s (Ellis *et al*. 1998). In addition, it has been suggested that the Leach's Storm-petrel breeding population on St Kilda may have declined significantly since the last full census in 1999/2000 (Mitchell 2004; Newson *et al*. 2008), and studies on breeding success may therefore give insights as to the reasons for this decline.

Methods
In 2007, 27 Leach's Storm-petrel burrows which were occupied (i.e. a response was obtained from playing a tape of a male 'St Kildan' chatter call in mid June and nest material was visible) and which were accessible by endoscope (Everest VIT PXL Videoprobe) were located and marked with two short bamboo canes with a tape flag. Burrows were situated on grassy slopes, under rocks and in cleits (man-made stone structures unique to St. Kilda), and were monitored by endoscope a total of 12 times throughout the breeding season. Burrow occupancy was determined on seven days during peak incubation time between 19 and 27 June, on three days during hatching and early chick stage (24 and 26 July, and 8 August) and twice during the late chick stage (on 10 and 26 September). Of the 27 initially occupied study burrows, eight (30%) did not contain an egg and therefore were presumably occupied by immature or prospecting birds. Eggs were laid in 19 burrows, two of which could not be relocated due to marker loss, leaving 17 burrows that were used in estimates of breeding success (Table 1).

Results
Phenology: The presence of unattended small chicks and incubating adults on 24 and 26 July, but only unattended chicks on 8 August (Table 1), suggested that hatching took place between mid and late July (assuming that chicks are brooded for an average of five days (Cramp & Simmons 1977)). Given an incubation period of six weeks and a fledging period of 9–10 weeks (Cramp & Simmons 1977) this would suggest a laying period from around late May to mid June and fledging from mid September. Indeed, our observations

showed that all study birds had laid their eggs by mid June and the majority of the chicks fledged between 10 and 26 September, with the remaining chicks presumably fledging after 26 September (Table 1). In Newfoundland, Canada, egg laying of Leach's Storm-petrel begins in late May, the mean hatching time is late July and fledging begins in mid September (Huntington *et al*. 1996; A. Hedd, unpubl.), suggesting that the phenology in these two geographically distinct populations is very similar. A study of nine burrows investigated by endoscopy on St Kilda in 2003 (O'Brien *et al*. 2005) found the first hatching to be on 9 July and a further three had hatched by 14 July, which indicates a similar (perhaps slightly earlier) timing to that presented here, and work carried out on Gruney in Shetland (Ellis *et al*. 1998) also found chicks on a slightly earlier date (6 July) than in the current study.

Breeding success: Out of 17 burrows in which an egg was recorded, ten were confirmed to have chicks by 10 or 26 September (Table 1). Of the remaining seven burrows, four failed at the egg stage, two stone cavity nesters (burrows 19 and 20) had ambiguous results

Table 1. Leach's Storm-petrel *Oceanodroma leucorhoa* burrow contents as determined by endoscopy.

	19 Jun	20 Jun	22 Jun	23 Jun	24 Jun	25 Jun	27 Jun	Egg	24, 26 Jul	8 Aug	10 Sep	26 Sep	Summary
1	0	0	0	0	0	0	0		0				No egg laid
2	R	R	R	1,E	1	1,E	R	Y	A,E	SC	LC	0	Presumed fledged
3	1	1	R	R	1,E	1,E	1	Y	SC		MC	0	Presumed fledged
4	R	1	1	0,E	0,E	1,E	0,E	Y	0	E			Abandoned egg
5	1	R	R	R	0	1,E	R	Y	SC		LC	0	Presumed fledged
6	R	0	0	1	0	0	0		0				No egg laid
7	R	R	1,E	R	R	1,E	R	Y	SC		MC	0	Presumed fledged
8	R	R	R	R	R	1,E	R	Y	0	0			Failed to hatch
9	1,E	R	R	R	1	1,E	1	Y	A,BE,SC?	SC	LC	LC	Presumed fledged
10	0	0	0	0	0	0	0		0				No egg laid
11	0	0	R	R	R	1,E	1,E	Y	A	E			Abandoned egg
12	0	R	R	R	R	1,E	1	Y	SC		0	0	Chick died/fledged early?
13	1	R	R	R	1	1,E	1	Y	?				Burrow not relocated
14	R	R	R	0,E	0,E	0,E	R	Y	0				Failed to hatch
15	R	R	R	1,E	1,E	1,E	R	Y	SC		LC	LC	Presumed fledged
16	R	R	0,E	1,E	1	1,E	R	Y	A,SC		LC	0	Presumed fledged
17	R	R	0	R	0	0	0		?	0			No egg laid
18	1	1	0,E	R	R	1,E	1	Y	SC		MC	LC	Presumed fledged
19	R	R	R	R	1	1,E	1	Y	A	BE	0	0	Failed to hatch?
20	1	0	1	1	R	1,E	R	Y	A	BE	BE	BE	Failed to hatch?
21	1	0	1	1,E	1	1,E	1	Y	BE	BE	MC	0	Presumed fledged
22	1,E	R	0,E	1,E	1	1,E	R	Y	?				Burrow not relocated
23	R	1	0	R	R	1	R		?				Burrow not relocated
24	0	R	0	0	R	1	R		0				No egg laid
25	0	0	0	0	0	0	0		0				No egg laid
26	0	0	0	0	0	0	0		0				No egg laid
27	0,E	R	R	0,E	1	1,E	R	Y	A	SC	MC	LC	Presumed fledged

R = Response, no endoscope
0 = No response, no adult
1 = Adult present
E = Egg seen

Y = Yes
0 = Empty burrow
A = Adult in burrow
A,E = Adult sitting on egg

BE = Broken eggshell
SC = Small unattended chick
MC = Medium chick
LC = Large, well-feathered chick

Figure 1. Sarah Money using endoscope on Hirta, summer 2006.

Figure 2. Leach's Storm-petrel *Oceanodroma leucorhoa*, Hirta, St Kilda, September 2007 © *Will Miles*.

due to the possible retreat of the chick out of view from the endoscope (which happened once in the case of one of the successful burrows) and one (burrow 12) held a chick which may have fledged before the first check on 10 September (fledged Leach's Storm-petrels have been observed on St Kilda by this date in previous years: National Trust for Scotland, unpubl.). Thus, the minimum estimate of productivity was 0.59 young per egg laid, comparable with published figures of breeding success of 0.48–0.73 from the northwest Atlantic (Huntington *et al*. 1996), and suggesting that Leach's Storm-petrels on St Kilda might not be currently experiencing major breeding problems. Of interest was the fact that during incubation a number of burrows were observed to hold unattended eggs for periods of up to three days. Three out of these six burrows (those where the eggs were left unattended for single days at a time) went on to produce chicks, which suggests that leaving the egg unattended for a single day does not necessarily prevent hatching. Indeed, this phenomenon has been observed for a wide range of petrel species (Warham 1990).

Discussion

This pilot study gives a useful insight into the breeding success and timing of breeding of Leach's Storm-petrel on St Kilda in 2007. It should be emphasised that this work was of an exploratory nature, rather than a detailed study of productivity and phenology, but can nonetheless be used for comparison with future studies both on St Kilda and elsewhere in Britain. Such work on Leach's Storm-petrels is of necessity always going to be difficult due to the remote locations involved and limitations on the use of endoscopes imposed by the weather. However, lessons to be learned which would refine monitoring techniques for future studies include:

- burrow marker loss could be prevented through the use of GPS and improved marking;
- increasing the sample size of burrows and the spread and frequency of monitoring dates would help determine breeding cycle dates and success more accurately, and;

- only grassy slope burrows instead of stone cavities should be monitored to prevent ambiguous outcomes from nesting chambers.

Information on the phenology of breeding is critical to the correct application of methods for monitoring breeding numbers of storm-petrels. The favoured technique of tape playback (Ratcliffe *et al*. 1998) should be undertaken during the peak period of incubation to maximise the likelihood of burrow occupancy at the time of survey; therefore, an understanding of phenology and its year-to-year variability has important practical applications.

Currently there are concerns about the conservation status of Leach's Storm-petrel on St Kilda. Surveys in 1999 and 2003 suggested a 48% decline in the population on Dun, an island within the St Kilda archipelago (Mitchell 2004), although a further survey in 2006 suggested that this rapid decrease may have ceased (Newson *et al*. 2008). Predation by Great Skuas *Stercorarius skua* is suggested as a potential explanation for the decline (Phillips *et al*. 1999; Mitchell 2004; Votier *et al*. 2005). However, alternative factors, such as food shortages, which currently affect a wide range of Britain's seabird species, may also have played a role. Our pilot study suggests that shortage of suitable food did not affect Leach's Storm-petrel chicks on Hirta, St Kilda during the 2007 breeding season, as breeding success was quite high, but caution should be applied in interpreting these results as our sample size was small. However, studies of breeding success (combined with those of adult survival) could contribute to an early warning of potential population change, and it would therefore be appropriate to establish a long-term productivity study for this species on St Kilda.

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