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Nocturnal colony attendance by Common Guillemots *Uria aalge* at colony in Shetland during the pre-breeding season

Natalie C. Sinclair*[1◊], Mike P. Harris[2], Ruedi G. Nager[1], Chris D. B. Leakey[3] And Alexandra M. C. Robbins[4]

*Correspondence author. Email: Natalie.sinclair3@googlemail.com

[1] *Institute of Biodiversity, Animal Health and Comparative Medicine, College of Medical, Veterinary and Life Sciences, University of Glasgow, G12 8QQ, Glasgow, UK;*

[2] *Centre for Ecology & Hydrology, Bush Estate, Penicuik, Midlothian EH26 0QB, UK;*

[3] *Scottish Natural Heritage, Battleby House, Redgorton, Perth, PH1 3EW, UK;*

[4] *Scottish Natural Heritage, Great Glen House, Leachkin Road, Inverness, IV3 8NW, UK.*

[◊] Current address: Scottish Oceans Institute, School of Biology, University of St Andrews, KY16 8LB, UK

Abstract

Time-lapse photography was used to describe daily and seasonal trends in attendance by Common Guillemot *Uria aalge* at a colony in Shetland prior to the breeding season, including detection of nocturnal presence. A camera took a photo every 30 minutes from 30 January until 21 April 2015. A total of 3,435 photos were analysed, of which 3,232 photos allowed birds to either be accurately counted (2,552) or estimated (680) within a representative plot. High quality moonlit shots showed that large numbers of Common Guillemots were present ashore at Sumburgh throughout the night, while manipulated non-moonlight night photos revealed attendance at the colony, even when counting was not possible. Clear cycles of attendance at the colony were apparent with day-time peaks of 90 – 120 birds occurring on average every 7 days over the study period. Pre-breeding attendance is described, as is the nocturnal presence of Common Guillemots in the three months prior to breeding.

Introduction

Monitoring during the non-breeding season is difficult for many seabirds since individuals often spread out widely (e.g. Frederiksen *et al*. 2012) and into areas where they are not easily observed. Paucity of data leads to a lack of conservation management outside of the breeding season, even though the non-breeding period is an important time for survival and acquisition of body reserves for breeding (Calvert *et al.* 2009). Telemetry has facilitated efforts to better understand the non-breeding season of migratory seabirds; however, it is difficult to apply this method to large numbers of individuals within a population as tags are frequently lost (Fort *et al.* 2013). Although the timing of breeding for most seabirds is documented in detail, little is known about the proportion of the year species spend visiting breeding colonies.

The Common Guillemot (*Uria aalge*; hereafter Guillemot) is an abundant colonial-breeding seabird in the northern North Atlantic and North Pacific. In the northern parts of its range, the species is strictly seasonal in its attendance at the breeding colonies. At the end of the breeding season adults disperse away from the colonies and undertake their main moult of the year during which they are flightless, and return to the colonies 4-6 weeks prior to the first eggs being laid (Gaston & Jones 1998). However, at the south-easternmost colonies in both the North Pacific (e.g. Farallon Islands, California) and North Atlantic (e.g. Britain), Guillemots visit breeding sites during the late autumn and the winter (Boekelheide *et al.* 1990; Greenwood 1972, Taylor & Reid 1981). In extreme cases, birds can be seen ashore during the day at the breeding ledges for 10 months of the year (Harris *et al.* 2006).

In Britain autumn and winter attendance during the day has been well documented at the Isle of May (Firth of Forth), St Abb's Head (Berwickshire), Fowlsheugh (Kincardineshire), and Iresgoe and An Dun (Moray Firth) (Harris 1984; Mudge *et al.* 1987). Although attendance varies both between and within years, there a clear pattern of daily attendance. Harris (1984) monitored the time Guillemots spent at Fowlsheugh, where the first eggs are typically laid in late April and the last chicks fledge in early August, from October 1981 to March 1982 and found that birds arrived at the colony just before dawn and typically left well before dusk. In contrast, Mudge *et al.* (1987) following attendance at colonies in the Moray Firth between September and April 1983-85 reported less frequent attendance. Again, birds were usually present at dawn, although during February and March, birds sometimes came ashore later in the day, and remained on land for less than a few hours, but occasionally were present until dark. These studies suggested that Guillemots are not present at the colonies overnight. However, the above studies used outdated Kodak 'Analyst' time-lapse film cameras and slow Kodachrome 40 film, so would not have been able to detect birds present overnight.

In early 2015, we monitored the attendance of Guillemots at a colony in Shetland for the three months prior to the breeding season using a more sensitive time-lapse camera setup than had been available for earlier studies. Here, we present evidence to show, for the first time, that Guillemots are often present at the breeding site throughout the night prior to the breeding season and that likelihood of attendance at the colony increased with approaching breeding season.

Methods

The study colony is located on a large sea stack in Smithfield Geo, Sumburgh Head (59°51'N, 1°16'W) at the southern tip of mainland Shetland, Scotland, where c. 2,000 individual Guillemots are present during the breeding season (M. Heubeck pers. comm.) (Figure 1a). This large sea stack was chosen as it is thought to be representative of whole colony attendance and provided accessible location to install and update the camera equipment. A Canon 550D with 18-megapixel photo quality and a 70–300 mm lens was fitted with a Godox timing system and installed in a waterproof case; technical details of the system can be found in Sinclair (2017). The camera was focused on the colony 160 m away (Figure 1b) and took pictures every 30 minutes, regardless of the light conditions, from 30 January to 21 April 2015 except for 14–17 March when battery failure occurred. The first Guillemot egg anywhere at Sumburgh in 2015 was seen on 5 May (M. Heubeck pers. comm.).

A plot outline encompassing a group of c. 200 Guillemots was overlain on each photo and the enclosed area was divided into four approximately equal quarters (Figure 2). The plot outline was chosen to follow the natural contours of the sea stack to allow accurate and easy application to new batch photos of which focal lens length and precise orientation may change between camera equipment updates. Each count was categorized as day or night according to the sunrise and sunset timings recorded on Nautical Twilight (data derived from www.timeanddate.com). In photographs taken in daylight hours individual Guillemots were counted using the novel method of Adobe Photoshop Count Tool (Version CC 15.0), in which the counter manually added a marker to each individual Guillemot (Sinclair 2017). Initially, on photographs taken in full daylight birds were counted in each of the four quarters but, because there was a highly significant correlation between the four counts (pairwise correlation between counts in the four quarters: $r > 0.9$, $p < 0.001$, $n = 82$ including only images when Guillemots were present at the colony), later counts were restricted to the top-right quarter as this quarter had the highest correlation coefficient with the total count ($r = 0.942$, $P < 0.001$, $n = 82$). Measuring a subset of each image reduced the time needed to count each picture from 7 minutes to 3 minutes. The maximum day count was taken as a measure of attendance during that date.

Dark photos (those photos not taken in full day light) were brightened to 100% in Adobe Photoshop (Figure 3), to increase the proportion of photographs where the number of Guillemots could at least be estimated. Even after lightening, Night photographs were of lower quality so that birds could not be counted as accurately as in day photographs. Therefore, each Night photograph was categorized as no birds visible, very low attendance (at least 1 bird unambiguously present), low attendance (at least 5 birds confidently counted) or high attendance (at least 50 birds confidently counted). These estimates of the minimum number of birds from dark night photos was used for the calculations but are likely an underestimate.

We recorded the number of days no Guillemots were present at the colony between two periods of attendance and correlated (non-parametric Spearman rank correlation) with the start date of the period of absence (date where 1 January = 1) in order to investigate seasonal changes in the duration of periods of absence.

Results

Of the 3,435 photographs, 3,232 (94.1%) photos allowed confirmation of whether birds were present or not, and either produced accurate count data (2,552, 74.3%) or allowed systematic estimation of number present (680, 19.8%). From February to April, Guillemots attended the colony for 38 (48.7%) of the 78 days in which the camera functioned (Table 1, Figure 4, Appendix). Guillemots were present at night during all periods when birds attended the colony on more than one day but numbers were lower at night as indicated by the minimum estimates derived from lower quality night photographs. It was not possible to determine whether individual birds came and went from the colony during the night.

Clear cycles of attendance at the colony were apparent, these are defined as at least one day when Guillemots were present at the colony followed by two or more days when they were absent from the colony. During the observation period there was a total of 11 cycles each with a peak count of 90–120 birds (except cycle 8) (Figure 4). Nine cycles followed the same trend in attendance (excluding cycle 5 which was subject to a data gap after day 1 and cycle 8, where relatively few birds were present on only one day. The average pattern of these cycles is shown in Figures 5 and details of each cycle in Figure 6. In each cycle, Guillemots were present during the day for between 3 to 5 days (mean ± SD = 3.78 ± 0.67, n = 9). On the first day Guillemots were present after an absence, the birds typically arrived early in the day (mean ± SD = 57.6 ± 28.1, n = 11) but many departed again after a few hours. Excluding cycle 8, Guillemots returned the next day in higher numbers (mean ± SD = 95.0 ± 11.3, n = 10) after which birds were present continuously for 2 to 4 days (mean ± SD = 3.33 ± 0.87, n = 9) (excluding cycle 5 due to data gap after day 2).

On the final day of attendance fewer birds (mean ± SD = 68.2 ± 27.8, n = 9) were present and all left before dark and then no birds were seen for two or more days. Absences became shorter as the breeding season approached (r_s = -0.82, p = 0.004). When birds remained overnight, numbers increased around first light, which was clear to the observer when accounting for both counting method and quality between day and night photographs (day: mean ± SD = 100.1 ± 10.4, n = 9; night: 70.4% with at least 50 birds present) (Figure 5).

Discussion

Guillemots regularly attended this colony from at least early February until the first egg was laid in early May. Attendance was cyclic with peaks in numbers occurring on average every 7 days. Such cycling has been reported elsewhere, although the periodicity varies greatly (Harris & Wanless 1984; Mudge *et al.* 1987). High quality night shots when the moon was near full and much of the sky was clear showed that large numbers of Guillemots were present ashore at Sumburgh throughout the night. Although the photographs from non-moonlit nights were of too low in quality to count accurately, they confirmed that Guillemots regularly attended this colony overnight but in lesser numbers than during the day. This appears to be the first documented evidence of overnight attendance at a colony site during the non-breeding season by Guillemots. The finding that birds are present overnight is in contrast to other accounts of Guillemot behaviour, which found that Guillemots typically vacate the colony at night (Harris 1984; Harris & Wanless 1989, 1990). Indeed, visits to colonies on the Isle of May prior to dawn over 50 mornings in October, March and April in the 1980s confirmed that birds had not been present overnight (Harris, unpublished data). It is not clear whether overnight attendance at Sumburgh was specific to this colony in this year, had been overlooked in earlier studies or the colony attendance behaviour of Guillemots has changed since the 1980s.

Since the birds we followed were not individually identifiable we could not determine whether the birds present were breeders or non-breeders or how long an individual spent at the colony during any day or cycle of attendance. However, studies of marked birds on the Isle of May in autumn and early winter have shown that the majority of Guillemots at the colony outside the breeding season are mature adults returning to their breeding sites (Harris & Wanless 1989, 1990). These authors concluded that colony visiting could be explained by (a) competition for the best sites to use the following season, or (b) birds returning to maintain pair bonds and found no evidence that immatures visited the colony during the winter.

Estimates of numbers of Guillemots attending overnight were predominantly categorized as 'minimum count 50' (70.4% of Nights in all recorded cycles). In contrast the mean daytime count was 100.1 ± 10.4 which was higher than most of the estimates during the night, and hence it is likely that fewer birds attended the colony site at night than at day. Day counts increased around first light as had been recorded by earlier studies (Harris 1984; Mudge *et al.* 1987), which raises the question as to what makes some individuals remain overnight while others may leave. Results from the deployment of archival tags in Newfoundland have shown Guillemots, usually considered to be a visual predator, forage at night during both moonlit and starlit periods (Regular *et al.* 2011). These authors found that some individuals dived only when there was moonlight whereas others dived regardless of the state of the moon so perhaps Guillemots present overnight at Sumburgh were those that cannot, or do not need to, forage nocturnally; for instance breeding Brünnich's Guillemot males tend to forage more at night than females (Elliot *et al*. 2010; Young *et al*. 2015). Why Guillemots show these regular patterns of presence and absence at the colony site and why the numbers differ between day and night remain unclear but factors other than stochastic environmental factors are required to explain the observed regular pattern of attendance at the colony.

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FIGURES

Figure 1a. Map of North of Scotland showing position of Sumburgh Head on most Southern tip of Shetland. Created using Google Earth and Paint X Lite.

Figure 1b. Sumburgh Head showing the relative positions of the stack at Smithfield Geo and the position of the camera c.160 m away near the visitor centre at the lighthouse. Created using Google Earth and Paint X Lite.

Figure 2. A plot outline encompassing a group of c.200 Guillemots *Uria aalge* was overlain on each photo and the enclosed area was divided into four approximately equal quarters. Ultimately, counts presented were obtained from the upper right quarter only.

Figure 3a. Non-manipulated night photograph of the counting plot at Sumburgh Head during clear moonlit night taken at 00:50 GMT, 4 March 2015. Common Guillemots *Uria aalge* are clearly visible before manipulation.

Figure 3b. Manipulated photograph of the counting plot at Sumburgh Head during non-moonlit night taken at 00:50 GMT, 11 April 2015. Photograph is brightened to 100% using Photoshop CC. Common Guillemots (*Uria aalge*) are clearly visible.

Figure 4. Pre-laying attendance of Common Guillemots *Uria aalge* at Sumburgh Head from 30 January (day 30) to 21 April (day 111) 2015. Points are daily maximum counts per day period (red line) and night period (blue line) Due to camera failure, data are lacking for days 73-76.

Figure 5. Mean number (mean ± SE) of Common Guillemots per two-hour period over ten cycles of attendance at counting plot at Sumburgh Head. Day values are mean maximum counts and night values are mean minimum estimates within each two-hour period. The

different colours shows the average onset of day (yellow) and night periods (blue) over study period.

Figure 6. Number of Common Guillemots *Uria aalge* per two-hour period (e.g. 00:00 – 02:00, 02:00 – 04:00 and so on) for each cycle of attendance at stack plot at Sumburgh. Day values are maximum counts within each two-hour period and NIGHT values are maximum estimates within each two-hour period. Cycles 1 to 10 of monitoring period in run up to laying. The different colours shows the average onset of day (lighter colour) and night periods (darker colour) over study period as determined by nautical twilight. Missing values due to camera failure or fog are omitted.

Cycle	Days in	Nights in	Days out	First night attendance
1	4	2	4	No attendance
2	3	1	6	No attendance
3	3	2	7	Low numbers
4	4	3	6	High numbers
5	2*	1*	?	No attendance
6	4	3	2	Low numbers
7	4	3	3	High numbers

8	1	0	2	No attendance
9	4	3	2	High numbers
10	3	1	2	No attendance
11	5	3	3+	No attendance

Table 1. Cycle characteristics of Common Guillemots *Uria aalge* over the study period. The cycles are shown in Figure 4 and detailed in the Appendix.

'No attendance': Colony deserted few hours after arrival, hence no overnight attendance.

'Low numbers': Attendance consistent over cycle but on first night numbers attending the colony drops to low numbers. Subsequent nights of cycle have high attendance.

'High numbers': Colony attended consistently from first day of attendance to last day of attendance in high numbers including overnight.

*Data gap during cycle.

APPENDIX

Day and night data for all dates monitored during pre-laying period when any birds were present.

Period: Day or night classified according to nautical dawn and dusk
Presence: Guillemots present within study plot at any time within daily period
Minimum attendance estimated from low quality night photographs (Low attendance = >5; High attendance = >50).

CYCLE	DATE	PERIOD	ATTENDANCE	DETAILS
1	03/02	DAY	67	Arrived early morning - left after 2hr
	04/02	DAY	102	Arrived during day
		NIGHT	>50	Present overnight
	05/02	DAY	104	Present
		NIGHT	>50	Present overnight
	06/02	DAY	94	Left during day
2	11/02	DAY	20	Arrived early morning - let after 1hr
	12/02	DAY	92	Arrived during day
		NIGHT	>50	Present overnight
	13/02	DAY	89	Left during day
3	20/02	DAY	60	Arrived during day
		NIGHT	>5	Present overnight
	21/02	DAY	88	Attendance
		NIGHT	>50	Present overnight
	22/02	DAY	86	Left during day
4	02/03	DAY	76	Arrived early morning
		NIGHT	>50	Present overnight
	03/03	DAY	105	Attendance
		NIGHT	>50	Present overnight
	04/03	DAY	112	Attendance
		NIGHT	>50	Present overnight
	05/03	DAY	48	Left early morning
5	12/03	DAY	52	Arrive early morning – leave after 1hr
	13/03	DAY	78	Arrived early morning
		NIGHT	NA	Present until 22.20hr (no data after)
6	18/03	DAY	20	Arrived during day
		NIGHT	>1	Present overnight in low numbers 2- 3 individuals
	19/03	DAY	80	Attendance
		NIGHT	>50	Present overnight
	20/03	DAY	91	Attendance

		NIGHT	>50	Present overnight
	21/03	DAY	15	Left at 10:19hr
7	24/03	DAY	66	Arrived during day
		NIGHT	>50	Present overnight
	25/03	DAY	100	Attendance
		NIGHT	>50	Present overnight
	26/03	DAY	93	Attendance
		NIGHT	>50	Present overnight
	27/03	DAY	53	Left during day
8	31/03	DAY	47	Arrived early morning, left couple hours later
9	03/04	DAY	111	Arrived during day
		NIGHT	>50	Present overnight
	04/04	DAY	115	Attendance
		NIGHT	>50	Present overnight
	05/04	DAY	102	Attendance
		NIGHT	>50	>50 present overnight
	06/04	DAY	50	Left at 07:48hr
10	09/04	DAY	22	Arrived early in morning and and left couple hours later
	10/04	DAY	97	Arrived during day
		NIGHT	>50	Present overnight
	11/04	DAY	85	Left during day - late afternoon
11	14/04	DAY	12	Arrived early in morning and and left couple hours later
	15/04	DAY	93	Arrived during day
		NIGHT	>50	Present overnight
	16/04	DAY	109	Attendance
		NIGHT	>50	Present overnight
	17/04	DAY	118	Attendance
		NIGHT	>50	Present overnight
	18/04	DAY	94	Left late evening

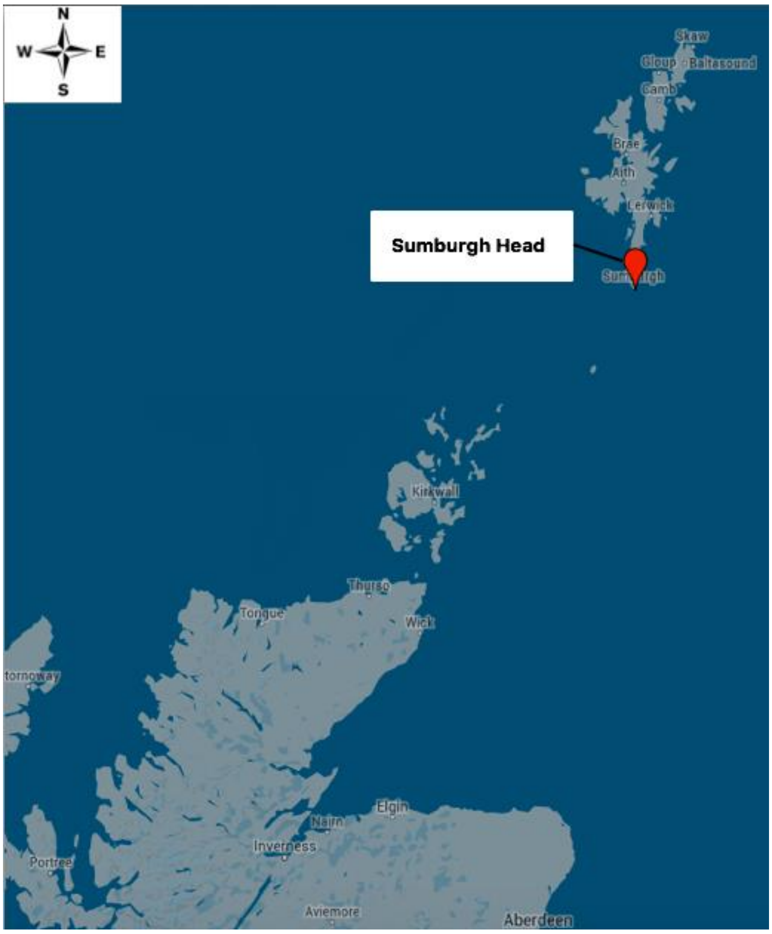


Figure 1a: Map of North of Scotland showing position of Sumburgh Head on most Southern tip of Shetland. Created using Google Earth and Paint X Lite

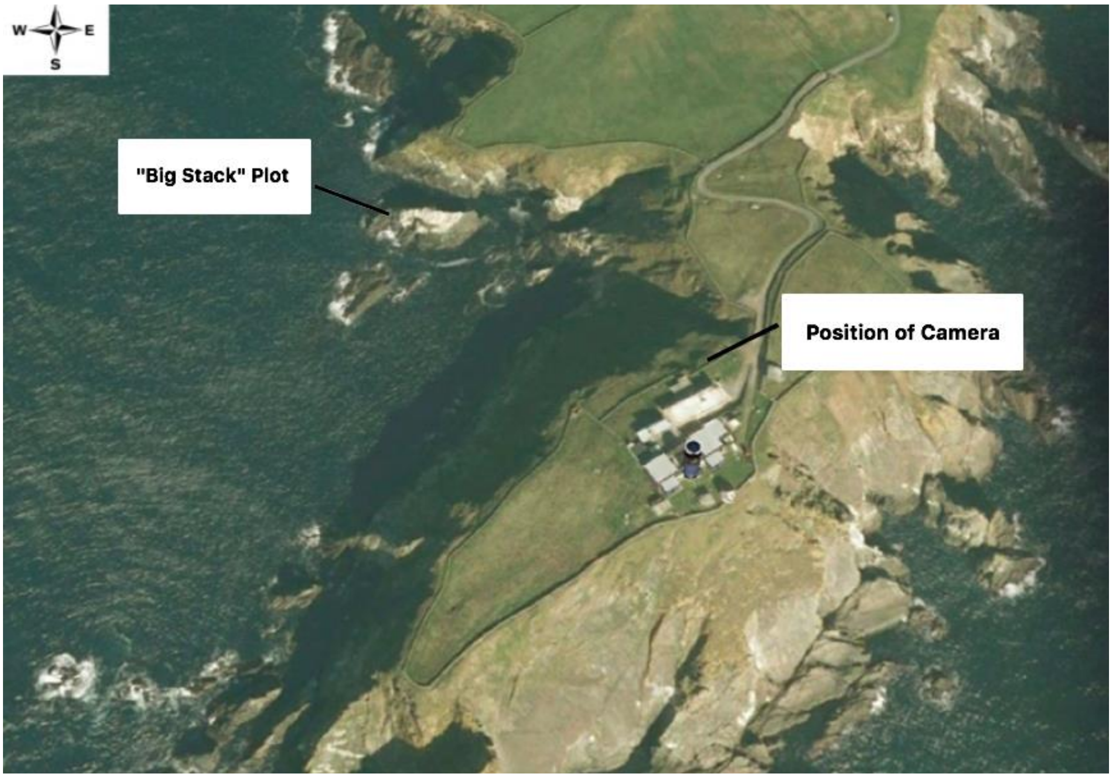
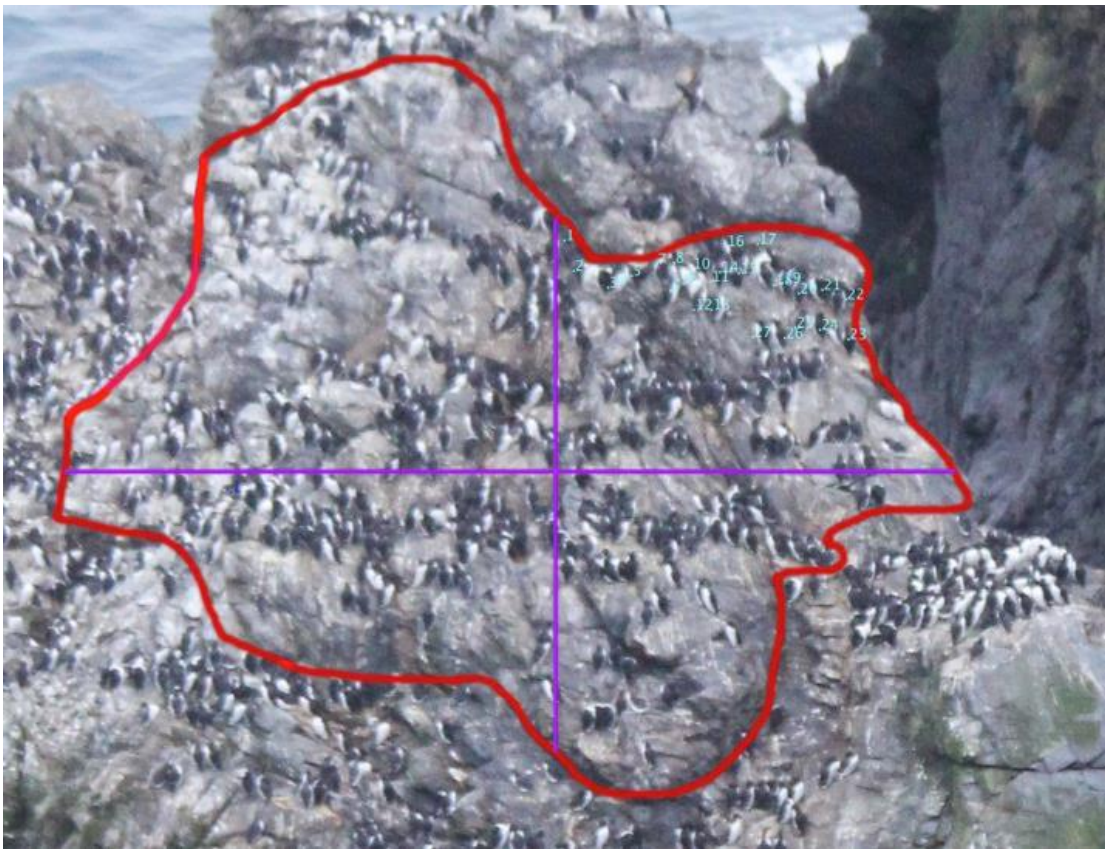


Figure 1b: Sumburgh Head showing the relative positions of the stack at Smithfield Geo and the position of the camera 160 m away near the visitor centre at the lighthouse. Created using Google Earth and Paint X Lite.



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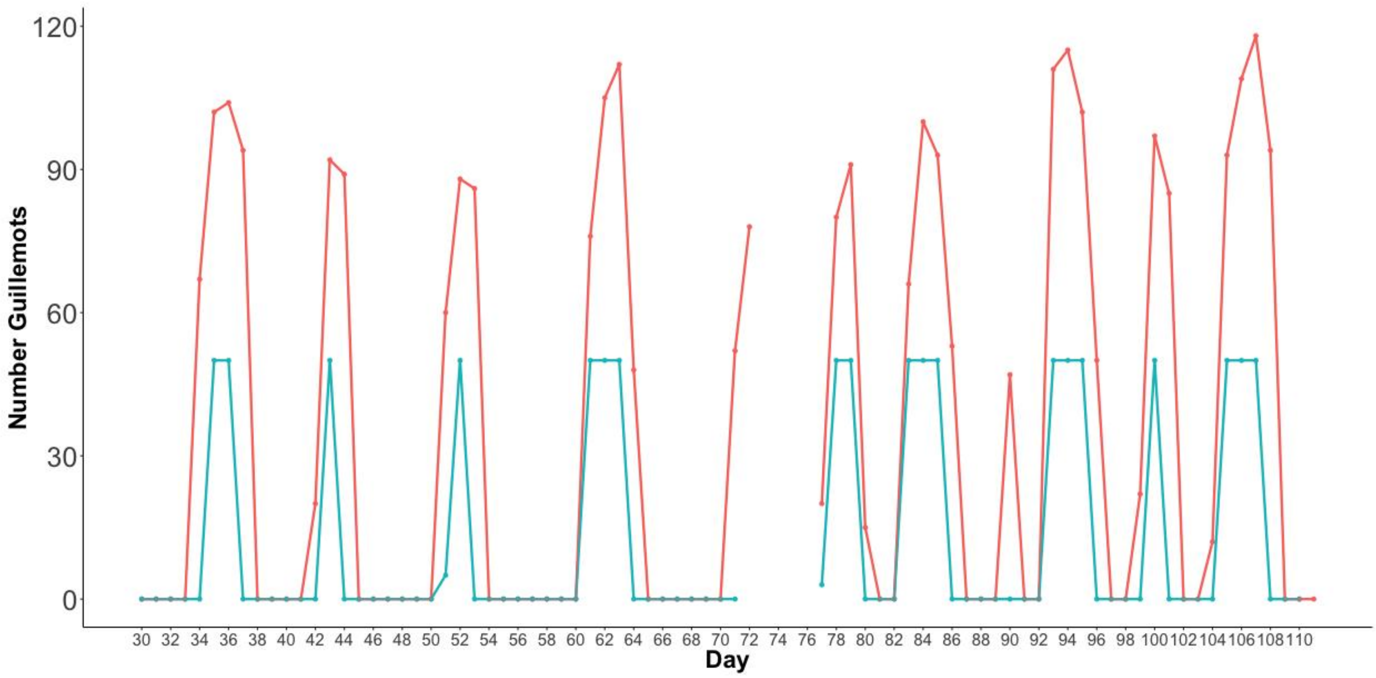

Figure 5. Mean number (mean ± SE) of Common guillemots per two-hour period over ten cycles of attendance at breeding colony at Sumburgh during the non-breeding period. Day values are mean maximum counts and night values are mean minimum estimates (as categorized in methods) within each two-hour period. Background colour shows average onset of day (yellow) and night (blue) periods over study period.

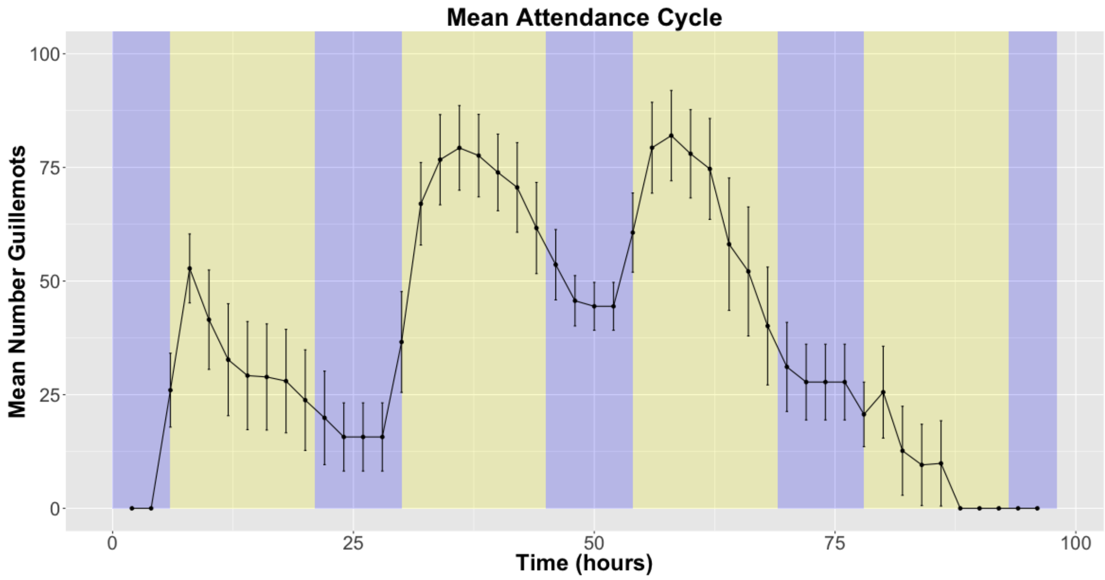

Figure 6. Number of Common Guillemots *Uria aalge* per two-hour period (e.g. 00:00 – 02:00, 02:00 – 04:00 and so on) for each cycle of attendance at colony at Sumburgh during non-breeding period. Day values are maximum counts within each two-hour period and night values are minimum estimates within each two-hour period as defined in method. Cycles 1 to 10 of monitoring period in the run up to breeding season. Background colour shows day (yellow) or night (blue) period as determined by nautical twilight. Missing values due to camera failure or fog are omitted.