Camera traps reveal predators of breeding Black Guillemots *Cepphus grylle*

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This paper is dedicated to the memory of our friend and colleague Colin Mckenzie.

Abstract

The occurrence of predation on Black Guillemots *Cepphus grylle*, of both adults and chicks, is an important consideration when assessing factors affecting breeding success. However, predators are often cryptic and confirmed interactions are difficult to identify. Through the use of camera traps, we recorded predation by mammalian and avian species on Black Guillemots on Stroma and North Ronaldsay in the 2016 and 2017 breeding seasons. Camera traps recorded two presumed instances of an Otter *Lutra lutra* predating chicks, one possible instance of an Otter predating an adult, one instance of a Hooded Crow *Corvus cornix* predating a chick, and the presence of several species of potential predators at nests. Camera traps were deployed concurrently during periods of visual observations, during which, sightings of predators were rare. We found the presence of camera traps to have no effect on breeding success between monitored (mean chicks fledged = 1.05, n = 52) and control (mean chicks fledged = 0.98, n = 98) nests. Here we highlight the potential role of camera traps in monitoring seabird nest success, and positively identifying sources of nest failure.

Introduction

Seabirds encounter many factors which influence adult survival and breeding success. These include, but are not limited to: predation (Craik 1997; Miles *et al*. 2015; Buchadas & Hof 2017); shifts in prey availability or abundance related to climate change (Gaston & Elliott 2014; Divoky *et al*. 2015) and fisheries practices (Furness & Tasker 2000; Frederiksen *et al*. 2004). Though fewer investigations exist, additional sources of pressure may arise from marine renewable energy devices (Grecian *et al*. 2010; Bailey *et al*. 2014), fisheries bycatch (Žydelis *et al*. 2009) and plastic pollution (O'Hanlon *et al*. 2017). Nest surveys are often carried out to assess the breeding success of a colony, a measurement that may in turn be linked to external drivers influencing a population (Gjerdrum *et al*. 2003). However, positively identifying the cause of breeding failure can be difficult, but would be beneficial in the management of these impacts. Similarly, nest surveys are often carried out to assess the impacts of research activities on target study species, including the attachment of telemetry devices such as geolocators or GPS tags (Phillips & Croxall 2003; Hamel *et al*. 2004; Symons & Diamond 2019). Understanding additional factors affecting breeding success can improve the monitoring of tag effects, as certain biases may be influencing tagged vs. control birds.

Black Guillemots have been shown to be vulnerable to several species of predator including: American Mink *Neovison vison* (Craik 1995; Nordström 2002), Hooded Crow *Corvus cornix* (Hario 2001; Foster 2011), Great Skua *Stercorarius skua* (Furness 1987), and Otter *Lutra lutra* (Ewins 1985). While auks make up only a small proportion of the overall diet for Mink and Otter (Clode & Macdonald 1995), predator-linked disturbance and mortality can have marked impacts on Black Guillemot nesting locations (Ewins & Tasker 1985), and success (Ewins 1985). Previously, intensive nest monitoring was required to positively identify predation of chicks (Ewins 1985; Nelson & Hamer 1995). Motion-sensor cameras (herein referred to as 'camera traps') provide an opportunity for constant monitoring of nests to observe behaviour, diet and interactions with other species. Infra-red lighting provided by camera traps overcomes the issue encountered with visual observations at night, allowing the discovery of previously unseen predation activity (Dilley *et al*. 2013).

Camera traps are becoming more commonly used in the study of seabird demography (Black 2018; Hinke *et al*. 2018; Jones *et al*. 2018), and diet (Gaglio *et al*. 2017). The use of camera traps is already recognised as a suitable method for the identification of predation on cryptic nesting waders (Macdonald & Bolton 2008; Teunissen *et al*. 2008; Calladine *et al*. 2017). Regarding seabirds, they have notably been used in the study of endemic and invasive predators on Procellariiformes in the Southern Hemisphere (Dilley *et al*. 2013, 2015; Davies *et al*. 2015). Boulder-beach nesting Black Guillemots are potentially feasible to observe using camera traps, as nests are generally enclosed and adults enter through a single crevice. Camera traps have recently been used in the study of Black Guillemot diet, predator presence, and chick fledging (Hof *et al*. 2018). Camera traps could prove a useful tool in current research on Black Guillemots aimed at assessing colony impacts related to the interaction with marine renewable energy devices, i.e. tidal stream turbines (Furness *et al*. 2012; Johnston *et al*. 2018). They may be used to improve monitoring of tag effects in relation to the recent increase in GPS tracking studies (Owen 2015). Camera traps may also identify potential disturbance, by humans or invasive predators, to breeding individuals within the landward boundaries of six Marine Protected Areas (MPAs) allocated to Black Guillemots across Scotland (Scottish Natural Heritage 2014).

In this study we report the predation of Black Guillemot chicks and adults recorded by camera traps at nests on Stroma, Caithness; and North Ronaldsay, Orkney. Camera trapping was performed concurrently with a project GPS tagging

Figure 1. Map of study sites (black/dashed) within Scotland. Including the islands of Stroma, Caithness, and North Ronaldsay, Orkney.

breeding adults. Nest checking was carried out for both camera-trapped, and control nests to monitor effects of camera trap presence on breeding success. Nest checks additionally identified the outcome of predator interactions seen in photos. We discuss how identification of these interactions improved the assessment of Black Guillemot nest failure.

Methods

Fieldwork took place on Stroma, Caithness (58°40′48″N 3°07′12″W) and North Ronaldsay, Orkney (59°22′6″N 2°25′29″W) (Figure 1), concurrently with a GPS/GLS tagging project. Black Guillemot nests were monitored on Stroma from 14 June to 28 July 2016 and 22 June to 2 August 2017, and on North Ronaldsay from 6 June to 21 July 2016 and 10 June to 26 July 2017. These periods incorporated both incubation and chick rearing breeding stages. Nests were often found under large boulder slabs, and were also present in cliff walls, abandoned Puffin *Fratercula arctica* burrows, pipe debris, and building rubble. Where nest contents could be ascertained, the nest was followed to determine success. Nests were visited every five days, however there were periods of absence (7–8 days) in monitoring when field work was being conducted on the alternate island.

Camera traps (Bushnell Aggressor No Glow, model 119776) were attached to wooden stands, supported by rocks, and placed 1–1.5 m from the nest entrance. Motion up to 10 m from the camera would trigger passive infrared sensors, recording movement in and out of the nest. A two second interval was set between each triggering of the camera. This interval was intended to reduce the demand on data storage and improve battery life. Of the 20 cameras, 10 were placed on North Ronaldsay and 10 on Stroma during each field season. In some instances, for example following nest failure, the cameras were redeployed on a second nest. Each photograph was analysed, through visual inspection, for the presence of Black Guillemots or any other species. The type of interaction with other species was recorded. The number of separate visits by a predator to a nest was calculated by grouping and counting series of photographs of continual predator presence.

Black Guillemot
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Separate visits, and the series of photographs taken of a visit, were distinguished by the appearance of a predator separated by >10 minutes. This interval period was selected pragmatically, as the likelihood of the same individual being observed may decline beyond this period (>10 minutes).

Additional visual observations were carried out from a viewpoint overlooking nest sites. Observers maintained a low profile to reduce disturbance, positioned 50±10 m from nests. Surveys were conducted three times a day, for two-hour periods each, alternating the area under observation between surveys. Additionally, the time of day a location was visited was rotated between days. This was carried out to mitigate any potential disturbance by reducing the continuous time one nesting group was subject to human presence.

Results

From the 20 cameras deployed on Stroma and North Ronaldsay during the 2016 and 2017 field seasons, 178,883 photographs of animal movement were captured. Photographs were taken of 52 nests, over a combined total of 180 days. A total of 117 periods of visual observation were carried out comprising 215 hours of observations. Otters were identified in 36 photographs, comprising 12 separate visits. Missing chicks were presumed to be predated in two of these visits, and an adult in one visit on Stroma in 2016. The instances of presumed chick predation occurred on 16 July 2016, at 16:44 on a single chick nest (Figure 2), and 19 July 2017 at 00:20, on a double chick nest with one chick being taken (Figure 3). In each case, photographs showed an Otter very close to the nest site, and the chick was subsequently found to be missing. The presumed predation on the adult occurred at 22:55, 1 July 2016 (Figure 4), the adult was associated with a nest containing a single egg, which was found untouched on subsequent nest checks. Hooded Crows were identified in 557 photographs, comprising 208 visits, with one instance of a chick being predated on North Ronaldsay on 6 July 2017, at 16:04, from a single chick nest (Figure 5). Other potential predators noted on the cameras, though no direct interaction was recorded, included feral Cats *Felis catus* (one sighting), House Mice *Mus musculus* (77 sightings), Great Black-backed Gulls *Larus marinus* (56 sightings), and Great Skuas (four sightings) (Figure 6). Feral Cats were exclusively seen on North Ronaldsay; currently there are no feral Cats present on Stroma.

No predation events were witnessed through the visual observations, including no observations of Hooded Crows within nest groups. An Otter was seen on 26 June 2016; the individual was attempting to predate adults outside of the nest, though no successful predation was observed.

The mean number of chicks fledged per nest on North Ronaldsay was 1.18 (n = 49) in 2016 and 0.98 (n = 49) in 2017 (Table 1). On Stroma the mean number of chicks fledged per nest was 0.88 (n = 33) in 2016, however, in 2017 several nests experienced flooding from storm swell on 24 June, causing the failure of eight nests containing eggs, reducing the breeding success to 0.63, n = 27 (Table 1).

Table 1. Table of nest monitoring, including incidences of failure identified through camera traps.

Island	Year	Nests	Eggs	Hatched	Hatched /per egg	Chicks fledged	Fledged /per hatched	Fledged /per nest	Camera monitored nests	Nest failures identified by camera traps
North	2016	49	87	74	0.85	58	0.78	1.18	12	
Ronaldsay	2017	49	88	62	0.70	48	0.77	0.98	12	1x Hooded Crow
Stroma	2016	33	60	37	0.62	29	0.78	0.88	14	2x Otter
	2017	27	48	27	0.56	17	0.63	0.63	16	1x chick fell from nest, 1x flooding

We found the presence of camera traps to have no effect (two sample t: $t = 0.49$, $P = 0.62$) on breeding success between monitored (mean chicks fledged = 1.05, $n = 52$) and control nests (mean chicks fledged = 0.98, $n = 98$).

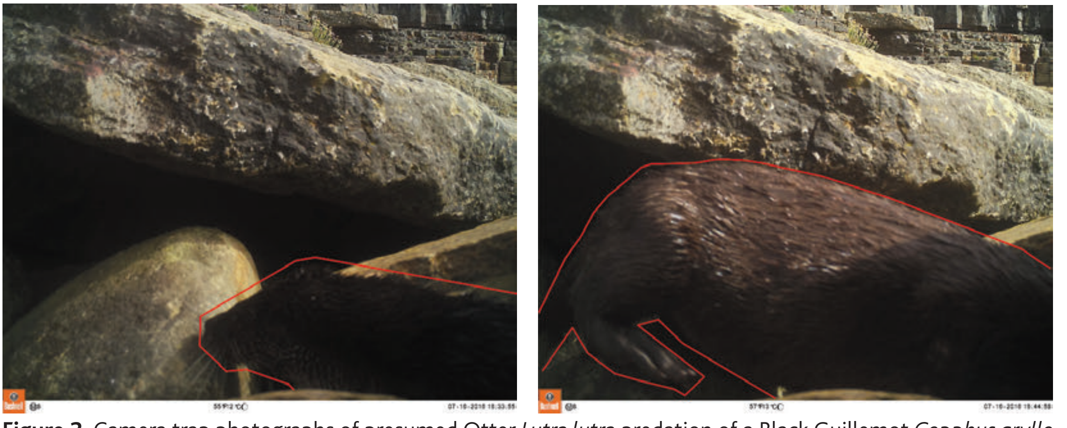


Figure 2. Camera trap photographs of presumed Otter *Lutra lutra* predation of a Black Guillemot *Cepphus grylle* chick, 16 July 2016, on Stroma. The red outline encompasses the Otter.

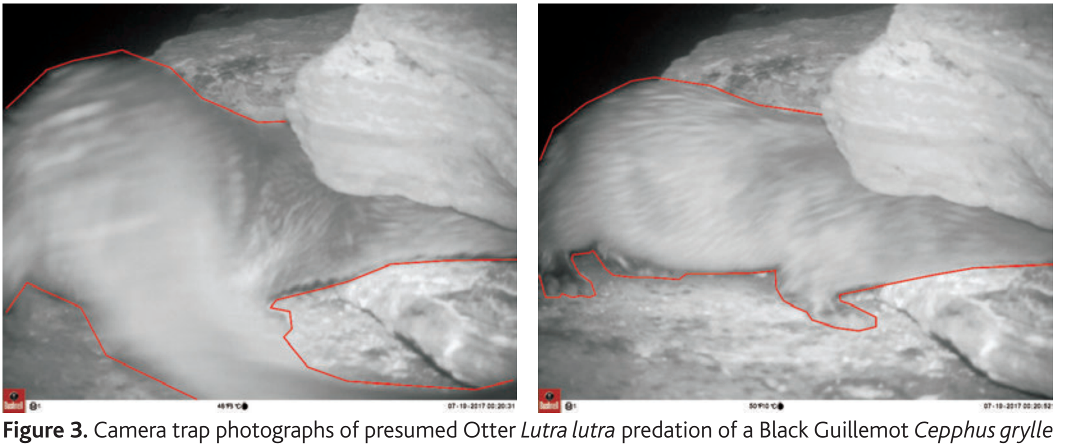


Figure 3. Camera trap photographs of presumed Otter *Lutra lutra* predation of a Black Guillemot *Cepphus grylle* chick, 19 July 2017, on Stroma. The red outline encompasses the Otter.

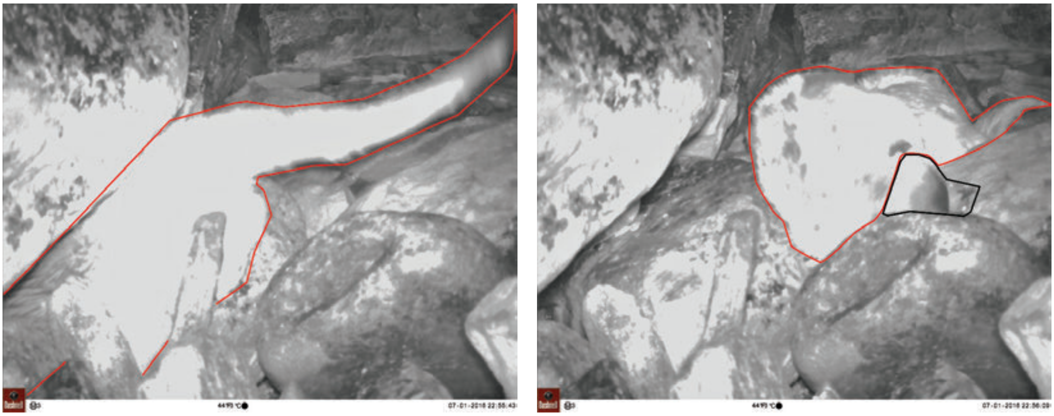


Figure 4. Camera trap photographs of Otter *Lutra lutra* predation of an adult Black Guillemot *Cepphus grylle*, 1 July 2016, on Stroma. The red outline encompasses the Otter, and black outline encompasses the adult Black Guillemot. Picture a) displays the Otter potentially raiding the nest crevice, b) displays the Otter with the adult Black Guillemot, with the eyes and beak visible.

Figure 5. Camera trap photographs of Hooded Crow *Corvus cornix* predation of a Black Guillemot *Cepphus grylle* chick, 6 July 2017, on North Ronaldsay.

Discussion

The identification of nest failure due to predation is an important consideration when carrying out nest success surveys or post-tagging monitoring to investigate tag effects. Accounting for predation is important when monitoring Black Guillemot nests, as we found evidence of Otter predation and directly witnessed Hooded Crow predation, and the presence of other potential mammalian and avian predators.

Regarding nest success surveys to monitor tag effects, the presence of a predator should affect control or tagged nests equally. However, tagged nest locations may be biased towards those more accessible for capture by both researchers and predators. This potentially occurred at a nest associated with a GPS tagged adult caught on the nest, where a chick was later missing following a visit by an Otter. In this instance, camera traps identified chick provisioning to resume post-tagging. They also identified the presumed predation event,

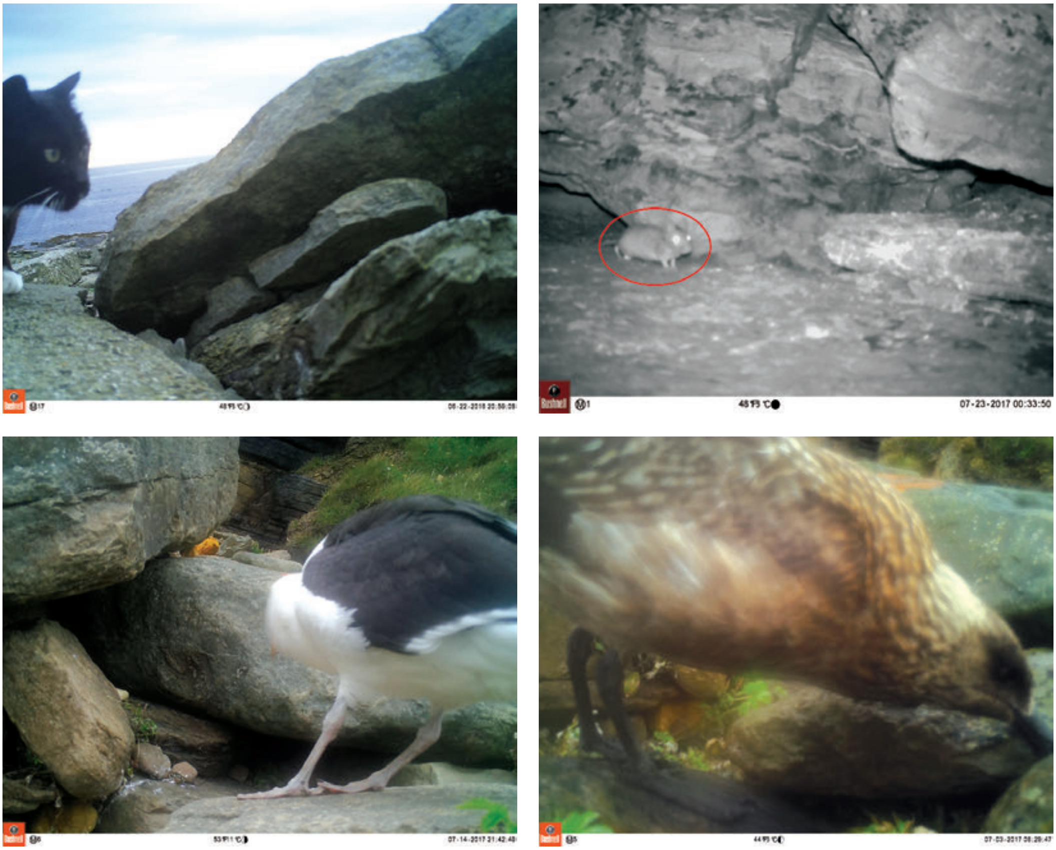


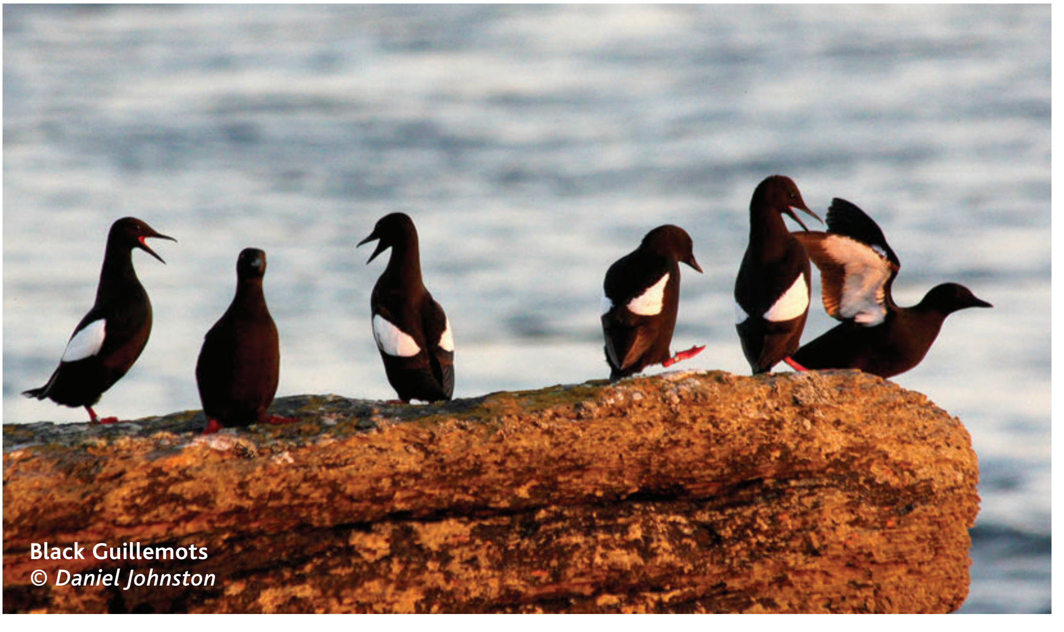
Figure 6. Sightings of potential mammalian and avian predators including: (a) a feral Cat *Felis catus* on North Ronaldsay; and on Stroma, (b) a House Mouse *Mus musculus*, (c) a Great Black-backed Gull *Larus marinus*, and (d) a Great Skua *Stercorarius skua*. Red outline added as a visual aid.

allowing predation to be indicated as the main cause of nest failure. Further research is needed to discern if tagging may expose adults to predation through the tag restricting movement, or lead to nest failure by causing the adult to abandon a breeding attempt. In tagging studies, the use of camera traps could aid in identifying the true cause of nest failure, due to an adverse reaction to tagging or otherwise, and inform measurements of nest success. This is particularly important in studies with small sample sizes, where each nest holds significant weight within the study.

In addition to nest checks, evidence from further observations may be required to deduce occurrences of predation. Where image quality may be low, in the case of the potential predation of an adult Black Guillemot recorded on 1 July 2016 on Stroma (Figure 4), contributing factors may provide circumstantial evidence as to the fate of the nest. In this instance, the lack of mammals of similar body size and form to Otters on Stroma, such as feral Cats, helped indicate the species. Before the predation event, an un-ringed adult and metal-ringed adult were present at the nest, and following the event only the ringed adult was present. In the instance of the 1 July 2016 predation, the visibility of beak and eyes in Figure 4b, helped indicate predation of an adult. In addition to further observations, the presence of spraint may help indicate predator presence and abundance to a species level (Bonesi *et al*. 2004).

Hof *et al*. (2018) displayed the potential use of camera traps for capturing timing of fledging. Here we describe the use of camera traps in identifying actual and potential species of predator. Camera traps are potentially most effective when deployed, in addition to nest checks, to identify possible causes of nest failure. While deploying camera traps on a majority of nests throughout the colony may not be practical, coverage of a sample of individual nests in combination with nest checks may enable the inference of predator presence throughout the colony. This may have been the case in Hof *et al*. (2018), who observed the presence of avian predators but no direct predation. Nest failure may be attributed to these observed predators. Sufficient coverage to observe predator presence may be gained with few cameras placed at a vantage point overlooking an entire group of nests.

Camera traps alleviate the need for direct visual observations to observe predator species and timing of predation. Visual observations may not be suitable as the lack of predator interactions witnessed, compared to those seen through camera traps, suggest the presence of humans potentially influenced predators. In particular, we note the high presence of Hooded Crows in camera trap records but although Hooded Crows were present on both islands, they were not seen at Black Guillemot nests during human observation periods, suggesting that crows avoided areas where people were present.



Black Guillemots
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Within the UK, average Black Guillemot fledging success was reported to be 1.05 fledged per nest between 1986–2018 (JNCC 2020). In general, fledging success found within this study does not deviate to a large degree from the UK mean (Table 1). However, nest success recorded on Stroma in 2016 (chicks fledged per nest = 0.63, Table 1), was lower than the national average, largely due to eight nests failing due to flooding. This indicated that storm swell, causing the failure of low-lying nests, may have a significant influence on colony productivity. By contrast, the effect of Otters and avian predators was not catastrophic, and depth of nest may play a large part in preventing predation. However, smaller predator species such as Mink (Craik 1997; 2000), Brown Rats *Rattus norvegicus* (Ewins & Tasker 1985), and Stoat *Mustela erminea* (Auld *et al*. 2019) may be able to access most crevice nests. The presence of Brown Rats and Mink have previously been linked to the redistribution of Black Guillemot breeding sites to inaccessible cliffs or islands (Ewins & Tasker 1985; Nordström & Korpimäki 2004). While the impacts to productivity by predators may not significantly affect breeding abundance, mortality of adults may have a greater impact. The long-lived nature of seabirds, and low survival rate to reach maturity, means predation of adults potentially witnessed here, and in Ewins (1985), may impact breeding abundance at colonies.

Camera traps in addition to nest checks may facilitate improved monitoring of breeding success for studies related to conservation or the assessment of tag effects. For the six Black Guillemot MPAs in Scotland to achieve their conservation goals, camera traps may be an effective method to assess the presence of cryptic invasive predators such as feral Cats or Mink.

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