



Southern Giant Petrels *Macronectes giganteus* depredating breeding Atlantic Yellow-nosed Albatrosses *Thalassarche chlororhynchos* on Gough Island

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Abstract

Giant petrels *Macronectes* spp. are the largest avian predator-scavengers in the Southern Ocean and feed both by direct predation and by scavenging carrion. However, they are not considered to be predators of adult albatrosses. We report the first records of Southern Giant Petrels *M. giganteus* attacking and killing incubating Atlantic Yellow-nosed Albatrosses *Thalassarche chlororhynchos* on Gough Island. From 2017 to 2019, a total of 87 adult carcasses were found near nests within long-term monitoring areas. In 2019, 16 motion-activated cameras filmed 32 nests between September and January, during incubation up until chicks were no longer guarded by their parents. Camera footage revealed at least six different male Southern Giant Petrels independently attacking 11 incubating Atlantic Yellow-nosed Albatrosses, killing and feeding on 5 of those. We also recorded a Southern Giant Petrel attacking a brooding Atlantic Yellow-nosed Albatross and carrying its chick away. Of these camera-monitored nests breeding success was 18.75%, nest failure was due to parent mortality ($n=6$), chick mortality (3) and nest abandonment (17), with giant petrels being confirmed or strongly suspected in at least 14 of 26 cases (54%). We observed these attacks in two out of 11 study areas, but it is uncertain whether this behaviour occurs elsewhere on Gough Island, or whether it is a novel hunting method learnt by a few individuals. However, if this behaviour spreads across albatross colonies, the resulting increase in adult mortality could have a significant impact on this endangered Atlantic Yellow-nosed Albatross population.

Keywords Foraging behaviour · Predation · Breeding success · Camera trap · *Tristan da Cunha Archipelago* · *Novel foraging tactics*

Introduction

Giant petrels *Macronectes* spp. are the largest and most dominant among the sub-Antarctic guild of avian predator-scavengers (Hunter 1985). For both Northern *M. halli* and Southern *M. giganteus* Giant Petrels during their breeding season, penguin remains, seals and burrowing petrels make up the majority of their diet (Hunter 1983, 1985; Copello et al. 2008). Their foraging techniques are known to differ by sex with females predominantly foraging at sea, whereas males spend considerably more time scavenging at penguin

and seal colonies (Hunter 1987; Hunter and Brooke 1992; González-Solís et al. 2000; de Bruyn and Cooper 2005). Northern and Southern Giant Petrels have been recorded hunting Northern Rockhopper Penguins *Eudyptes moseleyi* off breeding islands in the South Atlantic by drowning them (Ryan et al. 2008) and attacking injured/weak individuals at landing sites (Antje Steinfurth Pers. Obs.).

Despite their ability to kill penguins, giant petrels are not known to be significant predators of albatrosses (Tickell 2000). There has been a single record of a Southern Giant Petrel attacking an immature Black-browed Albatross *Thalassarche melanophris* at sea (Cox 1978). Most documented or suspected attacks of giant petrels on albatrosses have been by Northern Giant Petrels attacking albatross chicks (Snares Island, New Zealand: Sagar and Warham 1998; Bird Island, South Georgia: Forster and Phillips 2009; Marion Island, South Africa: Dilley et al. 2013). Records have been captured in person or on

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camera (Dilley et al. 2013) or inferred by the presence of Northern Giant Petrels at albatross breeding colonies and either the disappearance of chicks following such presence, or by observing giant petrels feeding on freshly killed albatross chick carcasses (Sagar and Warham 1998; Forster and Phillips 2009).

Southern Giant Petrels have a circumpolar distribution with Gough Island in the South Atlantic Ocean being the northern limit of their breeding range. At this site Southern Giant Petrels have been observed depredating Tristan Albatross *Diomedea dabbenena* chicks that have been weakened by wounds inflicted by introduced house mice *Mus musculus* (Davies et al. 2015). However, to date giant petrels have not been recorded depredating adult albatrosses of any species. We report the first records of male Southern Giant Petrels killing and feeding on incubating Atlantic Yellow-nosed Albatrosses and discuss the ramifications of this behaviour should it spread across albatross colonies on Gough Island.

Material and methods

Gough Island ($40^{\circ}19'S$, $9^{\circ}56'W$, 65 km^2) is a sub-Antarctic island located in the South Atlantic Ocean that is home to large breeding populations of seabirds and seals, including ~250 pairs of Southern Giant Petrels and ~5000 pairs of Atlantic Yellow-nosed Albatrosses (Ryan 2007). The island is uninhabited except by staff at a research station (Fig. 1) on the south east coast of the island (ACAP 2009).

Atlantic-Yellow nosed albatrosses have been counted annually during incubation in 11 long-term monitoring sites on the south and south-east coasts of the island since 2008. During surveys any unusual observations were routinely recorded. Any albatross carcasses found were inspected and coordinates of location were captured using a handheld GPS. Since 2010, a colony of Southern Giant Petrels *Macronectes giganteus* (120–180 nests per year) has been studied annually ~6.5 km from the monitored albatross colonies (Fig. 1) (Cooper and Parker 2011), and parents and fledglings are individually marked with unique numbered metal and plastic rings.

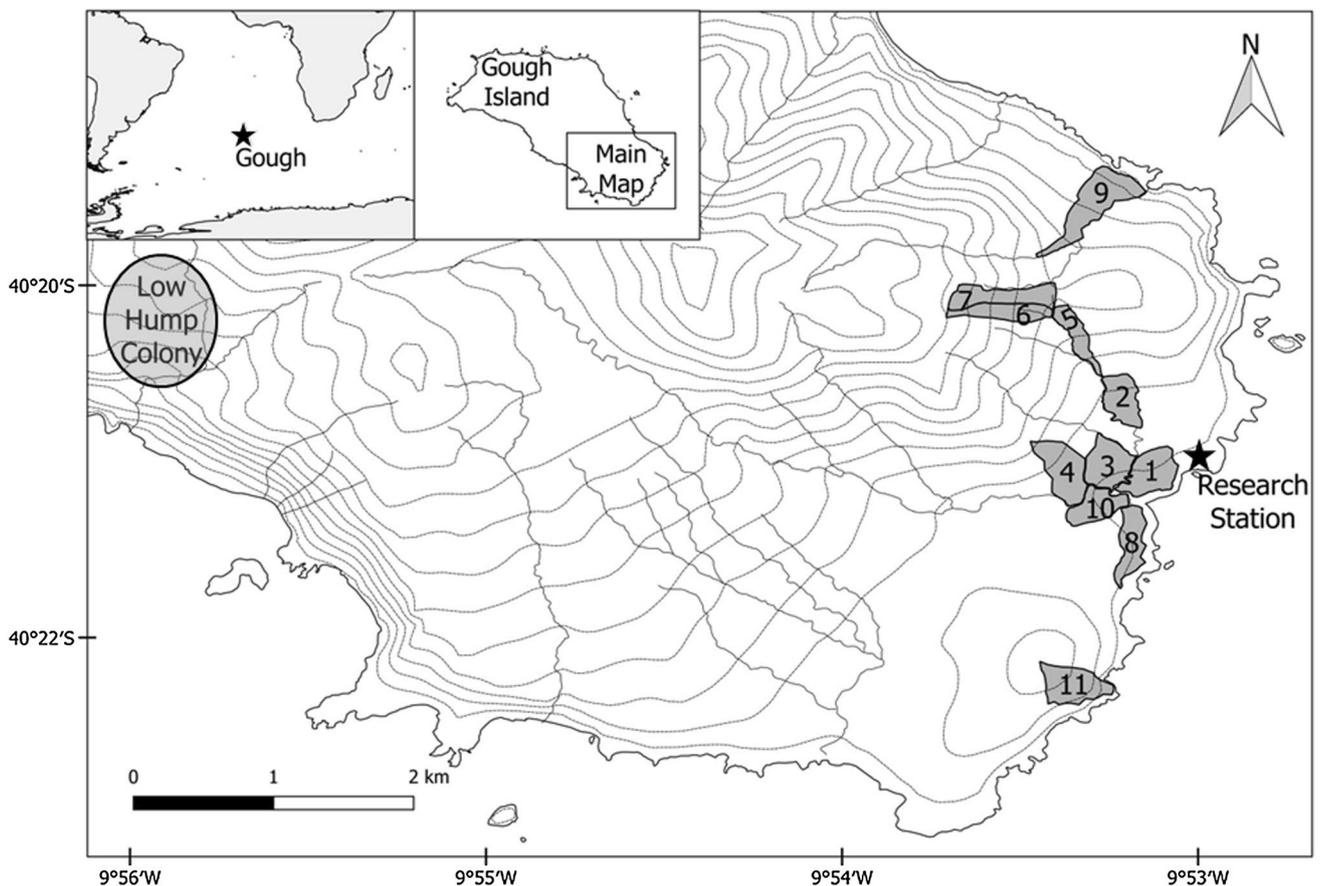


Fig. 1 Map showing the 11 long-term monitoring areas of Atlantic Yellow-nosed Albatross on Gough Island, the Southern Giant Petrel monitoring colony below Low Hump, and the location of the research station

Due to the unusually high number of adult carcasses found in one of the long-term monitoring sites (Area 11) in 2017 and 2018 ($n=45$), we deployed motion-activated cameras at nests in this area at the start of the breeding season in 2019. 16 motion-activated cameras (Reconyx model XP9, Bushnell models 119439, 119537, 119876 and Ezviz Mini O Plus) were mounted 0.5 m off the ground on PVC poles, placed 1–2 m away from nests and set to capture video footage and photos during day and night. The colony was visited weekly during incubation and early chick stages to replace batteries and SD cards, and as nests failed cameras were moved to different nests within the colony. Sex of Southern Giant Petrels captured on film was determined by the size of the bill (males have a larger bill, Cooper and Parker 2011), and when present and visible, the plastic ring number. We calculated breeding success as the proportion of monitored nests where chicks survived to fledging age.

To examine whether the observed mortality resulted in lower breeding population sizes, we compared the counts of incubating adults in Area 11 over time. We excluded data from before 2016, when natural borders such as streams or rock features were used to demarcate survey areas. These borders were replaced by GPS delineations in 2016 (Fig. 1).

Results

From October 2017 to February 2019, a total of 87 fresh adult Atlantic Yellow-nosed Albatross carcasses were found within a 2 km radius of the research station on Gough Island, with most carcasses (71) found in or near Area 11 (Fig. 1). On 21 October 2017, 19 adult Atlantic Yellow-nosed Albatross carcasses were found in Area 11, but the colony was not surveyed again that season. In 2018, 26 and eight adult carcasses were found in Area 11 and Area 8 respectively, during regular checks between incubation and hatch counts. In 2019, 26 carcasses were found in Area 11 during weekly visits in the time between the incubation and hatch count, three carcasses were found in Area 8 (one of which was still being consumed by a male Southern Giant Petrel) and four carcasses were found opportunistically outside of long-term monitoring areas. On several occasions male Southern Giant Petrels were seen loafing in Area 11 during the day.

Cameras were deployed at a total of 32 Atlantic Yellow-nosed Albatross nests for 1–97 days per nest, 974,826 images and 419.7 h of video footage were captured from 23 September 2019 to 03 February 2020. In six cases where carcasses were found close to nests, five of the attacks were captured on camera, and in the sixth case a carcass was close to the nest but the camera stopped filming before the nest failed (Table 1). Of the 26 failed nests 17 were abandoned (Table 1). Six of the abandoned nests were confirmed Southern Giant Petrel attacks on adults,

Table 1 Summary of the cause of failure for 26 out of 32 monitored Atlantic Yellow-nosed Albatross nests in survey Area 11 on Gough Island in 2019

	Nest abandoned	Adult mortality	Chick mortality
Suspect Southern Giant Petrel	2	0	0
Confirmed Southern Giant Petrel	6	5	1
Mice	1	0	1
Unknown	8	1	1
Total	17	6	3

where the attacked incubating albatross escaped but did not return to the nest and no carcass was found near the nest. In two of the abandoned nests, male Southern Giant Petrels made an unsuccessful attack on the incubating albatross the night before abandonment, despite the bird having initially resumed incubation after the attack. On 04 November 2019 an incubating bird was recorded being attacked by several mice (Online Resource 1), it had a 2 cm diameter wound on its rump which was observed when servicing the camera on 07 November 2019, and this adult abandoned the nest the following day (Table 1). For eight nests the reason for abandonment was unknown as the cameras stopped filming before capturing the failure of the nest. Male Southern Giant Petrels committed all recorded attacks on Atlantic Yellow-nosed Albatrosses, no females were captured on any of the camera footage.

Of the 32 nests that were monitored, six survived to large chick stage (breeding success 18.75%) and no giant petrel activity was detected at these nests. Once the nests reached chick stage, only three failures occurred, in one case a Southern Giant Petrel attacked the adult, pushed it off the nest and carried the small chick away in its bill (Online Resource 2). In another case a chick died from a mouse wound and in the last case the camera stopped filming before the nest failed.

Southern Giant Petrel attacks on adult albatrosses always occurred between dusk and dawn with the earliest attack in the evening 25 min before sunset, and the latest attack in the morning 30 min before sunrise. All adult albatrosses appeared to be aware of the presence of the Southern Giant Petrel before an attack occurred and appeared healthy and responsive. Southern Giant Petrels generally circled the nest and occasionally made a low growling sound. Adult albatrosses followed the giant petrel's movement on their nest, stood up and clapped their bills. In cases where the start of the attack was captured, the albatross lunged out and bit the Southern Giant Petrel first, and then the Southern Giant Petrel would bite the albatross on the neck and push it off the nest (Fig. 2, Online Resource 3). In all cases the albatross was dragged

Fig. 2 Male Southern Giant Petrel attacking an incubating Atlantic Yellow-nosed Albatross on Gough Island captured with a motion-sensor triggered camera in November 2019



out of view, so the method used to kill the albatross was not captured on film, but the carcasses were found near the nest.

Of the confirmed 14 nests where male Southern Giant Petrels attacked adult albatrosses, they were successful in killing five adults and one chick. Based on legible plastic rings, a minimum of six different male Southern Giant Petrels were identified as either attacking or consuming adult Atlantic Yellow-nosed Albatrosses. In attacks where the adult albatross escaped, the Southern Giant Petrel showed little interest in the exposed and unattended eggs and did not attempt to consume them. In nine cases where the eggs were left unattended and the camera was still active, the eggs were however depredated by mice, Tristan Skuas *Stercorarius antarcticus hamiltoni* or Gough Moorhens *Gallinula comeri*.

Census counts of the number of incubators in Area 11 since 2016 indicate a significant decline in the number of incubating Atlantic Yellow-nosed Albatross, particularly after 2017 when adult carcasses were first found, while 10 other long-term monitoring areas have remained stable (Fig. 3).

In addition to predation on adults, in April 2019 an Atlantic Yellow-nosed Albatross fledgling was opportunistically observed being attacked by giant petrels offshore near the research station at Gough Island. The incident occurred roughly 500 m offshore with up to 10 giant petrels crowded around the fledgling. After approximately 30 min of stalking and several missed attempts, one giant petrel managed to grab the back of the fledgling's head and drowned it. The carcass was then dismembered and consumed by several giant petrels over a further 10 min. Neither sex nor species of the giant petrels could be confirmed because the incident occurred too far offshore.

Discussion

We provide the first evidence that male Southern Giant Petrels can kill seemingly healthy adult albatrosses at their breeding grounds. Although the evidence prior to 2019 is circumstantial, it is likely that Southern Giant Petrels are partly responsible for the low breeding success of Atlantic Yellow-nosed Albatross recorded in recent years and thus might have a greater impact than introduced mice at certain sites on Gough Island (Jones et al. 2019). We further provide the first video footage of mice on Gough Island attacking adult albatrosses, resulting in nest abandonment, however this outcome was only recorded in one of the 22 monitored nests with known outcomes. During the study period a total of 87 adult Atlantic Yellow-nosed Albatross carcasses were found in the vicinity where the cameras recorded Southern Giant Petrel attacks, but this phenomenon appears to be very localised within our study areas. We also provide an observation of giant petrels depredating an Atlantic Yellow-nosed Albatross fledgling, suggesting giant petrels may have an impact on post fledging survival at Gough Island.

The majority of attacks on adult Atlantic Yellow-nosed Albatrosses on Gough Island occurred at night which supports findings by Le Bohec et al. (2003) who found that predation on King Penguin *Aptenodytes patagonicus* chicks by both Northern and Southern Giant Petrels was greater at night than during the day at the Crozet Islands in the South Indian Ocean. Attacking at night might help giant petrels evade an albatross's defences; although much of our filmed evidence indicates that Atlantic Yellow-nosed Albatrosses were aware of a giant petrel's presence and some were able to escape. Perhaps earlier detection

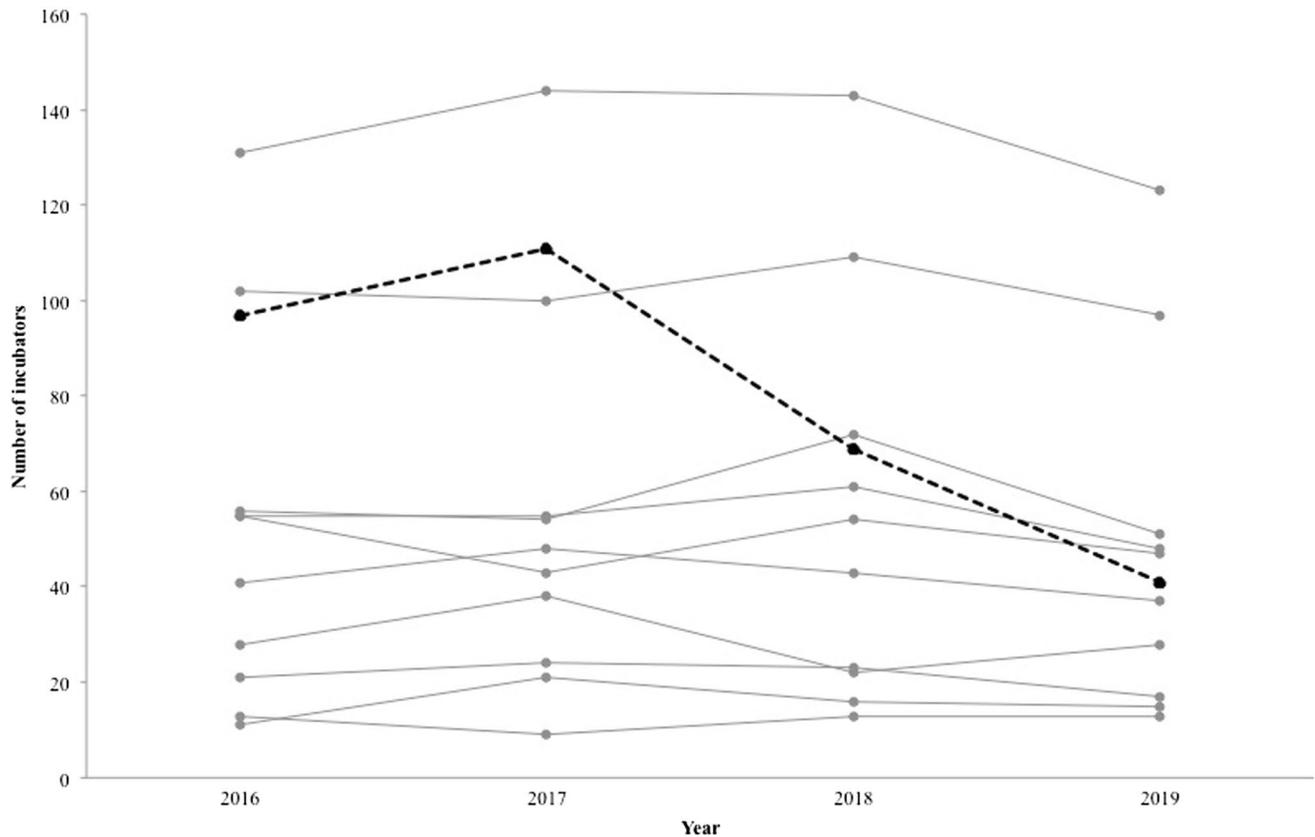


Fig. 3 The number of Atlantic Yellow-nosed Albatross nests surveyed at long-term monitoring sites (Areas 1–11) on Gough Island between 2016 and 2019, with Area 11 represented by a dashed line

of Southern Giant Petrels in daylight could have resulted in more birds escaping attack successfully. For the nests where the attack was recorded on video, the Atlantic Yellow-nosed Albatross made the first strike. The hunting technique of the Southern Giant Petrels appears to provoke this behaviour as they circle the nest many times, seemingly enticing the Atlantic Yellow-nosed Albatross to lunge at them; where the Southern Giant Petrels used that moment to grab the neck. The birds moved out of frame after the attacks, and we did not capture the exact moment the albatross was killed.

Our camera monitoring allows a crude extrapolation of the likely risk an albatross in our study area faces to be attacked by a Southern Giant Petrel. Because attacks occurred exclusively between dusk and dawn, we calculated that we monitored nests for a total of 10,529.88 night-time hours. During this period, 12 nests failed with photographic evidence of giant petrels approaching the nests, hence the average rate of a fatal attack is $12/10,529.88 = 0.0011$ per night-time hour. If we also include suspected giant petrel attacks ($n = 2$), the average rate would be 0.0013. Over the course of the incubation and brood guard period of approximately 87 days (857

night time hours), an Atlantic Yellow-nosed Albatross on Gough may therefore experience on average 0.98–1.14 attacks by a giant petrel in our study area. If the attack rate in our sample continues throughout the incubation and brood-guard period, it is possible that every Atlantic Yellow-nosed Albatross nest is attacked/harassed at least once.

Southern Giant Petrel chicks on Gough Island begin hatching in early October, attacks on adult albatrosses occurred from September to December. The fact that no giant petrels were detected around monitored nests during the post-guard phase of Atlantic Yellow-nosed Albatross (from January onwards), could be due to male Southern Giant Petrels spending more time foraging on beaches, as the majority of sub-Antarctic fur seal *Arctocephalus tropicalis* pups are born in December (Bester et al. 2006). Alternatively, Southern Giant Petrels may avoid albatross chicks to reduce the likelihood of having the chicks' defensive stomach oils regurgitated on them. Northern Giant Petrels on Marion Island in the South Indian Ocean however have learnt to get around the latter by rapidly circling Wandering Albatross chicks and largely avoiding any regurgitated stomach oil (Dilley et al. 2013).

Ryan et al. (2008) suggested that Northern Giant Petrels appear to be more inventive when it comes to attacking other birds than their southern counterpart. Dilley et al. (2013) found that at Marion Island, only male Northern Giant Petrels were confirmed to attack albatross chicks. Northern Giant Petrels do not breed on Gough Island, so perhaps Southern Giant Petrels are more likely to engage in novel foraging tactics in the absence of Northern Giant Petrels. Granroth-Wilding and Phillips (2019) highlighted that both giant petrel species are highly versatile in their feeding strategies and this has likely contributed to an increase in population numbers in South Georgia (Poncet et al. 2020). The Southern Giant Petrel population on Gough Island appears to be stable (RSPB unpublished data), ruling out the notion that a greater demand for food for the population is the driver for these attacks. Another possibility is that there may be a reduction in marine-based food availability for giant petrels at Gough Island. There is growing evidence to suggest climate induced regime shifts in foraging zones for marine top predators in the Southern Ocean (e.g. Rogers et al. 2019) which might motivate Southern Giant Petrels to explore new local land-based foraging opportunities at their breeding colonies.

Two factors suggest that Southern Giant Petrel predation on Atlantic Yellow-nosed Albatross is a relatively novel phenomenon at Gough Island. Firstly, of the 11 long-term monitoring areas, predation currently appears to be a localised phenomenon, confined to two adjacent areas; there is no evidence of adult carcasses next to nests in other long-term monitoring areas (Jones et al. 2019). Secondly, incubation counts in Area 11 only decreased markedly in 2018 and 2019 (Fig. 3). However, areas where Atlantic Yellow-nosed Albatrosses breed close to other Southern Giant Petrel breeding colonies (on the West and North coasts of Gough Island) have never been monitored, and it is therefore possible that Southern Giant Petrels might have been exhibiting this behaviour for much longer than observed in this study and hence have a more significant impact than our results suggest. One possible explanation is that some Southern Giant Petrels learned to opportunistically target adults after killing chicks weakened by mouse attacks (Davies et al. 2015). Alternatively, adult Atlantic Yellow-nosed Albatrosses may have become easier targets if they are weakened by increasing disturbance by invasive mice (Jones et al. 2019). Our cameras filmed mice climbing onto occupied nest mounds and onto some incubating adults at night, however the lower resolution on some of the camera models did not allow for mouse activity to be quantified at all nests.

The Gough Island Restoration Programme aims to eradicate house mice from Gough Island in the austral winter of 2021. If the eradication is successful and if house mice are rendering adult albatrosses more susceptible to giant petrel attacks, then we predict that the number of successful attacks

will decrease from the 2021 breeding season onwards. Close monitoring of Atlantic Yellow-nosed Albatrosses is necessary to assess whether the predatory behaviour of Southern Giant Petrels both increases in severity and/or spreads to other areas on Gough Island. The loss of breeding adults could have a much greater negative effect on this endangered species than chick predation by mice.

Supplementary Information The online version contains supplementary material available at <https://doi.org/10.1007/s00300-021-02810-x>.

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Author contributions MR, CJ and AO conceived and designed the research, and conducted the field work. MR viewed all footage, captured and analysed data. MR wrote the manuscript. All authors read and approved the manuscript.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interests.

Ethical approval Field procedures were approved by the Animal Ethics Committee of the Royal Society for the Protection of Birds.

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