

Short Communication

Recent changes in colony sizes of two seabird species in Scotland are not strongly influenced by Birds Directive status of the colony

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Special Protection Areas (SPAs) designated under the EU Birds Directive have improved the conservation status of many terrestrial bird species in Europe, but protecting breeding sites may be less effective for highly mobile birds such as seabirds. Colony census data for Great Skuas *Stercorarius skua* and Great Black-backed Gulls *Larus marinus* in Scotland show that breeding numbers have fared no better in sites where these species are SPA breeding features and, counter-intuitively, the evidence indicates better performance in non-SPA colonies, most likely because non-SPA colonies are generally smaller so are less subject to density-dependent competition. The main drivers of population change are widespread rather than colony-based in these two species with recent reductions in carrying capacity. Many other seabird species are vulnerable to similar widespread pressures so seabird conservation strategy needs to focus on mitigating these pressures, as designation of seabird breeding sites as SPAs is not enough to ensure effective seabird conservation.

Keywords: bird population trends, conservation policy, Great Black-backed Gull, Great Skua, special protection area.

It is widely recognized that the European Union (EU) Birds Directive can give strong protection to bird

populations (Prince *et al.* 2021). One strand of that protection is the establishment of Special Protection Areas (SPAs) conserving key sites for species that are listed in the Birds Directive Annex 1 and for migratory species of birds. Listing in Annex 1 can significantly contribute to population increase (Donald *et al.* 2007, Gamero *et al.* 2017), and population status (Sanderson *et al.* 2016). Listing in Annex 1 had a significant positive effect on reported population trends of these bird species in EU states, but no such effect was present in non-EU European countries (Koschova *et al.* 2018). These researchers therefore concluded that designations of SPAs for Annex 1 listed species had significantly improved the conservation status of those birds within the EU. However, not all bird species respond in the same way to site protection. Gamero *et al.* (2017) suggested that in agricultural habitats migrant species may gain less benefit from SPA designation than resident species, and this was confirmed by Sanderson *et al.* (2016). A greater decline in male Little Bustard *Tetrax tetrax* density within SPAs than in non-SPA areas suggested that when wider environmental conditions are unfavourable, declines can be more severe on sites with higher population densities (Silva *et al.* 2018). These authors concluded that designation of SPAs was not enough to conserve Little Bustards, but that landscape-scale measures were necessary. Similarly, Wauchope *et al.* (2022) concluded that management had more influence on waterbird population trajectory than site protection status.

Site protection for breeding birds may be more successful for birds that remain within small areas of clearly defined habitat but may possibly be less successful for birds that are wide ranging and require resources from outside SPAs as well as within their protected areas. One example of the latter is seabirds. During the breeding season, seabirds forage over very large areas outside the SPA sites designated for their breeding colonies. Most species also show seasonal migrations and exist independently of their breeding colony during the non-breeding season. To date, studies examining whether SPA designation of seabird breeding sites improves conservation status are lacking. Given the large financial cost associated with designating and protecting these sites, there is an urgent need to understand their efficiency for conservation.

Scotland holds some of the largest (breeding) populations of seabirds in Europe (Mitchell *et al.* 2004). Protected areas for breeding seabirds in Scotland include, for example, 30 SPAs designated for breeding Common Guillemots *Uria aalge* and 29 SPAs designated for breeding Black-legged Kittiwakes *Rissa tridactyla* (Stroud *et al.* 2016). Over 90% of Northern Gannets *Morus bassanus* breeding in Scotland do so on SPAs designated for that species. SPAs are also underpinned by national legislation to protect these sites as Sites of Special Scientific Interest (SSSIs). Most of the SPAs for breeding seabirds

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in Scotland were designated during the 1990s (Stroud *et al.* 2016) and this was the case for all sites considered in this analysis. National surveys of all seabird colony sizes were carried out in 1985–88 and again in 1998–2002 (Mitchell *et al.* 2004) and counts of breeding numbers in a third national survey in 2017–20 are available in the online Joint Nature Conservancy Committee (JNCC) Seabird Monitoring Programme database (JNCC 2021). These data allow an assessment of whether SPA designation of seabird breeding sites has resulted in significant relative improvement in conservation status of seabirds in SPAs since 2000 compared with colonies lacking protection as SPAs. However, not all seabirds provide suitable data for analysis of the efficacy of SPA designation. For example, in the case of Northern Gannet, very few birds nest on sites that are not SPAs. Census methods are less reliable for burrow- or cavity-nesting species of seabird such as storm petrels, shearwaters, Atlantic Puffins *Fratercula arctica*, or species that nest in high densities on cliffs such as Common Guillemots (Mitchell *et al.* 2004).

This study assesses whether SPA designation for two species of seabird has resulted in any relative gain in conservation status of designated populations between 2000 and 2018 compared with those in non-SPA colonies within the same area, and compares rates of change between 1985 and 2000. During this earlier period, sites were protected as SPAs for part of the period, so effects of site designation might be detectable then, but the data for 1985 to 2000 provide an opportunity to assess whether colony size influenced population trend. Two focal species of seabirds were chosen for this analysis, the Great Skua *Stercorarius skua* which has been increasing at most colonies in Scotland, and the ecologically similar Great Black-backed Gull *Larus marinus*, breeding numbers of which decreased by 50% in Scotland from 1986 to 2019 (JNCC 2021). Great Skuas and Great Black-backed Gulls were chosen because they breed in a relatively small number of colonies, where their breeding numbers are relatively easy to count following standardized protocols (Mitchell *et al.* 2004), so that census data are likely to be reliable.

In 2000, Scotland held 100% of the UK and 60% of the world breeding population of Great Skuas, and 85% of the UK and 8% of the world breeding population of Great Black-backed Gulls (Mitchell *et al.* 2004). Both species are designated features at several SPAs (nine SPAs for breeding Great Skua out of 24 colonies in Scotland, five SPAs for breeding Great Black-backed Gull out of 57 colonies in Scotland). The Birds Directive requires that the most important sites for each species are designated as SPAs, which generally means the largest seabird colonies. However, because sites that have been designated as SPAs were generally selected because they held the largest colonies of the species, it is important to consider whether changes in breeding numbers

reflect the consequences of density-dependent processes. For example, a reduction in food supply throughout the breeding range would be likely to reduce breeding success and adult survival and increase age of first breeding at larger colonies more than at smaller ones because there will be more intra-specific competition for food around larger colonies (Horswill *et al.* 2016). Such density-dependent effects on Great Skua have been noted (Furness 2015) but have not been clearly evident in Great Black-backed Gull (Nager & O'Hanlon 2016). Any density-dependent responses need to be separated from effects of SPA status on colony trajectory. The objective was to assess whether colonies with SPA status have a more favourable population trend than non-SPA colonies when accounting for effects of density.

METHODS

Data for breeding Great Skua and breeding Great Black-backed Gull 'Feature condition' classifications at SPAs were extracted from the SiteLink online database (NatureScot 2021). Feature condition is classified as 'Favourable' where numbers remain similar to numbers at designation or have increased, or 'Unfavourable' where numbers have fallen since site designation by more than about 30%. Data for Great Skua and Great Black-backed Gull colony sizes in Scotland were extracted from the Seabird Monitoring Programme online database (JNCC 2021) for the two national survey periods (1985–88 and 1998–2002), and for the period 2000 to June 2021 (data summarized in Table S1). In July 2021 several Great Skua colonies were affected by Highly Pathogenic Avian Influenza (Banyard *et al.* 2022). Great Black-backed Gulls are also known to be susceptible to Avian Influenza (Banyard *et al.* 2022). Therefore, no counts of either species from July 2021 onwards were included in order to ensure that the epidemic did not influence conclusions. For Great Skua colonies, 20 of 27 (74%) most recent counts were in 2017–19, with only two colonies not being counted since 2015. For Great Black-backed Gull colonies, 36 of 49 (73%) most recent counts were in 2017–19, with only four not being counted since 2015. The most recent colony-specific count was therefore taken as representative of colony size in 2017–19.

The recommended census metric for Great Skua is the 'Apparently Occupied Territory' (AOT) (Mitchell *et al.* 2004). Independent counts of Great Skua AOTs at Foula by different observers in the same season differed on average by less than 7% (Mitchell *et al.* 2004). Larger count errors may arise where counting conditions are difficult (conditions could be made difficult by bad weather but it is likely that counts were all made during good weather; however, some colonies have many high viewpoints from where numbers of AOTs can be counted by scanning without disturbing birds whereas

other sites lack such viewpoints so that it is difficult to count birds without causing some disturbance), but it is likely that counts of this species at colonies in Scotland are mostly within 10% of the true numbers. The recommended census metric for Great Black-backed Gull is either 'Apparently Occupied Nest' (AON) or, when actual nests cannot be discerned, the AOT (Mitchell *et al.* 2004). However, some colony counts are of pairs and in a few cases flush counts of adults in the air divided by 2 to give an approximation to the number of pairs (Mitchell *et al.* 2004). However, recorders considered that 80% of counts in Seabird 2000 were accurate, and all of these slightly different metrics provide similar numbers (Mitchell *et al.* 2004), so these units have usually been treated as equivalent in previous studies and that is the case here. Counts in more recent years are likely to be more reliable than older counts, as most counts now follow best practice guidance. The count data have therefore been taken as accurate for the purposes of this study.

A comparison between population trajectories in SPA and non-SPA populations was obtained as follows. From the extracted count data I calculated the change in breeding numbers at each colony between 1985–88 and 1998–2002. This was expressed as a percentage change in numbers and the distribution of percentages was compared using a Mann–Whitney *U* test between two groups: colonies where the species was designated as an SPA breeding feature in the 1990s, and colonies where the species was not an SPA breeding feature. Mann–Whitney *U* tests were two-tailed, with the level of statistical significance set at $P < 0.05$. The same calculation was carried out for 1998–2002 compared with the most recent count (representing the national census period focused on 2017–19).

To assess the influence of density-dependence for Great Skua I ranked the colonies by number of AOTs in Seabird 2000 and plotted the relationship between percentage change in numbers and rank of colony size. To assess the influence of density-dependence for Great Black-backed Gull the approach used for Great Skua needed slight modification because some Great Black-backed Gull colonies had declined in breeding numbers by between 80 and 100%, and many colonies were very small. Therefore, transformation of the data was required to provide an appropriate scatterplot. This was achieved by plotting the change in breeding numbers between Seabird 2000 and the most recent count (transformed to $\ln(100 + \text{per cent change})$) in relation to $\ln(1 + \text{colony size})$. A logarithmic regression was fitted to each scatterplot as that explained considerably more of the variance than did a linear regression. Positions of individual colonies where Great Skua or Great Black-backed Gull is a breeding feature of the SPA were then compared to the prediction from the logarithmic regression to assess whether SPA populations performed any

better or worse than non-SPA populations. Residuals from the regression were compared between SPA and non-SPA groups using a *t* test as these residuals were normally distributed.

RESULTS

Great skua

JNCC (2021) lists breeding numbers of Great Skuas at 24 distinct colonies in Scotland, with nine of these colonies being SPAs where the species is listed as a breeding feature. The most recent Site Condition Monitoring assessment by NatureScot classified Great Skua as in favourable conservation status at eight of the nine SPAs where it is a breeding feature (NatureScot 2021).

Changes in numbers at SPA and non-SPA sites 1985–2000

At the nine colonies designated as SPAs for breeding Great Skua in the 1990s, the change in numbers of pairs/AOTs between the two national censuses in 1985–88 and in 1998–2002 was an increase averaging 151% (median 70%; range –8 to +487%). At the 15 colonies that are not designated as SPAs for breeding Great Skuas, the change in numbers between 1985–88 and 1998–2002 was an increase averaging 212% (median 200%; range 0 to +700%). The increase was not significantly different at the sites that are SPAs for breeding Great Skuas and those that are not (Mann–Whitney $U = 48.5$, $P > 0.05$).

Changes in numbers at SPA and non-SPA sites 2000–18

The change in numbers of pairs/AOTs since 2000 at the nine SPAs for breeding Great Skua was an increase averaging 23% (median 10%; range –46 to +200%). At the 15 colonies that are not designated as SPAs for breeding Great Skuas, the change in numbers of pairs/AOTs since 2000 was an increase averaging 221% (median 240%; range –40 to +600%). The increase was significantly smaller at the sites that are SPAs for breeding Great Skuas than at colonies where Great Skua is not designated as an SPA breeding feature (Mann–Whitney $U = 26$, $P < 0.05$).

Changes in numbers 2000–18 in relation to colony size

Ranking by number of apparently occupied territories in each colony in 2000 and comparing the change in numbers between 2000 and the most recent count in relation to colony size ranking (Fig. 1) shows that change in

numbers was very strongly related to colony size ($r = 0.82$, 24 df, $P < 0.001$). In relation to the fitted line, three SPA colonies lie on or extremely close to the best-fit line (Foula, Noss, Handa), three lie below the line (Hoy, Ronas Hill, St Kilda) and three lie above the line (Hermaness, Fetlar, Fair Isle). There was no significant difference in residual from the fitted regression comparing SPA sites with non-SPA sites ($t = 0.28$, 24 df, $P = 0.788$).

Great Black-backed Gull

JNCC (2021) lists breeding numbers of Great Black-backed Gulls at 57 distinct colonies in Scotland, with five of these colonies being SPAs where the species is listed as a breeding feature. The most recent Site Condition Monitoring assessment by NatureScot classified Great Black-backed Gull as in unfavourable conservation status at all five SPA sites where this species is a breeding feature (NatureScot 2021).

Changes in numbers at SPA and non-SPA sites 1985–2000

At the five colonies designated as SPAs for breeding Great Black-backed Gull in the 1990s, the change in breeding numbers between the two national censuses, 1985–88 and 1998–2002, was a decrease averaging -3.5% (median -16% ; range -77 to $+92\%$). At the 46 colonies that are not designated as SPAs for breeding Great Black-backed Gulls where count data were available for this species in both national censuses, the change in breeding numbers between 1985–88 and 1998–2002 was an increase averaging 68% (median 0% ; range -100 to $+1050\%$). Despite the apparent large

difference in mean trajectory between SPA and non-SPA colonies, the change was not significantly different (Mann–Whitney $U = 97$, $P > 0.05$).

Changes in numbers at SPA and non-SPA sites 2000–18

The change in breeding numbers since 2000 at the five SPAs for breeding Great Black-backed Gulls was a decrease averaging -65% (median -91% ; range -95 to $+48\%$). At the 50 colonies that are not designated as SPAs for breeding Great Black-backed Gulls for which there were data, the change in breeding numbers since 2000 was a decrease averaging -6% (median -75% ; range -100 to $+1000\%$). The change was not significantly different between the sites that are SPAs for breeding Great Black-backed Gulls and those that are not (Mann–Whitney $U = 60.5$, $P > 0.05$).

Changes in numbers 2000–18 in relation to colony size

Comparing the change in breeding numbers between 2000 and the most recent count (transformed to Ln(100 + per cent change)) in relation to Ln(1 + colony size) (Fig. 2) shows that change in numbers was very strongly related to colony size ($r = 0.71$, 44 df, $P < 0.001$). In relation to the fitted line, three SPA populations lie on or very close to the best-fit line (Copinsay, Calf of Eday, Hoy), one lies below the line (North Rona & Sula Sgeir) and one lies above the line (East Caithness Cliffs). There was no significant difference in residual from the fitted regression comparing SPA sites with non-SPA sites ($t = 0.75$, 44 df, $P = 0.4599$).

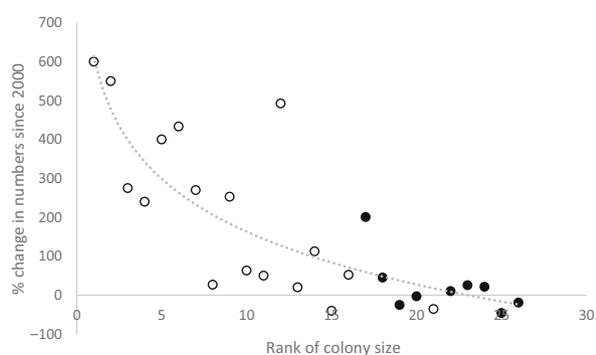


Figure 1. Change in breeding numbers of Great Skuas at colonies in Scotland since Seabird 2000 in relation to rank of colony size (from smallest rank 1 to largest rank 26). The dotted line shows the best-fit logarithmic regression ($r^2 = 0.68$, $P < 0.001$). Sites where Great Skua is an SPA breeding feature are shown as solid dots, and sites where Great Skua is not an SPA breeding feature are shown as open circles.

DISCUSSION

Mean changes in breeding numbers suggest a slightly greater increase in non-SPA Great Skua populations than in SPA populations between 1985–88 and Seabird 2000 (212% versus 151% but not statistically significant) and a considerably greater difference between 2000 and 2017–19 (221% versus 23% and $P < 0.05$). Lack of statistical significance in the first comparison could be attributed in part to high individual variation among colonies and the small number of SPAs where breeding Great Skua is a feature, and potentially to the fact that the SPA colonies were all designated part way through the period (in the 1990s). However, the significant difference during the period 2000 to 2017–19 could easily be misinterpreted as indicating worse performance of sites designated as SPAs for breeding Great Skua. Looking at the relationship between colony size and growth in numbers (Fig. 1), it is evident that colony size is an extremely strong influence on change in numbers.

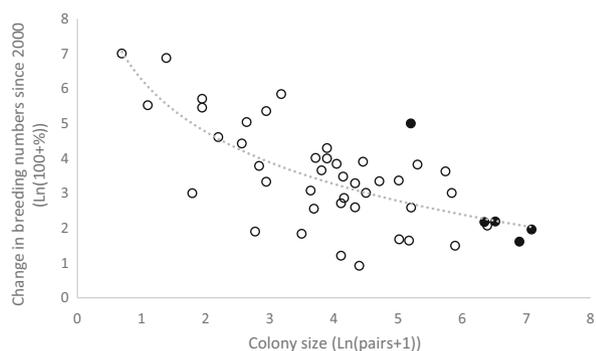


Figure 2. Change in breeding numbers of Great Black-backed Gulls (Ln-transformed) at colonies in Scotland since Seabird 2000 in relation to colony size (Ln-transformed). The dotted line shows the best-fit logarithmic regression ($r^2 = 0.51$, $P < 0.001$). Sites where Great Black-backed Gull is an SPA breeding feature are shown as solid dots, and sites where Great Black-backed Gull is not an SPA breeding feature are shown as open circles.

Colonies designated for Great Skua as a breeding feature are all among the largest Great Skua colonies in Scotland, and so any influence of SPA status is overwhelmed by the closely associated influence of colony size. As the nine SPA colonies fall close to the predicted logarithmic relationship between colony size and growth, with equal numbers above and below the prediction line, it seems that SPA status has had very little, if any, detectable influence on the change in breeding numbers of Great Skuas. The key conclusion from examination of these data is that wider environmental factors are driving change in Great Skua breeding numbers. The strong effect of colony size implies that increased competition for resources at larger colonies has much more influence than SPA status.

Data for Great Black-backed Gull led to the same conclusion. Breeding numbers have declined at most Great Black-backed Gull colonies in Scotland since 2000. Although the mean changes in numbers have tended to be more negative at sites where the species is an SPA breeding feature than at non-SPA colonies, the data show that colony size is the main factor influencing the trend rather than colony protection status. As for Great Skua, the strong effect of colony size implies increased competition at larger colonies having much more influence than SPA status. Indeed, for both species the data do not indicate any detectable influence of SPA protection status of individual colonies in mitigating adverse environmental pressures on these species. This consistent pattern for the two species is despite Great Skua being classified as broadly in favourable conservation status as a breeding feature of SPAs whereas Great Black-backed Gull is classified as in unfavourable conservation status at all its SPA colonies.

Mitchell *et al.* (2004) identified declines in sandeel stocks and in trawl fishery discards, and predatory and competitive interactions between Great Skuas and Great Black-backed Gulls as the probable main drivers of current change in both their breeding numbers in northern Scotland. Climate change is probably also having both direct and indirect impacts (Oswald *et al.* 2008). Church *et al.* (2019) showed that Great Skua diet has changed over recent decades as a reflection of changes in availability of sandeels and fishery discards. These changes in food availability imply a reduced carrying capacity of Scottish waters for Great Skua. The same most probably applies also for Great Black-backed Gull, as indicated by the decline in breeding numbers of that species, although less is known about its diet and ecology. For both these species it appears that designation as breeding features of SPAs has had negligible effect in mitigating adverse effects of environmental change across its wider foraging range. However, the more negative population trend in sites where these species are SPA breeding features probably reflects a density-dependent influence of colony size rather than any perverse influence of conservation status.

This is the first study to demonstrate that designating breeding site SPAs for seabirds is not enough to improve their conservation status. This study reaches the same conclusion as Silva *et al.* (2018), that populations of birds that are mobile need policies to protect foraging habitat at a wider spatial scale. It is not enough to designate SPAs for breeding seabirds without addressing wider scale pressures and threats that occur throughout their range. The Scottish Government has expressed a desire to develop a Scottish Seabird Conservation Strategy (Scottish Government 2019). However, 3 years on from that announcement, details of that strategy have yet to be published. The UK Government has also announced development of a Seabird Conservation Strategy. The UK Environment Minister announced on 16 January 2020 'This year we will be publishing a comprehensive Seabird Conservation Strategy' (UK Government 2020). However, no such publication was produced in 2020 or in 2021. A seabird conservation strategy must address challenges presented by climate change, fisheries and other pressures at a seascape scale, and not assume that designating breeding sites will be sufficient to protect our internationally important seabird populations.

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AUTHOR CONTRIBUTION

Robert W. Furness: Conceptualization (equal); formal analysis (equal); investigation (equal); methodology (equal).

CONFLICT OF INTEREST

The author has no conflicts of interest.

ETHICAL NOTE

None.

FUNDING

None.

Data Availability Statement

The data are freely available from the online database: <https://app.bto.org/seabirds> and the data used in this study have been provided as an Excel spreadsheet (Table S1).

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SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section at the end of the article.

Table S1. Colony count data of Great Skuas and Great Black-backed Gulls.