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Seabird population and demographic monitoring in the UK: a review and recommendations for future sampling

Nina J. O'Hanlon, Sarah J. Harris, Chris B. Thaxter, Philipp H. Boersch-Supan, Robert A. Robinson, Dawn E. Balmer and Niall H.K. Burton

BTO Birds Science People

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Report of work carried out by BTO on behalf of the Joint Nature Conservation Committee

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Executive summary

- The Seabird Monitoring Programme (SMP: https://www.bto.org/smp), funded by the British Trust for Ornithology and Joint Nature Conservation Committee (JNCC), in association with the Royal Society for the Protection of Birds, aims to ensure that sample data on seabird breeding numbers and breeding productivity are collected both regionally and nationally, for 25 species of seabird that regularly breed in Britain and Ireland, to enable their conservation status to be assessed.

- However, current annual trend information delivered by the SMP is imprecise, absent, or geographically limited for several UK breeding seabird species. As is recognised under the SMP development programme, it is therefore of high priority to review the current SMP sampling approach and develop a new sampling strategy to inform coordinated and targeted volunteer and professional monitoring to facilitate the collection of more representative data and, consequently, more robust evidence. The overarching objectives of this work are therefore to: (i) review the current SMP sampling strategy; (ii) develop a new SMP sampling strategy; and (iii) deliver the new SMP sampling strategy through the SMP Engagement Plan; this report focuses on the first two objectives.

- A summary of how seabird abundance and productivity trends are currently produced for annual SMP reporting, and associated considerations for sampling, highlighted that at present the confidence intervals of the abundance indices only reflect uncertainty in the imputation of missing counts. This emphasises a key need for replication and/or quantification of observation error in sampling, thus repeated visits throughout the breeding season for at least a sub-sample of sites, and where implemented, multiple representative Plot Colony Counts, especially at very large sites.

- To inform our recommendations to produce robust trends at the country and UK level for breeding seabird species we carried out a stock-take of the abundance and productivity data currently held within the SMP database, and summarised the annual data available. We also summarised monitoring data collected on survival through the SMP Key Sites and Retrapping for Adult Survival (RAS) studies, and on productivity from the Nest Record Scheme, to inform recommendations on integrating data across schemes.

- Data for 22 of the 25 seabird species that commonly breed in the UK from the most recent national seabird census 'Seabirds Count' were provided by JNCC and with the permission of the Seabirds Count Editorial Board to enable an assessment of the representativeness of SMP coverage. For each species, we assessed relative coverage by SMP 'annual' monitoring with respect to the number of sites and overall population count provided in the Seabirds Count census dataset, considering heterogeneity in the magnitude of colony size for individual species. Coverage varied by species and country but was generally low at the UK level for most species. These values, along with the results of the data simulations (used to assess consequences of varying sampling efforts – see below), formed the basis of updating the species-specific recommendations from previous reviews to produce robust abundance trends.

- To assess the precision to which reliable estimates of population size might be obtained under different levels of sampling and through stratification, and thus requirements to robustly monitor population trends, we used a re-sampling simulation approach, carried out on the Seabirds Count dataset, i.e. 'within-sample'. This approach therefore assumed that total population size was realised in the census for species and countries, and is thus a caveat to interpretation. Analyses were undertaken at both a UK level and for constituent countries within the UK. Precision (assessed considering the coefficients of variation around population estimates) increased with the proportion of sites sampled and, in all cases, with stratification of sites according to their size. The effect of stratifying sites by size on the precision of population estimates varied by species, highlighting the need for species-specific sampling approaches that also might vary between countries.

- Based on the stock-take of existing data and the results of the data simulations, we build upon and update the recommendation of previous reviews by: (i) providing overarching recommendations on the approaches for sampling of abundance, productivity and survival across species; (ii) providing more detailed species-specific recommendations on how sites should be selected for monitoring to produce more robust trends; and (iii) highlighting wider considerations for the SMP relating to the trend analysis, the Seabird Monitoring Handbook and engagement.

1. Background

1.1. The Seabird Monitoring Programme

The Seabird Monitoring Programme (SMP: www.bto.org/smp) is an ongoing annual monitoring programme, established in 1986, of 25 species of seabird that regularly breed in Britain and Ireland. It aims to ensure that sample data on seabird breeding numbers and breeding productivity are collected both regionally and nationally, to enable their conservation status to be assessed. The SMP is funded jointly by the British Trust for Ornithology (BTO) and Joint Nature Conservation Committee (JNCC), in association with the Royal Society for the Protection of Birds (RSPB), and is supported by Natural England, Natural Resources Wales, NatureScot and the Department of Agriculture, Environment and Rural Affairs, Northern Ireland, and a wider advisory group. Close collaboration with organisations in the Republic of Ireland enables all-Ireland interpretation of seabird trends.

Relating to this work, the core objectives of SMP include needs to:

1. deliver representative population, distribution, abundance, and demographic data for breeding seabird species;
2. provide integrated seabird population monitoring outputs which support the identification of trend drivers, their effects, and their management; and
3. maintain a SMP sampling strategy that is representative and adaptable based on the latest information (as populations and pressures affecting them change).

Annual monitoring of abundance and breeding productivity at sample sites forms the core of the SMP and enables annual reporting from the Scheme (https://jncc.gov.uk/our-work/smp-report-1986-2019). Phenology, diet and survival rate data are also collected as part of the Scheme at four Key Sites (Fair Isle, Canna, the Isle of May and Skomer). In parallel, additional data on breeding productivity and survival are collected for some seabird species through the JNCC/BTO Avian Demographic Scheme, i.e. the Nest Records Scheme and Ringing Scheme.

As part of the SMP development programme for 2022/23–2026/27, one of the high priorities that has been identified is a full review of the SMP sampling strategy, developed as part of a previous review (JNCC 2012, see below), to inform coordinated and targeted volunteer and professional monitoring to facilitate the collection of more representative data and, consequently, more robust evidence.

In particular, current annual trend information delivered by the SMP is imprecise, absent, or geographically limited for several UK breeding seabird species. Work is thus required to review the current SMP sampling approach and develop a new sampling strategy, which will enable the capture of data that can be used to deliver robust abundance and productivity trend information for the UK's breeding seabird populations, thereby:

- lowering the risk of failing to detect genuine population trends in a timely manner, or producing biased trends that do not fully represent wide-scale changes;
- providing the data to understand the underlying demographic drivers of those trends;
- through integrated population monitoring, facilitating analysis to provide understanding of the effects of pressures/environmental change on seabird populations and the ability to mitigate these;
- supporting Common Standards Monitoring (CSM) reporting of seabird features of Special Protection Areas (SPAs); and
- enabling informed and more rapid marine management decisions to be made.

1.2. Previous reviews of the Seabird Monitoring Programme

The SMP has been the subject of reviews in 2007 (Mitchell & Parsons 2007), 2012 (JNCC 2012) and more recently in 2019 (unpublished), the recommendations from the latter review leading to the formation of the new partnership for the Scheme, launched in July 2022.

The 2007 report provided a strategic review of the scheme, considering the following key questions.

- Has the SMP achieved its aims and are the existing aims appropriate for the future?
- Which species and parameters should be monitored?
- How representative is the SMP?
- Are current monitoring methods effective?
- Are data collated and stored effectively?
- Is information disseminated appropriately?

The outcomes of the 2007 SMP Review informed three additional pieces of work:

- a Seabird Surveillance Review (Way & Mitchell 2009) which identified a strategic direction for the SMP for the following 15 years, to 2014;
- a JNCC-commissioned study (Cook & Robinson 2010) which assessed the representivity, accuracy and precision of SMP sampling of 11 species identified in the 2007 SMP Review as requiring annual monitoring; and
- a JNCC-commissioned study which reviewed ways in which data on survival may be gathered to explain population change in seabirds (Robinson & Baillie 2012).

Cook & Robinson (2010) assessed the accuracy of abundance trends through comparison with changes calculated from the Seabird Colony Register (SCR) and Seabird 2000 censuses and used a simulation to assess the power of the data to detect changes in breeding productivity (see also Cook et al. 2011). Robinson & Baillie (2012) recommended that the Retrapping Adults for Survival (RAS; www.bto.org/ras) scheme, part of the wider Ringing Scheme, provided a cost-effective and time-efficient method of estimating survival rate.

The 2012 SMP Review collated recommendations from these reports to devise a future work plan for the scheme, considering not just the annual collection of data on abundance and productivity, but also of data on other parameters collected through the Key Sites and through complementary demographic monitoring. This encompassed:

- a summary of current monitoring, and recommendations for future monitoring, for each parameter (abundance, breeding productivity, survival, diet and phenology);
- assessment of the monitoring requirements of seabirds proposed as indicator species for the EC Marine Strategy Framework Directive (MSFD);
- evaluation of input into CSM;
- a more detailed review of current species specific monitoring and recommendations; and
- consideration of proposed work options for implementing a combination of recommendations set out in sections above.

Further commissioned work of relevance following the 2012 Review has included a review of mark-recapture studies on UK seabirds that are run through the RAS scheme, that provided recommendations on the sample sizes and frequency of sampling required to obtain robust survival estimates (Horswill et al. 2015, 2018).

Although not published, the 2019 SMP Review provided a wider consideration of the aims of the Scheme, including legal/policy, conservation, engagement, research and societal drivers, that is pertinent to the review presented here.

1.3. Objectives

The overarching objectives of this work are to:

1. review the current SMP sampling strategy;
2. develop a new SMP sampling strategy; and to
3. deliver the new SMP sampling strategy.

The core of this work is to deliver a new sampling strategy to support the capture of data within the SMP that can be used to deliver robust abundance and productivity trend information for the UK's breeding seabird populations. However, as recognised in the Scheme objectives, in order to understand the drivers of seabird population trends it is important to fully consider the demographic mechanisms through which these operate; thus the work also considers requirements for monitoring survival of seabirds and consequently for best providing integrated seabird population monitoring outputs.

The work also considers the framework of the overall Scheme development programme for 2022/23–2026/27, in particular interdependencies with annual trend analyses, methods (as outlined currently in the Seabird Monitoring Handbook: Walsh et al. 1995) and the SMP Engagement Plan.

2. APPROACH

2.1. Summary of current trend analysis and previous reviews of the SMP

The first part of the work considers the current approach used to produce trends in seabird abundance and productivity by the SMP and summarise previous reviews. Key points and recommendations from those past reviews are highlighted in bold and feed through to the recommendations of this work outlined in section 6.

2.1.1. Current trends analysis

To inform the review, as an initial step we first summarise how seabird abundance and productivity trends are currently produced for annual SMP reporting.

2.1.2. Previous reviews of the SMP

We provide a synopsis of the previous reviews of the SMP, and the extent to which they have been implemented, focusing in particular on the current sampling recommendations for individual species for the key metrics of abundance, breeding productivity and survival, but also of diet and phenology.

(i) Abundance and productivity

This work draws especially from the recommendations from the 2012 SMP Review, but also from preliminary work prepared to inform Working Group 2 (Sampling strategy, analysis and reporting) of the 2019 SMP Review. However, it is important to consider the wider drivers of evidence needs for data from the SMP and thus consider a more holistic review of the monitoring of seabirds provided by the scheme. The review also draws from the context provided by Working Group 1 on the drivers of the Scheme and by the aims and objectives encapsulated in the Scheme agreement. Based on this summary, recommendations on the frequency of monitoring of the 25 species of seabird that regularly breed in Britain and Ireland are reviewed.

(ii) Survival

The more recent recommendations on the sample sizes and frequency of sampling required to obtain robust survival estimates for seabirds through the RAS scheme provided by Horswill et al. (2015, 2018) are also summarised, with cross-reference to the recommendations from the 2012 SMP Review.

(iii) Integrated monitoring

The review also takes into consideration the recommendations from SMP Co-operating Organisations for repeat coverage in 2023 (and potentially future years) of sites covered by the latest (2015–2021) national seabird census, 'Seabirds Count' (https://jncc.gov.uk/our-work/seabirds-count), to be able to assess the impacts of the 2022 Highly Pathogenic Avian Influenza (HPAI) outbreak on seabirds.

2.2. Stock-take of current data/coverage

To inform our recommendations to produce robust trends for seabird species at the UK and country level across Britain and Ireland we carried out a stock-take of the data currently held within the SMP database, especially what annual data are currently collected. Data from the most recent Seabirds Count national census were also obtained from JNCC in February 2023 (which may thus differ from the final published results) to assess the representivity of SMP coverage. Both the census and annual SMP data were summarised based on the size of sites to assess this coverage whilst considering heterogeneity in colony size for individual species.

Given the importance of integrating monitoring of abundance and demographic rates in terms of understanding changes in seabird trends and identifying drivers of change, we also review what additional demographic data are collected as part of the SMP (via the key sites) as well as from other schemes (i.e. JNCC/BTO Avian Demographic Scheme) that collect data on productivity (Nest Record Scheme, NRS) and survival (RAS) that could be incorporated with the SMP data in the future.

In addition to abundance and breeding productivity data, the four SMP Key Sites (Fair Isle, Canna, the Isle of May and Skomer) also collect phenology, diet and survival rate data which are summarised in annual Key Site reports (by the Fair Isle Bird Observatory Trust, Highland Ringing Group, UK Centre for Ecology & Hydrology, and Wildlife Trust of South & West Wales/University of Gloucestershire respectively). Furthermore, abundance trends include data collected by JNCC and the National Trust for Scotland from 'Triennial sites' (sites where monitoring occurs every three years: Orkney mainland, St. Kilda and on the Grampian coast).

To provide an overview of what trends are currently produced, we reviewed the content of the most recent SMP annual report (JNCC 2021) and documented the outputs provided for the UK as a whole, as well as independent outcomes for Scotland, England, Wales, Northern Ireland, Republic of Ireland, all Ireland, Isle of Man and the Channel Islands (Appendix 1).

2.3. Data simulations

To assess the precision to which reliable estimates of population size might be obtained under different levels of sampling and through stratification, and thus requirements to robustly monitor population trends, we used a re-sampling simulation approach, carried out on the Seabirds Count dataset, i.e. 'within-sample'. This approach assumed that total population size was realised in the census for species and countries and is thus a caveat to interpretation. Analyses were undertaken at both a UK level and for constituent countries within the UK.

Initially, we took a global approach considering data from across all sites, for a given species and country, to simulate increasing numbers of sites (n) from 1:N, where N = the maximum number of sites in the sample. For each simulation of n, we randomly selected n sites from the available site pool with replacement, and summed up their associated counts of individual seabirds (i.e. 'colony sizes') scaling up to the number of N sites for the species/country. This resulted in an aggregated count for the species and country, per site increment value. This approach presented a computational challenge for larger combinations of site matrices that could not all be investigated due to the sheer number of possible combinations. Therefore, we took a bootstrapping approach (1,000 samples) and randomly sampled available sites for a given n. Thus, sequentially, the algorithm iterated over 1:N computing 1,000 aggregated country-wide population estimates per species, across which the mean, standard deviation and coefficient of variation (ratio of standard deviation to mean) was calculated.

The above routine was initially carried out across the 'global' sample of all sites available within the UK or country. However, as for some species, there is considerable variation (often of orders of magnitude) in the sizes of sites, and individual colony counts would not be considered 'exchangeable', i.e. within the bootstrapping routine, to achieve representative simulated population estimation. We therefore carried out a further 'stratified' simulation based on the colony size strata 's' presented in Table 6, i.e. 1–10, 11–100, 101–1,000, 1,001–10,000, and 10,001–100,000. For some species and countries, upper strata, i.e. the stratum representing the largest colony size and the next one down (e.g. 1,001–10,000 and 10,001–100,000), were pooled. This amalgamation ensured strata were not unnecessarily parameterised if the largest observed colony size of the distribution of colony sizes was close to the lower boundary of the largest stratum. We used a rule that if the maximum size of colonies in the largest colony-size stratum (NsxMax) was <30% upper stratum bound (NsxB), then categories were pooled. All pairs of strata were considered, thus for pairs of strata Ns1 to Nsx, where x is the total number of strata per species and country: if NsxMax / NsxB < 0.3, then Nsx = Nsx-1. Coefficients of variation (CVs) for the population estimate, i.e. the ratio of the standard deviation to the mean, were then generated per stratum s for sites 1:Ns, again where Ns is the total number of sites per strata.

The curves describing the relationship between global and stratified population estimate CV and the number of sites in a stratum were then examined. However, to compare the two more meaningfully required combining the stratified bootstrap samples as produced above into one curve, i.e. across different strata of varying number of Ns sites, per species and country. We therefore used a proportional approach to iterate

over an increasing sequence of proportions (p), from 0 to 1, at increments of 0.01, to determine p*Ns number of sites ('Nps') to draw simulations from within each individual stratum s (per species and region), such that sum(counts of Nps) from 1 to max s approximated the total aggregated count for the number of sites N in the global sample. This was carried out for the bootstrap draws of simulations for a given Nps, aggregating for each proportional increment to return a population value. As CVs cannot be summed directly, the variance of aggregated population estimates was taken for each stratum and the overall CV was recalculated as: sqrt(sum(variances))/sum(estimates). The same approach was thus also carried out for the global sample, but without the need for sums across strata, thus being p*N for a given number of sites and CVs calculated as previously to compare CVs for the realised number of sites to the stratified sample.

As a further component of the recombination of CV above, we included a 'minimum site threshold' T, as a rule to select a minimum number of sites to be surveyed within a stratum on any given p proportional increment within the simulation. Thus, if 10 sites were available for Ns, and p*Ns < T, then T was taken instead, or alternatively the number of sites available if Ns < T. For example, for a 'minimum site threshold' of 5 (T = 5), 10 sites (Ns = 10) and a proportion of 0.3 (p = 0.3), five sites would be chosen as opposed to three. This ensures that coverage exceeds single or even fractional sites in strata containing few sites. We examined the effect on CV over increasing T values per p increment as a 3D surface to inform a suitable T value to use in the comparison of global and stratified CVs.

To aid comparisons, results are visualised graphically for all CV curves plotted over increasing proportional increments for species and regions for global and stratified versions.

3. SUMMARY OF CURRENT TREND ANALYSIS AND PREVIOUS REVIEWS OF THE SMP

3.1. Summary of how seabird abundance and productivity trends are currently produced for annual SMP reporting and associated considerations for sampling

3.1.1. Abundance counts

The SMP aims to produce annual trends (or abundance indices) for the 25 seabird species that regularly breed in Britain and Ireland at the UK and country level (Channel Islands, England, Isle of Man, Northern Ireland, Republic of Ireland, Scotland, Wales) where sufficient data are available (Appendix 1). Counts are typically collected via Whole Colony Counts or, where this cannot be done, via within site Plot Colony Counts (Walsh et al. 1995). However, for the burrow-nesting species additional or different methods are required. For Puffin, site size estimates are typically extrapolated from apparently occupied burrows (AOB) detected along transects or randomly located quadrats located through the site. Extrapolation based on responses to play-back in sample quadrats is also used to estimate site sizes for Manx Shearwater and the storm petrels (Walsh et al. 1995, Ratcliffe et al. 1998).

At present, trends are not produced at the country or UK level for the four burrow-nesting species (Manx Shearwater, Storm Petrel, Leach's Petrel and Puffin), which are challenging to monitor. Although some annual monitoring, particularly from Plot Colony Counts, is carried out for Puffin, there is considerable uncertainty in the imputation of missing data, for years where data are not collected at a site, leading to very large confidence intervals around the trend estimate. Trends were also not published in the 2019 SMP online report (JNCC 2021) at the UK scale for Great Skua, Common Gull and Mediterranean Gull due to considerable uncertainty around the estimated trends. Not being able to produce trends at the UK level is particularly problematic from a policy perspective for species for which the UK holds significant breeding numbers, specifically Manx Shearwater (90% of the world breeding population; JNCC 2021, BirdLife International 2023) and Great Skua (60% of the world breeding population; JNCC 2021, BirdLife International 2023), and therefore for which the UK has a legal obligation to protect. For Common Gull, the uncertainty around estimated trends was attributed to recent submitted data being from a low number of unrepresentative small colonies. Currently, abundance trends for Black-headed Gull and Common Gull are only produced for coastal nesters, whilst for Lesser Black-backed Gull and Herring Gull these are only produced for natural nesters and therefore do not include gulls nesting inland or at urban sites respectively. The species for which annual trends are published at the country level varies considerably depending on which countries have sufficient data submitted (Appendix 1).

For those species for which the production of annual trends is considered feasible, all sites within the SMP database with at least three counts submitted since its inception in 1986 are included in the annual trend analysis. This therefore excludes a large number of sites that have only been counted once or twice (for example, during the Seabird 2000 or Seabirds Count censuses). However, these counts are still included in calculating the weightings for imputed counts (see below). The baseline year of the analysis is set to 1986, the start of the SMP.

For sites with missing data for a given year, values are currently estimated using an imputation method (Thomas 1993) implemented in R via a customised graphical front-end (the 'Seabird Wizard'). This approach calculates a value for the missing count using a weighted sum of all the non-missing counts for that site. Equal weights are used to determine the degree of temporal smoothing. For a given year, the total abundance across colonies is estimated by summing across the available observed data and imputed counts. Indices of abundance are produced by scaling the total abundance in the base year (1986), with subsequent years represented as a percentage relative to 1986.

This imputation approach can introduce uncertainty, which is quantified by bootstrapping (Marchant et al. 2004), resampling with replacement across the included colonies. This generates confidence intervals for the estimated total abundance in each year that reflect uncertainty in the estimation of missing counts. Further details on the method of analysis behind the trend analysis for the indices of abundance, and also estimation of productivity, are provided in: Methods of analysis for production of indices of abundance and estimation of productivity.

The analysis therefore produces an estimated trend index for each species with 95% confidence intervals, calculated through bootstrapping with replacement across sites (1,000 iterations), which reflects the confidence of the trend based on uncertainty around the imputed missing counts.

Due to uncertainty in the coverage of inland and non-natural (i.e. urban) nesting gulls, trends for Black-headed and Common Gulls are for coastal nesters only (sites within 5 km of the coast), whilst trends for Herring and Lesser Black-backed Gulls are for natural nesters only (so excluding urban colonies due to uncertainties around counts in these environments, but including moors, cliffs, marshes, beaches and other areas of semi-natural habitat). Better coverage and methods of monitoring of inland and non-natural sites is therefore required to produce trends for these species which more accurately reflect their status at the UK and country levels.

After the trend analysis is initially run an audit is undertaken to establish whether there were enough data to produce valid trends. Trends are considered not valid, and therefore not published, where:

1. there is a low number of colonies with submitted data;
2. there is high uncertainty around the population trend estimate resulting in wide confidence intervals; or
3. where there is a skewed balance in data submitted from only small colonies.

Trends must be based on data from at least 15% of sites present within the SMP database (with at least three counts) to be published in the annual report; i.e. if a trend has at least 15% of underlying actual data rather than imputed. However, there can be exceptions to this rule, e.g. for Puffin, for which, given the challenges of surveying this species, coverage is biased towards smaller (potentially unrepresentative) sites and thus, although the threshold of 15% of sites being covered is met, there remain very wide confidence intervals around the species trend.

3.1.2. Productivity

The SMP also aims to produce estimates of productivity (fledged chicks per pair) for the 25 seabird species that regularly breed in Britain and Ireland at both the UK and country level where sufficient data are available (Appendix 1). Productivity is estimated from data submitted on the total number of chicks fledged from a given number of nesting attempts at sample sites for each species. Productivity is estimated at within site plots which vary in size and number across sites or for the whole colony.

Estimates of productivity for each species in each year are currently calculated using Generalised Linear Mixed Models (GLMMs) in Genstat (VSN International Ltd). For species that lay a single egg the GLMM is run with a binomial error distribution and logit link function, with the sample size included as a binomial denominator. For species that lay more than one egg the GLMM is run with a Poisson error distribution and log link function with the sample size included as an offset. This is not ideal, as larger than feasible clutch sizes are considered possible. Site is included as a random intercept to account for repeated measures of productivity for colonies over multiple years.

For each species, up to five models are tested:

1. a full interactive model of year and region/regional sea (subdivisions of Britain and Ireland including the Isle of Man and the Channel Islands, formerly adopted as reporting regions in the SMP, e.g. Mavor et al. 2006) effects;
2. additive effects of year and region/regional sea;
3. year only;
4. region/regional sea only; and
5. constant productivity (null model).

Model fit is tested using F-ratio statistics and a backward elimination approach to arrive at the minimum adequate model. The parameter estimates are extracted from the minimum adequate model and back-transformed to produce estimates of productivity. No confidence intervals are currently implemented for this approach (see Methods of analysis for production of indices of abundance and estimation of productivity); therefore no measure of uncertainty in the productivity estimates is provided.

At present, both the abundance and productivity trends are calculated based on mean values across sites for each year. However, this can introduce biases, especially for species where colony size may vary considerably, and which may differ substantially in their demographic characteristics, e.g. due to density dependent processes, so ideally these should not be treated equally in the analysis. Using this average based approach may be appropriate for species where sites are relatively small and/or homogeneous in size, e.g. for Arctic Skua and Great Black-backed Gull, but are unlikely to be appropriate for most other species. A change in how trends are produced is therefore necessary to incorporate an aggregate approach across sites. Consideration is also needed as to how to account for movements between colonies, e.g. for terns that can abandon colonies and establish/re-establish new ones.

3.1.3. Confidence intervals around abundance and productivity trends

At present the confidence intervals of the abundance indices only reflect uncertainty in the imputation of missing counts. These confidence intervals therefore provide no information on uncertainty in the trend estimates associated with:

1. counting error when sites are surveyed;
2. variation in site (colony) attendance by individuals, which may vary within species by time of day and throughout the season (i.e. Hatch & Hatch 1988);
3. correction factors to convert between counts of individuals and breeding pairs;
4. records of zero counts versus species present but not counted;
5. how representative trends for Plot Colony Counts within sites are of trends at the site-level; and
6. prospecting but not breeding adults visiting colonies.

It is currently not possible to create meaningful confidence intervals as the SMP database largely only includes Whole Colony Counts so there are no measures of uncertainty associated with the above sources of observation error. Furthermore, no confidence intervals are currently produced for the annual productivity estimates; however, these could be implemented in principle (Dormann et al. 2018).

This highlights a key need for replication and/or quantification of observation error in sampling, thus repeated visits throughout the breeding season for at least a sub-sample of sites, and where implemented, multiple representative Plot Colony Counts, especially at very large sites.

3.2. Summary of previous sampling recommendations

Previous sampling recommendations have been in the context of the approach to the production of trends, as outlined above. In particular, the 2012 SMP review brought together recommendations from several reports that were commissioned to plan the future direction of work of the SMP, summarised below.

3.2.1. Abundance and productivity monitoring

Cook & Robinson (2010) undertook an analysis to determine the representativeness of breeding seabird monitoring in the UK between 1986 and 2008 for 11 species with high quality monitoring data: Fulmar, Gannet, Shag, Cormorant, Arctic Skua, Sandwich Tern, Little Tern, Herring Gull, Kittiwake, Guillemot and Razorbill. Specifically, this report looked at whether the monitoring of these species through the SMP was sufficient to produce adequate trends at the UK and regional scale. The accuracy of trends was assessed through comparing the trends estimated from the SMP annual data with changes calculated from the Seabird Colony Register (1986–1989) and Seabird 2000 (1998–2002) censuses. Trends were considered accurate if they were within 15% of the changes estimated by the censuses, and very inaccurate if they differed by 35% or more. An adequate match was found in 57% of cases; however, the accuracy and precision of trends varied among regions and species, with those for Herring Gull and Gannet considered particularly inaccurate.

The accuracy of breeding productivity trends was also undertaken to determine the power of data to detect changes. Based on the results of Monte Carlo simulations, the SMP data were considered to have sufficient power to detect declines of 10% or more in breeding productivity for all species except Razorbill, Arctic Skua and Little Tern. The data available were only powerful enough to detect declines of 5% in breeding productivity for Cormorant, Shag and Kittiwake. Overall, the number of nests currently sampled per site was considered insufficient to accurately represent breeding productivity at the site level.

Based on these analyses Cook & Robinson (2010) made the following broad scale recommendations to improve the power and accuracy of annual trend estimates for abundance and breeding productivity:

- the need to increase the number of colonies that are monitored on an annual basis to better capture regional differences;
- the need for more regular (i.e. annual) monitoring of abundance and breeding productivity at colonies which are currently monitored; and
- the need to increase the number of nests and plots used to estimate abundance and breeding productivity within colonies.

They also highlighted the importance of having a clear definition of what constitutes a colony and the need to consider the relative importance of small colonies within the population for each species.

3.2.2. Survival monitoring

Robinson & Baillie (2012) reviewed the monitoring of seabird demographic rates, and especially survival, using ringing, within the SMP but also more widely across the Ringing Scheme and RAS programme. Survival data are only collected for seabirds at a relatively small number of colonies due to the significant time and costs involved in obtaining data to estimate this metric, especially compared to monitoring abundance and breeding productivity. Current monitoring of survival rates was therefore found to be insufficient to adequately understand the impact of environmental change on UK seabird populations. Additionally, there was also an overall recommendation that existing Ringing Scheme data, such as those collected through the RAS programme, are better integrated into the SMP, to facilitate analyses.

Furthermore, it was recommended that integrated monitoring of abundance, productivity and survival should occur at a small number of representative colonies, with the current four SMP Key Sites being the core of this expanded network, to provide a greater understanding of seabird ecology and drivers of population change. Due to the analysis required to estimate survival rates it is better to monitor a few sites well than many more inadequately.

Robinson & Baillie (2012) made several recommendations specific to ringing, largely focused on obtaining adequate data to estimate survival rates (of different age-classes):

- aim to maintain a population of around 100–150 colour-marked birds at a site (Harris et al. 2000);
- maintain a sample of birds ringed as chicks at a sample of sites to determine the proportion of birds of a breeding age that do not breed in a given year (by age-class) and age of first breeding. This would be best achieved using metal ringing given that mortality is expected to be high for juveniles and immatures, although colour-ringing of chicks has the potential to provide valuable dispersal information (O'Hanlon et al. 2022); and
- monitor survival from multiple species at selected sites, ideally at sites where data on colony size and breeding productivity data are already, or can be, monitored; for example the triennial sites. This could be achieved through expanding the RAS network to improve the geographical representativeness of survival rates and estimate age-specific survival rates with greater precision.

It was considered that a combination of approaches would be expected to provide better estimates of survival probabilities: colour-marking and re-sighting individuals at specific colonies to estimate annual adult survival and recoveries of ringed birds from multiple colonies to estimate immature survival (to account for natal dispersal).

A further review, focused on reviewing mark-recapture studies on UK seabirds as part of the BTO's RAS network, was carried out by Horswill et al. (2015). An important part of this review was conducting power analysis to determine how different levels of ringing and recapture effort impacted the ability to estimate adult survival rates and detect annual and individual level variation (Horswill et al. 2018).

They concluded that at least 200 individuals needed to be ringed each year (or a high proportion of individuals for species with small populations i.e. Little Tern), with a minimum recapture rate of 0.4 (typical of current RAS studies) to accurately estimate survival over 10 years. Longer-term studies, over 20 years, could accurately estimate survival with lower levels of ringing and re-encounter effort. Achieving higher re-encounter rates would reduce the number of birds that need to be marked, but would likely require significantly more effort. Based on 33 seabird RAS studies that had at least four years of data, 35% were considered to have adequate levels of ringing and recapture effort for reliable constant adult survival rate estimates. Greater levels of ringing and recapture effort were required to detect temporal or individual-level variation in survival.

Overall, they highlighted the importance of consistent, long-term monitoring to obtain accurate estimates of survival rates, and made the following key recommendations.

- Provide advice, and if possible, financial support, to RAS studies that currently do not meet the necessary field effort to reliably estimate a constant adult survival rate.
- Identify and encourage ringing groups that are annually or biannually ringing specific seabirds at a site to establish RAS studies.
- Encourage RAS studies to incorporate colour-ringing to increase resighting effort without needing to recapture individuals.
- Evaluate lapsed RAS studies for potential continuation.
- Established new RAS studies to increase geographical representation, including of target species: Great Black-backed Gull, Herring Gull, and species of skua and tern.

The importance of integrated monitoring, and collecting data on multiple demographic rates at single colonies, including ringing, was emphasised further in Robinson & Ratcliffe (2012), which explored the feasibility of Integrated Population Monitoring of seabirds in Britain. They highlighted the importance of obtaining adequate data to calculate survival rates to:

- understand historical changes in relation to changes in environmental conditions;
- monitor future changes in annual survival rates; and
- provide demographic parameters for population models.

3.2.3. Integrated population monitoring

Both Robinson & Baillie (2012) and Robinson & Ratcliffe (2012) emphasised the importance of maintaining the four SMP Key Sites due to the vital data collected on multiple metrics for several species (including diet and phenology). Although monitoring diet and phenology is important to understand the impact of environmental

change on seabird populations, the 2012 review noted that collecting these data more widely is currently unfeasible for most species and sites due to time and cost constraints of current methods. As is recognised under current SMP development priorities, approaches that reduce these constraints therefore need to be developed and implemented at sites where appropriate.

3.2.4. Priority and indicator species

The SMP aims to collect sample data on seabird breeding numbers and breeding productivity, both regionally and nationally, to enable their conservation status to be assessed. However, there are various indicators that specifically require data on a subset of these species to provide a robust measure of how seabirds are faring at different geographical scales. Some species are also defined as priorities for annual monitoring of colony counts, productivity and survival due to their conservation status and legislative obligation (Table 1).

Table 1. The species included in seabird indicators, and priority species based on their conservation status.

Species	UK seabird indicator	Scotland seabird indicator	England seabird indicator	ICES Indicator species[1]	High Priority species[2]	Medium Priority species[2]	UK BAP Species[3]
Fulmar *Fulmarus glacialis*	x	x	x	x			
Manx Shearwater *Puffinus puffinus*						x	
Leach's Storm Petrel *Hydrobates leucorhoa*					x		
Storm Petrel *Hydrobates pelagicus*							
Gannet *Morus bassanus*			x	x		x	
Shag *Gularis aristotelis*	x	x	x	x	x		
Cormorant *Phalacrocorax carbo*	x		x				
Arctic Skua *Stercorarius parasiticus*	x	x			x		x
Great Skua *Stercorarius skua*						x	
Kittiwake *Rissa tridactyla*	x	x	x	x		x	
Black-headed Gull *Larus ridibundus*						x	
Lesser Black-backed Gull *Larus fuscus*						x	
Great Black-backed Gull *Larus marinus*	x	x					
Herring Gull *Larus argentatus*	x	x[4]	x		x		x
Common Gull *Larus canus*		x[5]				x	
Mediterranean Gull *Larus melanocephalus*						x	
Common Tern *Sterna hirundo*	x	x	x	x			
Arctic Tern *Sterna paradisaea*	x	x	x	x			
Sandwich Tern *Thalasseus sandvicensis*	x		x				
Roseate Tern *Sterna dougallii*					x		x
Little Tern *Sternula albifrons*	x		x		x		
Guillemot *Uria aalge*	x	x	x	x			
Razorbill *Alca torda*	x			x		x	
Black Guillemot *Cepphus grylle*		x					
Puffin *Fratercula arctica*							

[1] ICES Indicator species: Species deemed good indicator species accounting for ease of monitoring (quality of data) and indicator potential (usefulness of data) of the different prey categories recommended by ICES. Taken from Table 11 of 2012 review. [2] High and Medium Priority Species: Species were scored under conservation priority (population decline, rare breeder, limited distribution, international importance) and legislative obligation (UK priority – Wildlife and Countryside Act, Biodiversity Action Plan, International priority – Birds Directive) and summed to give an overall priority score. Species were then ranked by priority score and those in the 1st–35th percentiles were classed as 'Low' priority, those in the 36th–70th percentiles as 'Medium' and the 71st–100th as 'High' (see Mitchell & Parsons 2007 for more details). Obtained from the 2019 Seabird Drivers Spreadsheet. [3] UK Biodiversity Action Plan (BAP) species: https://jncc.gov.uk/our-work/uk-bap-priority-species. [4] Coastal nesters. [5] Natural nesting.

Table 2. Species-specific recommendations summarised from the 2012 SMP review on the main metrics currently collected within the SMP: abundance (colony counts) productivity, survival, diet and phenology. 'Continue' refers to continuing the current level of monitoring.

Species	Abundance	Productivity	Survival	Diet	Phenology
Fulmar	Continue	Continue	Establish colour ringing projects	Analyse data collected at Key Sites	Collect simple data at other sites than Isle of May
Manx Shearwater	Continue	Continue	Continue		Collect simple data at other sites than Skomer
Leach's Petrel	Monitor on St Kilda	Monitor on St Kilda	Monitor on St Kilda	Monitor on St Kilda	Monitor on St Kilda
Storm Petrel	Continue		Improve RAS studies		
Gannet	Expand Coverage	Expand Coverage	Establish colour-ringing projects	Monitor on Fair Isle	Collect data mid-April
Shag	Increase coverage	Continue	Increase metal and colour ringing	Continue	Continue
Cormorant	Expand coverage	Expand coverage	Improve colour-ringing		
Arctic Skua	Monitor more consistently	Monitor more consistently		Monitor at Fair Isle	
Great Skua	Continue	Continue		Monitor at Fair Isle, Canna	
Kittiwake	Continue	Improve in Celtic Seas	Increase number studies	Continue	Continue
Black-headed Gull	Continue	Continue	Ring Recoveries		
Lesser Black-backed Gull	Continue	Continue	Metal-ringing		
Greater Black-backed Gull	Continue	Continue	Metal-ringing		
Herring Gull	Expand coverage inland	Expand coverage inland	Colour-ringing	Monitor Skomer, Canna	
Common Gull	Continue	Continue			
Mediterranean Gull	Continue	Continue			
Little Tern	Continue	Continue		Encourage observations	
Sandwich Tern	Expand coverage	Expand coverage			
Common Tern	Continue	Expand Coverage			
Roseate Tern	Continue	Continue			
Arctic Tern	Continue	Increase Coverage		Encourage observations at breeding sites	
Guillemot	Small increase in number of colonies	Small increase in number of colonies	Colour-ringing supplemented by general metal ringing	Encourage observations at breeding productivity sites	Continue
Razorbill	Small increase in number of colonies	Small increase in number of colonies		Continue	Continue
Black Guillemot	Continue	Continue		Encourage observations at breeding productivity sites	
Puffin	Continue	Continue	Continue		Continue

3.2.4. Species-specific recommendations
Building on the recommendations outlined in the above reviews, the 2012 SMP Review proposed species-specific recommendations, briefly summarised in Table 2

4. STOCK-TAKE OF CURRENT DATA/COVERAGE

4.1. SMP abundance data

4.1.1. SMP Whole Colony Counts
To examine current annual SMP coverage we extracted data from the SMP database between 1986 and 2019. We excluded 2020 as limited data were submitted due to restrictions imposed as a response to the Covid19 pandemic, and 2021 and 2022 as not all data had yet been submitted to the SMP database and validated at the time of this work. Furthermore, data are expected to be reduced for 2022 due to fieldwork restrictions associated with the 2022 Highly Pathogenic Avian Influenza (HPAI) outbreak. We defined sites as having regular 'annual' data if data had been submitted for at least 50% of the years since 2000 (the mid-point of the last national seabird census, Seabird 2000, 1998–2002, previous to Seabirds Count). This approach was based on the Wetland Bird Survey (WeBS) protocol, where sites are only included in the annual indices if at least 50% of possible visits were undertaken. We modified this approach to include sites with 50% of data since 2000 to include sites that have recently or are currently being monitored. We also carried out the same approach for data submitted via Plot Colony Counts.

Data from the most recent Seabirds Count national census (2015–2021; Burnell et al. 2023) were then obtained from JNCC in February 2023 (which may thus differ from the final published results) to assess the relative coverage of annual SMP monitoring. Census data were available for all countries except the Republic of Ireland and for all species except Manx Shearwater, Storm Petrel and Leach's Petrel. Data were thus available for 22 of the 25 seabird species that commonly breed in the UK, and that are included within SMP monitoring. For each species, we assessed relative coverage by SMP 'annual' monitoring with respect to the number of sites and overall population count provided in the Seabirds Count census dataset (Table 3). The census data contained a high proportion of zero counts for some species, these included: a) sites where the species bred previously but was not recorded during Seabirds Count, or b) sites where the species had not been recorded previously but were surveyed for other species (i.e. to indicate that species was not observed breeding during Seabirds Count). For comparisons with the SMP 'annual' data, sites with zero counts were excluded. This resulted in actual zeros, where sites have since become 'extinct' also being removed, therefore, the comparisons provide an indication of how well current coverage is of existing sites. SMP 'annual' count totals were based on the sum of the most recent count for each site; as some recent data may not have been submitted, these totals only provide a broad indication of current coverage. Furthermore, these 'annual' data do not include data from the small number of sites that are covered by Plot Colony Counts, and sites that are monitored less regularly than our definition of annual. At present, SMP annual trends for Black-headed and Common Gull are only produced for coastal, natural nesters. Therefore, we also split information for these species by whether sites are defined as coastal (within 5 km of the high-water mark) or inland (Table 4).

The current coverage of all available sites (taken from the census data) by annual monitoring varied by species, from less than 1% for Great Skua to 100% for Roseate Tern. This variation between species reflects the number but also size and distribution of sites. Roseate Terns only breed at a single site in the UK in any numbers, which is monitored annually, with the occasional pair periodically breeding at other sites. Great Skuas have a widespread, low density distribution with only the larger colonies being monitored annually. The high number of sites in the census dataset for Arctic and Great Skua, as well as Great Black-backed Gulls to some extent, is due to these species being monitored in 1 km squares during the census (with each 1 km square being defined as a site). This variation in the percentage of sites covered is also reflected in the percentage of the population (estimated from the census) covered by annual monitoring. For the gull species, the coverage of inland sites is lower than coastal sites.

Table 3. Coverage by SMP 'annual' monitoring via Whole Colony Counts (see text for definition) relative to the total UK population and number of sites from the Seabirds Count census, based on a draft version of the dataset provided by JNCC in February 2023, which may thus differ from the final published results. The SMP Annual data and Percentage of UK sites covered by annual monitoring both relate to Whole Colony Counts. Plot Colony Counts are also monitored for a small number of species; therefore values in brackets relate to the site coverage of 'annual' Plot Colony Counts. Census data were not available to include Manx Shearwater, Storm Petrel or Leach's Petrel.

Species (count unit)[1]	Seabird Count census		SMP Annual data		Percentage of UK population covered by annual monitoring[3]	Percentage of UK sites covered by annual monitoring[3]
	Total count	Total sites[2]	Total count	Total sites		
Fulmar (AOS)	320,077	1,756	21,361	70	6.67	3.99
Gannet (AON)	304,176	20	5,803	2	1.91	10.00
Shag (AON)	20,218	945	3,691	54	18.26	5.71
Cormorant (AON)	8,861	233	5,412	115	61.08	49.36
Arctic Skua (AOT)	737	309	97	9	13.16	2.91
Great Skua (AOT)	11,329	780	640	7	5.65	0.90
Kittiwake (AON)	216,338	382	34,248	62	15.83	16.23
Black-headed Gull[4] (AON)	97,994	504	48,130	63	49.12	12.50
Lesser Black-backed Gull[5] (AON)	55,623	451	18,748	53	33.71	11.75
Great Black-backed Gull (AON)	8,084	1,550	1183	95	14.63	6.13
Herring Gull[5] (AON)	63,054	1,598	18,769	117	29.77	7.32
Common Gull[4] (AON)	23,501	1,147	2,014	63	8.57	5.49
Mediterranean Gull (AON)	2,296	60	319	12	13.89	20.00
Common Tern (AON)	12,299	348	7,733	94	62.88	27.01
Arctic Tern (AON)	30,516	620	12,796	72	41.93	11.61
Sandwich Tern (AON)	12,980	26	12,152	30	93.62	115.38[7]
Roseate Tern[6] (AON)	120	3	126	9	105.00	300.00[7]
Little Tern (AON)	1,387	72	1,111	66	80.10	91.67
Guillemot (IND)	1,268,353	429	199,745	50	15.75	11.66
Razorbill (IND)	224,381	562	31,381	55	13.99	9.79
Black Guillemot (IND)	35,153	1,120	3,439	27	9.78	2.41
Puffin (AOB)	474,679	301	46,401	20	9.78	6.64

[1] AOS – Apparently occupied sites, AON – Apparently occupied nests, AOT – Apparently occupied territories, IND – individuals, AOB – Apparently occupied burrows. [2] Excluding zero counts [3] Based on the count from the most recent year that sites were monitored. These values also do not include counts from Plot Colony Counts. [4] Data includes coastal and inland populations; however, SMP annual trends are only currently produced for coastal, natural nesters. [5] Data includes natural nesting populations only, so excludes urban nesters. [6] Annual data for Roseate Tern includes sites which have gone 'extinct' with data not yet updated from the census. [7] Values are higher than 100% due to counts in SMP database not updated with the latest results from the Seabirds Count census.

Table 4. Coverage by SMP 'annual' monitoring (see text for definition) relative to the total UK population and number of sites from the Seabirds Count census, based on a draft version of the dataset provided by JNCC in February 2023, which may thus differ from the final published results, for coastal and inland gulls.

Species (count unit)[1]	Coatal/ Inland sites	Seabird Count census		SMP Annual data		Percentage of UK population covered by annual monitoring[3]	Percentage of UK sites covered by annual monitoring[3]
		Total count	Total sites[2]	Total count	Total sites		
Black-headed Gull (AON)	Coastal	56,881	319	30,266	49	53.21	15.36
Black-headed Gull (AON)	Inland	41,113	185	17,864	14	43.45	7.57
Lesser Black-backed Gull (AON)	Coastal	36,381	387	15,644	50	43.00	12.92
Lesser Black-backed Gull (AON)	Inland	19,242	64	3,104	3	16.13	4.69
Herring Gull (AON)	Coastal	61,960	1,571	18,769	116	30.29	7.38
Herring Gull (AON)	Inland	1,094	27	0	1	0.00	3.70
Common Gull (AON)	Coastal	13,411	979	2,014	63	15.02	6.44
Common Gull (AON)	Inland	10,090	168	0	0	0.00	0.00

[1] AON – Apparently occupied nests. [2] Excluding zero counts [3] Based on the count from the most recent year that sites were monitored. These values also do not include counts from Plot Colony Counts or from urban sites.

Table 5. The sizes of sites (i.e. colonies) (mean ± standard deviation, SD, and Interquartile Range, IQR) covered by 'annual' SMP monitoring (see text for definition) in comparison to those reported in the Seabird Count Census dataset. The count unit is also given for each species. Census data were not available to include Manx Shearwater, Storm Petrel or Leach's Petrel.

Species (Count unit)[1]	Census data[2]		SMP Annual data	
	Mean ± SD	IQR	Mean ± SD	IQR
Fulmar (AOS)	182 ± 1044	87	21 ±24	33
Gannet (AON)	15,209 ± 21272	15,586	209 ± 505	112
Shag (AON)	21 ± 56	15	1482 ± 3929	690
Cormorant (AON)	38± 57	40	680 ± 1392	602
Arctic Skua (AOT)	2 ± 4	1	119 ± 114	137
Great Skua (AOT)	15 ± 82	7	5162 ± 11330	2,679
Kittiwake (AON)	565 ± 2,622	309	41 ± 81	33
Black-headed Gull[3] (AON)	194 ± 750	63	124 ± 265	120
Lesser Black-backed Gull[4] (AON)	123 ± 691	14	268 ± 1668	198
Great Black-backed Gull (AON)	5 ± 13	3	16 ± 28	19
Herring Gull[4] (AON)	39 ±160	23	54 ± 87	68
Common Gull[3] (AON)	20 ± 130	11	57 ± 111	32
Mediterranean Gull (AON)	38 ± 204	8	199 ± 531	167
Common Tern (AON)	35 ± 111	22	871 ± 2915	532
Arctic Tern (AON)	49 ± 216	30	714 ± 2312	249
Sandwich Tern (AON)	499 ± 987	379	24 ± 44	30
Roseate Tern[5] (AON)	40 ± 68	59	44 ± 167	16
Little Tern (AON)	19 ± 34	17	1853 ± 1503	2,904
Guillemot (IND)	2,957 ±10,629	1,297	612 ± 1777	306
Razorbill (IND)	399 ± 1,852	160	119 ± 323	71
Black Guillemot (IND)	31 ± 61	30	454 ± 766	640
Puffin (AOB)	1,526 ± 6,771	91	101 ± 182	108

[1] AOS – Apparently occupied sites, AON – Apparently occupied nests, AOT – Apparently occupied territories, IND – individuals, AOB – Apparently occupied burrows. [2] Excluding zero counts. [3] Data include coastal and inland populations; however, SMP annual trends are only currently produced for coastal, natural nesters. [4] Data include natural nesting populations only, so excludes urban nesters.

Recorded colony sizes vary considerably in magnitude, from single apparently occupied nests (AON; Great Black-backed Gull) to over 100,000 individuals (Guillemot; Table 3,5). The heterogeneity in colony size for individual species can introduce biases when analysing population trends using the current site average-based approach as demographic rates are likely to show varying degrees of density-dependence (Horswill et al. 2017). Therefore, for both the census and SMP 'annual' data we also determined the percentage of all sites and of the total population (estimated from the census) that fell within each magnitude of colony size (0, 1–10, 11–100, 101–1,000, 1,001–10,000, 10,001–100,000, 100,001+). By assigning sites to these size strata we could assess the extent of coverage of existing SMP 'annual' monitoring across the size distribution of colonies for each species and, in so doing, inform the stratification of sites to improve coverage moving forwards. For species for which the largest colonies account for the majority of the population, surveying these few colonies well will provide sufficiently robust trends. However, for species that are distributed more widely, at lower densities (such as Arctic Skuas and Great Black-backed Gulls), failing to sample an adequate proportion of these smaller sites may increase uncertainty in trends.

We selected six species that broadly represent the range of colony size distributions between UK seabird species, summarising the percentage of all sites and the total population that fell within each colony size strata (Table 6).

- Species occurring across many small sites (for example fewer than 100 breeding pairs) e.g. Arctic Skua.
- Species occurring at a small number of relatively small sites e.g. Little Tern.
- Species occurring at a mix of small and large sites e.g. Shag, Black-headed Gull.
- Species occurring at a mix of small and large sites but with the majority of the population within a small number of large sites e.g. Puffin.
- Species occurring (mostly) at a small number of very large sites e.g. Gannet.

Table 6. Percentage coverage by SMP 'annual' monitoring (see text for definition) of six representative species: Arctic Skua, Shag, Little Tern, Black-headed Gull, Puffin and Gannet, relative to a) the percentage (and number) of sites and b) the total UK population from the Seabird Count Census dataset and according to magnitude of colony size. Excludes sites where zeros were reported, with the number of sites monitored reported in brackets.

Arctic Skua

a) percentage of sites

Country	0 (n)	1– 10 (n)	11–100 (n)	101–1,000 (n)	1001–10,000 (n)	10,001–100,000 (n)	100,001+ (n)	Total no. of sites	Data
UK	–	96.44 (298)	3.56 (11)	–	–	–	–	309	Census
Scotland	–	96.44 (298)	3.56 (11)	–	–	–	–	309	Census
UK	–	1.62 (5)	1.29 (4)	–	–	–	–	9	Annual SMP
Scotland	–	1.62 (5)	1.29 (4)	–	–	–	–	9	Annual SMP

b) percentage of the population

Country	0 (n)	1– 10 (n)	11–100 (n)	101–1,000 (n)	1,001–10,000 (n)	10,001–100,000 (n)	100,001+ (n)	Data
UK	–	73.41	26.59	–	–	–	–	Census
Scotland	–	73.41	26.59	–	–	–	–	Census
UK	–	0.81	12.35	–	–	–	–	Annual SMP
Scotland	–	0.81	12.35	–	–	–	–	Annual SMP

Shag

a) percentage of sites

Country	0 (n)	1– 10 (n)	11–100 (n)	101–1,000 (n)	1,001–10,000 (n)	10,001–100,000 (n)	100,001+ (n)	Total no. of sites	Data
UK	–	55.66 (526)	40.95 (387)	3.28 (31)	0.11 (1)	–	–	945	Census
Channel Islands	–	40 (8)	45 (9)	15 (3)	–	–	–	20	Census
England	–	55.65 (69)	41.13 (51)	3.23 (4)	–	–	–	124	Census
Isle of Man	–	23.08 (3)	76.92 (10)	–	–	–	–	13	Census
Northern Ireland	–	56.25 (9)	43.75 (7)	–	–	–	–	16	Census
Scotland	–	54.27 (407)	42.13 (316)	3.47 (26)	–	–	–	750	Census
Wales	–	74.55 (41)	23.64 (13)	1.82 (1)	–	–	–	55	Census
UK	0.63 (6)	1.27 (12)	2.65 (25)	1.16 (11)	–	–	–	54	Annual SMP
England	–	0.81 (1)	0.81 (1)	0.81 (1)	–	–	–	3	Annual SMP
Isle of Man	–	–	–	7.69 (1)	–	–	–	1	Annual SMP
Northern Ireland	–	–	6.25 (1)	–	–	–	–	1	Annual SMP
Scotland	0.27 (2)	0.93 (7)	2.67 (20)	1.2 (9)	–	–	–	38	Annual SMP
Wales	7.27 (4)	7.27 (4)	5.45 (3)	1.82 (1)	–	–	–	12	Annual SMP

b) percentage of the population

Country	0 (n)	1– 10 (n)	11–100 (n)	101–1,000 (n)	1,001–10,000 (n)	10,001–100,000 (n)	100,001+ (n)	Data
UK	–	10.37	51.81	32.47	5.36	–	–	Census
Channel Islands	–	4.31	48.65	47.04	–	–	–	Census
England	–	11.12	54.49	34.39	–	–	–	Census
Isle of Man	–	3.83	96.17	–	–	–	–	Census
Northern Ireland	–	9.25	90.75	–	–	–	–	Census
Scotland	–	9.79	50.8	32.96	6.45	–	–	Census
Wales	–	22.89	50.69	26.42	–	–	–	Census
UK	0	0.26	5.37	12.62	–	–	–	Annual SMP
England	–	0.12	0.88	19.42	–	–	–	Annual SMP
Isle of Man	–	–	–	31.56	–	–	–	Annual SMP
Northern Ireland	–	–	13.52	–	–	–	–	Annual SMP
Scotland	0	0.24	5.44	11.59	–	–	–	Annual SMP
Wales	0	1.54	17.36	18.74	–	–	–	Annual SMP

Little Tern

a) percentage of sites

Country	0 (n)	1– 10 (n)	11–100 (n)	101–1,000 (n)	1,001–10,000 (n)	10,001–100,000 (n)	100,001+ (n)	Total no. of sites	Data
UK	–	59.72 (43)	36.11 (26)	4.17 (3)	–	–	–	72	Census
England	–	37.5 (12)	56.25 (18)	6.25 (2)	–	–	–	32	Census
Isle of Man	–	–	100 (1)	–	–	–	–	1	Census
Scotland	–	78.95 (30)	21.05 (8)	–	–	–	–	38	Census
Wales	–	50 (1)	–	50 (1)	–	–	–	2	Census
UK	41.67 (30)	20.83 (15)	23.61 (17)	5.56 (4)	–	–	–	66	Annual SMP
England	56.25 (18)	21.88 (7)	43.75 (14)	9.38 (3)	–	–	–	42	Annual SMP
Isle of Man	–	–	100 (1)	–	–	–	–	1	Annual SMP
Scotland	31.58 (12)	21.05 (8)	7.89 (3)	–	–	–	–	23	Annual SMP
Wales	–	–	–	50 (1)	–	–	–	1	Annual SMP

b) percentage of population

Country	0 (n)	1– 10 (n)	11–100 (n)	101–1,000 (n)	1,001–10,000 (n)	10,001–100,000 (n)	100,001+ (n)	Data
UK	–	9.81	56.74	33.45	–	–	–	Census
England	–	3.78	67.03	29.18	–	–	–	Census
Isle of Man	–	–	100	–	–	–	–	Census
Scotland	–	45.97	54.03	–	–	–	–	Census
Wales	–	0.58	–	99.42	–	–	–	Census
UK	0	3.82	34.03	42.25	–	–	–	Annual SMP
England	0	2.89	41.63	42.13	–	–	–	Annual SMP
Isle of Man	–	–	150	–	–	–	–	Annual SMP
Scotland	0	11.37	25.59	–	–	–	–	Annual SMP
Wales	–	–	–	94.77	–	–	–	Annual SMP

Black-headed Gull

a) percentage of sites

Country	0 (n)	1– 10 (n)	11–100 (n)	101–1,000 (n)	1,001–10,000 (n)	10,001–100,000 (n)	100,001+ (n)	Total no. of sites	Data
UK	–	40.28 (203)	38.49 (194)	16.87 (85)	4.17 (21)	0.2 (1)	–	504	Census
England	–	20.9 (37)	41.24 (73)	29.38 (52)	7.91 (14)	0.56 (1)	–	177	Census
Isle of Man	–	100 (1)	–	–	–	–	–	1	Census
Northern Ireland	–	18.18 (4)	22.73 (5)	31.82 (7)	27.27 (6)	–	–	22	Census
Scotland	–	54.76 (161)	37.41 (110)	7.48 (22)	0.34 (1)	–	–	294	Census
Wales	–	9.09 (1)	54.55 (6)	36.36 (4)	–	–	–	11	Census
UK	2.18 (11)	1.19 (6)	3.17 (16)	3.17 (16)	2.58 (13)	0.2 (1)	–	63	Annual SMP
England	3.39 (6)	–	3.39 (6)	6.78 (12)	5.08 (9)	0.56 (1)	–	34	Annual SMP
Northern Ireland	–	–	4.55 (1)	4.55 (1)	13.64 (3)	–	–	5	Annual SMP
Scotland	1.02 (3)	2.04 (6)	3.06 (9)	0.68 (2)	0.34 (1)	–	–	21	Annual SMP
Wales	18.18 (2)	–	–	9.09 (1)	–	–	–	3	Annual SMP

b) percentage of the population

Country	0 (n)	1– 10 (n)	11–100 (n)	101–1,000 (n)	1,001–10,000 (n)	10,001–100,000 (n)	100,001+ (n)	Data
UK	–	0.7	6.67	29.21	51.63	11.79	–	Census
England	–	0.21	4	27.47	52.5	15.82	–	Census
Isle of Man	–	100	–	–	–	–	–	Census
Northern Ireland	–	0.12	1.8	16.85	81.23	–	–	Census
Scotland	–	4.69	29.76	45.93	19.62	–	–	Census
Wales	–	0.3	10.36	89.34	–	–	–	Census
UK	0	0.03	1.32	13.37	61.27	24	–	Annual SMP
England	0	–	0.62	13.32	56.33	29.74	–	Annual SMP
Northern Ireland	–	–	0.81	4.03	95.16	–	–	Annual SMP
Scotland	0	0.51	10.99	26.17	62.34	–	–	Annual SMP
Wales	0	–	–	100	–	–	–	Annual SMP

Puffin

a) percentage of sites

Country	0 (n)	1– 10 (n)	11–100 (n)	101–1,000 (n)	1,001–10,000 (n)	10,001–100,000 (n)	100,001+ (n)	Total no. of sites	Data
UK	–	46.18 (139)	29.9 (90)	12.96 (39)	6.98 (21)	3.99 (12)	–	301	Census
Channel Islands	–	33.33 (2)	50 (3)	16.67 (1)	–	–	–	6	Census
England	–	42.11 (8)	36.84 (7)	5.26 (1)	5.26 (1)	10.53 (2)	–	19	Census
Isle of Man	–	100 (1)	–	–	–	–	–	1	Census
Northern Ireland	–	50 (3)	16.67 (1)	33.33 (2)	–	–	–	6	Census
Scotland	–	47.55 (126)	29.43 (78)	12.45 (33)	7.17 (19)	3.4 (9)	–	265	Census
Wales	–	18.18 (2)	36.36 (4)	27.27 (3)	9.09 (1)	9.09 (1)	–	11	Census
UK	0.66 (2)	1 (3)	1.66 (5)	1.66 (5)	1.33 (4)	0.33 (1)	–	20	Annual SMP
England	–	5.26 (1)	5.26 (1)	–	–	–	–	2	Annual SMP
Scotland	0.75 (2)	–	0.75 (2)	0.75 (2)	1.13 (3)	–	–	9	Annual SMP
Wales	–	18.18 (2)	18.18 (2)	27.27 (3)	9.09 (1)	9.09 (1)	–	9	Annual SMP

b) percentage of the population

Country	0 (n)	1– 10 (n)	11–100 (n)	101–1,000 (n)	1,001–10,000 (n)	10,001–100,000 (n)	100,001+ (n)	Data
UK	–	0.11	0.71	2.56	14.99	81.63	–	Census
Channel Islands	–	2.51	14.42	83.07	–	–	–	Census
England	–	0.04	0.31	1.14	5.77	92.74	–	Census
Isle of Man	–	100	–	–	–	–	–	Census
Northern Ireland	–	1.22	9.41	89.37	–	–	–	Census
Scotland	–	0.13	0.79	2.48	16.58	80.02	–	Census
Wales	–	0.03	0.48	5.25	18.55	75.69	–	Census
UK	0	0	0.02	0.36	2.88	6.51	–	Annual SMP
England	–	0.01	0.02	–	–	–	–	Annual SMP
Scotland	0	–	0.02	0.1	1.68	–	–	Annual SMP
Wales	–	0.01	0.14	4.44	24.29	100.76	–	Annual SMP

Gannet

a) percentage of sites

Country	0 (n)	1– 10 (n)	11–100 (n)	101–1,000 (n)	1,001–10,000 (n)	10,001–100,000 (n)	100,001+ (n)	Total no. of sites	Data
UK	–	10 (2)	10 (2)	–	40 (8)	40 (8)	–	20	Census
Channel Islands	–	–	–	–	100 (2)	–	–	2	Census
England	–	–	–	–	–	100 (1)	–	1	Census
Scotland	–	11.11 (2)	11.11 (2)	–	44.44 (8)	33.33 (6)	–	18	Census
Wales	–	–	–	–	–	100 (1)	–	1	Census
UK	–	–	–	–	10 (2)	–	–	2	Annual SMP
Scotland	–	–	–	–	11.11 (2)	–	–	2	Annual SMP

b) percentage of the population

Country	0 (n)	1– 10 (n)	11–100 (n)	101–1,000 (n)	1,001–10,000 (n)	10,001–100,000 (n)	100,001+ (n)	Data
UK	–	0.01	0.01	–	9.98	90.01	–	Census
Channel Islands	–	–	–	–	100	–	–	Census
England	–	–	–	–	–	100	–	Census
Scotland	–	0.01	0.02	–	11.91	88.07	–	Census
Wales	–	–	–	–	–	100	–	Census
UK	–	–	–	–	1.91	–	–	Annual SMP
Scotland	–	–	–	–	2.28	–	–	Annual SMP

4.1.2. SMP Plot Colony Counts

In addition to Whole Colony Counts, data are also submitted to the SMP from Plot Colony Counts at a sub-sample of sites for six species: Fulmar, Kittiwake, Shag, Guillemot, Razorbill and Puffin. The number of sites for which Plot Colony Count data have been submitted for each species between 1986 and 2019 is summarised in Table 7. Plots are distributed across the UK but are largely located in south Wales and Scotland, particularly in the Northern Isles (Figure 1).

The number of plots per site across species ranged from one to five; however, in the majority of cases there was only a single plot. There is no or limited information to assess how representative these Plot Colony Counts are, i.e. there are no comparative annual trends based on Whole Colony Counts (although comparisons might be made with trends between census periods) and no or limited information on the relative locations of plots within colonies. This latter point is important as occupancy and productivity might vary in different parts of the colony (Coulson et al. 2002). Therefore, it is important to establish how representative current productivity plots are of the site as a whole, and ensure that selected plots are randomly distributed across the site. For species where Plot Colony Counts are recommended, the Seabird Monitoring Handbook (Walsh et al. 1995) suggests that as many representative plots as can be counted in the available time should be selected, but at least five per site. For Fulmar, the Handbook recommends ideally 10 plots that cover 10–30% of the whole site population so that counts reflect any changes occurring at the whole site level. On average this is not currently being achieved. In 2019, only six (4%) of these species-sites monitored at least five Plot Colony Counts (Shag – 1, Kittiwake – 2, Guillemot – 2).

Table 7. Summary of SMP Plot Colony Count data by species including the mean number of sites for which Plot Colony Counts with data have been submitted for each species between 1986 and 2019 and the size and number of plots.

Species (count unit)	Number of sites with Plot Colony Counts (annual[1])	Mean plot size ± SD	Maximum plot size	Mean number of plots ± SD	Maximum number of plots per site
Fulmar (AON)	31 (11)	245 ± 265	1,404	1.14 ± 0.37	9
Guillemot (IND)	36 (16)	1,661 ± 1376	7,098	1.09 ± 0.40	5
Kittiwake (AON)	22 (8)	405 ± 413	2,067	1.09 ± 0.46	5
Puffin (AOB)	2 (0)	362 ± 337	893	1.89 ± 0.93	4
Razorbill (IND)	35 (16)	253 ± 319	1,830	1.08 ± 0.33	4
Shag (AON)	9 (2)	52 ± 63	248	1.01 ± 0.09	14

[1] The number of sites with Plot Colony Counts that are monitored annually (see text for definition).

In addition to the Plot Colony Count data which are currently held separately from the SMP Online database, an unknown proportion of counts in the SMP database may represent plots rather than Whole Colony Counts. This is attributed to participants not knowing about the separate Plot Colony Count spreadsheet, and who therefore submitted these plot counts through the online system, where they are treated as Whole Colony Counts. Going forward these Plot Colony Count data need to be identified and labelled as such for future analysis. The SMP online database is currently being updated so that such Plot Colony Count data can be submitted directly. In addition, for some sites and species, particularly at large sites, and for species where count estimates are extrapolated from transects/quadrats (i.e. Puffin, Manx Shearwater, Storm Petrel), the estimated/extrapolated counts are submitted directly to the SMP database with no information on how these values were calculated. This makes it impossible to account for uncertainty associated with these counts. Therefore, it is important that participants are able to also provide information on how such estimates are calculated; for example, details on correction factors (to convert individuals to breeding pairs) and response rates where calibrations are required (i.e. for burrow play-backs and Storm Petrels). Ideally the original counts would be submitted to be better able to assess uncertainty in trends within and across sites. It is also vital that these counts are labelled as Plot Colony Counts so they can be easily identified in the database.

4.2. SMP productivity data

4.2.1. SMP productivity plots

Productivity plot data have been submitted for 23 of the 25 SMP seabird species (Table 8). There are only limited submitted data for Leach's Petrel and Storm Petrel. The number of plots per site across species ranged from one to eight (although for three Kittiwake colonies there were up to 22 plots: Handa, Flamborough Head and Bempton Cliffs, and Isle of May). However, in the majority of cases productivity data are only recorded from a single plot. Furthermore, the number of plots varied across years for some sites, therefore, although the maximum number of plots at Flamborough Head and Bempton Cliffs was 22, only 16 of these were monitored in 2019. As for the Plot Colony Counts, we have no information to assess how representative the current breeding productivity plots are in relation to the wider site. However, at least five plots per site and species are typically recommended (Walsh et al. 1995). This level of coverage is only being achieved at a small proportion of sites. Furthermore, across species, the number of sites for which breeding productivity data have been submitted to the SMP has declined in recent years (Figure 2). We therefore need to re-engage participants to monitor breeding productivity at sites where monitoring was carried out in the past and emphasise the value of this in being able to detect species responses to environmental change at all survey sites.

At present, many participants only submit the aggregate productivity estimates to the SMP online database (i.e. the number of nests and total number of fledged young) even though participants may make several visits to a site during the breeding season. It is important to emphasise and encourage the submission of actual counts collected by participants from each visit.

Figure 1. Location of SMP Plot Colony Counts across the UK by the six species they are currently used for: Fulmar, Shag, Kittiwake, Guillemot, Razorbill and Puffin. Points are jittered to aid visualisation of sites where plots are monitored for multiple species.

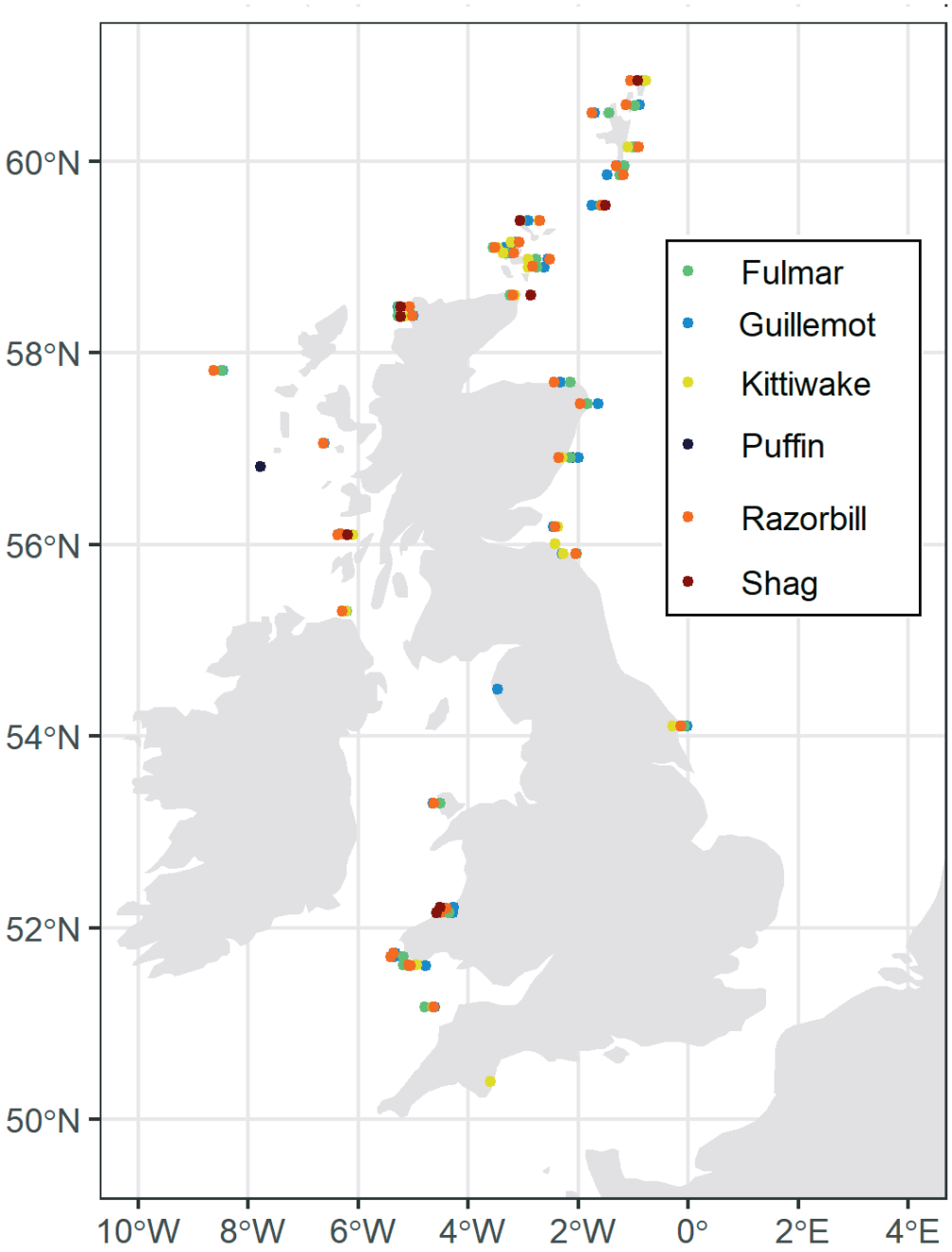


Figure 2. SMP breeding productivity coverage (n sites) by year, across species. Note that limited data were submitted in 2020 due to restrictions imposed as a response to the Covid19 pandemic, while not all data for 2021 and 2022 data had yet been submitted to the SMP database at the time of this work. Data from 2022 are also likely to be reduced due to fieldwork restrictions associated with the 2022 Highly Pathogenic Avian Influenza (HPAI) outbreak. Taken from the SMP Engagement Plan.

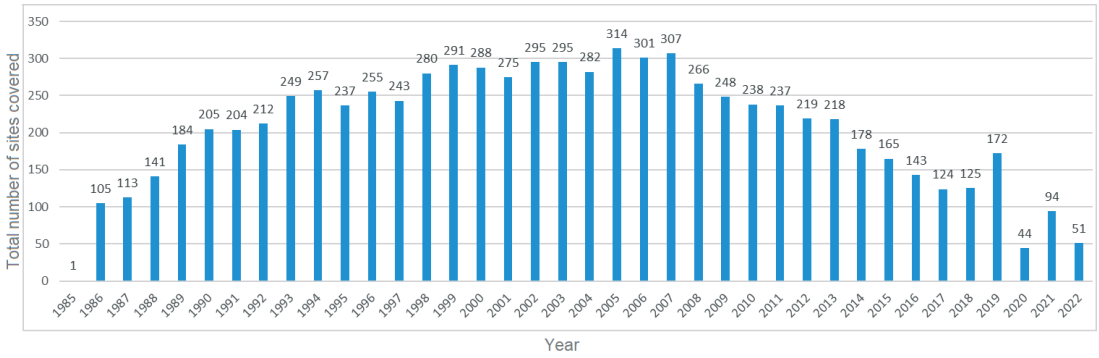


Table 8. Summary of productivity plot data in the SMP by species. Mean number and size of plots are across all sites and years. For small colonies a plot might cover 100% of the site.

Species (Count unit)[1]	Number of sites with plots	Date range across sites	Mean plot size ± SD	Maximum plot size	Mean number of plots ± SD	Maximum number of plots per site
Fulmar (AOS)	106	1986–2019	120 ± 164	1,214	1 ± 1	7
Manx Shearwater (AOS)	11	1986–2019	64 ± 45	171	1 ± 1	4
Leach's Petrel (AOS)	1	2007–2008	31 ± 20	45	1 ± 0	1
Storm-petrel (AOS)	2	2015–2019	7± 4	11	1 ± 0	1
Gannet (AON)	12	1986–2019	228 ± 258	1,592	2 ± 1	5
Shag (AOT)	89	1986–2019	54 ± 72	778	1 ± 1	8
Cormorant (AOT)	52	1986–2019	37 ± 42	422	1 ± 0	3
Arctic Skua (AON)	33	1986–2019	26 ± 33	159	1 ± 0	1
Great Skua (AON)	42	1987–2019	51 ± 72	520	1 ± 0	3
Kittiwake (AON)	135	1986–2019	141 ± 204	2,544	2 ± 2	22
Black-headed Gull (AON)	126	1987–2019	487 ± 1120	8,066	1 ± 0	1
Lesser Black-backed Gull (AON)	90	1989–2019	1091 ± 3241	23,100	1 ± 0	2
Great Black-backed Gull (AON)	162	1986–2019	13 ± 19	159	1 ± 0	1
Herring Gull (AON)	194	1989–2019	123 ± 274	3115	1 ± 0	6
Common Gull (AON)	167	1989–2019	29 ± 52	400	1 ± 0	1
Mediterranean Gull (AON)	17	2006–2019	28 ± 69	400	1 ± 0	1
Common Tern (AON)	294	1986–2019	88 ± 173	2191	1 ± 0	1
Arctic Tern (AON)	209	1986–2019	209 ± 474	5,000	1 ± 0	1
Sandwich Tern (AON)	44	1986–2019	593 ± 878	4,685	1 ± 0	1
Roseate Tern (AON)	16	1986–2019	105 ± 212	1,052	1 ± 0	1
Little Tern (AON)	143	1986–2019	30 ± 42	369	1 ± 0	3
Guillemot (IND)	36	1986–2019	99 ± 67	426	1 ± 1	6
Razorbill (IND)	29	1988–2019	62 ± 67	486	2 ± 2	8
Black Guillemot (IND)	17	1985–2014	30± 19	92	1 ± 0	1
Puffin (AOB)	12	1986–2019	92 ± 42	250	1 ± 0	2

[1] AOS – Apparently occupied sites, AON – Apparently occupied nests, AOT – Apparently occupied territories, IND – individuals, AOB – Apparently occupied burrows.

4.2.2. Nest Record Scheme data

Outside of the SMP, a number of seabird nests are monitored each year as part of BTO's Nest Record Scheme (NRS, https://www.bto.org/nrs). The extent of data currently submitted to the NRS in recent years (2017–2021) varies (Table 9) with relatively good sample sizes for some species, especially the gulls and terns, but also Manx Shearwater, Fulmar and Shag. Going forward, consideration should be given as to how these data could be better integrated with the productivity data collected by the SMP in the analysis of productivity trends.

Table 9. Total number of nest records submitted per year to the BTO's Nest Record Scheme between 2017 and 2021.

Species	2017	2018	2019	2020	2021
Fulmar	96	114	53	9	175
Manx Shearwater	0	125	11	281	228
Leach's Petrel	0	8	0	1	51
Storm Petrel	0	0	24	12	41
Gannet	0	0	1	0	36
Shag	112	184	251	88	165
Cormorant	42	15	21	6	135
Arctic Skua	13	12	20	1	12
Great Skua	43	45	32	2	12
Kittiwake	129	103	138	194	306
Black-headed Gull	381	102	24	18	115
Lesser Black-backed Gull	50	74	58	33	135
Great Black-backed Gull	29	68	44	1	46
Herring Gull	108	70	93	99	151
Common Gull	97	130	225	18	146
Mediterranean Gull	7	8	4	18	11
Common Tern	107	91	83	29	90
Arctic Tern	197	69	46	2	68
Sandwich Tern	8	25	6	0	0
Roseate Tern	1	1	2	1	151
Little Tern	588	71	244	35	214
Guillemot	23	0	5	9	42
Razorbill	9	25	58	48	179
Black Guillemot	4	4	4	5	2
Puffin	0	0	35	1	60

4.3 Survival, diet and phenology

The main focus of the SMP is to monitor abundance, through colony counts, and breeding productivity. However, to better understand change in seabird populations across the UK, the four SMP Key Sites were selected to provide more detailed monitoring of seabird breeding performance, survival rates and feeding ecology. These key sites are geographically dispersed around the UK to provide broad, representative coverage of British and Irish waters. However, there are currently no SMP Key Sites located in England, Northern Ireland or in Republic of Ireland. Therefore, to ensure representative coverage it is recommended that additional Key Sites are created at suitable locations especially in these countries, noting that there are also opportunities to enhance integrated demographic monitoring of seabirds more widely through development of RAS studies – see below – and through standardised recording of phenology and diet information.

Data on annual survival (or return rates where survey effort is high enough to ensure a re-encounter rate of close to one) for several species are therefore only collected as part of the SMP at these four Key Sites (Canna, Fair Isle, Isle of May and Skomer; Figure 3). Guillemot annual return rate data are additionally collected on Skomer. At present, diet data are only collected for a small number of species at the four Key Sites, whilst phenology data are only collected on Skomer (Table 10).

Table 10. Summary of information extracted from SMP Key Site reports on monitoring of annual survival or return rates, phenology and diet and summarised in the 2019 SMP online report (JNCC 2021).

Species	Annual return rate	Annual survival rate	Phenology[1]	Diet[2]
Fulmar			Skomer	
Manx Shearwater		Skomer		
Shag	Isle of May			Canna, Fair Isle, Isle of May
Kittiwake	Isle of May	Canna[3], Skomer	Skomer	Canna, Isle of May
Lesser Black-backed Gull		Skomer		
Herring Gull		Skomer		Canna
Great Black-backed Gull				Skomer
Guillemot	Isle of May	Canna	Skomer[4]	Canna, Fair Isle, Isle of May
Razorbill	Isle of May	Canna, Skomer	Skomer	Fair Isle, Isle of May
Puffin	Isle of May	Puffin, Skomer		Fair Isle, Isle of May, Skomer

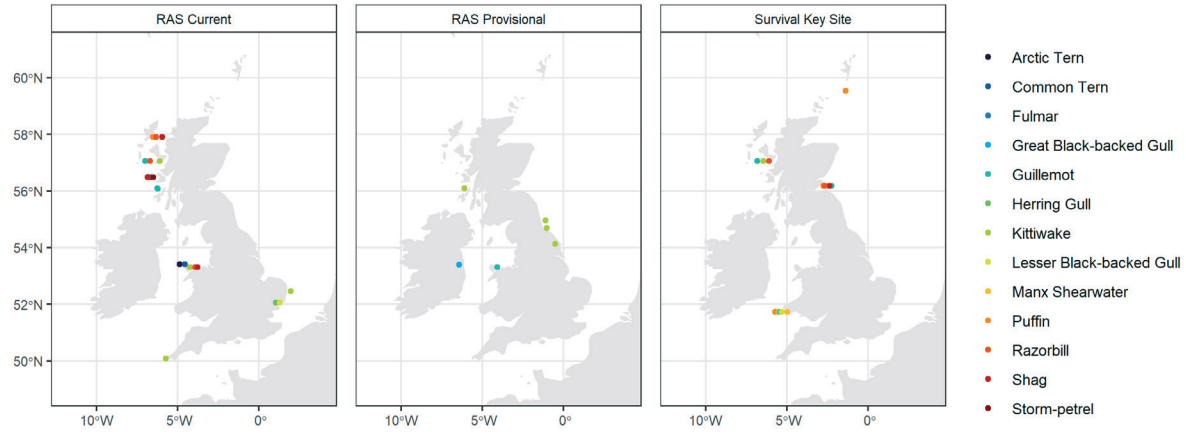
[1] Phenology on Skomer is timing of breeding assessed by recording the date each species lays its first egg. [2] Feeding frequencies are also collected for Puffin on Fair Isle and Skomer, and for Guillemot on Fair Isle. Chick weights are also collected for Puffin and Razorbill on Skomer. [3] Immature survival and age of first breeding of Guillemots are also assessed at Canna. [4] Collected as part of a long-term study by the University of Sheffield.

In addition, survival data are collected for 14 seabird species outside of the SMP as part of the RAS scheme, summarised in Table 11. Moving forwards, a key aim is to integrate reporting of these survival data with SMP reporting. The majority of current Seabird RAS studies are located in Wales and west Scotland, although three provisional RAS studies have been set up in the east of England for Kittiwake (Figure 3).

Table 11. Number of currently registered seabird 'Retrapping Adults for Survival' (RAS) projects across Britain and Ireland (with the number of these that are currently provisional in brackets) and information of seabird RAS projects that are no longer active.

Species	No. of registered RAS projects (provisional)	Range of start years of registered RAS projects	Additional historic RAS projects	Mean year length (±SD) of historic RAS projects	Year range of historic RAS projects
Fulmar	1	2020–2020	–	NA	NA
Manx Shearwater	0	NA	2	15 ± 7	1994–2014
Storm-petrel	2	2011–2011	3	14 ±5	1999–2018
Shag	3	2006–2023	2	11 ± 4	1992–2006
Kittiwake	8 (4)	2002–2021	3	14 ± 3	1992–2021
Black-headed Gull	0	NA	2	6 ± 1	2009–2017
Lesser Black-backed Gull	1	2019	2	17 ± 4	2011–2017
Great Black-backed Gull	1 (1)	2019	0	NA	NA
Herring Gull	1	2019–2019	0	NA	NA
Common Tern	1	2016	0	NA	NA
Arctic Tern	1	2013	1	3	2000–2003
Guillemot	4 (1)	2012–2020	1	5	2000–2013
Razorbill	3	2011–2013	1	8	1998–2006
Puffin	2	2008–2013	1	15	1970–1985

Figure 3. Location of sites across Britain and Ireland where monitoring of seabird survival occurs through a) existing Retrapping Adults for Survival (RAS) studies, b) provisional RAS studies, and c) Seabird Monitoring Programme (SMP) Key Sites. Points are jittered to aid visualisation of sites where survival monitoring occurs on multiple species.



4.4. Sites outwith SMP Key Sites which collect multiple metrics

An important objective of the SMP going forward, and as recommended by Robinson & Baillie (2012), is to increase integrated monitoring of multiple demographic rates outside of the Key Sites to improve our understanding of the demographic causes of changes in population trends and thus to identify the drivers behind these changes. By matching the names of SMP sites where Whole Colony Counts had been undertaken with sites monitored for breeding productivity, we calculated the number of sites where data exist for both metrics in any given year (Table 12). It is important to maintain this joint monitoring at sites where it currently occurs, noting the points above regarding the need to improve and understand the representivity of monitoring of productivity. Sites where data on both metrics have previously been collected, but are no longer, could also be the focus of future site allocations.

Based on the assessment above of SMP sites where we could match data on Whole Colony Counts, Plot Colony Counts and breeding productivity, we also identified sites (in addition to the SMP Key Sites) where current or provisional RAS studies provide monitoring of survival (Table 13). However, to improve integrated monitoring it is also useful to know which existing and defunct RAS studies exist and what data on abundance counts and productivity are collected at these sites (listed in Appendix 3). These sites can therefore be targeted in future as a starting point to obtain more consistent data on abundance, productivity and survival from multiple species at specific sites.

Outside the SMP and RAS scheme, survival and diet data are also collected by various organisations and academic projects, and would make a valuable contribution to the national monitoring of seabird populations. Diet data are not currently formally collated by the SMP, and while capturing such data, including from the Key Sites, within the SMP database is included as a core Research and Development area within the SMP Agreement, it is a relatively low-ranked priority compared to other development areas such as the need for this Sampling Strategy Review and an updated Seabird Monitoring Handbook. Registration of such seabird survival studies as RAS studies would be aided by the planned development of a facility to upload colour-ring resightings into the national Ringing Scheme database, Demography Online ('DemOn'). While it is a condition of ringing licences that all ringing and recapture data are submitted to the scheme, this does not currently apply to resighting data that are integral to many survival studies. Incorporation of the results of diet and survival studies into national monitoring will also need to adequately reflect data ownership, noting the intellectual property that is inherent in their production (https://www.ukri.org/wp-content/uploads/2022/03/NERC-080322-policy-data-021219.pdf), and thus that data may need to be excluded from open access download functions.

Table 12. Summary of the number of Seabird Monitoring Programme sites, by species, across the UK where data on abundance (by Whole Colony Counts or Plot Colony Counts) and breeding productivity occurs together between 1986 and 2019, and more recently over the last 10 years (2009–2019).

Species	1986–2019		2009–2019	
	Number of sites	mean number of years across sites ± SD	Number of sites	mean number of years across sites ± SD
Fulmar	75	7 ± 9	50	4 ± 4
Manx Shearwater	8	3 ± 3	4	4 ± 3
Leach's Petrel	0	0 ± 0	0	0 ± 0
Storm-petrel	2	4 ± 1	2	4 ± 1
Gannet	11	9 ± 9	10	4 ± 4
Shag	67	7 ± 9	40	4 ± 4
Cormorant	49	5 ± 5	25	3 ± 3
Arctic Skua	14	15 ± 11	14	6 ± 4
Great Skua	20	7 ± 8	16	4 ± 3
Kittiwake	99	11 ± 9	77	5 ± 3
Black-headed Gull	116	5 ± 6	81	3 ± 3
Lesser Black-backed Gull	82	5 ± 5	58	3 ± 2
Great Black-backed Gull	154	6 ± 6	89	3 ± 2
Herring Gull	178	7 ± 7	113	3 ± 3
Common Gull	153	6 ± 7	93	3 ± 2
Mediterranean Gull	17	3 ± 2	15	2 ± 1
Common Tern	262	7 ± 8	131	4 ± 3
Arctic Tern	168	7 ± 8	96	3 ± 3
Sandwich Tern	42	10 ± 10	20	6 ± 3
Roseate Tern	16	9 ± 8	8	1 ± 0
Little Tern	138	9 ± 8	75	2 ± 2
Guillemot	26	9 ± 10	17	4 ± 4
Razorbill	19	7 ± 8	13	5 ± 4
Black Guillemot	4	4 ± 5	3	1 ± 1
Puffin	9	6 ± 8	8	2 ± 2

Table 13. Sites across the UK where monitoring of multiple metrics (colony counts, breeding productivity and survival) occurs for specific species, outwith the SMP Key Sites.

Species	Country	Site	Years with both colony counts[1] and productivity estimates		Survival (start year)
			Number of years	Year range	
Shag	Wales	Puffin Island	12	2010–2022	RAS (2015)
Kittiwake	England	Flamborough Head and Bempton Cliffs	22	1986–2019	RAS (2016)
Kittiwake	England	Gateshead Kittiwake Tower	15	2000–2015	RAS (2016)
Kittiwake	England	Lowestoft	30	1986–2016	RAS (2012)
Kittiwake	England	Rinsey	5	2008–2016	RAS (2012)
Kittiwake	Scotland	Canna and Sanday	35	1986–2021	RAS (2011)
Kittiwake	Wales	Puffin Island	11	1991–2022	RAS (1982)
Lesser Black-backed Gull	England	Havergate Island	10	2009–2021	RAS (2012)
Herring Gull	England	Havergate Island	10	2009–2021	RAS (2012)
Common Tern	Wales	The Skerries RSPB	23	1991–2013	RAS (2016)
Arctic Tern	Wales	The Skerries RSPB	26	1986–2013	RAS (2013)

4.5. Summary of whether the previous recommendations have been achieved

The key recommendations from Cook & Robinson (2010) on improving the power and accuracy of annual abundance and productivity trend estimates are still valid and important. Therefore, our recommendations build on these to emphasise the need to still increase the number of sites that are monitored regularly, especially given that for many species and countries we are currently unable to produce annual trends (Appendix 1). This is particularly the case for productivity, given that the coverage of sites monitoring productivity has declined in recent years rather than increased (section 4).

In this report we were unable to explore the use of sample plots in depth, given the limited overall current level of sampling and that the number of plots used per site for monitoring abundance and productivity are also low with respect to the recommendations from the Seabird Monitoring Handbook. Therefore, more work needs to be done on ensuring that the number of plots per site is increased and that these are representative of what is occurring at the site level, as per previous recommendations.

Although we have provided a stock-take of current survival monitoring via the SMP Key Sites and RAS scheme we have not explored these data in detail to determine whether the recommendations from the above reviews (Table 2) are being achieved. The number of registered active seabird RAS studies is similar now to the Horswill et al. (2015) review (22 versus 21 active registered RAS studies). However, there are currently six additional provisional RAS studies that have since been established: four for Kittiwake and single studies for Great Black-backed Gull and Guillemot. The only phenology data currently being collected are for a small number of species on Skomer, whilst monitoring of diet is still limited to a small number of species at the four Key Sites so this has not been expanded as recommended. One option to achieve this is to develop the SMP database to enable diet and phenology data that are currently being collected outside the Key Sites to be submitted. Although this does not occur at present this was identified as an SMP development priority.

5. DATA SIMULATIONS

Data simulations were used to assess the precision to which reliable estimates of population size might be obtained under different levels of sampling and through stratification, and thus requirements to robustly monitor population trends. Example simulations are provided here for six species: Arctic Skua, Shag, Little

Tern, Black-headed Gull, Puffin and Gannet. These species were selected to reflect a range of site size distributions, ranging from Arctic Skua (with many small sites) to Gannet (with few, predominantly very large sites). A CV of 0.1 is typically required to provide precise population estimates (Dixon et al. 2005; Baraloto et al. 2013).

Initial evaluation considered the minimum sample number 'T' of sites to include in simulations. Coefficients of Variation (CVs) decreased as the proportion of sites sampled increased. However, stepped patterns, although more 'smooth' than when using a threshold of T = 0 (Appendix 4), were still nonetheless inherent within the resampling approach at all T values; this was more apparent for regions where sample sizes were smaller, given a smaller pool of sites available to draw unique simulations from, with this magnified further through stratification. There were flat lines in the relationships between CV and the proportion of sites sampled at low proportions if fewer than T = 5 sites were selected, and thus when the default minimum of five sites (or the maximum number of available sites per stratification category if less than five were available) was applied (see section 2.3).

Patterns in the decrease of CV values with an increase in the proportion of sites sampled varied across species given the site size distributions above (Figure 4) (results for all other species and countries are provided in Appendix 5). At the UK level, the relative decrease in CV in relation to the proportion of sites sampled was less for Little Tern and Gannet than other species. However, in all cases the stratification produced lower CVs, i.e. more precise population estimates, and a quicker drop off of uncertainty over proportion of sites sampled in comparison to the global curves. There was, however, considerable variation in these patterns by species and country.

There was also a high degree of variation in absolute CV values between species; for example, for the species for which results are presented here, CV values ranged from less than 1.0 for four species to up to 1.5 and 2.0 and for Black-headed Gull and Puffin respectively.

The difference between the global and stratified curves was most pronounced for Puffin and Gannet, followed by Black-headed Gull and Shag and least for Little Tern, highlighting the different relative value of stratifying by site size for different species. For Arctic Skua, sites are relatively homogeneous in size, with many monitored as 1 km squares, and hence CV values were low and showed a clear decline relative to the proportion of sites sampled. Only one curve was generated for this species as only one stratum was considered, with site size strata 1–9 and 10–99 grouped together (see section 2.3). Similarly, for other species, no stratified line is presented for a particular country if sites were all in the lowest size stratum or a decision was made to combine the lowest two strata.

For Shag, most sites (746 of 940) were in Scotland; hence the results for the UK and Scotland were similar. However, for England (124 sites) the CV decay relative to the proportion of sites sampled was much less steep and there was greater disparity between global and stratified lines than for Scotland. Interestingly, stratified lines for Scotland and England for Shag were much more similar than their global counterparts. For Wales, fewer sites fed into the sampling, with CV values decreasing less fast relative to the proportion of sites sampled, and stratified and global curves were similar once the proportion of sites sampled increased beyond 0.4, being highly disparate prior to that.

For Little Tern, site sizes were relatively homogeneous, and thus there was more similarity between global and stratified curves (Table 4); nevertheless, CVs were still reduced by carrying out stratification. Regional similarities were also apparent for this species with results for England (both global and stratified, 32 sites) aligning most closely with the UK pattern (72 sites).

For Black-headed Gull, an interesting difference was recorded between Scotland and England, where global CV curves were very congruent, but stratification resulted in greater reduction in CV values for England (n = 177 sites) than Scotland (n = 294 sites) – results for England being most similar to those for the UK. For Northern Ireland and Wales, smaller samples resulted in a more stepped pattern in CV values relative to the proportion of sites sampled. Note that annual trends currently produced for Black-headed Gull only consider coastal colonies, whereas this simulation considered a 'global' set of both inland and coastal sites from the Seabirds Count census. Sampling design for this species may thus require additional considerations of any inherent differences in expected trends between these areas.

For Puffin, site sizes vary greatly and there are some very big colonies accounting for a significant proportion of the UK population (Table 6). For this species there was consequently clear disparity between the global and stratified CV curves, most especially for Scotland and the UK, emphasising the need to stratify sampling. For Wales and England there was less of a clear decline in CV values relative to the proportion of sites sampled, due to very small sample sizes, but with stratification still showing benefits for estimation of populations in this country.

Gannets breed in a small number of large colonies in the UK. Cook & Robinson (2010) reported that trends estimated from the SMP annual data showed significant disparity to changes calculated from the Seabird Colony Register (1986–1989) and Seabird 2000 (1998–2002) censuses, because of biases in the annual sample towards smaller sites. As sample sizes for resampling were low and the application of a minimum threshold of T = 5 sites, there was a steady near-linear decay of CV values once the proportion of sites sampled increased beyond 0.3, for the UK and Scotland, with CV values also greatly reduced through stratification.

Results for Puffin and Gannet, especially, need to be interpreted with care, as the simulation approach employed here is aimed at assessing uncertainty arising from sampling across a set of colonies with heterogeneous sizes, but assumes that counts of individuals at each site are without error. This assumption is likely not met in reality for very large colonies (cf. section 3.1.3). Meaningful uncertainty estimates for species like Gannet can only be achieved if efforts are introduced to quantify observation error at the site-level.

We used a CV value of 0.1 as the basis for our species-specific recommendations for monitoring abundance. Specifically, we calculated the proportion of sites that need to be monitored for each species and country to achieve a CV less than 0.1. We also calculated the number of sites this relates to, to inform future engagement and recruitment of participants (see Appendix 6 for the CV results for each species and country based on the number of sites). For most species and countries, a high proportion of sites need to be monitored across size strata to meet the criterion of a CV of 0.1 or less, and this level of coverage is typically not currently being met (Table 14). At present, the only species for which the required level of coverage is being achieved to meet this criterion are Cormorant and Arctic Tern at the UK level and Cormorant at the England level. We also calculated the proportion and number of sites required to meet a CV value of 0.2, which although is not ideal, might be a more feasible target to meet. At current levels of monitoring this criterion is also not met for most species and countries (Table 15). Note, for some species (e.g. Roseate Tern) and countries (Isle of Man and Channel Islands) the sample sizes of sites were too small to produce CV values from the simulations.

Figure 4. Coefficient of Variation (CV) around estimates of population size obtained under different levels of sampling using a global approach sampling across all sites (solid line) and stratifying sites by size (dashed line) for six example seabird species for the UK, England, Wales, Scotland and Northern Ireland. Smaller CVs represent more precise population estimates. Sample sizes per species and region are displayed. Grey horizontal lines show where a CV of 0.1 and 0.2 intersect the strata curves. All CV curves use a minimum site threshold of T = 5, i.e. for 10 sites and a proportion of 0.3, five sites would be chosen as opposed to three (see section 2.3). CV lines were not produced for species/country combinations where less than 10 sites were available as sample sizes were deemed too low for a meaningful sampling appraisal. Only one curve was generated for Arctic Skua as only one stratum was considered, with site size strata 1–9 and 10-99 grouped together (see section 2.3). Similarly, for other species, no stratified line is presented for a particular country if sites were all in the lowest size stratum or a decision was made to combine the lowest two strata. For Puffin the stratified line for the UK is partially hidden by that for Scotland. Site-level counts of individuals are assumed to be known without error, hence the CV reduces to zero when all sites are sampled. This assumption is unlikely to hold in reality.

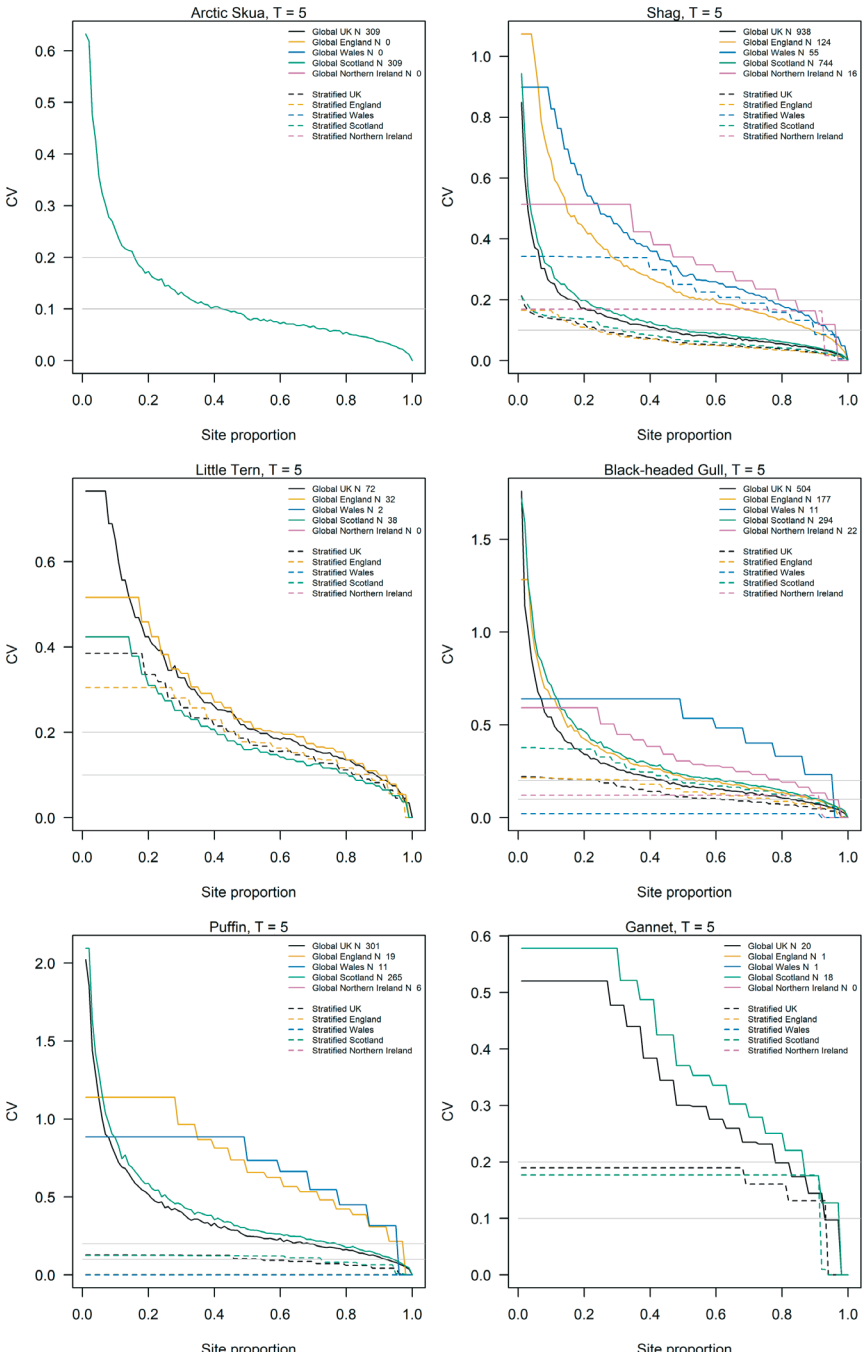


Table 14. The percentage (and number) of sites to be monitored across size strata to meet a Coefficient of Variation (CV) value of 0.1 or less around estimates of population size, stratifying sites by size, for each species and country, based on the results of the simulations. This includes monitoring at least five sites in each colony size strata (or the number of sites available if less than five). The Isle of Man and Channel Islands are not included due to the small number of sites per species. Blank cells (–) indicate no colonies or too few colonies for the sampling simulations. Census data were not available to include Manx Shearwater, Leach's Petrel or Storm Petrel in simulations. Values in bold are where the number of sites across size strata are currently being met by annual monitoring via Whole Colony Counts. See Table 2 in section 3.2.4 to compare with previous SMP recommendations.

Species	UK	Scotland	England	Wales	Northern Ireland
Fulmar	10 (174)	11 (148)	82 (185)	11 (14)[1]	92 (40)
Gannet	94 (19)	92 (17)	–	–	–
Shag	25 (234)	33 (246)	23 (29)	90 (50)	93 (15)
Cormorant	22 (51)	70 (66)	61 (65)	50 (14)[1]	–
Arctic Skua	43 (133)	43 (133)	–	–	–
Great Skua	83 (647)	83 (647)	–	–	–
Kittiwake	21 (80)	67 (196)	36 (21)[1]	95 (15)	93 (14)[1]
Black-headed Gull	62 (312)	85 (250)	77 (136)	91 (10)[1]	92 (20)
Lesser Black-backed Gull	80 (359)	8 (19)[1]	19 (20)[1]	24 (17)	93 (21)
Great Black-backed Gull	21 (322)	11 (146)	72 (100)	88 (46)	60 (9)[1]
Herring Gull	9 (142)	10 (105)	55 (201)	90 (137)	77 (13)[1]
Common Gull	4 (46)	4 (45)	60 (6)[1]	–	73 (11)[1]
Mediterranean Gull	22 (13)[1]	–	26 (13)[1]	–	–
Little Tern	85 (61)	81 (31)	88 (28)	–	–
Sandwich Tern	73 (19)[1]	–	92 (11)[1]	–	–
Common Tern	70 (244)	46 (69)	96 (168)	–	92 (12)
Roseate Tern	–	–	–	–	–
Arctic Tern	4 (25)	45 (266)	92 (11)[1]	–	–
Guillemot	47 (201)	44 (139)	43 (23)[1]	92 (49)	–
Razorbill	83 (466)	59 (238)	23 (18)[1]	30 (20)[1]	45 (5)[1]
Black Guillemot	14 (156)	16 (171)	–	–	85 (34)
Puffin	57 (172)	74 (196)	74 (14)[1]	100 (11)[1]	–

[1] Indicates where the recommended percentage (and number) of sites to be monitored across size strata is based on monitoring at least five sites in each colony size strata (or the number of sites available if less than five).

Table 15. The percentage (and number) of sites to be monitored across size strata to meet a Coefficient of Variation (CV) value of 0.2 or less around estimates of population size, stratifying sites by size, for each species and country, based on the results of the simulations. This includes monitoring at least five sites in each colony size strata (or the number of sites available if less than five). The Isle of Man and Channel Islands are not included due to the small number of sites per species. Blank cells (–) indicate no colonies or too few colonies for the sampling simulations. Census data were not available to include Manx Shearwater, Leach's Petrel or Storm Petrel in simulations. Values in bold are where the number of sites across size strata are currently being met by annual monitoring via Whole Colony Counts. See Table 2 in section 3.2.4 to compare with previous SMP recommendations.

Species	UK	Scotland	England	Wales	Northern Ireland
Fulmar	2 (29)[1]	2 (29)[1]	7 (16)	11 (14)[1]	92 (40)
Gannet	70 (14)[1]	78 (14)[1]	–	–	–
Shag	2 (19)	2 (15)	11 (14)[1]	68 (37)	63 (10)[1]
Cormorant	6 (15)[1]	31 (29)	25 (26)	50 (14)[1]	–
Arctic Skua	16 (49)	16 (49)	–	–	–
Great Skua	40 (312)	43 (335)	–	–	–
Kittiwake	6 (23)[1]	24 (70)	36 (21)[1]	79 (13)	93 (14)[1]
Black-headed Gull	25 (126)	50 (147)	37 (65)	91 (10)[1]	86 (19)[1]
Lesser Black-backed Gull	46 (207)	8 (19)[1]	19 (20)[1]	24 (17)[1]	93 (21)
Great Black-backed Gull	6 (92)	2 (27)	32 (44)	59 (31)	60 (9)[1]
Herring Gull	1 (20)	2 (20)	7 (26)	48 (73)	77 (13)[1]
Common Gull	2 (18)[1]	2 18)[1]	60 (6)[1]	–	73 (11)[1]
Mediterranean Gull	22 (13)[1]	–	26 (13)[1]	–	–
Little Tern	48 (35)	41 (16)	48 (15)	–	–
Sandwich Tern	73 (19)[1]	–	92 (11)[1]	–	–
Common Tern	31 (108)	10 (15)	78 (136)	–	92 (12)[1]
Roseate Tern	–	–	–	–	–
Arctic Tern	3 (20)[1]	17 (100)	92 (11)[1]	–	–
Guillemot	12 (51)[1]	8 (25)1	43 (23)[1]	74 (39)	–
Razorbill	40 (224)	7 (28)	23 (18)[1]	30 (20)[1]	100 (11)[1]
Black Guillemot	2 (22)	2 (21)	–	–	47 (19)
Puffin	8 (25)[1]	9 (25)[1]	74 (14)[1]	100 (11)[1]	–

[1] Indicates where the recommended percentage (and number) of sites to be monitored across size strata is based on monitoring at least five sites in each colony size strata (or the number of sites available if less than five).

6. DISCUSSION AND RECOMMENDATIONS

6.1. Discussion

The key messages from the previous reviews of the SMP all emphasise that to produce robust trends for seabird species for the UK, its constituent countries and Crown dependencies, and for Britain and Ireland, we need to increase the number of sites that are consistently monitored on an annual basis and ensure that these are geographically representative. There was also an emphasis on monitoring multiple species and metrics at the same sites, particularly abundance, breeding productivity and survival, to better understand seabird ecology and the mechanisms and thus drivers of population change by taking a unified approach to monitoring across colonies.

Without robust data on seabird demographics, it will be challenging to:

- identify key stressors acting on populations, and by which mechanisms;
- detect population impacts of known stressors, such as marine renewables and disease outbreaks (Cook et al. 2019; Pearce-Higgins et al. 2023); and
- identify and implement necessary conservation and management actions.

The main focus of this review has been on abundance, as it has been possible to compare current levels of monitoring in the context of the up to date population estimates of seabirds in Great Britain provided by the recent Seabirds Count national census (Burnell et al. 2023). Furthermore, this process has enabled us to consider the way the current abundance trends are calculated and also consequently how we might approach producing trends and conduct surveying for species that are more challenging to monitor (e.g. the burrow nesters and urban gulls) and for which the UK holds internationally important breeding populations, specifically Manx Shearwater and Great Skua.

Specifically, this review aimed to build upon and update the recommendations of previous reviews, by providing: (i) overarching recommendations on the approaches for sampling across species; (ii) more detailed species-specific recommendations on how sites should be selected for monitoring to produce more robust trends; and (iii) highlighting wider considerations for the Seabird Monitoring Programme.

Given that seabird sites can show considerable heterogeneity in size, our main recommendations focus on ensuring that, for abundance monitoring, sites are sampled appropriately so that an adequate proportion of the total population is included at the country level in the first instance, and then at the wider UK level. It is further crucial for species breeding at large colonies (>1,000 individuals) that wherever possible, the uncertainty in site-level counts of individuals is quantified.

Our recommendations are largely based on the review and simulations of abundance counts, which have been informed by the recent census data and the simulations in section 5. It is important to point out that these simulations assume that counts of individuals at each site are known without error. This assumption is likely not met in reality, in particular for very large colonies (cf. section 3.1.3). Meaningful uncertainty estimates for species breeding in a relatively small number of very large colonies can only be achieved if efforts are introduced to quantify observation uncertainty at the site-level (e.g. through multiple visits). Where it is not possible to conduct annual Whole Colony Counts, representative Plot Colony Counts, that capture changes at the centre and edge of sites, should be implemented across and within sites to reduce uncertainty.

6.2. Overarching recommendations

Our overarching recommendations highlight the need for improved integrated monitoring of seabird abundance, productivity and survival, as well as diet and phenology. However, while we were able to quantify the requirements for robust monitoring of abundance – and previous work has considered the sampling protocols for estimating the survival rates of seabirds (Horswill et al. 2015, 2018) – it was not feasible to provide a similar assessment of the sampling requirements for monitoring productivity. It is thus important that the recommendations with respect to these metrics from previous reviews (summarised in section 2) should continue to be implemented. The recommendations below thus bring together both updated recommendations and others carried forward from previous reviews.

- Increase regular abundance monitoring at a greater proportion of sites to obtain robust population trends. Specifically, aim to obtain a CV of 0.1 around estimates of population size and thus to robustly monitor population trends (see Section 6.3 and Table 16). This requires a stratified approach to ensure that sites are monitored across size strata, especially in the largest strata. Regular checks should be made to determine whether the CV thresholds are being met.
- Implement an approach to prioritise sites within site size strata for future abundance monitoring, accounting for colony size heterogeneity, whilst ensuring an adequate proportion of the population is covered.
- Promote the use of abundance sample plots (Plot Colony Counts) for all species and sites, especially where Whole Colony Counts cannot be achieved. This should be promoted alongside updating the Seabird Monitoring Handbook where clear and concise methods for plot selection will be incorporated, emphasising that multiple, representative plots per site are required.
- Capitalise on opportunities where multiple visits are currently being made to colonies (i.e. to collect productivity data) to obtain repeated abundance counts at sites.
- Promote repeat abundance counts at a sub-sample of sites that can be visited multiple times during the breeding season, and ensure count data from all visits are submitted, to quantify the extent of variation attributed to occupancy (i.e. variation in attendance of birds within sites at different times of the season) and observer count error. This is particularly important for species breeding in relatively few large colonies and should be incorporated into the updated Seabird Monitoring Handbook.
- Promote the submission of data for abundance and productivity plots on a nest by nest basis, and coordination with the Nest Record Scheme. For Plot Colony Counts this will require changes in the SMP database so that data can be submitted by participants along with details on correction factors and response rates where calibrations are required (i.e. for burrow play-backs and Storm Petrels).
- Prioritise monitoring of sites for abundance and productivity at the individual country level so that country-level trends can be produced in addition to those at the UK level.
- Promote the importance of monitoring breeding productivity from a representative number of nests and plots and re-engage participants at sites where these data have been collected in the past, where contact permissions have been granted. It is also important that participants submit data on the number of sample nests and young fledged for all site visits rather than just providing a summary of all visits.
- Produce confidence intervals for productivity trends, noting that depending on how these are calculated they may not fully represent the uncertainty around productivity estimates.
- Promote coverage of inland sites and non-natural nesters to allow representative abundance and productivity trends to be produced for these components of a species populations.
- Integrate reporting of survival data for RAS studies into SMP reporting.
- Encourage and prioritise monitoring at sites where existing monitoring of other demographic rates or species is taking place, especially existing RAS studies, to improve the number and geographical representation of sites with integrated monitoring. This includes the creation of additional Key Sites, specifically in England and Northern Ireland, to ensure representation of enhanced integrated monitoring, including of diet and phenology, across the UK and open up data submission for phenology and diet details in SMP Online for all.
- Collate and incorporate existing long-term abundance, breeding success, diet and phenology data that are not currently submitted to the SMP, and encourage the registration of seabird survival studies as RAS studies, whilst considering data ownership.

For productivity, the above overarching recommendations incorporate the key recommendations from Cook & Robinson (2010) in emphasising the need for more regular monitoring of productivity from more geographically representative sites, and to increase the number of nests and plots monitored at each site to ensure representative productivity estimates at the site level. It will also be valuable to explore how data

submitted to the NRS can be integrated with productivity data in the SMP. Considering the records that are currently submitted to NRS (Table 9) this could be particularly useful for Shag, gulls and terns, as well as for box-nesting Black Guillemot.

Considering the potential of seabird RAS studies, the key recommendations from Robinson & Baillie (2012) and Horswill et al. (2015, 2018) to obtain accurate survival rates and related demographic rates were to:

- monitor survival from multiple species, ideally at sites where data on colony size and breeding productivity data are already, or can be, monitored.
- increase the geographical representation of RAS studies, especially through encouraging existing ringing groups that regularly ring seabirds to establish RAS studies as well as evaluating the potential continuation of lapsed RAS studies.
- encourage RAS studies to incorporate colour-ringing to increase resighting effort; and
- maintain a sample of birds ringed as chicks at a sample of sites to determine the proportion of birds of a breeding age that do not breed in a given year (by age-class) and age of first breeding.

6.3. Species-specific abundance monitoring recommendations

For the species-specific recommendations we considered what approach is required for monitoring abundance at each country level and at the UK level. Our recommendations consider the distribution of site sizes and therefore whether we should stratify sampling across site strata, and if so what proportion of sites should be targeted within each strata following the decision tree set out in Appendix 7.

Based on the considerations outlined in the decision tree we identified four approaches to monitor abundance, taking into consideration the data simulation (section 5) and assessment of the number of sites that need to be monitored to reach a CV of 0.1 (Gold standard, Table 14) or 0.2 (Silver standard, Table 15) around estimates of population size and thus to robustly monitor population trends.

> **Approach 1.** Aim to monitor X% of sites via Whole Colony Counts or plots where necessary.
>
> **Approach 2.** Aim to monitor the majority of sites / the population via Whole Colony Counts or plots where necessary.
>
> **Approach 3.** Aim to monitor X% of sites in the largest size strata via plots, plus continue to monitor current smaller sites through via Whole Colony Counts or plots where necessary.
>
> **Approach 4.** Aim to monitor X% of sites across size strata via Whole Colony Counts or plots where necessary.

Where the value of X refers to the percentage of species-specific sites calculated at the UK (Table 16, 17) or country (Appendix 8) level.

The sampling approach that is recommended for each species at the UK level is provided in Table 16. In the first instance, at each species and country level, we recommend aiming to obtain CV values of 0.1 to ensure robust trends. Where the level of coverage that would be needed to achieve this is not practical for a species or country, obtaining a CV value of 0.2 is recommended. Considering a CV of 0.1, recommendations for the number of sites that should be monitored across size strata at the UK level were only met for three species: Cormorant, Arctic Tern and Roseate Tern (Table 16). Although the number of sites covered by current annual monitoring is higher than the recommended values for Common Gull, a greater proportion of sites within the largest size strata need to be monitored to produce robust trends (Table 16, Appendix 2). For the remaining 18 species, the number of sites to be monitored (across size strata, dependent on the recommended approach) needs to increase.

Furthermore, for some species and countries, recommendations from the data simulations on the proportion of sites to be monitored are relatively low (i.e. less than 5% for Common Gull and Arctic Tern at the UK level, Table 16), especially if a CV of 0.2 is the criterion (Table 15). Although this may be adequate for producing robust trends, the data collected from monitoring abundance is used for numerous reasons, especially at a local scale. Therefore, to ensure that we collect representative data for each species and country, we also recommend that a minimum of 15% of sites are monitored on an annual basis, ideally across size strata to detect potential differences in population trends related to site size and associated density dependence.

This links to the current approach for producing abundance trends, where indices are generally considered representative if they are based on actual (rather than imputed) data from at least 15% of sites present within the SMP database (with at least three counts). We modified that general rule here, by considering whether at least 15% of occupied UK sites from the latest seabird census, 'Seabirds Count', are currently covered by annual (at least 50% of years since 2000) monitoring, as ideally we want robust trends based on data from sites that are consistently monitored on a frequent basis, preferably every year.

At each species and country level, if the number of sites currently being covered is adequate to obtain a CV of 0.1 around estimates of population size, and this represents at least 15% of all sites and the population currently monitored, we recommend that this current level of monitoring should continue. However, it is important to regularly check that these thresholds are being met.

Where 15% of sites and the population are not currently monitored we recommend increasing coverage so that these thresholds are met. For most species and countries, stratifying the sites by size of site and targeting greater coverage in the larger colony-size strata provides an effective way of ensuring that a greater proportion of the population is covered. The exception to this rule is for Arctic Skua, as given that most sites are small, there is no need to stratify. This is also the case for countries where only a small number of relatively small colonies occur, such as for several species in the Channel Islands, Isle of Man and Northern Ireland. When only a small number of sites occur for a species we recommend a minimum of five sites should be monitored per colony-size stratum, or all colonies where the number is lower than five (based on the initial evaluation of CV values in relation to the proportion of sites sampled and the number of sites included; see section 5 and Appendix 4). For some species and countries, there are few sites in particular size strata (i.e. five or fewer), with the result that it is recommended that a very high proportion of the population should be monitored; for example, for many species in Northern Ireland (Appendix 8). Where it is not feasible to achieve this level of monitoring, we recommend targeting monitoring of the largest colonies in the first instance to ensure a representative proportion of the population is covered.

It is vital that feasible annual monitoring approaches are developed for burrow-nesting species through representative Plot Colony Counts to ensure that we can produce annual trend estimates for these species, especially Manx Shearwater for which we have internationally important breeding populations (JNCC 2023).

Currently, abundance trends for Black-headed Gull and Common Gull are only produced for coastal nesters, whilst trends for Lesser Black-backed Gull and Herring Gull are only produced for natural nesters, and therefore do not include gulls nesting inland or at urban sites, respectively. The approach outlined here, stratifying sites according to the relative size of sites and thus their representativeness of each other, might need to be further enhanced to consider any inherent differences in trends that might be expected between inland and coastal habitats for these species.

For Lesser Black-backed Gull and Herring Gull, particular consideration has been given to: (i) whether ground based surveys might be used to assess numbers of urban-nesting gulls and consequently (ii) the appropriate sampling design for estimating the size of the urban component of the species' populations. Pilot work (Woodward et al. 2020) compared ground level counts with counts made from digital aerial surveys in two study areas. Models with four urban habitat strata were then used for estimating populations. The work indicated that counts of Apparently Occupied Nests (AON) from aerial surveys were best predicted by ground level counts of individual gulls or Apparently Occupied Territories (AOT) and separately for each species, but the poor fit of models and poor match of predicted to expected population estimates suggested that models were not robust enough to produce reliable population estimates for a national survey. Further work (Burnell 2021a, 2021b) built on this study to extend the comparison of ground level and digital aerial survey counts to further study areas, and thus increase the sample for modelling, while also developing the modelling approach. While this provided improvements, there remained uncertainty in the robustness of the correction model and the inherent detectability issue with the survey method itself. Additional comparison of ground level and digital aerial survey counts further expanded the sampling available for modelling and provided a basis for estimating the species' urban populations as part of Seabirds Count.

While the approach provided a means to extensively sample the species' population across the urban environment and also an appropriate stratification, uncertainty in population estimates through this approach is likely to be high given the need to propagate the error associated with the relationships between ground level counts of individuals and aerial survey counts of AONs together with that associated with extrapolating these sample counts to population estimates through bootstrapping. Consequently, it

Table 16. Approach and recommendation required to monitor the abundance of breeding seabird species at the UK level (based on the decision tree in Appendix 7). The recommended percentage and number of sites to be monitored to obtain a CV of 0.1 around estimates of population size and thus to robustly monitor population trends are also provided. These approaches may need to be enhanced to ensure inland and urban colonies are also adequately covered for Black-headed Gull, Common Gull, Lesser Black-backed Gull and Herring Gull. Census data were not available to include Manx Shearwater, Leach's Petrel or Storm Petrel in simulations and thus recommendations.

Species	Recommended approach	Recommended percentage (and number) of sites	Number of sites covered through annual monitoring via Whole Colony Counts[1]	Overall recommendation to obtain a CV of 0.1[2]
Fulmar	4	10 (174)	67[3]	Increase coverage by 160%
Gannet	3	94 (19)	2[3]	Increase coverage by 850%
Shag	4	25 (234)	48	Increase coverage by 388%
Cormorant	4	22 (51)	79	Continue
Arctic Skua	1	43 (133)	9	Increase coverage by 1378%
Great Skua	4	83 (647)	7	Increase coverage by 9143%
Kittiwake	3	21 (80)	60[3]	Increase coverage by 33%
Black-headed Gull	4	62 (312)	52	Increase coverage by 500%
Lesser Black-backed Gull	4	80 (359)	46	Increase coverage by 680%
Great Black-backed Gull	4	21 (322)	87	Increase coverage by 270%
Herring Gull	4	9 (142)	104	Increase coverage by 37%[4]
Common Gull	4	4 (46)	61[3]	Increase coverage in larger strata[4]
Mediterranean Gull	2	22 (13)	9[3]	Increase coverage by 44%
Little Tern	2	85 (61)	36	Increase coverage by 69%
Sandwich Tern	2	73 (19)	16	Increase coverage by 19%
Common Tern	4	70 (244)	71	Increase coverage by 244%
Roseate Tern	2	Majority/all (3)	4	Continue
Arctic Tern	4	4 (25)	50	Continue[4]
Guillemot	3	47 (201)	48	Increase coverage by 319%
Razorbill	3	83 (466)	54[3]	Increase coverage by 763%
Black Guillemot	4	14 (156)	27[3]	Increase coverage by 478%
Puffin	3	57 (172)	18[3]	Increase coverage by 856%

[1] Excludes sites where the last recorded count was zero. See Table 6 and Appendix 2 for the number of sites monitored within each size strata. [2] This is a simplified recommendation and also needs to take into the recommended approach to sampling across size strata. [3] Current annual monitoring under-represents sites in the largest size strata. [4] Although the recommended percentage of sites is expected to be adequate to meet a target CV of 0.1, we recommend aiming to cover at least 15% of sites to ensure data are representative.

Table 17. Approach and recommendation required to monitor the abundance of breeding seabird species at the UK level (based on the decision tree in Appendix 7). The recommended percentage and number of sites to be monitored to obtain a CV of 0.2 around estimates of population size and thus to robustly monitor population trends are also provided. These approaches may need to be enhanced to ensure inland and urban colonies are also adequately covered for Black-headed Gull, Common Gull, Lesser Black-backed Gull and Herring Gull. Census data were not available to include Manx Shearwater, Leach's Petrel or Storm Petrel in simulations and thus recommendations.

Species	Recommended approach	Recommended percentage (and number) of sites	Number of sites covered through annual monitoring via Whole Colony Counts[1]	Overall recommendation to obtain a CV of 0.2[2]
Fulmar	4	2 (29)	67[3]	Increase coverage in larger strata[4]
Gannet	3	70 (14)	2[3]	Increase coverage by 600%
Shag	4	2 (19)	48	Continue[4]
Cormorant	4	6 (15)	79	Continue[4]
Arctic Skua	1	16 (49)	9	Increase coverage by 444%
Great Skua	4	40 (312)	7	Increase coverage by 4357%
Kittiwake	3	6 (23)	60[3]	Increase coverage in larger strata[4]
Black-headed Gull	4	25 (126)	52	Increase coverage by 142%
Lesser Black-backed Gull	4	46 (207)	46	Increase coverage by 350%
Great Black-backed Gull	4	6 (92)	87	Increase coverage by 6%[4]
Herring Gull	4	1 (20)	104	Continue[4]
Common Gull	4	2 (18)	61[3]	Continue[4]
Mediterranean Gull	2	22 (13)	9[3]	Increase coverage by 44%
Little Tern	2	48 (35)	36	Continue
Sandwich Tern	2	73 (19)	16	Increase coverage by 19%
Common Tern	4	31 (108)	71	Increase coverage by 52%
Roseate Tern	2	Majority/all (3)	4	Continue
Arctic Tern	4	3 (20)	50	Continue[4]
Guillemot	3	12 (51)	48	Increase coverage by 6%[4]
Razorbill	3	40 (224)	54[3]	Increase coverage by 315%
Black Guillemot	4	2 (22)	27[3]	Increase coverage in larger strata[4]
Puffin	3	8 (25)	18[3]	Increase coverage by 39%[4]

[1] Excludes sites where the last recorded count was zero. See Table 6 and Appendix 2 for the number of sites monitored within each size strata. [2] This is a simplified recommendation and also needs to take into the recommended approach to sampling across size strata. [3] Current annual monitoring under-represents sites in the largest size strata. [4] Although the recommended percentage of sites is expected to be adequate to meet a target CV of 0.1, we recommend aiming to cover at least 15% of sites to ensure data are representative.

may be unrealistic to achieve the sampling effort that might be required using this survey approach to robustly estimate populations and thus population trends on an annual basis. Furthermore, while alternative approaches to surveying urban gulls, e.g. vantage point counts, might reduce uncertainty in sample counts, sampling effort using these methods might be expected to be more limited and thus the adequacy of such alternatives for production of population trends on an annual basis may also be questionable. Given this, it may remain appropriate to only assess trends in the urban component of gulls' populations on a periodic basis, for example, through censuses. It may be possible to monitor urban gulls more frequently between census periods; however, there will be a trade-off between the frequency of monitoring and the level of coverage that can be achieved and thus the robustness of sampling. Coverage will be influenced by how easy it is to recruit volunteers and whether funding is available to fill gaps in coverage by professional surveyors.

There is the potential for abundance data to be collected through other surveys, specifically the Heronries Census which includes surveying of Cormorant colonies (https://www.bto.org/our-science/projects/heronries-census), the Breeding Bird Survey (BBS: https://www.bto.org/bbs) and Waterways Breeding Bird Survey (WBBS: https://www.bto.org/wbbs) through the surveys existing Colony Count recording, for species that occur across the wider inland landscape, such as Cormorant and Common Tern, but also potentially for inland gulls. Joint analyses of data collected across different schemes (Isaac et al. 2020; Boersch-Supan & Robinson 2021) may have great potential to achieve higher precision and accuracy for trends of some species (notably Common Tern and Cormorant).

6.4. Assessing the impacts of the 2022 Highly Pathogenic Avian Influenza (HPAI) outbreak on seabirds

The focus of this review has been on the sampling needed to provide robust trends of seabird abundance, productivity and survival through the Seabird Monitoring Programme and how monitoring of these metrics might be integrated to best identify the mechanisms and thus drivers of population change. The outbreak of Highly Pathogenic Avian Influenza (HPAI) in seabird populations that began in 2021 has already been observed to have had significant impacts on the populations of several species in the UK (Pearce-Higgins et al. 2023). To better evaluate these impacts, a task and finish group set-up under the auspices of the Seabird Monitoring Programme and including representatives from its wider Advisory Group considered priorities for monitoring in 2023 to enable a rapid evaluation of impacts in 2022. The RSPB led on coordination of this programme of extra counts, in partnership with SMP partners, JNCC and BTO, and together with Marine Scotland, NatureScot and Natural England. These priorities considered criteria that included species conservation status, the UK's responsibility for these species, the feasibility of implementing additional repeat surveys and the ability to detect an impact associated with HPAI. The latter aspect has included an assessment of whether recent surveys might have been carried out as part of Seabirds Count and the frequency and sufficiency of annual monitoring provided through the SMP.

While this was directly informed and aided by the annual monitoring provided through the SMP, it is important that the sampling approach outlined here might consider the specific sites – typically protected sites where species of concern are designated features – identified as priorities in the targeting of future longer-term monitoring. Nevertheless, it should be noted that the aim of the repeat surveys in 2023 was to provide a one-off rapid assessment, with priorities informed by the ability and feasibility of doing this. In assessing the potential longer-term impacts of HPAI, alongside population changes in response to other drivers, there is a need to ensure that sampling remains representative of populations as a whole.

6.5. Considerations and implications for the wider development of the SMP

The implementation of the above recommendations needs to take place whilst also considering the wider implications to the Seabird Monitoring Programme and its participants – both voluntary and professional.

6.5.1. Trend analysis

In particular, with respect to abundance, there is a need to establish a revised trend model that employs an aggregate trend approach rather than the current mean derived trend, as the average site-level trend may be a poor measure of the total population trend when sites cannot be treated as exchangeable because they are very heterogeneous in their size. It is vital that the analytical approach used to create the population trends is appropriate, i.e. that it takes into account this heterogeneity in site sizes through stratification of sites according to their size for the majority of species, and where required the uncertainty in site-level counts of individuals. This includes ensuring that errors around counting and site attendance are accounted for.

There is also a need to revise the analysis of productivity trends to also capture uncertainty around estimates. For species that lay more than one egg, it is also necessary to reassess the use of the Poisson distribution for analysis, as larger than feasible clutch sizes are currently considered possible.

6.5.2. Seabird Monitoring Handbook

The previous reviews of the SMP identified the need to update the current Seabird Monitoring Handbook for Britain and Ireland (Walsh et al. 1995). An important part of this update will be ensuring that approaches to achieve the recommendations of this, and previous, reviews are incorporated. Specifically, this includes clearly setting out:

- the use and selection of representative Plot Colony Counts for all species;
- the need for repeat counts at sites where multiple visits during the breeding season are feasible;
- the need to submit raw data from all site visits to abundance and productivity plots into the SMP database, including zero values (rather than summaries from these multiple visits which is often the case currently)
- the need to submit details on correction factors and response rates to the SMP database; and
- the methods for phenology and diet collection for future SMP Online developments to encourage this recording beyond Key Sites and capture this information where it is already being collated.

The update of the Seabird Monitoring Handbook will require a review of the currently recommended, species-specific methodologies to ensure that they are up-to date and fit for purpose. These need to be presented in a way which is easy to follow and implement by participants to ensure data collection is standardised across sites.

6.5.3. Dependencies

To achieve the ambitious recommendations set out to improve the accuracy and robustness of trends produced by the Seabird Monitoring Programme there are a number of dependencies that also need to be considered.

6.5.3.1. Site boundaries

To ensure that data collection is efficient and standardised between years it is important that site boundaries are clearly defined within the SMP database, and that it is straightforward to identify the boundaries of sites in the field. Ongoing work aims to review existing site boundary definitions and address outstanding issues. A particular consideration is how to define tern colonies that move from one year to the next, to ensure these sites are properly matched (as appropriate) in the trend analysis. At present, if a tern colony is over 500 m from a previous colony it is considered a different site, with a new site being created in the SMP database.

To benefit Common Standards Monitoring of protected sites such as SPAs and Sites of Special Scientific Interest (SSSIs), there is also a need to ensure that SMP site boundaries match those of those protected sites or other existing management units. A review of matching is in progress for some sites, specifically RSPB nature reserves.

Mapping and image uploads for Plot Colony Count / Plot Breeding Success location recording in SMP Online is also key to consistency in monitoring year-on-year and for safe storage of this information long-term.

6.5.3.2. Quality of data used to produce trends

To produce robust abundance and productivity trends there are several issues that need to be considered to ensure that the underlying data used to produce the trends are themselves robust. The first relates to the inclusion of zero counts and how these should be accounted for in the analysis, specifically:

1. where a species is no longer present at a site, how long should zero counts / productivity be submitted for?
2. for sites where a species no longer breeds, and which are not visited to monitor other species, how frequently should they be re-visited to determine whether that species has recolonised? This is particularly an issue for terns which can move sites periodically.

The second relates to the need for adequate, and standardised, species-specific record validation to ensure that the data being used to produce trends adhere to the survey methodologies set out in the Seabird Monitoring Handbook (Walsh et al. 1995). This should consider:

1. the survey period;
2. the time of day;
3. the survey methods;
4. the count units;
5. weather conditions;
6. whether it is feasible that species breeds at the site; and
7. how to deal with duplicate counts.

As noted above, it is vital that data are collected following standardised methodologies, to ensure they are comparable between years and sites. This will be emphasised through the planned update to the Seabird Monitoring Handbook, changes to the SMP Online data verification functions and engagement with participants.

The third relates to the need to identify and label Plot Colony Count data (separate from Whole Colony Counts) in the SMP database to ensure that these data are appropriately incorporated into the abundance trend analysis.

Moving forwards, it is important that the coverage of sites is reported alongside the annual abundance and productivity trend estimates to be explicit about the potential representativeness of the underlying data used in their calculation, e.g. in the SMP annual report alongside trend figures and in the 'Coverage' section.

6.6. Implementation

6.6.1. Engagement

The main objectives of this report have been to review and develop the existing SMP sampling strategy with the overarching aim to achieve more robust trends, especially of abundance and productivity. However, our recommendations also recognise the importance of integrated monitoring that includes survival, diet and phenology data.

The next step will be to determine how to achieve these ambitious recommendations to increase the proportion of sites monitored on an annual basis, especially for species where current coverage needs to increase substantially. Key to the implementation of the recommendations will be the SMP Engagement Plan, which aims to increase participation and therefore survey coverage. In association with this, it will also be important to ensure that any changes in approaches and methods are clearly explained and set out in the planned update to the Seabird Monitoring Handbook. It is vital that this should be done in a way that is straightforward to follow and carry out by participants.

Ways to achieve the required increase in coverage and the number of participants monitoring sites for abundance need to be considered to determine whether they will be effective and also feasible. Given the scale of the increase required, one possible option is to rotate sites each year with some overlap so that more sites are monitored long-term, albeit with some sites therefore being monitored on a bi- or triennial basis rather than annually, as is currently done at the SMP triennial sites. This could be achieved to some extent through taking advantage of sites outside the SMP being visited through other surveys, especially those that involve participants visiting sites that are randomly selected across the landscape such as through Heronries Census, BBS and WBBS.

Increasing participation in productivity monitoring is also critical considering the decline in the amount of data submitted to the SMP over the last 10 years. Whether this decline is due to a decline in coverage, the number of accessible nests and/or current status (e.g. extinct), or people not submitting data needs to be determined. Either way, effort is required to increase the number of sites where breeding productivity monitoring takes place across the UK and ensure that data are submitted.

Although we have provided no new analysis of breeding productivity or survival data, where possible the stock-take of current data in the SMP database and other relevant BTO schemes should further help identify sites where integrated monitoring of multiple metrics can be focused on and encouraged in future. For example, monitoring productivity at current triennial sites and collecting abundance and productivity data at sites that have existing RAS studies. Opportunities for further engagement with SMP Advisory Group organisations that manage or own reserves hosting breeding seabirds (such as Natural Trust for Scotland and RSPB) could also be pursued to promote integrated monitoring at these sites.

In addition to increasing coverage through participant recruitment, alternative opportunities should be considered such as the use of fixed cameras and time-lapse images to obtain data on phenology and breeding productivity, as is being done through Seabirdwatch, as well as audio recorders (Arneill et al. 2019) and the use of uncrewed aerial vehicles (UAVs) to obtain abundance counts for certain species (Edney & Wood 2021). There is a need to include such new technological developments in seabird monitoring within the updated Seabird Monitoring Handbook to ensure methods are standardised and comparable with more traditional methodologies.

6.6.2. Prioritisation

Given the extent of the recommendations, there will likely be a need to prioritise them, recognising that some, especially those around species-specific coverage, will be more difficult to achieve than others.

Although the SMP aims to monitor all breeding seabirds across the UK, there may be merit in prioritising recommendations for species based on their conservation status or which are currently data deficient. The lists of priority and indicator species in Table 1 (section 3.2.4) may be a useful starting point. However, these will likely need to be re-evaluated given changes in the population trends and conservation status of some species since these lists were created and country-specific priorities. The prioritisation of species and sites for data collection should also consider evidence needs for decision-making around specific stressors/threats.

To provide robust abundance trends it is important to prioritise sites that we would like to be covered, such as the larger sites within each country so that a representative proportion of each population is included in the analyses. One option is to prioritise monitoring of SPAs with seabirds as a qualifying feature on a more annual basis, rather than simply following the minimum Common Standards Monitoring recommendation that sites are covered at least once in a six-yearly cycle, as these SPAs cover sites that hold large and important concentrations of breeding seabirds across the UK (Stroud et al. 2016). However, it is also important to continue monitoring at all existing sites as all sites are important to include in the trend analysis and this will also maintain participant engagement. Existing sites may have importance outside the trend analysis where the data are important on a more local scale, for example, for environmental impact assessments or the designation/monitoring of protected sites. A similar approach to WeBS can be implemented where priorities are given for vacant WeBS sites indicating which we would prefer people to take on (noting that this is not done for sites which are already being covered).

6.6.3. The potential to integrate data from other monitoring schemes

Our recommendations are based on the existing state of knowledge of the size and location of sites across the UK, taken from the recent national Seabird Count census (Burnell et al. 2023). However, not all sites may have been covered in the census, especially inland sites. Furthermore, the distribution of occupied sites may change due to local extinctions and colonisations, especially for mobile species such as terns. Disregarding such extinctions and colonisations by only monitoring sites within the historically known distribution has the potential to substantially bias population trends (Dambly et al. 2021). Therefore, it is important that these distribution changes are captured in some way on a semi-regular basis. This should be done as a minimum through future seabird censuses and national atlases. This could also be achieved to a less comprehensive extent through review of data from sites visited through other surveys, especially those that involve participants visiting sites that are randomly selected across the landscape (such as through BBS and WBBS). These schemes also have the potential to provide sample data for species that occur across the wider inland landscape, particularly for Cormorant and Common Tern, but also potentially for inland gulls. Joint analyses of data collected across different schemes (Isaac et al. 2020; Boersch-Supan & Robinson 2021) may have great potential to achieve higher precision and accuracy for trends of some species (notably Common Tern and Cormorant).

The move to integrate across monitoring schemes could also be a good outreach tool. Data for Cormorant collected through the BTO Heronries Census already feed into the SMP but do not include productivity data. There may be other further opportunities to engage with participants from other schemes, such as BBS and WBBS, to collect abundance data on inland colonies of gulls and terns, and NRS to collect productivity data from a range of species.

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Appendices

APPENDIX 1. Review of trends published in the 2019 SMP online report (JNCC 2021).

Table 1.1. Overview of results presented in the most recent online SMP annual report for breeding seabirds in the UK, based on data from the periodic seabird censuses (pale orange columns) and annual SMP monitoring data. Species shown in bold contribute to the UK seabird indicator.

Species	Population change (%) 1969-70 to 1985-88	Population change (%) 1985-88 to 1998-2002	Population change (%) 2000 to 2019	Index of abundance 1986 to 2019	Productivity 1986 to 2019	Phenology	Diet [11]	Survival (S) / Return (R) rates [11]
Northern Fulmar	✓	✓	✓[5]	✓	✓	×	×	×
Manx Shearwater	×	×	×	×	✓	×	×	Sk (S)
European Storm-petrel	×	×	×	×	×	×	×	×
Leach's Storm-petrel	×	×	×	×	×	×	×	×
Northern Gannet	✓	✓[2]	✓[3]	✓[4]	✓	×	×	×
Great Cormorant	✓	✓	✓	✓	×	×	×	×
European Shag	✓	✓	✓[5]	✓	✓	×	IoM	IoM (R)
Arctic Skua	✓	✓	✓	✓	✓	×	×	×
Great Skua	✓	✓	×	×[6]	✓	×	×	×
Black-legged Kittiwake	✓	✓	✓[5]	✓	✓	×	IoM	IoM (R), Sk (S)
Black-headed Gull	✓[1]	✓[1]	✓	✓[7]	✓	×	×	×
Mediterranean Gull	✓	✓	✓	×[6]	×	×	×	×
Common Gull	✓[1]	✓[1]	×	×[6]	✓	×	×	×
Lesser Black-backed Gull	✓[1]	✓[1]	×	✓[8]	✓[8]	×	×	Sk (S)
Herring Gull	✓[1]	✓[1]	×	✓[8]	✓[8]	×	×	Sk (S)
Great Black-backed Gull	✓	✓	✓	✓	✓	×	Sk	×
Little Tern	✓	✓	✓	✓	✓	×	×	×
Sandwich Tern	✓	✓	✓	✓	✓	×	×	×
Common Tern	✓	✓	✓	✓	✓	×	×	×
Roseate Tern	✓	✓	✓	✓	✓	×	×	×
Arctic Tern	✓	✓	✓	✓	✓	×	×	×
Common Guillemot	✓	✓	✓[5]	✓	✓	✓[9]	IoM	IoM (R), Sk (R)
Razorbill	✓	✓	✓[5]	✓	✓	×	×	IoM (R), Sk (S)
Black Guillemot	×	✓[2]	×	✓	×	✓[10]	×	×
Atlantic Puffin	✓	✓	×	×[6]	✓	×	FI, IoM	IoM (R), Sk (S)

[1] Inland colonies were not counted during the first two national censuses, so, to enable direct comparison, percentage changes refer to coastal colonies only. [2] Change between censuses in 1984-85 and 2003-04. [3] Change between censuses in 2003-04 and 2013–15. [4] Interpolated and extrapolated values from complete censuses, expressed as an index. [5] Abundance change (%) also provided between Seabird 2000 and more recent count for Special Protection Areas. [6] Not currently published due to large uncertainty in the trend estiamtes. [7] Coastal-nesting only. [8] Natural-nesting only. Defined as on moors, cliffs, marshes, beaches and other areas of semi-natural habitat, while 'urban-nesting' is defined as on human-built structures. [9] Data from Skomer (Tim Birkhead, University of Sheffield) & Sumburgh (SOTEAG). [10] Data from Bangor Marina, 1986–2014 (J. Greenwood). [11] Data from Key Site monitoring: FI – Fair Isle, IoM – Isle of May, Sk – Skomer.

Table 1.2. Overview of results presented in the most recent online SMP annual report for breeding seabirds in Scotland, based on data from the periodic seabird censuses (pale orange columns) and annual SMP monitoring data. Species shown in bold contribute to the Scottish Biodiversity Indicator.

Species	Population change (%) 1969-70 to 1985-88	Population change (%) 1985-88 to 1998-2002	Index of abundance 1986 to 2019 [3]	Productivity 1986 to 2019	Phenology [6]	Diet [7]	Return rates [7]
Northern Fulmar	✓	✓	✓	✓	×	×	×
Manx Shearwater	×	×	×	×	×	×	×
European Storm-petrel	×	×	×	×	×	×	×
Leach's Storm-petrel	×	×	×	×	×	×	×
Northern Gannet	✓	✓	×	✓	×	×	×
Great Cormorant	✓	✓	×	×	×	×	×
European Shag	✓	✓	✓	✓	×	IoM	IoM
Arctic Skua	✓	✓	✓	✓	×	×	×
Great Skua	×	×	×	✓	×	×	×
Black-legged Kittiwake	✓	✓	✓	✓	×	IoM	IoM
Black-headed Gull	✓[2]	✓[2]	LoS, SoF, IM	✓	×	×	×
Mediterranean Gull	-	-	-	-	-	-	-
Common Gull	✓[2]	✓[2]	✓[4]	✓	×	×	×
Lesser Black-backed Gull	✓[2]	✓[2]	✓[5]	✓[5]	×	×	×
Herring Gull	✓[2]	✓[2]	✓[5]	✓[5]	×	×	×
Great Black-backed Gull	✓[2]	✓[2]	✓	✓	×	×	×
Little Tern	✓	✓	✓	✓	×	×	×
Sandwich Tern	✓	✓	SoF	✓	×	×	×
Common Tern	✓	✓	✓	✓	×	×	×
Roseate Tern	✓	✓	FIs	×	×	×	×
Arctic Tern	✓	✓	✓	✓	×	×	×
Common Guillemot	✓	✓	✓	✓	Sum	IoM	IoM
Razorbill	✓	✓	✓	✓	×	×	IoM
Black Guillemot	×	✓	✓	×	×	×	×
Atlantic Puffin	✓	✓	FI, IoM, SS	✓	×	FI, IoM	IoM

[1] Different dates of Gannet censuses plus population change provided for 1969-70 to 1985-88, 1985-88 to 2003-04, and 2003-04 to 2013-15. [2] Inland colonies were not counted during the first two national censuses, so, to enable direct comparison, the percentage change refers to coastal colonies only. [3] Indicated are instances where Index of abundance cannot be calculated at the country level but are provided for specific colonies: LoS - Loch of Strathbeg, SoF - Sands of Forvie, IM - Insh Marshes, FIs - Forth Islands, FI - Fair Isle, IoM - Isle of May, SS - Sule Skerry. [4] Coastal-nesting only. [5] Natural-nesting only. [6] Data for Common Guillemot for Sumburgh Head (Sum) from SOTEAG. [7] Data from Key Site monitoring: FI – Fair Isle, IoM – Isle of May. * Scottish Biodiversity Index for numbers of seabirds (11 species): Arctic Skua, Arctic Tern, Black Guillemot, Kittiwake, Common gull (coastal), Common Tern, Shag, Great Black-backed Gull, Guillemot, Herring Gull (natural-nesting), Fulmar. Scottish Biodiversity Index for breeding success for seabirds (11 species): Arctic Skua, Arctic Tern, Puffin, Kittiwake, Common Tern, Great Skua, Guillemot, Herring Gull (natural-nesting), Little Tern, Fulmar, Gannet.

Table 1.3. Overview of results presented in the most recent online SMP annual report for breeding seabirds in England, based on data from the periodic seabird censuses (pale orange columns) and annual SMP monitoring data. Species shown in bold contribute to the England Biodiversity Indicators.

Species	Population change (%) 1969-70 to 1985-88	Population change (%) 1985-88 to 1998-2002	Index of abundance 1986 to 2019 [3]	Productivity 1986 to 2019 [3]	Phenology	Diet	Return rates
Northern Fulmar	✓	✓	✓	✓	×	×	×
Manx Shearwater	×	×	×	×	×	×	×
European Storm-petrel	×	×	×	×	×	×	×
Leach's Storm-petrel	-	-	-	-	-	-	-
Northern Gannet [1]	✓	✓	BC	×	×	×	×
Great Cormorant	✓	✓	✓	×	×	×	×
European Shag	✓	✓	FaI	FaI	×	×	×
Arctic Skua	-	-	-	-	-	-	-
Great Skua	-	-	-	-	-	-	-
Black-legged Kittiwake	✓	✓	✓	✓	×	×	×
Black-headed Gull	✓[2]	✓[2]	✓[4]	✓	×	×	×
Mediterranean Gull	×	✓	×	×	×	×	×
Common Gull	✓[2]	✓[2]	×	×	×	×	×
Lesser Black-backed Gull	✓[2]	✓[2]	SW	×	×	×	×
Herring Gull	✓[2]	✓[2]	✓[5]	×	×	×	×
Great Black-backed Gull	✓[2]	✓[2]	An, Lu	×	×	×	×
Little Tern	✓	✓	✓	✓	×	×	×
Sandwich Tern	✓	✓	✓	✓	×	×	×
Common Tern	✓	✓	✓	✓	×	×	×
Roseate Tern	✓	✓	Coq	×	×	×	×
Arctic Tern	✓	✓	✓	✓	×	×	×
Common Guillemot	✓	✓	×	✓	×	×	×
Razorbill	✓	✓	BC, FlH	×	×	×	×
Black Guillemot	×	✓	×	×	×	×	×
Atlantic Puffin	✓	✓	Coq, FaI	FaI	×	×	×

[1] Different dates of Gannet censuses plus population change provided for 1969-70 to 1985-88, 1985-88 to 2003-04, and 2003-04 to 2013-15. [2] Inland colonies were not counted during the first two national censuses, so, to enable direct comparison, the percentage change refers to coastal colonies only. [3] Indicated are instances where Index of abundance cannot be calculated at the country level but are provided for specific colonies: BC - Bempton Cliffs, FaI - Farne Islands, SW - South Walney, An - Annet, Lu - Lundy, Coq - Coquet Island, FlH - Flamborough Head. [4] Coastal-nesting only. [5] Natural-nesting only.

Table 1.4. Overview of results presented in the most recent online SMP annual report for breeding seabirds in Wales, based on data from the periodic seabird censuses (pale orange columns) and annual SMP monitoring data.

Species	Population change (%) 1969-70 to 1985-88	Population change (%) 1985-88 to 1998-2002	Index of abundance 1986 to 2019 [3]	Productivity 1986 to 2019 [3]	Phenology [5]	Diet [5]	Survival (S) / Return (R) rates [5]
Northern Fulmar	✓	✓	✓	✓	×	×	×
Manx Shearwater	×	×	×	×	×	×	Sk
European Storm-petrel	[illegible]	×	×	×	×	×	×
Leach's Storm-petrel	-	-	-	-	-	-	-
Northern Gannet [1]	✓	✓	Gr	×	×	×	×
Great Cormorant	✓	✓	✓	×	×	×	×
European Shag	✓	✓	✓	✓	×	×	×
Arctic Skua	-	-	-	-	-	-	-
Great Skua	-	-	-	-	-	-	-
Black-legged Kittiwake	✓	✓	✓	✓	×	×	Sk (S)
Black-headed Gull	✓[2]	✓[2]	×	×	×	×	×
Mediterranean Gull	×	×	×	×	×	×	×
Common Gull	✓[2]	✓[2]	×	×	×	×	×
Lesser Black-backed Gull	✓[2]	✓[2]	✓[4]	Sk	×	×	Sk (S)
Herring Gull	✓[2]	✓[2]	✓[4]	✓[4]	×	×	Sk (S)
Great Black-backed Gull	✓[2]	✓[2]	✓	×	×	Sk[7]	×
Little Tern	✓	✓	Gron	×	×	×	×
Sandwich Tern	×	✓	CL	CL	×	×	×
Common Tern	×	✓	CL, YnF, SS	SS	×	×	×
Roseate Tern	✓	✓	✓	×	×	×	×
Arctic Tern	✓	✓	Sker	×	×	×	×
Common Guillemot	✓	✓	×	×	Sk[6]	×	Sk (R)
Razorbill	✓	✓	✓	Sk	×	×	Sk (S)
Black Guillemot	×	✓	×	×	×	×	×
Atlantic Puffin	✓	✓	Sk	×	×	×	Sk (S)

[1] Different dates of Gannet censuses plus population change provided for 1969-70 to 1985-88, 1985-88 to 2003-04, and 2003-04 to 2013-15. [2] Inland colonies were not counted during the first two national censuses, so, to enable direct comparison, the percentage change refers to coastal colonies only. [3] Indicated are instances where Index of abundance cannot be calculated at the country level but are provided for specific colonies: Gr - Grassholm, Gron - Gronart, CL - Cemlyn Lagoon, YnF - Ynys Feurig, SS - Shotton Steels, Sker - The Skerries. [4] Natural-nesting only. [5] Data from Key Site monitoring: Sk – Skomer. [6] Data from Tim Birkhead. [7] Initiated in 2008, modified in 2012.

Table 1.5. Overview of results presented in the most recent online SMP annual report for breeding seabirds in Northern Ireland, based on data from the periodic seabird censuses (pale orange columns) and annual SMP monitoring data.

Species	Population change (%) 1969-70 to 1985-88	Population change (%) 1985-88 to 1998-2002	Index of abundance 1986 to 2019 [4]	Productivity 1986 to 2019	Phenology	Diet	Return rates
Northern Fulmar	✓	✓	×	×	×	×	×
Manx Shearwater	×	×	×	×	×	×	×
European Storm-petrel	-	-	-	-	-	-	-
Leach's Storm-petrel	-	-	-	-	-	-	-
Northern Gannet [1]	-	-	-	-	-	-	-
Great Cormorant	✓	✓	SL	×	×	×	×
European Shag	✓	✓	×	×	×	×	×
Arctic Skua	-	-	-	-	-	-	-
Great Skua	×	×	×	×	×	×	×
Black-legged Kittiwake	✓	✓	×	×	×	×	×
Black-headed Gull	✓[3]	✓[3]	SL	×	×	×	×
Mediterranean Gull	×	×	×	×	×	×	×
Common Gull	✓[3]	✓[3]	SL	×	×	×	×
Lesser Black-backed Gull	✓[3]	✓[3]	SL	×	×	×	×
Herring Gull	✓[3]	✓[3]	×	×	×	×	×
Great Black-backed Gull	✓[3]	✓[3]	SL	×	×	×	×
Little Tern	✓	✓	×	×	×	×	×
Sandwich Tern	✓	✓	✓	×	×	×	×
Common Tern	✓	✓	✓	×	×	×	×
Roseate Tern	✓	✓	✓	×	×	×	×
Arctic Tern	✓	✓	SL, CL, CocI	×	×	×	×
Common Guillemot	✓	✓	×	×	×	×	×
Razorbill	✓	✓	×	×	×	×	×
Black Guillemot	×	✓	×	×	BM [5]	×	×
Atlantic Puffin	✓	✓	×	×	×	×	×

[1] Recently colonised - first bred in 2011. [2] Recently colonised – first bred in 1995. [3] Inland colonies were not counted during the first two national censuses, so, to enable direct comparison, the percentage change refers to coastal colonies only. [4] Indicated are instances where Index of abundance cannot be calculated at the country level but are provided for specific colonies: SL - Strangford Lough, CI - Carlingford Lough, CocI - Cockle Island. [5] Data from Bangor Marina (BM), 1986–2014. J. Greenwood.

Table 1.6. Overview of results presented in the most recent online SMP annual report for breeding seabirds in the Republic of Ireland, based on data from the periodic seabird censuses (pale orange columns) and annual SMP monitoring data.

Species	Population change (%) 1969-70 to 1985-88	Population change (%) 1985-88 to 1998-2002	Population change (%) 1998-2002 to 2015-18	Index of abundance 1986 to 2019 [6]	Productivity 1986 to 2019 [6]	Phenology	Diet	Return rates
Northern Fulmar	✗	✗	✓	✗	✗	✗	✗	✗
Manx Shearwater	✗	✗	✗	✗	✗	✗	✗	✗
European Storm-petrel	✗	✗	✗	✗	✗	✗	✗	✗
Leach's Storm-petrel	✗	✗	✗	✗	✗	✗	✗	✗
Northern Gannet [1]	✓	✓	✓	✗	✗	✗	✗	✗
Great Cormorant	✓	✓	✓	✗	✗	✗	✗	✗
European Shag	✓	✓	✓	✗	✗	✗	✗	✗
Arctic Skua	-	-	-	-	-	-	-	-
Great Skua	✗	✗	✗	✗	✗	✗	✗	✗
Black-legged Kittiwake	✓	✓	✓	✗	✗	✗	✗	✗
Black-headed Gull	✓[4]	✓[4]	✓[4]	✗	✗	✗	✗	✗
Mediterranean Gull	✗	✗	✓	✗	✗	✗	✗	✗
Common Gull	✓[5]	✓[5]	✓[5]	✗	✗	✗	✗	✗
Lesser Black-backed Gull	✓[4]	✓[4]	✓[4]	✗	✗	✗	✗	✗
Herring Gull	✓[4]	✓[4]	✓[4]	✗	✗	✗	✗	✗
Great Black-backed Gull	✓[5]	✓[5]	✓[5]	✗	✗	✗	✗	✗
Little Tern	✓	✓	✓	Kil	✗	✗	✗	✗
Sandwich Tern	✓	✓	✓	LIL	✗	✗	✗	✗
Common Tern	✓	✓	✓	Roc	✗	✗	✗	✗
Roseate Tern	✓	✓	✓	Roc	LIL	✗	✗	✗
Arctic Tern	✓	✓	✓	Roc, LIL	✗	✗	✗	✗
Common Guillemot	✓	✓	✓	✗	✗	✗	✗	✗
Razorbill	✓	✓	✓	✗	✗	✗	✗	✗
Black Guillemot	✗	✗	✓	✗	✗	✗	✗	✗
Atlantic Puffin	✓	✓	✗	✗	✗	✗	✗	✗

[1] Different dates of Gannet censuses plus population change provided for 1969-70 to 1985-88, 1985-88 to 2003-04, and 2003-04 to 2013-15. [2] Recent colonist – first bred in the late 1990s. [3] Recent colonist – first bred in 1996. [4] Inland colonies were not counted during the first two national censuses, so, to enable direct comparison, the percentage change refers to coastal colonies only. However, the 1998-2002 to 2015-2018 population change figure is a combination of inland and coastal as information on the split were not available. [5] Inland colonies were not counted during the first two national censuses, so, to enable direct comparison, the percentage change refers to coastal colonies only. [6] Indicated are instances where Index of abundance cannot be calculated at the country level but are provided for specific colonies: Kil - Kilcoole, LIL - Lady's Island Lake, Roc - Rockabill.

Table 1.7. Overview of results presented in the most recent online SMP annual report for All Ireland breeding seabirds, based on data from the periodic seabird censuses (pale orange columns) and annual SMP monitoring data.

Species	Population change (%) 1969-70 to 1985-88	Population change (%) 1985-88 to 1998-2002	Index of abundance 1986 to 2019	Productivity 1986 to 2019	Phenology	Diet	Return rates
Northern Fulmar	✓	✓	×	×	×	×	×
Manx Shearwater	×	×	×	×	×	×	×
European Storm-petrel	×	×	×	×	×	×	×
Leach's Storm-petrel	×	×	×	×	×	×	×
Northern Gannet [1]	✓	✓	×	×	×	×	×
Great Cormorant	✓	✓	×	×	×	×	×
European Shag	✓	✓	×	×	×	×	×
Arctic Skua	-	-	-	-	-	-	-
Great Skua	×	×	×	×	×	×	×
Black-legged Kittiwake	✓	✓	×	✓	×	×	×
Black-headed Gull	✓[4]	✓[4]	×	×	×	×	×
Mediterranean Gull	×	×	×	×	×	×	×
Common Gull	✓[4]	✓[4]	×	×	×	×	×
Lesser Black-backed Gull	✓[4]	✓[4]	×	×	×	×	×
Herring Gull	✓[4]	✓[4]	×	×	×	×	×
Great Black-backed Gull	✓[4]	✓[4]	×	×	×	×	×
Little Tern	✓	✓	×	×	×	×	×
Sandwich Tern	✓	✓	✓	✓	×	×	×
Common Tern	✓	✓	×	×	×	×	×
Roseate Tern	✓	✓	×	×	×	×	×
Arctic Tern	✓	✓	×	×	×	×	×
Common Guillemot	✓	✓	×	×	×	×	×
Razorbill	✓	✓	×	×	×	×	×
Black Guillemot	×	×	×	×	×	×	×
Atlantic Puffin	✓	✓	×	×	×	×	×

[1] Different dates of Gannet censuses plus population change provided for 1969-70 to 1985-88, 1985-88 to 2003-04, and 2003-04 to 2013-15. [2] Recent colonist – first bred in the late 1990s. [3] Recent colonist – first bred in 1995. [4] Inland colonies were not counted during the first two national censuses, so, to enable direct comparison, the percentage change refers to coastal colonies only.

Table 1.8. Overview of results presented in the most recent online SMP annual report for breeding seabirds in the Isle of Man, based on data from the periodic seabird censuses (pale orange columns) and annual SMP monitoring data.

Species	Population change (%) 1969-70 to 1985-88	Population change (%) 1985-88 to 1998-2002	Population change (%) 1998-2002 to 2017-18	Index of abundance 1986 to 2019 [3]	Productivity 1986 to 2019	Phenology	Diet	Return rates
Northern Fulmar	✓	✓	✓	×	✓	×	×	×
Manx Shearwater	×	×	✓	×	×	×	×	×
European Storm-petrel	-	-	-	-	-	-	-	-
Leach's Storm-petrel	-	-	-	-	-	-	-	-
Northern Gannet [1]	-	-	-	-	-	-	-	-
Great Cormorant	✓	✓	✓	×	×	×	×	×
European Shag	✓	✓	✓	CoM	×	×	×	×
Arctic Skua	-	-	-	-	-	-	-	-
Great Skua	-	-	-	-	-	-	-	-
Black-legged Kittiwake	✓	✓	✓	CoM[4]	×	×	×	×
Black-headed Gull	×	✓[2]	✓[2]	×	×	×	×	×
Mediterranean Gull	-	-	-	-	-	-	-	-
Common Gull	×	✓[2]	✓[2]	×	×	×	×	×
Lesser Black-backed Gull	✓[2]	✓[2]	✓[2]	CoM	×	×	×	×
Herring Gull	✓[2]	✓[2]	✓[2]	CoM	×	×	×	×
Great Black-backed Gull	✓[2]	✓[2]	✓[2]	CoM	×	×	×	×
Little Tern	✓	✓	✓	×	×	×	×	×
Sandwich Tern	-	-	-	-	-	-	-	-
Common Tern	✓	✓	✓	×	×	×	×	×
Roseate Tern	-	-	-	-	-	-	-	-
Arctic Tern	✓	✓	✓	×	×	×	×	×
Common Guillemot	✓	✓	✓	CoM	×	×	×	×
Razorbill	✓	✓	✓	CoM	×	×	×	×
Black Guillemot	×	✓	✓	×	×	×	×	×
Atlantic Puffin	✓	✓	✓	×	×	×	×	×

[1] None bred in Seabird 2000 or more recently. [2] Inland colonies were not counted during the first two national censuses, so, to enable direct comparison, the percentage change refers to coastal colonies only. [3] Indicated are instances where Index of abundance cannot be calculated at the country level but are provided for specific colonies: CoM – Calf of Man. [4] Extirpated by 2017.

Table 1.9. Overview of results presented in the most recent online SMP annual report for breeding seabirds in the Channel Islands, based on data from the periodic seabird censuses (pale orange columns) and annual SMP monitoring data.

Species	Population change (%) 1969-70 to 1985-88	Population change (%) 1985-88 to 1998-2002	Population change (%) 1998-2002 to 2015-2016	Index of abundance 1986 to 2019	Productivity 1986 to 2019	Phenology	Diet	Return rates
Northern Fulmar	×	✓	✓	×	×	×	×	×
Manx Shearwater	×	×	×	×	×	×	×	×
European Storm-petrel	×	×	×	×	×	×	×	×
Leach's Storm-petrel	-	-	-	-	-	-	-	-
Northern Gannet [1]	✓	✓	✓	✓[3]	×	×	×	×
Great Cormorant	✓	✓	✓	×	×	×	×	×
European Shag	✓	✓	✓	×	×	×	×	×
Arctic Skua	-	-	-	-	-	-	-	-
Great Skua	-	-	-	-	-	-	-	-
Black-legged Kittiwake	✓	✓	✓	×	×	×	×	×
Black-headed Gull	-	-	-	-	-	-	-	-
Mediterranean Gull	-	-	-	-	-	-	-	-
Common Gull	-	-	-	-	-	-	-	-
Lesser Black-backed Gull	✓[2]	✓[2]	✓[2]	×	×	×	×	×
Herring Gull	✓[2]	✓[2]	✓[2]	×	×	×	×	×
Great Black-backed Gull	✓[2]	✓[2]	✓[2]	×	×	×	×	×
Little Tern	-	-	-	-	-	-	-	-
Sandwich Tern	-	-	-	-	-	-	-	-
Common Tern	✓	✓	✓	×	×	×	×	×
Roseate Tern	-	-	-	-	-	-	-	-
Arctic Tern	-	-	-	-	-	-	-	-
Common Guillemot	✓	✓	✓	×	×	×	×	×
Razorbill	✓	✓	✓	×	×	×	×	×
Black Guillemot	-	-	-	-	-	-	-	-
Atlantic Puffin	✓	✓	✓	×	×	×	×	×

[1] No breeding recorded in 2015-2016, believed to be extinct. [2] Inland colonies were not counted during the first two national censuses, so, to enable direct comparison, the percentage change refers to coastal colonies only. [3] Data up to 2016.

APPENDIX 2. Coverage by SMP 'annual' monitoring (see text for definition) of the seabird species not reported in Table 4, relative to a) the percentage (and number) of sites and b) the total UK population from the Seabird Count Census dataset and according to magnitude of colony size.

Fulmar

a) percentage of sites

Country	0 (n)	1 - 10 (n)	11 - 100 (n)	101 - 1000 (n)	1001 - 10000 (n)	10001 - 100000 (n)	100001+ (n)	Total number of sites	Data
UK	-	31.95 (561)	43.96 (772)	20.56 (361)	3.30 (58)	0.23 (4)	-	1756	Census
Channel Islands	-	27.27 (3)	72.73 (8)	-	-	-	-	11	Census
England	-	56.64 (128)	39.82 (90)	3.54 (8)	-	-	-	226	Census
Isle of Man	-	15.79 (3)	68.42 (13)	15.79 (3)	-	-	-	19	Census
Northern Ireland	-	40.91 (18)	45.45 (20)	11.36 (5)	2.27 (1)	-	-	44	Census
Scotland	-	24.74 (335)	45.35 (614)	25.41 (344)	4.21 (57)	0.30 (4)	-	1354	Census
Wales	-	60.61 (80)	36.36 (48)	3.03 (4)	-	-	-	132	Census
UK	0.17 (3)	0.80 (14)	1.48 (26)	1.48 (26)	-	0.06 (1)	-	70	Annual SMP
England	-	0.88 (2)	2.21 (5)	1.33 (3)	-	-	-	10	Annual SMP
Isle of Man	-	-	5.26 (1)	-	-	-	-	1	Annual SMP
Northern Ireland	-	-	4.55 (2)	-	-	-	-	2	Annual SMP
Scotland	0.07 (1)	0.22 (3)	0.81 (11)	1.48 (20)	-	0.07 (1)	-	36	Annual SMP
Wales	1.52 (2)	6.82 (9)	6.06 (8)	2.27 (3)	-	-	-	22	Annual SMP

b) percentage of the population

Country	0	1 - 10	11 - 100	101 - 1000	1001 - 10000	10001 - 100000	100001+	Data
UK	-	0.73	8.37	33.65	34.55	22.69	-	Census
Channel Islands	-	5.75	94.25	-	-	-	-	Census
England	-	10.93	49.11	39.96	-	-	-	Census
Isle of Man	-	1.55	55.71	42.74	-	-	-	Census
Northern Ireland	-	3.23	28.22	28.10	40.45	-	-	Census
Scotland	-	0.46	7.29	33.51	35.32	23.42	-	Census
Wales	-	12.23	42.54	45.23	-	-	-	Census
UK	0.00	0.02	0.29	2.54	-	3.82	-	Annual SMP
England	-	0.16	3.79	8.13	-	-	-	Annual SMP
Isle of Man	-	-	4.93	-	-	-	-	Annual SMP
Northern Ireland	-	-	2.77	-	-	-	-	Annual SMP
Scotland	0.00	0.00	0.15	2.17	-	3.94	-	Annual SMP
Wales	0.00	1.40	8.30	40.18	-	-	-	Annual SMP

Cormorant

a) percentage of sites

Country	0 (n)	1 - 10 (n)	11 - 100 (n)	101 - 1000 (n)	1001 - 10000 (n)	10001 - 100000 (n)	100001+ (n)	Total number of sites	Data
UK	-	30.90 (72)	59.66 (139)	9.44 (22)	-	-	-	233	Census
Channel Islands	-	16.67 (1)	83.33 (5)	-	-	-	-	6	Census
England	-	36.79 (39)	57.55 (61)	5.66 (6)	-	-	-	106	Census
Isle of Man	-	42.86 (3)	42.86 (3)	14.29 (1)	-	-	-	7	Census
Northern Ireland	-	-	80.00 (4)	20.00 (1)	-	-	-	5	Census
Scotland	-	28.72 (27)	59.57 (56)	11.70 (11)	-	-	-	94	Census
Wales	-	21.43 (6)	64.29 (18)	14.29 (4)	-	-	-	28	Census
UK	15.45 (36)	5.58 (13)	23.18 (54)	5.15 (12)	-	-	-	115	Annual SMP
England	19.81 (21)	9.43 (10)	34.91 (37)	5.66 (6)	-	-	-	74	Annual SMP
Northern Ireland	-	-	20.00 (1)	20.00 (1)	-	-	-	2	Annual SMP
Scotland	14.89 (14)	2.13 (2)	13.83 (13)	1.06 (1)	-	-	-	30	Annual SMP
Wales	3.57 (1)	3.57 (1)	10.71 (3)	14.29 (4)	-	-	-	9	Annual SMP

b) percentage of the population

Country	0	1 - 10	11 - 100	101 - 1000	1001 - 10000	10001 - 100000	100001+	Data
UK	-	3.07	52.05	44.88	-	-	-	Census
Channel Islands	-	0.79	99.21	-	-	-	-	Census
England	-	4.28	63.89	31.84	-	-	-	Census
Isle of Man	-	6.77	19.52	73.71	-	-	-	Census
Northern Ireland	-	-	44.03	55.97	-	-	-	Census
Scotland	-	2.97	48.63	48.40	-	-	-	Census
Wales	-	1.75	36.64	61.61	-	-	-	Census
UK	0.00	0.53	26.76	33.79	-	-	-	Annual SMP
England	0.00	0.99	49.88	29.67	-	-	-	Annual SMP
Northern Ireland	-	-	15.69	69.16	-	-	-	Annual SMP
Scotland	0.00	0.29	14.98	4.43	-	-	-	Annual SMP
Wales	0.00	0.27	6.95	98.92	-	-	-	Annual SMP

Great Skua

a) percentage of sites

Country	0 (n)	1 - 10 (n)	11 - 100 (n)	101 - 1000 (n)	1001 - 10000 (n)	10001 - 100000 (n)	100001+ (n)	Total number of sites	Data
UK	-	78.72 (614)	19.49 (152)	1.67 (13)	0.13 (1)	-	-	780	Census
Northern Ireland	-	100.00 (1)	-	-	-	-	-	1	Census
Scotland	-	78.69 (613)	19.51 (152)	1.67 (13)	0.13 (1)	-	-	779	Census
UK	-	0.38 (3)	0.38 (3)	0.13 (1)	-	-	-	7	Annual SMP
Scotland	-	0.39 (3)	0.39 (3)	0.13 (1)	-	-	-	7	Annual SMP

b) percentage of the population

Country	0	1 - 10	11 - 100	101 - 1000	1001 - 10000	10001 - 100000	100001+	Data
UK	-	14.86	34.79	34.05	16.29	-	-	Census
Northern Ireland	-	100.00	-	-	-	-	-	Census
Scotland	-	14.85	34.79	34.06	16.30	-	-	Census
UK	-	0.14	1.18	4.33	-	-	-	Annual SMP
Scotland	-	0.14	1.18	4.33	-	-	-	Annual SMP

Kittiwake

a) percentage of sites

Country	0 (n)	1 - 10 (n)	11 - 100 (n)	101 - 1000 (n)	1001 - 10000 (n)	10001 - 100000 (n)	100001+ (n)	Total number of sites	Data
UK	-	12.57 (48)	36.65 (140)	41.88 (160)	8.12 (31)	0.79 (3)	-	382	Census
England	-	8.62 (5)	29.31 (17)	48.28 (28)	12.07 (7)	1.72 (1)	-	58	Census
Isle of Man	-	-	66.67 (2)	33.33 (1)	-	-	-	3	Census
Northern Ireland	-	13.33 (2)	33.33 (5)	40.00 (6)	6.67 (1)	6.67 (1)	-	15	Census
Scotland	-	13.99 (41)	37.88 (111)	40.27 (118)	7.51 (22)	0.34 (1)	-	293	Census
Wales	-	-	43.75 (7)	50.00 (8)	6.25 (1)	-	-	16	Census
UK	0.52 (2)	0.52 (2)	4.97 (19)	7.59 (29)	2.62 (10)	-	-	62	Annual SMP
England	1.72 (1)	1.72 (1)	13.79 (8)	15.52 (9)	10.34 (6)	-	-	25	Annual SMP
Northern Ireland	-	-	6.67 (1)	6.67 (1)	-	-	-	2	Annual SMP
Scotland	0.34 (1)	-	2.73 (8)	4.78 (14)	1.02 (3)	-	-	26	Annual SMP
Wales	-	6.25 (1)	12.50 (2)	31.25 (5)	6.25 (1)	-	-	9	Annual SMP

b) percentage of the population

Country	0	1 - 10	11 - 100	101 - 1000	1001 - 10000	10001 - 100000	100001+	Data
UK	-	0.09	2.92	26.23	38.16	32.59	-	Census
England	-	0.03	1.18	12.61	23.76	62.42	-	Census
Isle of Man	-	-	19.64	80.36	-	-	-	Census
Northern Ireland	-	0.06	1.58	11.77	6.68	79.91	-	Census
Scotland	-	0.13	3.99	35.01	51.57	9.30	-	Census
Wales	-	-	7.15	62.76	30.09	-	-	Census
UK	0.00	0.00	0.37	4.80	10.65	-	-	Annual SMP
England	0.00	0.01	0.46	4.02	18.09	-	-	Annual SMP
Northern Ireland	-	-	0.44	3.03	-	-	-	Annual SMP
Scotland	0.00	-	0.25	4.20	7.10	-	-	Annual SMP
Wales	-	0.02	1.97	38.41	25.85	-	-	Annual SMP

Lesser Black-backed Gull

a) percentage of sites

Country	0 (n)	1 - 10 (n)	11 - 100 (n)	101 - 1000 (n)	1001 - 10000 (n)	10001 - 100000 (n)	100001+ (n)	Total number of sites	Data
UK	-	70.95 (320)	19.07 (86)	7.32 (33)	2.66 (12)	-	-	451	Census
Channel Islands	-	47.62 (10)	38.1 (8)	14.29 (3)	-	-	-	21	Census
England	-	63.89 (69)	21.3 (23)	10.19 (11)	4.63 (5)	-	-	108	Census
Isle of Man	-	85.71 (6)	14.29 (1)	-	-	-	-	7	Census
Northern Ireland	-	21.74 (5)	47.83 (11)	26.09 (6)	4.35 (1)	-	-	23	Census
Scotland	-	80.32 (200)	14.46 (36)	3.61 (9)	1.61 (4)	-	-	249	Census
Wales	-	64.79 (46)	22.54 (16)	9.86 (7)	2.82 (2)	-	-	71	Census
UK	13.21 (7)	41.51 (22)	13.21 (7)	20.75 (11)	11.32 (6)	-	-	53	Annual SMP
England	14.29 (2)	50.00 (7)	14.29 (2)	14.29 (2)	7.14 (1)	-	-	14	Annual SMP
Isle of Man	-	-	100.00 (1)	-	-	-	-	1	Annual SMP
Northern Ireland	-	25.00 (1)	-	50.00 (2)	25.00 (1)	-	-	4	Annual SMP
Scotland	14.29 (3)	38.10 (8)	19.05 (4)	19.05 (4)	9.52 (2)	-	-	21	Annual SMP
Wales	14.29 (2)	42.86 (6)	7.14 (1)	21.43 (3)	14.29 (2)	-	-	14	Annual SMP

b) percentage of the population

Country	0	1 - 10	11 - 100	101 - 1000	1001 - 10000	10001 - 100000	100001+	Data
UK	-	1.49	5.25	20.17	73.09	-	-	Census
Channel Islands	-	2.26	18.71	79.03	-	-	-	Census
England	-	0.65	3.12	15.60	80.63	-	-	Census
Isle of Man	-	18.18	81.82	-	-	-	-	Census
Northern Ireland	-	0.20	14.67	45.07	40.06	-	-	Census
Scotland	-	4.54	9.62	20.53	65.31	-	-	Census
Wales	-	1.03	3.11	21.92	73.94	-	-	Census
UK	0.00	0.13	0.34	7.25	25.98	-	-	Annual SMP
England	0.00	0.07	0.43	3.91	6.10	-	-	Annual SMP
Isle of Man	-	-	81.82	-	-	-	-	Annual SMP
Northern Ireland	-	0.13	-	21.83	40.06	-	-	Annual SMP
Scotland	0.00	0.31	0.54	12.12	42.69	-	-	Annual SMP
Wales	0.00	0.09	0.11	5.67	49.05	-	-	Annual SMP

Great Black-backed Gull

a) percentage of sites

Country	0 (n)	1 - 10 (n)	11 - 100 (n)	101 - 1000 (n)	1001 - 10000 (n)	10001 - 100000 (n)	100001+ (n)	Total number of sites	Data
UK	-	88.71 (1375)	10.97 (170)	0.32 (5)	-	-	-	1550	Census
Channel Islands	-	58.62 (17)	37.93 (11)	3.45 (1)	-	-	-	29	Census
England	-	73.38 (102)	25.9 (36)	0.72 (1)	-	-	-	139	Census
Isle of Man	-	88.24 (15)	11.76 (2)	-	-	-	-	17	Census
Northern Ireland	-	73.33 (11)	13.33 (2)	13.33 (2)	-	-	-	15	Census
Scotland	-	90.92 (1222)	9.08 (122)	-	-	-	-	1344	Census
Wales	-	76.92 (40)	19.23 (10)	3.85 (2)	-	-	-	52	Census
UK	8.42 (8)	60.00 (57)	29.47 (28)	2.11 (2)	-	-	-	95	Annual SMP
England	25.00 (3)	50.00 (6)	25.00 (3)	-	-	-	-	12	Annual SMP
Isle of Man	-	-	100.00 (1)	-	-	-	-	1	Annual SMP
Northern Ireland	-	75.00 (3)	-	25.00 (1)	-	-	-	4	Annual SMP
Scotland	5.88 (4)	61.76 (42)	32.35 (22)	-	-	-	-	68	Annual SMP
Wales	9.09 (1)	54.55 (6)	27.27 (3)	9.09 (1)	-	-	-	11	Annual SMP

b) percentage of the population

Country	0	1 - 10	11 - 100	101 - 1000	1001 - 10000	10001 - 100000	100001+	Data
UK	-	37.18	53.28	9.54	-	-	-	Census
Channel Islands	-	13.85	59.78	26.37	-	-	-	Census
England	-	14.03	73.79	12.18	-	-	-	Census
Isle of Man	-	52.94	47.06	-	-	-	-	Census
Northern Ireland	-	5.30	11.48	83.22	-	-	-	Census
Scotland	-	49.01	50.99	-	-	-	-	Census
Wales	-	13.58	54.01	32.41	-	-	-	Census
UK	0.00	2.19	9.64	2.81	-	-	-	Annual SMP
England	0.00	0.86	5.63	-	-	-	-	Annual SMP
Isle of Man	-	-	25.88	-	-	-	-	Annual SMP
Northern Ireland	-	1.99	-	23.62	-	-	-	Annual SMP
Scotland	0.00	2.54	9.72	-	-	-	-	Annual SMP
Wales	0.00	2.47	25.00	18.52	-	-	-	Annual SMP

Herring Gull

a) percentage of sites

Country	0 (n)	1 - 10 (n)	11 - 100 (n)	101 - 1000 (n)	1001 - 10000 (n)	10001 - 100000 (n)	100001+ (n)	Total number of sites	Data
UK	-	54.82 (876)	38.17 (610)	6.38 (102)	0.63 (10)	-	-	1598	Census
Channel Islands	-	18.52 (5)	40.74 (11)	40.74 (11)	-	-	-	27	Census
England	-	52.73 (193)	41.53 (152)	5.46 (20)	0.27 (1)	-	-	366	Census
Isle of Man	-	23.81 (5)	66.67 (14)	9.52 (2)	-	-	-	21	Census
Northern Ireland	-	47.06 (8)	35.29 (6)	11.76 (2)	5.88 (1)	-	-	17	Census
Scotland	-	58.51 (622)	35.09 (373)	5.74 (61)	0.66 (7)	-	-	1063	Census
Wales	-	34.87 (53)	51.97 (79)	12.5 (19)	0.66 (1)	-	-	152	Census
UK	0.81 (13)	1.94 (31)	2.44 (39)	1.81 (29)	0.31 (5)	-	-	117	Annual SMP
England	0.27 (1)	2.19 (8)	2.46 (9)	1.37 (5)	0.27 (1)	-	-	24	Annual SMP
Isle of Man	-	-	-	4.76 (1)	-	-	-	1	Annual SMP
Northern Ireland	5.88 (1)	11.76 (2)	-	11.76 (2)	5.88 (1)	-	-	6	Annual SMP
Scotland	0.38 (4)	1.13 (12)	2.35 (25)	1.6 (17)	0.19 (2)	-	-	60	Annual SMP
Wales	4.61 (7)	5.92 (9)	3.29 (5)	3.29 (5)	0.66 (1)	-	-	27	Annual SMP

b) percentage of the population

Country	0	1 - 10	11 - 100	101 - 1000	1001 - 10000	10001 - 100000	100001+	Data
UK	-	4.18	30.14	39.26	26.42	-	-	Census
Channel Islands	-	0.75	13.76	85.49	-	-	-	Census
England	-	5.21	36.96	50.02	7.80	-	-	Census
Isle of Man	-	2.54	60.24	37.22	-	-	-	Census
Northern Ireland	-	0.78	9.97	30.78	58.47	-	-	Census
Scotland	-	4.75	29.24	33.47	32.54	-	-	Census
Wales	-	1.41	29.20	49.57	19.81	-	-	Census
UK	0.00	0.15	2.93	12.86	13.83	-	-	Annual SMP
England	0.00	0.20	3.65	13.09	9.02	-	-	Annual SMP
Isle of Man	-	-	-	27.73	-	-	-	Annual SMP
Northern Ireland	0.00	0.37	-	42.12	58.47	-	-	Annual SMP
Scotland	0.00	0.09	2.70	9.47	11.67	-	-	Annual SMP
Wales	0.00	0.23	3.54	19.24	18.61	-	-	Annual SMP

Common Gull

a) percentage of sites

Country	0 (n)	1 - 10 (n)	11 - 100 (n)	101 - 1000 (n)	1001 - 10000 (n)	10001 - 100000 (n)	100001+ (n)	Total number of sites	Data
UK	-	68.61 (787)	29.29 (336)	1.83 (21)	0.26 (3)	-	-	1147	Census
England	-	90.00 (9)	10.00 (1)	-	-	-	-	10	Census
Isle of Man	-	100.00 (1)	-	-	-	-	-	1	Census
Northern Ireland	-	26.67 (4)	60.00 (9)	13.33 (2)	-	-	-	15	Census
Scotland	-	68.98 (774)	29.06 (326)	1.69 (19)	0.27 (3)	-	-	1122	Census
UK	0.17 (2)	3.23 (37)	1.66 (19)	0.44 (5)	-	-	-	63	Annual SMP
England	10.00 (1)	40.00 (4)	-	-	-	-	-	5	Annual SMP
Northern Ireland	-	13.33 (2)	13.33 (2)	20.00 (3)	-	-	-	7	Annual SMP
Scotland	0.09 (1)	2.76 (31)	1.52 (17)	0.18 (2)	-	-	-	51	Annual SMP

b) percentage of the population

Country	0	1 - 10	11 - 100	101 - 1000	1001 - 10000	10001 - 100000	100001+	Data
UK	-	10.68	39.51	19.72	30.09	-	-	Census
England	-	40.30	59.70	-	-	-	-	Census
Isle of Man	-	100.00	-	-	-	-	-	Census
Northern Ireland	-	0.89	32.44	66.67	-	-	-	Census
Scotland	-	10.93	39.69	18.16	31.22	-	-	Census
UK	0.00	0.51	2.24	5.82	-	-	-	Annual SMP
England	0.00	20.90	-	-	-	-	-	Annual SMP
Northern Ireland	-	1.79	5.24	136.53	-	-	-	Annual SMP
Scotland	0.00	0.41	2.15	1.32	-	-	-	Annual SMP

Mediterranean Gull

a) percentage of sites

Country	0 (n)	1 - 10 (n)	11 - 100 (n)	101 - 1000 (n)	1001 - 10000 (n)	10001 - 100000 (n)	100001+ (n)	Total number of sites	Data
UK	-	75.00 (45)	20.00 (12)	3.33 (2)	1.67 (1)	-	-	60	Census
England	-	70.00 (35)	24.00 (12)	4.00 (2)	2.00 (1)	-	-	50	Census
Northern Ireland	-	100.00 (5)	-	-	-	-	-	5	Census
Wales	-	100.00 (5)	-	-	-	-	-	5	Census
UK	5.00 (3)	8.33 (5)	5.00 (3)	1.67 (1)	-	-	-	12	Annual SMP
England	4.00 (2)	8.00 (4)	6.00 (3)	2.00 (1)	-	-	-	10	Annual SMP
Northern Ireland	20.00 (1)	20.00 (1)	-	-	-	-	-	2	Annual SMP

b) percentage of the population

Country	0	1 - 10	11 - 100	101 - 1000	1001 - 10000	10001 - 100000	100001+	Data
UK	-	4.09	15.77	11.37	68.77	-	-	Census
England	-	3.04	15.94	11.49	69.53	-	-	Census
Northern Ireland	-	100.00	-	-	-	-	-	Census
Wales	-	100.00	-	-	-	-	-	Census
UK	0.00	0.83	5.40	7.67	-	-	-	Annual SMP
England	0.00	0.79	5.46	7.75	-	-	-	Annual SMP
Northern Ireland	0.00	12.5	-	-	-	-	-	Annual SMP

Sandwich Tern

a) percentage of sites

Country	0 (n)	1 - 10 (n)	11 - 100 (n)	101 - 1000 (n)	1001 - 10000 (n)	10001 - 100000 (n)	100001+ (n)	Total number of sites	Data
UK	-	19.23 (5)	19.23 (5)	46.15 (12)	15.38 (4)	-	-	26	Census
Channel Islands	-	-	100.00 (1)	-	-	-	-	1	Census
England	-	-	25.00 (3)	50.00 (6)	25.00 (3)	-	-	12	Census
Northern Ireland	-	20.00 (1)	-	60.00 (3)	20.00 (1)	-	-	5	Census
Scotland	-	50.00 (4)	25.00 (2)	25.00 (2)	-	-	-	8	Census
Wales	-	-	-	100.00 (1)	-	-	-	1	Census
UK	53.85 (14)	-	11.54 (3)	30.77 (8)	19.23 (5)	-	-	30	Annual SMP
England	66.67 (8)	-	16.67 (2)	50.00 (6)	16.67 (2)	-	-	18	Annual SMP
Northern Ireland	20.00 (1)	-	20.00 (1)	40.00 (2)	20.00 (1)	-	-	5	Annual SMP
Scotland	50.00 (4)	-	-	-	12.50 (1)	-	-	5	Annual SMP
Wales	100.00 (1)	-	-	-	100.00 (1)	-	-	2	Annual SMP

b) percentage of the population

Country	0	1 - 10	11 - 100	101 - 1000	1001 - 10000	10001 - 100000	100001+	Data
UK	-	0.12	1.46	26.93	71.49	-	-	Census
Channel Islands	-	-	100.00	-	-	-	-	Census
England	-	-	1.59	13.70	84.71	-	-	Census
Northern Ireland	-	0.36	-	36.42	63.22	-	-	Census
Scotland	-	0.89	3.75	95.36	-	-	-	Census
Wales	-	-	-	100.00	-	-	-	Census
UK	0.00	-	1.02	25.75	66.85	-	-	Annual SMP
England	0.00	-	1.15	28.18	57.42	-	-	Annual SMP
Northern Ireland	0.00	-	1.23	34.16	51.95	-	-	Annual SMP
Scotland	0.00	-	-	-	99.61	-	-	Annual SMP
Wales	0.00	-	-	-	231.21	-	-	Annual SMP

Common Tern

a) percentage of sites

Country	0 (n)	1 - 10 (n)	11 - 100 (n)	101 - 1000 (n)	1001 - 10000 (n)	10001 - 100000 (n)	100001+ (n)	Total number of sites	Data
UK	-	57.18 (199)	34.20 (119)	8.33 (29)	0.29 (1)	-	-	348	Census
Channel Islands	-	25.00 (1)	75.00 (3)	-	-	-	-	4	Census
England	-	61.14 (107)	32.57 (57)	5.71 (10)	0.57 (1)	-	-	175	Census
Northern Ireland	-	15.38 (2)	38.46 (5)	46.15 (6)	-	-	-	13	Census
Scotland	-	57.62 (87)	35.76 (54)	6.62 (10)	-	-	-	151	Census
Wales	-	33.33 (3)	33.33 (3)	33.33 (3)	-	-	-	9	Census
UK	6.61 (23)	3.16 (11)	10.63 (37)	6.32 (22)	0.29 (1)	-	-	94	Annual SMP
England	3.43 (6)	2.29 (4)	9.71 (17)	4.57 (8)	0.57 (1)	-	-	36	Annual SMP
Northern Ireland	7.69 (1)	-	15.38 (2)	30.77 (4)	-	-	-	7	Annual SMP
Scotland	10.60 (16)	4.64 (7)	11.26 (17)	4.64 (7)	-	-	-	47	Annual SMP
Wales	-	-	11.11 (1)	33.33 (3)	-	-	-	4	Annual SMP

b) percentage of the population

Country	0	1 - 10	11 - 100	101 - 1000	1001 - 10000	10001 - 100000	100001+	Data
UK	-	4.81	29.77	51.87	13.55	-	-	Census
Channel Islands	-	2.11	97.89	-	-	-	-	Census
England	-	5.80	33.10	30.43	30.67	-	-	Census
Northern Ireland	-	0.16	9.88	89.95	-	-	-	Census
Scotland	-	6.36	38.60	55.04	-	-	-	Census
Wales	-	1.45	11.36	87.19	-	-	-	Census
UK	0	0.20	9.15	40.10	13.43	-	-	Annual SMP
England	0	0.24	9.27	23.00	30.40	-	-	Annual SMP
Northern Ireland	0	-	4.12	74.96	-	-	-	Annual SMP
Scotland	0	0.27	12.79	34.67	-	-	-	Annual SMP
Wales	-	-	2.58	93.39	-	-	-	Annual SMP

Roseate Tern

a) percentage of sites

Country	0 (n)	1 - 10 (n)	11 - 100 (n)	101 - 1000 (n)	1001 - 10000 (n)	10001 - 100000 (n)	100001+ (n)	Total number of sites	Data
UK	-	66.67 (2)	-	33.33 (1)	-	-	-	3	Census
Channel Islands	-	100.00 (1)	-	-	-	-	-	1	Census
England	-	-	-	100.00 (1)	-	-	-	1	Census
Northern Ireland	-	100.00 (1)	-	-	-	-	-	1	Census
Wales	-	100.00 (1)	-	-	-	-	-	1	Census
UK	166.67 (5)	100.00 (3)	-	33.33 (1)	-	-	-	9	Annual SMP
England	200.00 (2)	-	-	100.00 (1)	-	-	-	3	Annual SMP
Northern Ireland	100.00 (1)	100.00 (1)	-	-	-	-	-	2	Annual SMP
Wales	200.00 (2)	100.00 (1)	-	-	-	-	-	3	Annual SMP

b) percentage of the population

Country	0	1 - 10	11 - 100	101 - 1000	1001 - 10000	10001 - 100000	100001+	Data
UK	-	1.67	-	98.33	-	-	-	Census
Channel Islands	-	100.00	-	-	-	-	-	Census
England	-	-	-	100.00	-	-	-	Census
Northern Ireland	-	100.00	-	-	-	-	-	Census
Scotland	-	-	-	-	-	-	-	Census
Wales	-	100.00	-	-	-	-	-	Census
UK	0.00	3.33	-	101.67	-	-	-	Annual SMP
England	0.00	-	-	103.39	-	-	-	Annual SMP
Northern Ireland	0.00	100.00	-	-	-	-	-	Annual SMP
Scotland	-	100.00	-	-	-	-	-	Annual SMP
Wales	0.00	200.00	-	-	-	-	-	Annual SMP

Arctic Tern

a) percentage of sites

Country	0 (n)	1 - 10 (n)	11 - 100 (n)	101 - 1000 (n)	1001 - 10000 (n)	10001 - 100000 (n)	10000 1+ (n)	Total number of sites	Data
UK	-	41.45 (257)	51.77 (321)	5.97 (37)	0.81 (5)	-	-	620	Census
England	-	50.00 (6)	16.67 (2)	8.33 (1)	25.00 (3)	-	-	12	Census
Isle of Man	-	-	100.0 0 (1)	-	-	-	-	1	Census
Northern Ireland	-	25.00 (2)	25.00 (2)	50.00 (4)	-	-	-	8	Census
Scotland	-	41.71 (249)	52.93 (316)	5.19 (31)	0.17 (1)	-	-	597	Census
Wales	-	-	33.33 (1)	33.33 (1)	33.33 (1)	-	-	3	Census
UK	3.55 (22)	2.10 (13)	3.39 (21)	1.77 (11)	0.81 (5)	-	-	72	Annual SMP
England	8.33 (1)	25.00 (3)	16.67 (2)	-	25.00 (3)	-	-	9	Annual SMP
Isle of Man	-	-	100.0 0 (1)	-	-	-	-	1	Annual SMP
Northern Ireland	12.50 (1)	12.50 (1)	12.50 (1)	37.50 (3)	-	-	-	6	Annual SMP
Scotland	3.35 (20)	1.51 (9)	2.85 (17)	1.17 (7)	0.17 (1)	-	-	54	Annual SMP
Wales	-	-	33.33 (1)	33.33 (1)	33.33 (1)	-	-	3	Annual SMP

b) percentage of the population

Country	0	1 - 10	11 - 100	101 - 1000	1001 - 10000	10001 - 100000	100001+	Data
UK	-	3.51	34.42	26.35	35.72	-	-	Census
England	-	0.39	1.75	1.96	95.90	-	-	Census
Isle of Man	-	-	100.00	-	-	-	-	Census
Northern Ireland	-	0.62	10.50	88.88	-	-	-	Census
Scotland	-	5.31	52.49	34.06	8.14	-	-	Census
Wales	-	-	0.35	13.30	86.35	-	-	Census
UK	0.00	0.12	2.51	11.61	27.69	-	-	Annual SMP
England	0.00	0.10	2.01	-	66.00	-	-	Annual SMP
Isle of Man	-	-	89.29	-	-	-	-	Annual SMP
Northern Ireland	0.00	0.12	6.25	159.38	-	-	-	Annual SMP
Scotland	0.00	0.15	2.97	9.61	8.14	-	-	Annual SMP
Wales	-	-	0.25	9.60	70.74	-	-	Annual SMP

Guillemot

a) percentage of sites

Country	0 (n)	1 - 10 (n)	11 - 100 (n)	101 - 1000 (n)	1001 - 10000 (n)	10001 - 100000 (n)	100001+ (n)	Total number of sites	Data
UK	-	11.42 (49)	24.48 (105)	33.57 (144)	23.78 (102)	6.53 (28)	0.23 (1)	429	Census
Channel Islands	-	28.57 (2)	57.14 (4)	14.29 (1)	-	-	-	7	Census
England	-	9.43 (5)	37.74 (20)	33.96 (18)	13.21 (7)	5.66 (3)	-	53	Census
Isle of Man	-	-	-	75.00 (3)	25.00 (1)	-	-	4	Census
Northern Ireland	-	14.29 (1)	14.29 (1)	28.57 (2)	28.57 (2)	-	14.29 (1)	7	Census
Scotland	-	12.03 (38)	22.15 (70)	33.86 (107)	25 (79)	6.96 (22)	-	316	Census
Wales	-	9.43 (5)	26.42 (14)	32.08 (17)	26.42 (14)	5.66 (3)	-	53	Census
UK	0.47 (2)	0.70 (3)	0.93 (4)	2.80 (12)	5.36 (23)	1.40 (6)	-	50	Annual SMP
England	-	-	-	-	5.66 (3)	3.77 (2)	-	5	Annual SMP
Isle of Man	-	-	-	25.00 (1)	-	-	-	1	Annual SMP
Northern Ireland	-	-	-	-	14.29 (1)	-	-	1	Annual SMP
Scotland	0.63 (2)	-	0.63 (2)	2.22 (7)	3.48 (11)	0.95 (3)	-	25	Annual SMP
Wales	-	5.66 (3)	3.77 (2)	9.43 (5)	15.09 (8)	1.89 (1)	-	19	Annual SMP

b) percentage of the population

Country	0	1 - 10	11 - 100	101 - 1000	1001 - 10000	10001 - 100000	100001+	Data
UK	-	0.02	0.41	4.47	26.07	57.25	11.79	Census
Channel Islands	-	1.02	39.34	59.64	-	-	-	Census
England	-	0.01	0.52	3.51	10.54	85.41	-	Census
Isle of Man	-	-	-	24.1	75.90	-	-	Census
Northern Ireland	-	0.00	0.06	0.57	3.46	-	95.91	Census
Scotland	-	0.02	0.41	5.28	31.88	62.41	-	Census
Wales	-	0.02	0.70	5.72	43.5	50.07	-	Census
UK	0.00	0.00	0.02	0.40	4.34	10.99	-	Annual SMP
England	-	-	-	-	1.87	39.45	-	Annual SMP
Isle of Man	-	-	-	2.38	-	-	-	Annual SMP
Northern Ireland	-	-	-	-	1.78	-	-	Annual SMP
Scotland	0.00	-	0.01	0.38	3.16	5.93	-	Annual SMP
Wales	-	0.01	0.09	1.84	21.96	13.81	-	Annual SMP

Razorbill

a) percentage of sites

Country	0 (n)	1 - 10 (n)	11 - 100 (n)	101 - 1000 (n)	1001 - 10000 (n)	10001 - 100000 (n)	100001+ (n)	Total number of sites	Data
UK	-	21.53 (121)	45.02 (253)	28.11 (158)	4.63 (26)	0.71 (4)	-	562	Census
Channel Islands	-	57.14 (4)	42.86 (3)	-	-	-	-	7	Census
England	-	28.75 (23)	51.25 (41)	16.25 (13)	2.50 (2)	1.25 (1)	-	80	Census
Isle of Man	-	11.11 (1)	66.67 (6)	22.22 (2)	-	-	-	9	Census
Northern Ireland	-	27.27 (3)	27.27 (3)	27.27 (3)	9.09 (1)	9.09 (1)	-	11	Census
Scotland	-	20.99 (85)	43.95 (178)	30.12 (122)	4.44 (18)	0.49 (2)	-	405	Census
Wales	-	15.15 (10)	46.97 (31)	30.30 (20)	7.58 (5)	-	-	66	Census
UK	0.18 (1)	0.53 (3)	3.91 (22)	3.91 (22)	1.25 (7)	-	-	55	Annual SMP
England	-	-	1.25 (1)	5.00 (4)	-	-	-	5	Annual SMP
Isle of Man	-	-	-	11.11 (1)	-	-	-	1	Annual SMP
Northern Ireland	-	-	-	-	9.09 (1)	-	-	1	Annual SMP
Scotland	-	0.49 (2)	2.47 (10)	2.96 (12)	0.49 (2)	-	-	26	Annual SMP
Wales	1.52 (1)	1.52 (1)	16.67 (11)	9.09 (6)	6.06 (4)	-	-	23	Annual SMP

b) percentage of the population

Country	0	1 - 10	11 - 100	101 - 1000	1001 - 10000	10001 - 100000	100001+	Data
UK	-	0.23	4.72	24.11	38.15	32.80	-	Census
Channel Islands	-	21.43	78.57	-	-	-	-	Census
England	-	0.30	4.27	8.44	12.92	74.06	-	Census
Isle of Man	-	0.48	36.58	62.94	-	-	-	Census
Northern Ireland	-	0.06	0.85	4.19	4.24	90.66	-	Census
Scotland	-	0.25	5.25	32.04	45.69	16.78	-	Census
Wales	-	0.17	6.40	23.62	69.82	-	-	Census
UK	0.00	0.01	0.31	3.40	10.27	-	-	Annual SMP
England	-	-	0.07	4.38	-	-	-	Annual SMP
Isle of Man	-	-	-	17.25	-	-	-	Annual SMP
Northern Ireland	-	-	-	-	4.52	-	-	Annual SMP
Scotland	-	0.01	0.21	2.77	9.72	-	-	Annual SMP
Wales	0.00	0.02	1.64	9.06	35.91	-	-	Annual SMP

Black Guillemot

a) percentage of sites

Country	0 (n)	1 - 10 (n)	11 - 100 (n)	101 - 1000 (n)	1001 - 10000 (n)	10001 - 100000 (n)	100001+ (n)	Total number of sites	Data
UK	-	39.02 (437)	54.55 (611)	6.34 (71)	0.09 (1)	-	-	1120	Census
England	-	100.00 (1)	-	-	-	-	-	1	Census
Isle of Man	-	43.75 (7)	56.25 (9)	-	-	-	-	16	Census
Northern Ireland	-	27.50 (11)	67.50 (27)	5.00 (2)	-	-	-	40	Census
Scotland	-	39.41 (424)	54.09 (582)	6.41 (69)	0.09 (1)	-	-	1076	Census
Wales	-	33.33 (1)	66.67 (2)	-	-	-	-	3	Census
UK	-	0.36 (4)	0.98 (11)	1.07 (12)	-	-	-	27	Annual SMP
England	-	100.00 (1)	-	-	-	-	-	1	Annual SMP
Northern Ireland	-	-	7.50 (3)	-	-	-	-	3	Annual SMP
Scotland	-	0.19 (2)	0.74 (8)	1.12 (12)	-	-	-	22	Annual SMP
Wales	-	33.33 (1)	-	-	-	-	-	1	Annual SMP

b) percentage of the population

Country	0	1 - 10	11 - 100	101 - 1000	1001 - 10000	10001 - 100000	100001+	Data
UK	-	4.94	56.33	35.73	3.01	-	-	Census
England	-	100.00	-	-	-	-	-	Census
Isle of Man	-	14.69	85.31	-	-	-	-	Census
Northern Ireland	-	5.32	69.30	25.39	-	-	-	Census
Scotland	-	4.91	55.84	36.13	3.11	-	-	Census
Wales	-	5.26	94.74	-	-	-	-	Census
UK	-	0.03	1.65	8.10	-	-	-	Annual SMP
England	-	166.67	-	-	-	-	-	Annual SMP
Northern Ireland	-	-	11.49	-	-	-	-	Annual SMP
Scotland	-	0.02	1.32	8.38	-	-	-	Annual SMP
Wales	-	2.63	-	-	-	-	-	Annual SMP

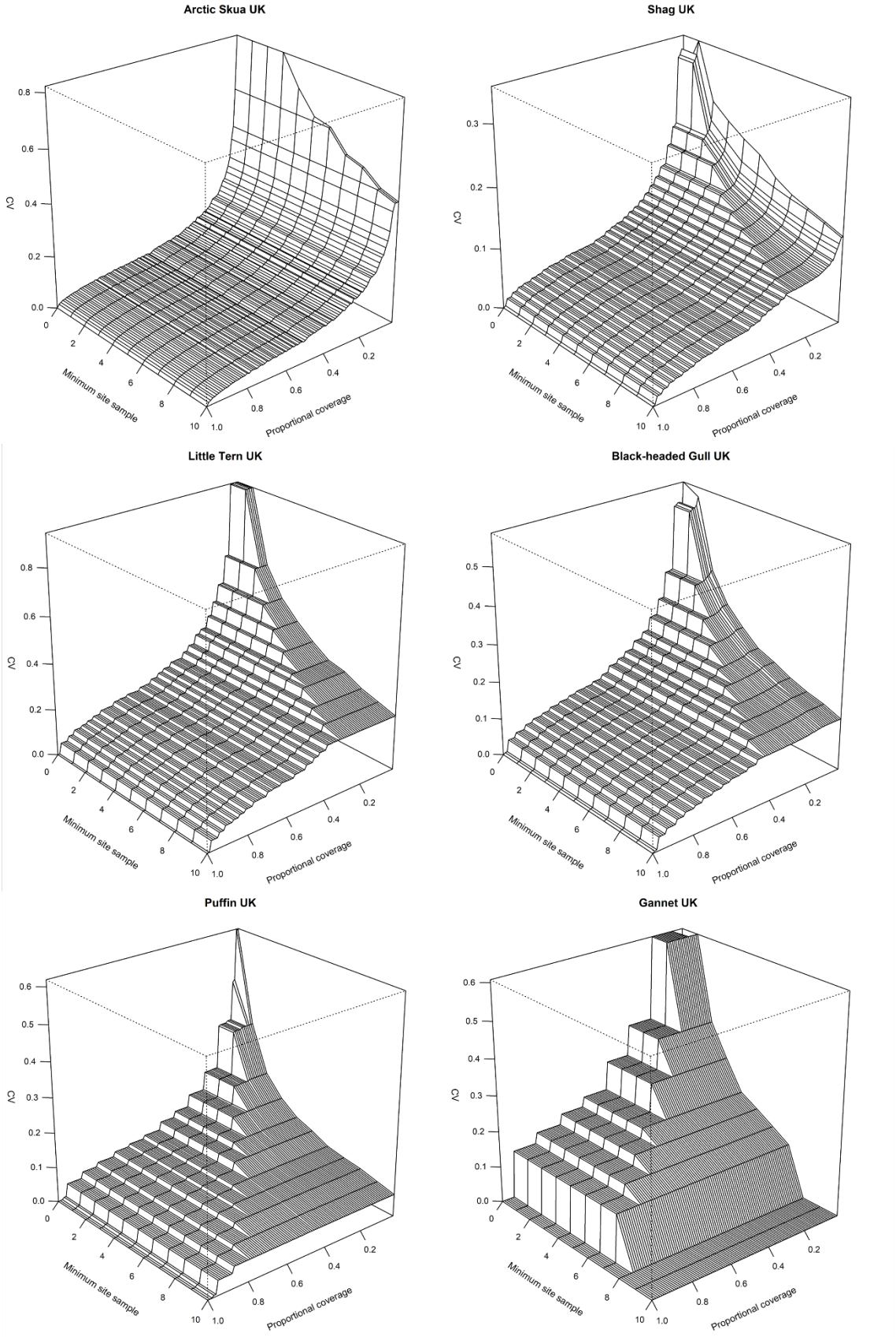
APPENDIX 3. Current and defunct Retrapping Adults for Survival (RAS) study sites for seabirds where more consistent monitoring of multiple metrics (abundance, productivity and survival) might be targeted, with a summary of the data on abundance and productivity that have been collected through the Seabird Monitoring Programme (SMP) at these sites.

Species	Country	Site	Status	Start year	Ran from	End year	Productivity		Abundance counts [1]	
							No. of years	Year range	No. of years	Year range
Arctic Tern	Wales	Skerries, Anglesey	Current	2013	-	-	26	1986 - 2013	34	1986 - 2019
Arctic Tern	England	Coquet Island	Defunct	2000	-	2003	32	1986 - 2021	36	1986 - 2021
Black-headed Gull	England	Cotswold Water Park	Defunct	2009	-	2014	-	-	-	-
Black-headed Gull	England	Hosehill Lake LNR	Defunct	2010	2010	2017	-	-	-	-
Common Tern	Wales	Skerries	Current	2016	2016	-	23	1991 - 2013	29	1991 - 2019
Fulmar	Scotland	Isle of Tiree	Current	2016	2020	-	-	-	-	-
Guillemot	Scotland	Geugasgor Cliffs, Canna	Current	2013	1973	-	-	-	-	-
Guillemot	Scotland	Port Ban, Colonsay	Current	2012	1989	-	-	-	-	-
Guillemot	Wales	Puffin Island	Provisional	2020	2007	-	-	-	23	1986 - 2022
Guillemot	Scotland	Sanda Island	Defunct	2000	-	2013	-	-	23	1986 - 2019
Herring Gull	England	Havergate Island	Current	2016	2012	-	10	2009 - 2021	24	1995 - 2021
Kittiwake	England	Claremont Pier, Lowestoft	Current	2016	2012	-	32	1986 - 2017	31	1986 - 2018
Kittiwake	Scotland	Isle of Canna	Current	2016	2011	-	35	1986 - 2021	36	1986 - 2022
Kittiwake	Wales	Puffin Island	Current	2016	1982	-	13	1991 - 2022	23	1986 - 2022
Kittiwake	England	Rinsey Cliffs	Current	2016	2012	-	8	2006 - 2016	6	2000 - 2016
Kittiwake	England	Flamborough [2]	Provisional	2016	2018	-	34	1986 - 2021	23	1986 - 2019
Kittiwake	England	Gateshead Kittiwake Tower	Provisional	2016	2016	-	17	1998 - 2015	16	2000 - 2015
Kittiwake	England	Hartlepool	Provisional	2016	-	-	-	-	-	-
Kittiwake	Scotland	Poll Ban, Isle of Colonsay	Provisional	2016	-	-	6	1987 - 1992	5	1986 - 2018
Kittiwake	Scotland	Inchkeith	Defunct	1992	-	2007	-	-	37	1986 - 2022
Lesser Black-backed Gull	England	Havergate Island	Current	2016	2012	-	10	2009 - 2021	35	1986 - 2021

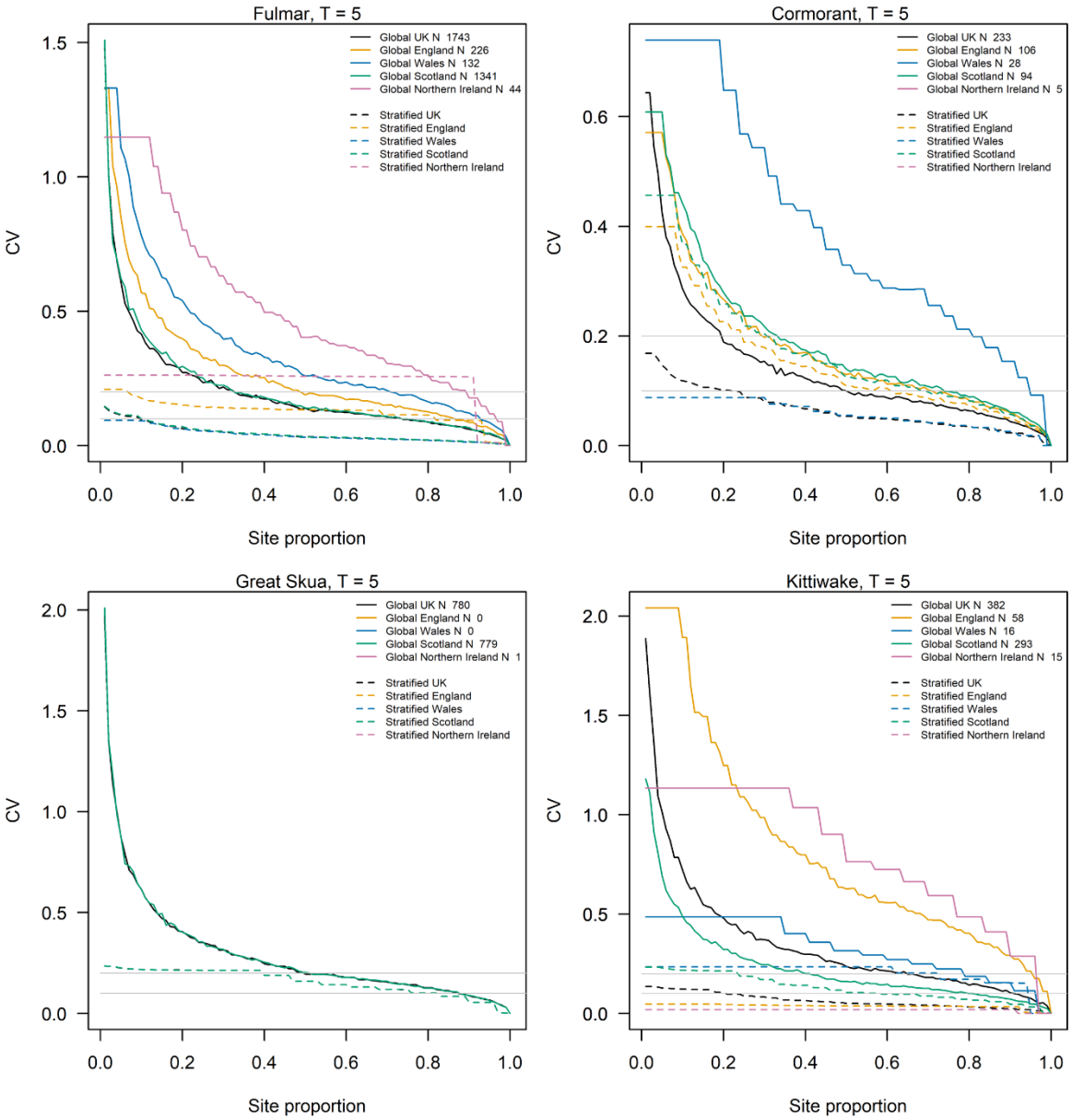
Lesser Black-backed Gull	Wales	Flat Holm	Defunct	2011	1995	2016	-	-	8	1986 - 2018
Lesser Black-backed Gull	England	Orfordness	Defunct	2011	2003	2017	-	-	30	1986 - 2018
Manx Shearwater	Scotland	Hallival, Askival & Trollaval, Isle of Rum	Defunct	1994	-	2014	25	1986 - 2018	-	-
Manx Shearwater	Scotland	Sanda Island	Defunct	2000	-	2013	5	2001 - 2005	20	1986 - 2006
Puffin	Scotland	Garbh Eilean, Shiant Islands	Current	2008	-	-	-	-	-	-
Puffin	Scotland	North Beach, Garbh Eilean	Current	2013	2007	-	-	-	-	-
Puffin	Scotland	Garbh Eilean, Shiant Islands	Defunct	1970	1970	1985	-	-	-	-
Razorbill	Scotland	Geugasgor Cliffs, Canna	Current	2016	1973	-	-	-	-	-
Razorbill	Scotland	North Beach, Carnach Mhor, Shiant Isles	Current	2016	1970	-	-	-	-	-
Razorbill	Wales	Puffin Island	Current	2016	2009	-	-	-	22	1986 - 2022
Razorbill	Scotland	Sanda Island	Defunct	1998	-	2006	-	-	23	1986 - 2019
Shag	Scotland	Carnach Mhor, Shiant Isles	Current	2016	-	-	-	-	-	-
Shag	Scotland	Lunga, Treshnish Isles	Current	2016	-	-	-	-	30	1986 - 2022
Shag	Wales	Puffin Island	Current	2016	2015	-	12	2010 - 2022	23	1986 - 2022
Shag	Scotland	Craigleith	Defunct	1992	-	2006	-	-	37	1986 - 2022
Shag	England	Staple Island, Farnes	Defunct	2000	-	2006	29	1987 - 2015	34	1986 - 2019
Storm-petrel	Scotland	Lunga (1)	Current	2016	-	-	-	-	-	-
Storm-petrel	Scotland	Lunga (2)	Current	2016	-	-	-	-	-	-
Storm-petrel	Scotland	Eilean Hoan	Defunct	1999	1996	2012	-	-	-	-
Storm-petrel	Scotland	Priest Island	Defunct	2001	-	2018	-	-	5	1999 - 2019
Storm-petrel	Scotland	Sanda Island	Defunct	2000	-	2013	-	-	-	-

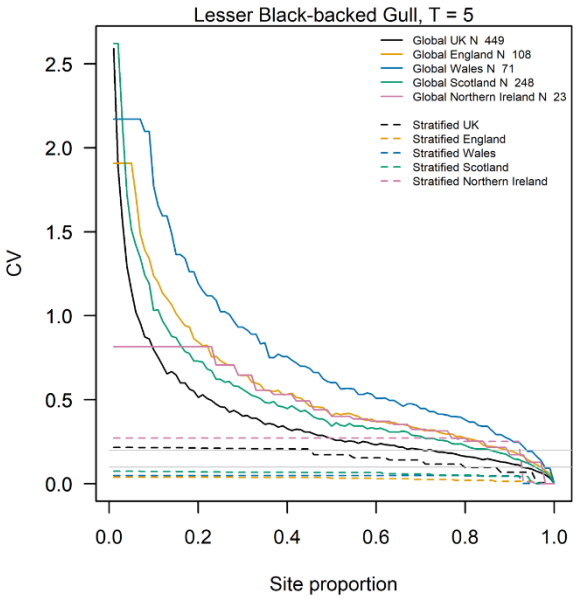
[1] Included if more frequent counts than for the four national censuses. [2] Productivity and counts for Flamborough Head and Bempton Cliffs.

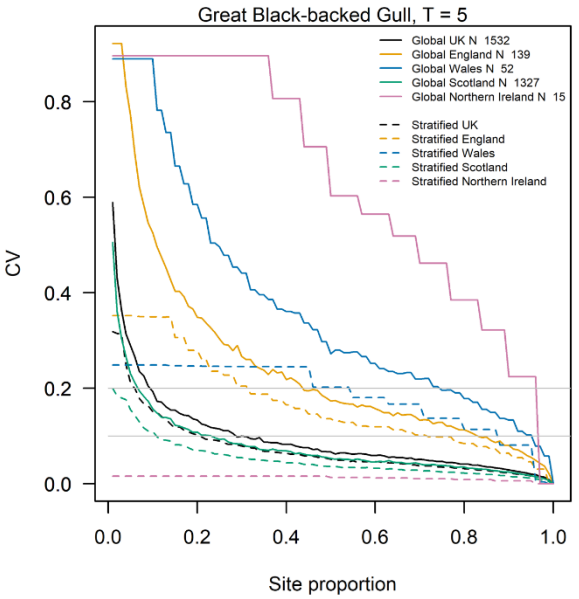
APPENDIX 4. Initial evaluation of the minimum sample number 'T' of sites to include in simulations, considering six example species at the UK level: Arctic Skua, Shag, Little Tern, Black-headed Gull, Puffin and Gannet.

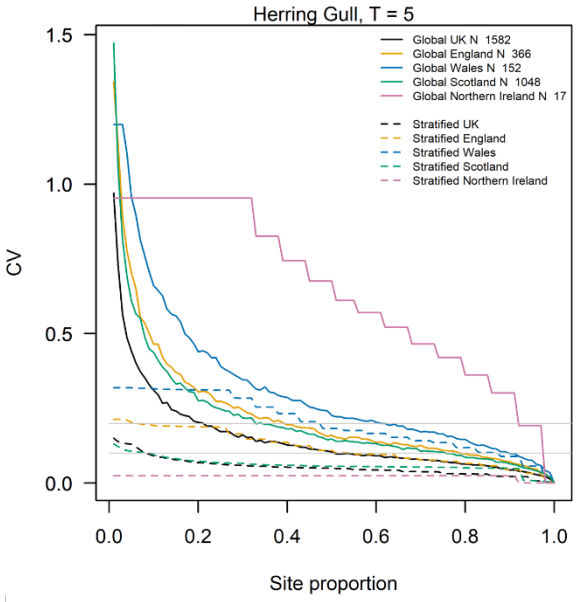


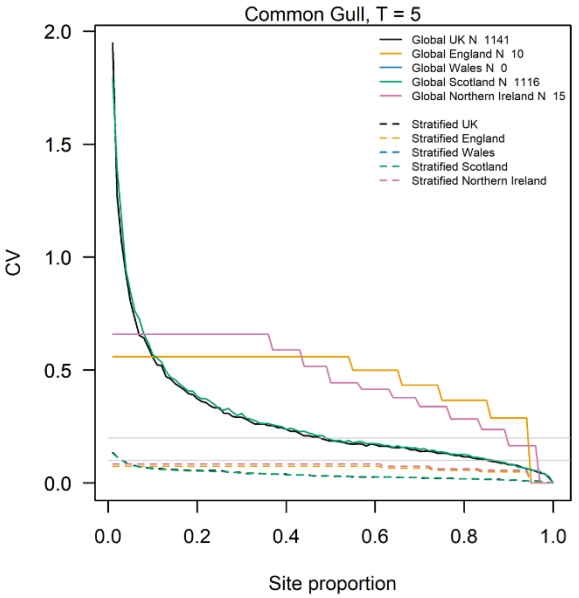
APPENDIX 5. Coefficient of Variation (CV) around estimates of population size obtained under different levels of sampling using a global approach sampling across all sites (solid line) and stratifying sites by size (dashed line) for seabird species not shown in Figure 4 for the UK, England, Wales, Scotland and Northern Ireland. Smaller CVs represent more precise population estimates. Sample sizes per species and region are displayed. Grey horizontal lines show where a CV of 0.1 or 0.2 intersect the curves. All CV curves use a minimum site threshold of T = 5, i.e. for 10 sites and a proportion of 0.3, five sites would be chosen as opposed to three (see section 2.4). CV lines were not produced for species/country combinations where less than 10 sites were available as sample sizes were deemed too low for a meaningful sampling appraisal. Site-level counts of individuals are assumed to be known without error, hence the CV reduces to zero when all sites are sampled. This assumption is unlikely to hold in reality. No figure was produced for Roseate Tern as there is only one main site.

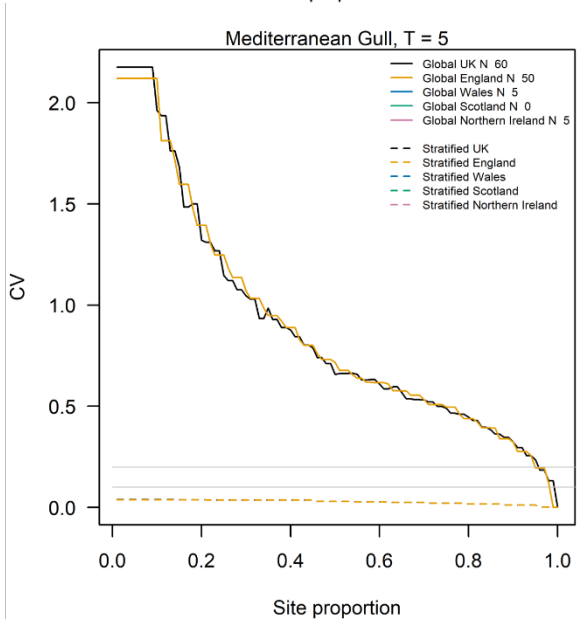


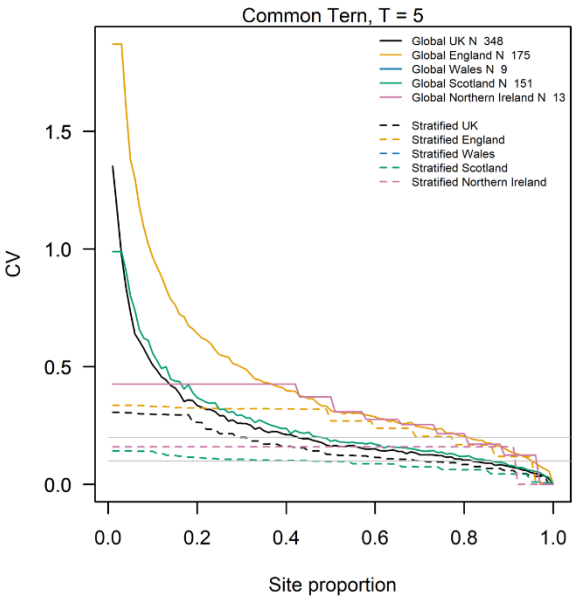

Lesser Black-backed Gull, T = 5
Global UK N 449
Global England N 108
Global Wales N 71
Global Scotland N 248
Global Northern Ireland N 23
Stratified UK
Stratified England
Stratified Wales
Stratified Scotland
Stratified Northern Ireland
CV
Site proportion

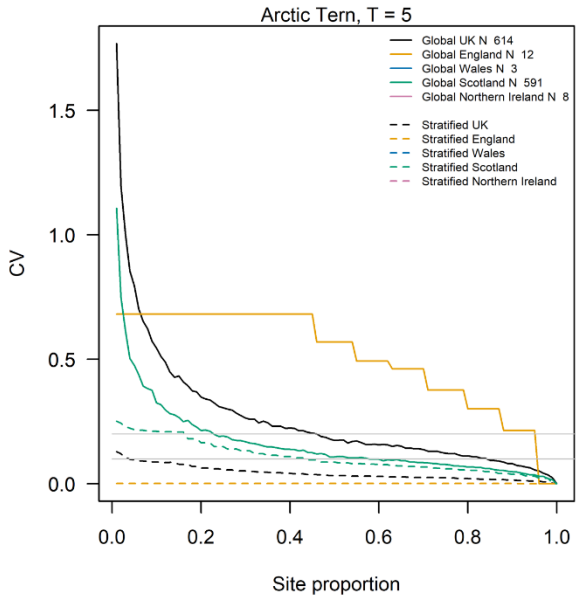

Great Black-backed Gull, T = 5
Global UK N 1532
Global England N 139
Global Wales N 52
Global Scotland N 1327
Global Northern Ireland N 15
Stratified UK
Stratified England
Stratified Wales
Stratified Scotland
Stratified Northern Ireland
CV
Site proportion

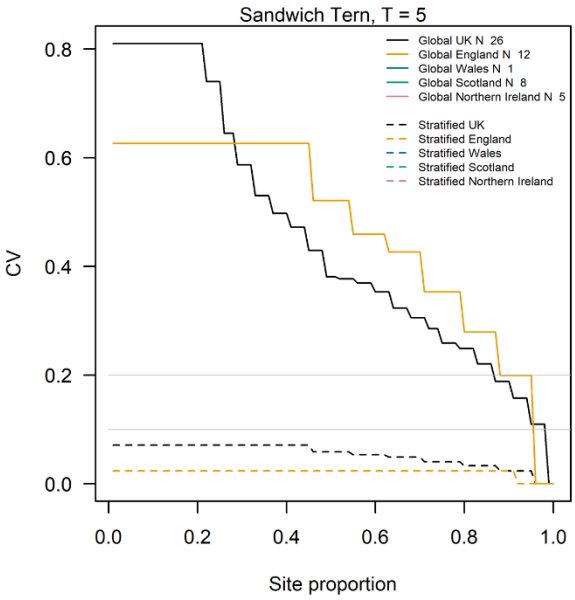

Herring Gull, T = 5
Global UK N 1582
Global England N 366
Global Wales N 152
Global Scotland N 1048
Global Northern Ireland N 17
Stratified UK
Stratified England
Stratified Wales
Stratified Scotland
Stratified Northern Ireland
CV
Site proportion

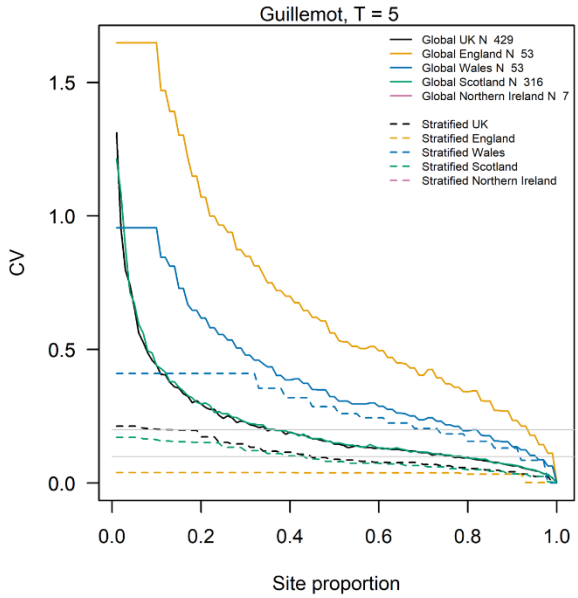

Common Gull, T = 5
Global UK N 1141
Global England N 10
Global Wales N 0
Global Scotland N 1116
Global Northern Ireland N 15
Stratified UK
Stratified England
Stratified Wales
Stratified Scotland
Stratified Northern Ireland
CV
Site proportion

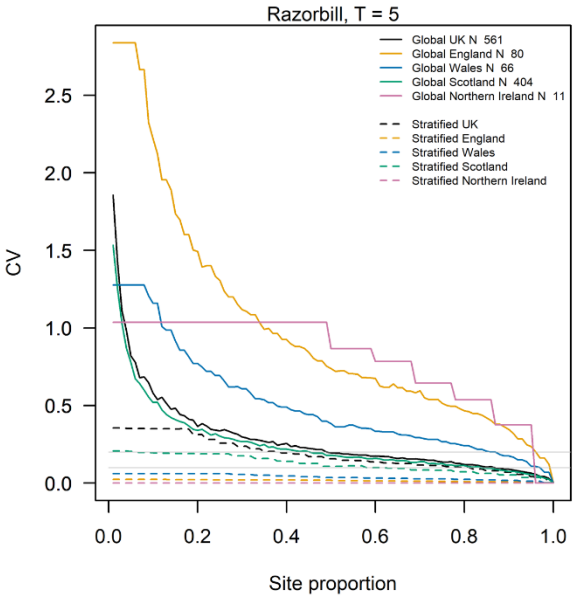

Mediterranean Gull, T = 5
Global UK N 60
Global England N 50
Global Wales N 5
Global Scotland N 0
Global Northern Ireland N 5
Stratified UK
Stratified England
Stratified Wales
Stratified Scotland
Stratified Northern Ireland
CV
Site proportion

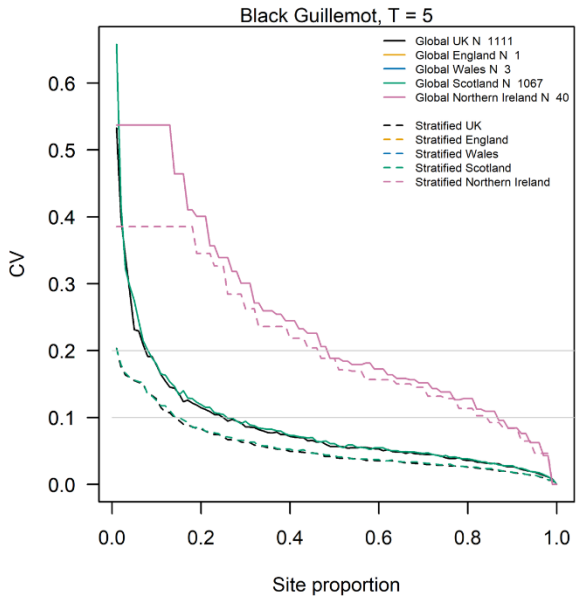

Common Tern, T = 5
Global UK N 348
Global England N 175
Global Wales N 9
Global Scotland N 151
Global Northern Ireland N 13
Stratified UK
Stratified England
Stratified Wales
Stratified Scotland
Stratified Northern Ireland
CV
Site proportion


Arctic Tern, T = 5
Global UK N 614
Global England N 12
Global Wales N 3
Global Scotland N 591
Global Northern Ireland N 8
Stratified UK
Stratified England
Stratified Wales
Stratified Scotland
Stratified Northern Ireland
CV
Site proportion

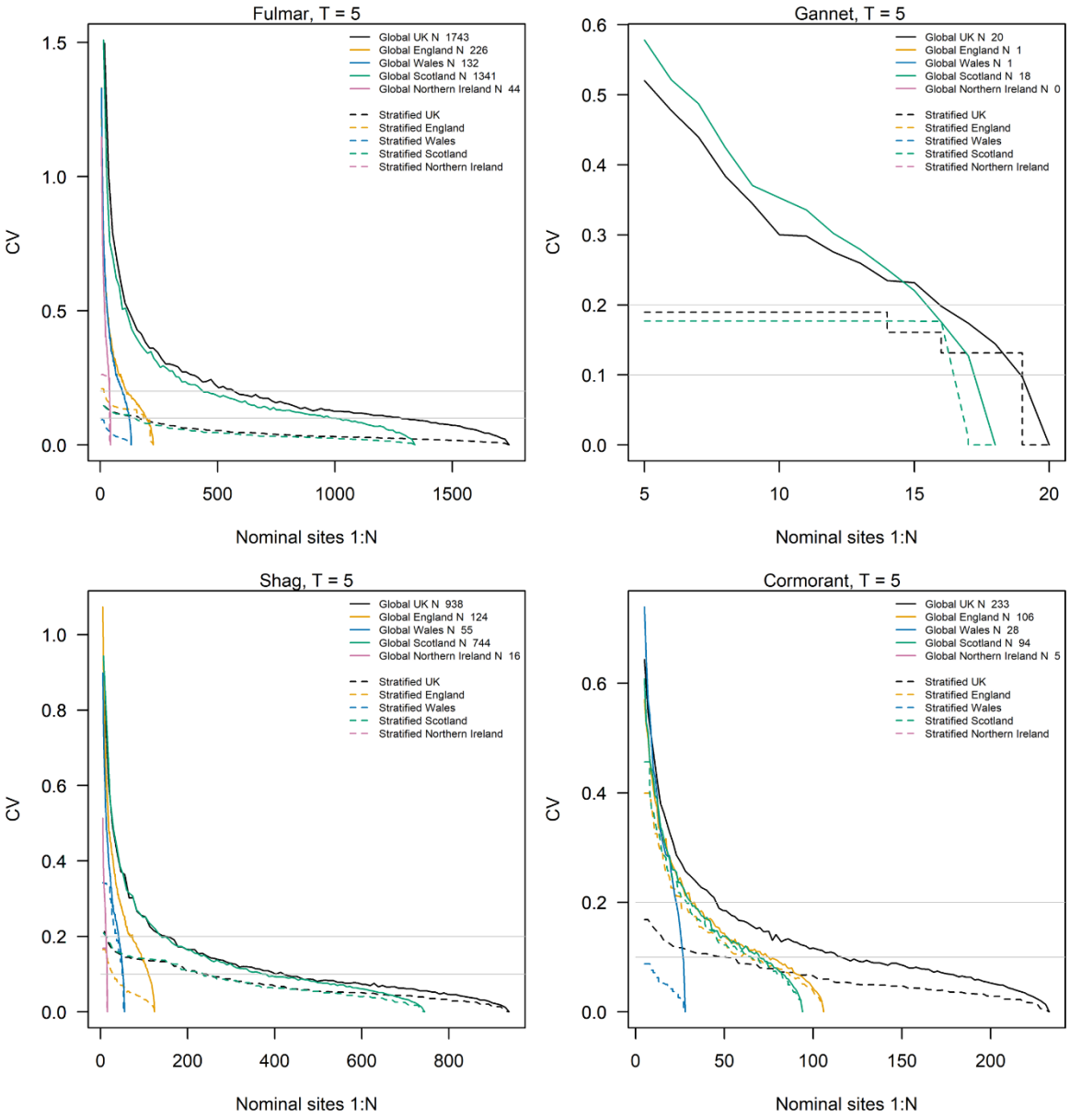

Sandwich Tern, T = 5
Global UK N 26
Global England N 12
Global Wales N 1
Global Scotland N 8
Global Northern Ireland N 5
Stratified UK
Stratified England
Stratified Wales
Stratified Scotland
Stratified Northern Ireland
CV
Site proportion

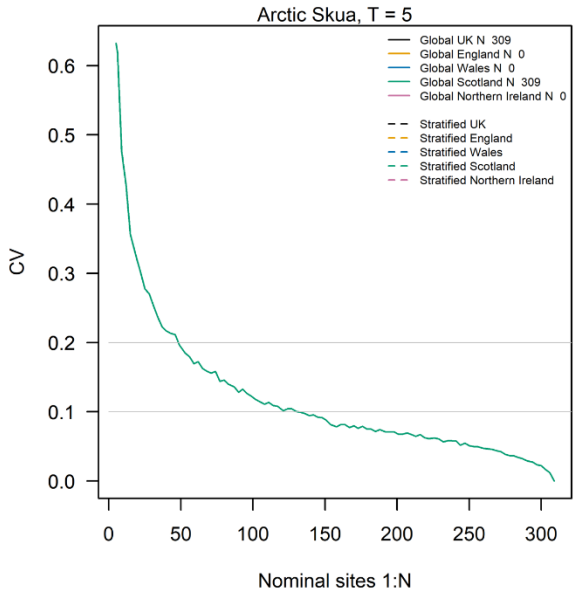

Guillemot, T = 5
Global UK N 429
Global England N 53
Global Wales N 53
Global Scotland N 316
Global Northern Ireland N 7
Stratified UK
Stratified England
Stratified Wales
Stratified Scotland
Stratified Northern Ireland
CV
Site proportion

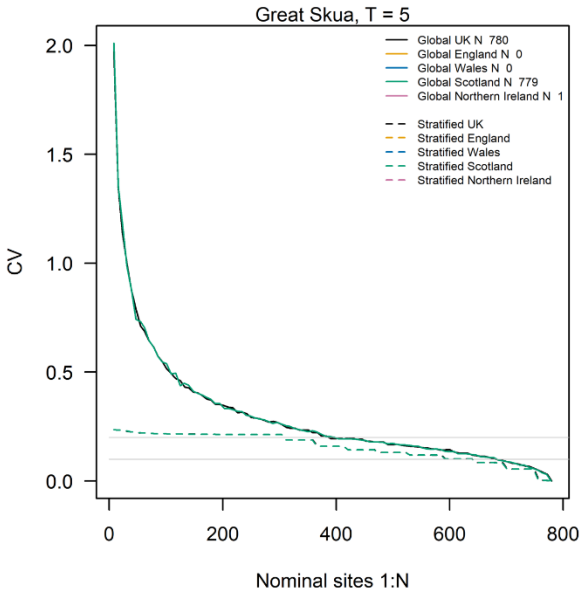

Razorbill, T = 5
Global UK N 561
Global England N 80
Global Wales N 66
Global Scotland N 404
Global Northern Ireland N 11
Stratified UK
Stratified England
Stratified Wales
Stratified Scotland
Stratified Northern Ireland
CV
Site proportion

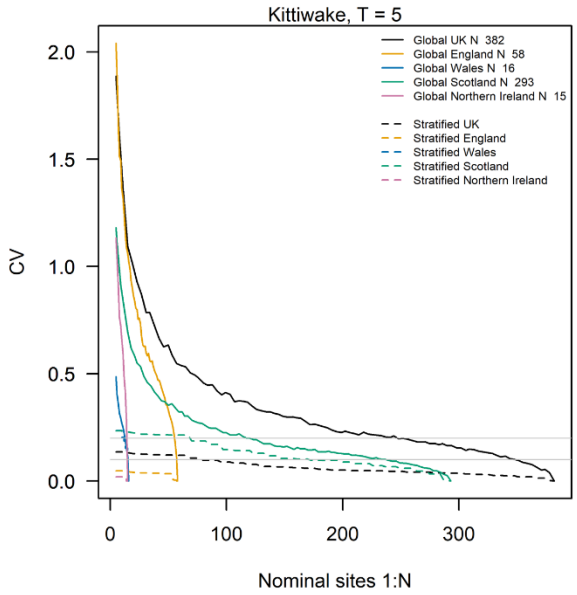

Black Guillemot, T = 5
Global UK N 1111
Global England N 1
Global Wales N 3
Global Scotland N 1067
Global Northern Ireland N 40
Stratified UK
Stratified England
Stratified Wales
Stratified Scotland
Stratified Northern Ireland
CV
Site proportion

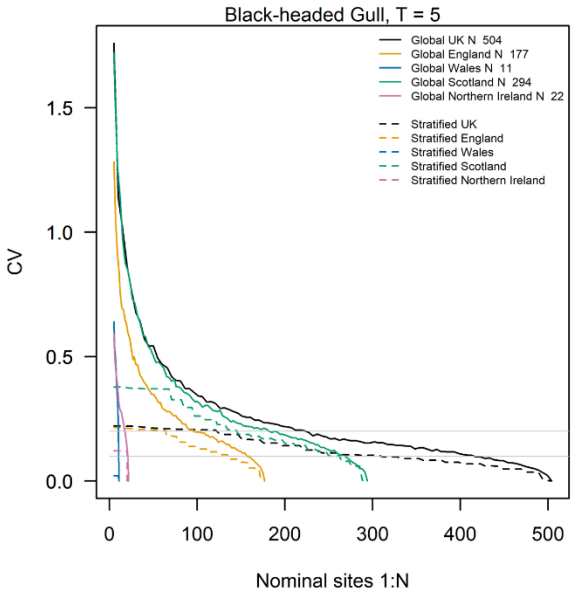
APPENDIX 6. Coefficient of Variation (CV) around estimates of population size obtained under different levels of sampling using a global approach sampling across all sites (solid line) and stratifying sites by size (dashed line) for seabird species showing the nominal number of sites of the x axis instead of the proportion of sites (see Figure 4 and Appendix 5) for use in engagement planning.

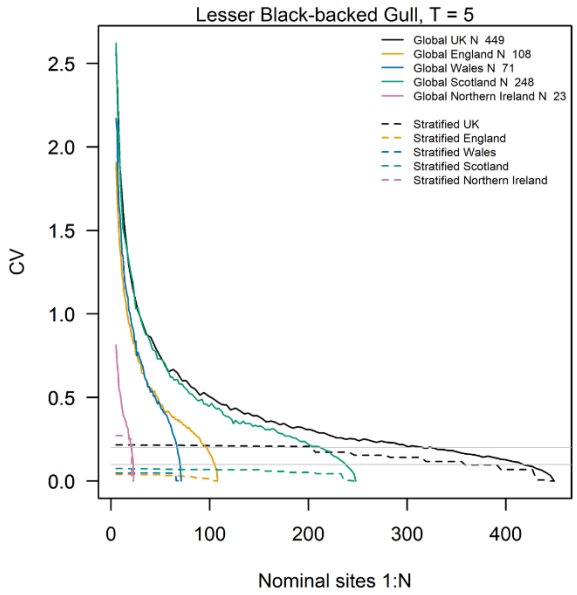


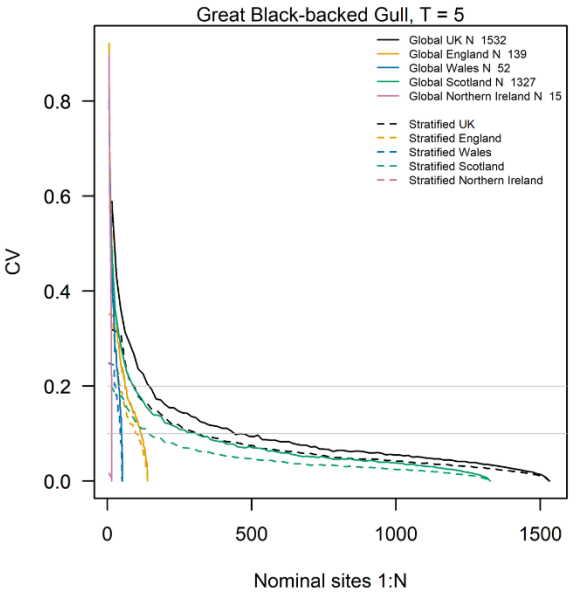

Arctic Skua, T = 5
Global UK N 309
Global England N 0
Global Wales N 0
Global Scotland N 309
Global Northern Ireland N 0
Stratified UK
Stratified England
Stratified Wales
Stratified Scotland
Stratified Northern Ireland
CV
Nominal sites 1:N

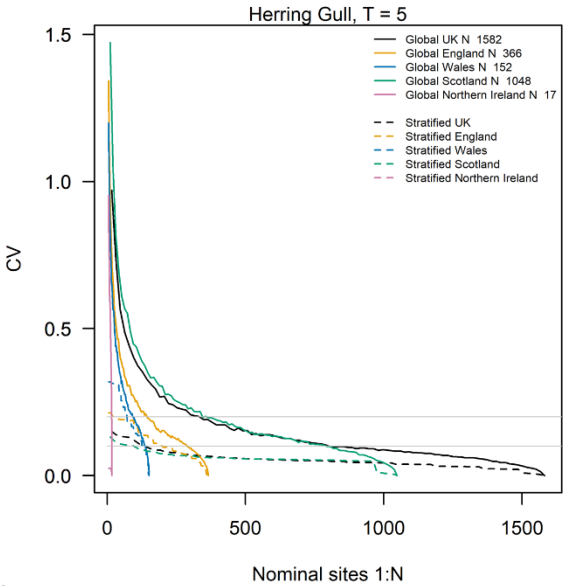

Great Skua, T = 5
Global UK N 780
Global England N 0
Global Wales N 0
Global Scotland N 779
Global Northern Ireland N 1
Stratified UK
Stratified England
Stratified Wales
Stratified Scotland
Stratified Northern Ireland
CV
Nominal sites 1:N

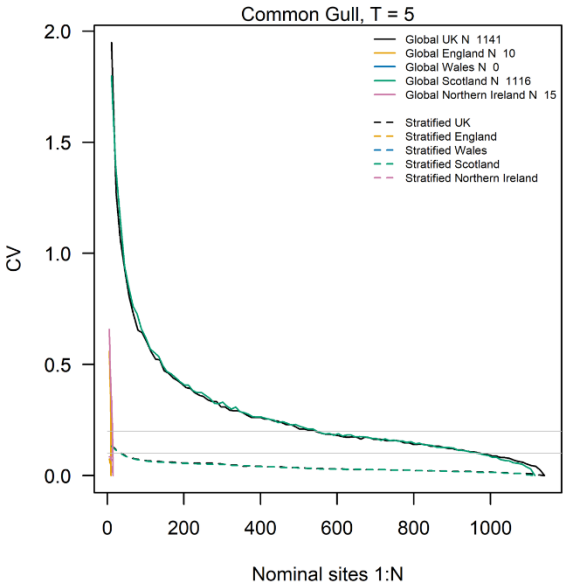

Kittiwake, T = 5
Global UK N 382
Global England N 58
Global Wales N 16
Global Scotland N 293
Global Northern Ireland N 15
Stratified UK
Stratified England
Stratified Wales
Stratified Scotland
Stratified Northern Ireland
CV
Nominal sites 1:N

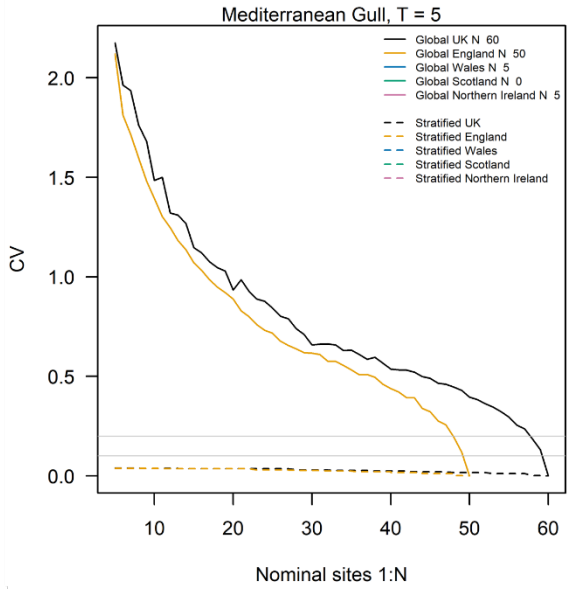

Black-headed Gull, T = 5
Global UK N 504
Global England N 177
Global Wales N 11
Global Scotland N 294
Global Northern Ireland N 22
Stratified UK
Stratified England
Stratified Wales
Stratified Scotland
Stratified Northern Ireland
CV
Nominal sites 1:N

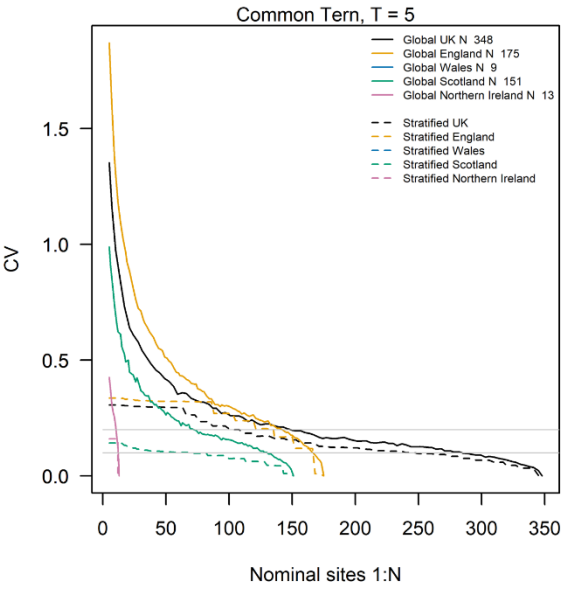

Lesser Black-backed Gull, T = 5
Global UK N 449
Global England N 108
Global Wales N 71
Global Scotland N 248
Global Northern Ireland N 23
Stratified UK
Stratified England
Stratified Wales
Stratified Scotland
Stratified Northern Ireland
CV
Nominal sites 1:N

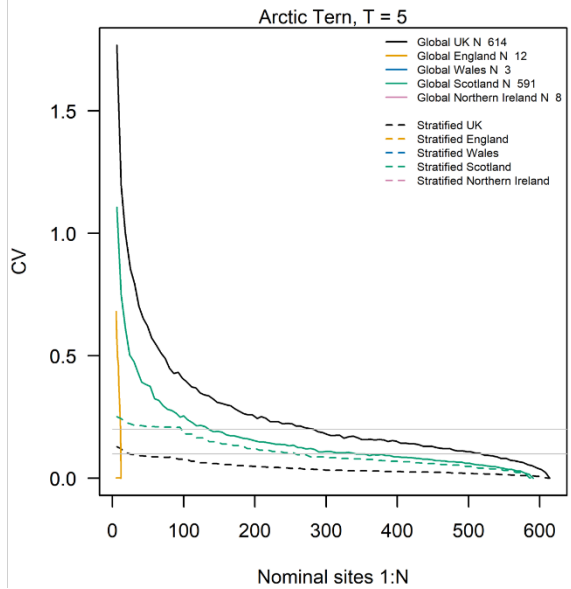

Great Black-backed Gull, T = 5
Global UK N 1532
Global England N 139
Global Wales N 52
Global Scotland N 1327
Global Northern Ireland N 15
Stratified UK
Stratified England
Stratified Wales
Stratified Scotland
Stratified Northern Ireland
CV
Nominal sites 1:N

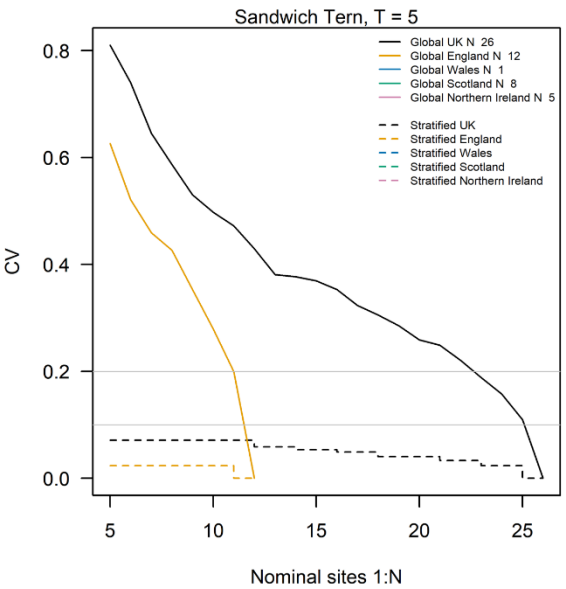

Herring Gull, T = 5
Global UK N 1582
Global England N 366
Global Wales N 152
Global Scotland N 1048
Global Northern Ireland N 17
Stratified UK
Stratified England
Stratified Wales
Stratified Scotland
Stratified Northern Ireland
CV
Nominal sites 1:N

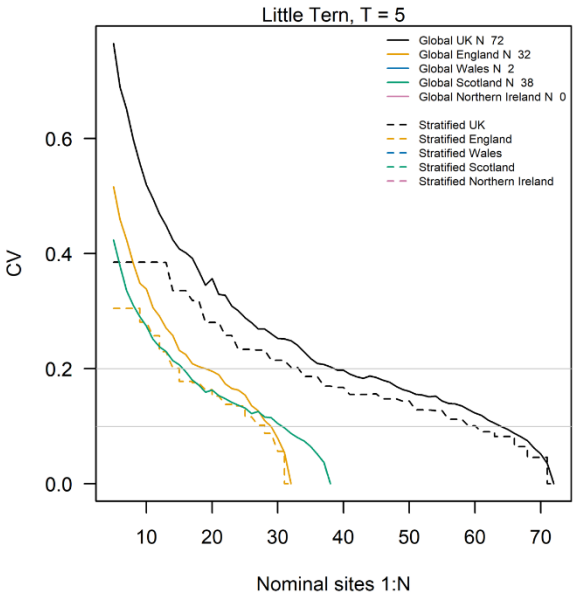

Common Gull, T = 5
Global UK N 1141
Global England N 10
Global Wales N 0
Global Scotland N 1116
Global Northern Ireland N 15
Stratified UK
Stratified England
Stratified Wales
Stratified Scotland
Stratified Northern Ireland
CV
Nominal sites 1:N

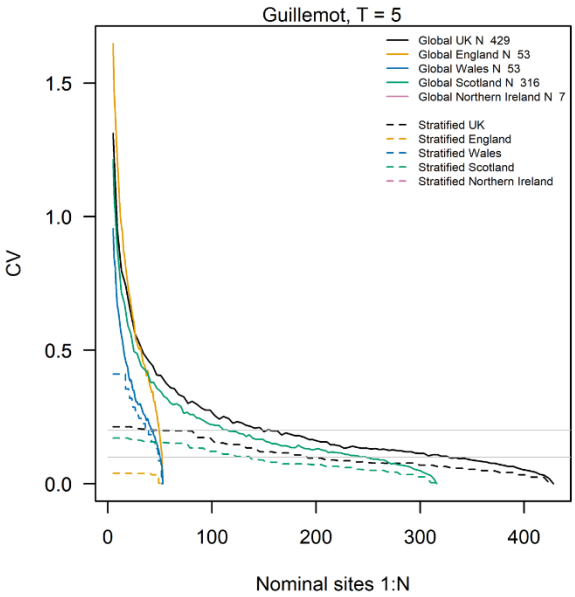

Mediterranean Gull, T = 5
Global UK N 60
Global England N 50
Global Wales N 5
Global Scotland N 0
Global Northern Ireland N 5
Stratified UK
Stratified England
Stratified Wales
Stratified Scotland
Stratified Northern Ireland
CV
Nominal sites 1:N

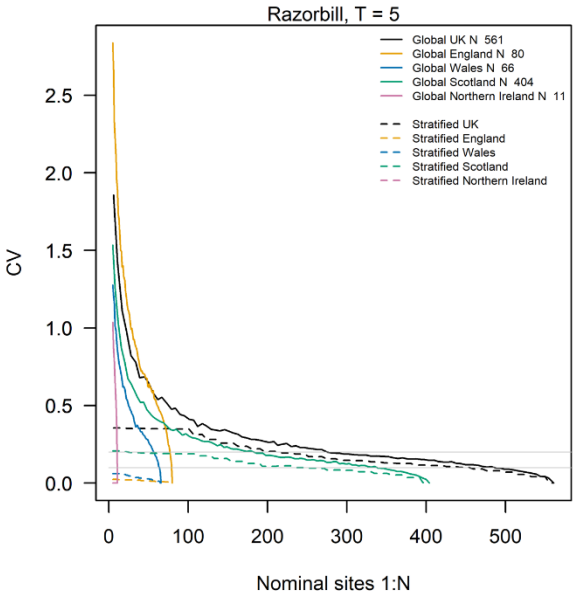

Common Tern, T = 5
Global UK N 348
Global England N 175
Global Wales N 9
Global Scotland N 151
Global Northern Ireland N 13
Stratified UK
Stratified England
Stratified Wales
Stratified Scotland
Stratified Northern Ireland
CV
Nominal sites 1:N

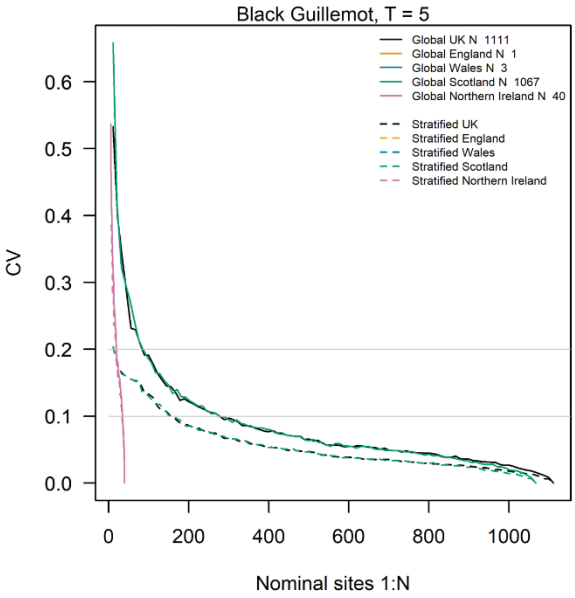

Arctic Tern, T = 5
Global UK N 614
Global England N 12
Global Wales N 3
Global Scotland N 591
Global Northern Ireland N 8
Stratified UK
Stratified England
Stratified Wales
Stratified Scotland
Stratified Northern Ireland
CV
Nominal sites 1:N

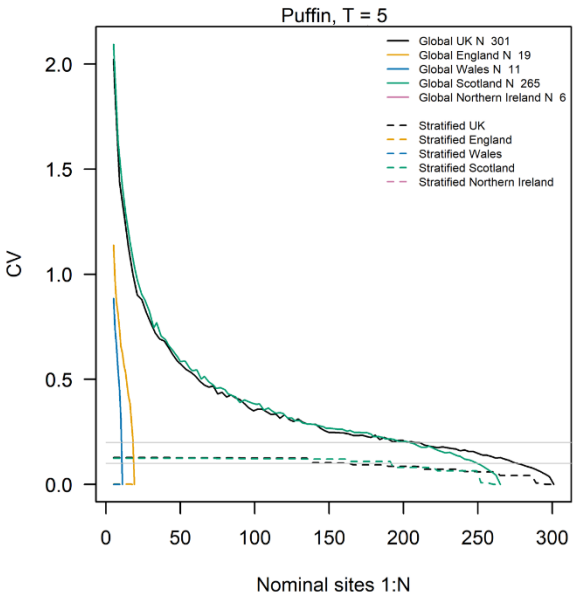

Sandwich Tern, T = 5
Global UK N 26
Global England N 12
Global Wales N 1
Global Scotland N 8
Global Northern Ireland N 5
Stratified UK
Stratified England
Stratified Wales
Stratified Scotland
Stratified Northern Ireland
CV
Nominal sites 1:N


Little Tern, T = 5
Global UK N 72
Global England N 32
Global Wales N 2
Global Scotland N 38
Global Northern Ireland N 0
Stratified UK
Stratified England
Stratified Wales
Stratified Scotland
Stratified Northern Ireland
CV
Nominal sites 1:N

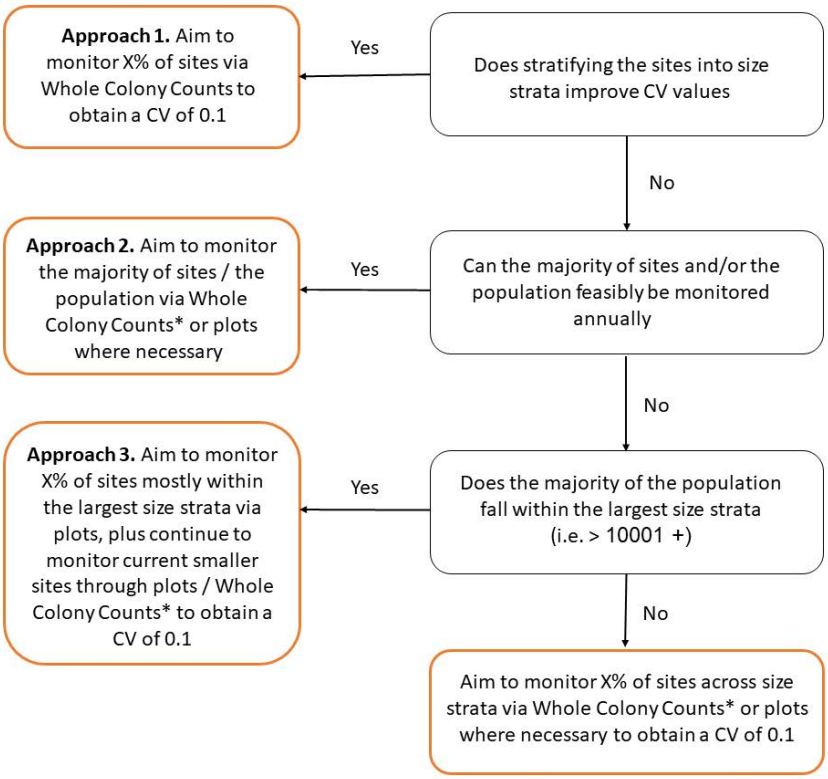

Guillemot, T = 5
Global UK N 429
Global England N 53
Global Wales N 53
Global Scotland N 316
Global Northern Ireland N 7
Stratified UK
Stratified England
Stratified Wales
Stratified Scotland
Stratified Northern Ireland
CV
Nominal sites 1:N


Razorbill, T = 5
Global UK N 561
Global England N 80
Global Wales N 66
Global Scotland N 404
Global Northern Ireland N 11
Stratified UK
Stratified England
Stratified Wales
Stratified Scotland
Stratified Northern Ireland
CV
Nominal sites 1:N


Black Guillemot, T = 5
Global UK N 1111
Global England N 1
Global Wales N 3
Global Scotland N 1067
Global Northern Ireland N 40
Stratified UK
Stratified England
Stratified Wales
Stratified Scotland
Stratified Northern Ireland
CV
Nominal sites 1:N


Puffin, T = 5
Global UK N 301
Global England N 19
Global Wales N 11
Global Scotland N 265
Global Northern Ireland N 6
Stratified UK
Stratified England
Stratified Wales
Stratified Scotland
Stratified Northern Ireland
CV
Nominal sites 1:N

APPENDIX 7. Decision tree to determine the sampling approach for monitoring the abundance of seabird species at the UK and country level to obtain a CV of 0.1 or 0.2 around estimates of population size and thus to robustly monitor population trends. The percentage (and number) of sites that should be monitored (X%) for each species and country are provided in Tables 14 and 15[1].



*Aim to quantify uncertainty in Whole Colony Counts through repeat sampling at a subset of sites (see General Recommendations)

[1] For species and countries where the overall number of sites per strata is low (i.e. fives sites or less) we recommend focusing first on monitoring sites within the largest strata.

APPENDIX 8. Country-level species specific abundance monitoring recommendations.

Table 1. Approach required to monitor the abundance of breeding seabird species at the Scotland level (based on the decision tree in Appendix 7). The recommended percentage and number of sites to be monitored to obtain a CV of 0.1 around estimates of population size and thus to robustly monitor population trends are also provided. Census data were not available to include Manx Shearwater, Leach's Petrel or Storm Petrel in simulations and thus recommendations.

Species	Recommended approach	Recommended percentage (and number) of sites	Number of sites covered through annual monitoring via Whole Colony Counts[1]	Overall recommendation to obtain a CV of 0.1[2]
Fulmar	4	11 (148)	35	Increase coverage by 323%[3]
Gannet	3	92 (17)	2	Increase coverage by 750%
Shag	4	33 (246)	36	Increase coverage by 583%
Cormorant	4	70 (66)	16	Increase coverage by 313%
Arctic Skua	1	43 (133)	9	Increase coverage by 1378%
Great Skua	4	83 (647)	7	Increase coverage by 9143%
Kittiwake	4	67 (196)	25	Increase coverage by 684%
Black-headed Gull	4	85 (250)	18	Increase coverage by 1289%
Lesser Black-backed Gull	4	8 (19)	18	Increase coverage by 6%[3]
Great Black-backed Gull	4	11 (146)	64	Increase coverage by 128%[3]
Herring Gull	4	10 (105)	56	Increase coverage by 88%[3]
Common Gull	4	4 (45)	50	Increase coverage in large strata[3]
Mediterranean Gull	-	-	-	-
Little Tern	2	81 (31)	11	Increase coverage by 182%
Sandwich Tern	2	100 (8)	1	Increase coverage of smaller sites[4]
Common Tern	4	46 (69)	31	Increase coverage by 123%
Roseate Tern	-	-	-	-
Arctic Tern	4	45 (266)	34	Increase coverage by 682%
Guillemot	3	44 (139)	23	Increase coverage by 504%
Razorbill	4	59 (238)	26	Increase coverage by 815%
Black Guillemot	4	16 (171)	22	Increase coverage by 677%
Puffin	3	74 (196)	7	Increase coverage by 2700%

[1] Excludes sites where the last recorded count was zero. See Table 6 and Appendix 2 for the number of sites monitored within each size strata. [2] This is a simplified recommendation and also needs to take into the recommended approach to sampling across size strata. [3] Although the recommended percentage of sites is expected to be adequate to meet a target CV of 0.1, we recommend aiming to cover at least 15% of sites to ensure data is representative. [4] Current annual monitoring only covers most of the population at the largest site however it would also be beneficial to also monitor smaller sites to ensure representation.

Table 2. Approach required to monitor the abundance of breeding seabird species at the Scotland level (based on the decision tree in Appendix 7). The recommended percentage and number of sites to be monitored to obtain a CV of 0.2 around estimates of population size and thus to robustly monitor population trends are also provided. Census data were not available to include Manx Shearwater, Leach's Petrel or Storm Petrel in simulations and thus recommendations.

Species	Recommended approach	Recommended percentage (and number) of sites	Number of sites covered through annual monitoring via Whole Colony Counts[1]	Overall recommendation to obtain a CV of 0.2[2]
Fulmar	4	2 (29)	35	Continue[3]
Gannet	3	78 (14)	2	Increase coverage by 600%
Shag	4	2 (15)	36	Continue[3]
Cormorant	4	31 (29)	16	Increase coverage by 81%
Arctic Skua	1	16 (49)	9	Increase coverage by 444%
Great Skua	4	43 (335)	7	Increase coverage by 4686%
Kittiwake	4	24 (70)	25	Increase coverage by 180%
Black-headed Gull	4	50 (147)	18	Increase coverage by 717%
Lesser Black-backed Gull	4	8 (19)	18	Increase coverage by 6%[3]
Great Black-backed Gull	4	2 (27)	64	Continue[3]
Herring Gull	4	2 (20)	56	Continue[3]
Common Gull	4	2 (18)	50	Continue[3]
Mediterranean Gull	-	-	-	-
Little Tern	2	41 (16)	11	Increase coverage by 45%
Sandwich Tern	2	8 (100)	1	Increase coverage of smaller sites[3,4]
Common Tern	4	10 (15)	31	Continue[3]
Roseate Tern	-	-	-	-
Arctic Tern	4	17 (100)	34	Increase coverage by 194%
Guillemot	3	8 (25)	23	Increase coverage by 9%[3]
Razorbill	4	7 (28)	26	Increase coverage by 8%[3]
Black Guillemot	4	2 (21)	22	Continue[3]
Puffin	3	9 (25)	7	Increase coverage by 257%[3]

[1] Excludes sites where the last recorded count was zero. See Table 6 and Appendix 2 for the number of sites monitored within each size strata. [2] This is a simplified recommendation and also needs to take into the recommended approach to sampling across size strata. [3] Although the recommended percentage of sites is expected to be adequate to meet a target CV of 0.1, we recommend aiming to cover at least 15% of sites to ensure data is representative. [4] Current annual monitoring only covers most of the population at the largest site however it would also be beneficial to also monitor smaller sites to ensure representation.

Table 3. Approach required to monitor the abundance of breeding seabird species at the England level (based on the decision tree in Appendix 7). The recommended percentage and number of sites to be monitored to obtain a CV of 0.1 around estimates of population size and thus to robustly monitor population trends are also provided. Census data were not available to include Manx Shearwater, Leach's Petrel or Storm Petrel in simulations and thus recommendations.

Species	Recommended approach	Recommended percentage (and number) of sites	Number of sites covered through annual monitoring via Whole Colony Counts[1]	Overall recommendation to obtain a CV of 0.1[2]
Fulmar	4	82 (185)	10	Increase coverage by 1750%
Gannet	2	100 (1)	0	Monitor the single site
Shag	4	23 (29)	3	Increase coverage by 867%
Cormorant	4	61 (65)	53	Increase coverage by 23%
Arctic Skua	-	-	-	-
Great Skua	-	-	-	-
Kittiwake	3	36 (21)	24	Continue
Black-headed Gull	4	77 (136)	28	Increase coverage by 386%
Lesser Black-backed Gull	4	19 (20)	12	Increase coverage by 67%
Great Black-backed Gull	4	72 (100)	9	Increase coverage by 1011%
Herring Gull	4	55 (201)	23	Increase coverage by774%
Common Gull	2	60 (6)	4	Increase coverage by 50%
Mediterranean Gull	4	26 (13)	8	Increase coverage by 63%
Little Tern	2	88 (28)	24	Increase coverage by 17%
Sandwich Tern	2	92 (11)	10	Continue
Common Tern	4	96 (168)	30	Increase coverage by 460%
Roseate Tern	2	100 (1)	1	Continue
Arctic Tern	2	92 (11)	8	Continue
Guillemot	3	43 (23)	5	Increase coverage by 360%
Razorbill	3	23 (18)	5	Increase coverage by 260%
Black Guillemot	2	100 (1)	1	Continue
Puffin	3	74 (14)	2	Increase coverage by 600%

[1] Excludes sites where the last recorded count was zero. See Table 6 and Appendix 2 for the number of sites monitored within each size strata. [2] This is a simplified recommendation and also needs to take into the recommended approach to sampling across size strata. [3] Although the recommended percentage of sites is expected to be adequate to meet a target CV of 0.1, we recommend aiming to cover at least 15% of sites to ensure data is representative.

Table 4. Approach required to monitor the abundance of breeding seabird species at the England level (based on the decision tree in Appendix 7). The recommended percentage and number of sites to be monitored to obtain a CV of 0.2 around estimates of population size and thus to robustly monitor population trends are also provided. Census data were not available to include Manx Shearwater, Leach's Petrel or Storm Petrel in simulations and thus recommendations.

Species	Recommended approach	Recommended percentage (and number) of sites	Number of sites covered through annual monitoring via Whole Colony Counts[1]	Overall recommendation to obtain a CV of 0.2[2]
Fulmar	4	7 (16)	10	Increase coverage by 60%[3]
Gannet	2	100 (1)	0	Monitor the single site
Shag	4	11 (14)	3	Increase coverage by 367%[3]
Cormorant	4	25 (26)	53	Continue
Arctic Skua	-	-	-	-
Great Skua	-	-	-	-
Kittiwake	3	36 (21)	24	Continue
Black-headed Gull	4	37 (65)	28	Increase coverage by 132%
Lesser Black-backed Gull	4	19 (20)	12	Increase coverage by 67%
Great Black-backed Gull	4	32 (44)	9	Increase coverage by 389%
Herring Gull	4	7 (26)	23	Increase coverage by 13%[3]
Common Gull	2	60 (6)	4	Increase coverage by 50%
Mediterranean Gull	4	26 (13)	8	Increase coverage by 63%
Little Tern	2	48 (15)	24	Continue
Sandwich Tern	2	92 (11)	10	Continue
Common Tern	4	78 (136)	30	Increase coverage by 353%
Roseate Tern	2	100 (1)	1	Continue
Arctic Tern	2	92 (11)	8	Continue
Guillemot	3	43 (23)	5	Increase coverage by 360%
Razorbill	3	23 (18)	5	Increase coverage by 260%
Black Guillemot	2	100 (1)	1	Continue
Puffin	3	74 (14)	2	Increase coverage by 600%

[1] Excludes sites where the last recorded count was zero. See Table 6 and Appendix 2 for the number of sites monitored within each size strata. [2] This is a simplified recommendation and also needs to take into the recommended approach to sampling across size strata. [3] Although the recommended percentage of sites is expected to be adequate to meet a target CV of 0.1, we recommend aiming to cover at least 15% of sites to ensure data is representative.

Table 5. Approach required to monitor the abundance of breeding seabird species at the Wales level (based on the decision tree in Appendix 7). The recommended percentage and number of sites to be monitored to obtain a CV of 0.1 around estimates of population size and thus to robustly monitor population trends are also provided. Census data were not available to include Manx Shearwater, Leach's Petrel or Storm Petrel in simulations and thus recommendations.

Species	Recommended approach	Recommended percentage (and number) of sites	Number of sites covered through annual monitoring via Whole Colony Counts[1]	Overall recommendation to obtain a CV of 0.1[2]
Fulmar	4	11 (14)	20	Continue
Gannet	2	100 (1)	0	Monitor the single site
Shag	4	90 (50)	8	Increase coverage by 525%
Cormorant	4	50 (14)	8	Increase coverage by 75%
Arctic Skua	-	-	-	-
Great Skua	-	-	-	-
Kittiwake	2	95 (15)	9	Increase coverage by 67%
Black-headed Gull	2	91 (10)	1	Increase coverage by 900%
Lesser Black-backed Gull	4	24 (17)	12	Increase coverage by 42%
Great Black-backed Gull	4	88 (46)	10	Increase coverage by 360%
Herring Gull	4	90 (137)	20	Increase coverage by 585%
Common Gull	-	-	-	-
Mediterranean Gull	2	100 (5)	0	Monitor all sites
Little Tern	2	100 (2)[2]	1	Monitor all sites
Sandwich Tern	2	100 (1)	1	Continue
Common Tern	2	100 (9)	4	Increase coverage of smaller sites[4]
Roseate Tern	2	100 (1)	1	Continue
Arctic Tern	2	100 (3)	3	Continue
Guillemot	3	92 (49)	19	Increase coverage by 158%
Razorbill	4	30 (20)	22	Continue
Black Guillemot	2	100 (3)	1	Increase coverage by 200%
Puffin	2	100 (11)	9	Continue

[1] Excludes sites where the last recorded count was zero. See Table 6 and Appendix 2 for the number of sites monitored within each size strata. [2] This is a simplified recommendation and also needs to take into the recommended approach to sampling across size strata. [3] Although the recommended percentage of sites is expected to be adequate to meet a target CV of 0.1, we recommend aiming to cover at least 15% of sites to ensure data is representative. [4] Current annual monitoring only covers most of the population at the largest sites however it would also be beneficial to also monitor smaller sites to ensure representation.

Table 6. Approach required to monitor the abundance of breeding seabird species at the Wales level (based on the decision tree in Appendix 7). The recommended percentage and number of sites to be monitored to obtain a CV of 0.2 around estimates of population size and thus to robustly monitor population trends are also provided. Census data were not available to include Manx Shearwater, Leach's Petrel or Storm Petrel in simulations and thus recommendations.

Species	Recommended approach	Recommended percentage (and number) of sites	Number of sites covered through annual monitoring via Whole Colony Counts[1]	Overall recommendation to obtain a CV of 0.2[2]
Fulmar	4	11 (14)	20	Continue[3]
Gannet	2	100 (1)	0	Monitor the single site
Shag	4	68 (37)	8	Increase coverage by 363%
Cormorant	4	50 (14)	8	Increase coverage by 75%
Arctic Skua	-	-	-	-
Great Skua	-	-	-	-
Kittiwake	2	79 (13)	9	Increase coverage by 44%
Black-headed Gull	2	91 (10)	1	Increase coverage by 900%
Lesser Black-backed Gull	4	24 (17)	12	Increase coverage by 42%
Great Black-backed Gull	4	59 (31)	10	Increase coverage by 210%
Herring Gull	4	48 (73)	20	Increase coverage by 265%
Common Gull	-	-	-	-
Mediterranean Gull	2	100 (5)	0	Monitor all sites
Little Tern	2	100 (2)[2]	1	Monitor all sites
Sandwich Tern	2	100 (1)	1	Continue
Common Tern	2	100 (9)	4	Increase coverage of smaller sites[4]
Roseate Tern	2	100 (1)	1	Continue
Arctic Tern	2	100 (3)	3	Continue
Guillemot	3	74 (39)	19	Increase coverage by 105%
Razorbill	4	30 (20)	22	Continue
Black Guillemot	2	100 (3)	1	Increase coverage by 200%
Puffin	2	100 (11)	9	Continue

[1] Excludes sites where the last recorded count was zero. See Table 6 and Appendix 2 for the number of sites monitored within each size strata. [2] This is a simplified recommendation and also needs to take into the recommended approach to sampling across size strata. [3] Although the recommended percentage of sites is expected to be adequate to meet a target CV of 0.1, we recommend aiming to cover at least 15% of sites to ensure data is representative. [4] Current annual monitoring only covers most of the population at the largest sites however it would also be beneficial to also monitor smaller sites to ensure representation.

Table 7. Approach required to monitor the abundance of breeding seabird species at the Northern Ireland level (based on the decision tree in Appendix 7). The recommended percentage and number of sites to be monitored to obtain a CV of 0.1 around estimates of population size and thus to robustly monitor population trends are also provided. Census data were not available to include Manx Shearwater, Leach's Petrel or Storm Petrel in simulations and thus recommendations.

Species	Recommended approach	Recommended percentage (and number) of sites	Number of sites covered through annual monitoring via Whole Colony Counts[1]	Overall recommendation to obtain a CV of 0.1[2]
Fulmar	4	92 (40)	2	Increase coverage by 1900%
Gannet	-	-	-	-
Shag	2	93 (15)	1	Increase coverage by 1400%
Cormorant	2	100 (5)	2	Increase coverage by 150%
Arctic Skua	-	-	-	-
Great Skua	2	100 (1)	0	Monitor site where present
Kittiwake	2	93 (14)	2	Increase coverage by 600%
Black-headed Gull	2	92 (20)	5	Increase coverage by 300%
Lesser Black-backed Gull	4	93 (21)	4	Increase coverage by 425%
Great Black-backed Gull	2	60 (9)	4	Increase coverage by 125%
Herring Gull	2	77 (13)	5	Increase coverage by 160%
Common Gull	2	73 (11)	7	Increase coverage by 57%
Mediterranean Gull	2	100 (5)	1	Increase coverage by 400%
Little Tern	-	-	-	-
Sandwich Tern	2	100 (5)	4	Increase coverage by 25%
Common Tern	4	92 (12)	6	Increase coverage by 100%
Roseate Tern	2	100 (1)	1	Continue
Arctic Tern	2	100 (8)	5	Continue[3]
Guillemot	3	100 (7)	1	Increase coverage by 600%
Razorbill	3	100 (11)	1	Increase coverage by 1000%
Black Guillemot	4	85 (34)	3	Increase coverage by 1033%
Puffin	2	100 (6)	0	Monitor most/all sites

[1] Excludes sites where the last recorded count was zero. See Table 6 and Appendix 2 for the number of sites monitored within each size strata. [2] This is a simplified recommendation and also needs to take into the recommended approach to sampling across size strata. [3] Although the recommended percentage of sites is expected to be adequate to meet a target CV of 0.1, we recommend aiming to cover at least 15% of sites to ensure data is representative.

Table 8. Approach required to monitor the abundance of breeding seabird species at the Northern Ireland level (based on the decision tree in Appendix 7). The recommended percentage and number of sites to be monitored to obtain a CV of 0.2 around estimates of population size and thus to robustly monitor population trends are also provided. Census data were not available to include Manx Shearwater, Leach's Petrel or Storm Petrel in simulations and thus recommendations.

Species	Recommended approach	Recommended percentage (and number) of sites	Number of sites covered through annual monitoring via Whole Colony Counts[1]	Overall recommendation to obtain a CV of 0.2[2]
Fulmar	4	92 (40)	2	Increase coverage by 1900%
Gannet	-	-	-	-
Shag	2	63 (10)	1	Increase coverage by 900%
Cormorant	2	100 (5)	2	Increase coverage by 150%
Arctic Skua	-	-	-	-
Great Skua	2	100 (1)	0	Monitor site where present
Kittiwake	2	93 (14)	2	Increase coverage by 600%
Black-headed Gull	2	86 (19)	5	Increase coverage by280%
Lesser Black-backed Gull	4	93 (21)	4	Increase coverage by 425%
Great Black-backed Gull	2	60 (9)	4	Increase coverage by 125%
Herring Gull	2	77 (13)	5	Increase coverage by 160%
Common Gull	2	73 (11)	7	Increase coverage by 57%
Mediterranean Gull	2	100 (5)	1	Increase coverage by 400%
Little Tern	-	-	-	-
Sandwich Tern	2	100 (5)	4	Increase coverage by25%
Common Tern	4	92 (12)	6	Increase coverage by 100%
Roseate Tern	2	100 (1)	1	Continue
Arctic Tern	2	100 (8)	5	Continue
Guillemot	3	100 (7)	1	Increase coverage by 600%
Razorbill	3	100 (11)	1	Increase coverage by 1000%
Black Guillemot	4	47 (19)	3	Increase coverage by 200%
Puffin	2	100 (6)	0	Monitor most/all sites

[1] Excludes sites where the last recorded count was zero. See Table 6 and Appendix 2 for the number of sites monitored within each size strata. [2] This is a simplified recommendation and also needs to take into the recommended approach to sampling across size strata. [3] Although the recommended percentage of sites is expected to be adequate to meet a target CV of 0.1, we recommend aiming to cover at least 15% of sites to ensure data is representative.

Front cover: Kittiwakes, by Sam Langlois / BTO; Back cover: Gannets, by Liz Cutting / BTO

Seabird population and demographic monitoring in the UK: a review and recommendations for future sampling

The Seabird Monitoring Programme, funded by the British Trust for Ornithology and Joint Nature Conservation Committee (JNCC), in association with the Royal Society for the Protection of Birds, aims to ensure that sample data on seabird breeding numbers and breeding productivity are collected both regionally and nationally, for 25 species of seabird that regularly breed in Britain and Ireland, to enable their conservation status to be assessed.

However, current annual trend information delivered by the SMP is imprecise, absent, or geographically limited for several UK breeding seabird species. It is therefore of high priority to review the current SMP sampling approach and develop a new sampling strategy to inform coordinated and targeted volunteer and professional monitoring to facilitate the collection of more representative data and consequently more robust evidence. This report constitutes that review.

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