Identification of possible marine SPAs for seabirds:
The European Seabirds at Sea database, analysis and boundary delineation

Joint Nature Conservation Committee
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1. Background and overview

In 1979 the European Commission adopted the Birds Directive which, amongst other conservation measures, requires Member States to classify Special Protection Areas (SPAs) for birds listed on Annex I to the Directive and for regularly occurring migratory species. As part of the UK's work to identify important marine areas, an analysis of seabirds in UK waters was undertaken. This looks at the distributions of 31 seabird species at sea. Full details of the analysis can be found in JNCC reports 431 and 461 (Kober *et al* 2010), and is summarised in this document.

Each species was analysed separately for the different seasons it occurs in UK waters. There were a total of 57 species-season combinations for which analysis was undertaken.

Seabirds can aggregate anywhere in marine UK waters, particularly outside of the breeding season when they do not need to return regularly to their nest. The analysis covered an area from the UK coastline out to the British Fishery Limit (which reaches to approximately 200 nautical miles). This summary document provides an overview of the data used for this work and the analyses carried out.

Table 1 shows all the combinations of species and season that were included in this analysis; species which occur in UK waters in numbers greater than 50 and for which there was sufficient data available were included, and for the seasons for which they occur in UK waters.

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Table 1: Seabird species and seasons of interest.

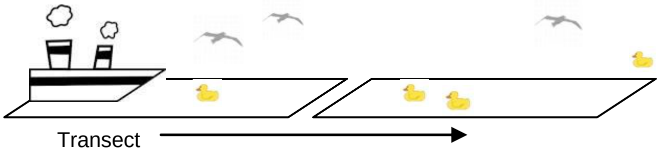
common name	scientific name	Season		
		breeding/summer	winter	additional season
northern fulmar	*Fulmarus glacialis*	March - July	Aug - Feb	
Cory's shearwater	*Calonectris diomedea*	July - Oct		
great shearwater	*Puffinus gravis*	July - Oct		
sooty shearwater	*Puffinus griseus*	July - Nov		
Manx shearwater	*Puffinus puffinus*	May - Sep		Oct – Nov
European storm-petrel	*Hydrobates pelagicus*	June - Oct		
Leach's Storm-petrel	*Oceanodroma leucorhoa*	June - Oct		
northern gannet	*Morus bassanus*	May - Sep	Oct - April	
great cormorant	*Phalacrocorax carbo*	April - Aug	Sep - March	
European shag	*Phalacrocorax aristotelis*	March - Sep	Oct - Feb	
pomarine skua	*Stercorarius pomarinus*			March – June, Aug – Nov
Arctic skua	*Stercorarius parasiticus*	May - Aug		Sep – Nov
long-tailed skua	*Stercorarius longicaudus*			May – June, Sep – Nov
great skua	*Stercorarius skua*	May - Aug	Sep - April	
black-legged kittiwake	*Rissa tridactyla*	May - Sep	Oct - April	
black-headed gull	*Larus ridibundus*	April - Aug	Sep - March	
little gull	*Hydrocoloeus minutus*	May - July	Dec-April	Aug – Nov
great black-backed gull	*Chroicocephalus ridibundus*	April - Aug	Sep - March	
Mediterranean gull	*Larus melanocephalus*			All year
common gull	*Larus canus*	May - Aug	Sep - April	
lesser black-backed gull	*Larus fuscus*	May - Aug	Sep - April	
herring gull	*Larus argentatus*	April - Aug	Sep - March	
Iceland gull	*Larus glaucoides*		Nov - April	
glaucous gull	*Larus hyperboreus*		Oct - March	
Sandwich tern	*Sterna sandvicensis*	May - Aug	Sep – Oct	
common tern	*Sterna hirundo*	May - Sep		
Arctic tern	*Sterna paradisaea*	May - Aug		
common guillemot	*Uria aalge*	May - June	Oct - April	Aug – Sep
Razorbill	*Alca torda*	May - June	Oct - April	Aug – Sep
little auk	*Alle alle*		Nov - March	
Atlantic puffin	*Fratercula arctica*	April - July	Aug - March	
seabird assemblage		All breeding months	Nov - March	July – Aug

2. The European Seabirds at Sea database

It would be logistically and financially unachievable to collect sufficient bespoke data across the whole area for all species and seasons. Instead JNCC used existing boat based seabird counts collected to standard methods (see Box 1). The data are held in the European Seabirds at Sea (ESAS) database which contains survey data covering much of the UK waters of interest, and extends from 1978 to the present day. Other data sources were considered, such as tracking data collected from breeding individuals, but rejected because too few of these data were available at the time of analysis to provide sufficient information across the UK for the task. Figure 1 shows the distribution of ESAS data across the UK, with colour coding to indicate the level of survey effort that has occurred within each grid cell. Red grid cells have had the highest level of survey effort, with green intermediate and blue grid cells having a relatively lower level or survey effort.

Box 1: ESAS data collection from boats

Observers counted all birds in a line transect running parallel to the track line of the boat. Transects were divided into smaller sections and the position of the boat was recorded at each section start. Birds sitting on the water were recorded when they were level with the observer as the boat passed by. Flying birds were counted at once from the starting point of each transect section for the entire section ('snapshot count') to avoid double counting. For each transect section, seabird numbers were summarised, together with the area surveyed in that section and assigned to the location of the section starting point.



Data collection is described in detail by Tasker *et al* (1984), Webb and Durinck (1992) and Camphuysen *et al* (2004).

ESAS data were prepared for analysis by excluding those collected during unfavourable weather conditions (bad visibility, strong winds etc.) when there might be bias in the observations. Then, a correction was made to the seabird counts observed in the data to allow for the fact that observers will be less likely to detect a bird the further it is from the boat (details in Box 2). Without this correction, all counts are likely to be underestimates. Data were then divided into the species and season combinations presented in Table 1.

The ESAS database reaches as far back as 1978, and analysis started in 2005. The data used for analysis covers the period 1980 to 2005. To get a sufficient sample size for each species/season combination, data from all years were analysed together.

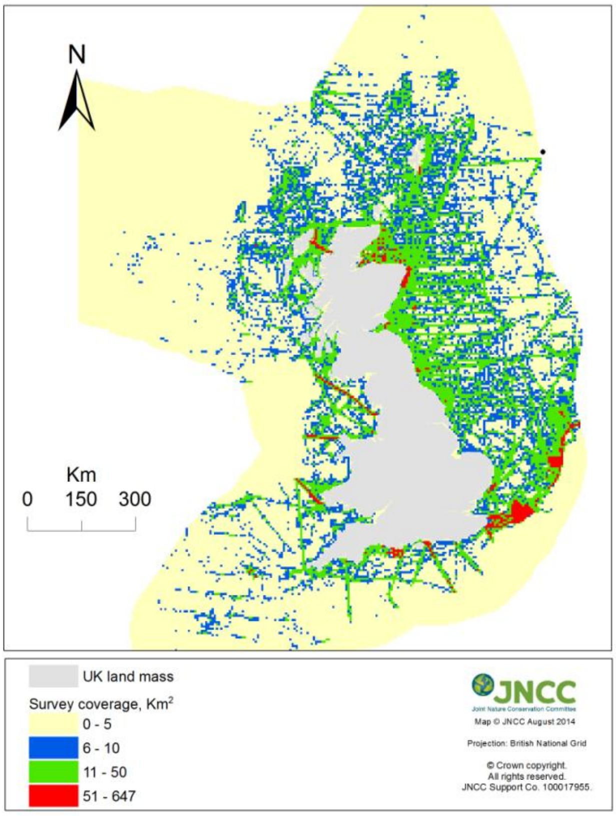


Figure 1: ESAS survey coverage used to identify important areas for seabirds in the UK. Red grid cells have had the highest level of survey effort, with green intermediate and blue grid cells having a

Box 2: Correction to seabird counts to allow for observers being less likely to detect birds further from the survey line.

It is generally the case that the further a bird is from the boat or transect line the less likely it is to be observed (Buckland *et al* 2001). In order to account for this, a correction for undetected birds was applied to the data to give an estimate of the true numbers of birds in a survey area.

All data for birds on the water of a particular species were summed, separately by distance band (A = 0-100m, B = 100-200m, C = 200-300m). It was assumed that all birds on the water in the first 100m were detected. The detecting-correction-factor is the factor by which the bird density on the water in the first 100m from the observer departs from the overall bird density on the water in the entire transect. The factor (y) was calculated for each species as follows:

$$Y = (x(A) * z) / (x(A) + x(B) + x(C))$$

where x(A) is the sum of birds recorded in distance band A. Z is the factor by which the area size of A departs from that of A+B+C. The total sum of birds seen on the water in the (entire) transect are then multiplied by y (Stone *et al* 1995) to give an estimate of the number of birds actually on the water, out to 300m from the transect line, during the survey.

Detection correction factors do not apply to flying individuals, only for those sitting on the water.

3. Analysis

To analyse the ESAS data, a three step process was applied (shown in Figure 2).

Step 1: Seabird density maps were produced based on observations from the ESAS data.

Step 2: The highest and most aggregated bird densities (‘seabird hotspots’) were identified on these maps.

Step 3: These ‘seabird hotspots’ were assessed against the raw data to see which ones had high densities on a regular basis.

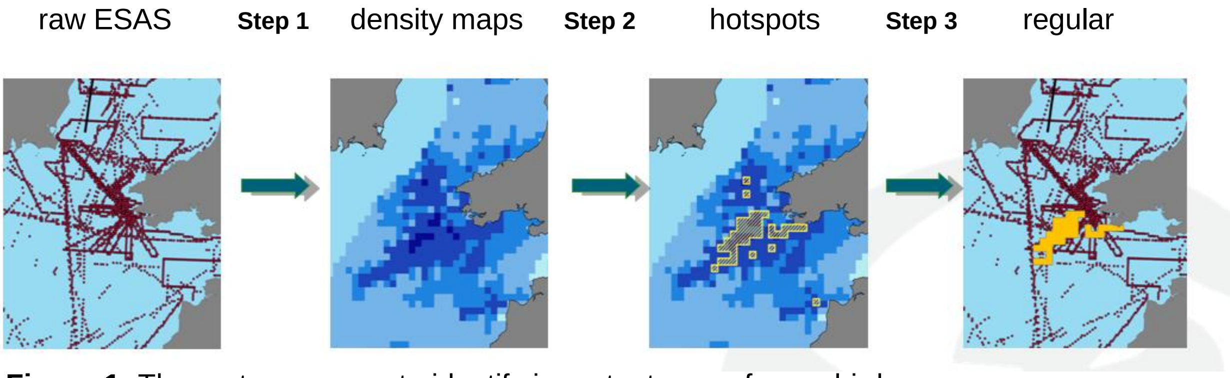


Figure 1: Three-step process to identify important areas for seabirds.

3.1. Step 1: Seabird density maps

To create seabird density maps from bird observation data, data were analysed using Poisson kriging (see box 3).

The area of search was divided into a grid of 6 km x 6 km grid cells and Poisson kriging predicted a density of seabirds for each cell, based on the data in that cell and nearby cells. This process is demonstrated in Figure 3.

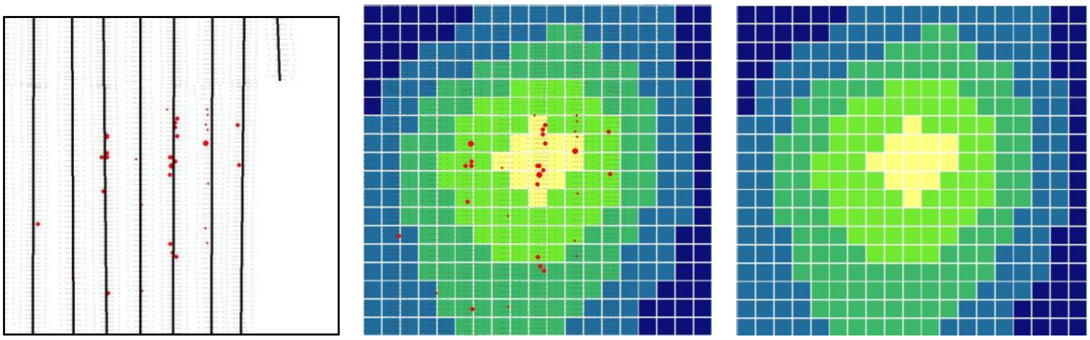


Figure 3: Poisson kriging provides a grid of estimated density, based on the observed seabirds.

Box 3: Creating density maps: Poisson kriging

There is a wide variety of spatial interpolation techniques available which can be used to fill gaps between existing data to produce density maps. JNCC used for example **kernel density estimation (**KDE, Silverman 1998) in its analysis of aggregations of wintering waterbirds as this method is suitable for aerial survey data of the type collected for that analysis (O'Brien *et al* 2012). The ESAS data has some areas much more frequent survey effort in some areas of the UK waters than others, and large spaces between data points in some areas, making Poisson kriging more suitable (Monestiez *et al* 2005) for analysis of the ESAS data.

Poison kriging is an analysis technique which makes use of the property that things closer together in space are more similar than things that are further away (autocorrelation). Kriging looks at this relationship in a given dataset, describes it as a mathematical function specific for these particular data, and uses it to predict values at locations with no data. This means that an estimate of seabird density can be obtained for areas that do not have much (or any) survey passing through them, based on densities observed from surveys nearby.

These density maps were then rescaled for some species so that the total number of birds in the entire survey region would match population estimates from Barrett *et al* (2006) for those species. This was done to account for issues such as ship following habits in some species and unequal sampling effort in space and time; biases which could mean that there is an overall underestimate or overestimate of densities without this rescaling[1].

3.2. Step 2: Seabird hotspots on the density maps

A technique called Getis-Ord Gi* was used to identify 'hotspots' of high density (Anselin 1995). Gi* is a statistic which is calculated for each individual grid cell on the bird density maps (created in step 1). It will be high where seabird densities are high, and increase even more where these high densities are surrounded by other high density grid cells. Gi* therefore identifies not only areas with high numbers, but areas with particularly aggregated high numbers of seabirds. This analysis was applied to all 57 seabird density surface maps, thus producing a total of 57 maps of Getis-Ord Gi* values.

To define seabird hotspots from the Getis-Ord Gi* maps, all grid cells on a map were ranked according to their value of Gi*. The top 1% of all cells were then selected. Those selected cells which were next to each other were merged into larger areas with a combined hotspot boundary. The resulting areas are called hotspots; the highest and most aggregated densities as found on a UK-wide scale for each species and season. Hotspots were identified for each species/season combination in Table 1.

3.3. Step 3: Further assessment of hotspots

These seabird hotspots were assessed using the UK SPA site selection guidelines. The first stage of these guidelines involves looking at numbers of birds within each hotspot, and checking if they contain high densities on a regular basis.

To estimate the seabird population size in a given hotspot, the boundary of the hotspot was superimposed on the relevant seabird density map, and population size was calculated from the map (i.e. adding up the number of birds within each grid cell within the hotspot boundary).

Hotspots which had significantly higher densities than surrounding grid cells for (1) more than three years, and (2) at least two thirds of all years when data were sufficient for testing, were defined as containing high densities of birds on a regular basis. Borderline regularly occurring cases (i.e. where the hotspot had significantly higher densities on almost two thirds of all years when data were sufficient for testing) were also identified and noted as near regularly occurring.

[1] Such biases affect the total number of birds estimated to be present in the whole survey area, but does not affect the relative distribution (or the hotspot locations based on relative distributions.

Hotspots which were seen as regularly containing high densities of seabirds were considered further by JNCC for hotspots which are primarily or exclusively in offshore waters (from 12 to 200 nautical miles). Hotspots which are primarily or exclusively in inshore waters (up to 12 nautical miles from coast) will be considered further by Department of Environment Northern Ireland for Northern Irish inshore waters, Natural England for English inshore waters, Natural Resources Wales for Welsh inshore waters and Scottish Natural Heritage for Scottish inshore waters.

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