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Summary of evidence of aggregations of Balearic shearwaters in the UK up to 2013

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Summary

Balearic shearwater *Puffinus mauretanicus* is listed on Annex I of the EU Birds Directive (2009/*147/*EC). The EU Birds Directive requires Member States to classify Special Protection Areas (SPA) for birds listed on Annex I of the Directive and for regularly occurring migratory species.

Balearic shearwater breeds solely in the western Mediterranean, numbering some 3000 pairs; it is listed by IUCN as Critically Endangered. Movements after the breeding season bring birds into Atlantic waters, primarily off Iberia and western France but also into UK waters, especially those of the English Channel during June to October. Most breeding colonies are SPAs, as are major aggregations around the French coast. There are currently no SPAs for this species in the UK.

The Statutory Nature Conservation Bodies (SNCBs) are seeking to identify important marine areas in the UK that are used by aggregations of Balearic shearwater, to inform their identification of areas that may be suitable for classification as SPAs under the EC Birds Directive (2009/147/EC) and according to the UK SPA Selection Guidelines (Stroud et al. 2001). In this report JNCC provides a summary of evidence (gathered up to and including 2013) from a number of sources on the size and distribution of aggregations, to help the SNCB to identify possible sites.

The main finding of this study was that analyses of a number of data sources on seabird distribution at sea did not detect any regularly occurring hotspots (as defined by established and peer-reviewed techniques) for Balearic shearwaters in UK waters that would be appropriate for identification as SPA. These data sources include a long-term and extensive dataset of seabird records at sea (ESAS) from which we detected one small hotspot in UK waters that subsequently failed to meet the regularity test required by the UK SPA selection guidelines to qualify as a SPA. On a finer geographical scale, in only one season out of three recent seasons of bespoke systematic surveys for the species, in west Lyme Bay and around Portland, were densities high enough to be measured. This level of regularity of use would not satisfy the UK SPA selection guidelines. Systematic July-October observations from coastal watch-points around SW England over four years indicated mean passage rates of 1.0-2.8 bird per hour, indicating the species regularly passes through much of that coastline, though there were few records of birds engaged in feeding or other types of behaviour where they remained in the area very long that would justify any SPA classification. Small numbers were recorded from coastal watch-points in midwinter.

We conclude, based on the evidence reviewed, that conservation effort for Balearic shearwater in UK waters would be more appropriately targeted at spatially dispersed measures to combat threats at sea.

Contents

1 Introduction

The Statutory Nature Conservation Bodies (SNCBs) are seeking to identify important marine areas in the UK that are used by aggregations of Balearic shearwater *Puffinus mauretanicus*, to inform their identification of areas that may be suitable for classification as Special Protection Areas (SPAs) under the EC Birds Directive (2009/147/EC), and according to the UK SPA Selection Guidelines (Stroud *et al.* 2001). In this report JNCC provides a summary of evidence from a number of sources, on the size and distribution of aggregations, to help the SNCB to identify possible sites.

Balearic shearwater is listed on Annex I of the EU Birds Directive (EU 2009). The EU Birds Directive requires Member States to classify Special Protection Areas (SPA) for birds listed on Annex I of the Directive and for regularly occurring migratory species. There are currently no SPAs for this species in the UK.

The objectives of this report are to summarise all pertinent information on numbers and distribution of the species, primarily in UK waters but set in the context of the species' wider distribution. The emphasis is to assess this information to identify the location, size and regularity of occurrence of any aggregations, in the context of the obligations of Article 4 of the Birds Directive. Article 4 states that "Member States shall classify in particular the most suitable territories in number and size as special protection areas for the conservation of these [Annex I] species in the geographical sea and land area where this Directive applies". The UK SPA Selection Guidelines (Stroud *et al.* 2001) assist in the delivery of this aim; the report's findings are discussed in the context of these guidelines (section 5.4).

2 Species status and distribution

Balearic shearwater is an Annex I species under the Birds Directive and is considered by IUCN as Critically Endangered on a global, and so European, level (Birdlife 2013).

Its breeding distribution is confined to the Balearic Islands in Spain, with the latest breeding population estimate given as 3,193 pairs (CMA 2010). Less certainty surrounds estimates of the population obtained outside the breeding season, but 25,000 or more individuals has been proposed for the world population (Arcos 2011b; Arroyo *et al.* 2015). If this non-breeding estimate is accurate the implication is that either the breeding population size has been under-estimated or that there is an unusually large non- and/or pre-breeding population in this species (Arcos *et al.* 2012). A Population Viability Analysis (PVA), based on an assumed breeding number of 3,200 to 7,000 pairs, concluded that global extinction would probably occur in 70-80 years, with a decline to 10% within 23 years (Oro & Arcos, unpublished, quoted in Boué *et al.* 2013). Annual adult survival, studied at two colonies where terrestrial predation is low, was estimated at 0.78, unusually low for such a seabird (Boué *et al.* 2013). As adult survival is the most sensitive parameter controlling population size in such a species, these rates need to be confirmed by studies from other colonies to refine the PVA. There is currently no GB or all-Ireland population estimate for the species, in part because the species' occurrence is unpredictable in timing and location and because of uncertainties around population turnover, especially when analysing observations from land counts at headlands.

During the breeding season (March-July, Ruiz & Marti 2004) birds tagged at a major breeding colony ranged largely within the Mediterranean basin, but outside the breeding season those birds moved to the more productive Atlantic waters off Spain, Portugal and western France, though none sampled entered UK waters (Guilford *et al.* 2012). It therefore appears that Balearic shearwater entering UK waters may be pre- or non-breeders (or possibly that birds breeding at non-studied colonies use different areas to those studied).

Balearic shearwater occurs in UK waters (mostly English inshore) in greatest numbers in June to October (though there is much variation within this range), with small numbers recently found in mid-winter off SW England (Wynn *et al.* 2011). Large aggregations occur in coastal waters off western and north western France (e.g. an aggregation of 4,600 in the Baie de Lannion, Brittany in August 2010, Thébault *et al.* 2013). The species is protected outwith its Mediterranean breeding colonies in several French SPAs (e.g. 2,500-4,000 individuals at each of two SPAs on France's Atlantic coast, plus three SPA on the northern French coast each holding an estimated maximum of 1,200-2,000 individuals) and at four sites on the Spanish Atlantic coast. The majority of its known breeding population is protected by SPAs. It appears that Balearic shearwaters entering UK waters derive – to an extent - from the French non-breeding aggregations, especially during strong southerly or westerly winds (Darlaston & Wynn 2012).

During the last two decades it has been postulated that there has been a northward shift in distribution outside the breeding season, with fewer birds present in the Bay of Biscay and more off the coasts of southern England and northern Brittany (Yésou 2003; Wynn *et al.* 2007). The apparent range shift has been attributed to increases in sea surface temperature and consequent impacts on the food chain (Wynn *et al.* 2007; Luczac *et al.* 2011) but this proposed cause has been disputed (Votier *et al.* 2008); it is also possible that changes in survey effort have contributed to an apparent range shift.

Primary threats to the population include mammalian predation at the breeding colonies and fishery by-catch at sea, especially on longlines, but also in nets of various kinds (Arcos 2011). Preliminary results suggest that there is little spatial overlap between Balearic shearwater occurrence and longline fisheries in UK waters, though there is significant overlap and associated mortality off Iberia and in Mediterranean waters (ICES 2013).

3 Methods

Information on the numbers and distribution of Balearic shearwater in UK waters comes from a number of sources, both from surveys at sea and land-based counts. With at-sea observations one can estimate the position of the observation with some accuracy and, for the higher quality datasets, estimate a bird density surface across the entire survey area, using spatial interpolation. Land-based counts of seabirds have generally not been considered to represent high quality data from which to make assessments in relation to possible marine SPA provision, particularly if a single count location is used to sample an entire area of search (AoS). This primarily concerns their inability to detect birds beyond a few kilometres from land, or to provide precise spatial information (except where equipment such as theodolites are used, as in 3.4, below, though these too are not free from possible sampling error).

Analyses were designed to achieve the following, in the context of providing evidence that may be assessed against guidelines for SPA selection (Stroud *et al.* 2001):

1. identify the occurrence of the species at a given location;
2. detect aggregations, i.e. identify any area holding elevated concentrations of birds in comparison to surround areas (i.e. "hotspots");
3. where possible, estimate the number of birds within aggregations; and
4. establish the regularity of any aggregations, primarily between year regularity.

The irregular occurrence and comparatively low density of aggregations of Balearic shearwaters in UK waters presents significant logistical and methodological challenges in order to successfully achieve all of the above aims, given the analytical techniques currently available.

3.1. European Seabirds At Sea (ESAS) boat-based surveys

ESAS is the most geographically and temporally extensive effort-related dataset for seabirds at sea, covering the UK fisheries limit area at a relatively high level of survey effort and extending south and westwards to French and Iberian waters, also into the North Sea, Baltic Sea and Norwegian Sea (Figure 1). Temporal variability in ESAS survey effort within the UK and the Atlantic sea area of those countries that form the stronghold of Balearic shearwater is shown in Figure 2.

A "hotspot analysis" similar to that undertaken by Kober *et al.* (2010, 2012) was performed on ESAS data (methods of collection according to Camphuysen *et al.* 2004) collected from May to October between 1979 and 2010. In order to maximise data coverage, all years were combined. Only bird records within transect were retained for analysis (i.e. for birds on the sea, only those recorded within the transect band – generally a 300m band to one side of the survey vessel; for flying birds, only those within the transect band at the time of a snapshot count). Bird records associated with vessels other than the survey vessel itself were identified and retained for analysis, as in Kober *et al.* (2010, 2012).

For the ESAS hotspot analysis, no population estimate was attempted, because there were too few in-transect observations in the area of primary interest, in UK waters (Figure 4). This would have prevented the application of a detection correction using Distance software (see also section 3.5). Furthermore, alternative methods of obtaining a population estimate, such as assuming 100% detection within the 300m survey strip and extrapolating this to the un-surveyed area, would have risked introducing unacceptably high errors, as the mean area surveyed per year in UK waters, approximately 5,000km^2 (Figure 2), equates to only approximately 0.6% of the UK continental shelf area. Instead, the density surface was not scaled to a population estimate, and thus represents a relative density surface.

While Kober *et al.* (2010, 2012) concluded that Balearic shearwater was one of the four species that existed in such low densities in UK waters as to prevent the identification of a meaningful continuous density surface, we sought to examine the robustness of their conclusion by repeating their approach, but using an alternative method to produce a bird density surface: kernel density estimation (KDE) rather than the Poisson kriging that Kober *et al.* used. We assess KDE to be an appropriate alternative to Poisson kriging; it is a widely-used method to create a smoothed surface of estimated densities (Silverman 1986) and has been applied in a number of marine SPA applications (e.g. Lawson *et al.* 2016; Win *et al.* 2016). In addition, Kober *et al.* (2010, 2012) included the years 1980-2006 while we analysed a slightly longer time period, from 1979-2010. KDE interpolates observation to locations where no data were collected and smoothes the surface (see Silverman 1986; O'Brien *et al.* 2012). To standardise variation in survey effort between areas and between years, effort (survey vessel track length x transect width) was calculated for each cell within a 6x6km grid overlain onto the entire area of search (Figure 1). As per Kober *et al.* (2010), the choice of a 6x6km grid was based on the maximum possible resolution of the data, with the minimum length of most transect sections being 6km. An estimate of mean bird density over the survey period (1979-2010) was generated for each cell from the sum of observed birds divided by the sum of effort over that period. It was not possible, due to the relatively small number of Balearic shearwater observations per year, to produce a density surface for each year separately. It is unknown whether this would lead to an under- or overestimate of numbers/density, as temporal occurrence of records was not analysed. Kernel density estimation was performed in Geospatial Modelling Environment (GME; ArcGIS v10.1), using a smoothing parameter of 9km (i.e. 1.5 times the minimum transect length, to ensure that density estimates at any point on the surface were derived from data collected on at least one whole transect length; see also O'Brien *et al.* 2012).

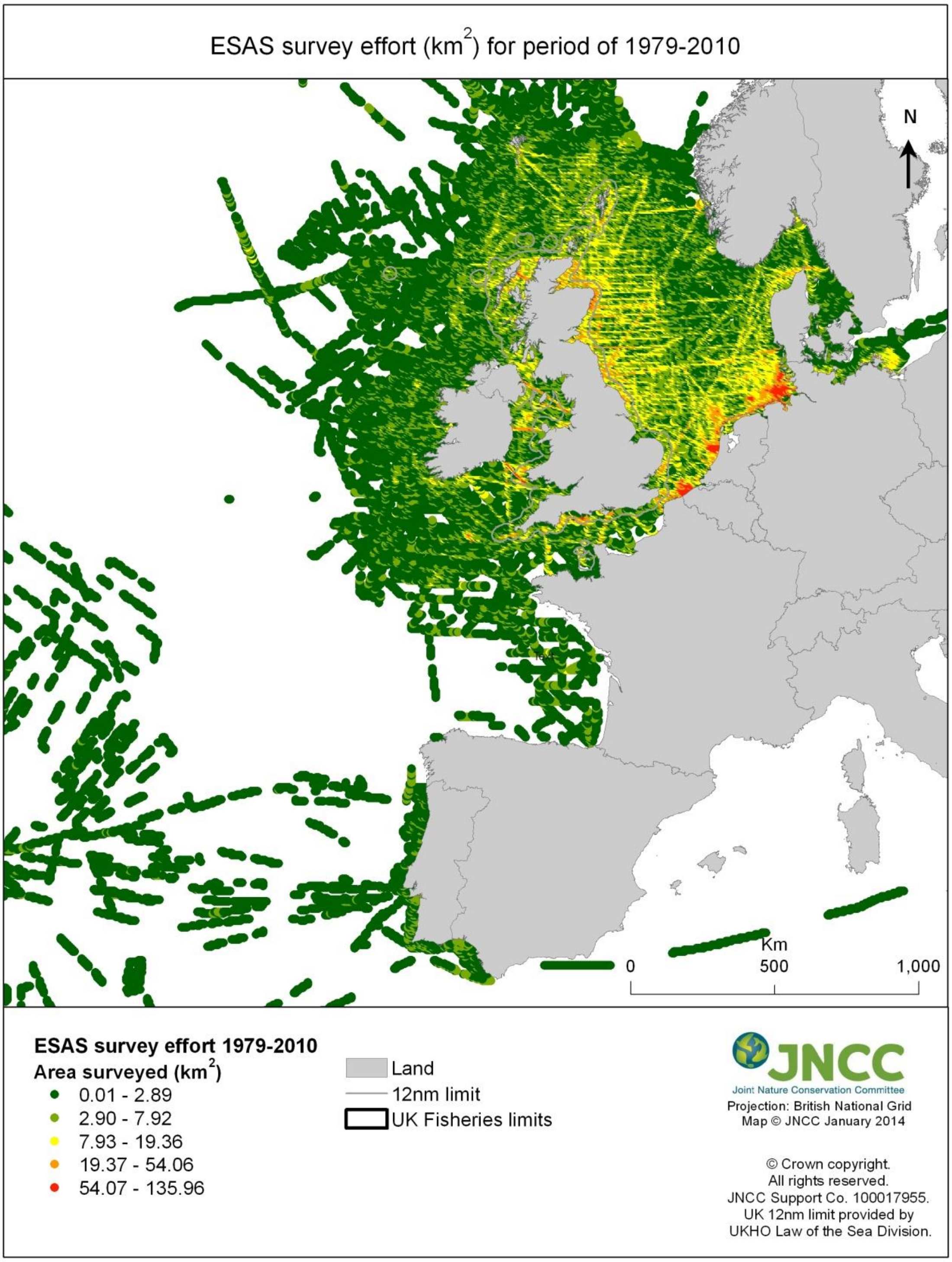

Figure 1. Survey effort undertaken by ESAS surveys between 1979-2010. Effort is equal to the length of survey vessel transect (km) multiplied by transect width (usually 0.3km). Data summarised within 6 x 6km grid cells.

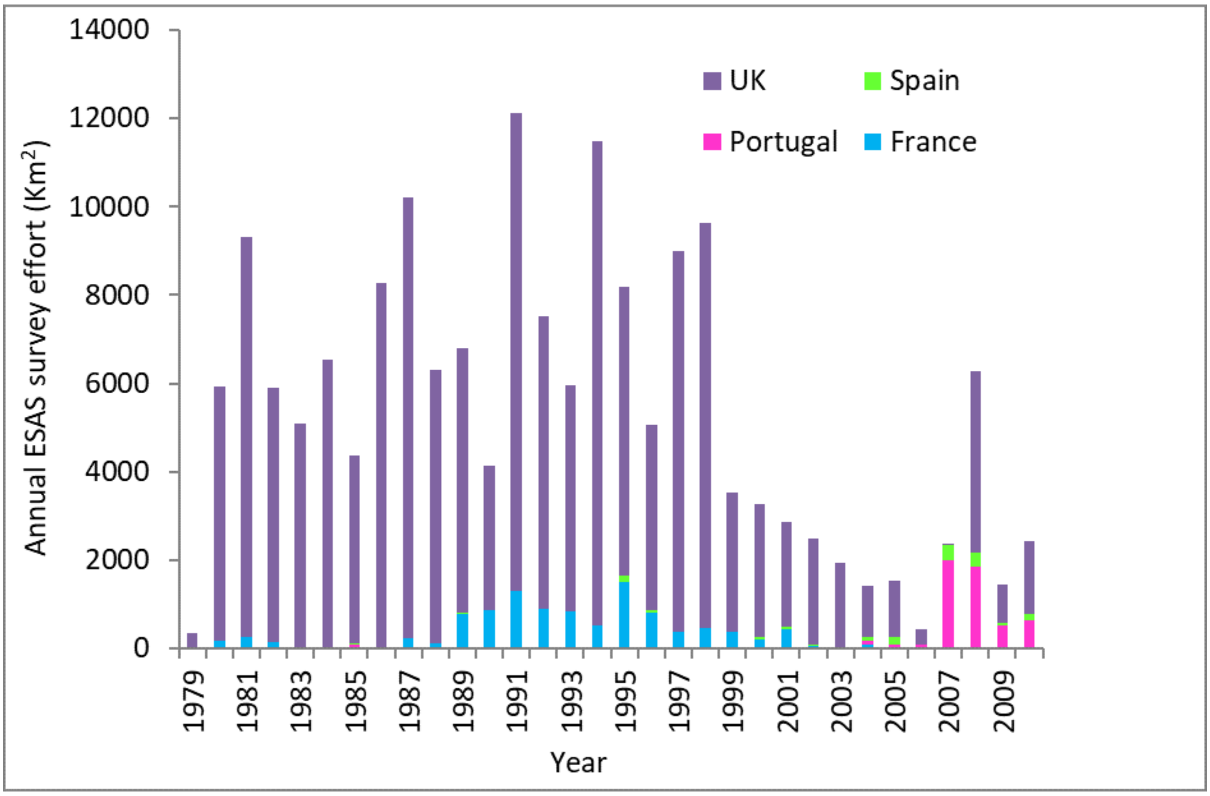

Figure 2. Annual variation in ESAS survey effort in the UK, Atlantic waters of France and Spain, and Portugal, 1979-2010.

The Getis-Ord Gi* statistic (Anselin 1995) was applied to the density surface to identify the location of consistently high bird densities across the area of search. This statistic is derived from both the number of birds at a location and the degree of clustering of high values around that location (see also Kober *et al.* 2010). In line with Kober *et al.* (2010), threshold values of the top 5% and the top 1% of all positive Getis-Ord Gi* values were used to define hotspots. These values, although essentially arbitrary, are analogous to the thresholds used in formal tests of statistical significance (Kober *et al.* 2010). Only those Getis-Ord Gi*s at locations with seabird densities >0 birds/km^2 were taken into consideration; this is because Gi* values were attributed to some cells with zero density, as the Gi* statistic takes account of both density of the cell itself (which may have zero density) and of neighbouring cells (which may have positive density). This hotspot analysis was carried out on both the Europe-wide density surface, as well as on a UK-wide surface (the Europe-wide density surface clipped to the UK Fisheries Limit). For the latter, two analyses were performed: firstly, with a buffer of 100km applied to the UK Fisheries Limit in order to allow inclusion of cells around the border of the UK Fisheries Limit, as it was known that records of Balearic shearwater occurred close to the border; secondly including only cells within the UK Fisheries Limit.

3.2. Marinelife boat-based surveys and other information

Results of various surveys collected by Marinelife (Brereton 2011) within the English Channel region were interrogated. These comprised:

- surveys from cross-channel ferries (Plymouth-Roscoff and Portsmouth-Bilbao; Poole-Santander);
- systematic and targeted surveys adopting ESAS-type method during August-October 2009-10;
- opportunistic sightings obtained from vessels of opportunity; and
- casual sightings submitted by members of the public.

Only data from targeted surveys in 2009-10, which adopted ESAS-type methodology, (Camphuysen *et al.* 2004) were analysed, because only during these surveys could bird density be standardised and properly corrected for the amount of recording effort undertaken. Standardisation of bird density was achieved by counting birds on the sea within an estimated 300m transect band and by the use of snapshot counts of flying birds (to take account of the flux of flying birds entering and leaving the survey area). Consistent recording of bird behaviour (e.g. whether flying or on the sea surface) is an additional requirement for correct density assessment. Calculating effort is important as survey effort tends to be unevenly distributed across the area of search; without correction for effort there would be a significant risk of producing a biased picture of seabird distribution and density (see Kober *et al.* 2010 for details). Figure 3 shows the density of survey effort from systematic and targeted surveys in 2009-10. Methods of data collection were not wholly consistent with the ESAS method (e.g. snapshots of flying birds were taken every 10 minutes, rather than being calibrated according to the speed of the survey vessel). Therefore, these data could not be combined with ESAS data under the analyses described in 3.1 above, as they would have tended to under-estimate the density of flying birds, known to constitute a large proportion of all records.

Given the sparseness of the data, the appropriateness of any currently available analytical technique to ascribe a density surface and thereby identify hotspots in density is questionable. Nevertheless, as with the analysis of ESAS data (see 2.1), a density surface was produced using KDE (Silverman 1986; O'Brien *et al.* 2012), followed by a "hotspot analysis" (Kober *et al.* 2010, 2012), applying the Getis-Ord Gi* statistic (Anselin 1995). Only those Getis-Ord Gi*s at locations with seabird densities >0 birds/km^2 were taken into consideration (see above). To standardise variation in survey effort between areas and between years, effort (survey vessel track length x transect width) was calculated for each cell within a 7x7km grid overlain onto the entire area of search. As per Kober *et al.* (2010), the choice of grid size was based on the maximum possible resolution of the data, with the minimum length of most transect sections being 7km. Kernel density estimation was performed in GME (ArcGIS v10.1), using a smoothing parameter of 10.5km (i.e. 1.5 times the minimum transect length, to ensure that density estimates at any point on the surface were derived from data collected on at least one whole transect length; see also O'Brien *et al.* 2012). An estimate of mean bird density over the survey period was generated for each cell from the sum of observed birds divided by the sum of effort. It was not possible, due to the small number of Balearic shearwater observations per year, to produce a density surface for each year separately.

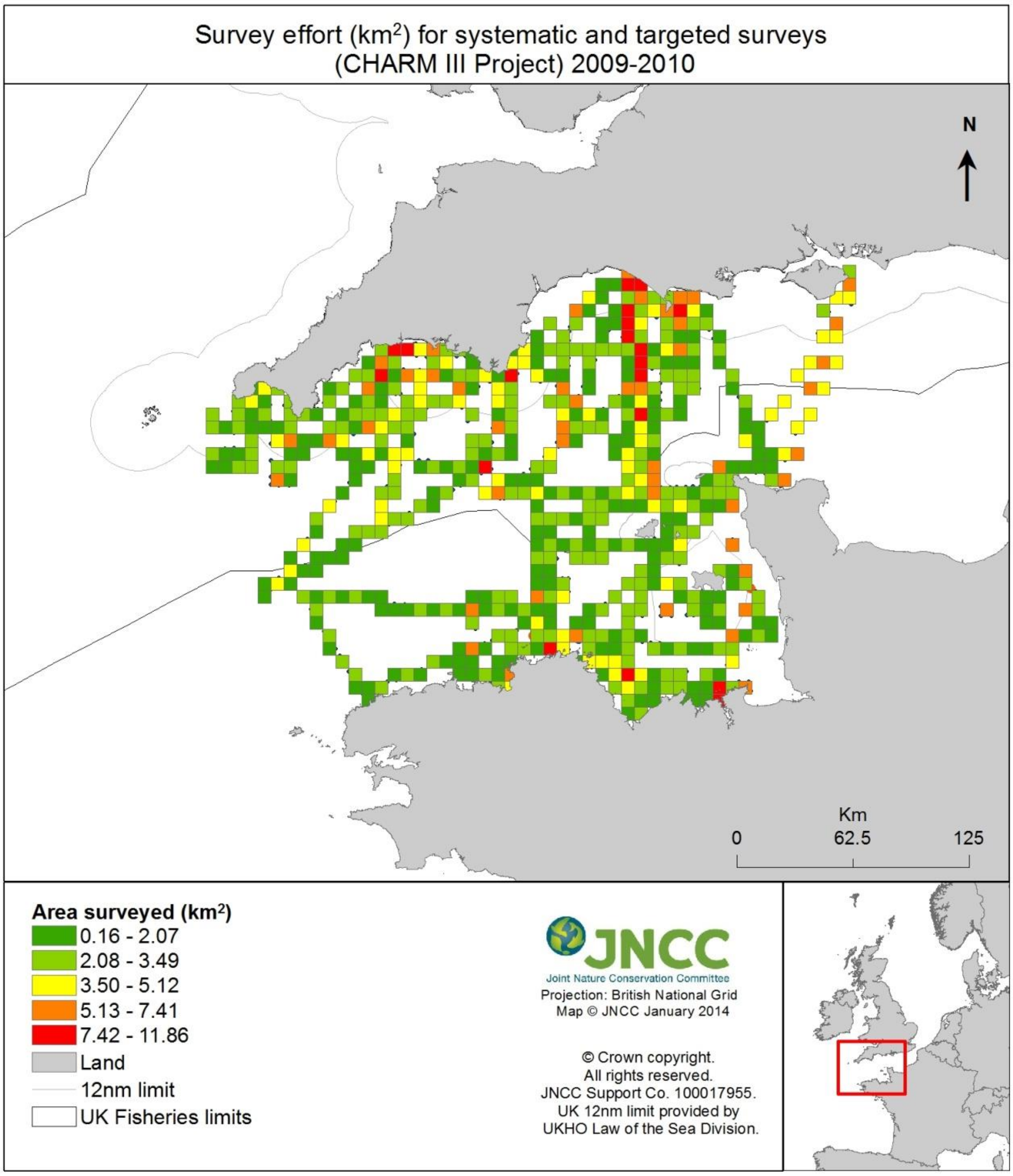

Figure 3. Density of survey effort employed in Marinelife systematic and targeted surveys, 2009-10. Density calculated from survey track length multiplied by transect width (usually 300m).

3.3. SeaWatch SouthWest land-based surveys

Effort-based land counts of Balearic shearwaters from coastal migration watch-points, conducted between 2007 and 2010, have highlighted areas that appear to represent notable flyways and aggregations (Wynn *et al.* 2011). Most observations came from effort-based sightings from Gwennap Head (at the southwest tip of the UK mainland; Figure 9), collected from 15 July to 15 October annually from 2007-10, totalling about 4000 hours of observations. Continuous observation was undertaken during all available daylight periods during these dates, regardless of weather conditions, helping to reduce biases. All records included information on date, time, number of birds, flight direction and distance from watchpoint. The latter was facilitated by the presence of the Runnelstone Buoy, located at a distance of 1.6km offshore in the centre of the field of the view. Observations at other SeaWatch SW survey locations around SW Britain were also conducted (Figure 9).

Many records also included moult stage, plumage morph, behaviour, and associations with other species. All SeaWatch SW observers were experienced seabird observers with proven prior experience of Balearic Shearwater identification. However, the data would be affected by varying levels of observer bias, e.g. variable ability, optical equipment, weather conditions (glare, visibility) *etc*. It is also possible that there will be duplication due to birds repeatedly passing the watchpoint on the same or subsequent dates.

A series of 'sister sites' was established in southwest to UK in order to put the effort-based observations at Gwennap Head into a regional context. All records of Balearic Shearwater at these sister sites included date and number of birds, while those from Berry Head/Start Point also include time, flight direction and behaviour. All sister site observers were experienced and fully capable of correct Balearic Shearwater identification. However, note that the sister sites data are not effort-based and are subject to the usual biases associated with casual sightings data (e.g. observer/site bias, optics, glare, visibility *etc*.).

3.4. Mid-winter land-based pilot survey of St Ives Bay, west Cornwall

The National Oceanography Centre, in conjunction with Natural England, RSPB, Cornwall Inshore Fisheries and Conservation Authority and Marinelife, conducted seabird and cetacean surveys using a theodolite combined with conventional visual observations to accurately establish organisms' location within the Bay. St Ives Bay (SIB) has been reported to hold regionally-important numbers of foraging seabirds during midwinter, including Balearic shearwater (Wynn *et al.* 2011) and recent seabird bycatch incidents in the Bay prompted the requirement for improved information on numbers of seabirds and their potential interaction with fisheries.

The SIB study area comprised approximately 35km^2. Observations were conducted during two periods in the winter of 2012/13; from 7-15 December 2012 comprised 46 hours of observations over eight days, and from 13-24 January 2013, comprising 61 hours over nine days. Survey work was conducted from a single vantage point, selected due to its ease of access and shelter during adverse viewing conditions. To detect foraging aggregations from shore, a team of three or more observers was equipped with 10x binoculars, 30x telescope and the 30x monocular of the theodolite (Leica FlexLine TS02 Total Station). Communication was maintained between observers at all times, and sightings were immediately fixed and recorded by the theodolite. Positions of foraging seabirds were automatically date- and time-stamped and saved electronically. For each sighting, the theodolite record number, along with species composition and group size, were noted. Data on weather conditions and other environmental variables (e.g. sea state, wind vector/velocity, and cloud cover) were also collected every 30 minutes. Full details of method are provided in Wynn *et al.* (2013). Further surveys were undertaken in 2013/14 and 2014/15 (not presented here).

3.5. JNCC/NE-commissioned systematic boat-based surveys

Systematic boat surveys for Balearic shearwater were conducted in Lyme Bay and around Portland in 2009 (JNCC in-house), 2011 (JNCC in-house and contracted to Marinelife by JNCC) and 2013 (contracted to Marinelife by NE), deploying ESAS methodology (Camphuysen *et al.* 2004), with the modification of also recording the range and bearing of observations at first sighting (so that estimates of bird position could be made). The Lyme Bay and Portland area has a long history of records of Balearic shearwater, principally from shore-based observations from Portland Bird Observatory and other coastal watch-points but latterly also from boat surveys such as those undertaken by Marinelife (e.g. Brereton

2011). In addition, the West Lyme Bay area of search was selected to cover areas of sea that had received little spatial coverage by previous sea-based surveys.

Three summer/autumn years of observations were conducted:

- 2009 (one complete survey of Lyme Bay-Portland on 7 days between 25 July and 7 August);
- 2011 (five repeat surveys of two study areas -West Lyme Bay and around Portland -on 11 days between 13 July and 23 September) and
- 2013 (five repeat surveys of the two study areas surveyed in 2011 on 10 days between 1 August and 7 October).

Line transect data, where observations of birds on the sea are allocated to distance bands, are usually corrected for decreasing detectability of birds with increasing distance from the vessel, in order to estimate the total numbers of birds within a survey area. The ‘detection function’, determined using the software *Distance* (Thomas *et al.* 2010), can usually only be reliably estimated when there are a minimum of 20-30 observations per survey. However, the number of Balearic shearwaters seen on the sea (loafing or foraging) during these surveys was low (54% of all ESAS observations by number of birds, 29% by number of observations); distance sampling methods are generally not recommended for data of this kind due to the difficulty of estimating exact distances to flying birds. Population estimates for 2011 surveys were therefore generated by effectively assuming 100% detectability of Balearic shearwaters within the ESAS 300m by 300m search area and then extrapolating up to the wider survey area. There were too few in-transect observations in 2009 and 2013 to estimate population size (or produce a density surface).

It is thought that the species habitually follows vessels; our results showed that 15 out of 76 birds observed on surveys were thought to be associated with fishing vessels. Therefore, records of birds associated with ships were excluded from the spatial analyses using kernel density estimation (see below). All birds associated with the survey vessel were excluded, as per standard ESAS practice. This was done to help ensure that the analysis identified only aggregations of birds associated with natural features and not man-made ones. However, population estimates for the areas of search included birds associated with fishing vessels, on the basis that it was likely that birds which fed in this way also at times fed ‘naturally’; to exclude them would have risked underestimating the total number of birds present.

For each survey, the number of individual Balearic shearwaters within the AoS was estimated by adding together all the birds seen ‘in transect’ (i.e. those birds recorded on the sea in bands A to D, plus flying birds recorded during ESAS snapshots in a ‘box’ 300m to the side and 300m ahead of the vessel). These raw numbers were then used to calculate bird densities within the surveyed areas. Overall population estimates for each survey were then calculated by extrapolating to the whole area of search (thus including some un-surveyed areas). In this way, variations in survey effort within each AoS were accounted for. Population estimate calculations were checked, and confidence intervals generated (using bootstrapping) in Distance 6.0 (uniform model, bootstrapping with 5000 resamples).

Kernel density estimation of 2011 data was performed in Hawth’s Tools (ArcGIS v9.2; equivalent analysis to that implemented in GME for ESAS data), with the smoothing parameter set to 1.5 times the distance between transects (i.e. 4.5km for Portland surveys, where parallel transects spaced 3km apart were used). The same smoothing parameter was used for West Lyme Bay surveys but, there, zig-zag transects were used to obtain efficient coverage of the indented coastline. The relative densities from each KDE surface (one surface for each survey) were scaled to the relevant population estimate (see above). A mean KDE surface was derived by taking a mean of the density values of individual cells within the AoS.

4 Results

4.1. European Seabirds At Sea (ESAS)

Figure 4 shows the locations of observations of Balearic shearwater from ESAS surveys 1979-2010, analysed on an ESAS-wide scale. Note the location of 1% (and 5%) hotspots from the Getis Ord analysis all occur outwith UK waters, off the coast of Portugal, where other studies have identified concentrations of Balearic shearwaters (Guilford *et al.* 2012; Oppel *et al.* 2011).

Figure 5 shows the 1% and 5% hotspots from ESAS data, analysed at a UK scale but including a buffer that extends into neighbouring waters. No hotspot occurred within UK waters; the identified hotspots were located off the north-western coast of France, where other studies (e.g. Thébault *et al.* 2013) have recorded large aggregations; these are included within the UK analysis because of the 100km buffer around the British Fishery Limit boundary (see methods 3.1). However, the hotspot off France, as identified from ESAS data, is based on observations from just one year (1996), in which a single record of two individuals were recorded. The observations of Thébault *et al.* (2013), from 2010, are not part of the ESAS dataset, due to differences in method and hence comparability with ESAS.

Figure 6 shows the 1% and 5% hotspots from ESAS data analysed at a UK scale but this time excluding cells in neighbouring waters. This analysis used the same absolute Getis Ord GI* values as used in Figure 5, but now the ranking of top 1% and 5% is undertaken solely on cells within British Fishery Limit. Two cells emerged as 5% hotspots and one cell (also a 5% hotspot) as a 1% hotspot, both in the southern Irish Sea close to the British Fishery Limit, just outwith 12nm from the coast of Wales. Of course, the method, by its nature, will necessarily identify hotspots in any given area so long as there are cells with positive GI* values in the distribution, because it identifies the top-ranking cells in terms of relative density and aggregation, but no minimum absolute density is required. There was just one observation of the species in 1998 in the hotspot, of a single individual, demonstrating the scarcity of the species in UK waters as identified from ESAS surveys.

Analysis of the regularity of use of the UK hotspots shown in Figure 6 shows that for both the 1% and the 5% hotspot, ESAS surveys were conducted in eight years (1983, 1990-91, 1994-98), in which only one (1998) were Balearic shearwaters recorded. The UK SPA selection guidelines require that the “requisite number” of birds should occur in two thirds of the seasons for which adequate data are available; clearly one out of 8 years with any records of Balearic shearwaters (0.13) is very much less regular than the 0.67 or greater suggested.

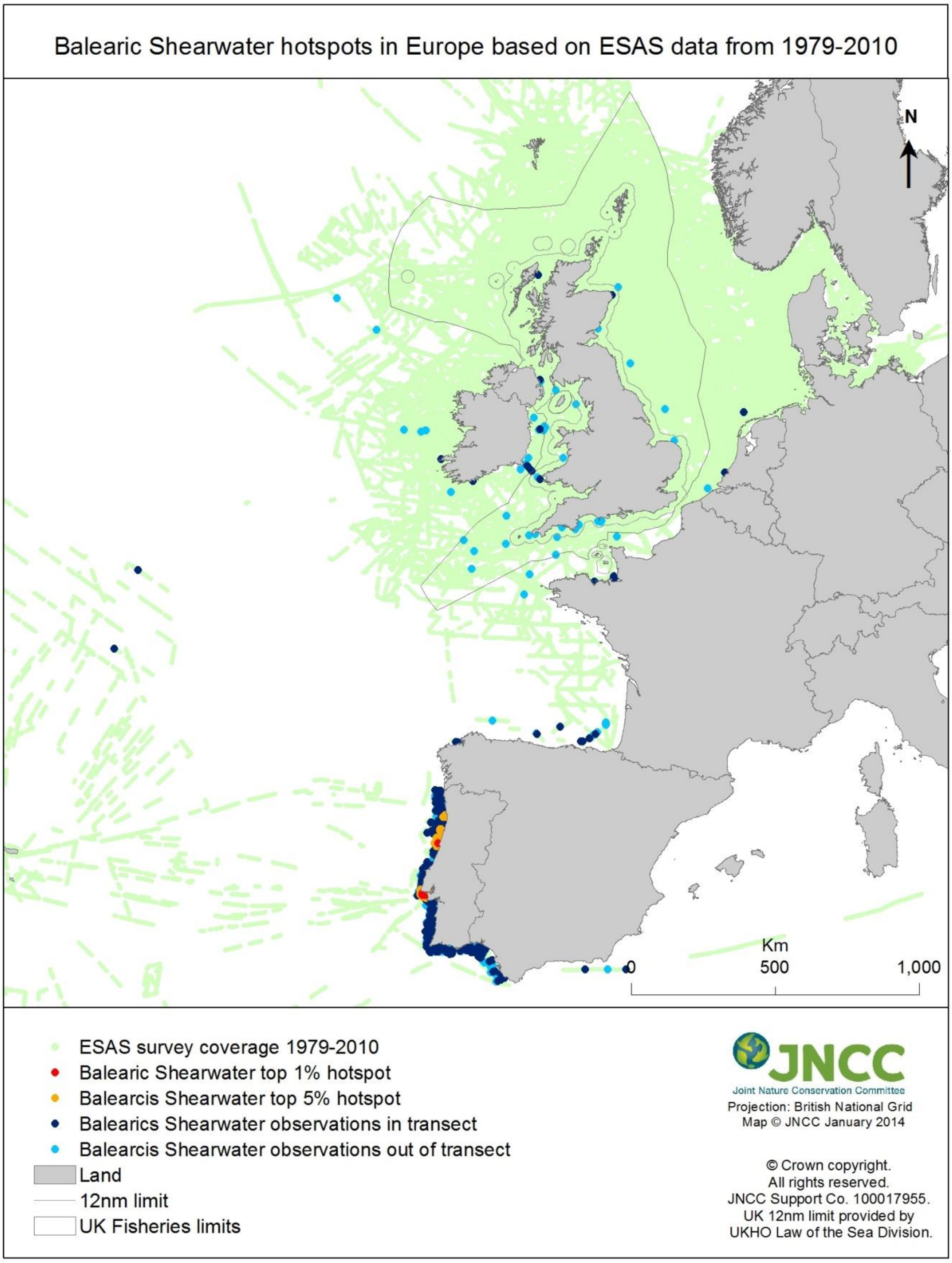

Figure 4. Europe-wide ESAS Balearic shearwater observations and hotspots derived from Kernel Density Estimation and Getis Ord hotspot analysis. In-transect observations comprise those records that were within the 300m transect band parallel to the survey vessel; flying birds are recorded as in-transect only at the time of instantaneous snapshot counts. For ease of viewing, hotspots are denoted by symbols larger than the 6km square grid cells.

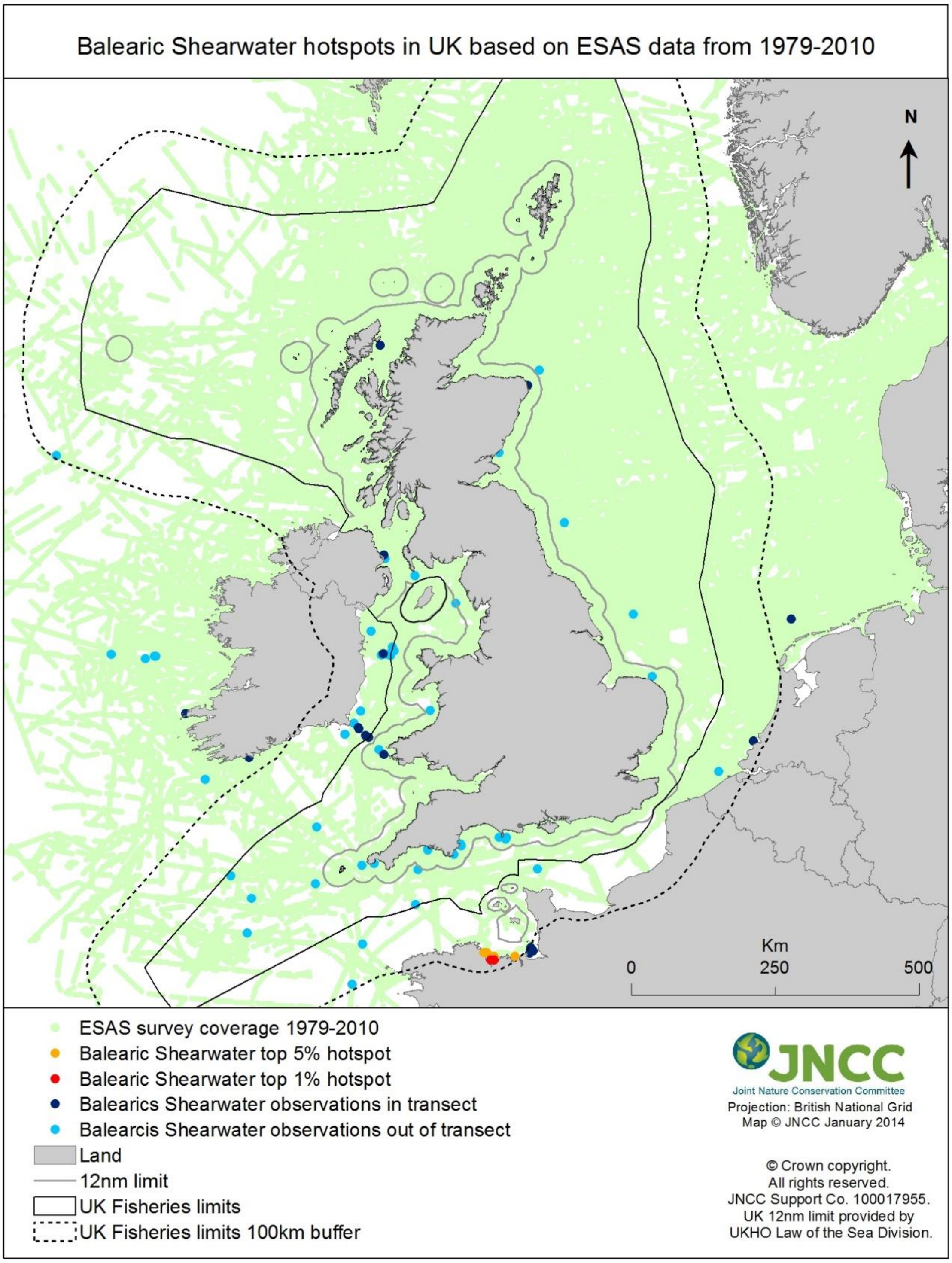

Figure 5. Balearic shearwater hotspots within UK fisheries limit **(**with buffer into neighbouring waters) based on ESAS observations, with hotspots derived from Kernel Density Estimation and Getis Ord hotspot analysis. In-transect observations comprise those records that were within the 300m transect band parallel to the survey vessel; flying birds are recorded as in-transect only at the time of instantaneous snapshot counts. For ease of viewing, hotspots are denoted by symbols larger than the 6km square grid cells.

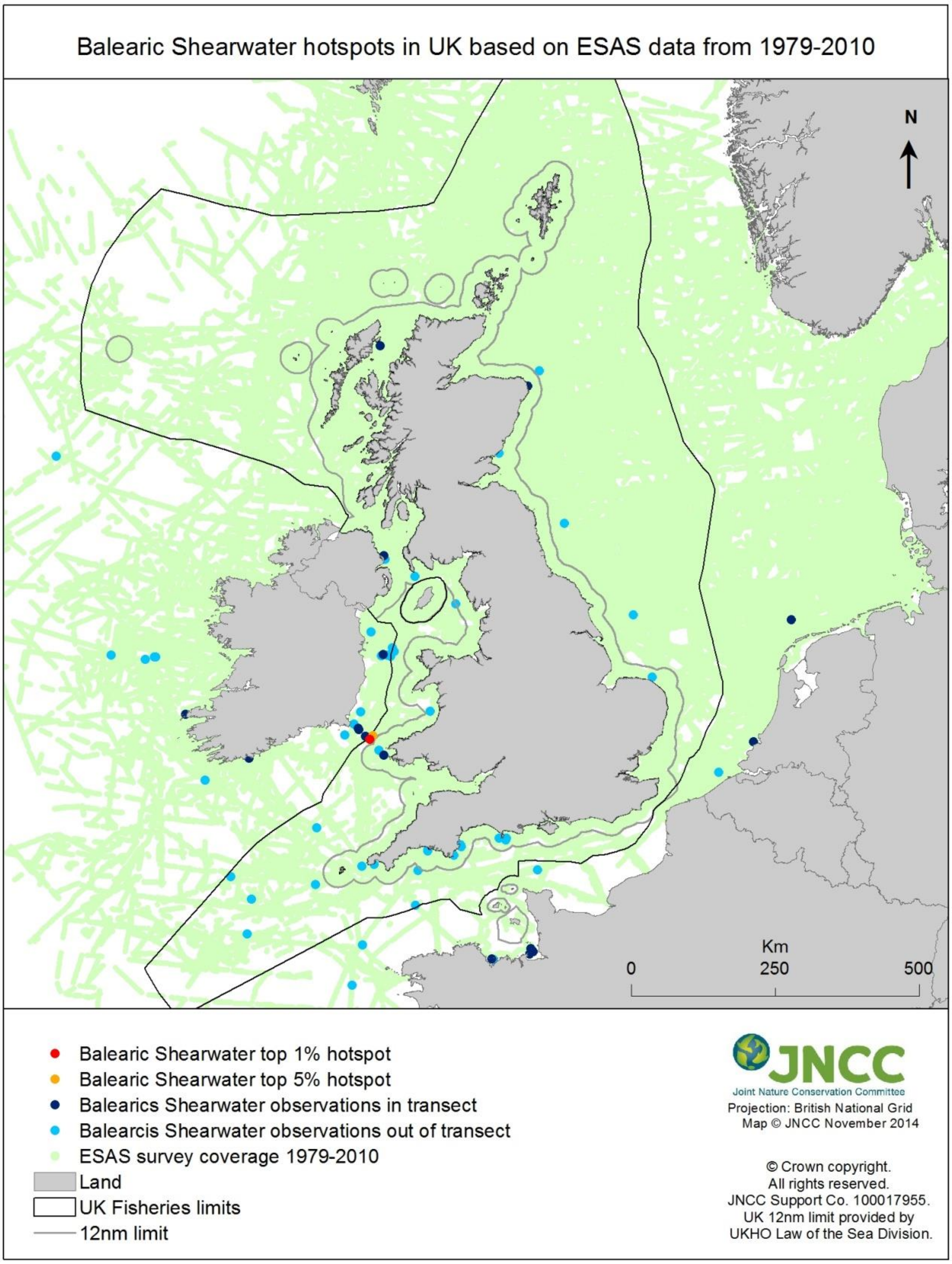

Figure 6. Balearic shearwater hotspots within UK fisheries limit **(**without buffer into neighbouring waters) based on ESAS observations, with hotspots derived from Kernel Density Estimation and Getis Ord hotspot analysis. In-transect observations comprise those records that were within the 300m transect band parallel to the survey vessel; flying birds are recorded as in-transect only at the time of instantaneous snapshot counts. For ease of viewing, hotspots are denoted by symbols larger than the 6km square grid cells.

4.2. Marinelife boat-based surveys

Figure 7 shows the results of the hotspot analysis conducted on Marinelife “targeted and systematic surveys” during 2009-10. It is important to highlight the restricted number of usable (i.e. ‘in transect’) observations from these surveys; there are only 15 records of Balearic shearwater, of which only three were definitely in transect. Out of these 15 records, only two were within the UK’s fisheries limit, with only one of these definitely in transect. As a precautionary measure, KDE was run using all 15 records, and the resultant 1% hotspot map (based on the whole area, not clipped to UK) is shown in Figure 5. Only four cells emerged as hotspots (rather than “coldspots”, i.e. effectively areas with fewer birds than the mean value); 1% of those 4 is 0.04 of a cell, i.e. considerably less than one whole cell. This cell is located in a similar position – in the Baie de St Brieuc off northwestern France - as the hotspot identified from the ESAS analysis (see 4.1). Clearly, given so few cells, deriving a 1% calculation is problematic and would result in a “hotspot” comprising a small fraction of a single cell. Effectively, then a hotspot in this case can only be identified by selecting the top 25% of cells, considerably higher than the 1% or 5% defined by Kober *et al.* (2010).

Figure 8 shows all Balearic shearwater records from Marinelife surveys, including records from surveys which do not fully account for survey effort, and hence did not allow for a density analysis. Note the high density of opportunistic and casual observations which are concentrated in Lyme Bay and around Portland; the possible biases associated with such data should be remembered, for example the likelihood that surveys were more likely to be undertaken at times or in locations when/where particularly high number of Balearic shearwaters occurred.

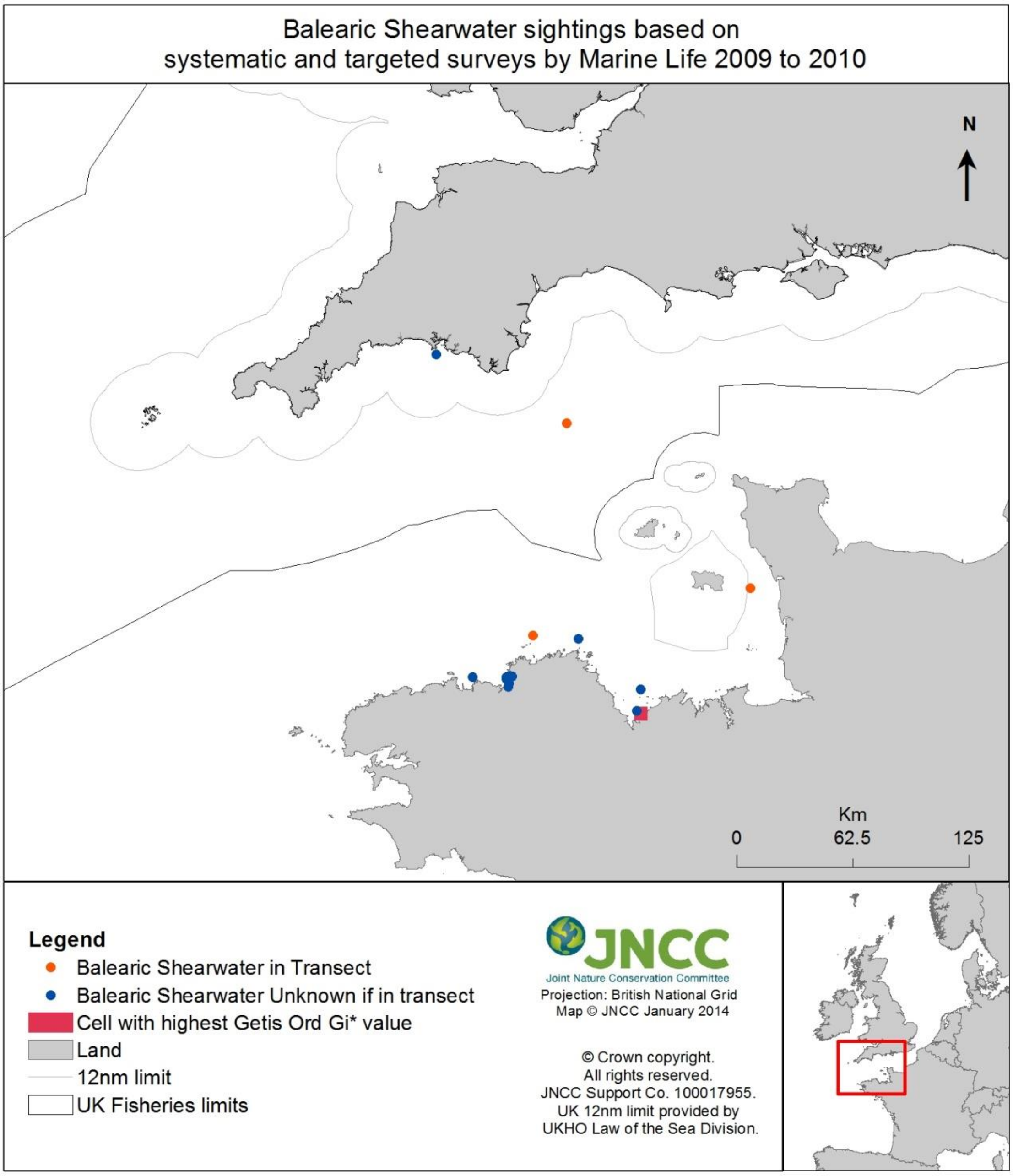

Figure 7. Hotspot analysis of Marinelife "targeted and systematic" surveys 2009-10.

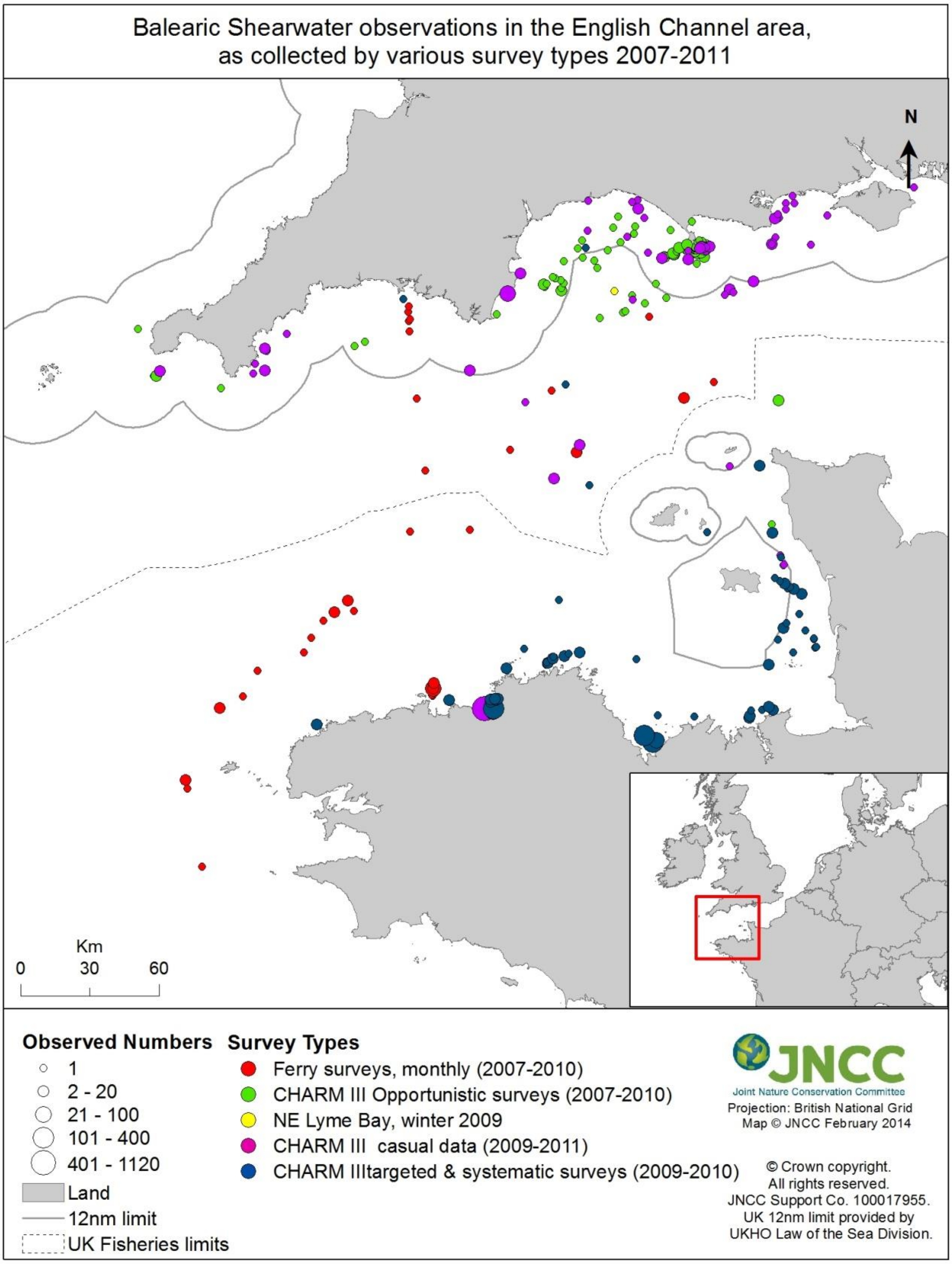

Figure 8. All observations of Balearic shearwaters undertaken by Marinelife during 2007-10, from various survey methods and other observations.

4.3. SeaWatch SouthWest land-based surveys

At Gwennap Head, Wynn *et al.* (2011) report a 'bird per hour' (bph) rate of 1.0-1.4 during the three years 2007-09 but a higher rate of 2.8bph in 2010. Data from a series of other sites in southwest England (Berry Head, Pendeen, Trevose Head, see Figure 9) indicate that most prominent headlands in the region experience passage rates of 1.0-2.8bph in the July to October period (a similar range to Gwennap Head), with 0.3-0.7bph at Strumble Head in southwest Pembrokeshire but very few at Whitburn (Tyne and Wear) in the North Sea.

Records that specifically refer to foraging birds or birds remaining at a location for a number of minutes (as opposed to passing through) were relatively scarce, although this was partly because most records did not specify behaviour. All records supplied by SeaWatch SW of aggregations of 20 birds or more are shown in Table 1.

In winter (December-February), sites holding foraging aggregations are restricted to the far southwest of the UK, particularly southwest Cornwall, the Isles of Scilly and Portland Bill. The peak count at this season is 25 birds in Carbis Bay (near St Ives) in December 2010. This phenomenon appears from available evidence to be relatively recent, being first recorded in 2003/04 (Wynn 2009), but see also 4.4 below.

Other than from Gwennap Head, summer aggregations (June-August) at other SeaWatch SW survey sites were most commonly reported from the Portland Bill area, which has seen a series of records since the mid-1900s (Wynn & Yésou 2007). The Shambles Bank (near Portland Bill) at times appears to have been a favoured feeding and roosting area (though it should be noted that in only one year out of three surveyed did JNCC boat transect surveys detect significant aggregations there; see 4.5). Most other summer aggregations were distributed along the south coast from Kent to Cornwall. Three of the autumn (September-November) aggregations were in Ireland (Cork and Waterford), with the remainder in southwest Cornwall.

The alongshore extent of observations was not quantified but there are estimates of the seaward distribution. Analysis of the Gwennap Head data (using topographical features as reference points) indicates that peak numbers of Balearic shearwaters are seen at 200-1000m range (Figure 10); this contrasts with sooty shearwater, which shows a marked concentration at 1400-1600m range and over a third of observations >1600m offshore. However, the extent of annual variation or the effect of weather conditions upon distance of birds from shore has not been investigated.

Table 1. Records of aggregations of Balearic shearwaters from land-based observations 2007-10. Source: Wynn *et al.* 2011.

	Date	**Number**	**Location**	**Notes**
2007	8 July	117	Portland Bill	Moulting flock; also 2380 Manx shearwaters
	9 July	88	Portland Bill	20+ seen regularly from 19 June-9 July
	8 July	41	Lyme Bay	Pelagic trip; probably same birds as Portland observations on same date
	1 Jan	20	St Ives	
2008	22 July	35	Selsey Bill	Probably an over-estimate
2009	18 Sept	20	Galley Head	2 miles to west
2010	3 Aug	50-100	Portland Bill	
	23 July	40	Dartmouth	With ~400 Manx shearwaters
	26 July	20	Dawlish Warren	
	2 Aug	40	Portland Bill	
	1 Aug	26	Portland Bill	Roosting over Shambles Bank – sunset
	7 Dec	25	Carbis Bay	Also 20-22 on 11-13 December

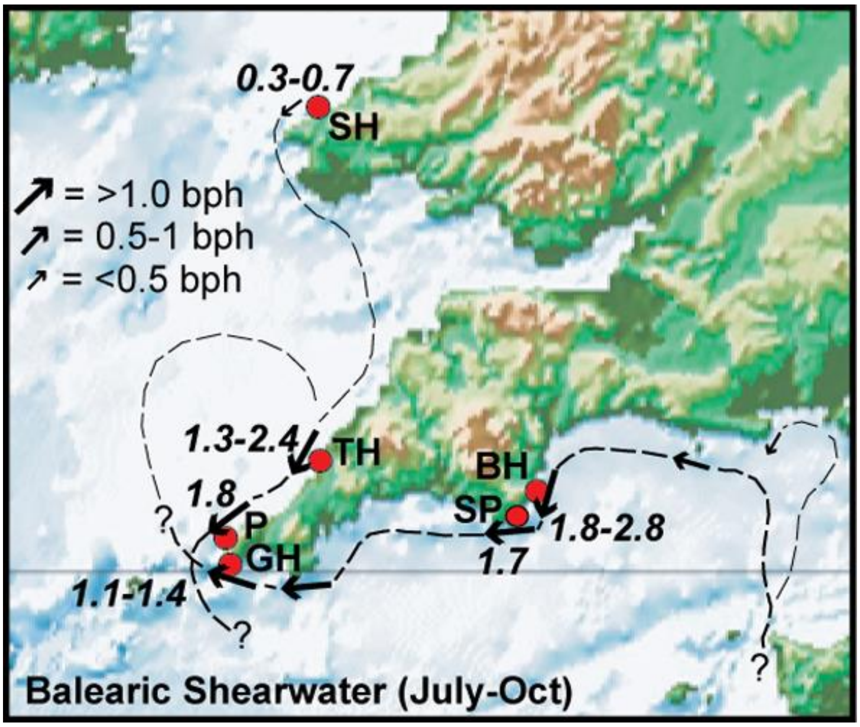

Figure 9. Estimated passage rates of Balearic Shearwater at locations in southwest UK, based upon data collected from Gwennap Head and other SeaWatch SW survey locations in 2007-10. BH = Berry Head; SP = Start Point; GH = Gwennap Head; P = Pendeen; TH = Trevose Head; SH = Strumble Head. Figures are in bph. Arrows indicate dominant flight direction of observations and broken line represents the preliminary proposal by Wynn *et al.* (2011) for a possible flyway schema. Source: Wynn *et al.* (2011).

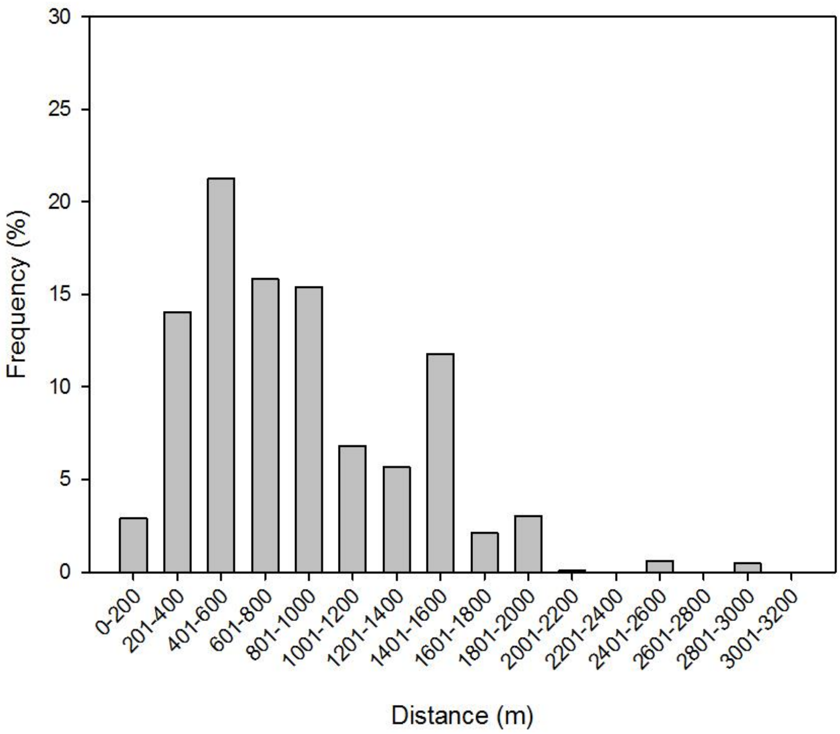

Figure. 10. Flight distance of Balearic Shearwaters passing Gwennap Head from 15 July-15 October in 2007-10 (n=6187). Peak frequency is at 401-600 m range. Source: Wynn *et al.* 2011.

4.4. Mid-winter pilot survey of St Ives Bay, west Cornwall

Wynn *et al.* (2013) reported that during the first year of a pilot study to gather information on seabird and cetacean feeding aggregations in SIB, a maximum of 15 Balearic shearwaters were observed (on 13-14 January 2013), with at least one individual present on all but one of the survey days. Outwith the effort-based surveys, 58 were seen moving west past St Ives Island on 30 December 2012, when 45 were seen within Carbis Bay. Theodolite observations showed that feeding concentration of seabirds, including Balearic shearwaters, occurred primarily around the visible tide race to the north and northeast of St Ives Island, and in the shallow sandy nearshore zone of the southern Bay.

While these data have confirmed the regional importance of SIB for Balearic shearwaters in midwinter, its relative importance is unclear compared with other areas of Cornwall or the southwest coast. This is largely due to relatively sparse survey effort from other areas during winter, though SeaWatchSW data (Wynn *et al.* 2011) show other occurrences from south and west Cornwall, the Isles of Scilly, south Devon and Portland Bill.

4.5. JNCC/NE-commissioned systematic boat-based surveys

Systematic boat surveys for Balearic shearwater were conducted around Lyme Bay and Portland in 2009, 2011 and 2013.

4.5.1. 2009 surveys

Just one Balearic shearwater was observed during effort-based surveys in 2009. In that survey, one complete survey of Lyme Bay-Portland was conducted on 7 days between 25 July and 7 August, but no repeat surveys were obtained. The short survey period, combined with likely relatively low densities of birds in that year (as revealed by shore-based counts during a similar period), resulted in few observations.

4.5.2. 2011 surveys

Surveys in 2011 (Parsons *et al.* 2012; Reid 2012) were conducted on 11 days over a longer period of time than in 2009 (between 13 July and 23 September). Five repeat surveys of each of two study areas (West Lyme Bay and an area around Portland) were conducted (Table 2). Of the 37 individuals recorded in transect 14 were thought to be associated with nearby fishing vessels. Population estimates were rather low (range: 0-36) on most days of survey but were high on one survey in each area: 229 on 15 September in West Lyme Bay and 122 on 14 July at Portland. The high numbers recorded in September in West Lyme Bay were part of an unprecedented influx of Balearic shearwaters in waters off SW England in 2011 as recorded by shore-based counts (Darlaston & Wynn 2012). This influx was probably weather-related; sustained periods of onshore winds concentrating birds previously present off the coast of Brittany (Darlaston & Wynn 2012). Figure 11 shows the Kernel Density Estimation surfaces from the 2011 surveys where there was a sufficient number of observations to produce a KDE surface.

Table 2. Numbers of Balearic shearwater recorded during boat transect surveys of West Lyme Bay and Portland in 2011.

i) West Lyme Bay

Survey date	Total no. birds seen	No. birds in transect[1]	Population estimate (95% CL)[2]
13/07/2011	4	1	12 (0-37)
29/07/2011	5	3	36 (0-73)
31/07/2011	1	0	0 (N/A)
14/08/2011	4	1	12 (0-36)
15/09/2011	116	19	229 (48-471)
Mean			**58**

ii) Portland

Survey date	Total no. birds seen	No. birds in transect[1]	Population estimate (95% CL)[2]
14/07/2011	26	12	122 (40-223)
28/07/2011	3	0	0 (N/A)
15 & 17/08/2011[3]	2	0	0 (N/A)
02/09/2011	8	1	10 (0-30)
23/09/2011	0	0	0 (N/A)
Mean			**26**

[1] Birds 'in transect' were those recorded on the sea in bands A to D, plus flying birds recorded during ESAS snapshots in a 'box' 300m to one side and 300m ahead of the survey vessel. Birds thought to be associated with fishing vessels are included.

[2] Population estimates were obtained by extrapolating up from the raw numbers of birds recorded 'in transect' by the ESAS observer – see 3.5.

[3] The survey carried out to the east and west of Portland in mid-August covered a large area and therefore took two full days to complete.

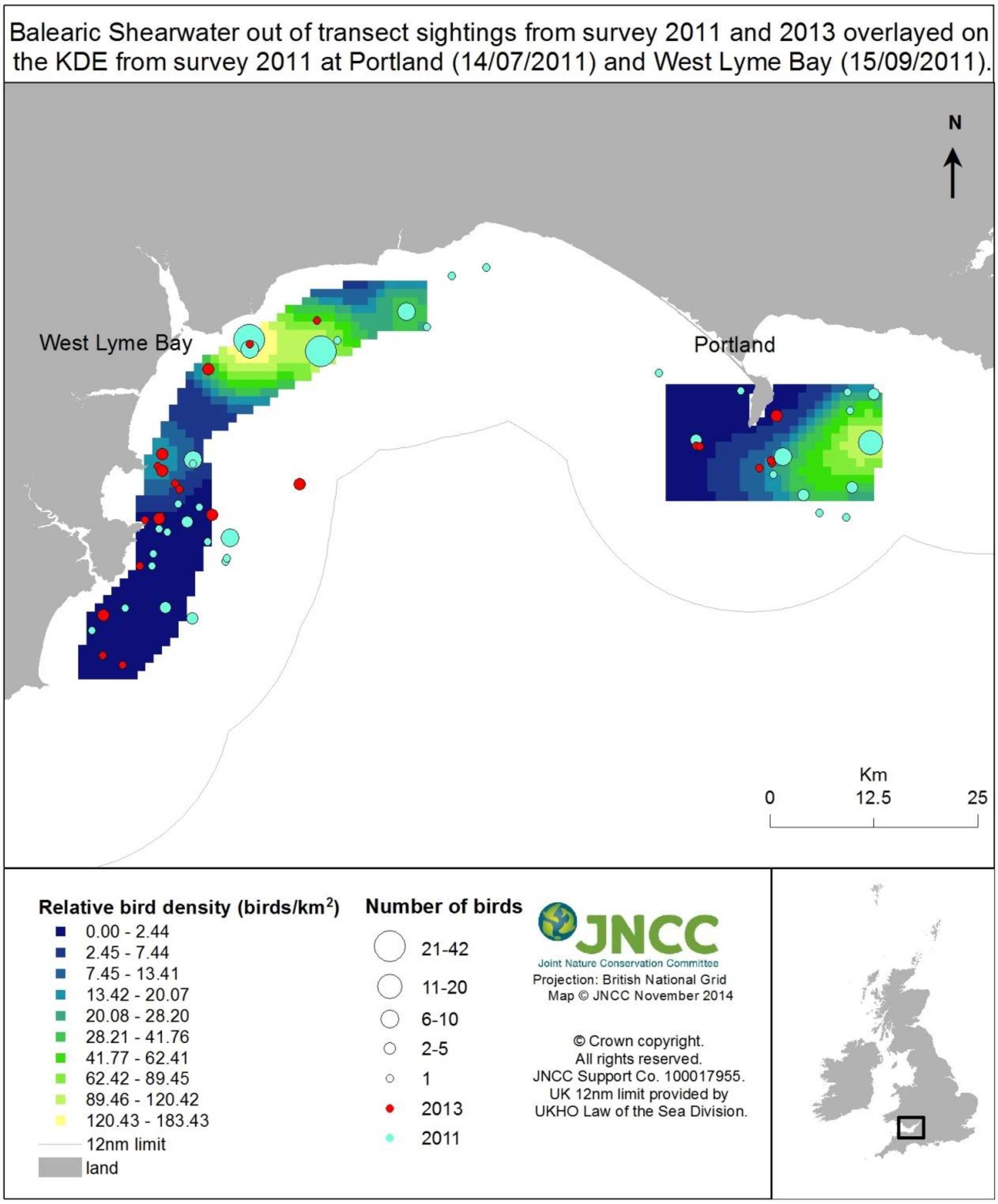

Figure 11. Kernel Density Estimation surfaces from around Portland and in West Lyme Bay Areas of Search, July-September 2011. Overlain are out-of-transect observations from 2011 and 2013 to indicate annual variability in dispersion; only out-of-transect records shown for this comparison because no in-transect observations occurred in 2013. Records of birds associating with ships are excluded. An observation from 2013, east of West Lyme Bay and approaching 12nm limit, was obtained on transit between survey areas.

4.5.3. 2013 surveys

Five repeat surveys were conducted over 10 days between 1 August and 7 October, of the same study areas surveyed in 2011 (i.e. West Lyme Bay and Portland) – Table 3. No birds were recorded in transect; most (36/39) were flying birds, either outwith the 300m transect or within the transect band but not observed during a snapshot count. One bird out of the 39 observed was possibly associated with a fishing vessel. The Portland area of search gave particularly few records, with a mean of 1.8 birds (not in transect) per survey. West Lyme Bay surveys yielded a mean of 6.0 birds (not in transect) per survey. Given that no birds were recorded in transect, estimation of population size within the area of search and estimations of density could not be derived. The absence of birds in transect in the 2013 surveys is probably largely a function of the low absolute numbers of birds recorded in 2013; surveys in 2011 recorded low proportions of in-transect birds (0.16 for West Lyme Bay, 0.25 for Portland). Additionally, the absence of birds in transect may be related to weather-related impacts of bird behaviour during surveys, if for example a greater proportion of birds present were flying at any given time.

Figure 11 shows an overlay of the positions of out-of-transect Balearic shearwaters in 2011 and 2013 with the density surface derived from 2011 (in-transect) surveys. Generally, the fine-scale location of observations in 2013 is outwith the highest density areas from 2011; the locations of out-of-transect observations between the two years were more similar, except for the larger flocks in 2011, which were separate from the 2013 observations. This indicates a high degree of variability in the location used between years. Indeed, only one 2013 record, of a single Balearic shearwater, overlapped with the two categories of highest density in 2011 (89-183 in Figure 11).

Table 3. Numbers of Balearic shearwaters recorded during boat transect surveys of West Lyme Bay and Portland in 2013. Birds 'out of transect' were those recorded on the sea outwith bands A to D (i.e. outwith 300m from vessel), plus flying outwith ESAS snapshots in a 'box' 300m to one side and 300m ahead of the survey vessel.

Survey No	Date	Destination	Balearics (in transect)	Balearics (out of transect)
1	01/08/2013	Portland	0	1
2	07/08/2013	W Lyme Bay	0	11
3	22/08/2013	W Lyme Bay		6
4	28/08/2013	Portland	0	1
5	12/09/2013	Portland	0	4
6	21/09/2013	W Lyme Bay	0	5
7	22/09/2013	W Lyme Bay	0	4
8	24/09/2013	Portland	0	3
9	25/09/2013	Portland	0	0
10	07/10/2013	W Lyme Bay	0	4
		Total	**0**	**39**

5 Discussion

5.1. Results from other published analysis

Kober *et al.* (2010, 2012), after having concluded that Balearic shearwater existed in such low densities in the ESAS dataset as to prevent the identification of a meaningful density surface, sought to identify hotspots (based on the top 1% and top 5% of Getis Ord GI* values) for other shearwater species in UK waters. In the summer these were Cory's shearwater *Calonectris diomedia*, sooty shearwater *Puffinus griseus*, great shearwater *P. gravis* and Manx shearwater *P. Puffinus* and, outwith the breeding season, Manx shearwater. Only two regularly occurring hotspots emerged from that analysis at the 1% GI* level – for Manx shearwater in summer. A hotspot for Cory's shearwater emerged, but only when assessed at the top 5% of Getis Ord GI* values and regularity of use could not be shown. Our results for Balearic shearwater in the current analysis that used the same buffer around the British Fisheries limit as used by Kober *et al.* (2010, 2012), but incorporating a few more years of data and using KDE instead of Poisson kriging, identified no hotspots in UK waters. Only when the analysis was restricted to UK waters (excluding adjacent French waters where relatively higher densities of Balearics shearwaters occurred) did a UK hotspot emerge in the present analysis. That hotspot failed to pass regularity tests of the UK SPA Guidelines.

Jones *et al.* (2014) analysed some of the same data as are considered in this report, and in particular drew conclusions about the presence of aggregations of Balearic shearwater off Portland and in Lyme Bay, based upon boat surveys conducted in 2007-10 by Marinelife. However, Jones *et al.* (2014) included many of the data that we excluded from our analysis of hotspots on the basis that they were not capable of being standardised or properly corrected for the amount of recording effort undertaken, or because they were out of transect (see 4.2). We therefore caution against the use of such data. However, Jones *et al.*'s (2014) conclusion, that the highest densities anywhere in the western Channel study area occurred in coastal bays off northern France, agrees with our analyses of ESAS data presented in section 4.1.

5.2. Possible bias in evidence sources

ESAS survey effort (Figure 2) in UK waters fluctuated over the survey period, with often high effort up to the late 1990s (mean 1979-1999 of 6,500km^2) after which effort declined (mean 1,700km^2 between 2000 and 2010), with a small spike in 2008. Therefore, mean effort decreased over the study period and it is possible that this may have resulted in decreased detectability of birds in UK waters, potentially significant if decreased effort coincided with the period, since 1996, that Luczac *et al.* (2011) suggest is one of high Balearic shearwater abundance in Northern (e.g. UK) waters. To test this further, we compared UK ESAS effort over the entire study period with numbers of encounters of Balearic shearwaters (Figure 12), which gave a very weak correlation (r=0.14); similarly, if we consider only those years after Luczak's change period, i.e. 1997-2010, the correlation is very weakly negative r=-0.048. In this latter period, it is perhaps significant that two years of high ESAS effort, 1997&1998, yielded no Balearic shearwater records. This result would suggest that variable ESAS effort appears not be have limited detection of Balearic shearwaters in UK waters over the study period. However, it is possible, in a species which shows such variability in numbers, that survey effort did not sufficiently coincide - spatially and/or temporally - with Balearic shearwaters to reveal aggregations that may have at times occurred.

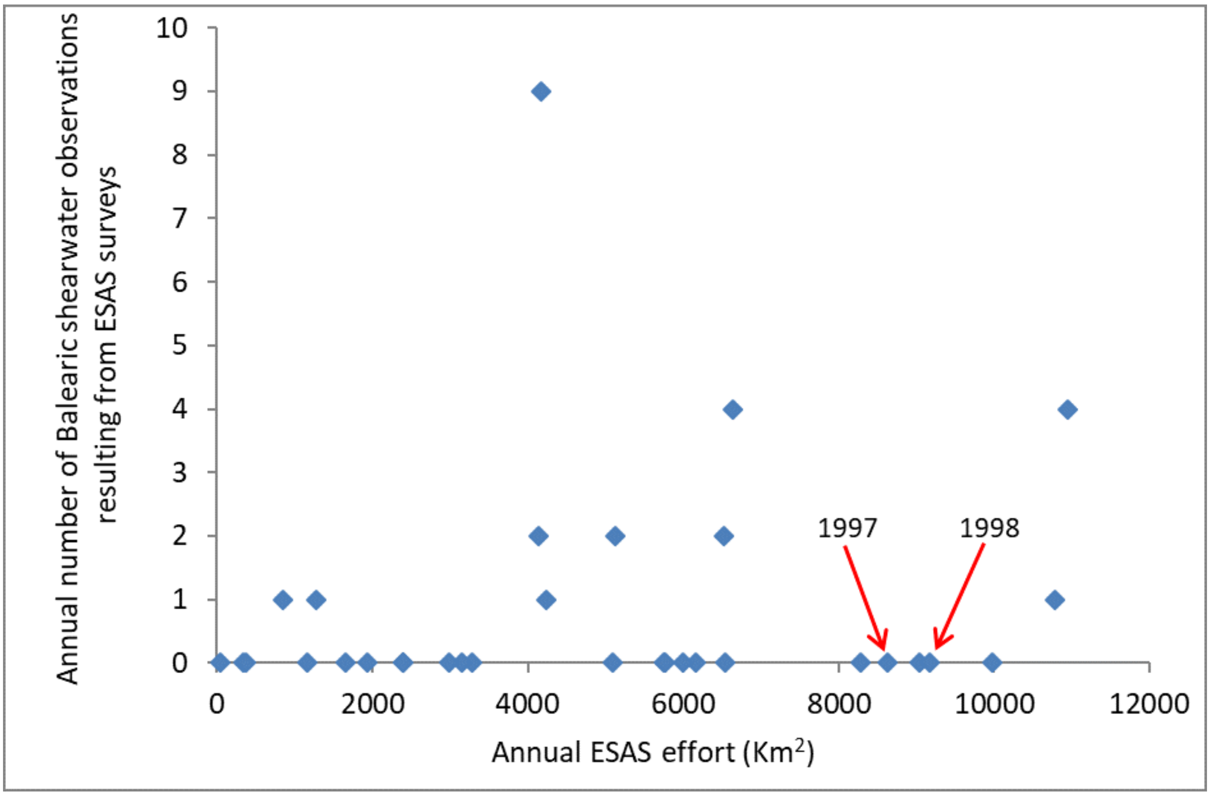

Figure 12. Relationship between UK ESAS survey effort and number of resulting observations of Balearic shearwaters, 1979-2010.

There is evidence from a number of studies to suggest that Balearic shearwater uses predominantly coastal waters rather than those further offshore (Wynn *et al.* 2011 summarised in Section 4.3; Louzao *et al.* 2006, Figures 4 and 5 of this study). Certainly, the largest numbers recorded in UK waters have been from observations made from land (Wynn *et al.* 2011) with relatively few from boat surveys such as ESAS (this present report). The reason for this observation is unclear; UK-wide ESAS sampling effort (area surveyed per unit area of sea; Figure 13) was fairly high in the distance-from-shore band that Wynn *et al.* (2011) identified as having the greatest density of observations, i.e. 0-1km from land. Greatest ESAS effort density occurred in the band 2-5km from shore (in which Wynn *et al.* estimated was more rarely used by Balearic shearwaters, but effort was only slightly less in the band 1-2km, which Wynn *et al.* found still to be used, albeit at lower intensity. Therefore, it would appear that there is at best weak evidence for under-sampling of the species in those areas where it most commonly occurs. Indeed, any biases would have been mitigated to an extent in our study by correcting observed bird density for survey effort. In fact, inshore survey coverage in UK waters over the study period is largely complete (Figure 1; Figures 4 and 5), though there are some gaps in offshore waters (>12nm) in SW Britain and notable gaps in coverage around the coast of France bordering the Bay of Biscay (Figure 4). An alternative possible explanation for the disparity is related to the fact that shore-based surveys can be undertaken in most weather conditions, whereas ESAS boat surveys are limited to winds of less than F5; this, in combination with the likelihood that greatest bird numbers are associated with period of strong onshore winds (Darlaston & Wynn 2012) increases the chance of land-surveys recording high numbers compared with ESAS surveys.

Recent geolocator studies have shown that Balearic shearwaters tagged at their breeding colonies in the Mediterranean subsequently use coastal Atlantic waters off western Iberia and in the Bay of Biscay off western France, though none entered UK waters (Guilford *et al.* 2012). This occurrence is corroborated by ESAS survey information for the Iberian locations but not so for the French ones (Figure 4); relatively sparse ESAS coverage off western

France could explain this. However, this provides little evidence for systematic bias or under-recording of Balearic shearwaters in UK waters.

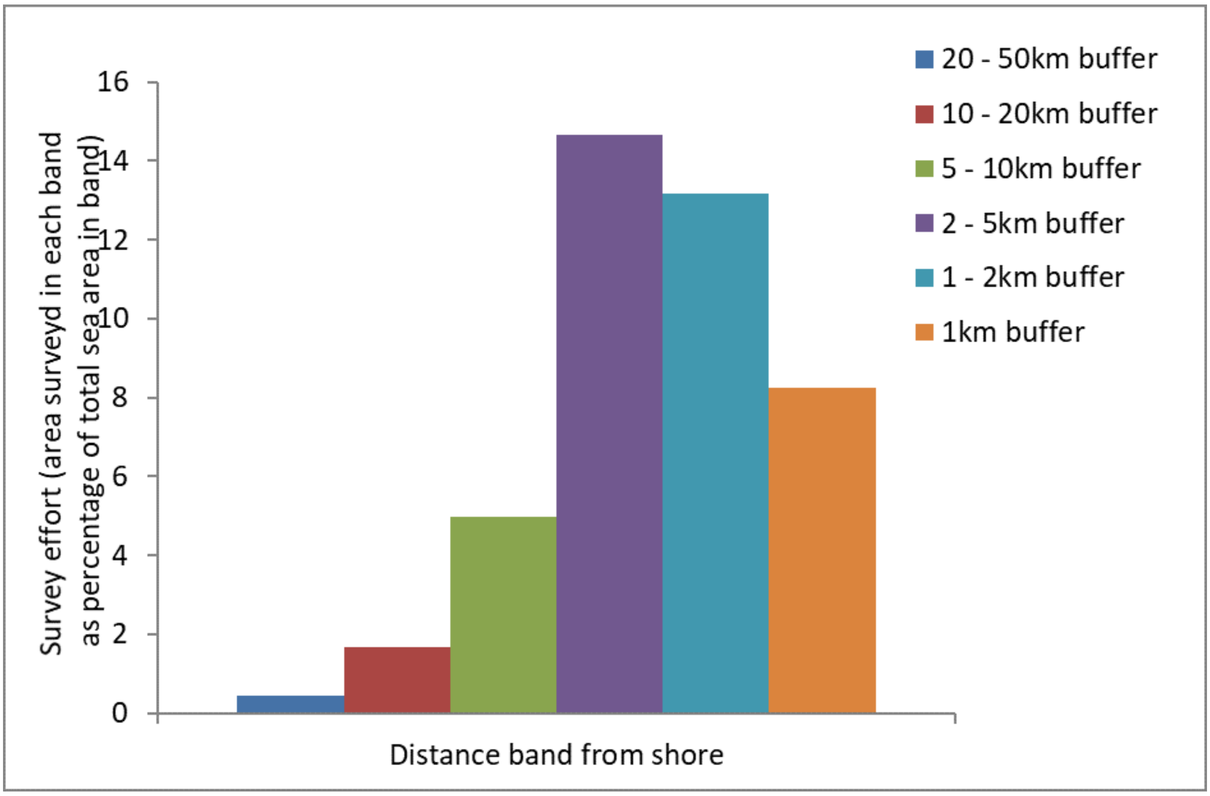

Figure 13. UK ESAS survey effort in relation to distance from shore.

5.3. Assessment of strengths and weaknesses of data sources

Table 4 presents an assessment of the relative strengths and weaknesses of the various data sources used to provide evidence of aggregations of Balearic shearwater in this study.

Table 4. Strengths and weaknesses of data sources used to assess occurrence of Balearic shearwater aggregations in UK waters

Data set/analysis	Strengths	Weaknesses
ESAS boat-based surveys	ESAS is the most geographically and temporally extensive effort-related dataset for seabirds at sea, covering the UK fisheries limit area at a relatively high level of survey effort ESAS method (effort-based sampling) allows comparable assessments across time and space Fairly high UK inshore survey coverage in the inshore zone where most Balearic shearwaters are expected to occur. Variable survey effort within	Some offshore areas (i.e.>12nm) relatively sparsely covered e.g. off SW UK. Relatively few Balearic shearwater records in dataset compared with contemporaneous land-based observations, meaning that annual assessments of density are not possible and so data were aggregated over a 30year period. ESAS method cannot be applied in wind strengths above F5; but evidence that these are the very conditions in which largest numbers occur in coastal water.

	study period appears not to have limited detectability. Allows precise position of birds to be determined Results of "hotspot" analysis (i.e. no regularly-occurring UK hotspots) confirm earlier results of Kober *et al.* (2010, 2012)	Correction for decreasing detectability of birds using "Distance" software could not be applied to population size estimates, due to low absolute numbers of birds encountered and because a high proportion were of flying birds, for which estimation of distance to observer is inherently difficult.
Marinelife boat-based surveys and other information	Area surveyed is one which has a long history of occurrence of the target species	Systematic survey effort only available in two years (surveys in other years did not effectively account for survey effort and may be biased to periods when unusually high numbers of bird were present) Few Balearic shearwater records (i.e. only two "in transect" records in UK waters over two years) prevented population estimate or production of an interpolated density surface.
SeaWatch SouthWest land-based surveys	Continuous Jul-Oct survey effort at one key site (Gwenapp Head) for four consecutive years allows regularity of occurrence to be assessed Observations possible in most weather conditions (c.f limitation of boat-based surveys) Rough estimates of passage rates achieved from a number of watch-points around SW Britain Estimates of birds' distance from shore made at one site.	Limited capacity to quantify along-shore extent of bird use, hindering mapping of bird densities and/or spatial interpolation Detection limited to a maximum of a few Km from the observation point. Unquantified risk of double counting of individuals Data collection at "sister sites" was not effort-based, so more prone to bias. Few records of feeding or other behaviours where birds remain in area, as opposed to passing through (due in large part to many sites not recording behaviour).
Mid-winter land-based pilot survey of St Ives Bay, west Cornwall	Mid-winter data sources are relatively unusual (e.g. boat surveys are scarce at this time due to weather restrictions) Spatial information of birds estimated (via theodolite)	Relatively few years of data so far available, so regularity could not be fully assessed Relative importance of this locality compared with other possible areas is unclear

JNCC/NE-commissioned systematic boat-based surveys	Focused at: areas with high expected likelihood of encounter with target species (Portland) and area with low historical coverage (west Lyme Bay). Three years of surveys allow assessment of regularity of use Five repeat surveys in 2 out of three years maximised encounters with target species ESAS method (effort-based sampling) allows comparable assessments across time and space Allows precise position of birds to be determined	Limited to wind strengths up to and including F5; as a consequence, surveys could not be conducted when contemporaneous land-based watches detected large numbers during strong onshore winds Relatively small area could be surveyed in a season in comparison to possible range Few repeat surveys in one year of the three surveyed. Bird densities encountered were high enough to produce a population estimate and interpolated density surface only in one year of three.
Geolocator studies	Starting to reveal broad-scale spatial and temporal use of UK waters, perhaps to help focus future survey effort.	Currently limited to coarse spatial scale determination of location – not appropriate to help delineate protected sites.

5.4. Application of SPA selection guidelines

Stage 1.1 of the UK SPA selection guidelines (Stroud *et al.* 2001), which applies to species listed under Annex 1 of the Birds Directive, which includes Balearic shearwater, requires that an area is used ‘regularly’ by 1% or more of the relevant national population before recommendations can be drawn up for a site. However, because there is no agreed UK population estimate for Balearic shearwater, 1.1 cannot be applied and therefore Guideline 1.4 may be considered. This states: *“An area which meets the requirements of one or more of the Stage 2 guidelines in any season, where the application of Stage 1 guidelines 1, 2 or 3 for a species does not identify an adequate suite of most suitable sites for the conservation of that species”.*

There has been a long-standing practice to use 50 individuals as a default minimum number of non-breeding waterbirds to define an aggregation of SPA status for rare species (Salmon 1981) which could therefore be deemed a threshold value for SPA identification. However, the minimum of 50 rule applies only to cases where Guideline 1.1 is applicable (David Stroud, pers. comm.), whereas 1.4 is applied in this case. It is concluded, therefore, that aggregations of fewer than 50 individuals could be considered for this species.

Regularity is attained where ‘a wetland regularly supports a population of a given size if the requisite number of birds is known to have occurred in two thirds of the seasons for which adequate data are available, the total number of seasons being not less than three’ (Conference of the Contracting Parties to the Ramsar Convention). However, Webb and Reid (2004) suggest a site could be selected with only two years of good data, a third being provided by poorer quality data.

It is judged that two years of systematic, spatially explicit information gathered at an appropriate spatial scale now exist for Balearic shearwater around Lyme Bay and Portland: the JNCC/NE surveys in 2011 and 2013; this allows an assessment of regularity of use. The data supplied by the JNCC survey of Portland and Lyme Bay in 2009 (conducted over a limited number of days) and those from Marinelife in 2009-2010 provide important supplementary evidence.

As to whether any area meets the regularity test of presence of the required number of birds in two-thirds of seasons surveyed, an assessment is hindered by the fact that the absence of in-transect observations in 2013 prevented the production of a density surface or population estimate. Therefore, we know there were birds present in 2013, at a density too low to be assessed, but we have no absolute number against which to assess regularity.

Notwithstanding the absence of a density surface or population estimate for 2013, we can look to the distribution of records –albeit off-transect records –to assess the spatial overlap between the two years of observations. While there is overlap at the scale of the individual area of search, there is little overlap at a finer spatial scale. Possible reasons for this distribution between years include a more or less random distribution of birds in relation to available habitat, or that spatio-temporal variability in habitat or food location results in different areas being used by birds from one year to the next. Either way, there is little evidence for regularly occurring aggregations in either West Lyme Bay or Portland. Of the two years of good quality evidence, in only one (2011) were numbers sufficient to be assessed. Of the other years where surveys were undertaken, only one bird was recorded in 2009 (JNCC survey) and none were recorded within the Portland or West Lyme Bay areas of search in Marinelife surveys in 2009-10.

Returning to Stage 2 of the UK SPA selection guidelines, these are as follows:

- **Population size and density** - Areas holding or supporting more birds than others and/or holding or supporting birds at higher concentrations are favoured for selection.
- **Species range** - Areas selected for a given species provide as wide a geographic coverage across the species' range as possible.
- **Breeding success** - Areas of higher breeding success than others are favoured for selection.
- **History of occupancy** - Areas known to have a longer history of occupation or use by the relevant species are favoured for selection.
- **Multi-species areas** - Areas holding or supporting the larger number of qualifying species under Article 4 of the Directive are favoured for selection.
- **Naturalness** - Areas comprising natural or semi-natural habitats are favoured for selection over those which do not.
- **Severe weather refuges**

If we apply these guidelines to the areas of search considered in this report, the following should be considered.

5.4.1. Population size and density

Available information at a UK scale comes primarily from the 1% hotspot analyses (after Kober *et al.* 2010, 2012) of ESAS data, but also from Marinelife data from systematic and targeted surveys over a more restricted area. These show no regularly occurring hotspots in UK waters at either a Europe-wide scale or UK scale (Figures 4 -7). Moreover, even if we relax the definition of a hotspot to include the top 5% of Getis Ord values, the conclusion remains the same. Other categories of survey information from Marinelife surveys cannot be used to make a relative assessment of numbers or density between different parts of the area of search (for reasons explained in 3.2 and 4.2).

Considering other sources of information, the land-based observations from SeaWatch SW show that a number of prominent headlands in SW Britain experience passage rates during summer and autumn similar to that of the focal study site of Gwennap Head (Wynn *et al.* 2011). Four years of SeaWatch SW data have been collected (2007-10), satisfying the requirement for evidence of regularity, but data defining the spatial extent of bird use are incomplete. For example, while Wynn *et al.* (2011) estimated the perpendicular distance out to sea of birds passing by the coastal observation point at Gwennap Head, the along-shore limits to any concentrations are unknown. Birds may, for example, extend in a more or less continuous band along the coast between migration observation points, or be concentrated by local geography near to them. It would be difficult to define an area for migrating birds and it is questionable as to how effective designation of an SPA would be in contributing to the conservation of the species. Given the fairly similar passage rates identified at discrete migration watch-points for birds passing along the south coast and the likely broad front that these birds pass along, defining a discrete area is likely to be problematic. The alternative would be to classify a band of sea along the whole of the south west coast, which would provide little conservation benefit.

Among the known mid-winter concentrations of Balearic shearwaters, largest numbers appear to occur in St Ives Bay (up to 25 individuals in December 2010, up to 15 in January 2013 and a maximum of eight in any one day during January 2014). Further surveys planned for this area will reveal the regularity of any concentration. However, given the relative paucity of comprehensive information on winter distribution, it is unknown whether St Ives Bay would represent a “most suitable territory”, as required by Article 4 of the Birds Directive, or if there may be other areas holding aggregations that have not been sufficiently surveyed.

5.4.2. Species range

Given the restricted range of the species in UK waters, seeking to represent a number of localities with that range in any SPA suite is probably inappropriate, even if regularly occurring hotspots could be identified. However, if the relevant scale at which to consider this guideline is the species’ entire non-breeding range (within the EU), then it may be appropriate to seek to provide representation within the UK. Nevertheless, a primary factor to be considered alongside that of range must be the density at which the species is present in UK waters and as we have shown in 5.3.1, this is low.

5.4.3. Breeding success

As the species does not breed in the UK, this consideration is not applicable.

5.4.4. History of occupancy

The longest history of information on Balearic shearwater numbers comes from the Portland area, notably from Portland Bird Observatory, where records go back to 1953. Maximum day counts of passage birds were between 11 and 229 birds in the 1950-60s, up to 100 (on the sea, as opposed to flying past) in the 1970s and 180 on the sea in the 1990s. While this history of occupancy would favour the selection of the Portland area over others, recent bespoke at-sea surveys failed to identify regularly occurring aggregations and there appear to be fewer land-based records from Portland in recent years.

5.4.5. Multi-species areas

The only area of overlap between known Balearic shearwater aggregations and areas of search for other marine birds being considered within the SNCBs SPA programme is at Falmouth Bay to St Austell Bay. This pSPA has been put forward to protect important aggregations of black-throated diver, great northern diver and Slavonian grebe. Balearic shearwater records from within the proposed boundary there derive from SeaWatch SW information (Wynn *et al.* 2011), with maximum counts from Killigerran Head of 52 in August 2008, 17 in July 2009, 7 in August 2007, and lower numbers from nearby headlands at Gorran Haven, Falmouth, Pentewan, Portmellon and Mevagissey. However, the same difficulty in establishing a rationale would apply here as for other occurrences of Balearic shearwaters on migration (see discussion under Population size and density). A hotspot of wintering northern gannet distribution identified by Kober *et al.* (2010, 2012), which straddles the 12nm boundary off the coast of south Cornwall and south Devon, was assessed as a possible SPA by NE and JNCC. There is one ESAS record of Balearic shearwater within this hotspot, though it did not emerge as a 1% or 5% hotspot (nor did any cell within the UK). The only other records from this area are two from Marinelife opportunistic surveys, within 4.7km and 5.8km of the gannet hotspot, and two from Marlinelife ferry surveys, 6.0km and 10.4km from the gannet hotspot.

5.4.6. Naturalness

There is little to distinguish possible concentrations of Balearic shearwater based on an application of this criterion.

5.4.7. Severe weather refuges

Balearic shearwater, along with other shearwaters, is well adapted to surviving severe weather conditions at sea. The concept of a severe weather refuge for this species is therefore unlikely to play a significant role in its conservation. There is evidence that highest numbers of Balearic shearwaters are seen in UK coastal waters during and after periods of strong onshore winds, when it is postulated that such weather conditions concentrate birds previously present off the coast of Brittany, where substantial summer aggregations have been noted (Darlaston & Wynn 2012). However, to characterise the UK areas as severe weather refuges is incorrect, as there is no reason to believe that conditions in the UK where the birds would be concentrated under such weather conditions are any more benign than conditions off the French coast.

5.5. Use of bird-borne telemetry devices: state of knowledge and potential future applications

Tracking of breeding adults showed no evidence that those birds used UK waters (Guilford *et al.* 2012) and instead concluded that it is probably non- or pre-breeders that enter UK waters, though sample-size in that study was quite small. A telemetry study (Russell Wynn, unpublished) is ongoing of pre-breeding Balearic shearwaters captured at their breeding colonies in the Mediterranean and mounted with geolocators (miniature light level detectors from which longitude and latitude can be calculated). Whilst sightings of one of these marked pre-breeding birds have been made off the Isles of Scilly (Wynn *pers. comm*.), data from them are yet to be comprehensively recovered or published. Even when data are recovered their spatial resolution (at least 200km: Bridge *et al.* 2011) would preclude their use in defining possible site boundaries, at least with currently available equipment, though they would indicate the degree to which non-breeders use UK waters. There is the potential for increasing our understanding of the numbers and distribution of Balearic shearwaters in UK waters by way of telemetry studies. However, there are currently important constraints which would need to be overcome for them to become practicable. For example, detailed high resolution spatial information could be revealed by the use of Platform Transmitter Terminal (PTT) tags (using satellite technology) or Geographical Positioning Systems (GPS) tags, but the battery size required to power these devices is large and demands attachment techniques that pose potential risks, either to the welfare of the bird (in the case of harnesses; Russell Wynn *pers. comm*.) or to the longevity of the device remaining attached to the bird (if using devices attached to plumage, which can either be readily removed by the bird or fall off naturally after a short period of time). Such difficulties would be circumvented if birds could be caught and tagged while at sea within UK waters, since high resolution GPS or PTT tags could be used and longevity constraints would be far less prevalent, as tags would yield information as soon as the birds are released. This is in contrast to the marking of birds at the breeding colony, where battery charge starts to run down before the birds have migrated from the Mediterranean out into Atlantic and UK waters. However, the likelihood of capturing even a few Balearic shearwaters in UK waters is extremely low, as preliminary attempts by French researchers have confirmed (Russell Wynn pers. comm.), a factor of their scarcity and relative reluctance to be drawn close enough to vessels for them to be caught.

6 Conclusions

A range of sources of information on the numbers and distribution of Balearic shearwater up to and including 2013 were interrogated and, where possible, analysed. Strengths and weaknesses of each were assessed (summarised in Table 4). Despite this, analysis of comparable data across a wide spatial and temporal scale identified no regularly occurring hotspot within UK waters that would be appropriate for identification as possible SPA. While it can be concluded that the occurrence of the species in UK waters is regular, this is only when considered over a very wide spatial scale such as the whole Channel, and generally densities were low. Such low densities, as revealed by the ESAS dataset, which has widest geographical coverage of extant surveys, would be unlikely to satisfy the UK SPA selection guideline 2.1, relating to population size and density. Regular use of specific areas - for example used by foraging or moulting aggregations – could not be demonstrated, despite an appropriate number of bespoke surveys having been undertaken.

However, we still have gaps in our understanding of the drivers for movements of this species and of its particular habitat associations. Habitat modelling would be a potentially useful analysis for explaining the observed pattern of distribution, perhaps also pointing to areas that could be targeted in any future survey. Nevertheless, the primary focus of this study was to identify aggregations that may qualify as SPA and for this it is doubtful whether such an analysis alone would have sufficient power, and hence why it was not pursued in this instance. Another area of potential future work that was beyond the scope of this study would be an analysis that seeks to combine into a single density surface different sources of bird survey data such as boat-based and land-based surveys.

Technological developments, including those of digital aerial survey and of bird-borne telemetry, may in future be capable of providing additional insights into the patterns of distribution of this and similar species. In particular, digital aerial survey could potentially enable the coverage of extensive areas of sea at an acceptable cost, though the current difficulty of separating images of the closely related Manx shearwater from Balearic shearwater would need to be overcome. Such surveys may be capable of accurately revealing the patterns of use of UK waters by Balearic shearwaters over a timeframe much shorter than could be achieved by boat-based surveys. This would apply particularly if Balearic shearwater densities in UK waters were to increase, for example as a result of increases in sea-surface temperature, as has been postulated by a few authors (Wynn *et al.* 2007; Luczac *et al.* 2011).

In summary, analysis of the best available data did not reveal any areas that met the criteria for classification as a SPA. We conclude, based on the evidence reviewed, that conservation effort for Balearic shearwater in UK waters would be more appropriately targeted at spatially dispersed measures to combat threats at sea.

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