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Analysis of long-term effort-related land-based observations to identify whether coastal areas of harbour porpoise and bottlenose dolphin have persistent high occurrence and abundance (revised June 2015)

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Summary

Dedicated shore watches for cetaceans have been conducted at a number of sites around the UK since 1965. Here, over 75,000 hours of watches and *c*50,000 associated sightings of bottlenose dolphin and harbour porpoise from 678 sites around the coasts of Britain are analysed, in order to determine whether areas of persistent high occurrence and relative abundance of the two species can be identified.

Average sightings rates (sightings per unit hour of search) and count rates (animals per unit hour of search) were calculated from each site over the full time period that watches were conducted.

For use in statistical modelling, results were summarised by site and by day (thus eliminating within-day autocorrelation), and records associated with high Beaufort 'sea state' and short observation duration were filtered out. Bottlenose dolphin or harbour porpoise presence was modelled to predict probability of occurrence at the numerous observation sites around the UK. Statistical properties of data on sightings rates or numbers of animals or groups sighted made them less suitable for modelling, due to the excessive number of observation periods (watches) with no sightings. Models were run for several time periods (1965-1993, 1994-2003, 2004-2014) but priority is given to results for the combined data from 1994-2014. Two basic Generalised Additive Model (GAM) formats were used, specifying location either by (A) latitude and longitude or (B) site number (considering the coastline as a continuous linear feature); the latter offers the advantages that two additional models could be run, namely (C) mixed models (GAMMs) to quantify the effect of autocorrelation between consecutive days of observation, and (D) GAMs with a site and year interaction (to reveal year-to-year changes in distribution). Predictions generated from all models were filtered to exclude sites with few data: the cut-off used was at least three years of effort, with a minimum of 100 minutes per year (i.e. five hours minimum of '*watch effort'* overall) within a modelled time period. The 90th percentile of the filtered data was identified and sites with predicted occurrence above this threshold were identified. Prediction standard errors provide an additional check on the reliability of sites identified.

The land-watch effort is reasonably well distributed around the UK, but certain areas (notably the west of Scotland, and to a lesser extent, south-east England) had relatively poor coverage, and a few areas (e.g. the Shetland Islands) have had little watch effort since the 1990s. Although dedicated cetacean watch effort started as long ago as 1965, the majority of effort has been in the last ten years. Similarly, effort has been concentrated on the summer months between May and September. For the most part, protocols used for land watches throughout UK have been very similar, despite large numbers of observers and local groups being involved over several decades. Around 100 sites each had total effort exceeding 50 hours over the time-span of the data set.

Results from the models A to D for each time period were generally similar. However, for the larger data sets, mixed models could not be run due to convergence problems. Where mixed models could be run, predictions from (the GAM component) of these models, in terms of identifying important sites, were similar to those of the GAMs, implying that temporal autocorrelation was not greatly affecting the results. Overall, the general similarity of results from different time periods and different models provides some support for the robustness of the models. However, the complexity of the dataset (and the fact that some data were excluded due to being incomplete or erroneous) means that further analysis is still desirable and may reveal additional information.

Results from models, combined with consideration of the variations between site and year, highlighted the occurrence of changes in distribution of the cetaceans under study; this

distribution change was more evident in porpoises than for bottlenose dolphins. Comparison of results from different time periods also highlighted some changes in distribution, most obviously for porpoises. There has been a decline in the importance of the east coast of Scotland (especially pronounced in the north) and an increase in importance on the east and south coasts of England.

The modelled coastal distributions of the two species broadly accord with current knowledge: bottlenose dolphins are concentrated around west Wales and eastern Scotland, with very few along North Sea coasts south of Edinburgh and the coast of southern England east of Devon; harbour porpoises, on the other hand, are much more evenly distributed. Strikingly, the distributions of the two species show relatively little overlap, possibly due to the fact that bottlenose dolphins are known to attack porpoises where the two co-occur.

Unsurprisingly, the GAMs function best for Management Units (MUs) (division of populations of a particular species into smaller units based on ecological evidence and/or divisions used for the management of human activities), where there are a lot of data. Thus, the results from West Scotland, for example, are less meaningful, whereas predictions are more robust in the Irish Sea, western Channel, east coast of Scotland, and eastern England.

The GAM predictions indicate that coastal bottlenose dolphins are concentrated in two main regions: (1) eastern Scotland from Brora to Carnoustie, with a relatively even distribution; and (2) the Welsh coast in Cardigan Bay and to a lesser extent off north and east Anglesey. Elsewhere, the species occurs only occasionally, except possibly for the following locations: Falmouth Bay and around the Lizard Peninsula in Cornwall, and in Bideford Bay in north Devon. The species is also known to range around the Inner Hebrides in small numbers, with a small (<15 individuals) apparently site-faithful population off Barra (Grellier & Wilson, 2003; Thompson *et al*, 2011); and to range around the northern Irish Sea including the Isle of Man, the Cumbrian coast, and coasts of Counties Down and Antrim.

Harbour porpoises are more widely distributed, with hotspots in the following coastal areas:

- North Sea Management Unit: 1) southern and eastern Shetland; 2) along the northeast Grampian coast; and 3) along the coast of eastern England between Scarborough and Flamborough Head, in Yorkshire. Areas with moderate count rates and predicted likelihoods of occurrence include the coast of north Caithness and around Scapa Flow, Orkney, and around the Wash and parts of East Anglia (Norfolk and Suffolk).
- Celtic and Irish Sea Management Unit: 1) the south Devon coast between Babbacombe Bay and Bigbury Bay; 2) the south side of the outer Bristol Channel between Bideford, north Devon and Minehead, Somerset; 3) Swansea Bay and the Gower Peninsula; 4) west and north Pembrokeshire coast and islands; and 5) north-west and north coasts of Anglesey.

No conclusions from the land-based data can be drawn for the west coast of Scotland and Hebrides management unit due to low watch effort in that region. However, offshore effort indicates that the species is abundant in this region (Reid *et al*, 2003; Evans *et al*, 2003, Marubini *et al*, 2009; Booth, 2010; Embling *et al*, 2010).

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1 Background to the project

Under Article 4 of the EU Habitats Directive[1] there is a requirement, where certain conditions are met, to protect bottlenose dolphins and harbour porpoises through the designation of Special Areas of Conservation (SACs) as part of the Natura 2000 network. The sites are graded 'A' (15% to 100% of national population) to 'D' ('non-significant presence'). The UK has a number of sites graded D for both species (26 for harbour porpoises and 7 for bottlenose dolphins). Three sites are graded C or above for bottlenose dolphins (the Moray Firth in Scotland, Cardigan Bay, the Llŷn Peninsula and the Sarnau in Wales), and one site graded C for harbour porpoise (Skerries and Causeway in Northern Ireland).

The key criterion as set out in Annex III of the Habitats Directive – 'Criteria for selecting sites eligible for identification as Sites of Community Importance and designation as Special Areas of Conservation' - is: *(a) Size and density of the population of the species present on the site in relation to the populations present within national territory*. The explanatory notes to the Natura 2000 standard data form suggest the following progressive model to classify the size of the population in the site relative to the population in the national territory:

A: >15% to 100% of national population
B: >2% to 15% of national population
C: >0% to 2% of national population.

A fourth category (D) is used in all cases where a population of the species concerned is present on a site in a non-significant manner. No suggestion is made on how to classify the site in relation to density (number of animals per unit area) however, despite this being listed as one of the key criteria for identifying special sites. Considering abundance of a species without density data means that sites could be defined with harbour porpoises as a qualifying species based entirely on the area covered by the site. For example, assuming that, for category C, >0% means > or = to 0.1% of the national population, it then follows, with a porpoise population within the North Sea of *c*250,000 individuals (from Hammond *et al, 2013)* that a site large enough to contain 0.1% (*c*250 individuals) will meet the size component of this criterion. Therefore, if porpoises were distributed evenly, all sites in the North Sea larger than 450km^2 could potentially be considered for inclusion of harbour porpoise as a qualifying feature. This situation is avoided if the density aspect is taken into account (Pinn, 2008; Mendes *et al*, 2009).

The size and density criterion has been recognised as difficult to apply to the harbour porpoise in particular. To address this problem, the European Commission produced guidance in 2007 (EU, 2007). This included the results of a workshop held in December 2000. The workshop concluded that

> "*It is possible to identify areas representing crucial factors for the life cycle of this species. These areas would be identifiable on the basis of: i. the continuous or regular presence of the species (although subject to seasonal variations); ii. good population density (in relation to neighbouring areas); iii. high ratio of young to adults during certain periods of the year; iv. additionally, other biological elements are characteristic of these areas, such as very developed social and sexual life*."

[1] See http://www.central2013.eu/fileadmin/user_upload/Downloads/Document_Centre/OP_Resources/HABITAT_DIRECTIVE_92-43-EEC.pdf

These guidelines represent the views of the Commission, but they are not legally binding and are secondary to the provisions of the Directive. Additionally, the Commission's guidance provides very little information on the practical application of these additional criteria, and as such, this has resulted in the guidance being interpreted and applied differently by each Member State.

The UK will continue to search for SACs for harbour porpoises, and this project report is to complement additional analysis already being undertaken for the wider UK marine environment through the focus on data collected from shore-based stations.

2 Terms of reference

This project comprised two parts.

Part 1 assessed the availability of effort-related shore-based sightings data and feasibility of collating this if there are multiple organisations involved.

Part 2 focused on the analysis of the data in order to determine whether there are clearly identifiable and persistent areas of relatively high harbour porpoise and bottlenose dolphin density in the coastal waters of the UK.

The term 'clearly identifiable' has been taken to mean that the area can be delineated from the surrounding (neighbouring) waters by, for example, an elevated abundance on a regular basis and over a reasonable period of time. The UK's Interagency Marine Mammal Working Group (IAMMWG) agreed that *three years* of data were the minimum requirement to demonstrate regularity of occurrence over a reasonable period of time (the three years should ideally not be concurrent).

However, where monthly sightings data were available over the entire period of the year, this could be reduced to two years, preferably with discontinuous reporting periods.

Given the mobile nature of these species, particularly harbour porpoise, a reasonably high degree of confidence in the results was also required. The work required:

1. Part 1: Identification and mapping of the location of shore-based sightings sites. This included a summary of the basic sightings methodology used at particular locations, the frequency of surveys, and the length of time they have been running. There was also a need to gain agreement from data holders for inclusion of their data for part 2.
2. Part 2: Assessment of the compatibility of different datasets, taking methodology and other relevant factors (e.g. Beaufort sea state, realised area of search) into account. Land-based data generally fall into two methodological types: conventional timed watches and scan samples depending on the density of animals in an area, and the issue of repeat sightings (reporting the sighting of the same animal in an area during a watch). Where animals occur in low densities, then timed watches are the most appropriate. As density increases, it becomes difficult to keep track of animals already recorded and, consequently, a scan sampling method that distinguishes repeat sightings becomes more appropriate.

The work also took into account the following considerations:

1. Locations where there has been insufficient temporal effort (seasonal and interannaul distribution of effort) should also be identified and mapped. Any persistent areas of high density identified through the modelling that correspond to areas with insufficient temporal data would not be considered at this time. Such results should, however, be reported as they would be used to provide an indication of where surveys could potentially be focused in the future.
2. The analyses should be undertaken using the proposed management unit regions for harbour porpoise and bottlenose dolphin respectively. These have recently been agreed by the IAMMWG and were provided by the project officer.

3. The sightings data needed to be standardised taking effort into account and a suitable statistic proposed (e.g. sightings per hour search). These proposed analyses should apply the most robust analytical tools to the available data resource, enabling the identification of persistent high-density areas in a proactive way. The analyses should also allow the importance and context of any predefined area to be assessed in a post-hoc way if possible.

3 Data sources

3.1 Shore watches for cetaceans in the UK

During the late 1960s and 1970s, sea watching for cetaceans started from a number of land-based sites (Evans, 1976, 1980), as a by-product of the burgeoning interest for observing and recording passage movements of seabirds (see, for example, Philips & Lea, 1966; Pettitt, 1972; Upton, 1976). At first, sightings reports were recorded on a casual basis, but especially from the 1980s onwards, dedicated cetacean watching effort started in a number of locations, mainly at headlands and at some bird observatories. Those watches that were sustained over a period of years allowed seasonal and longer-term trends to be obtained, for those specific locations (Evans *et al*, 1986; Evans, 1992).

Typically, a watch would involve a single observer situated on a cliff-top at an elevation of 15-50 metres above sea level. The observer would record the start and end time of the watch, and, in between, scan the sea largely with the naked eye but interspersed with binocular or telescope scans. Sea conditions and visibility would be noted at the start, and subsequently, should they change. Whereas sea watching for birds tended to be conducted in rough sea conditions because that was when passage was often greatest, cetacean watches would generally only be started in conditions of Beaufort sea state (SS) 3 or less (and where possible SS 0-1). Recordings would also be typically conducted in good visibility (10km or more), although cetaceans would rarely be detected beyond 2km range. Watch duration would vary but was usually one to two hours. Any cetacean seen would be recorded, identified to species (where possible), and group size and behaviour noted. If noticeably smaller individuals were observed, these would be recorded as calves or juveniles. However, generally, these were not distinguished, and so are not analysed further herein. In a minority of cases, distances and angles to sightings have been recorded (but with unknown accuracy), and a few studies have used theodolites to track movements of animals. However, since these form only a very small portion of the project database, those measurements have also not been included here.

Data collected by observers from the Sea Watch Foundation (SWF) (and its predecessor the UK Mammal Society Cetacean Group) since the late 1970s (Evans, 1976, 1980, 1992; Evans *et al*, 2003*)* and from the Irish Whale & Dolphin Group (IWDG) and Northern Ireland's Department of the Environment (DOENI), almost all since the early 2000s (Berrow, 2008; Berrow *et al*, 2010; Whooley & Berrow, 2012), have followed very similar protocols. The data submitted to SWF included data from the Manx Whale & Dolphin Watch (Isle of Man), Marine Awareness North Wales (MANW) (mainly Anglesey), and Gower Marine Mammal Project (Gower Peninsula). A few other data sets have been collected with specific projects in mind. Ceredigion County Council (CCC) have co-ordinated watches along the coast of southern Cardigan Bay since 1994, with observers targeting bottlenose dolphins as part of a study to monitor possible impacts of recreational boat activity (Pierpoint *et al*, 2009). Cardigan Bay Marine Wildlife Centre provided data from watches undertaken from New Quay in Wales but these were not used as they duplicated effort already processed in the SWF database.

Russell Wynn (National Oceanography Centre, Southampton University) has organised systematic watches targeting porpoises (and shearwaters) from Gwennap Head, Cornwall since July 2007 (mainly between July and October), some of the later data being collected using a theodolite to plot tracks. Data for bottlenose

dolphins were not available for the earlier years (2007-2010). During 2012 and 2013, watches were also conducted in St Ives Bay, Cornwall.

Whale & Dolphin Conservation (WDC) collected data for specific projects (at Bardsey Island, Melvaig near Gairloch, North-West Scotland, and Tiumpan Head, Isle of Lewis) at periods between 2008 and 2012, as well as effort-related data from various sites in Scotland using volunteers, mainly since 2010 (WDC Shore Watch project). Also, in Scotland, the Hebridean Whale & Dolphin Trust undertook systematic watches at Ardnamurchan Point (Highland Region) from June to September 2001-2005.

The renewable energy company, European Marine Energy Centre (EMEC), has contracted local shore-based observers in Orkney to conduct watches for marine mammals and birds at Fall of Warness since July 2005 (Duck *et al*, 2006; Lonergan *et al*, 2007), Billia Croo since March 2009 (Robbins, 2012), Scapa Flow (St Mary's) and Shapinsay Sound (Head of Holland and Head of Work) since January 2011. However, the emphasis has been on birds, and raw systematic effort data were only available for Billia Croo, although EMEC state that effort data for the other sites may be available towards the end of 2014. Two other energy companies have contracted local observers to collect data on marine mammal occurrence: MeyGen Ltd along the north Caithness coast, and Tidal Energy Ltd (TEL) across Ramsey Sound, Pembrokeshire since 2007. Unfortunately, those data were not made available for this project. Finally, watch data collected by SeaTrust south & west Wales at Strumble Head, Pembrokeshire, were also not made available. Otherwise, the authors are not aware of any other major data sets missing.

3.2 Types of land-based data

Land-based data fall into two methodological types: conventional timed watches and scan samples (Baines and Evans, 2012). In the former case, start and end times of watches are recorded, together with environmental variables such as sea state. When a sighting is made, then, as a minimum, the time of first sighting is recorded, with species and group size. Repeat sightings of the same animals may be recorded, but if so, the status of such sightings as repeats is noted as far as possible, so that these can be excluded from analyses, if appropriate. This approach is adequate in low animal- density situations, but it may become difficult to keep track of animals already recorded where densities are higher. Consequently, at a few sites, a scan sampling method has been adopted for land-based watches in order to cope with situations in which there may be a flux of animals entering and leaving the observer's field of view.

In land-based watches using a scan sampling method, the field of view is scanned generally with optics (binoculars/telescope) for a fixed period of time, e.g. 10 or 20 minutes, and the number of animals of each species (where identifiable) present during that period is recorded, together with environmental data such as sea state. This is then repeated in successive (usually contiguous) periods until the end of the watch. The EMEC renewables project at Billia Croo, Orkney employed a specific variant of scan sampling. Since EMEC was surveying for both marine mammals and birds, it divided the area into sectors and using optics, routinely scanned different sectors for 5-minute periods, alternating sectors for searches of either birds or marine mammals.

Some sites involved scan sampling as well as in most cases recording individual sightings. These included SWF (in Shetland), WDC (in north-west Wales and some

sites in Scotland); MANW (in Anglesey); CCC (in southern Cardigan Bay, west Wales); Gower Marine Mammal Project (on the Gower Peninsula, south Wales); RWE nPower (at Rhyl Flats, north-east Wales); Marijke de Boer (three Cornish sites); and Southampton University's NOC Cornish Project (Gwennap Head and St Ives Bay). In the last case, they usually involved 10-minute scans (two sets of four minutes with binoculars, one minute with naked eye; no more than one scan per hour). At a number of sites in Scotland, WDC undertook short (10 minute) watches on a regular basis. At the other end of the scale, Spurn Bird Observatory personnel (East Riding) recorded animals over time periods up to 900 minutes. Otherwise, all other sites involved logging individual sightings from conventional timed watches.

4 Data treatment

Validation procedures (checking species identification, incomplete fields, etc.) were imposed on all SWF and IWDG data by the respective organisations before they were processed. It was assumed the same validation was undertaken for external data sets by the respective data collection bodies. Before incorporating data into the database for the current analysis, they were further checked and corrected for duplicates and other coding errors (incorrect observer codes, incorrect coordinates, unrealistic start or end times and durations, incomplete information, etc.).

4.1 Data collation and fields

From the cleaned data, a number of data fields were selected and extracted, supplemented by information on observation height and search area if not already recorded, those being derived from the internet using Streetmap.com, Ordnance Survey infromation, or Google Earth.

The data were divided into three main categories:

General site information

- Recording group
- Location (site name, county, geographical area)
- Coordinates (latitude and longitude)
- Observation height (in metres above sea level)
- Observation area (i.e. area of search: 1 = uninterrupted 180^{o}+ view limited only by visibility; 2 = uninterrupted 90-180^{o} view limited in front only by visibility; 3 = 180^{o}+ view limited in front by land within 1km (measured from maps); 4 = 90-180^{o} view limited by land 1-2km distance on all sides)
- Optics: - 1 = mainly naked eye but supplemented by binoculars/telescope; 2 = use of binoculars/telescope for continuous scanning
- Observation method: 1 = regular scans; 2 = slow timed scans (duration variable between recording groups); 3 = slow scans but targeting particular sections of the sea (alternating with sections targeted for bird counts – used only in renewables studies that also involved birds – Alex Robbins in Blue Mull Sound, Shetland, and EMEC at Billia Croo, Orkney)
- Recording method: 1 = record of individual sightings (with group size count); 2 = counts of animals per watch period (typically 10 or 15 minute duration)

Watch- Effort information

- Date of watch
- Start time (GMT)
- End time (GMT)
- Number of observers
- Sea state

Sightings information

- Species
- Group size
- Best estimate of number of adults
- Best estimate of number of calves
- Time of sighting
- Sea state

For all external data sets, the recording group or individual was asked to sign a Data Provider Agreement, which was then passed to JNCC.

4.2 Data processing

All effort records (approximately 120,000) and sightings records (approximately 50,000) data were accumulated separately in Microsoft Excel files. *Effort records* include location, date, time and weather information as well as recording whether observation was continuous, based on scans or undefined methodology (casual watches). *Sightings records* indicated species, number of individuals, information of calves, juveniles and behaviour (recorded in some data sets but not consistently across the full database), as well as date and time. A third file contained site characteristics for all *c* 700 observation sites. For each site, fields were added for the management units for harbour porpoise (HP) and bottlenose dolphin (BND).

Additional data cleaning was performed after the project database had been constructed. Data were checked for missing values, non-numeric values (e.g. '1-2' for Sea State) and inappropriate missing values codes (e.g. -1) and numbers formatted as text. Fully numerical copies of relevant fields were created (e.g. month, year, start time, duration, latitude, longitude, sea state). New 'site codes'[2] were created for locations not already assigned a code.

Site Identifiers (Ids) were compared to latitude and longitude values to check correct allocation of site codes. A new numerical site code was created.

Effort data were filtered to exclude casual observations, zero durations (start time=end time), records from vessels, and records from the Republic of Ireland.

Sightings data were filtered to exclude previously identified repeat sightings, and sightings records labelled as 'casual', as well as to exclude all species except HP and BND.

These three main files were uploaded into a Microsoft Access database for additional exploration and screening. These files were formed into three main tables and were linked, with the effort table as the centre of the links (linked to sightings records by 'effort code' (unique identifier for a period of effort) and to sites by 'site code').

Duplicate effort records were detected and corrected where possible; associated sightings records were then also corrected. For the effort file, agreement between latitude, longitude, site name and site ID code was checked and some reassignments made. The sites file was checked for discrepancies in latitude and longitude by plotting all values. For the reasons given above, about 5% of data were excluded.

For harbour porpoise and bottlenose dolphin, secondary sightings files were created, grouping sightings records by effort code and containing information on the number of sightings records, number of groups and number of animals per effort code. Every effort line had a link to whether or not there was a sighting associated. Any sightings not corresponding to an effort code retained in the effort file were treated as casual and excluded from further analysis.

[2] Sites were numbered consecutively considering the coastline as a continuous linear feature.

Summary analyses were completed in Access, queries created to extract data for each management unit (harbour porpoise and bottlenose dolphin), and the resulting data exported to Excel. Missing values were detected and replaced by 'NA' (Not Available) and missing sightings totals (i.e. where there were no sightings) replaced by zeros. Files were then saved as tab delimited text, suitable for analysis in the statistical software package R.

4.3 Data exploration and variable selection

Exploratory Analyses

The full dataset comprised approximately 120,000 effort records and more than 75,000 hours of watches.

The first dedicated effort-related watching from land sites took place in 1965. Records started in that year and the series analysed ends in early 2014. Effort remained low and confined to a few sites throughout the 1970s and 1980s, increasing to a small peak in the 1990s (though still restricted to a few locations) but with the great majority of effort from 2000 onwards. However, some areas (e.g. Shetland, and some sites in southern and South-West England) had most watch effort in the 1990s whereas others (e.g. Northern Ireland, North Wales) had effort largely confined to the most recent period from 2000 onwards. A few areas (e.g. Moray Firth, Grampian Region, Cardigan Bay) have had watch effort spanning two or three decades. Temporal details of effort can be found site by site in Appendix 3. Of a total of 117,045 'effort codes', 105,245 were collected from 1994 onwards, with 86,401 of these collected since 2003.

Although further data cleaning was undertaken before transfer of the data to R, the data at this stage included some records that were then excluded from analysis, specifically very short observation periods (as short as 30 seconds) and observations collected at sea states >5.

For reasons discussed further below (in relation to temporal autocorrelation), effort codes were grouped by site and date so that the new unit of data is the 'site-day'. Bearing in mind the progressive improvement in spatial and temporal coverage over the years, the data was divided into three periods: (1) 1965–1993 (the patchiest coverage), (2) 1994–2003 and (3) 2004–2014 (although the latter set includes only a small number of records from 2014). Since coverage was lowest and most uneven in the first time period, analyses focused on 1994–2014 (i.e. periods 2 and 3 combined).

During 1994-2014, most observations took place in April to September, between 08:00h and 15:00h. Effort was highest in 2010–2013 (Figure 1). The great majority of effort records were collected in sea states 1 or 2 with very few in sea states above 3.

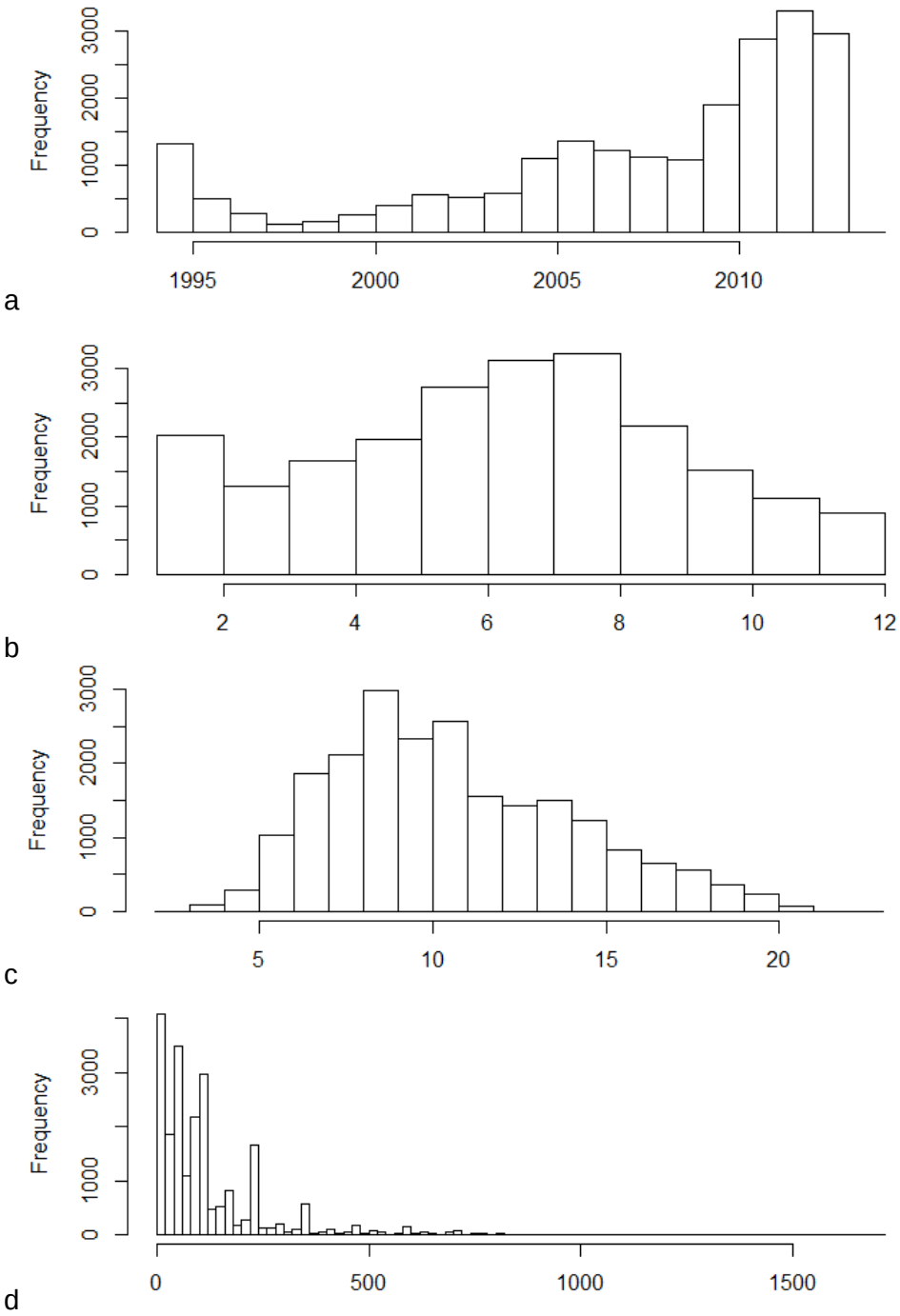


Figure 1. Histograms of 1994–2014 effort data, using site-day as the data unit (frequency of site days on the y-axis) and plotted by: (a) year, (b) month, (c) hour of day (at which observations started) and (d) daily observation duration in minutes.

Explanatory variables

The explanatory variables available were: observation duration, year, year fraction (i.e. a code to represent each day of the year), hour (of start of observation), sea state, and the series of variables specifically associated with each site: latitude and longitude (or site number), elevation, effort type, optics type, area observed, observation method, and recording method (see Table A1.1 for further definition).

In general, the potential explanatory variables available were not highly correlated with each other. However, observation method is highly correlated with optics (regression correlation coefficient, R=0.89) and only the latter were therefore retained. *A priori*, the recording method should not affect the presence-absence data (and in theory not total numbers of animals and groups recorded either) and this variable was therefore excluded.

There remains the potential for some of the effects to be confounded with effects of site location, notably for observation duration and elevation. Observations at some bird observatories were continuous over a number of hours, but long observation periods were rare elsewhere; rather than lose data from these sites it was decided to constrain the effect of observation duration on the response variables (basically, requiring it to fit a simple curve). A similar approach was applied to elevation.

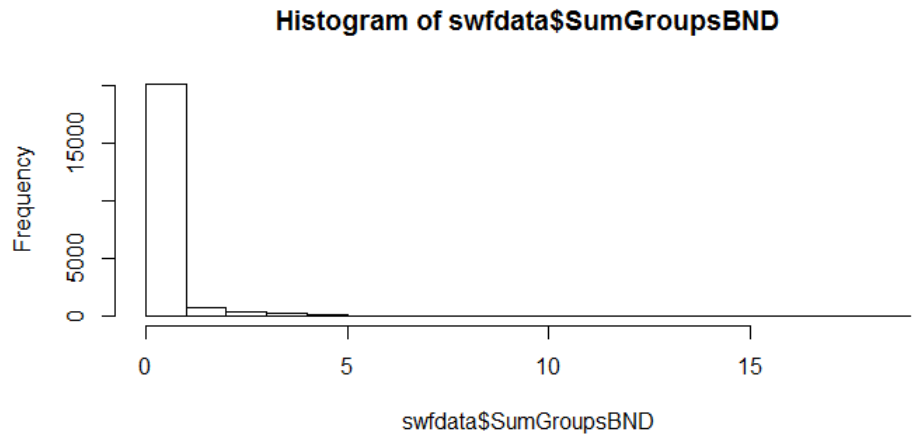
Other potentially important interactions include latitude and longitude (the description of spatial variation should include both main effects and their interaction), as well as location and year (reflecting distribution changes). Investigating the latter interaction requires reduction of location to a one-dimensional variable and, having numbered sites approximately sequentially along the coast, site number was therefore also used as a one-dimensional representation of location (see Pierce *et al*, 2010, for a similar approach, albeit for a much shorter length of coastline). Anticipating the need for mixed models to account for autocorrelation, runs of consecutive days with observations at each site were also identified and labelled.

Response variables

The data offer several possible choices for response variable, including presence, number of animals seen, number of groups seen and the associated sightings rates (here termed Animals Per Unit Effort, APUE and Groups Per Unit Effort, GPUE) (see Figure 2 for histograms). There is also a subset of data that distinguishes calves and juveniles (although since this was not recorded consistently by all research groups, it was not analysed further here).

Aside from presence, which obviously follows a binomial distribution, the count variables can be modelled using quasi-Poisson models, to account for overdispersion. Note that although repeat sightings within effort codes could be excluded, repeat sightings across consecutive effort codes cannot be identified from the data so the average number of groups or animals seen per effort code per site-day is used. Sighting rate variables are more problematic; regardless of how they are calculated, due to the high number of zeroes (no sightings) and the fact that these are not count data, neither Gaussian nor quasi-Poison models are appropriate. The skewedness of these distributions is exaggerated by the high variability in observation duration, but the preponderance of zeros represents a real problem. In principle, zero-inflated models could be used, but the size and complexity of the datasets, with multiple explanatory variables, and the potential necessity to run the models as mixed models, essentially preclude this option.

Most of the information is in the presence-absence component of the data and it is therefore realistic to treat the data as binary. Overall, 14.7% of site-date combinations were associated with presence of bottlenose dolphin and 26.1% with presence of harbour porpoise. Binomial models have the advantage of giving results that represent probability of sighting or occurrence (i.e. they are in the range 0 to 1).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Frequency
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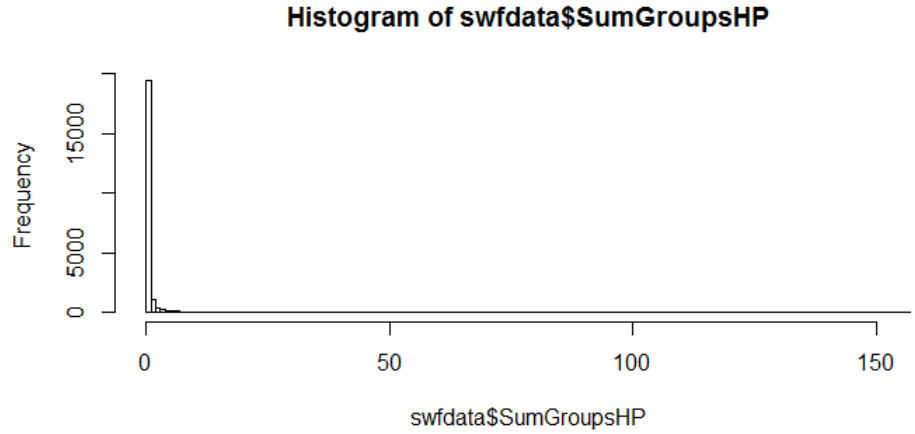
5000
15000
0
5
10
15
swfdata$SumGroupsBND

a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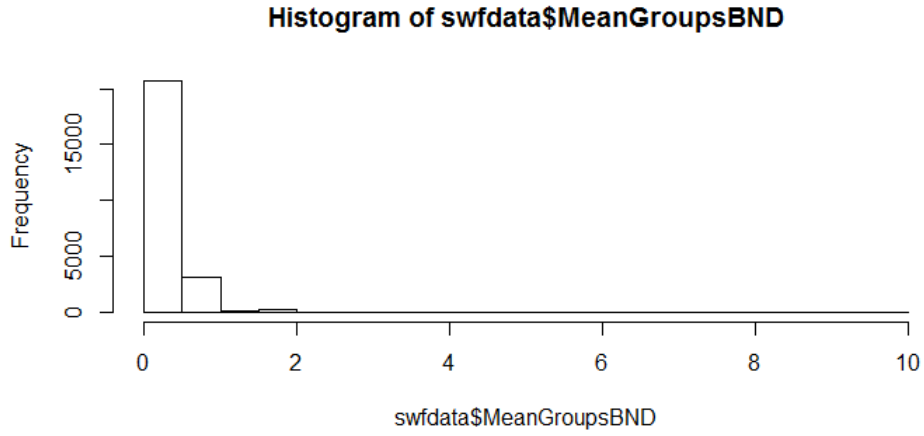
100
150
swfdata$SumGroupsHP

b


Histogram of swfdata$MeanGroupsBND
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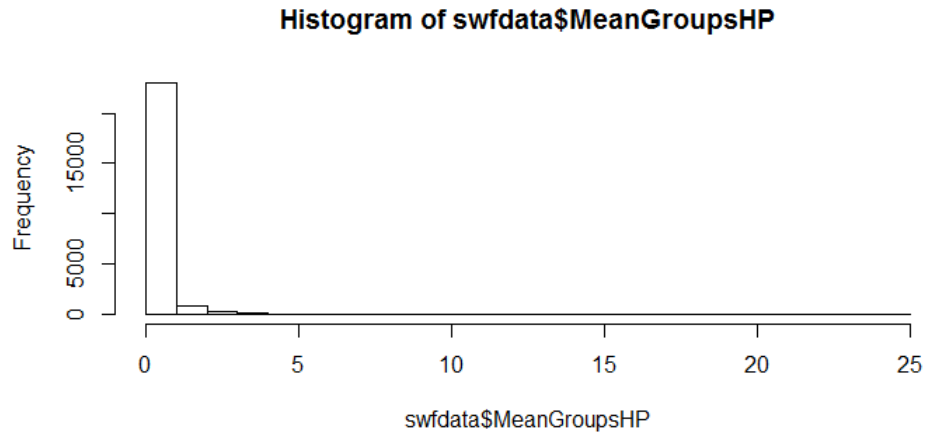
15000
0
2
4
6
8
10
swfdata$MeanGroupsBND

c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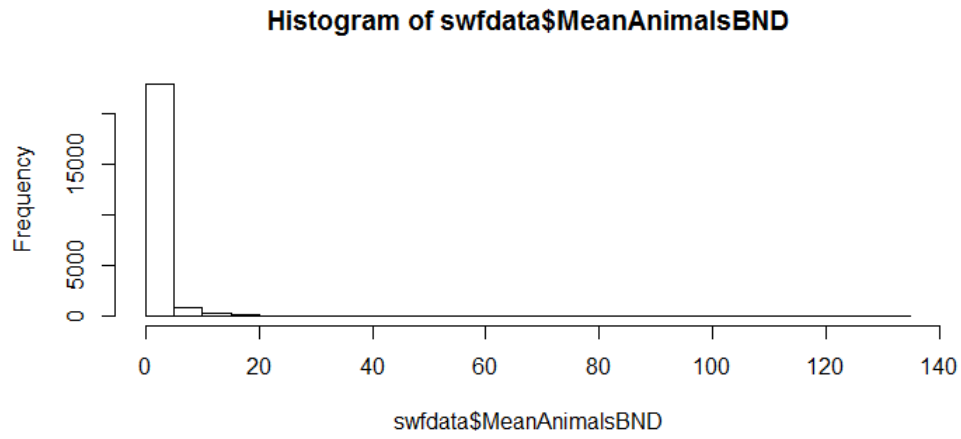
0
5
10
15
20
25
swfdata$MeanGroupsHP

d


Histogram of swfdata$MeanAnimalsBND
Frequency
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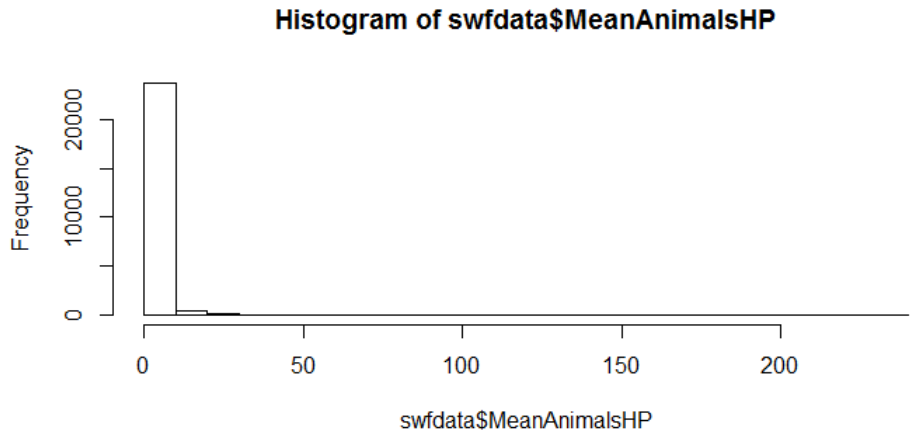
15000
0
20
40
60
80
100
120
140
swfdata$MeanAnimalsBND

e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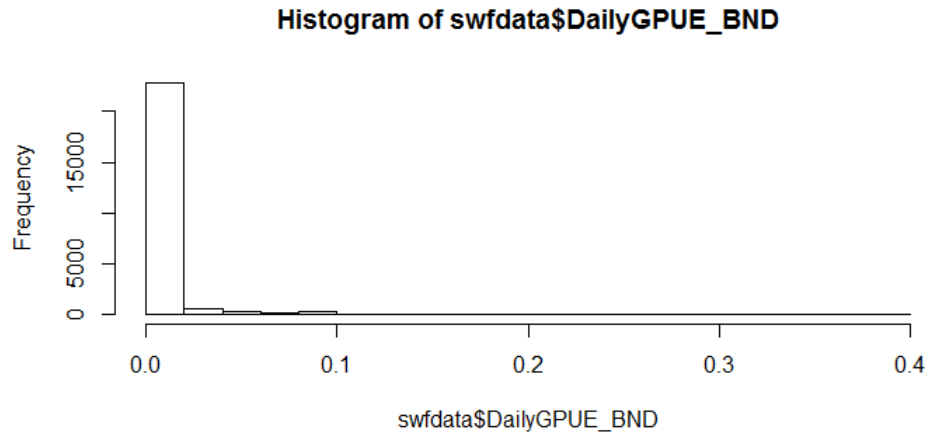
150
200
swfdata$MeanAnimalsHP

f


Histogram of swfdata$DailyGPUE_BND
Frequency
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15000
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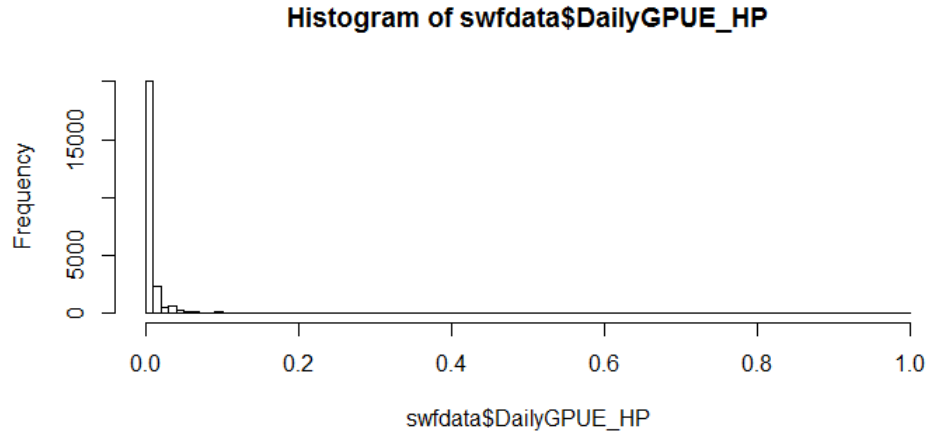
0.1
0.2
0.3
0.4
swfdata$DailyGPUE_BND

g


Histogram of swfdata$DailyGPUE_HP
Frequency
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15000
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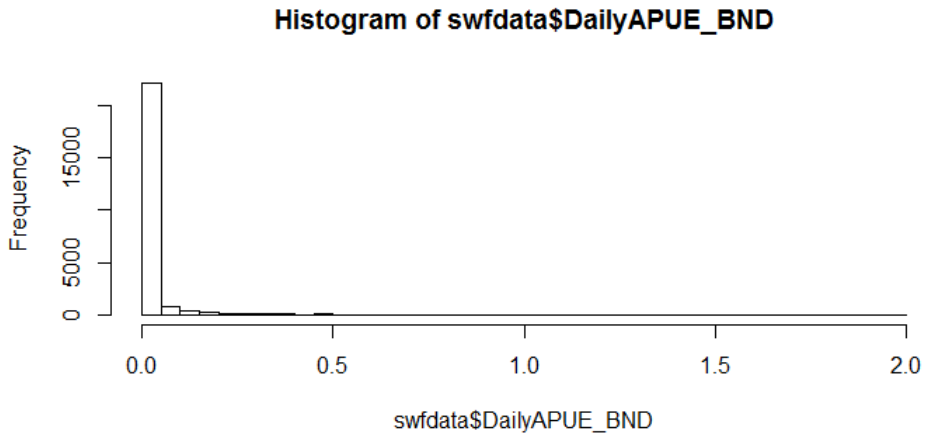
0.2
0.4
0.6
0.8
1.0
swfdata$DailyGPUE_HP

h


Histogram of swfdata$DailyAPUE_BND
Frequency
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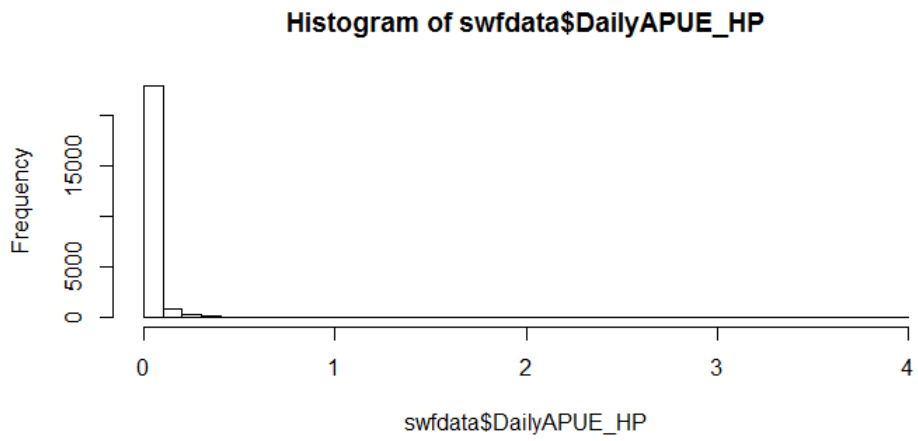
5000
15000
0.0
0.5
1.0
1.5
2.0
swfdata$DailyAPUE_BND

i



j

Figure 2. Histograms of 1994-2014 data, using site-day as the data unit (frequency of site-days on y axis). X-axes variables for bottlenose dolphins and harbour porpoises as follows: total number of groups seen, for (a) Bottlenosed Dolphins (BND) (SumGroupsBND) and (b) Harbour porpoise (HP) (SumGroupsHP); mean number of groups (per effort code) for (c) BND (MeanGroupsBND) and (d) HP (MeanGroupsHP); mean number of animals seen for (e) BND (MeanAnimalsBND) and (f) HP (MeanAnimalsHP); daily average number of groups per unit effort for (g) BND (DailyGPUE_BND) and (h) HP (DailyGPUE_HP); daily average number of animals seen per unit effort for (i) BND (DailyAPUE_BND) and (j) HP (DailyAPUE_HP). All histograms show the extremely right-skewed nature of the data. See text for further explanation[3].

Autocorrelation

Aside from gaps and inconsistencies in the distribution of observer coverage over the years, the most likely issue when analysing these data is temporal autocorrelation, particularly within a single day's observation at a single site. Out of the original 105,245 effort codes, only 11,732 refer to unique site-date combinations. The rest represent multiple watches per day per site. In total there were 24,315 site-date combinations. Site-days with single observations thus represent 48% of the total site-days (but a much smaller proportion of effort records). In 90% of cases there were 10 or fewer effort codes per site-day; 99.4% had 30 or fewer effort codes. The maximum number of effort codes per site-day was 152. Notably, around 400 site-days (mostly in Wales and south-west England) had exactly 24 effort codes, each representing a total of six hours divided into 24 consecutive 15-minute periods.

A mixed model, which used the effort code as a data unit and allowed temporal autocorrelation within site-day, would effectively contain 24,315 different 'transects'. Running such a model is not computationally feasible on a standard Personal Compuet (PC). Therefore, it was decided to use the site-day as the basic unit of analysis. Sightings were summed across all effort codes for the same site and date. Following this approach, all site-specific variables are preserved unchanged. Effort-code-specific variables are treated as follows:

- Duration – the sum and the mean (permitting alternative filters for short duration watches) duration was calculated, as well as the minimum and maximum (providing insight into the consistency of the observation protocol);
- sighted groups – the sum and the mean;
- sighted animals – the sum and the mean;

[3] swfdata$'is simply the dataset identified used by the contractor.

- sightings rates (GPUE, APUE: averaged across effort codes and overall values (total sightings/total duration for each site-day);
- start time – the lowest (i.e. earliest) value for each site-day;
- sea state – mean

The reduced dataset (i.e. one row per site-date combination) is not necessarily free of temporal autocorrelation. Looking at consecutive days of observation at individual sites during 1994–2014, there are 13,294 separate sequences of observations, of which 9,819 consist of a single day and a further 1671 consist of two days. There are however 193 sequences of ten or more consecutive days, including one of 138 days and another of 185 days (both from Bird Observatories).

Again, there are several options for allowing autocorrelation, e.g. among all records from a site, site-year or run of consecutive days (i.e. different scales of compound symmetrical correlation), or assuming an AutoRegressive-Moving Average (ARMA) correlation structure within runs of consecutive days (i.e. values are most strongly related to the previous one or few values). In practice the only plausible correlation structure for which models converged on a solution was an AR1[4] correlation structure within runs (but only when site number was used as the location descriptor, rather than latitude and longitude). The random part of the model was thus coded in statistical package 'R' as follows:

Random=list(Run_ID=~1), correlation=corAR1(form=~1).

In other words, it was assumed that there is correlation between consecutive days of observation at each site but no temporal autocorrelation with a longer periodicity and no across-site spatial autocorrelation. Alternative plausible correlation structures (simple compound symmetry, more complex ARMA forms) did not produce satisfactory models. A least part of the issue is the (potentially) high number of explanatory variables in the fixed part of the model, making it difficult to simultaneously estimate the random part. However, at least for some of the simpler models, it is possible to see how accounting for temporal autocorrelation affects the model outcomes.

Filtering

Prior to model-fitting two filters were applied, retaining records with summed duration of observations per day >9 minutes (since land watches by WDC were routinely of 10 minutes duration) and sea state <5 (a higher threshold was applied than is normally used for offshore data because one may expect a much lower effect of sea state at elevated land sites – Evans & Hammond, 2004). It should be noted, however, that these choices are a compromise between removing flawed data and removing too much data. The main concern with short observations is that they could be biased towards presence records (i.e. some observers submitted such records only if they saw cetaceans). The authors were assured by WDC that observers initiated 10-minute watches independently of a sighting. With very high sea states, the likelihood of seeing porpoises and, to a lesser extent, larger species will probably be reduced. The higher the sea state, the more pronounced the effect and the more variable the outcome. Preliminary explorations suggested such a bias might be present, but it was no longer evident once very short records were excluded. Both observation duration and sea state are included as explanatory variables and their effects on both the probability of sighting a cetacean and on the confidence associated with that probability are thus taken into account.

[4] First order correlation of the noise of a time series.

4.4 Model fitting and validation

The basic approach used was a combination of generalised additive (GAM) and generalised additive mixed (GAMM) models, fitted using routines from the mgcv[5] library in R. This approach was used to account for the likely non-linearity of effects of most explanatory variables.

In such a heterogeneous data set, the authors considered it important to check a range of subsets of the data (different time-periods) and different ways of modelling spatial variation to confirm that conclusions are similar, or to identify important differences. The main model variants (options) were:

A. Including spatial variation as the combined effects of latitude, longitude and their interaction. This has the minor disadvantage that units of latitude and longitude are always treated as representing the same distance and the more important limitation that distances between points are taken to be the linear minimum distance and do not take into account land barriers.

B. Including spatial variation as an effect of site number. This treats the coast as a linear feature and effectively assumes that the difference between successive sites in the sequence is always the same. The numbering series in fact does not always strictly follow the coastline and there are inevitably 'jumps' when moving from mainland to island coasts and back.

C. Model B fitted with a site-year interaction (to allow visualisation of spatial variation in temporal trends).

D. Model B fitted as a GAMM to take into account temporal autocorrelation. The other model types were generally unsuitable to run as GAMMs, especially with the larger subsets of data, either because the fixed part of best model contained too many terms or model runs could not be completed in a reasonable length of time with available processing power. Model runs were discontinued if they had not terminated within 72 hours.

For a coastal dataset it is difficult to accurately represent the true distance between points as experienced by a marine animal. While neither option A or B is perfect, as mentioned above, option B has the advantage that it permits further investigation of effects of time and autocorrelation. For each subset of data used, the authors initially fitted full models and where necessary used backwards selection to eliminate non-significant terms, checking that AIC was reduced by removing them and, where the effect of removal appeared to be marginal, the nested models were compared using ANOVA (model1, model2,'Chisq'). [For binomial models, an F-test is not appropriate].

The full models included main effects only except for (where relevant)

- Latitude and longitude: capturing spatial variation in cetacean presence depends on considering the interaction between these variables. Other specific interactions were checked subsequently.
- Site number by year: this allowed use to check for changes in distribution over time.

[5] The 'mgcv' package (Mixed GAM Computation Vehicle) mgcv is an R package for estimating penalized Generalized Linear models including Generalized Additive Models and Generalized Additive Mixed Models.

Model validation was based on checking for influential outliers (for some models a few estimated values approached 1.0 but none exceeded 1.0) and examination of residual plots for patterns and trends. The code “gam.check” in R was also used to ensure that degrees of freedom for smoothers were adequate. Where interactions between effects of different explanatory variables were suspected, these were checked. Note however that the GAM framework does not permit all interactions to be considered simultaneously nor can three-way and more complex interactions between continuous explanatory variables be analysed.

To recap, the variables used in the models were as follows:

Response variables: presence BND, presence HP (binary distribution). This implies use of a binary GAM or GAMM, using a logit link (i.e. effectively a transformation which linearises a sigmoid curve).

Explanatory variables:

- Latitude and longitude (fitted as 2-way smoother, allowing as many degrees of freedom (df) as were needed; maximum knots in the smoother (k) was increased until the limit was not reached).
- Site number (an alternative to latitude and longitude; again, a high k value was allowed to ensure spatial patterns were captured adequately).
- Sum duration (i.e. total number of minutes of observation in a day; here k=4 was used due to apparent overfitting at high durations, probably reflecting an interaction between site location and observation duration (at least partly because observers at certain sites, like bird observatories, tended to undertake long watches). The alternative of filtering out long duration observations was not used to avoid losing data for certain sites).
- Area of observation, optics used, effort type, recording method, observation method. These are all categorical variables.
- Hour, year fraction. Smoothers for these variables sometimes approached the default limit of 9 df (k=10). Although the authors do not necessarily expect a simple form of variation in presence over the course of a day or a year, nor do they expect a very complex form. Therefore, k was not increased.
- Year. For the runs using datasets exceeding 20 years, the df for smoothers sometimes approached 9 and we therefore allowed a higher k value.
- Elevation. This variable is site-specific and its effect, while partly real, in relation to observer ability to see cetaceans, could be confounded with site differences. The value of k was therefore constrained to k=4.

All models were run in R.

Predictions

Having identified a ‘best’ model for each time period, predictions were derived for each site, based on standardised settings (year fraction = 0.5, time = 11.00h, elevation = 20, effort Type = 1, optics = 1, observation method = 1, recording method =1, sea state = 2, observation duration = 90 minutes) and an ‘average’ year for the subset.

For each site, model output comprises a predicted occurrence value and the associated Standard Error (SE). The approximate 95% confidence intervals were calculated (as predicted value ± 2 SE) and all values then inverse transformed to reverse the logit transformation, giving final values in the range 0 to 1.

The (inverse transformed) 95% confidence limits on predictions from a binomial model can be misleadingly narrow when predicted values are near zero so it is

important to check the actual standard error: Where few data were available for a given site, the (inverse transformed) SE often approached 1.0, i.e. effectively no confidence attaches to the predicted occurrence value. To provide a measure of confidence that is positively related to the reliability of the prediction 1 minus SE was plotted.

The authors also used filters on the model output. While sites with few observations can justifiably be included in the models, it is unsurprisingly evident that predicted occurrence for such sites has very wide confidence limits. A filter was used, therefore, which included predictions only for sites with ≥100 minutes of observation per year for at least 3 years (within the time period considered). In addition, derived frequency distributions for predicted occurrence at all sites retained by the filter, to allow for the identification of sites where data were sufficient and predicted occurrence was above the 90th percentile.

Models fitted

The alternative models fitted were as follows:

(a) For different time-periods: 1994-2003, 2004-2014, both these periods together, and the older (1965-1993) data.
(b) Latitude and longitude or site number to code for location; the latter choice permits examining the site by year interaction and fitting of GAMMs
(c) Using the middle 6 months (April to September) of the year only (these are the months most consistently represented in the data

4.5 Persistence

Data summaries were generated using an Access database and Pivot tables in Excel, both to indicate the distribution of effort across years and the 'persistence' of sightings.

Count rates per year were calculated for each of the 678 sites. Appendix 3 (along with an accompanying Excel spreadsheet) provides full details of effort and count rates by year from 1965 to the present, for each site within that management unit. Any entry in blue indicates effort in that year without any sightings of that species. Entries in yellow indicate positive sightings and provide the count rates for that year. Count rates are expressed as numbers of animals per hour of observation. At the end of the matrix is the sum of years for which there was watch effort from 1965 onwards, and then since 2000.

Tables 3 and 6 present, for bottlenose dolphin and harbour porpoise respectively, GAM predictions for those high effort sites (>300mins of observation annually for at least three years) that exceed the 90th percentile for different time periods.

5 Results

5.1 Site summaries

Appendix 1 summarises basic information from the 678 sites at which some dedicated systematic watching for cetaceans have been conducted, and for which data were available to the project. The two tables that form Appendix 1 summarise the following information for each site: in Table A1.1, site name, region, location (coordinates), site elevation, observation area (field of view), use of optics, observation method, recording method, and to which management unit that site was assigned for bottlenose dolphin and harbour porpoise; and in Table A1.2, site name, region, total amount of effort, number of years in which watches were conducted, span of years and, again, the management unit to which that site was assigned, for bottlenose dolphin and harbour porpoise. Each site was numbered in ascending order from the Northern Isles south down the east coast of Britain and then in a clockwise manner around southern and western Britain, ending up with the Channel Islands and Northern Ireland. Thus, sites in the same area have numbers close to each other. If a site was within 1-2km, it was given the same number before a decimal point, e.g. 1.1, 1.2, 1.3.

The geographical locations of these are plotted as four maps in Figure 3, each showing sites for which there are different levels of effort overall: Figure 3a - sites with up to 3h of effort; Figure 3b – sites with between 3 and 10h of effort; Figure 3c – sites with between 10 and 50h of effort; and Figure 3d – sites with more than 50h of effort. Some sites had watches conducted from more than one location within close proximity (<2km). These were generally satellite locations near a site with much more effort, but they have been kept separate for the GAM analyses which took account of any differences in site elevation, field of view, observing or recording protocol.

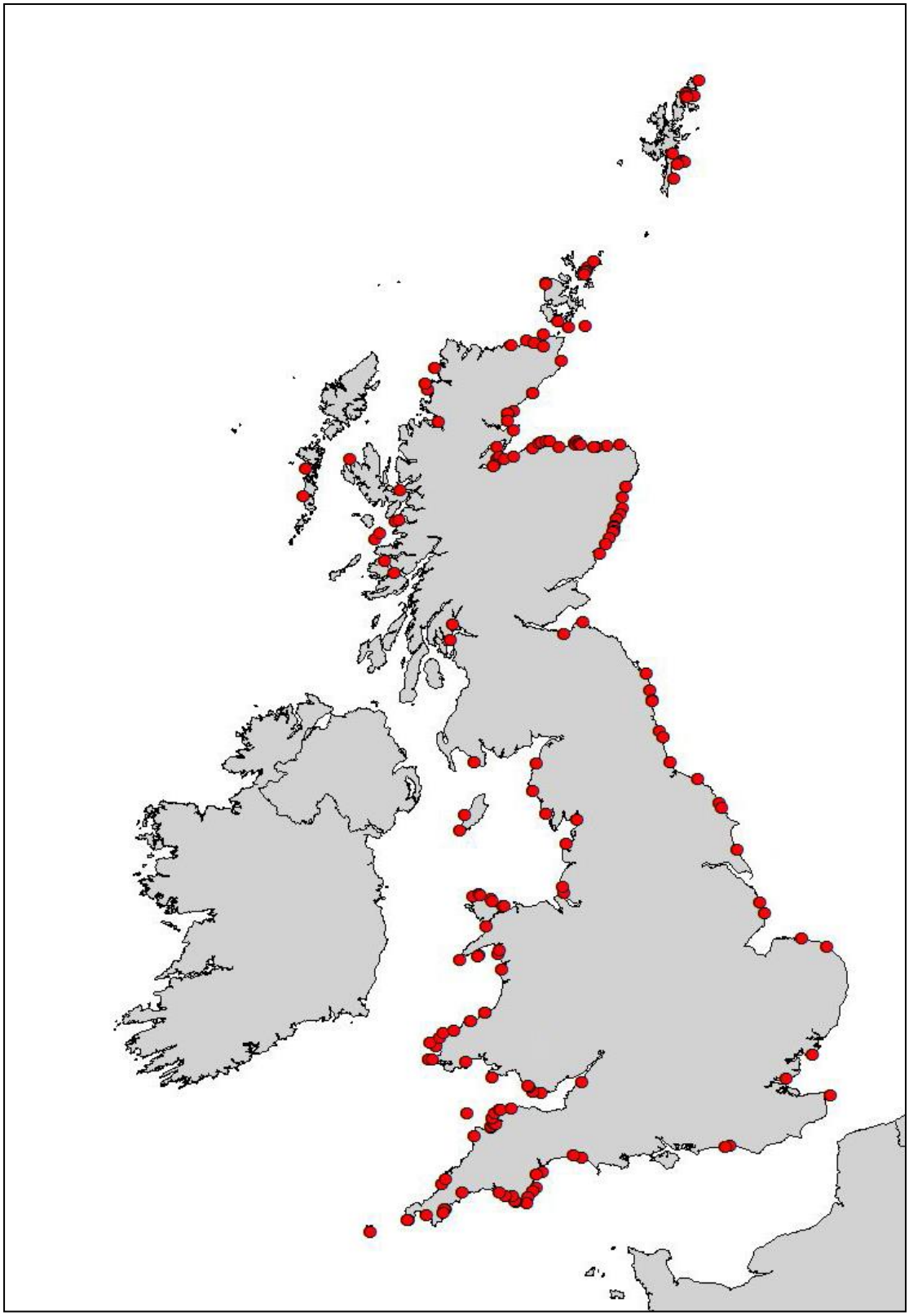


Figure 3 a. Map of land-watch sites with up to 3h of total effort.

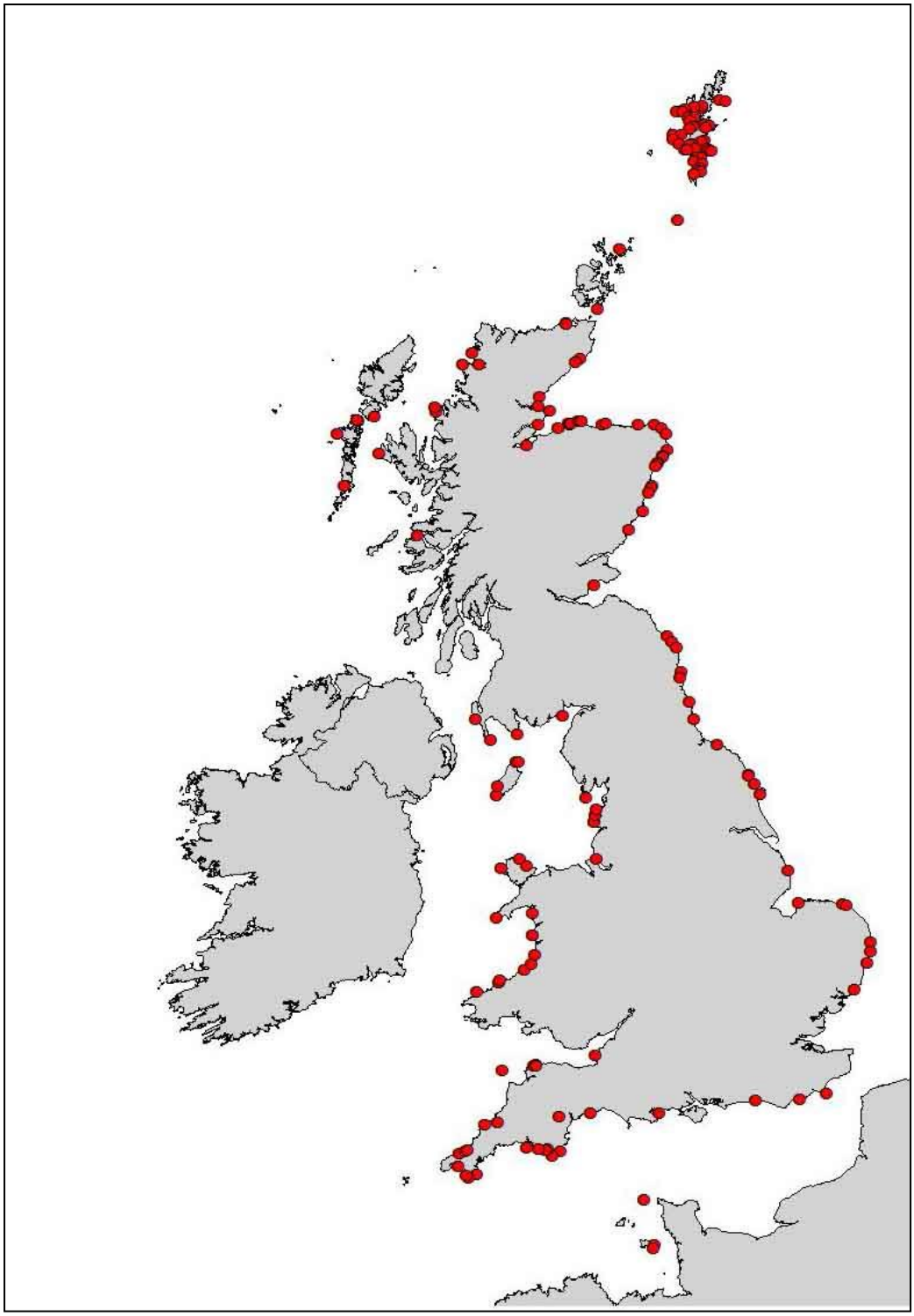


Figure 3 b. Map of land watch sites with 3-10h of total effort.

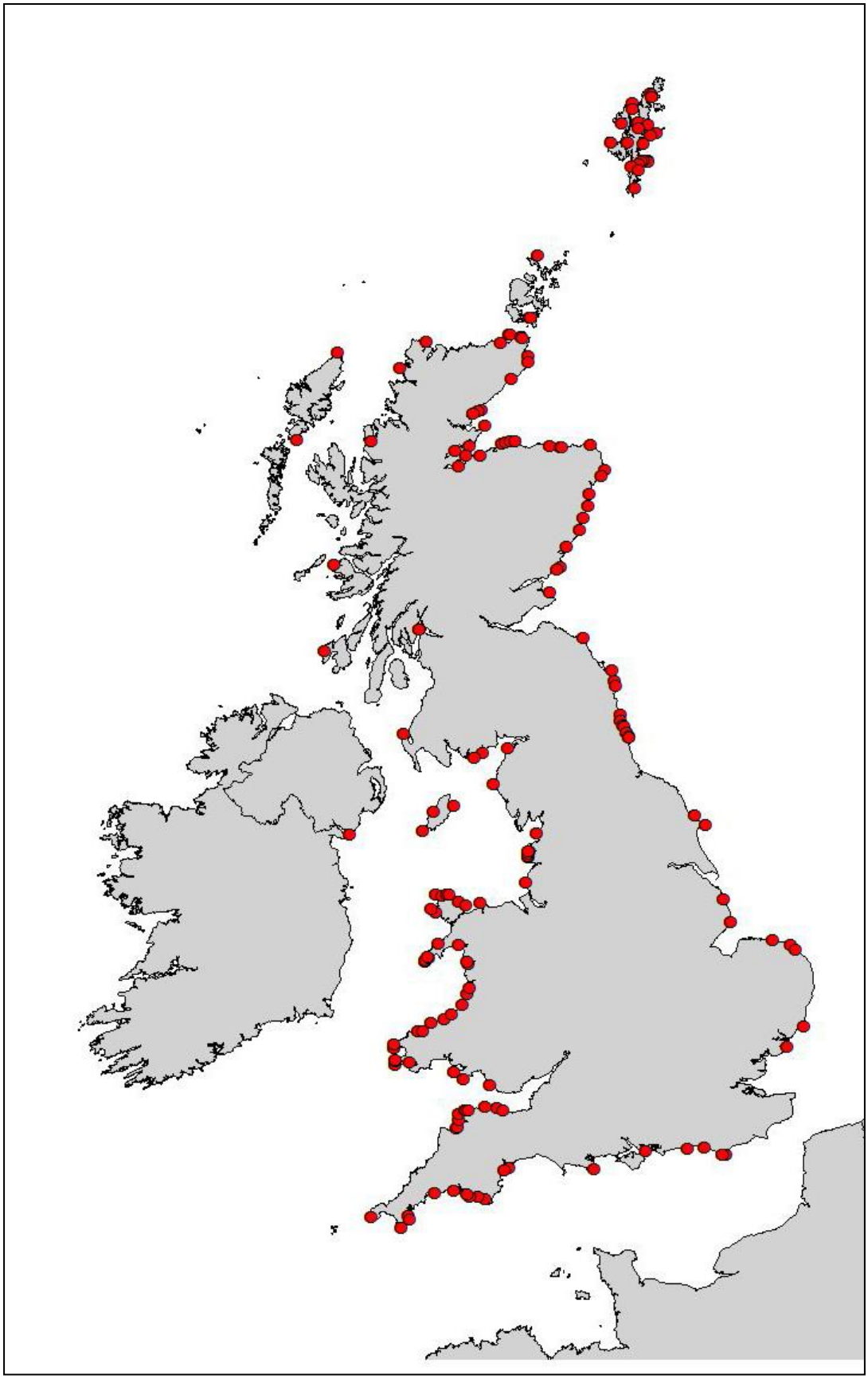


Figure 3 c. Map of land watch sites with 10-50h of total effort.

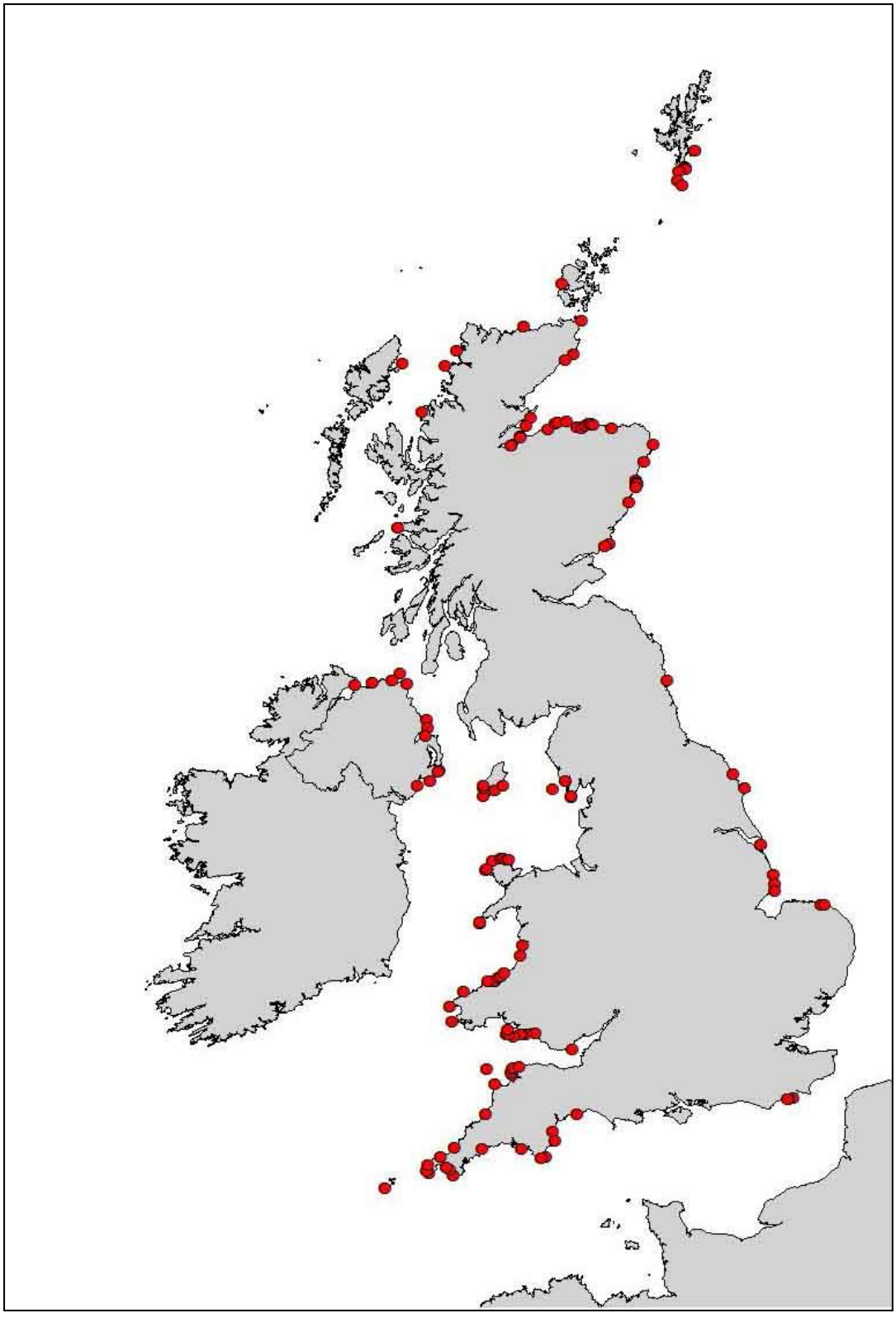


Figure 3 d. Map of land watch sites with more than 50h of total effort.

Effort has been greatest around north-east Scotland, south-west England and west Wales, and has been least in west Scotland (including the Hebrides), the Firth of Forth, over most of eastern England, and particularly between Suffolk and Dorset (Figure 3).

5.2 Bottlenose dolphin

Sightings rates (number of sightings per hour effort) were analysed separately from count rates since they indicate the frequency at which sites are occupied by the species (Appendix 2; Figures A2.1a-d) as opposed to overall numbers. For the 678 sites around the UK, the average sighting rate was 0.09 sightings per hour, with a range of 0 to 4 sightings per hour.

The plots for four different levels of effort show similar patterns, with sightings concentrated in the Moray Firth and Cardigan Bay, but also revealed is the importance of the outer Moray Firth as far north as the Dornoch Firth and the east Grampian coast south towards the Firth of Forth in eastern Scotland; and the North Wales coast and Isle of Anglesey, in Wales (see Figures A2.1a-d). Six sites in south-west England with reasonable levels of effort (>5h) have sightings rates of 0.2-0.4/h: Blackstone Point, south Devon; Bass Point and Predannack Head on the Lizard Peninsula in south Cornwall; Land's End, west Cornwall; St Ives Bay, north Cornwall; and around Croyde Bay in north Devon.

Average count rate for the 678 sites around the UK was 0.57 of the selected animal type per hour, with a range of 0 to 17.6 animals per hour. Figure 5 shows count rates at sites partitioned by varying levels of effort. The four maps show similar patterns, count rates consistently being highest in the Moray Firth and East Grampian region and along the coasts of Cardigan Bay and around North Wales. Relatively high-count rates occur also along the Angus coast, and at most of the same sites referred to in Appendix 2 in north Devon and Cornwall. Although effort-related observations were made in the Poole Bay area, these generally involved cliff top walks and so were not comparable with the static watches analysed here. Nevertheless, they did yield fairly regular sightings of bottlenose dolphins (Owens *et al*., 2001). Elsewhere, high count rates occur at Port Erin, Isle of Man, and the Isle of Mull, and Kildonan, South Uist in west Scotland, as well as Grouville Bay, Jersey in the Channel Isles. It is worth noting that bottlenose dolphin group sizes are often higher away from core areas. In Wales, for example, mean group size for the species in Cardigan Bay is 4.2 whereas off Anglesey in North Wales (to which region the Cardigan Bay population largely moves in winter), mean group size is 18.0 (Pesante *et al*., 2008a; Feingold and Evans, 2014). On the other hand, count rates will not necessarily be higher because the frequency of occurrence of bottlenose dolphins at a particular site is much lower (Pesante *et al*., 2008a).

Using the management units for bottlenose dolphin recommended by the UK IAMMWG (see Figure 4), sites were allocated to one of the following: 184 in East Coast Scotland (ECS), 154 in North Sea (NS), 163 in Channel and South-west England (CSW), 128 in Irish Sea (IS), and 49 in Coastal West Scotland & Hebrides (CWSH) (including five sites from Northern Ireland).

Table 1 lists sites where there has been more than 5h of effort (at least 300 minutes of watch effort per year over three years) and where count rates exceed a 90th percentile per management unit. Those sites are mapped in Figure 6.

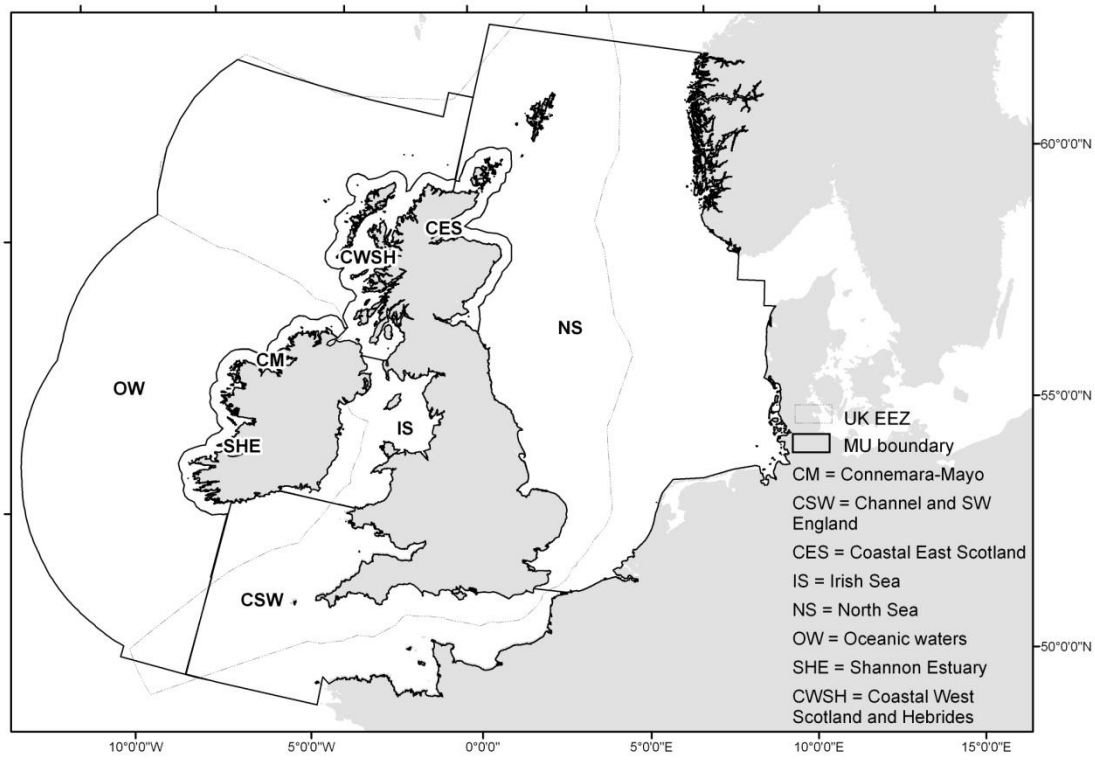


Figure 4. Map showing management units used for bottlenose dolphin.

It should be noted that by applying the 90th percentile, a number of sites known to be important for the species (Thompson *et. al.*, 2011; Feingold & Evans, 2014) are excluded. These include Sutors of Cromarty, Chanonry Point and Fort George in the Moray Firth SAC, north-east Scotland, most sites along the south side of the outer Moray Firth, and several sites within the Pen Llŷn a'r Sarnau SAC, west Wales.

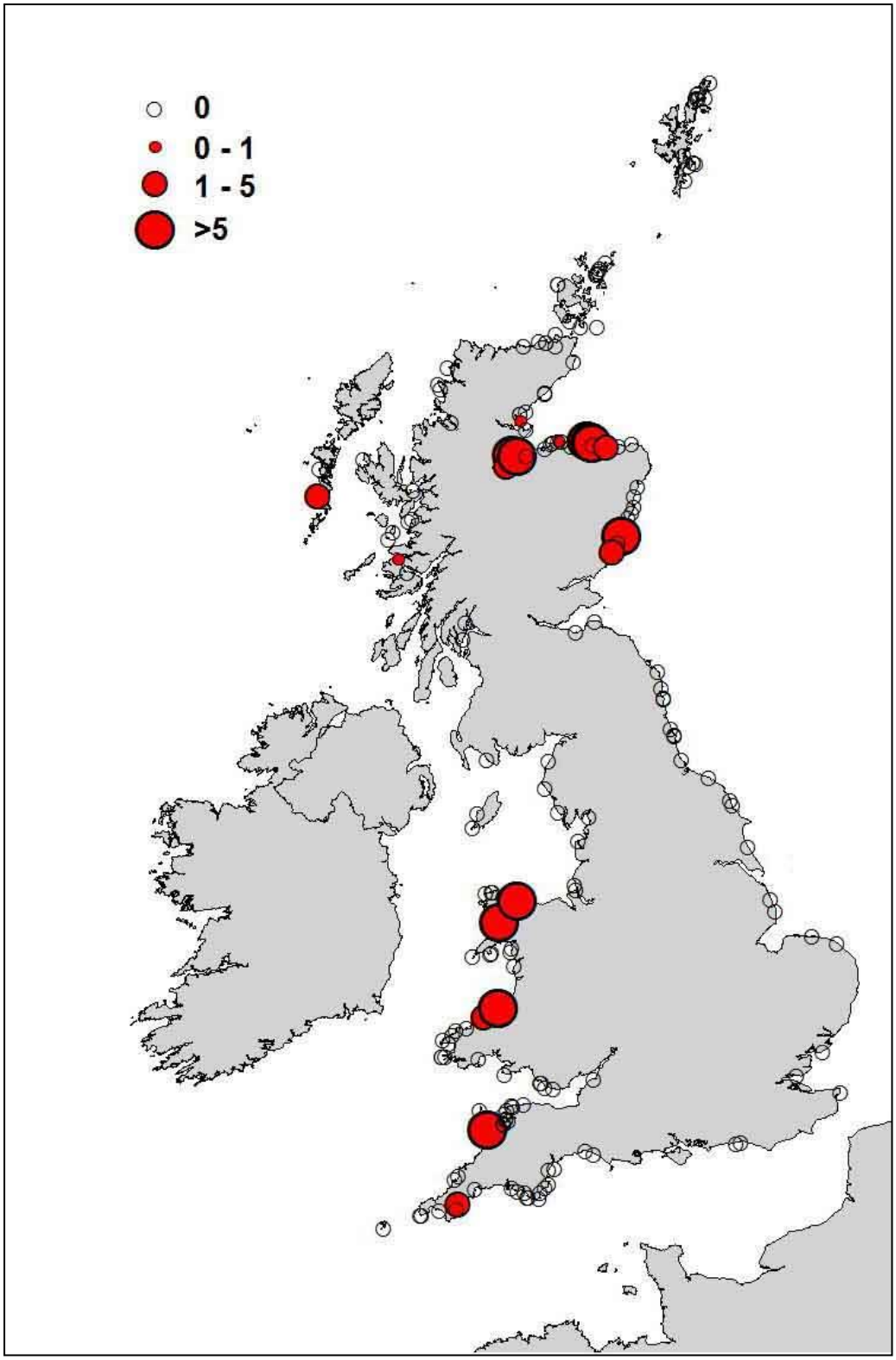


Figure 5 a. Map of bottlenose dolphin count rates (numbers of animals per hour effort) by site (for watches with <3h of total effort).

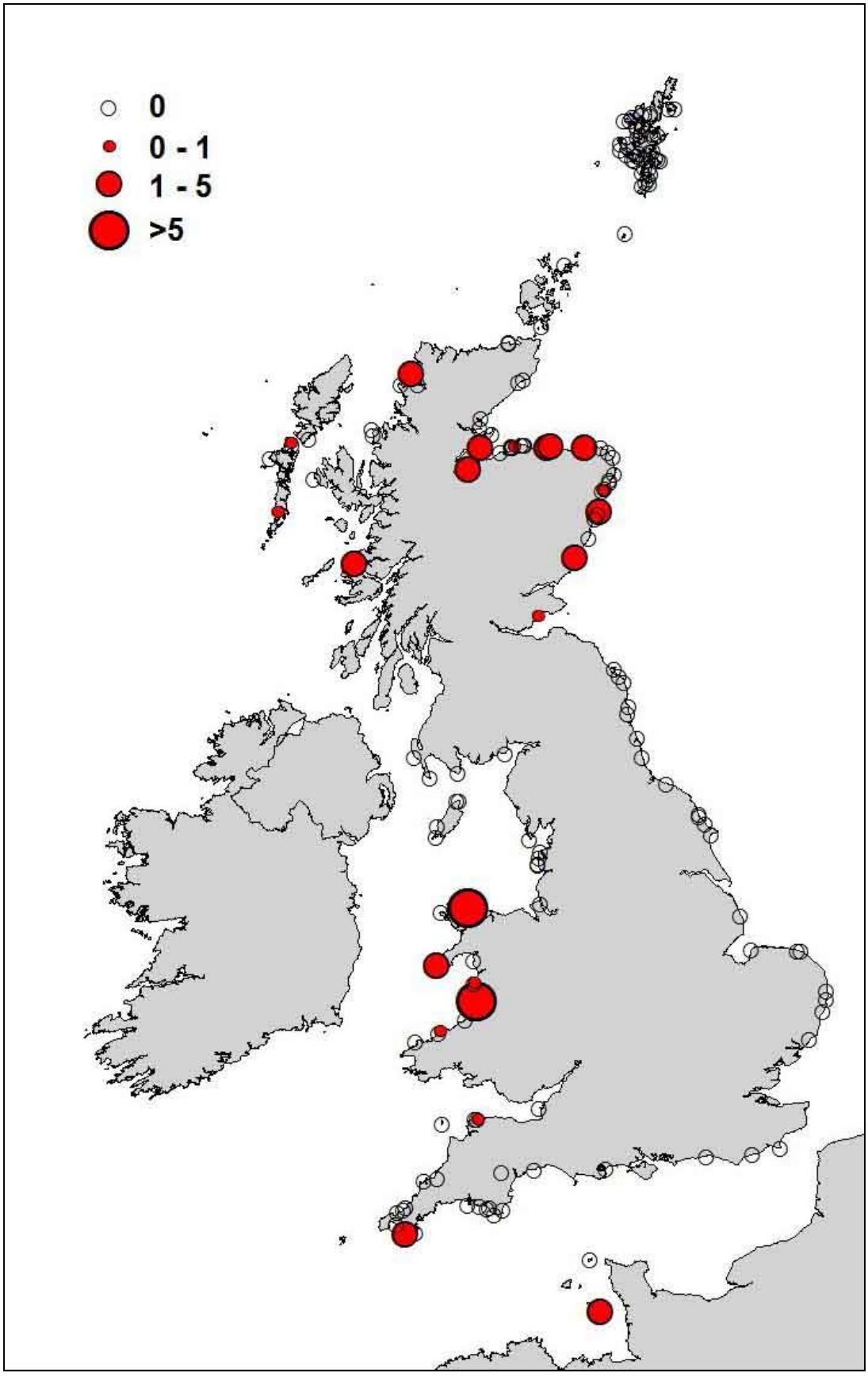


Figure 5 b. Map of bottlenose dolphin count rates (numbers of animals per hour effort) by site (for watches with 3-10h of total effort).

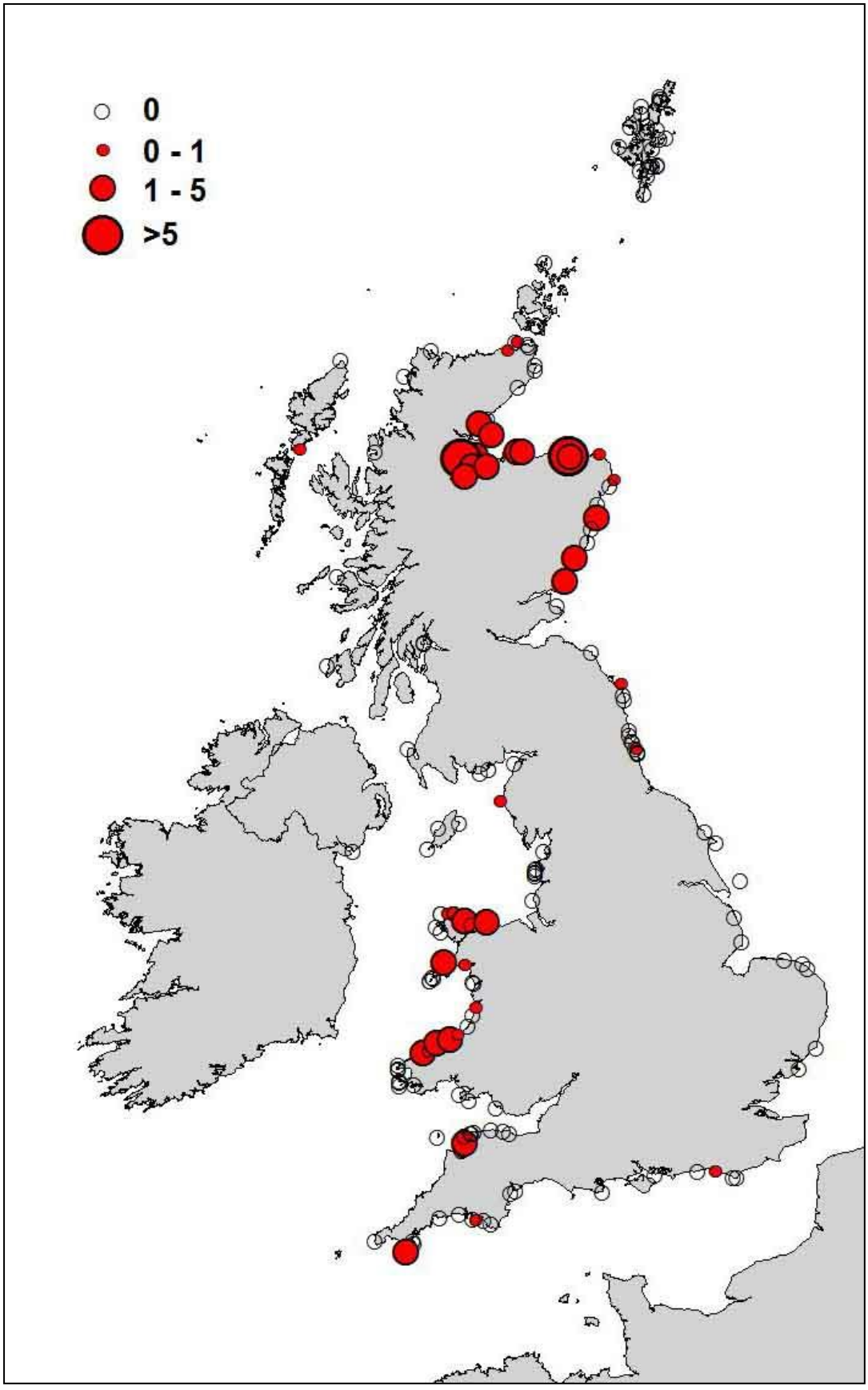


Figure 5 c. Map of bottlenose dolphin count rates (numbers of animals per hour effort) by site (for watches with 10-50h of total effort).

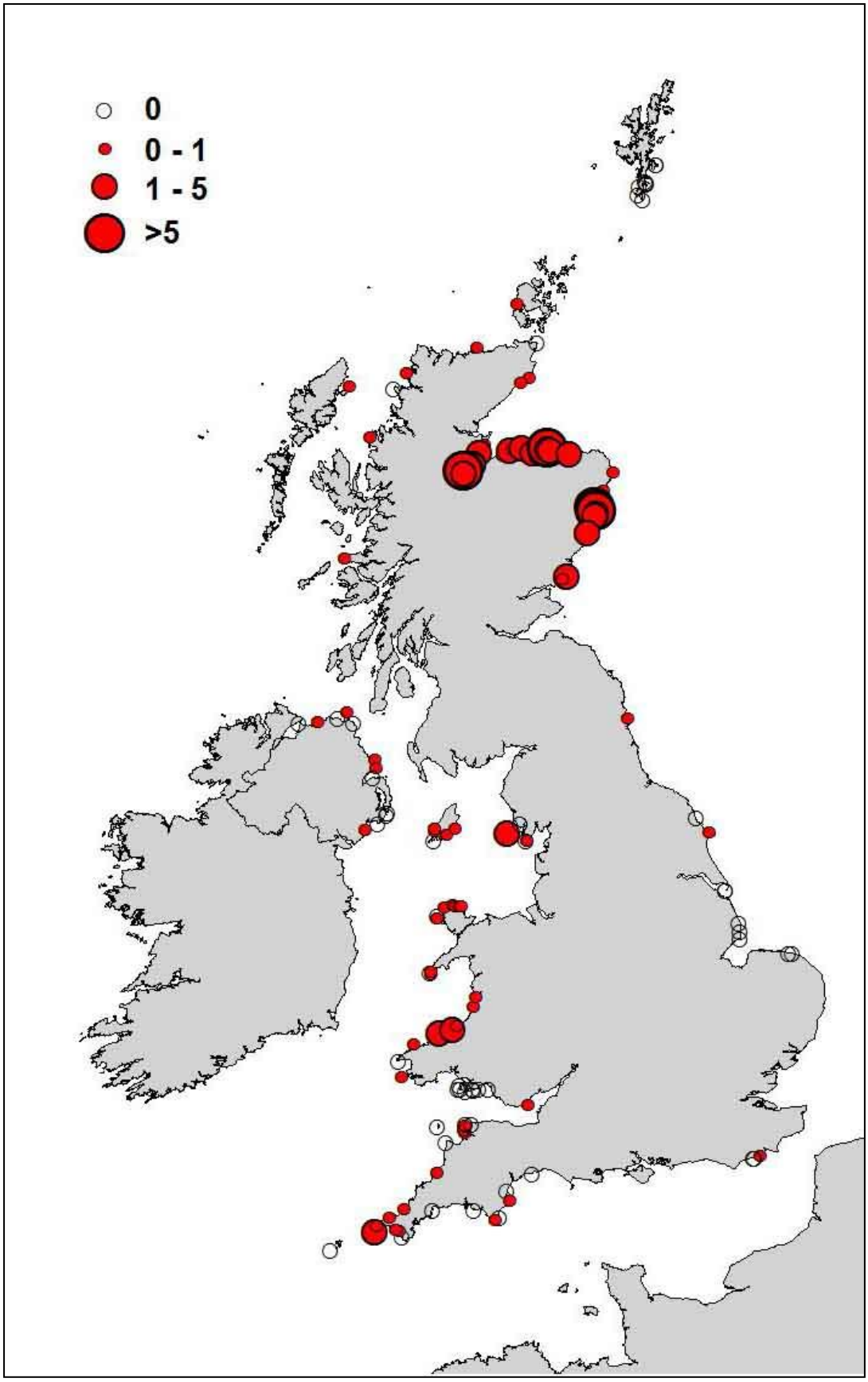


Figure 5 d. Map of bottlenose dolphin count rates (numbers of animals per hour effort) by site (for watches with >50h of total effort).

Table 1. List of sites with >5h effort (>100mins per year for 3+ yrs) and bottlenose dolphin count rates above 90th percentile. Note that this is based on raw data before effects of various explanatory variables have been taken into account. (SPUE = Sightings Per Unit Effort; CPUE = Count of animals Per Unit Eeffort)

Site No	MU	Site name	Region	Effort hrs	SPUE	CPUE
126.1	ECS	North Kessock	Highland	205.1	2.72	7.52
145.2	ECS	N. of Portknockie Harbour	Moray	233.1	0.45	5.45
170.1	ECS	Donmouth	Aberdeenshire	80.8	0.68	5.72
170.3	ECS	Aberdeen Harbour	Aberdeenshire	230.0	1.23	11.37
170.4	ECS	Aberdeen Torry Battery	Aberdeenshire	423.4	1.31	11.52
172	ECS	Nigg Bay	Aberdeenshire	18.0	0.89	4.67
187	ECS	Montrose	Montrose	6.3	0.32	4.42
207	NS	Cresswell	Northumberland	74.9	0.01	0.05
280	CSW	Berry Head	South Devon	250.5	0.04	0.16
328	CSW	Cape Cornwall	Cornwall	3774.0	0.04	0.45
329	CSW	St. Ives Bay	Cornwall	573.0	0.17	0.90
333	CSW	St Agnes Head	Cornwall	89.4	0.07	0.51
401.1	CSW	Dinas Head	Pembrokeshire	17.5	0.23	1.26
406.1	IS	Aberporth A	Ceredigion	77.4	0.39	0.96
406.2	IS	Aberporth B	Ceredigion	673.6	0.23	0.63
409	IS	Mwnt	Ceredigion	1569.1	0.40	1.66
411	IS	Ynys Lochtyn	Ceredigion	360.3	0.26	0.99
413.4	IS	New Quay Headland	Ceredigion	2097.8	0.22	0.70
455	IS	Moelfre	Anglesey	11.0	0.09	2.00
516.2	CWSH	Melvaig, Gairloch	Highland	214.9	0.01	0.18
536	CWSH	Tiumpan Head	Outer Hebrides	199.6	0.04	0.24
542	CWSH	Rathlin Island	Co. Antrim	73.2	0.01	0.27
544	CWSH	Ramore Head	Co. Antrim	297.1	0.01	0.16

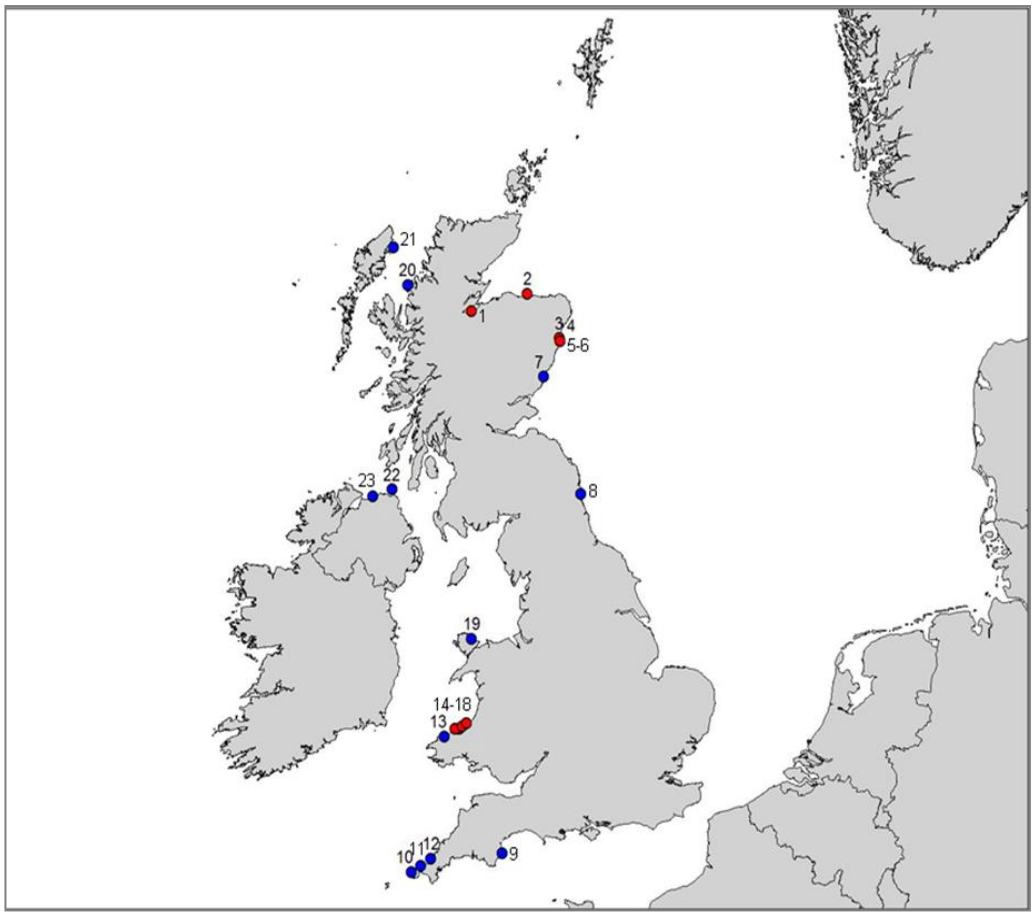


Figure 6. Sites with bottlenose dolphin counts per hour above 90th percentile threshold: 1=North Kessock; 2=N of Portnockie; 3=Donmouth; 4=Aberdeen Harbour; 5=Torry Battery; 6=Nigg Bay; 7=Montrose; 8=Cresswell; 9=Berry Head; 10=Cape Cornwall; 11=St. Ives Bay; 12=St Agnes Hd; 13=Dinas Hd; 14=Aberporth A; 15=Aberporth B; 16=Mwnt; 17=Ynys Lochtyn; 18=New Quay Head; 19=Moelfre; 20=Melvaig, Gairloch; 21=Tiumpan Head; 22=Rahlin Island; 23=Ramore Head (red=sites also >90percentile GAM predictions; blue=other sites).

Modelling results

For both species, results for 1994-2014 is firstly described, based on models which (A) use latitude and longitude and (B) treat the coastline as a continuous linear feature. The authors then compare results with those for other models. Further details appear in Appendix 4.

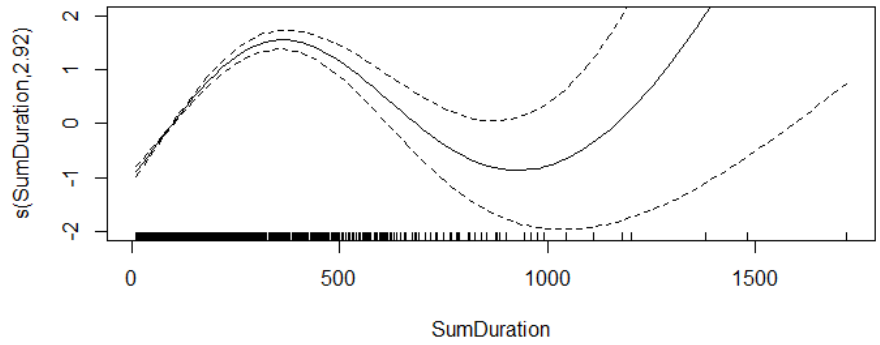
The 1994-2014 data for bottlenose dolphins used in the models are summarised below in Table 2.

Table 2. Summary of 1994-2014 sightings data for bottlenose dolphins. Figures are all-site summaries of site averages. Site averages in turn were averages of daily summaries (presence per day, average sightings rates across all effort codes in a day). Note that after excluding very short observations and high sea-states, and all data prior to 1994, only 592 sites are represented.

METRIC	PRESENCE	GROUPS/HOUR	ANIMALS/HOUR
Count	592	592	592
Mean	0.081	0.214	1.153
Median	0.000	0.000	0.000
Min	0.000	0.000	0.000
Max	1.000	8.952	72.000
90th Percentile	0.269	0.496	2.427

The final GAM for 1994-2014 data, using latitude and longitude to characterise location, includes effects of site elevation (constrained to follow a simple form) and area, effort type, observation duration (also constrained to follow a simple form), latitude and longitude, sea state, effort type, time of day, time of year, and year (for which the default limit of degrees of freedom was increased). Significant ($P<0.001$) smooth terms included duration, latitude and longitude, sea state, elevation, time of day, time of year and year.

Detection of cetaceans was lower for Effort type 2 than for Effort type 1 ($P=0.0115$), and for Area 1 than for Area 2 ($P<0.0001$, i.e. increasing the observation area increased detection of animals). The effect of duration was initially positive, but detection dropped again for very long watches (perhaps implying a lower efficiency of observations for long watches; multiple causes are possible). Detection of animals dropped slightly with increasing sea state, increased with elevation, and varied with time of day, time of year and year (all $P<0.0001$). The strongest effect on detection of bottlenose dolphins was location (note the high Chi-squared value, Appendix 4). Degrees of freedom associated with smoothers for time of day and time of year were high, indicating a relatively complex form, but this is plausible since no specific functional form was expected. The model explains 43% of ‘deviance’ (broadly equivalent to variance) in the occurrence of sightings, although this percentage comprises components due to effects of the environment on observers as well as those that may reflect dolphin site preferences. The forms of the fitted ‘smoothers’ are illustrated in Figure 7. Note that Figure 7b represents the spatial variation and emphasises the wide variation in sightings rate between the best and worse sites (while not being in a format such that these sites can be identified).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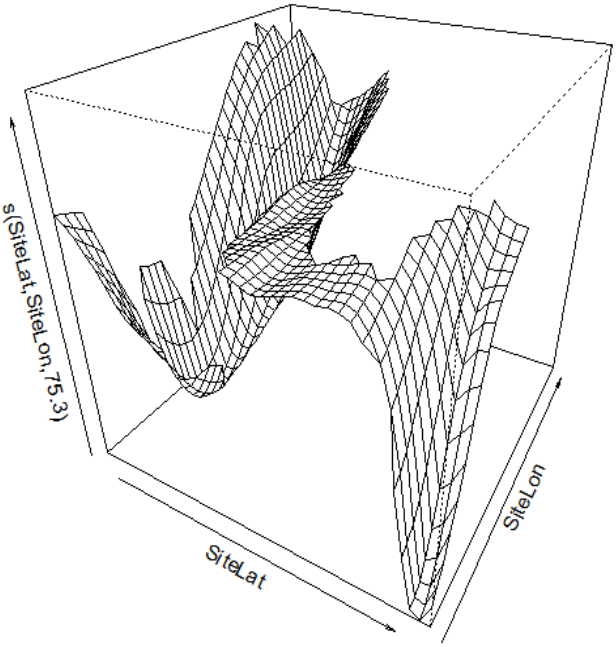
-2
0
500
1000
1500
SumDuration

a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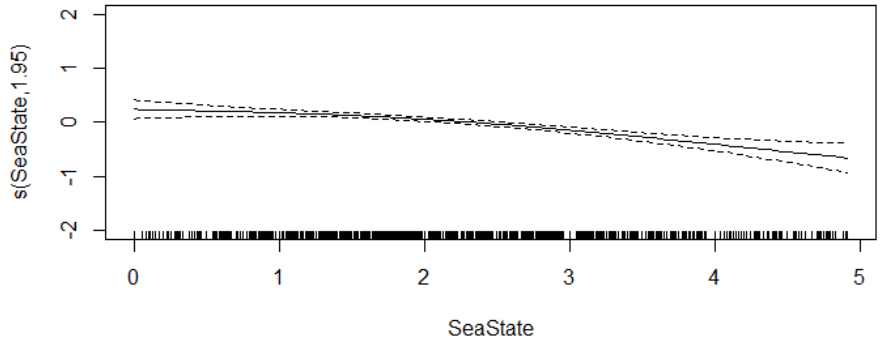
SiteLat
SiteLon

b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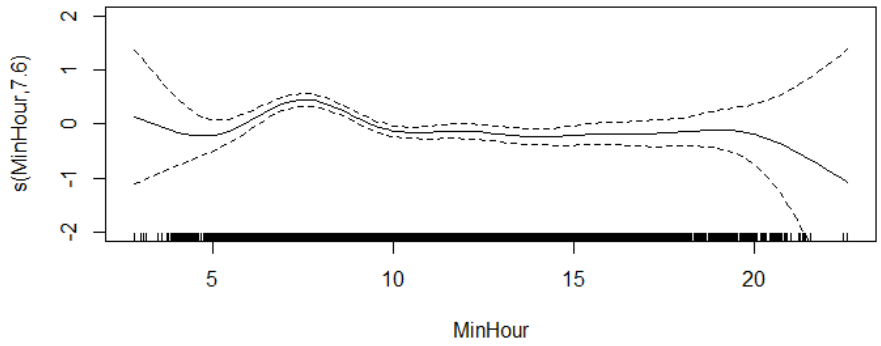
-2
0
1
2
3
4
5
SeaState

c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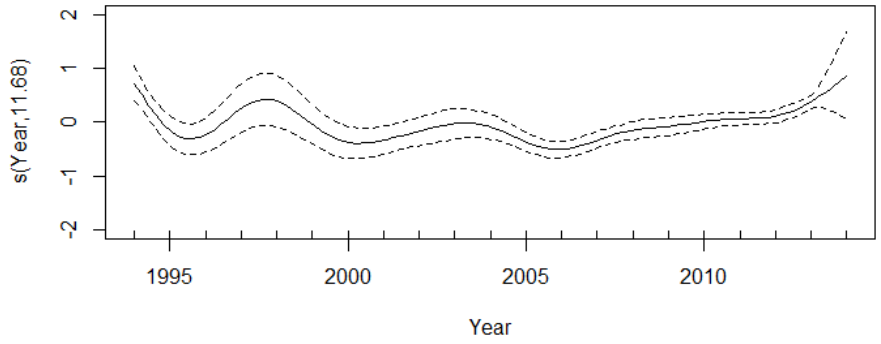
-2
5
10
15
20
MinHour

d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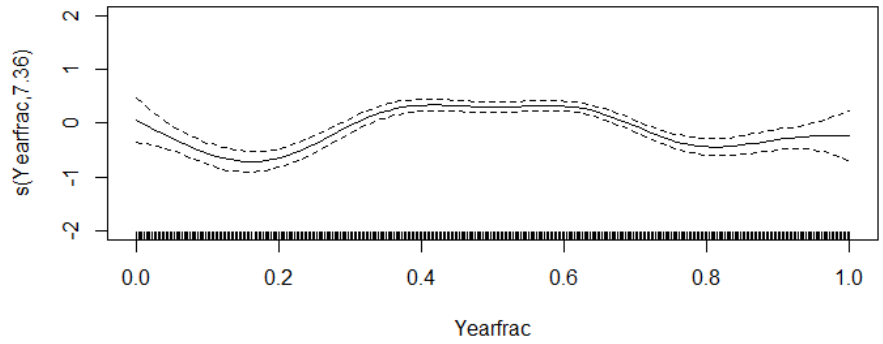
1
0
-1
-2
1995
2000
2005
2010
Year

e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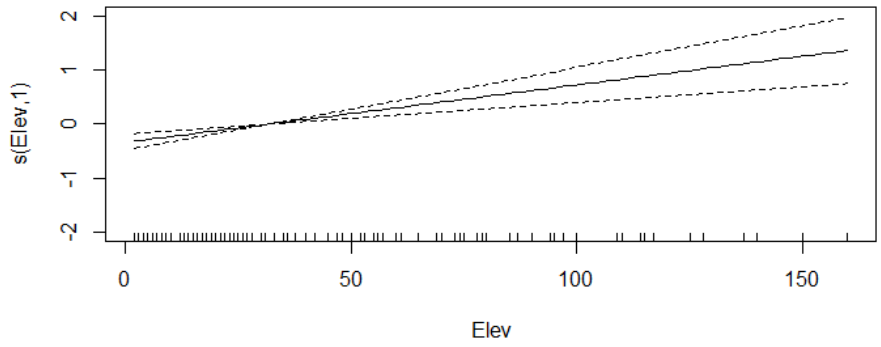
0.0
0.2
0.4
0.6
0.8
1.0
Yearfrac

f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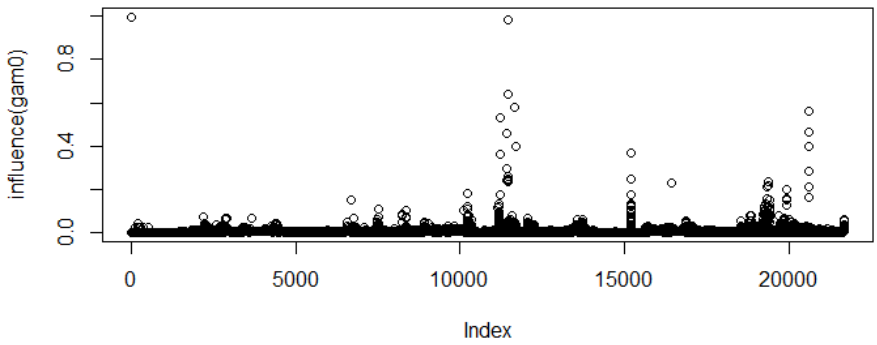
-1
-2
0
50
100
150
Elev

g



h

Figure 7. GAM graphical outputs.

a. Effect of duration on dolphin occurrence. Note the wide confidence limits for long durations, reflecting few data
b. Effect of latitude, longitude and their interaction; this is the spatial component of the fitted model
c. Effect of seastate
d. Effect of time of day
e. Effect of year. Note that there is significant annual variation in occurrence
f. Effect of time of year
g. Effect of elevation
h. Occurrence of influential data points: values above 1.0 are cause for concern; here two points approach but do not exceed this limit.

Model validation confirmed that there were no highly influential outliers or unusual patterns in residuals. Predicted occurrence, by site number for periods of 90 minutes of observation (i.e. approximately the average daily total period of observations) is shown in Figure 8, which highlights some of the limitations of the data. The upper part of the panel related to reliability of predictions. Gaps between the vertical lines are sites with too little data (according to the filter applied) while the solid blue area represents confidence in the data and shows that for some areas it is low or even zero. The lower panel shows the predicted probability of occurrence as well as filtered predictions at each site in relation to the 90th percentile. It makes clear that relatively few sites meet the conditions of the filter.

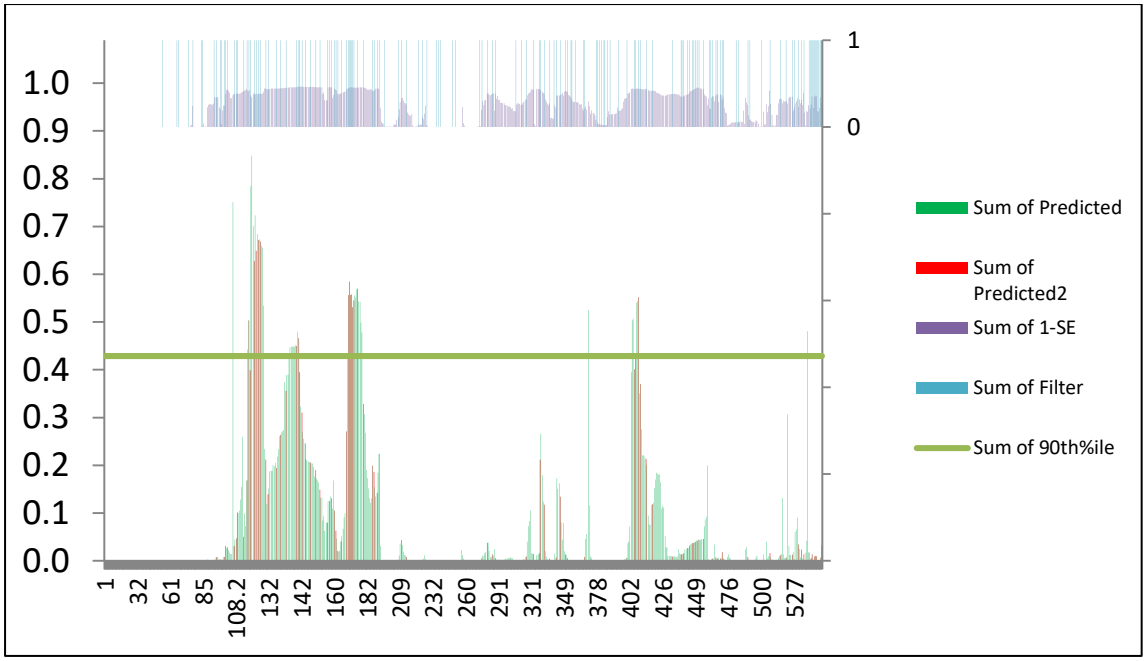


Figure 8. Illustration of GAM output: sites appear sequentially along the x axis while the left-hand y axis shows bottlenose dolphin occurrence. This figure is included to illustrate variability and reliability of the data and cannot be used to identify the best sites. The green lines ('all predicted') show the modelled occurrence values. Indications of their reliability appear at the top of the graph. The shaded purple area represents 1-SE (values shown on the right-hand y axis), so high values imply high statistical confidence in predictions and low values indicate low confidence. The blue lines at the top of the graph (right hand y axis) indicate sites with at least three years of 100+ minutes of observation. Using this as a filter generates the red lines (filtered predictions): occurrence values for sites with sufficient data. It can be seen that these sites usually also have relatively high values of 1-SE. The horizontal green line represents the 90th percentile for the filtered data. For mapping only the filtered data were used; furthermore, results were divided by MU so that sites can be identified.

The second model was fitted using site number instead of latitude and longitude to represent spatial variation. This has the advantage that it is in principle possible to compare results with those from a mixed model version of the GAM and with a version which includes an interaction with year (which are called Models B, C and D herein. Model B explained 39.5% of deviance. Visually, compared with Model A, differences between sites are somewhat smoothed out (see unfiltered data in Figure 8.). Filtered predictions are also broadly similar although Model B appears to be slightly more conservative (see filtered data illustrated in Figure 9, also Appendix 4).

For the dataset 1994-2014, the mixed model (C) did not converge. The model with site by year interaction (Model D) reveals how bottlenose dolphin occurrence has shifted from year to year. The smooth surface for the site number-year interaction effect suggests that there are sites where occurrence has declined over the years although spatial variation in occurrence remains more important than interannual variation. Further analysis would be needed to confirm the identity of the sites where a decline occurred, but findings are consistent with results presented in Table 3, which suggests that some sites that were important early in the time series became less important later on.

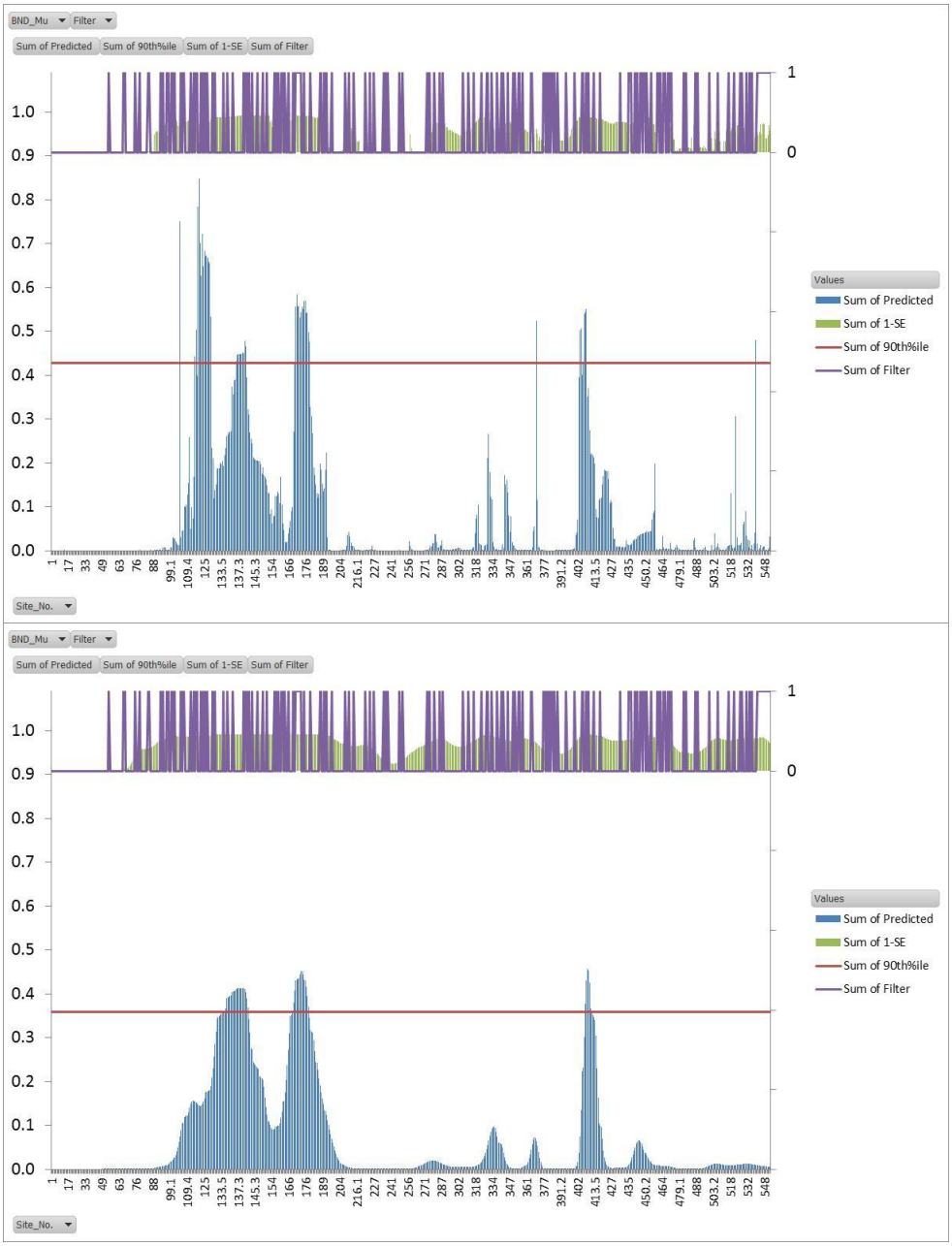


Figure 9. GAM predictions for bottlenose dolphin occurrence during 1994-2014, using Models A (based on latitude and longitude, above) and B, which treats the coast as a linear feature with site number representing position along the coast (below). Unfiltered results. As in Figure 8, occurrence figures appear in the lower part of each panel, confidence measures in the upper part and the horizontal line is the 90th percentile for the filtered data.

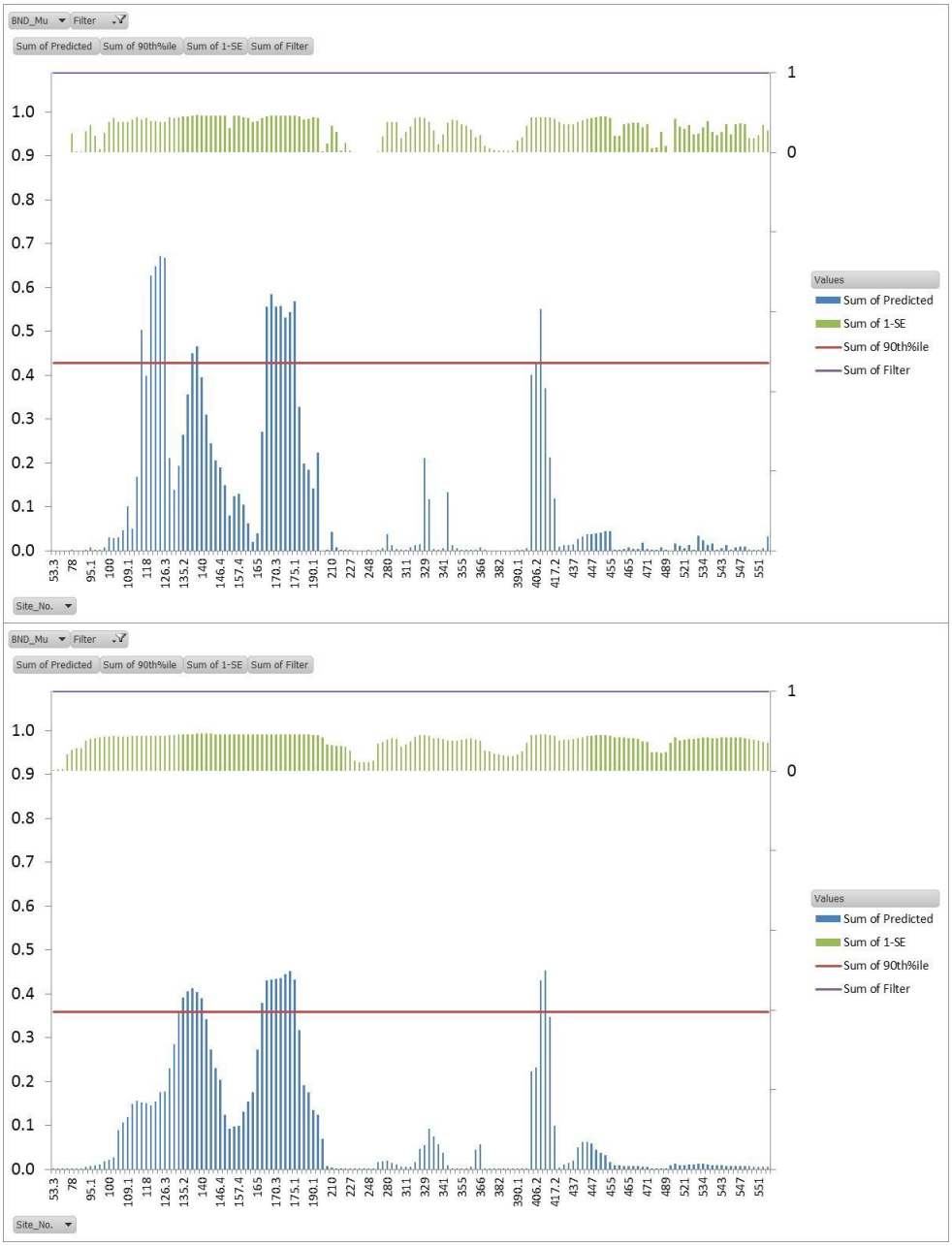


Figure 10. GAM predictions for bottlenose dolphin occurrence during 1994-2014, using Models A (based on latitude and longitude, above) and B, which treats the coast as a linear feature with site number representing position along the coast (below). Filtered results. Note that the occurrence at sites with numbers in the approximate range 110-130 is rather lower in Model B. As in Figure 8, occurrence figures appear in the lower part of each panel, confidence measures in the upper part and the horizontal line is the 90th percentile for the filtered data.

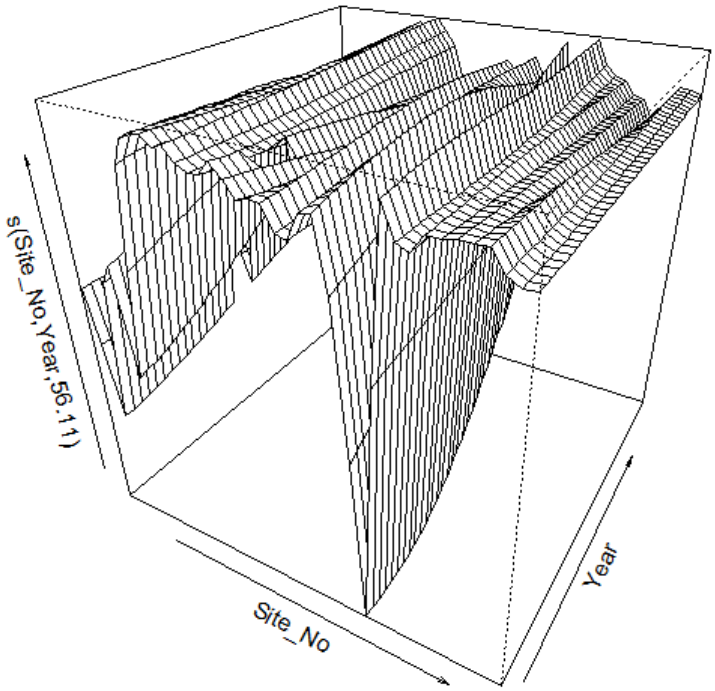


Figure 11. 'Smoother' for combined effect of site number and year on bottlenose dolphin occurrence 1994-2003. The vertical axis shows the effect on probability of occurrence, which is much more variable along the site axis than it is along the year axis. Thus, overall shape of the surface suggests that interannual variation is small compared to spatial variation. Furthermore, the similarity of the year-to year trend across sites suggests relatively little temporal variation in spatial pattern of occurrence. However, for a few sites there appears to be a downward trend over times, providing evidence that the importance of some sites has declined over the years.

Models were also fitted for the time periods 1994-2003, 2004-2014, and 1965-1993. Further details appear in the appendices. While there is broad similarity in the sites identified by all models, it is noticeable that certain locations with high occurrence are identified only for the earlier years in the series (see Table 3).

For the 1994-2003 dataset, it was possible to run a mixed model version of Model B (i.e. Model C). The R2 value for the GAM part of this model was slightly lower than that for the B model (0.28 as compared to 0.314). The graphical outputs are compared in Figures 11 and 12.

In this case, Models B and C both picked out five sites: Hopeman, Portessie, Spey Bay A or B, Portgordon were selected by both models. The 5th site for Model B was New Quay Headland whereas it was Findhorn Bay for Model C. These differences between models imply the need for some caution in choosing the cut-off percentile, but the similarity of the GAMM and GAM outputs is encouraging.

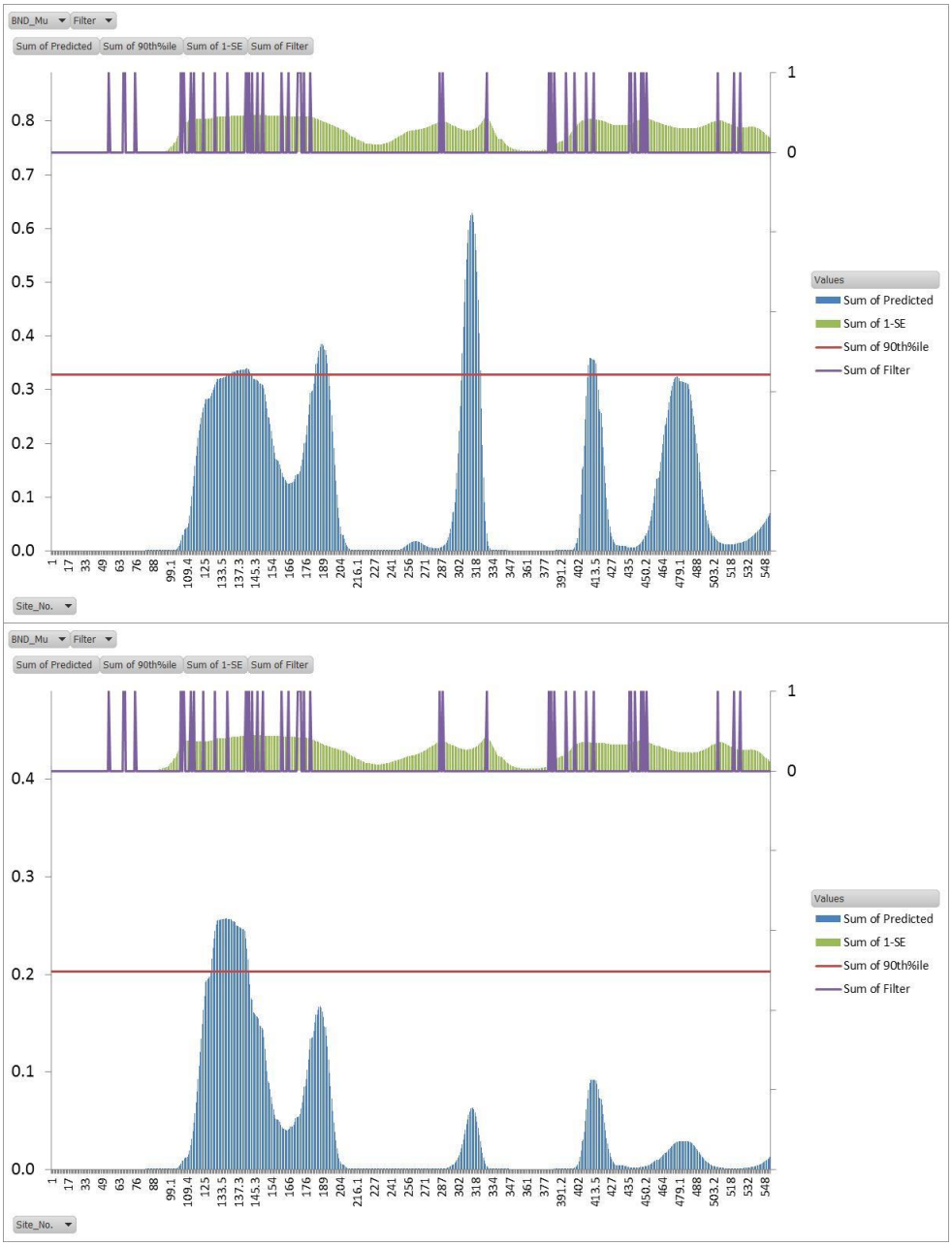


Figure 12. GAM and GAMM predictions for bottlenose dolphin occurrence during 1994-2014, using Models B (the GAM based on site number, above) and C (the GAMM, which adds a variance structure to account for autocorrelation within runs of consecutive days of observation). Unfiltered results. As in Figure 8, occurrence figures appear in the lower part of each panel, confidence measures in the upper part and the horizontal line is the 90th percentile for the filtered data. Note that absolute values of occurrence are reduced in Model C.

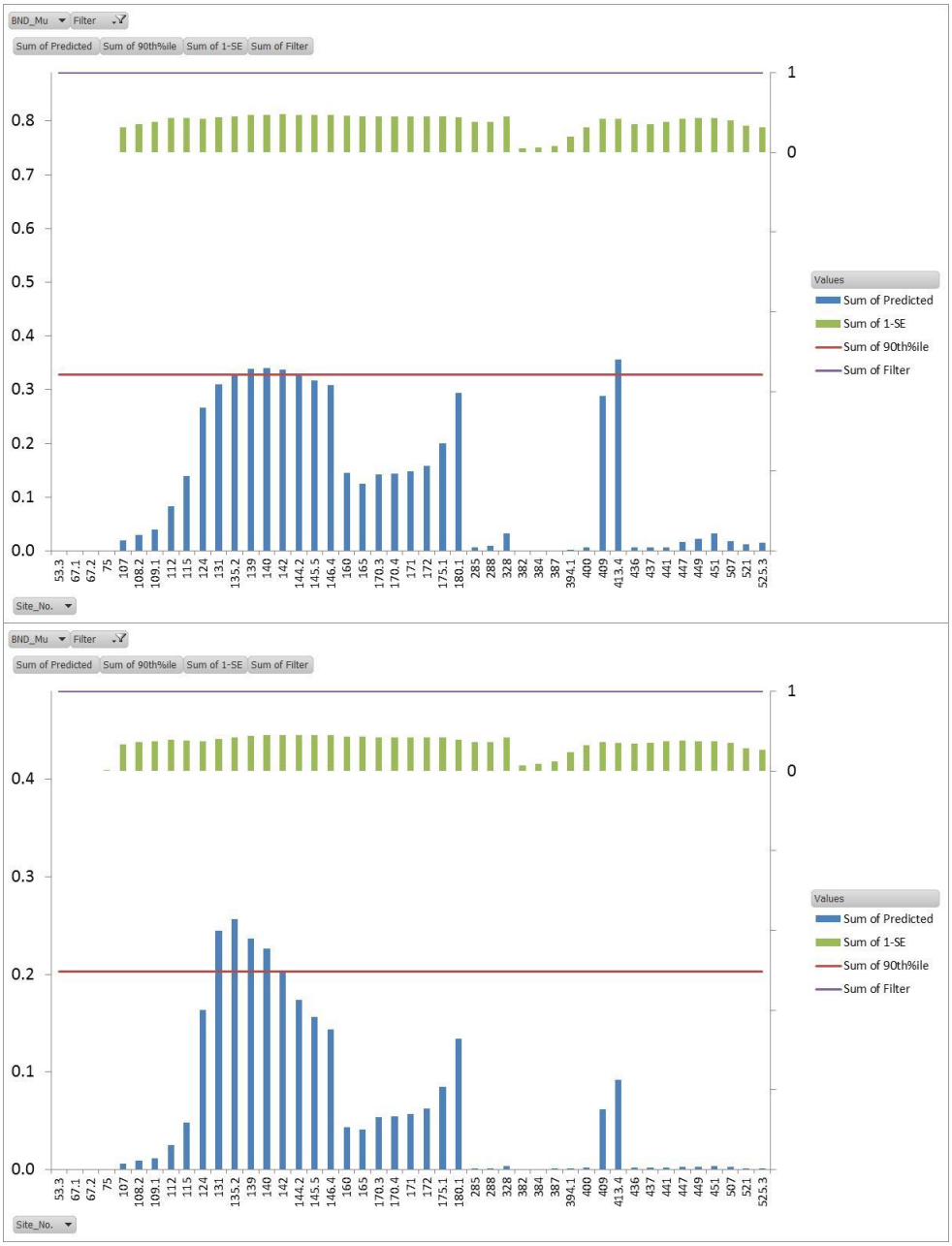


Figure 13. GAM and GAMM predictions for bottlenose dolphin occurrence during 1994-2014, using Models B (the GAM based on site number, above) and C (the GAMM, which adds a variance structure to account for autocorrelation within runs of consecutive days of observation). Filtered results. As in Figure 8, occurrence figures appear in the lower part of each panel, confidence measures in the upper part and the horizontal line is the 90th percentile for the filtered data. Note the broad similarity but that some different sites appear above the 90th percentile.

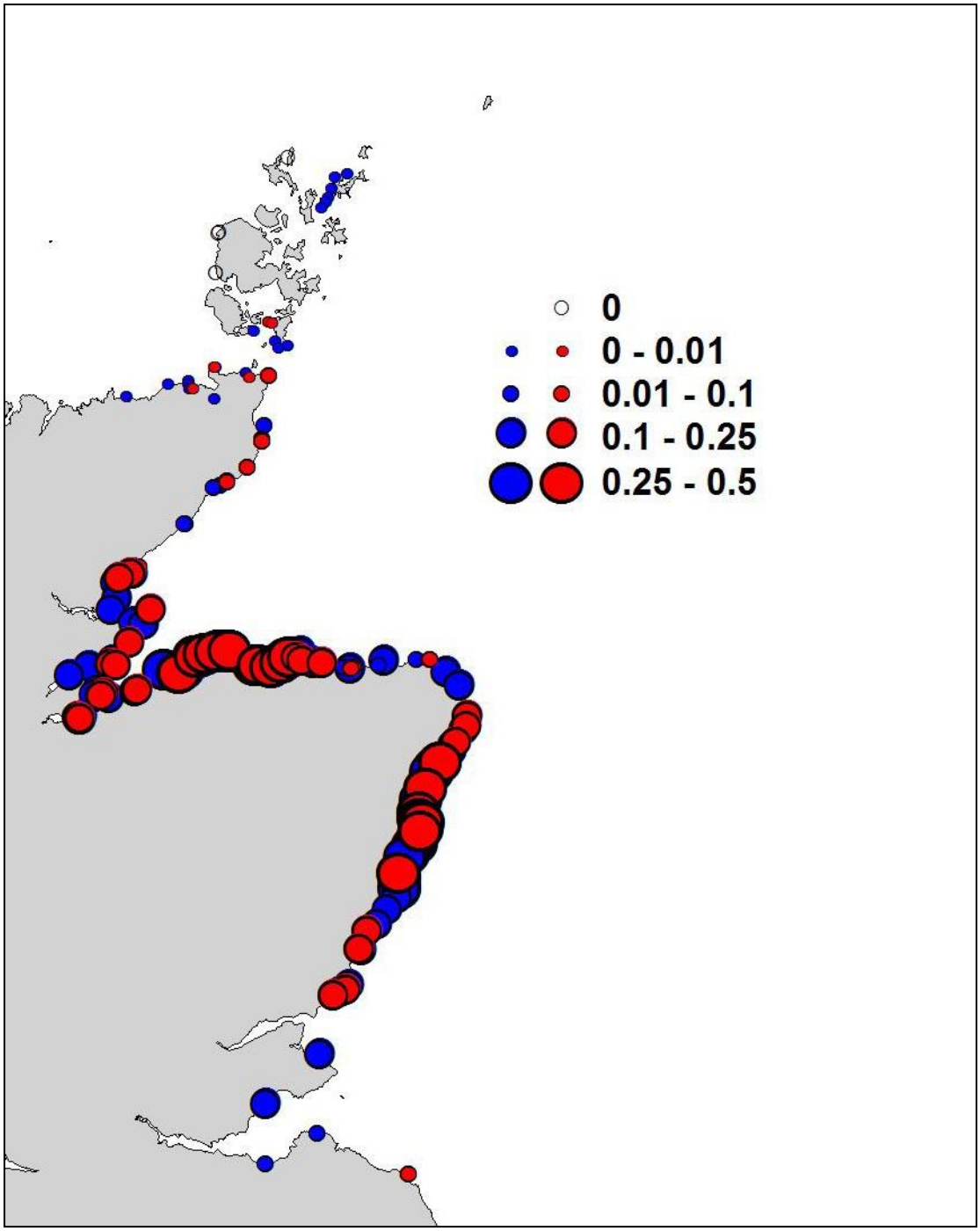


Figure 14 a. Map of GAM (by site number) predicted likelihood of occurrence for bottlenose dolphin East Coast Scotland management unit, 1994-2014 (red symbols = sites with >100mins effort for 3+ years; blue symbols = remaining sites).

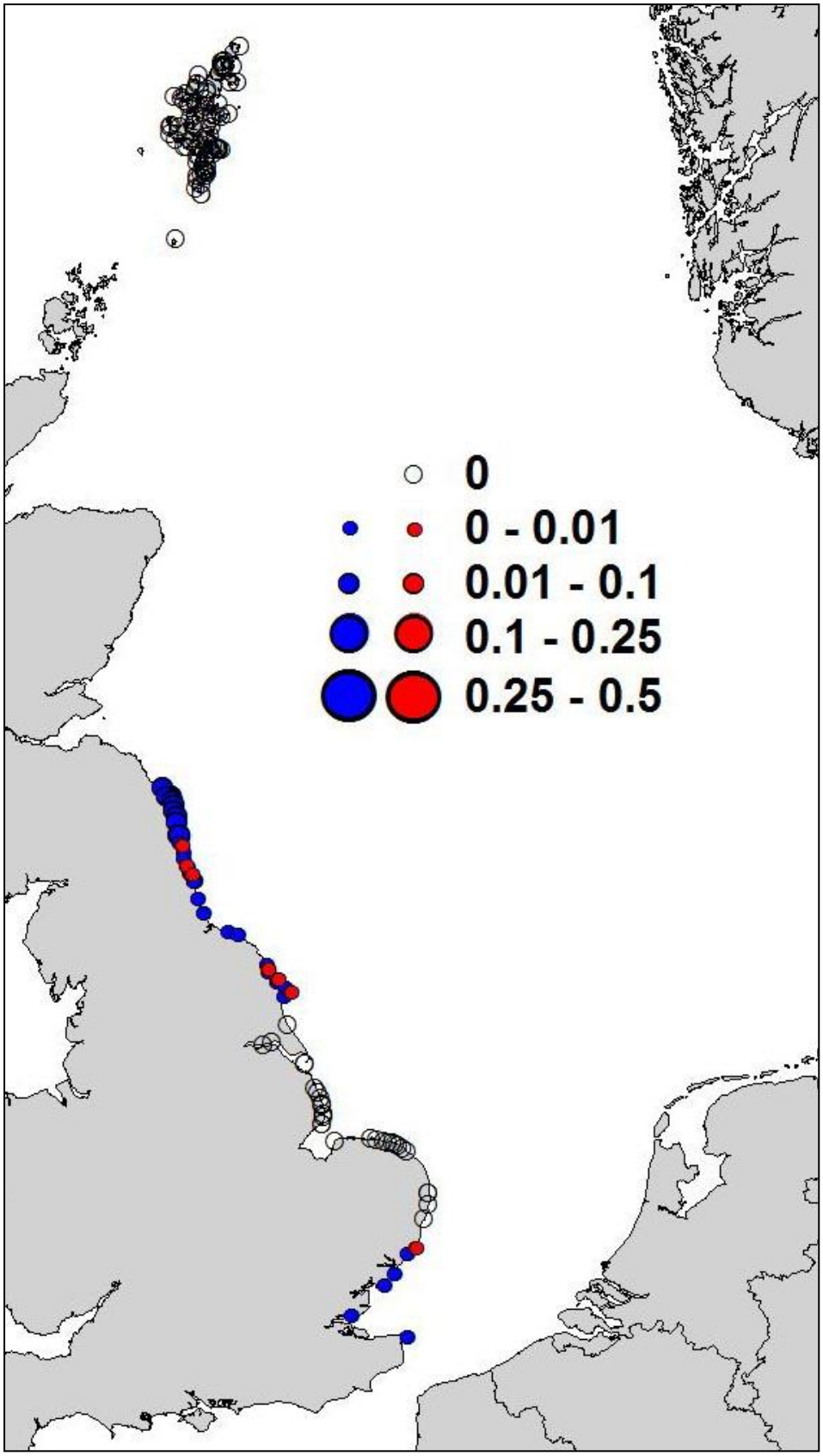


Figure 14 b. Map of GAM (by site number) predicted likelihood of occurrence for bottlenose dolphin North Sea management unit, 1994-2014 (red symbols = sites with >100mins effort for 3+ years; blue symbols = remaining sites).

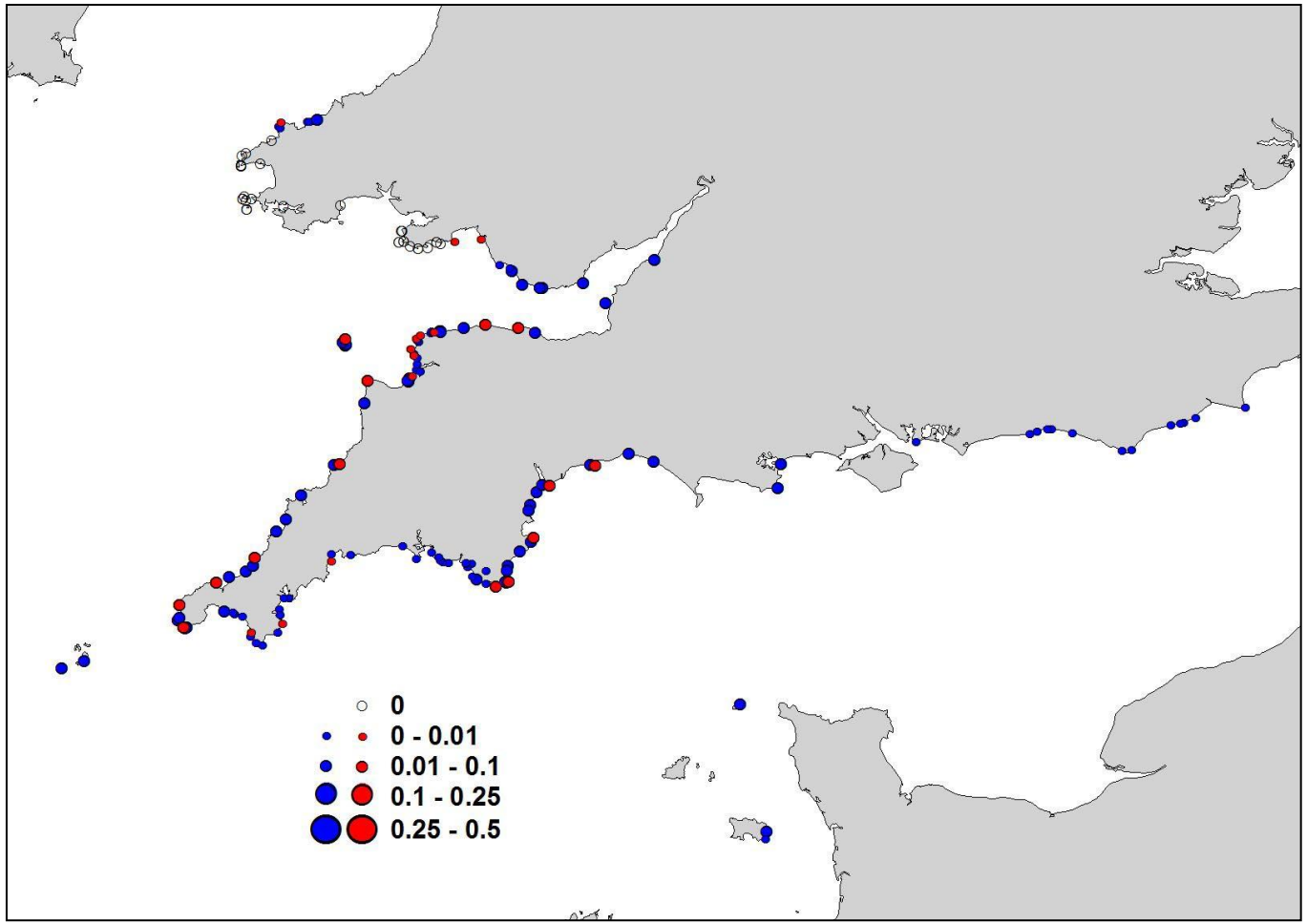


Figure 14 c. Map of GAM (by site number) predicted likelihood of occurrence for bottlenose dolphin Channel & SW England management unit, 1994-2014 (red symbols = sites with >100mins effort for 3+ years; blue symbols = remaining sites).

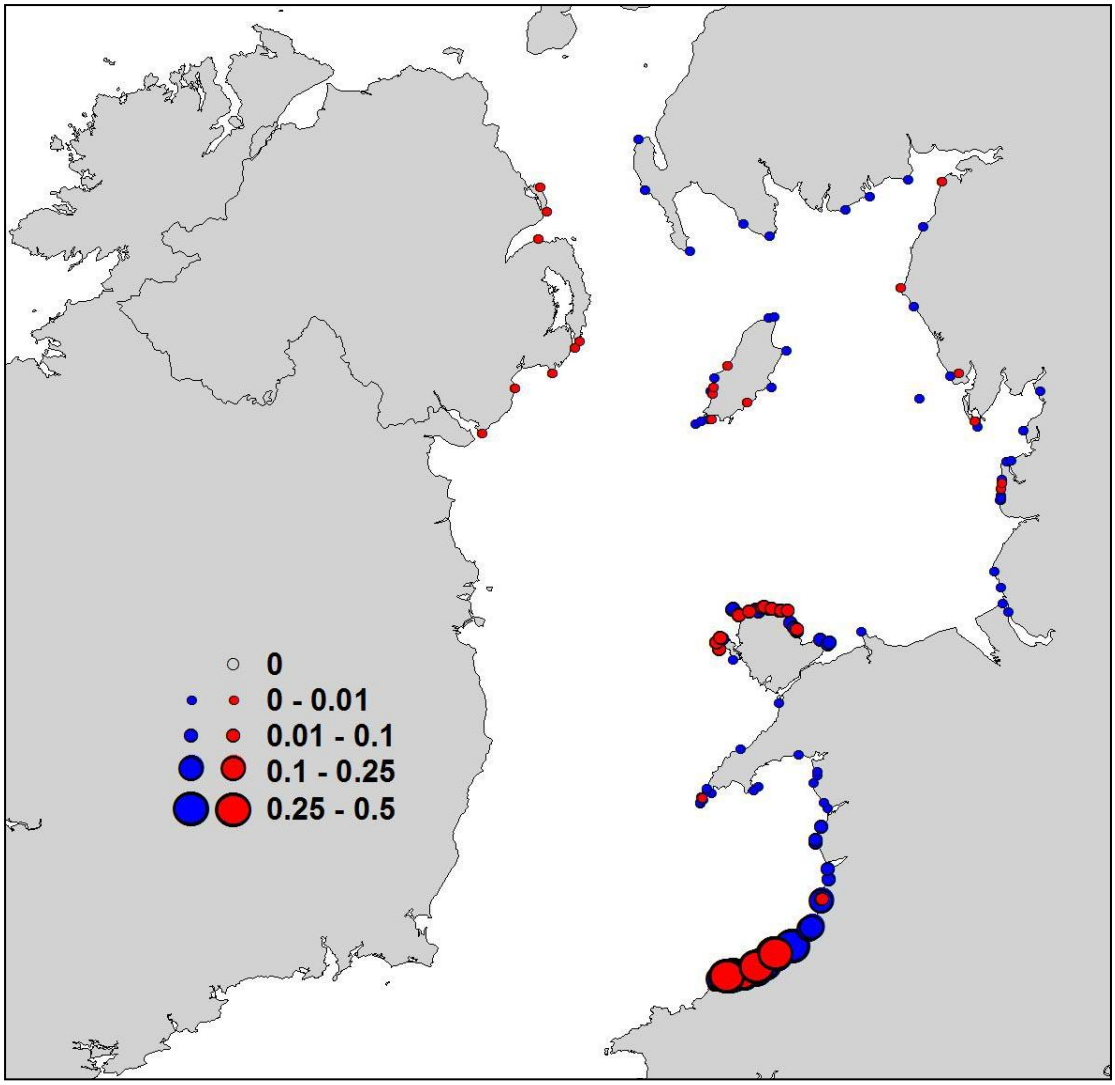


Figure 14 d. Map of GAM (by site number) predicted likelihood of occurrence for bottlenose dolphin Irish Sea management unit, 1994-2014 (red symbols = sites with >100mins effort for 3+ years; blue symbols = remaining sites).

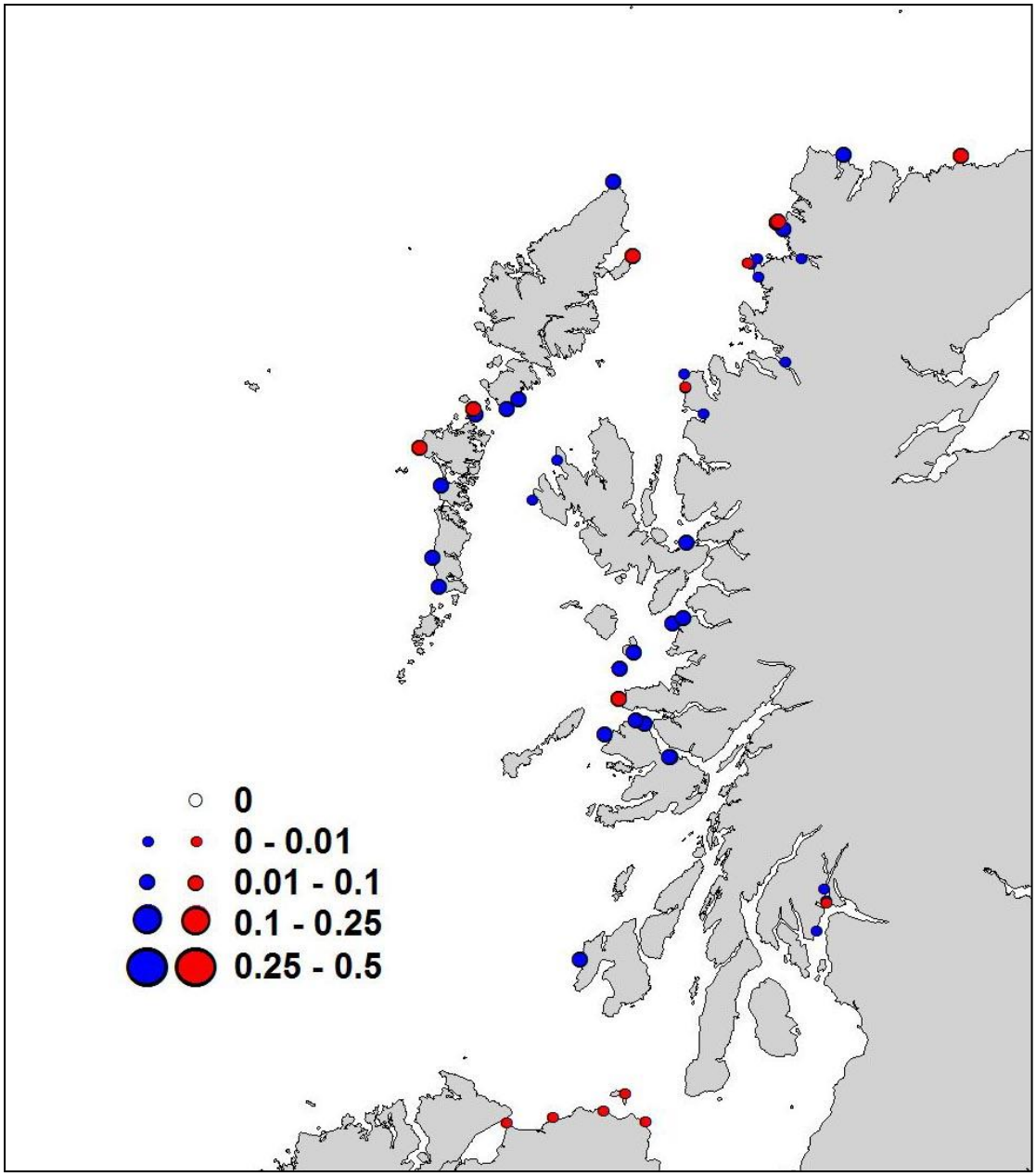


Figure 14 e. Map of GAM (by site number) predicted likelihood of occurrence for bottlenose dolphin West Coast Scotland & Hebrides management unit, 1994-2014 (red symbols = sites with >100mins effort for 3+ years; blue symbols = remaining sites).

Figure 14a highlights the relatively even distribution of East Coast Scottish bottlenose dolphins between Brora (north of the Dornoch Firth) and Carnoustie along the Angus coast. There are a few outlying sites to the north, with observations on the north-east Caithness coast. Further south, there has been limited land watch effort in Fife, which is probably why the well-known presence of the species in St Andrews Bay (Thompson *et al*, 2011; Cheney *et al*, 2013) shows up poorly here.

There is a general low likelihood of occurrence of the species within the North Sea management unit (Figure 14b). Although bottlenose dolphins occur occasionally in this region, this accords with our general knowledge of the species (Reid *et al*, 2003; Evans *et al*, 2003).

The Channel and South-west England management unit has a relatively low likelihood of occurrence, mainly around the South-West Peninsula (Figure 14c).

The importance of southern Cardigan Bay, west Wales, to bottlenose dolphins is reflected in the likelihood of occurrence prediction map for the Irish Sea management unit (Figure 14d), although the known presence of the species in northern Cardigan Bay and around the Llŷn Peninsula (Baines & Evans, 2012; Feingold & Evans, 2014) is likely to be under-estimated due to limited land watch effort there. The north and east coasts of Anglesey, particularly Red Wharf Bay, is also highlighted. Elsewhere, the species occurs around the Isle of Man, and at sites along the Cumbrian coast to the east, and in Counties Down and Antrim in Northern Ireland to the west.

The coastal West Scotland & Hebrides management unit has very limited long-term coverage, and the only area with a relatively high prediction is on the west coast of North Uist (Figure 14e). Elsewhere, the species is recorded at sites along the County Antrim coast, Northern Ireland, and at scattered locations along the west mainland coast of Scotland. These results accord with our knowledge from offshore surveys, with low numbers of the species ranging around the Hebrides (Evans, 1997b; Reid *et al*, 2003; Evans *et al*, 2003). The small resident population that inhabits the Sound of Barra (Grellier & Wilson, 2003) is not identified here due to lack of land watch effort in that area.

Using the 90th percentile threshold for likelihood of occurrence, the GAM predictions yielded 28 sites (using one or other model over one or more time periods) (Table 3; Figure 15). Of those sites, 16 were in the Moray Firth, eight along the east Grampian coast, and four in southern Cardigan Bay. Although these encompass the best-known areas for the species in Scotland (Thompson *et al*, 2011), as a result of low land watch effort north of New Quay, they omit large areas of northern Cardigan Bay that are known to be important for the species (Baines and Evans, 2012; Feingold and Evans, 2014).

Table 3: Sites (shown in red) with Bottlenose Dolphin likelihood of occurrence above 90th percentile threshold from GAMs (model A = lat x long; model B = site no.), and filtered by effort (at least three years each with at least 100 mins of effort)

Site name	Model A: 1965-1993	Model B: 1965-1993	Model A: 1994-2003	Model B: 1994-2003	Model A: 2004-2014	Model B: 2004-2014	Model A: 1994-2014	Model B: 1994-2014
Cromarty								
South Sutor								
Fort George								
Chanonry Pt								
N Kessock								
Kessock Bridge								
Burghead								
Hopeman								
Covesea								
Lossiemouth								
Spey Bay								
Portgordon								
Portessie								
N of Portnockie Hbr								
Portnockie								
Cullen								
Balmedie								
Donmouth								
Aberdeen Beach								
Aberdeen Harbour								
Torry Battery								
Girdleness								
Nigg Bay								
Souter Head, Cove								
Aberporth A & B								
Mwnt								
Ynys Lochtyn								
New Quay Head								

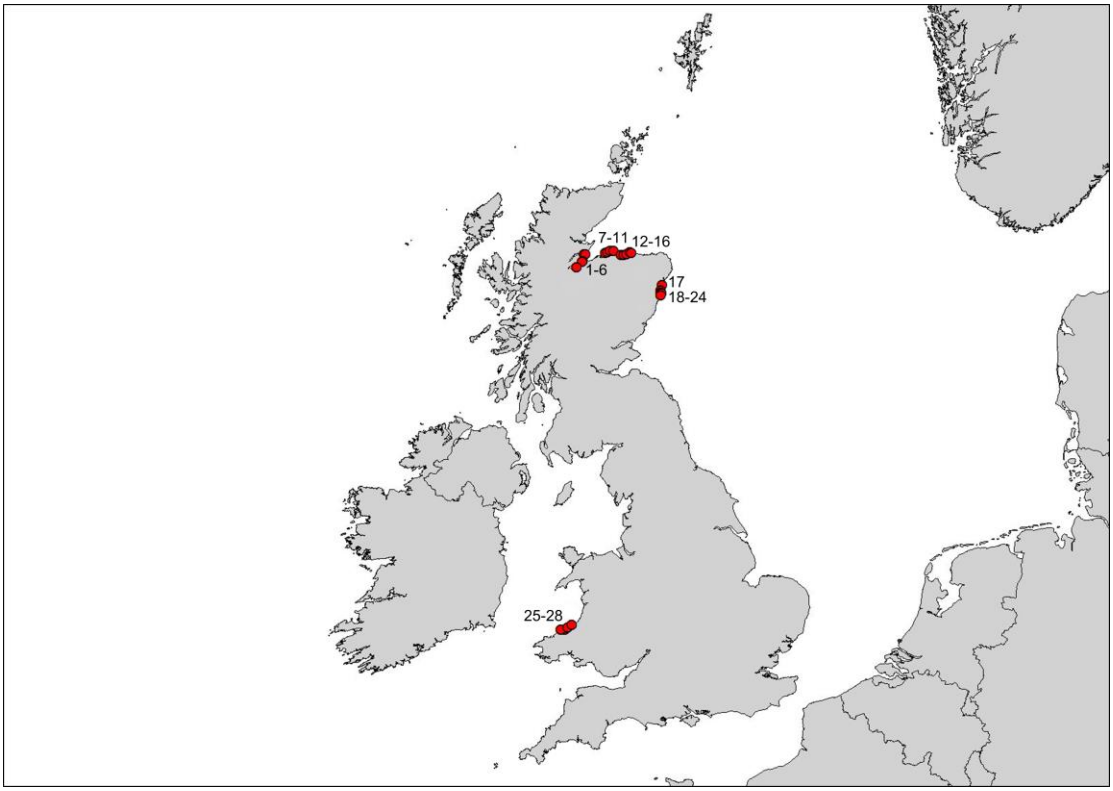


Figure 15. Sites with Bottlenose Dolphin likelihood of occurrence above 90th percentile threshold from GAMs (1=Cromarty; 2=South Sutor; 3=Fort George; 4=Chanonry Point; 5=Kessock Bridge; 6=North Kessock; 7=Burghead; 8=Hopeman; 9=Covesea; 10=Lossiemouth; 11=Spey Bay; 12=Portgordon; 13=Portessie; 14=N of Portnockie Harbour; 15=Portnockie; 16=Cullen; 17=Balmedie; 18=Donmouth; 19=Aberdeen Beach; 20=Aberdeen Harbour; 21=Torry Battery; 22=Girdleness; 23=Nigg Bay; 24=Souter Head, Cove; 25=Aberporth; 26=Mwnt; 27=Ynys Lochtyn; 28=New Quay Head

5.3 Harbour porpoise

A plot of sightings rates (number of sightings per hour effort) shows the widespread distribution of harbour porpoise around the British Isles (Appendix 2: Figure A2.2a-d). For the 678 sites around the UK, the average sighting rate was 0.38 sightings per hour, with a range of 0 to 6.5 sightings per hour. Highest rates occur in Shetland. However, those were derived from dedicated land watch effort in the 1990s and there has been very little such effort since then. Opportunistic sightings and offshore effort indicate that the species has become much less common in the region since the 1990s, probably due to the collapse of sandeel stocks there which has also had a profound effect on seabird breeding success in the region (Evans, 1997a; Rindorf *et al*, 2000; Evans *et al*, 2003; Hammond *et al*, 2013; Sea Watch unpublished data). Other areas where relatively high sightings rates occur include north-west Scotland, east Grampian region, North Yorkshire and East Riding, west Pembrokeshire, the western end of the Llŷn Peninsula, and around Anglesey (Appendix 2; Figure A2.2a-d).

Count rates (number of animals per hour effort) highlight two areas in particular: 1) the southern part of Shetland, and 2) west Pembrokeshire (Figure 16). As noted earlier, the relative importance of the species in the first of these areas has almost certainly diminished over the last decade. Porpoises off the west coast of Scotland and around the Hebrides are clearly under-represented by land watches, as

indicated from vessel surveys and opportunistic sightings (Reid *et al*, 2003; Evans *et al*, 2003; Marubini *et al*, 2009; Booth, 2010; Embling *et al*, 2010).

Average count rates for the 678 sites around the UK was 1.11 animals per hour, with a range of 0 to 73.8 animals per hour. Figure 16 shows count rates at sites partitioned by varying levels of effort, and Table 4 gives details of those sites with high values. Several of the locations with high sightings rates also had high count rates. Consistently high count rates (>3.0 animals/h) were observed in east and south Shetland, notably at Fethaland, Tresta on Fetlar, Skaw on Whalsay, Bressay Broch, Noss Sound and the Isle of Noss, Mousa Sound, Noness, St Ninian's Isle, Boddam, Quendale Bay, and Sumburgh Head. Most of these were based on >25h of effort.

Although several sites in Orkney had a regular porpoise presence, only The Wing in North Ronaldsay had a high count rate (11.0/h) but that was based on just 1h of effort. All other Orkney sites had count rates of 2.0/h or less.

In north Caithness, average count rates of *c* 3-4 animals/h occurred at Scrabster Lighthouse (>9h total effort) and St John's Point, Gills Bay (>10h effort), and on the northeast coast, Shelligoe Clifftop (*c*5h effort), Brora (>25h effort), Strathsteven (>15h effort), and Golspie (>10h effort) all had count rates of 3-5 amimals/h. On the south side of the Dornoch Firtth, count rates at Dornoch (*c*3h effort), Tarbat Ness (>30h effort), and Rockfield (5h effort) all exceeded 3 animals/h. The inner Moray Firth had consistently low count rates (<1 animal/h) as did the southern shores of the outer Moray Firth including north Aberdeenshire (<2 animals/h), with the exception of Covesea with 3.4 animals/h (*c*30h effort). On the east Aberdeenshire coast, high count rates (3.2-7.8 animals/h) occurred at Collieston (>100h effort), Newburgh (>10h effort), Balmedie (>45h effort), Cove (*c*100h effort), and Downie Point, Stonehaven (*c* 3h effort). Count rates were then low (1 animal/h or less) until Souter, Sunderland (3.7 animals/h, but based on only 3h effort), Scarborough (4.2 animals/h with >500h effort) and Filey Bay (4.6 animals/h; *c*4h effort) in north Yorkshire. Although slightly elevated at Bempton and Flamborough (*c*1.5 animals/h at both, with >40h effort), count rates remained low (generally *c*0.2 animal/h) at all sites in eastern England south to the Thames Estuary (except Blakeney Point with 1.7 animals/h, but with just 3h effort), and westwards along the south coast only increasing somewhat from Start Point (1.4 animal/h) in south Devon. The only site on the south coast with a high count rate (3.7 animals/h) was Warren Point, south Devon (*c*15h effort), count rates at sites in south Cornwall being all <2 animals/h.

In north Cornwall, Stepper Point near Padstow had an extremely high count rate (73.8 animals/h), but based upon just 3h effort and presumably the result of unusual conditions leading to an aggregation of porpoises. Along the north Devon coast, Hartland Point (>75h effort), Baggy Point (>350h effort), and Morte Point (*c*400h effort) all had high count rates (3-5 animals/h). Count rates at Lundy Island were between 1-2.5 animals/h (*c*90h effort overall).

Further east into the Bristol Channel, count rates were consistently around 1-2 animals/h, except at High Veer Point where 4.5 animal/h (but based on just 2h effort). Sites along the south coast of Wales had count rates of 1-2 animals/h, except Paviland on the Gower Peninsula with 3.2 animals/h (but based on only 2.5h effort). The islands of Skomer and Skokholm had count rates of 1-2 animals/h (effort >30h for both islands).

On the north Pembrokeshire coast, sites had high count rates (3-6 animals/h), notably at Ramsey Sound (>350h effort), Strumble Head >500h effort), and Needle

Rock, by Dinas Head (but with <3h effort). The coast surrounding Cardigan Bay had low count rates of porpoises (<0.5 animal/h) until the western end of the Llŷn Peninsula where Bardsey Island (particularly overlooking Bardsey Sound) (>150h effort) has a very high count rate (10 animals/h).

In North Wales, count rates are high (3-5 animals/h) around Anglesey at North Stack (>50h effort), Llanbadrig (>35h effort), and Point Lynas (>2,000h effort), and 1-3 animals/h at north coast sites in between. The east side of Anglesey and northeast mainland coast of Wales have low count rates (<1 animal/h).

Further north, sites in the Isle of Man generally had count rates around 1 animal/h, being high (5.7-10.9 animals/h only at Elby Point, Ballaghennie, and Point of Ayre (but all three sites with <5h effort).

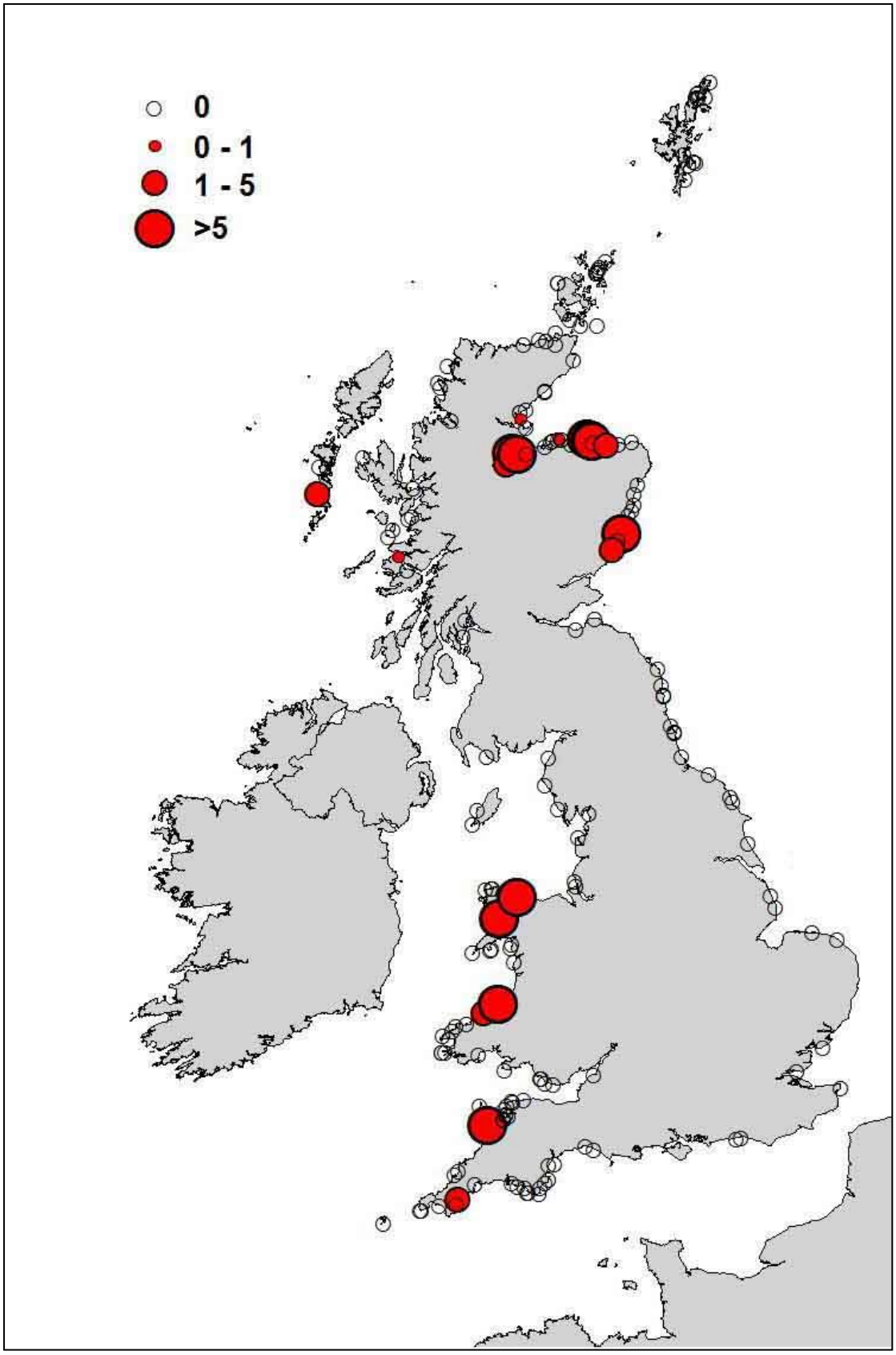


Figure 16 a. Map of harbour porpoise count rates (number of individuals per hour effort) by site (for watches with <3h of total effort).

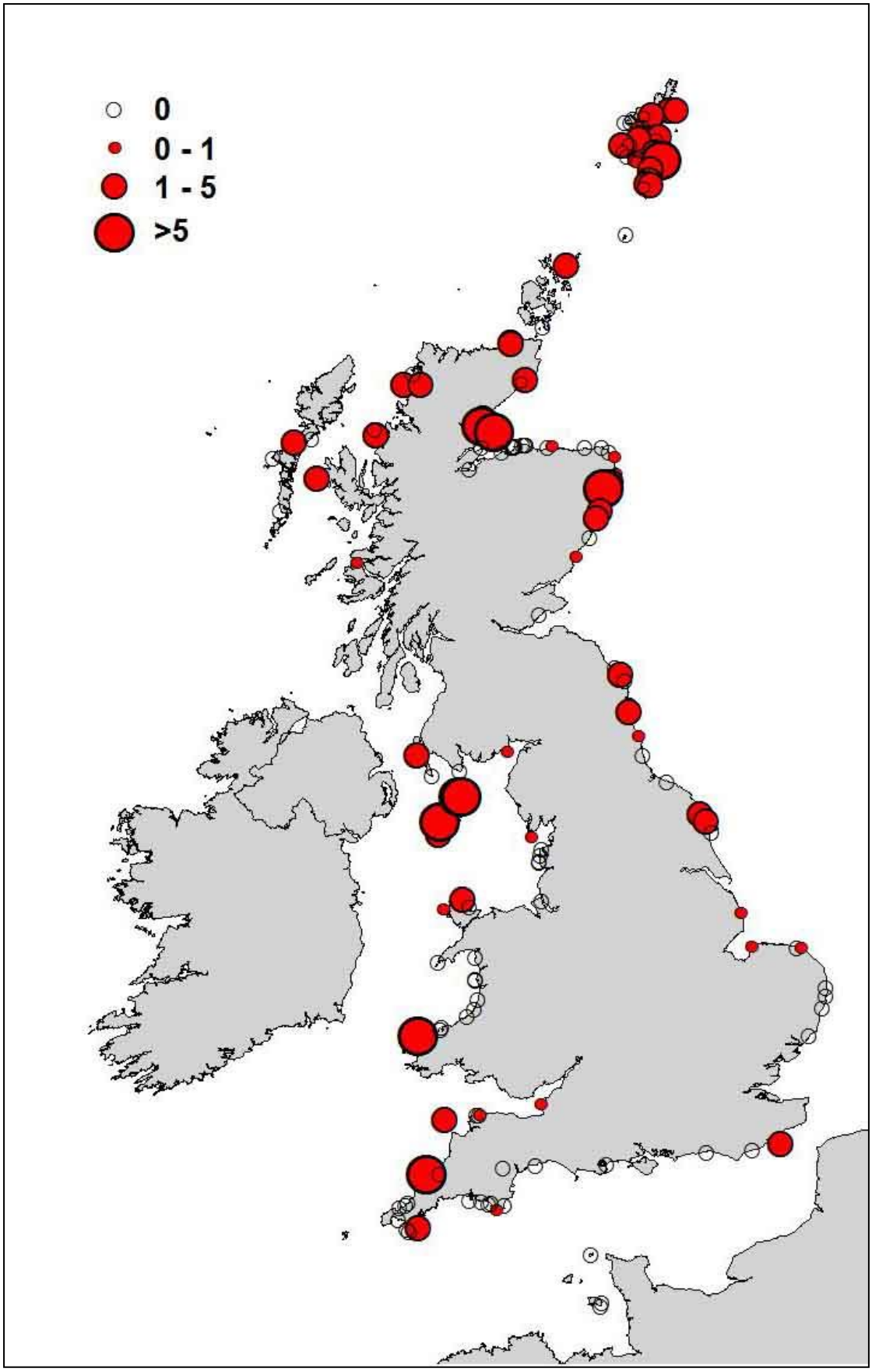


Figure 16 b. Map of harbour porpoise count rates (number of individuals per hour effort) by site (for watches with 3-10h of total effort).

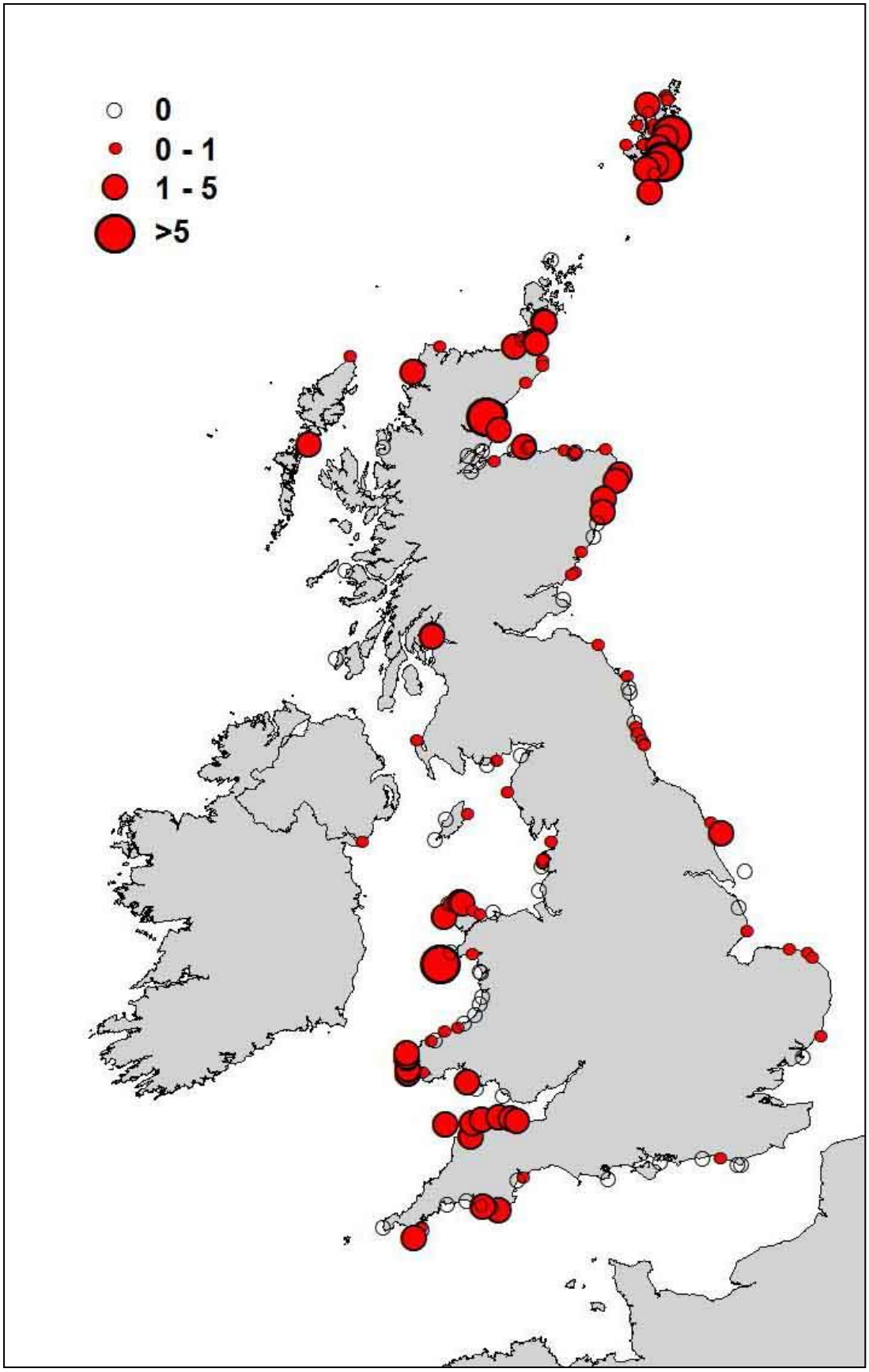


Figure 16 c. Map of harbour porpoise count rates (number of individuals per hour effort) by site (for watches with 10-50h of total effort).

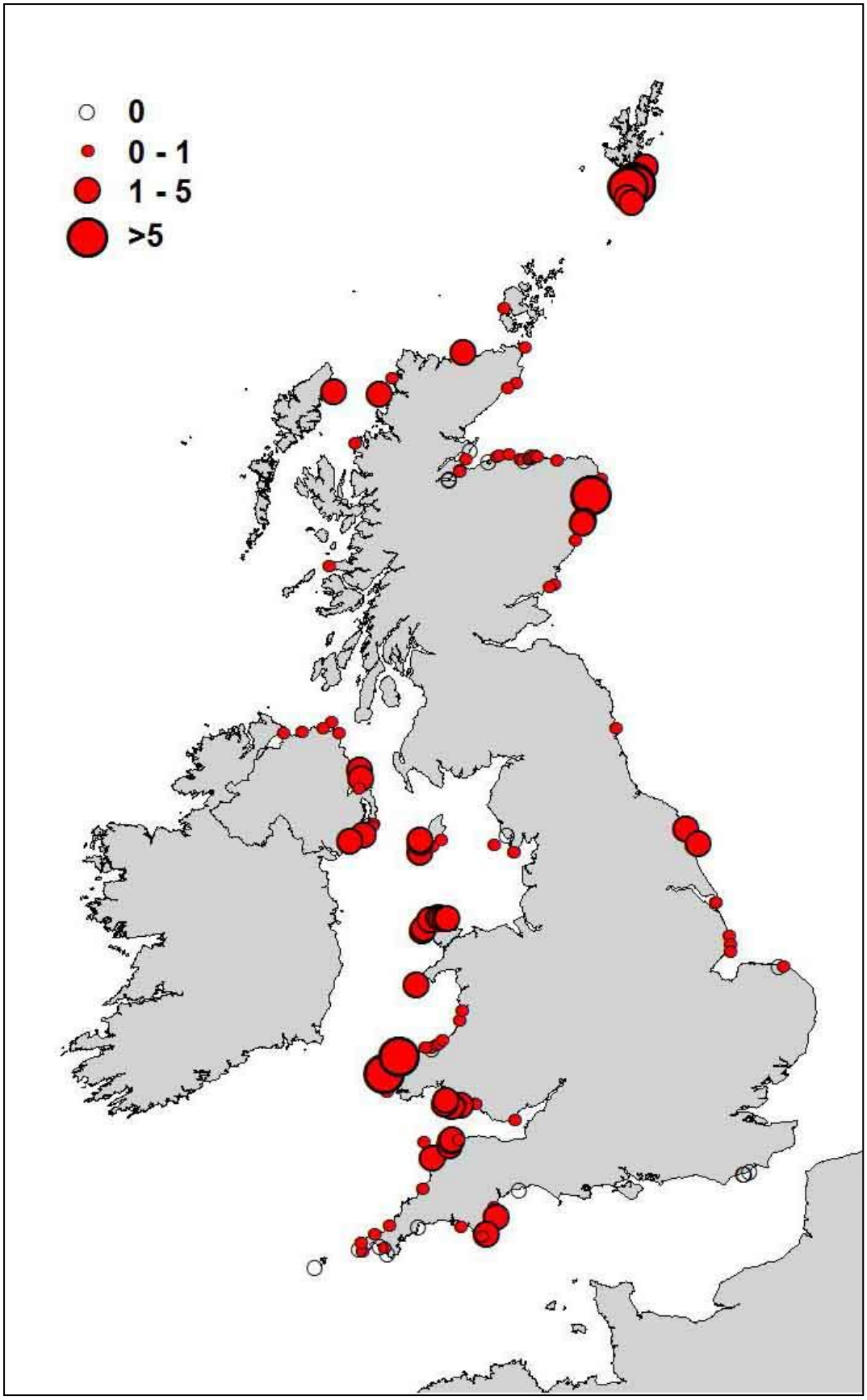


Figure 16 d. Map of harbour porpoise count rates (number of individuals per hour effort) by site (for watches with >50h of total effort).

Table 4. List of sites with >5h effort (>100mins per year for 3+ yrs) and harbour porpoise count rates above 90th percentile. Note that this is based on raw data before effects of various explanatory variables have been taken into account.
(SPUE = Sightings Per Unit Effort; CPUE = Count of animals Per Unit Effort)

Site No	MU	Site name	Region	Effort hrs	SPUE	CPUE
53.3	NS	Noss Sound	Shetland	357.3	1.82	4.44
67.1	NS	Mousa North Site	Shetland	467.9	4.47	8.78
67.2	NS	Mousa Sound Central	Shetland	484.5	4.23	7.59
71	NS	St. Ninians Isle	Shetland	54.1	2.77	6.73
74	NS	Quendale Bay	Shetland	101.2	1.63	3.71
75	NS	Sumburgh Head	Shetland	183.0	0.37	4.34
108.2	NS	Strathsteven	Highland	17.0	1.88	4.94
109.1	NS	Golspie	Highland	10.8	2.14	5.58
165	NS	Collieston	Aberdeenshire	108.8	0.84	5.04
168	NS	Balmedie	Aberdeenshire	45.5	0.64	3.76
222.1	NS	Scarborough	North Yorkshire	704.1	1.81	4.20
352	CIS	Baggy Point	North Devon	352.2	0.54	3.00
341	CIS	Hartland Point	North Devon	75.9	0.57	3.08
355	CIS	Morte Point	North Devon	401.9	0.64	3.17
394.1	CIS	S. Ramsey Sound	Pembrokeshire	389.8	1.27	5.26
400	CIS	Strumble Head	Pembrokeshire	638.5	0.35	5.89
437	CIS	North Stack	Anglesey	64.7	1.18	3.76
446	CIS	Llanbadrig	Anglesey	36.7	1.20	3.68
447	CIS	Middle Mouse	Anglesey	105.5	0.82	2.78
451	CIS	Point Lynas	Anglesey	2111.7	0.59	4.59
546	CIS	Portmuck, Island Magee	Co. Down	192.0	0.63	3.41
521	WS	Stoer Head Lighthouse	Highland	79.4	1.39	4.01
534	WS	Berneray	Outer Hebrides	8.2	0.86	1.84
536	WS	Tiumpan Head	Outer Hebrides	199.6	0.54	1.54

Count rates remain low (<1 animal/h) in Lancashire, Cumbria and south-west Scotland until Strone and Dunoon where count rates increased to between 1-2.5 animals/h, and to between 3-4 animals/h on the Isle of Mull. Of the few sites in west Scotland where watches have occurred, high count rates of 3-4 animals/h are found at Stoer Head (*c*80h effort) and in the Outer Hebrides, at Rodel, Harris (>20h effort), the rest all averages between 1-2 animals/h. Only moderate count rates (1.5 animals/h) have been recorded at the intensively watched Tiumpan Head, Isle of Lewis.

In Northern Ireland, count rates are <2 animals/h at all sites except Black Head (2.1 animals/h with >200h effort), and Portmuck, Island Magee (3.4 animals/h with *c*200h effort) in County Antrim. No porpoises were recorded during limited watching in the Channel Isles.

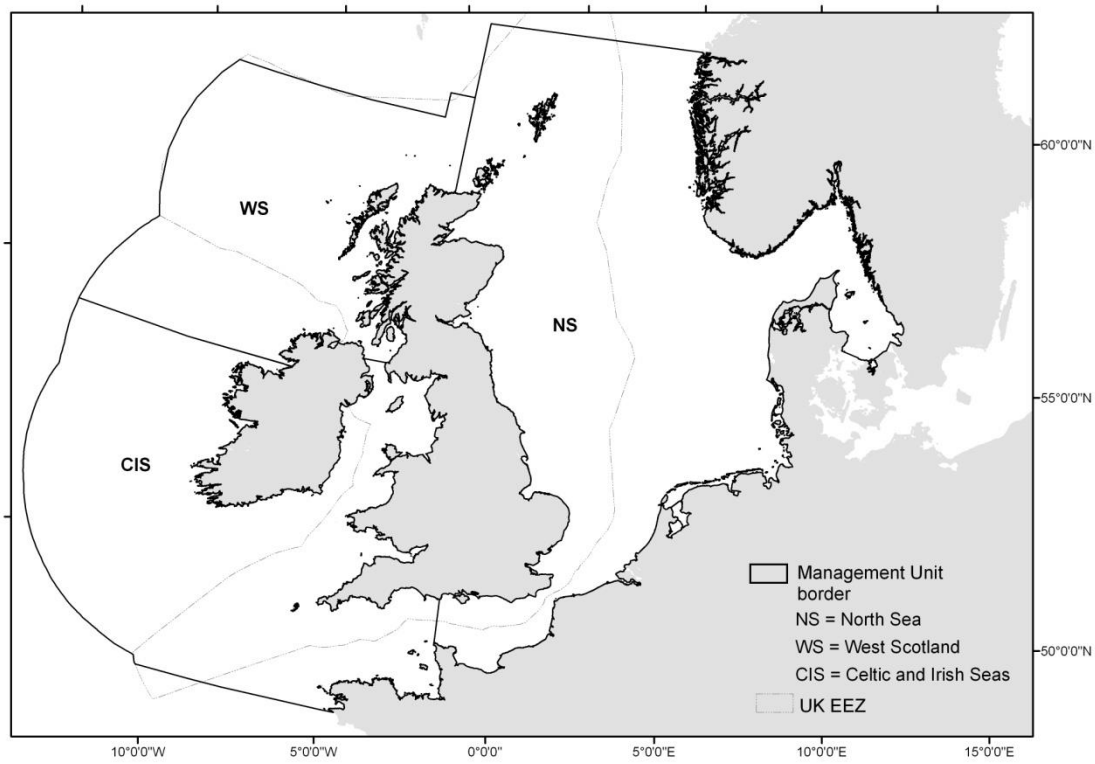


Figure 17. Map showing management units used for harbour porpoise.

Using the three management units for harbour porpoise recommended by the UK IAMMWG (see Figure 17), sites were allocated to one of the following: 352 in North Sea (NS), 278 in Celtic and Irish Sea (CIS), and 48 in West Scotland (WS).

Table 4 lists sites where there has been more than 5h of effort (at least 300 minutes of watch effort per year over three years) and where count rates exceed a 90th percentile per management unit. Those sites are mapped in Figure 18.

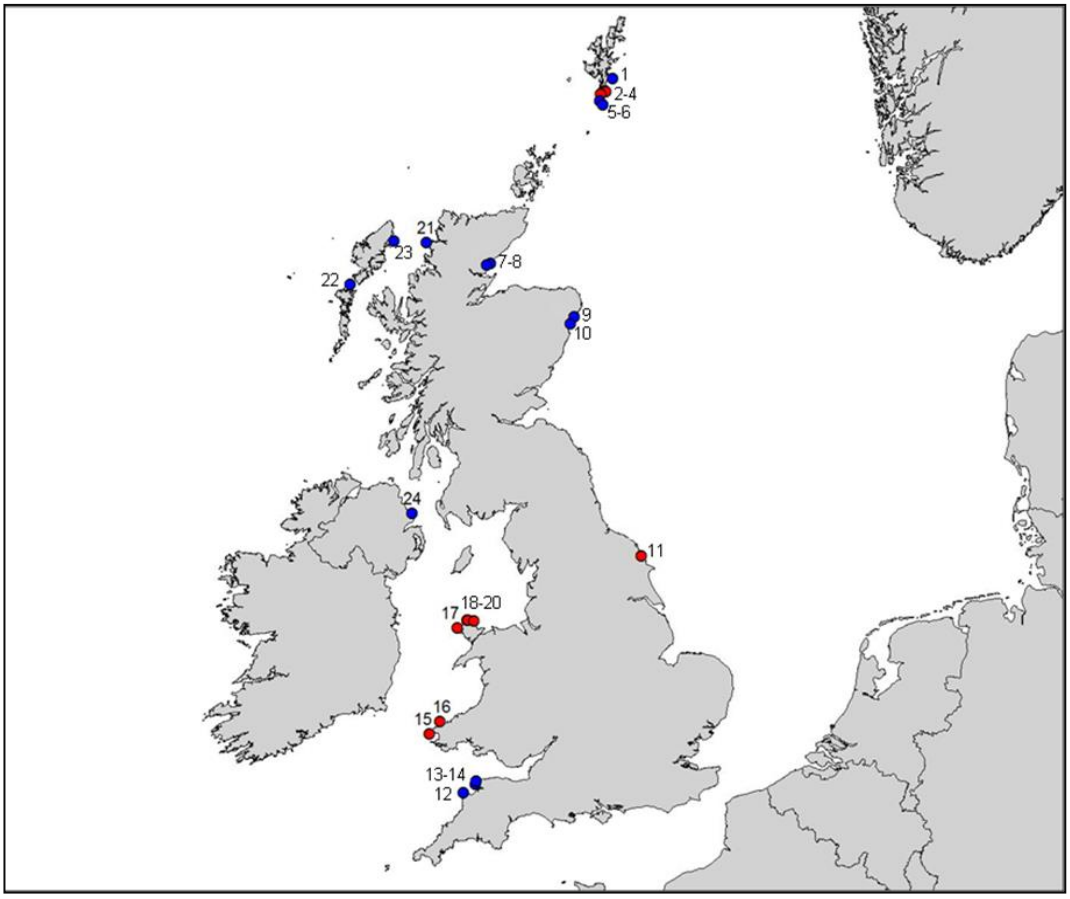


Figure 18. Sites with harbour porpoise counts per hour above 90th percentile threshold: 1=Noss Sound; 2=Mousa North; 3=Mousa Sound; 4=St Ninian's Isle; 5=Quendale Bay; 6=Sumburgh Hd; 7=Strathsteven; 8=Golspie; 9=Collieston; 10=Balmediel; 11=Scarborough; 12=Hartland Pt; 13=Baggy Pt; 14=Morte Pt; 15=S. Ramsey Sound; 16=Strumble Hd; 17=North Stack; 18=Llanbadrig; 19=Middle Mouse; 20=Point Lynas; 21=Stoer Hd; 22=Berneray; 23=Tiumpan Hd; 24=Portmuck, Island Magee (red=sites also >90percentile GAM predictions; blue=other sites).

Modelling results

As for bottlenose dolphin, firstly results for 1994-2014 are described, based on models which (A) use latitude and longitude and (B) treat the coastline as a continuous linear feature. The authors then compare results with those for other models. Further details appear in Appendix 4. As for the bottlenose dolphin models, predictions from the GAMs were filtered according to the amount of effort at each site. The 1994-2014 data for harbour porpoises used in the models are summarised below in Table 5.

Table 5. Summary of 1994-2014 sightings data, for harbour porpoises. Figures are all-site summaries of site averages. Site averages in turn were averages of daily summaries (presence per day, average sightings rates across all effort codes in a day). Note that after excluding very short observations and high sea states, and all data prior to 1994, only 592 sites are represented.

METRIC	PRESENCE	GROUPS/HOUR	ANIMALS/HOUR
Count	592	592	592
Mean	0.277	0.910	2.289
Median	0.057	0.073	0.135
Min	0.000	0.000	0.000
Max	1.000	28.460	73.846
90th Percentile	1.000	2.569	6.498

The final GAM using latitude and longitude to characterise location, included significant effects (P <0.001) of observation duration, effort type, observation area, optics, sea state, elevation, time of day, time of year, and year, as well as the latitude and longitude effect; the latter is the most important component of the model as suggested by the Chi-squared value and the associated smoother is shown in Figure 19. Overall, 34% of deviance is explained.

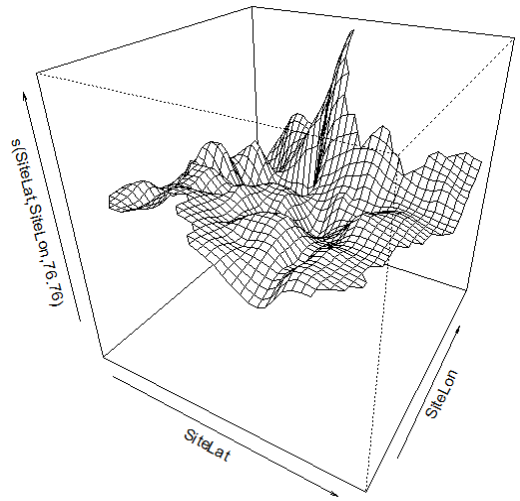


Figure 19. 'Smoother' for effect of latitude and longitude on porpoise presence, 1994-2014 (Model A).

The alternative Model (B) using site number is detailed below. This model explained 31% of deviance and contained the same explanatory variables (i.e. observation duration, effort type, observation area, optics, sea state, elevation, time of day, time of year, and year, as well as the latitude and longitude).

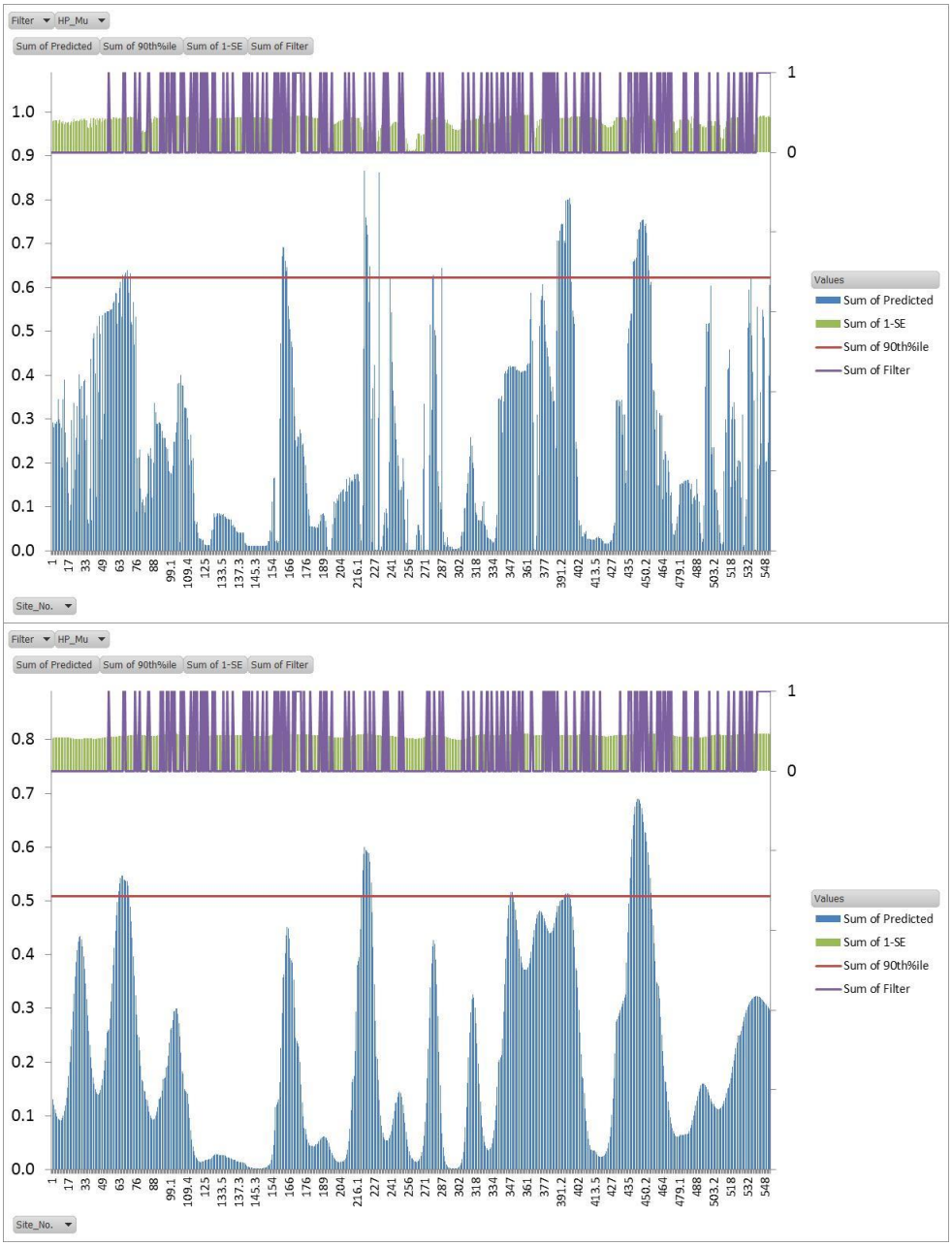


Figure 20. GAM predictions for harbour porpoise occurrence during 1994-2014, using Models A (based on latitude and longitude, above) and B, which treats the coast as a linear feature with site number representing position along the coast (below). Unfiltered results. As in Figure 8, occurrence figures appear in the lower part of each panel, confidence measures in the upper part, and the horizontal line is the 90th percentile for the filtered data.

As for the bottlenose dolphins, predictions from these two models can be compared graphically (Figures 20 and 21). While Model B shows less differentiation between adjacent sites (Figure 20), filtered results from both models (Figure 21) are quite similar.

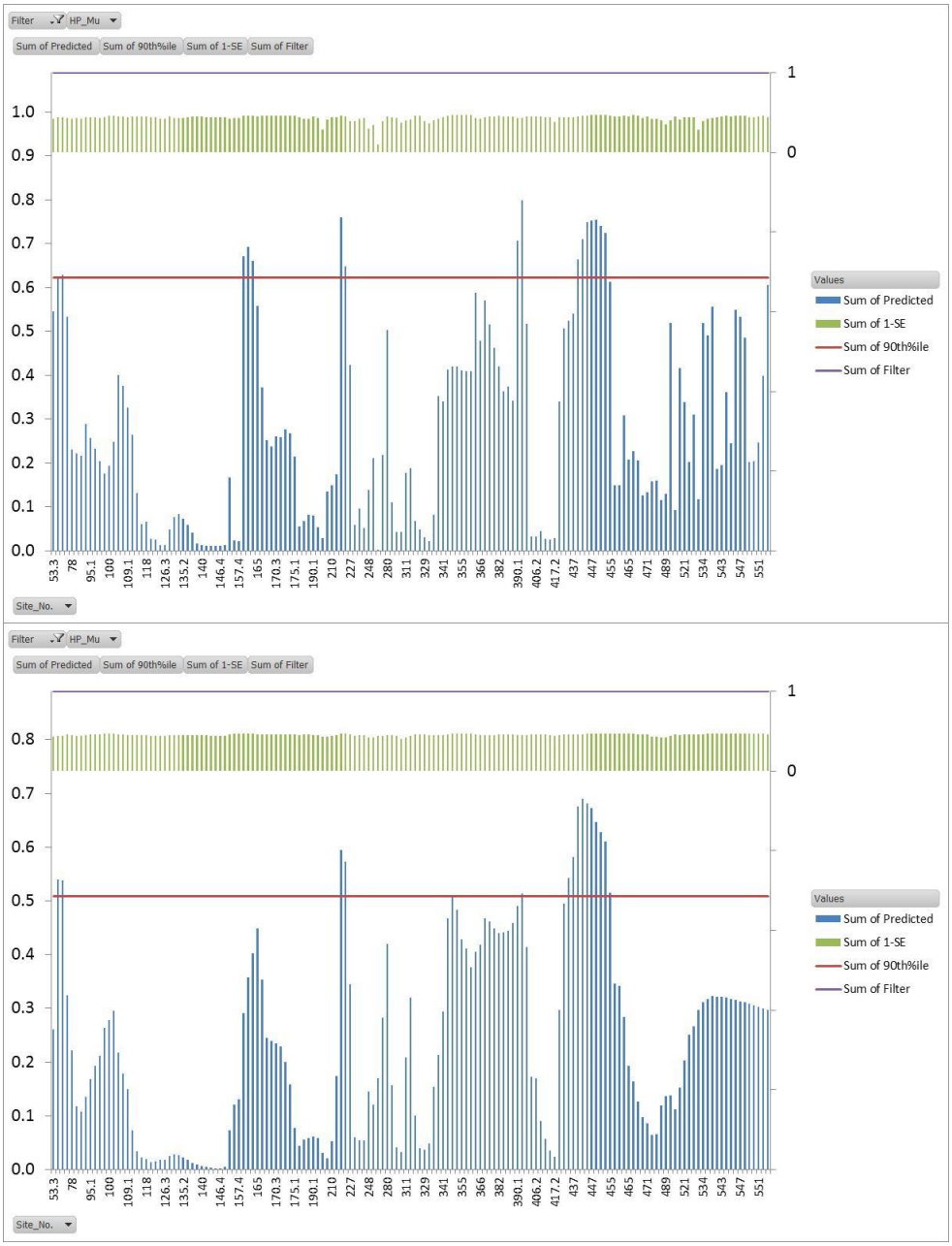


Figure 21. GAM predictions for harbour occurrence during 1994-2014, using models A (based on latitude and longitude, above) and B, which treats the coast as a linear feature with site number representing position along the coast (below). Filtered results. As in Figure 8, occurrence figures appear in the lower part of each panel, confidence measures in the upper part and the horizontal line is the 90th percentile for the filtered data.

As was the case for bottlenose dolphins, for the dataset 1994-2014, the mixed model (C) did not converge. The model with site x year interaction (Model D) reveals how porpoise occurrence has shifted from year to year. A less-detailed version of the site x year smoother for illustration purposes was generated (Figure 22). It can be seen that there was an apparent decline in porpoise presence at low site numbers (corresponding to Shetland, Orkney and the east coast of Scotland and an increase at intermediate numbered sites corresponding to southern England. This may be equivalent to the shift in distribution identified by the two SCANS surveys.

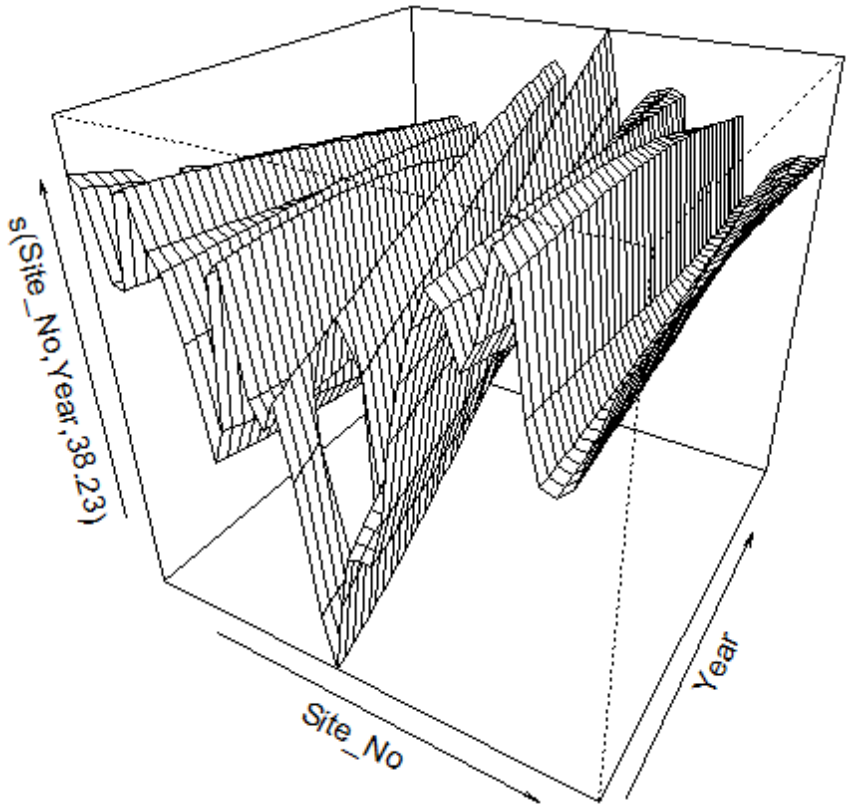


Figure 22. Interaction between year and site effects for harbour porpoise (Model D for 1994-2014; note that degrees of freedom have been reduced to make the patterns more evident.

Models were also fitted for the middle six months of the year for the period 1994-2014, and for the whole year during time periods 1994-2003, 2004-2014, and 1965-1993. Further details appear in Appendix 4.

Models for the whole year and the middle six months of the years, 1994-2014, gave very similar predictions (Figure 23). For the 1994-2003 data, the mixed model (Model C) could be run and there was a similarly good correspondence between predictions from the GAM component of this model and the Model B (site number-based) GAM (Figure 24).

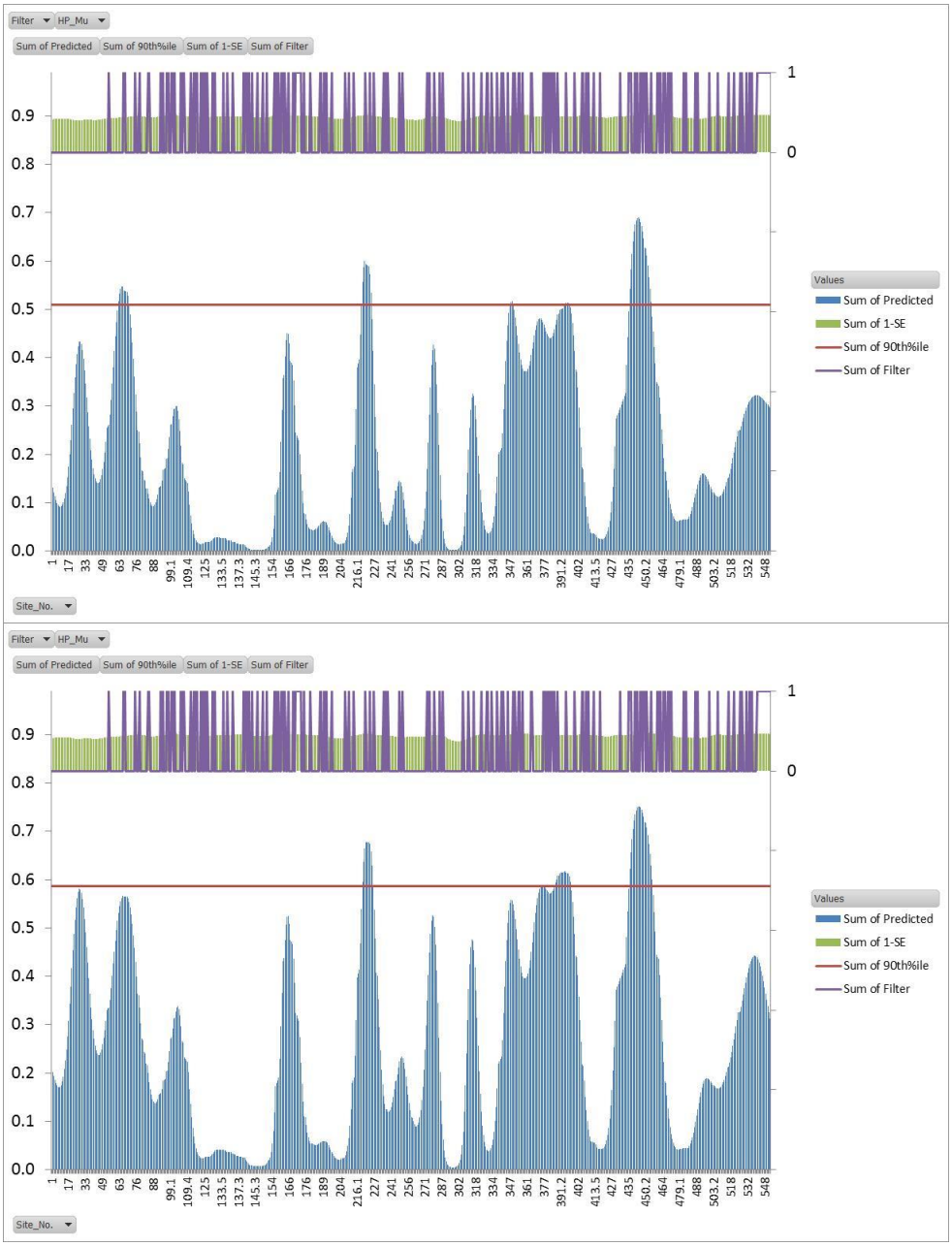


Figure 23. GAM predictions for harbour occurrence during 1994-2014, using Model B and data for the whole year (above) or only the middle six months (below). Unfiltered results. As in Figure 8, occurrence figures appear in the lower part of each panel, confidence measures in the upper part and the horizontal line is the 90th percentile for the filtered data.

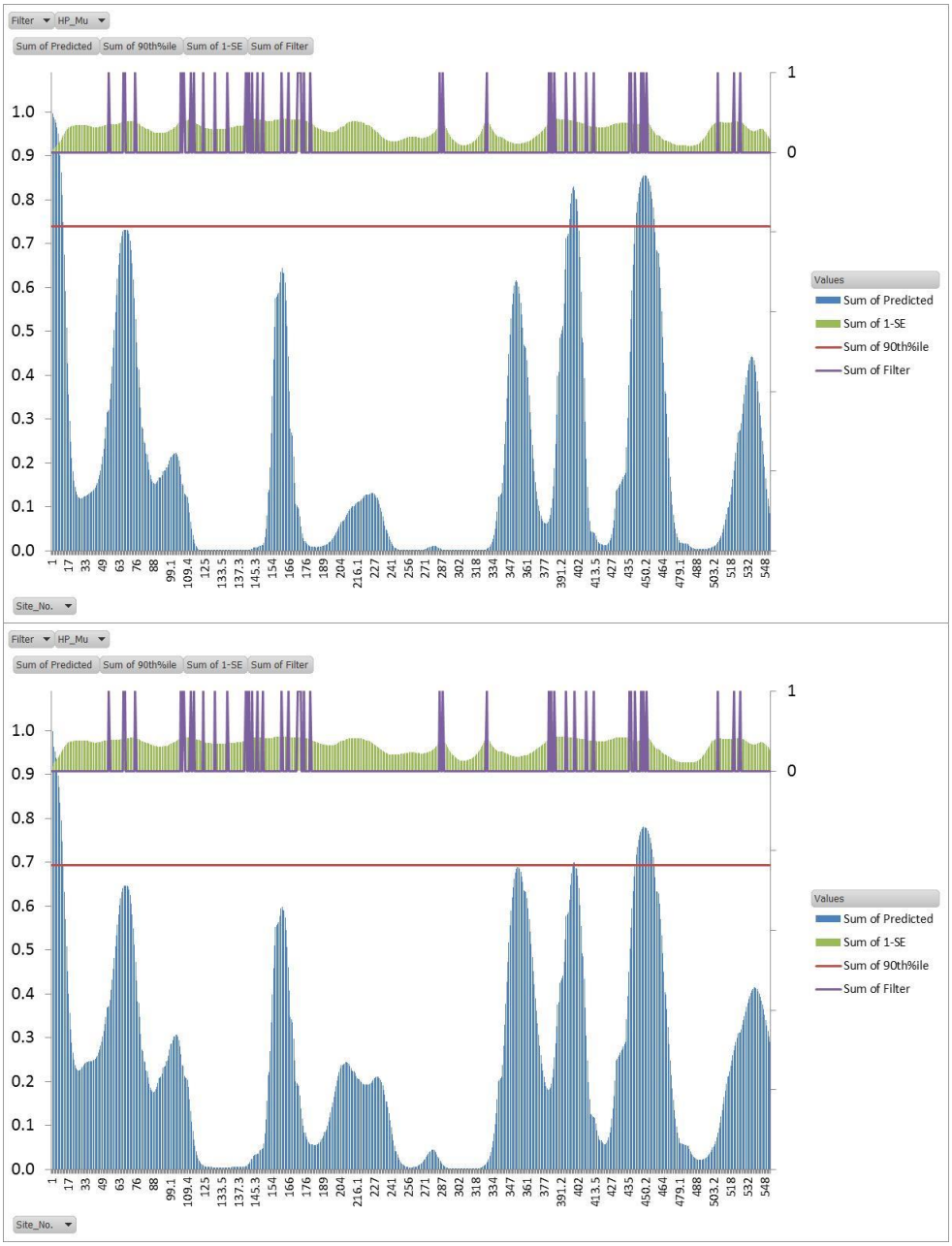


Figure 24. GAM predictions for harbour occurrence during 1994-2003, using Model B (above) and the mixed model (GAMM, Model C). Unfiltered results. As in Figure 8, occurrence figures appear in the lower part of each panel, confidence measures in the upper part and the horizontal line is the 90th percentile for the filtered data.

Interestingly, there was somewhat less correspondence between models for the different time periods, and this is well illustrated by the results presented in Table 6 below. The 1965-1993 models picked up some important occurrences in Shetland that were not seen in 1994-2003 or 2004-2014, which could reflect an ongoing, southwards shift in distribution (although some other northern sites remain important) but other differences are less easily explained and the choice of the 90th percentile as a cut-off may be a problem. A slightly lower cut-off would probably reveal more consistency across different models.

Since harbour porpoise count rates in Shetland were lower over the last decade compared with the 1990s, and watch effort there was much reduced since 1995, we

have plotted here the predicted likelihoods of occurrence by management unit for the most recent period, 2004-2014.

Within the North Sea management unit, however, predicted highest likelihoods of occurrence still occur in Shetland, as well as the north-east Grampian coast, and along the coast of eastern England between Scarborough and Flamborough Head, in Yorkshire (Figure 25a).

Moderately strong predictions occur along the coast of north Caithness and around Scapa Flow, Orkney, and, interestingly, around the Wash and parts of East Anglia (Norfolk and Suffolk).

Porpoises within the Celtic and Irish Sea management unit are more evenly distributed but with five main focal areas: 1) The south coast of Devon between Babbacombe Bay and Bigbury Bay; 2) the south side of the outer Bristol Channel between Bideford, north Devon and Minehead, Somerset; 3) Swansea Bay and the Gower Peninsula; 4) west and north Pembrokeshire coast and islands; and 5) north-west and north coasts of Anglesey (Figure 25b).

Predictions for the West Scotland management unit are weak due to the paucity of land watch data, with no area showing up particularly strongly (Figure 25c).

Using the 90th percentile threshold for likelihood of occurrence, the GAM predictions yielded 30 sites (using one or other model over one or more time periods) (Table 6). These are mapped in Figure 26. Of those sites, five were in Shetland, three were in east Grampian, two in Yorkshire, two in south Devon, one in north Devon, four in south Wales (Swansea Bay and the Gower Peninsula), three in west Pembrokeshire, two in north Pembrokeshire (on the southern edge of Cardigan Bay), and eight in northwest and north Anglesey.

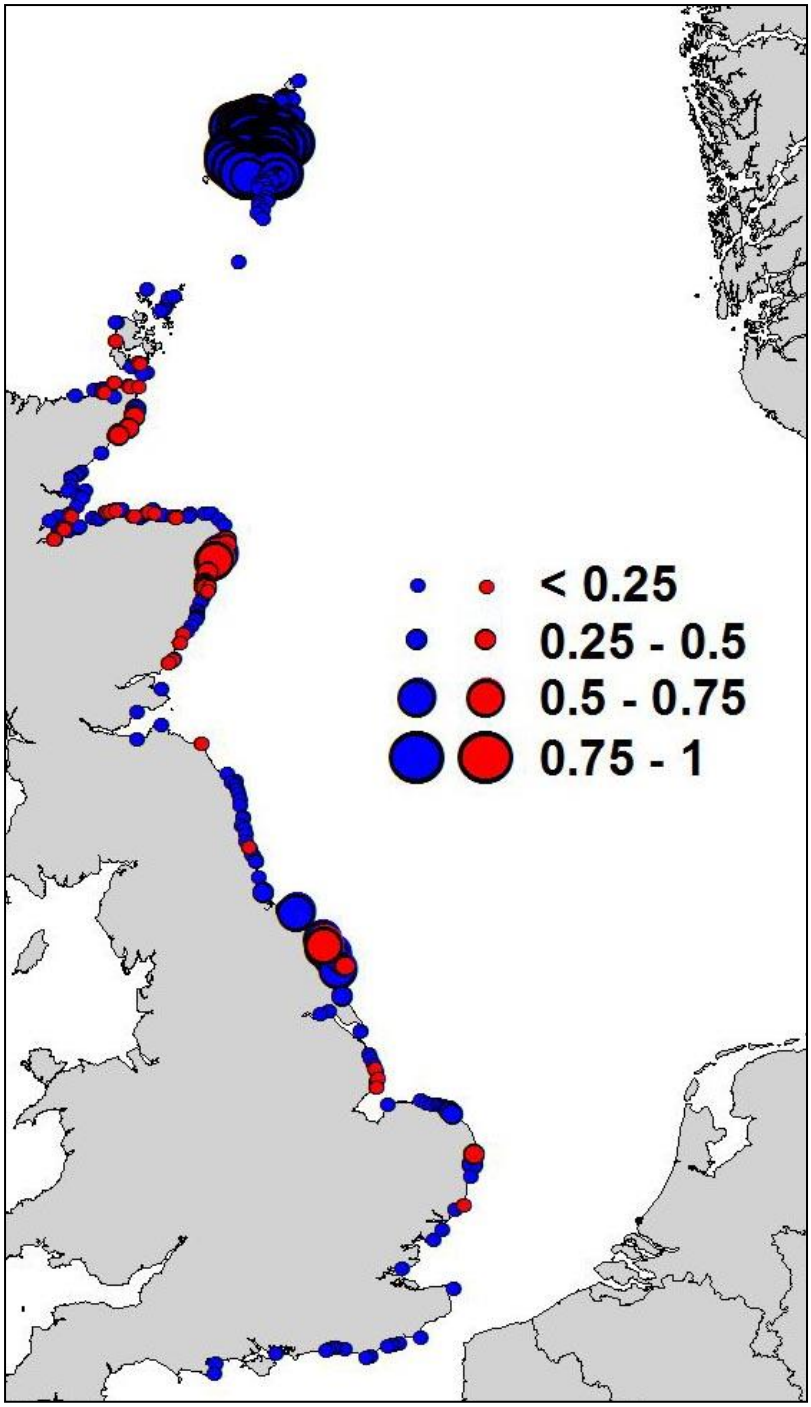


Figure 25 a. Map of GAM predicted likelihood of occurrence for harbour porpoise North Sea management unit, 2004-14 (red symbols = sites with >100mins effort for 3+ years).

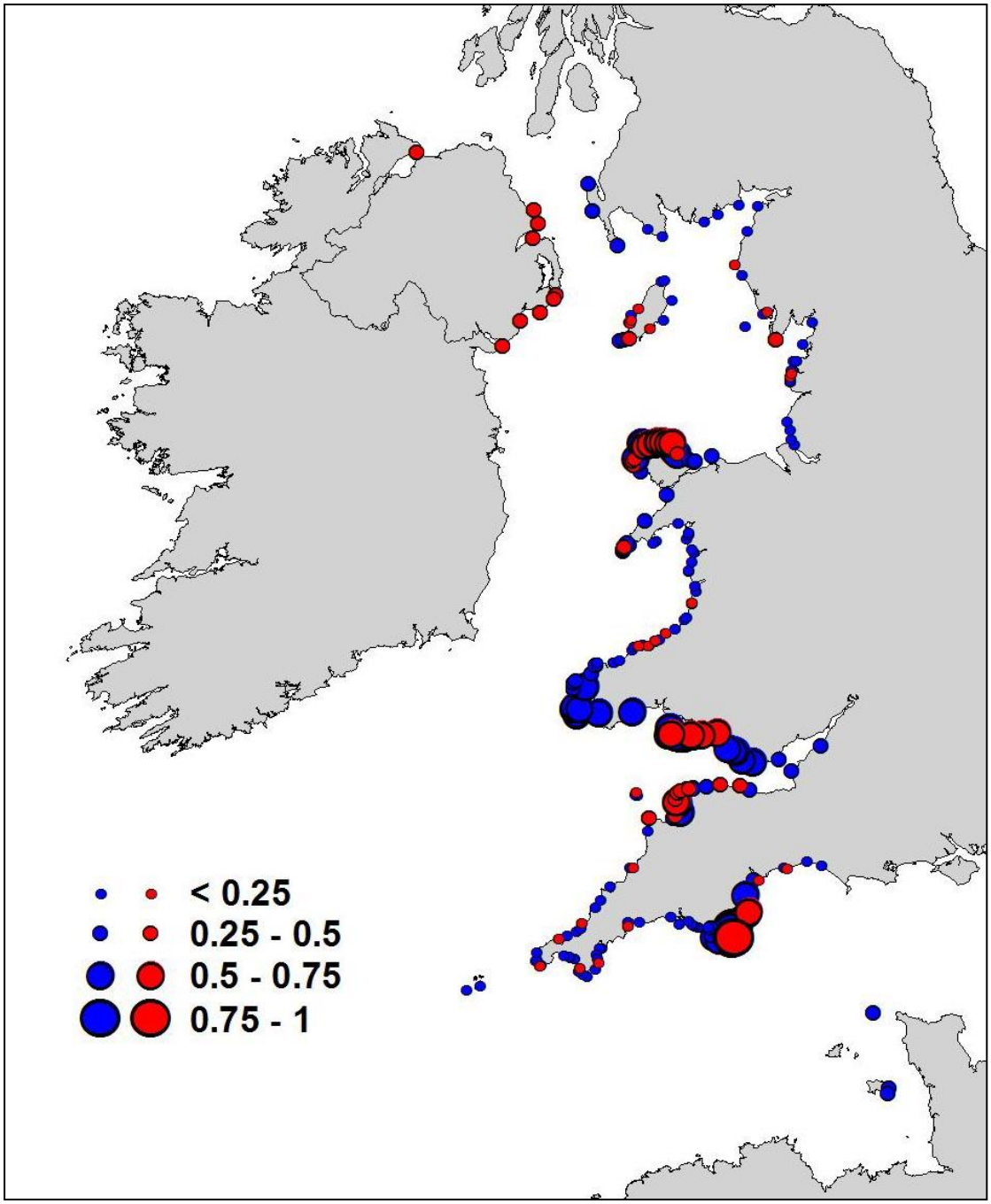


Figure 25 b. Map of GAM predicted likelihood of occurrence for harbour porpoise Celtic & Irish Sea management unit, 2004-14.
(red symbols = sites with >100mins effort for 3+ years).

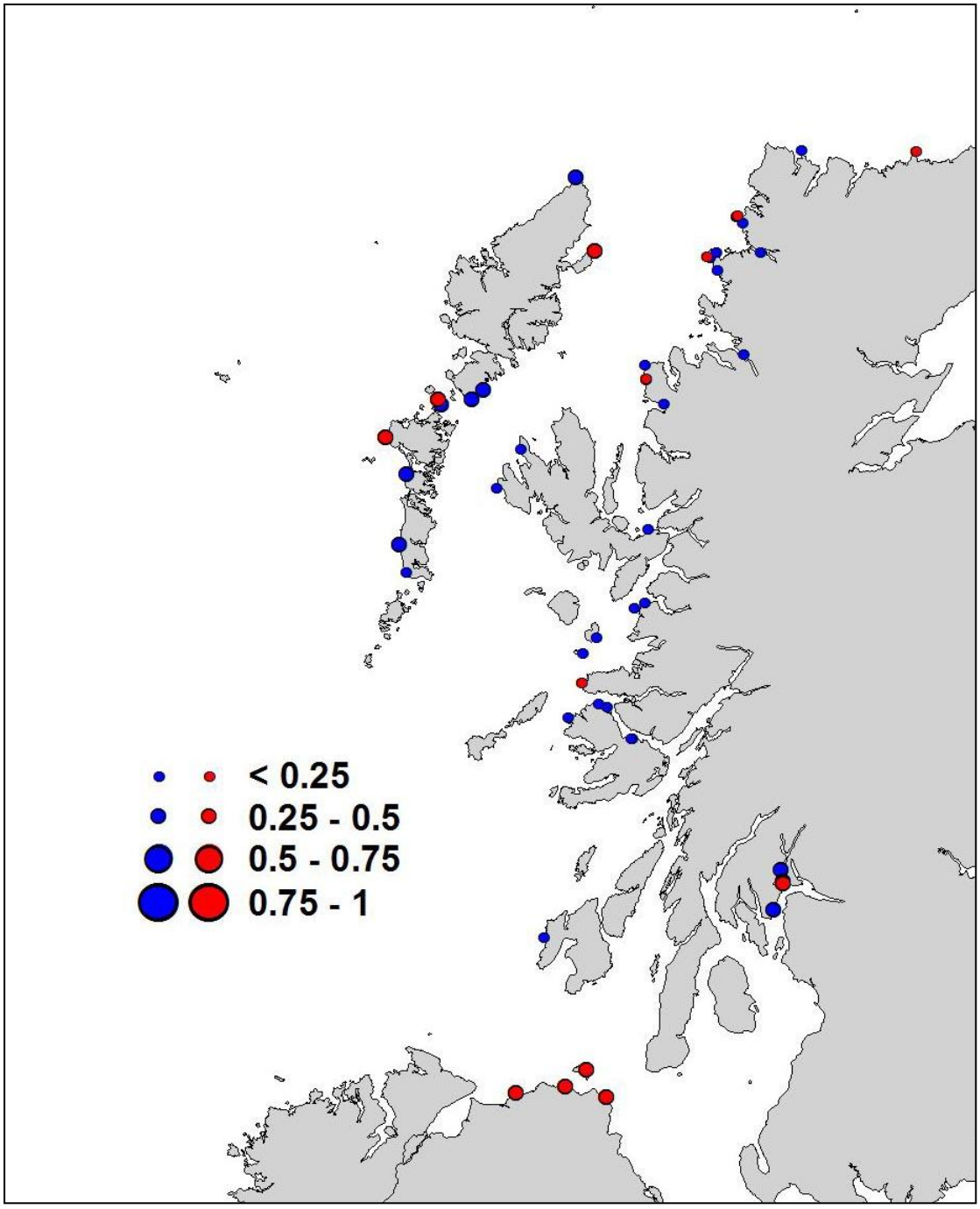


Figure 25 c. Map of GAM predicted likelihood of occurrence for harbour porpoise West Coast Scotland management unit, 2004-14.
(red symbols = sites with >100mins effort for 3+ years).

Table 6. Sites (shown in red) with Harbour Porpoise likelihood of occurrence above 90th percentile threshold from GAMs (model A = lat x long; model B = site no.), and filtered by effort (at least three years each with at least 100 mins of effort)

Site name	Model A: 1965-1993	Model B: 1965-1993	Model A: 1994-2003	Model B: 1994-2003	Model A: 2004-2014	Model B: 2004-2014	Model A: 1994-2014	Model B: 1994-2014
Channerwick								
Mousa North								
Mousa Sound								
St Ninians Isle								
Peterhead								
Buchan								
Slains Castle								
Scarborough Mar. Dr.								
Filey Brigg								
Berry Head								
Start Point								
Downend Point								
Port Talbot								
Mumbles								
Southgate								
Rhossili								
Skokholm Island								
S Ransey Sound								
St Davids Head								
Strumble Head								
South Stack								
North Stack								
Carmel Head								
Cemlyn								
Llanbadrig								
Middle Mouse								
Bull Bay								
Llam Carw								
Point Lynas								
Moelfre								

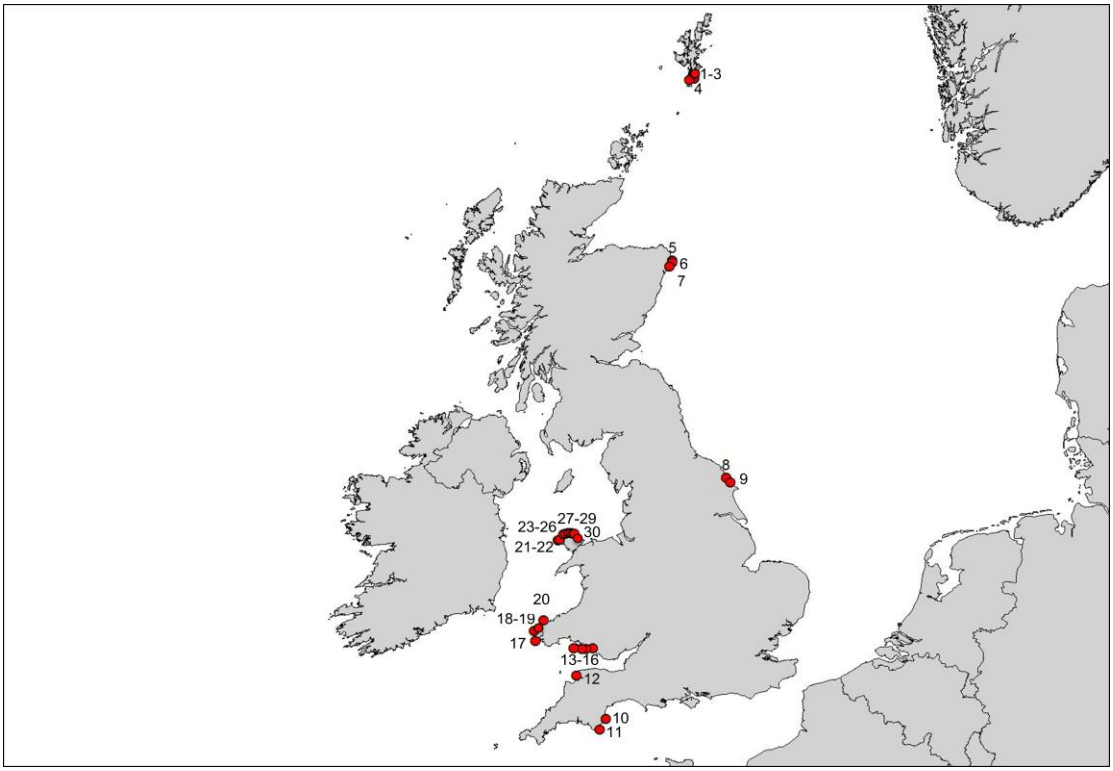


Figure 26. Sites with harbour porpoise likelihood of occurrence above 90th percentile threshold from GAMs for sites with more than 100min effort for 3+ years (1=Channerwick; 2=Mousa North; 3=Mousa Sound; 4=St Ninian's Isle; 5=Peterhead; 6=Buchan; 7=Slains Castle; 8=Scarborough; 9=Filey Brigg; 10=Berry Head; 11=Start Point; 12=Downend Point; 13=Port Talbot; 14=Mumbles; 15=Southgate; 16=Rhossili; 7=Skokholm Is.; 18=S Ramsey Sound; 19=St David's Head; 20=Strumble Head; 21=South Stack; 22=North Stack; 23=Carmel Head; 24=Cemlyn; 25=Llanbadrig; 26=Middle Mouse; 27=Bull Bay; 28=Llam Carw; 29=Point Lynas; 30=Moelfre)

6 Discussion and conclusions

Land-watch effort is reasonably well distributed around the UK. However, there are certain areas where coverage is poor. Notable amongst these are the west mainland coast of Scotland, the Hebrides, and to a lesser extent, south-east England, whilst some areas (e.g. Shetland) have had very little effort in the last decade. Although dedicated effort started as long ago as 1965, the majority has been in the last ten years. Similarly, effort has been concentrated very much on the summer months between May and September. For the most part, protocols used for land watches have been very comparable, despite large numbers of observers and local groups being involved over several decades. Compared with offshore vessel surveys, land watch effort is significantly greater over the same spatial areas (with effort exceeding 50 hours at around 100 sites), and effort may extend over several months and several years. On the other hand, the fact that observations are at a static location means that it is impossible to derive absolute densities or abundance from observations. The other potential limitations of land watches are 1) temporal autocorrelation, where because observations are static, successive watches are likely to record the same individuals; and 2) watch effort at particular locations may be greater than at other simply because observers are more likely to see animals there. Despite these limitations (which the GAM and GAMM analyses have tried to address), the results presented indicate that there are areas of relative high occurrence, which should complement offshore surveys.

The coastal distributions of the two species accord with our current knowledge: bottlenose dolphins are concentrated around west Wales and eastern Scotland, with very few along North Sea coasts south of Edinburgh and the coast of southern England east of Poole; harbour porpoises, on the other hand, are much more evenly distributed but nevertheless occur in a few areas in relatively high numbers. Strikingly, the distributions of the two species more-or-less displace one another. This is further demonstrated by the results of the GAM model comparing harbour porpoise and bottlenose dolphin distributions by site, which emphasises the negative relationship between the occurrences of the two species. Wherever bottlenose dolphins occur regularly (south side of the Moray Firth around the Grampian coast south to the Firth of Forth, coastal Cardigan Bay, and east coast of Anglesey), porpoise are relatively uncommon. This may well be due to the fact that bottlenose dolphins are known to attack porpoises where the two occur in the same areas (Ross and Wilson, 1996; Jepson and Baker, 1998; Pesante *et al*, 2008b).

It is recommended to apply caution in using the arbitrary 90th percentile threshold of predicted occurrence. As can be seen clearly with regards to its application to count rates, several locations already identified as important for bottlenose dolphin and awarded SAC designation, are below this threshold. The same may be the case also for harbour porpoise, and it is advised that consideration be given to sites with >5h effort that have average count rates slightly below this threshold. This would be more in-line with already well-established criteria for SAC designation applied to the bottlenose dolphin.

The Generalised Additive Models (GAMs) functioned best for management units where there was a lot of data. Thus, the results from west Scotland, for example, are least meaningful. In contrast, the predictions are more robust in the Irish Sea, western Channel, east coast of Scotland, and eastern England. The modelling framework is relatively robust and there is reasonable confidence in the distribution patterns identified, at least once sites with less effort have been excluded. However, especially in the case of porpoises, there is evidence that distribution has shifted over time and presumably further shifts are plausible.

In addition, the dataset would benefit from a fuller analysis, less constrained by resources (including time and computer processor power; some GAMMs take several days to run on an ordinary modern PC), which could reveal additional features not apparent here. Given the

highly skewed nature of the count and sighting-rate data, the possibility of using zero-inflated models should be explored; again, these can require considerable processor power for large and complex datasets. Finally, the project database itself would benefit from an overhaul, which might help recover some of the 5% or so of data that were eliminated due to incompleteness or errors.

To conclude, land watches indicate that coastal bottlenose dolphins are concentrated in two main regions: 1) eastern Scotland from Brora to Carnoustie, with a relatively even distribution; and 2) the Welsh coast in Cardigan Bay and to a lesser extent off north & east Anglesey. Elsewhere, the species occurs only occasionally, except possibly for the following locations: Falmouth Bay and around the Lizard Peninsula in Cornwall, and in Bideford Bay in north Devon. The species is also known to range around the Inner Hebrides in small numbers, with a small (<15 individuals) apparently site faithful population off Barra (Grellier & Wilson, 2003; Thompson *et al*, 2011); and the northern Irish Sea including the Isle of Man, the Cumbrian coast, and coasts of Counties Down and Antrim.

Harbour porpoises are more widely distributed, with hotspots in the following coastal areas: North Sea Management Unit: 1) southern and eastern Shetland; 2) along the northeast Grampian coast; and 3) along the coast of eastern England between Scarborough and Flamborough Head, in Yorkshire. Areas with moderate count rates and predicted likelihoods of occurrence include the coast of north Caithness and around Scapa Flow, Orkney, and around the Wash and parts of East Anglia (Norfolk and Suffolk).

Celtic and Irish Sea Management Unit: 1) the south Devon coast between Babbacombe Bay and Bigbury Bay; 2) the south side of the outer Bristol Channel between Bideford, north Devon and Minehead, Somerset; 3) Swansea Bay and the Gower Peninsula; 4) west and north Pembrokeshire coast and islands; and 5) north-west and north coasts of Anglesey.

No conclusions from the land-based data can be drawn for the West Coast of Scotland and Hebrides management unit due to low observational effort in that region. However, offshore effort indicates that the species is abundant in this region (Reid *et al*, 2003; Evans *et al*, 2003; Marubini *et al*, 2009; Booth, 2010; Embling *et al*, 2010).

These analyses have followed the management units prescribed by the UK Inter-Agency Marine Mammal Working Group. It is perhaps worth noting, however, that for bottlenose dolphin, photo-identified individuals from the Moray Firth have been observed inside the current North Sea management unit (as far south as Whitby in Yorkshire), whereas, with the Channel and Irish Sea management unit, there is no current evidence of any bottlenose dolphin photo-identified from the Channel Isles and adjacent coast of Normandy (where a resident population, numbering around 400 animals, lives) being photographed along the coast of southern England (and the converse) (Liret *et al*, 1998, 2006; Louis *et al*, 2012; Sea Watch Foundation unpublished data). There is also evidence to suggest that the harbour porpoise population in Shetland is more closely related to that in southern Scandinavia (Tolley *et al*, 1999; Teilmann *et al*, 2008) and both appear to be experiencing similar demographic changes (Desportes, 2013).

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Appendix 1: Tables with Site Summaries

KEY
Table A1.1:
Site number: Numbered consecutively using extra values for sites in close proximity to one another, e.g. 1.1, 1.2, 1.3. These start in the Northern Isles and then go clockwise around the coast of Britain from NE Caithness before ending back on the north coast of mainland Scotland. The Channel Isles and then Northern Ireland follow at the end.

Site name: Name given to that site (often with mention of neighbouring location to help locate the site)

Region: County (sometimes using old county boundaries to subdivide a region)

Lat_decimal, Long_decimal: decimal degrees, negative sign for west of Greenwich

Site elevation: in metres, to the nearest 5-10 metres except at lowest elevations when to nearest 1 metre

Number of observers: either 1 or 2 (typically one)

Observation area: 1 = 1 = uninterrupted 180^{o}+ view, limited only by visibility; 2 = uninterrupted 90-180^{o} view, limited in front only by visibility; 3 = 180^{o}+ view, limited in front by land within 1km; 4 = 90-180^{o} view, limited by land 1-2km distance on all sides

Optics: 1 = mainly naked eye but supplemented by binoculars/telescope; 2 = use of binoculars/telescope continuously

Observation method: 1 = regular scans; 2 = slow timed scans (duration variable between recording groups); 3 = slow scans but targeting particular sections of the sea (alternating with sections targeted for bird counts – used only in renewables studies that also involved birds – Alex Robbins in Blue Mull Sound, Shetland, and EMEC at Billia Croo, Orkney)

Recording method: 1 = record of individual sightings (with group size count); 2 = counts of animals per watch period (typically 10- or 15-min duration).

Table A1.2
Site number: As for Table A1.

Site name: As for Table A1.

Region: As for Table A1.

Total effort: Number of minutes of dedicated observation.

No of years: Number of years for which dedicated watches were undertaken.

Year span: First and last years for which dedicated watches took place.

BND MUs: Bottle Nosed Dolphin Management Units - NS = North Sea; ECS = East Coast Scotland; CSW = Channel & SW England; IS = Irish Sea; WCS = West Coast Scotland; OS = Offshore.

HP MUs: Harbour Porpoise Management Units – NS = North Sea; CIS = Celtic & Irish Seas; WS = West Scotland.

Table A1. 1. List of sites with environmental and recording details.

Site No	Site	Region	Lat decimal	Long decimal	Elev (m)	No Obs	Obs Area	Optics	Obs Method	Rec method	BND MUs	HP MUs
1	Lamba Ness, Unst	Shetland	60.8169	-0.7599	13	1	1	1	1	1	NS	NS
2	Westing, Unst	Shetland	60.7266	-0.9653	30	1	1	1	1	1	NS	NS
3	Papil VP, Yell, Bluemull Sound	Shetland	60.7163	-1.0015	8	1	3	2	3	1	NS	NS
4	Bluemull VP, Unst, Bluemull Sound	Shetland	60.7156	-0.9778	6	1	3	2	3	1	NS	NS
5	The Ness VP, Yell, Bluemull Sound	Shetland	60.7003	-0.9879	7	1	3	2	3	1	NS	NS
6	Wadbister VP, Unst, Bluemull Sound	Shetland	60.6907	-0.9777	3	1	3	2	3	1	NS	NS
7	Muness, Unst	Shetland	60.6880	-0.8467	15	1	1	1	1	1	NS	NS
8	Belmont VP, Unst, Bluemull Sound	Shetland	60.6801	-0.9660	12	1	4	2	3	1	NS	NS
9	Gutcher VP, Yell, Bluemull Sound	Shetland	60.6781	-0.9947	18	1	3	2	3	1	NS	NS
10	Ness of Sound, Yell	Shetland	60.5260	-1.1797	20	1	1	1	1	1	NS	NS
11	Fethaland	Shetland	60.6337	-1.3047	35	1	2	1	1	1	NS	NS
12	Tresta, Fetlar	Shetland	60.5930	-0.8758	30	1	4	1	1	1	NS	NS
13	Funzie Bay, Fetlar	Shetland	60.5845	-0.7900	10	1	2	1	1	1	NS	NS
14	Head of Brough, Yell	Shetland	60.5456	-1.1869	30	1	1	1	1	1	NS	NS
15	Burra Voe (from North Voe)	Shetland	60.5803	-1.3165	3	1	2	1	1	1	NS	NS
16	Collafirth	Shetland	60.5383	-1.3308	20	1	2	1	1	1	NS	NS
17	Ronas Voe	Shetland	60.5149	-1.4799	50	1	3	1	1	1	NS	NS
18	Eshaness	Shetland	60.4912	-1.6218	52	1	1	1	1	1	NS	NS
19	Braewick, nr Eshaness	Shetland	60.4903	-1.5385	20	1	2	1	1	1	NS	NS
20	Brough (Toft) - Toft Ness	Shetland	60.4793	-1.1997	30	1	1	1	1	1	NS	NS
21	Hillswick	Shetland	60.4655	-1.4850	15	1	3	1	1	1	NS	NS
22	Lunna Ness	Shetland	60.4502	-1.0443	30	1	1	1	1	1	NS	NS
23	Gunnister Voe	Shetland	60.4467	-1.4347	35	1	4	1	1	1	NS	NS
24	Sullom Voe from Sullom	Shetland	60.4448	-1.3363	15	1	3	1	1	1	NS	NS
25	Dales Voe	Shetland	60.4268	-1.2022	90	1	4	1	1	1	NS	NS
26	Mangaster Voe	Shetland	60.4178	-1.4080	50	1	4	1	1	1	NS	NS
27	Skaw, Whalsay	Shetland	60.3840	-0.8995	25	1	1	1	1	1	NS	NS
28	Vidlin/Gunna Voe	Shetland	60.3828	-1.1369	5	1	3	1	1	1	NS	NS
29	Lunning Sound from Lunning	Shetland	60.3738	-1.0670	30	1	1	1	1	1	NS	NS
30	Wethersta overlooking Olna Firth	Shetland	60.3697	-1.3455	20	1	3	1	1	1	NS	NS
31	Marrister, Whalsay	Shetland	60.3653	-1.0063	20	1	3	1	1	1	NS	NS
32	Dury Voe	Shetland	60.3530	-1.1295	45	1	4	1	1	1	NS	NS
33	Muckle Roe to Swarbacks Minn	Shetland	60.3497	-1.4143	35	1	2	1	1	1	NS	NS
34	Aithvoe from East Burrafirth	Shetland	60.3103	-1.3830	50	1	4	1	1	1	NS	NS

Site No	Site	Region	Lat decimal	Long decimal	Elev (m)	No Obs	Obs Area	Optics	Obs Method	Rec method	BND MUs	HP MUs
35	Melby	Shetland	60.3058	-1.6625	4	1	1	1	1	1	NS	NS
36	Huxter	Shetland	60.2992	-1.6887	20	1	1	1	1	1	NS	NS
37	West Burrafirth	Shetland	60.2965	-1.5462	30	1	4	1	1	1	NS	NS
38	South Nesting Voe	Shetland	60.2945	-1.1275	20	1	1	1	1	1	NS	NS
39	Voe of Dale	Shetland	60.2520	-1.6830	12	1	3	1	1	1	NS	NS
40	Gletness	Shetland	60.2447	-1.1548	12	1	2	1	1	1	NS	NS
41	Wadbister Voe from Girlsta	Shetland	60.2305	-1.2035	15	1	3	1	1	1	NS	NS
42	Sandsound Voe	Shetland	60.2200	-1.3578	30	1	4	1	1	1	NS	NS
43	Burrastow/Vaila Sound	Shetland	60.2128	-1.5978	20	1	4	1	1	1	NS	NS
44	Laxfirth	Shetland	60.2121	-1.2106	30	1	3	1	1	1	NS	NS
45	Sandvoe/Kirkaness	Shetland	60.2005	-1.4013	25	1	3	1	1	1	NS	NS
46	Beosetter/Gunnista	Shetland	60.1803	-1.1043	12	1	1	1	1	1	NS	NS
47	Whiteness Voe	Shetland	60.1758	-1.3043	20	1	3	1	1	1	NS	NS
48	Westerwick	Shetland	60.1680	-1.4887	5	1	4	1	1	1	NS	NS
49	Cullingsburgh	Shetland	60.1678	-1.0693	8	1	2	1	1	1	NS	NS
50	Scarvister	Shetland	60.1645	-1.4488	30	1	3	1	1	1	NS	NS
51	Bressay Broch	Shetland	60.1573	-1.0493	50	1	1	1	1	1	NS	NS
52	Mansies Berg, Noss	Shetland	60.1560	-1.0323	10	1	3	1	1	1	NS	NS
53.1	Cols Ness, Noss	Shetland	60.1532	-1.0413	5	1	2	1	1	1	NS	NS
53.2	Noss Head, Noss	Shetland	60.1523	-1.0427	150	1	1	1	1	1	NS	NS
53.3	Noss Sound from Noss	Shetland	60.1519	-1.0446	2	1	3	1	1	1	NS	NS
54	Big Ness, Noss	Shetland	60.1490	-1.0452	5	1	3	1	1	1	NS	NS
55	Turr Ness, Noss	Shetland	60.1472	-1.0395	10	1	2	1	1	1	NS	NS
56	Heogatoug, Noss	Shetland	60.1452	-1.0032	90	1	1	1	1	1	NS	NS
57	The Knab, Lerwick	Shetland	60.1507	-1.1322	10	1	1	1	1	1	NS	NS
58	Brei Wick	Shetland	60.1497	-1.1570	20	1	2	1	1	1	NS	NS
59	Gulberwick	Shetland	60.1220	-1.1968	65	1	2	1	1	1	NS	NS
60	Bressay LH, Kirkabister Ness	Shetland	60.1205	-1.1213	20	1	1	1	1	1	NS	NS
61	Hamnavoe	Shetland	60.1067	-1.3232	30	1	2	1	1	1	NS	NS
62	Wester Quarff	Shetland	60.0973	-1.2777	15	1	2	1	1	1	NS	NS
63	Easter Quarff (East Voe of Quarff)	Shetland	60.0973	-1.2163	8	1	2	1	1	1	NS	NS
64	Fladdabister	Shetland	60.0737	-1.2077	50	1	1	1	1	1	NS	NS
65	East Burra from Houss	Shetland	60.0643	-1.3208	15	1	4	1	1	1	NS	NS
66	Aithwick	Shetland	60.0452	-1.1882	10	1	1	1	1	1	NS	NS
67.1	Mousa North Site	Shetland	60.0115	-1.2220	50	1	2	1	1	1	NS	NS
67.2	Mousa Sound Central Site	Shetland	60.0028	-1.2122	25	1	3	1	1	1	NS	NS
67.3	Mousa South Site	Shetland	59.9915	-1.1977	20	1	3	1	1	1	NS	NS
67.4	Mousa Island	Shetland	60.0003	-1.1827	10	1	3	1	1	1	NS	NS
68	Sandwick	Shetland	60.0077	-1.2178	20	1	2	1	1	1	NS	NS

Site No	Site	Region	Lat decimal	Long decimal	Elev (m)	No Obs	Obs Area	Optics	Obs Method	Rec method	BND MUs	HP MUs
69	Channerwick/Levenwick	Shetland	59.9837	-1.2685	50	1	2	1	1	1	NS	NS
70	Noness	Shetland	59.9740	-1.2023	20	1	1	1	1	1	NS	NS
71	St. Ninian's Isle	Shetland	59.9723	-1.3277	20	1	4	1	1	1	NS	NS
72	Scousburgh	Shetland	59.9502	-1.3275	40	1	4	1	1	1	NS	NS
73	Boddam (OutVoe)	Shetland	59.9217	-1.2733	10	1	2	1	1	1	NS	NS
74	Quendale Bay	Shetland	59.8952	-1.3438	20	1	2	1	1	1	NS	NS
75	Sumburgh Head	Shetland	59.8537	-1.2735	80	1	1	1	1	1	NS	NS
76	Fair Isle (Buness)	Shetland	59.5521	-1.6060	35	1	1	1	1	1	NS	NS
77.1	Marwick Head	Orkney	59.1132	-3.3381	80	1	1	1	1	1	ECS	NS
77.2	Kitchener Memorial, Marwick Head	Orkney	59.1082	-3.3499	87	1	1	1	1	1	ECS	NS
78	Billia Croo	Orkney	58.9794	-3.3604	90	1	1	2	3	1	ECS	NS
79	Hundland, Papa Westray	Orkney	59.3531	-2.9074	10	1	1	1	1	1	ECS	NS
80.1	Clay Face, Sanday	Orkney	59.2510	-2.6307	25	1	1	1	1	1	ECS	NS
80.2	Warsetter, Sanday	Orkney	59.2230	-2.6538	50	1	1	1	1	1	ECS	NS
81.1	Whalepoint, Sanday	Orkney	59.2908	-2.6136	10	1	1	1	1	1	ECS	NS
81.2	Whitemill Bay, Sanday	Orkney	59.3015	-2.5334	5	1	1	1	1	1	ECS	NS
82.1	Doun Helzie, Sanday	Orkney	59.2081	-2.6683	20	1	1	1	1	1	ECS	NS
82.2	Loth Pier, Sanday	Orkney	59.1918	-2.6986	5	1	1	1	1	1	ECS	NS
83	Hoxa Head, S Ronaldsay	Orkney	58.8197	-3.0365	20	1	1	1	1	1	ECS	NS
84	Herston Head, S Ronaldsay	Orkney	58.8133	-3.0117	30	1	1	1	1	1	ECS	NS
85	Cantick Head, South Walls	Orkney	58.7876	-3.1301	20	1	1	1	1	1	ECS	NS
86	Barswick/Barth Head, S Ronaldsay	Orkney	58.7541	-2.9927	30	1	1	1	1	1	ECS	NS
87	Bur Wick, S Ronaldsay	Orkney	58.7417	-2.6670	10	1	2	1	1	1	ECS	NS
88	The Wing, S Ronaldsay	Orkney	58.7333	-2.9667	10	1	1	1	1	1	ECS	NS
89	Portskerra	Sutherland	58.5726	-3.9329	30	1	1	1	1	1	ECS	NS
90	Ushat Head	Caithness (N)	58.6150	-3.6680	37	1	1	1	1	1	ECS	NS
91	Holborn Head, Thurso	Caithness (N)	58.6240	-3.5446	6	1	2	1	1	1	ECS	NS
92	Scrabster Lighthouse	Caithness (N)	58.6145	-3.5394	12	1	1	2	2	2	ECS	NS
93.1	Thurso Bay	Caithness (N)	58.6005	-3.5362	24	1	2	1	1	1	ECS	NS
93.2	Thurso caravan park	Caithness (N)	58.5990	-3.5349	20	1	2	1	1	1	ECS	NS
93.3	Thurso	Caithness (N)	58.5991	-3.5134	30	1	2	1	1	1	ECS	NS
94	Castletown, Dunnet Bay	Caithness (N)	58.5660	-3.3797	10	1	2	1	1	1	ECS	NS
95.1	Dunnet Head (West)	Caithness (N)	58.6708	-3.3752	55	1	1	2	2	1	ECS	NS
95.2	Dunnet Head	Caithness (N)	58.6713	-3.3738	100	1	1	1	1	1	ECS	NS
95.3	Dunnet Head (East)	Caithness (N)	58.6699	-3.3709	69	1	1	2	2	1	ECS	NS

Site No	Site	Region	Lat decimal	Long decimal	Elev (m)	No Obs	Obs Area	Optics	Obs Method	Rec method	BND MUs	HP MUs
96.1	St. John's Point, Gill's Bay	Caithness (N)	58.6522	-3.1761	30	1	1	1	1	1	ECS	NS
96.2	Gill's Bay	Caithness (N)	58.6370	-3.1557	30	1	1	1	1	1	ECS	NS
97	Duncansby Head	Caithness (N)	58.6441	-3.0267	60	1	1	1	1	1	ECS	NS
98	Noss Head, Wick	Caithness (E)	58.4794	-3.0540	10	1	1	1	1	1	ECS	NS
99.1	Wick	Caithness (E)	58.4349	-3.0729	17	1	1	1	1	1	ECS	NS
99.2	Trinkie, Wick	Caithness (E)	58.4290	-3.0590	33	1	1	1	1	1	ECS	NS
100	Whaligoe	Caithness (E)	58.3425	-3.1648	75	1	1	1	1	1	ECS	NS
101.1	Shelligoe Clifftop	Caithness (E)	58.2982	-3.2935	50	1	1	1	1	1	ECS	NS
101.2	Lybster Viewpoint	Caithness (E)	58.2916	-3.2935	55	1	1	1	1	1	ECS	NS
102	Forse	Caithness (E)	58.2824	-3.3334	56	1	1	1	2	1	ECS	NS
103	Latheronwheel	Caithness (E)	58.2730	-3.3759	50	1	1	1	1	1	ECS	NS
104	Badbea	Caithness (E)	58.1528	-3.5581	150	1	1	1	1	1	ECS	NS
105	Ousdale nr Badbea	Caithness (E)	58.1521	-3.5613	160	1	1	1	1	1	ECS	NS
106	Avoch	Highland	57.5659	-4.1709	15	1	1	1	1	1	ECS	NS
107	Brora	Highland	58.0085	-3.8471	10	1	1	1	1	1	ECS	NS
108.1	Dunrobin Point, Golspie	Highland	57.9883	-3.8945	5	1	1	1	1	1	ECS	NS
108.2	Strathsteven, near Brora	Highland	57.9883	-3.9033	20	1	1	1	1	1	ECS	NS
109.1	Golspie, Iain Macdonald's house	Highland	57.9706	-3.9809	8	1	1	1	1	1	ECS	NS
109.2	Golspie Pier	Highland	57.9699	-3.9798	5	1	1	1	1	1	ECS	NS
109.3	Road to Golspie	Highland	57.9694	-3.9844	10	1	1	1	1	1	ECS	NS
109.4	Golspie go cart track	Highland	57.9553	-3.9978	10	1	1	1	1	1	ECS	NS
110	Embo	Highland	57.9041	-3.9930	10	1	1	1	1	1	ECS	NS
111	Dornoch	Highland	57.8660	-4.0291	10	1	1	1	1	1	ECS	NS
112	Tarbat Ness	Highland	57.8652	-3.7769	10	1	1	1	1	1	ECS	NS
113	Portmahomack	Highland	57.8228	-3.8856	10	1	2	1	1	1	ECS	NS
114	Rockfield	Highland	57.8175	-3.8214	25	1	1	1	1	1	ECS	NS
115	Balintore Harbour	Highland	57.7533	-3.9097	6	1	1	1	1	1	ECS	NS
116	Nigg (near Cromarty)	Highland	57.6933	-4.0183	5	1	3	1	1	1	ECS	NS
117	Cromarty	Highland	57.6840	-4.0379	100	1	3	1	1	1	ECS	NS
118	South Sutor, Cromarty	Highland	57.6787	-3.9957	50	1	1	1	1	1	ECS	NS
119	Balblair, By Cromarty	Highland	57.6750	-4.1717	10	1	3	1	1	1	ECS	NS
120	Castlecraig	Highland	57.6434	-4.2934	125	1	1	1	1	1	ECS	NS
121	Rosemarkie	Highland	57.5935	-4.1151	6	1	1	1	1	1	ECS	NS
122	Fort George	Highland	57.5829	-4.0781	10	1	3	1	1	1	ECS	NS
123	Fortrose	Highland	57.5798	-4.1355	20	1	3	1	1	1	ECS	NS
124	Chanonry Point	Highland	57.5741	-4.0916	3	1	3	1	1	1	ECS	NS
125	Kilmuir, Black Isle	Highland	57.5064	-4.2129	10	1	1	1	1	1	ECS	NS
126	North Kessock	Highland	57.5008	-4.2393	31	1	3	1	1	1	ECS	NS

Site No	Site	Region	Lat decimal	Long decimal	Elev (m)	No Obs	Obs Area	Optics	Obs Method	Rec method	BND MUs	HP MUs
.1												
126.2	Kessock bridge (north)	Highland	57.5011	-4.2345	10	1	3	1	1	1	ECS	NS
126.3	Kessock Bridge, Inverness	Highland	57.4992	-4.2298	10	1	3	1	1	1	ECS	NS
126.4	Kessock bridge (south)	Highland	57.4960	-4.2227	10	1	3	1	1	1	ECS	NS
126.5	South Kessock	Highland	57.4947	-4.2380	5	1	1	1	1	1	ECS	NS
127	Ardersier	Moray	57.5676	-4.0391	8	1	3	1	1	1	ECS	NS
128	Nairn	Moray	57.5893	-3.8798	5	1	1	1	1	1	ECS	NS
129	Nairn Harbour	Moray	57.5942	-3.8606	5	1	1	1	1	1	ECS	NS
130	Culbin Sands	Moray	57.6591	-3.6922	2	1	1	1	1	1	ECS	NS
131	Findhorn Bay	Moray	57.6500	-3.6000	5	1	1	1	1	1	ECS	NS
132	Kinloss	Moray	57.6600	-3.5679	3	1	1	1	1	1	ECS	NS
133.1	Burghead Harbour	Moray	57.7021	-3.4992	5	1	1	1	1	1	ECS	NS
133.2	Burghead Point	Moray	57.7035	-3.4973	3	1	1	1	1	1	ECS	NS
133.3	Burghead (near Fort)	Moray	57.7037	-3.4970	5	1	1	1	1	1	ECS	NS
133.4	Burghead Bay	Moray	57.6974	-3.4883	5	1	1	1	1	1	ECS	NS
133.5	Burghead Beach	Moray	57.7034	-3.4882	2	1	1	1	1	1	ECS	NS
133.6	Burghead East	Moray	57.7028	-3.4817	5	1	1	1	1	1	ECS	NS
133.7	Burghead	Moray	57.7030	-3.4913	5	1	1	1	1	1	ECS	NS
133.8	Burghead (near Red Craig)	Moray	57.7032	-3.4701	5	1	1	1	1	1	ECS	NS
134	Cummingston	Moray	57.7046	-3.4571	30	1	1	1	1	1	ECS	NS
135.1	Hopeman Beach	Moray	57.7103	-3.4348	3	1	1	1	1	1	ECS	NS
135.2	Hopeman	Moray	57.7113	-3.4323	10	1	1	1	1	1	ECS	NS
135.3	Hopeman East Beach	Moray	57.7112	-3.4286	3	1	1	1	1	1	ECS	NS
135.4	Hopeman Caves	Moray	57.7129	-3.4261	35	1	1	1	1	1	ECS	NS
135.5	Clasach Cove	Moray	57.7127	-3.4250	40	1	1	1	1	1	ECS	NS
136.1	Covesea Coastguard Station	Moray	57.7249	-3.3499	30	1	1	1	1	1	ECS	NS
136.2	Covesea	Moray	57.7223	-3.3643	40	1	1	1	1	1	ECS	NS
136.3	Covesea Lighthouse	Moray	57.7243	-3.3386	40	1	1	1	1	1	ECS	NS
136.4	Covesea Cliffs	Moray	57.7245	-3.3381	40	1	1	1	1	1	ECS	NS
137.1	Lossiemouth West Beach	Moray	57.7215	-3.3009	2	1	1	1	1	1	ECS	NS
137.2	Lossiemouth Coastguard Station	Moray	57.7205	-3.2840	5	1	1	1	1	1	ECS	NS
137.3	Lossiemouth Harbour	Moray	57.7237	-3.2794	5	1	1	1	1	1	ECS	NS
137.4	Lossiemouth Prospect Terrace	Moray	57.7203	-3.2823	5	1	1	1	1	1	ECS	NS

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137.5	Lossiemouth East End Shore St	Moray	57.7237	-3.2794	5	1	1	1	1	1	ECS	NS
137.6	Lossiemouth Pier	Moray	57.7244	-3.2789	5	1	1	1	1	1	ECS	NS
137.7	Lossiemouth East Beach	Moray	57.7200	-3.2786	2	1	1	1	1	1	ECS	NS
137.8	Lossiemouth	Moray	57.7237	-3.2775	5	1	1	1	1	1	ECS	NS
138	Kingston by River Spey	Moray	57.6761	-3.1161	5	1	1	1	1	1	ECS	NS
139	Spey Bay	Moray	57.6740	-3.0935	6	1	1	1	1	1	ECS	NS
140	Portgordon	Moray	57.6656	-3.0127	15	1	1	1	1	1	ECS	NS
141	Buckie	Moray	57.6808	-2.9583	10	1	1	1	1	1	ECS	NS
142	Portessie	Moray	57.6838	-2.9492	15	1	1	1	1	1	ECS	NS
143	Craig Head west of Findochty	Moray	57.6979	-2.9203	30	1	1	1	1	1	ECS	NS
144.1	Findochty Harbour	Moray	57.6992	-2.9075	5	1	1	1	1	1	ECS	NS
144.2	Findochty	Moray	57.7015	-2.8993	30	1	1	1	1	1	ECS	NS
145.1	West of Portnockie Harbour	Moray	57.7038	-2.8643	10	1	1	1	1	1	ECS	NS
145.2	North of Portknockie Harbour	Moray	57.7056	-2.8617	15	1	1	1	1	1	ECS	NS
145.3	Green Castle Rock, Portknockie	Moray	57.7061	-2.8586	40	1	1	1	1	1	ECS	NS
145.4	Portknockie cliffs	Moray	57.7054	-2.8563	30	1	1	1	1	1	ECS	NS
145.5	Portknockie	Moray	57.7054	-2.8559	40	1	1	1	1	1	ECS	NS
145.6	Bow Fiddle, Portnockie	Moray	57.7054	-2.8528	40	1	1	1	1	1	ECS	NS
146.1	Cullen Bay near Scar Nose	Moray	57.7045	-2.8528	40	1	1	1	1	1	ECS	NS
146.2	Cullen Bay	Moray	57.6934	-2.8317	6	1	2	1	1	1	ECS	NS
146.3	Cullen (east of harbour)	Moray	57.7249	-2.8239	20	1	1	1	1	1	ECS	NS
146.4	Cullen	Moray	57.6947	-2.8203	20	1	1	2	2	1	ECS	NS
147	Between Cullen & Sandend Bay	Moray	57.6993	-2.7892	50	1	1	1	1	1	ECS	NS
148	Findlater Castle	Aberdeenshire	57.6924	-2.7704	50	1	1	1	1	1	ECS	NS
149	Sandend	Aberdeenshire	57.6877	-2.7484	20	1	2	1	1	1	ECS	NS
150	Portsoy	Aberdeenshire	57.6863	-2.6902	10	1	1	1	1	1	ECS	NS
151.1	Banff Harbour	Aberdeenshire	57.6662	-2.5152	15	1	1	1	1	1	ECS	NS
151.2	Banff	Aberdeenshire	57.6662	-2.5152	15	1	1	1	1	1	ECS	NS
152	Troup Head	Aberdeenshire	57.6942	-2.2978	100	1	1	1	1	1	ECS	NS
153	Crovie north of Gardenstown	Aberdeenshire	57.6792	-2.3239	55	1	1	1	1	1	ECS	NS
154	Sandhaven	Aberdeenshire	57.6977	-2.0930	5	1	1	1	1	1	ECS	NS
155	Fraserburgh	Aberdeenshire	57.6979	-2.0045	20	1	1	1	1	1	ECS	NS
156	Kinnaird Head, By Fraserburgh	Aberdeenshire	57.6972	-2.0028	10	1	1	1	1	1	ECS	NS
157.1	Macduff	Aberdeenshire	57.6729	-2.4932	30	1	1	1	2	1	ECS	NS

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157.2	Macduff Marine Aquarium	Aberdeenshire	57.6721	-2.4916	4	1	1	1	2	1	ECS	NS
157.3	Boyndie Bay east of Whitehills	Aberdeenshire	57.6697	-2.5443	15	1	1	1	1	1	ECS	NS
157.4	Macduff, Gellymill	Aberdeenshire	57.6654	-2.5013	53	1	1	1	1	1	ECS	NS
158	St Combs south of Inverallochy	Aberdeenshire	57.6566	-1.9009	15	1	1	1	2	2	ECS	NS
159	Rattray Head, Buchan	Aberdeenshire	57.6097	-1.8208	19	1	1	1	1	1	ECS	NS
160	Peterhead	Aberdeenshire	57.5048	-1.7688	5	1	1	1	1	1	ECS	NS
161.1	Buchan	Aberdeenshire	57.4708	-1.7764	10	1	1	1	1	1	ECS	NS
161.2	Longhaven Cliffs	Aberdeenshire	57.4583	-1.7872	50	1	1	1	1	1	ECS	NS
162	Slains Castle S of Bullers of Buchan	Aberdeenshire	57.4161	-1.8403	30	1	1	1	1	1	ECS	NS
163	Cruden Bay	Aberdeenshire	57.4056	-1.8639	15	1	1	1	1	1	ECS	NS
164	Whinnyfold S of Cruden Bay	Aberdeenshire	57.3889	-1.8653	25	1	1	1	1	1	ECS	NS
165	Collieston N of Newburgh	Aberdeenshire	57.3431	-1.9403	30	1	1	1	1	1	ECS	NS
166	Hackley Bay	Aberdeenshire	57.3349	-1.9593	30	1	2	1	1	1	ECS	NS
167.1	Sands of Forvie	Aberdeenshire	57.3236	-1.9736	26	1	1	1	1	1	ECS	NS
167.2	Ythan river mouth	Aberdeenshire	57.3115	-1.9890	14	1	1	1	1	1	ECS	NS
167.3	Newburgh	Aberdeenshire	57.3085	-1.9948	25	1	1	1	1	1	ECS	NS
168	Balmedie Beach	Aberdeenshire	57.2542	-2.0361	10	1	1	1	1	1	ECS	NS
169	Blackdog, Aberdeen	Aberdeenshire	57.2181	-2.0611	10	1	1	1	1	1	ECS	NS
170.1	Donmouth	Aberdeenshire	57.1750	-2.0764	5	1	1	1	1	1	ECS	NS
170.2	Aberdeen Beach	Aberdeenshire	57.1500	-2.0744	3	1	1	1	1	1	ECS	NS
170.3	Aberdeen Harbour	Aberdeenshire	57.1428	-2.0569	5	1	2	1	1	1	ECS	NS
170.4	Aberdeen Torry Battery	Aberdeenshire	57.1423	-2.0576	20	1	2	1	1	1	ECS	NS
171	Girdleness	Aberdeenshire	57.1394	-2.0456	15	1	1	1	1	1	ECS	NS
172	Nigg Bay	Aberdeenshire	57.1387	-2.0511	5	1	2	1	1	1	ECS	NS
173	North Broad Craig	Aberdeenshire	57.1190	-2.0560	30	1	1	1	1	1	ECS	NS
174	Doonies Farm	Aberdeenshire	57.1181	-2.0542	40	1	1	1	1	1	ECS	NS
175.1	Souter Head, Cove	Aberdeenshire	57.1069	-2.0667	30	1	1	1	1	1	ECS	NS
175.2	Cove Bay harbour	Aberdeenshire	57.0963	-2.0751	15	1	2	1	1	1	ECS	NS
176	Findon Ness N of Portlethen	Aberdeenshire	57.0667	-2.0917	42	1	1	1	1	1	ECS	NS
177	Portlethen	Aberdeenshire	57.0573	-2.1092	30	1	1	1	1	1	ECS	NS
178	Newtonhill	Aberdeenshire	57.0306	-2.1417	20	1	1	1	1	1	ECS	NS
179	Muchalls S of Newtonhill	Aberdeenshire	57.0194	-2.1597	30	1	1	1	1	1	ECS	NS
180.1	Stonehaven	Aberdeenshire	56.9635	-2.2035	5	1	1	1	1	1	ECS	NS
180.2	Downie Point, Stonehaven	Aberdeenshire	56.9585	-2.1969	20	1	1	1	1	1	ECS	NS

Site No	Site	Region	Lat decimal	Long decimal	Elev (m)	No Obs	Obs Area	Optics	Obs Method	Rec method	BND MUs	HP MUs
180.3	Dunnottar Castle, Stonehaven	Aberdeenshire	56.9461	-2.1960	40	1	1	1	1	1	ECS	NS
181	Fowlsheugh	Aberdeenshire	56.9167	-2.1986	50	1	1	1	1	1	ECS	NS
182	Crawton Ness N of Catterline	Aberdeenshire	56.9097	-2.1972	40	1	1	1	1	1	ECS	NS
183.1	Catterline S of Stonehaven	Aberdeenshire	56.8931	-2.2139	25	1	1	1	1	1	ECS	NS
183.2	Todhead Point, N of Inverbervie	Aberdeenshire	56.8819	-2.2139	30	1	1	1	1	1	ECS	NS
184	Inverbervie S of Stonehaven	Aberdeenshire	56.8417	-2.2750	5	1	1	1	1	1	ECS	NS
185	Johnshaven S of Inverbervie	Aberdeenshire	56.7931	-2.3431	25	1	1	1	1	1	ECS	NS
186	St Cyrus	Aberdeenshire	56.7708	-2.4083	5	1	1	1	1	1	ECS	NS
187	Montrose	Angus	56.7052	-2.4533	5	1	1	1	1	1	ECS	NS
188	Scurdie Ness	Angus	56.7009	-2.4387	30	1	1	1	1	1	ECS	NS
189	Auchmithie, Lud Castle	Angus	56.5818	-2.5216	50	1	1	1	1	1	ECS	NS
190.1	Three Storey Hoose, Arbroath	Angus	56.5661	-2.5400	20	1	1	1	1	1	ECS	NS
190.2	Arbroath	Angus	56.5565	-2.5760	25	1	1	1	1	1	ECS	NS
191	Elliot Links, S of Arbroath	Angus	56.5446	-2.6166	15	1	1	1	1	1	ECS	NS
192	St. Andrews	Fife	56.3412	-2.7033	10	1	1	1	1	1	ECS	NS
193	East Wemyss N of Kirkcaldy	Fife	56.1670	-3.0505	36	1	1	1	2	2	ECS	NS
194	Musselburgh	East Lothian	55.9518	-3.0485	5	1	1	1	1	1	ECS	NS
195	North Berwick	East Lothian	56.0623	-2.7177	10	1	1	1	1	1	ECS	NS
196	St. Abb's Head	Berwickshire	55.9168	-2.1375	94	1	1	1	1	1	ECS	NS
197	Lindisfarne (Holy Island)	Northumberland	55.6741	-1.7835	12	1	1	1	1	1	NS	NS
198	Farne Islands (Inner Farne LH)	Northumberland	55.6159	-1.6552	19	1	1	1	1	1	NS	NS
199	Bamburgh	Northumberland	55.6115	-1.7123	20	1	1	1	1	1	NS	NS
200	Seahouses	Northumberland	55.5817	-1.6466	10	1	1	1	1	1	NS	NS
201	Beadnell	Northumberland	55.5522	-1.6237	8	1	1	1	1	1	NS	NS
202	Dunstanburgh Castle, Craster	Northumberland	55.5096	-1.6160	10	1	1	1	1	1	NS	NS
203	Cullernose Point S of Craster	Northumberland	55.4640	-1.5915	20	1	1	1	1	1	NS	NS
204	Boulmer	Northumberland	55.4227	-1.5808	10	1	1	1	1	1	NS	NS
205.1	Amble Sand Dunes opp. Coquet Is.	Northumberland	55.3270	-1.5589	5	1	1	1	1	1	NS	NS
205.2	Low Hauxley	Northumberland	55.3163	-1.5531	10	1	1	1	1	1	NS	NS
205.3	Hauxley Nature Reserve	Northumberland	55.3167	-1.5513	6	1	1	1	1	1	NS	NS
206	Druridge Bay S of Amble	Northumberland	55.2569	-1.5662	3	1	1	1	1	1	NS	NS
207	Cresswell	Northumberland	55.2356	-1.5386	10	1	1	1	1	1	NS	NS
208	Newbiggin-by-the-Sea (Church Pt)	Northumberland	55.1854	-1.5018	5	1	1	1	1	1	NS	NS
209	Blyth	Northumberland	55.1327	-1.5048	5	1	1	1	1	1	NS	NS
210	Rocky Island, Seaton Sluice	Northumberland	55.0850	-1.4703	2	1	1	1	1	1	NS	NS

Site No	Site	Region	Lat decimal	Long decimal	Elev (m)	No Obs	Obs Area	Optics	Obs Method	Rec method	BND MUs	HP MUs
211	St. Mary's Lighthouse	Northumberland	55.0717	-1.4496	10	1	1	1	2	2	NS	NS
212	Cullercoats	Tyne and Wear	55.0329	-1.4295	10	1	1	1	1	1	NS	NS
213.1	King Edward's Bay, Tynemouth	Tyne and Wear	55.0188	-1.4161	20	1	1	1	1	1	NS	NS
213.2	Spanish Battery, Tynemouth	Tyne and Wear	55.0153	-1.4166	5	1	1	1	1	1	NS	NS
213.3	Tynemouth North Pier	Tyne and Wear	55.0149	-1.4038	5	1	1	1	1	1	NS	NS
214	Marsden Lea, South Shields	Tyne and Wear	54.9767	-1.3771	25	1	1	1	1	1	NS	NS
215	Lizard Point, Mardsen	Tyne and Wear	54.9727	-1.3652	35	1	1	1	1	1	NS	NS
216.1	Souter Lighthouse B, Sunderland	Tyne and Wear	54.9709	-1.3614	20	1	1	1	2	2	NS	NS
216.2	The Wherry, Whitburn	Tyne and Wear	54.9685	-1.3608	20	1	1	1	1	1	NS	NS
216.3	Souter Lighthouse A, Sunderland	Tyne and Wear	54.9681	-1.3718	20	1	1	1	1	1	NS	NS
217	Seaham	Durham	54.8380	-1.3215	20	1	1	1	1	1	NS	NS
218	Crimdon Dene, nr. Hartlepool	Durham	54.7281	-1.2527	50	1	1	1	1	1	NS	NS
219	Saltburn Top	Yorkshire	54.5856	-0.9269	100	1	1	1	1	1	NS	NS
220	Staithes	Yorkshire	54.5586	-0.7837	40	1	1	1	1	1	NS	NS
221	Long Nab, Burniston	Yorkshire	54.3314	-0.4189	30	1	1	1	1	1	NS	NS
222.1	Marine Drive, Scarborough	Yorkshire	54.2903	-0.3881	10	1	1	1	1	1	NS	NS
222.2	Scarborough	Yorkshire	54.2877	-0.3880	78	1	1	1	1	1	NS	NS
222.3	East Pier, Scarborough	Yorkshire	54.2838	-0.3862	5	1	1	1	1	1	NS	NS
222.4	Scarborough, Holbeck Bay	Yorkshire	54.2679	-0.3891	50	1	1	1	1	1	NS	NS
223	Filey Brigg	Yorkshire	54.2163	-0.2662	50	1	1	1	1	1	NS	NS
224	Filey Bay	Yorkshire	54.1885	-0.2775	10	1	1	1	1	1	NS	NS
225	Bridlington Bay	Yorkshire	54.0850	-0.1840	10	1	1	1	1	1	NS	NS
226	Bempton Cliffs	Yorkshire	54.1503	-0.1714	90	1	1	1	1	1	NS	NS
227	Flamborough Head	Yorkshire	54.1162	-0.0807	40	1	1	1	1	1	NS	NS
228	Mappleton south of Hornsea	Yorkshire	53.8717	-0.1230	15	1	1	1	1	1	NS	NS
229.1	Spurn Head	Yorkshire	53.5725	0.1105	10	1	1	1	1	1	NS	NS
229.2	Spurn Head Bird Observatory	Yorkshire	53.5723	0.1100	4	1	1	1	1	1	NS	NS
230	The Deep, Hull	Humberside	53.7389	-0.3302	10	1	1	1	1	1	NS	NS
231	Humber Bridge, Hull	Humberside	53.7141	-0.4504	5	1	1	1	1	1	NS	NS
232	Theddlethorpe Beach	Lincolnshire	53.3801	0.2322	2	1	1	1	1	1	NS	NS
233	Mablethorpe	Lincolnshire	53.3441	0.2642	3	1	1	1	1	1	NS	NS
234	Huttoft Car Terrace S of Sandilands	Lincolnshire	53.2933	0.3021	3	1	1	1	1	1	NS	NS
235	Anderby Creek S of Mablethorpe	Lincolnshire	53.2542	0.3223	3	1	1	1	1	1	NS	NS
236	Chapel Point, Chapel St Leonards	Lincolnshire	53.2333	0.3398	3	1	1	1	1	1	NS	NS
237.1	Winthorpe Tower, Skegness	Lincolnshire	53.1664	0.3509	8	1	1	1	1	1	NS	NS

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237.2	Skegness Pier	Lincolnshire	53.1446	0.3494	5	1	1	1	1	1	NS	NS
238	Gibraltar Point NNR	Lincolnshire	53.0922	0.3392	4	1	1	1	1	1	NS	NS
239	Hunstanton	Norfolk	52.9505	0.4949	22	1	1	1	1	1	NS	NS
240	Blakeney Point	Norfolk	52.9796	0.9767	5	1	1	1	1	1	NS	NS
241	Cley next the Sea	Norfolk	52.9653	1.0476	3	1	1	1	1	1	NS	NS
242	Weybourne	Norfolk	52.9493	1.1425	20	1	1	1	1	1	NS	NS
243	Sheringham	Norfolk	52.9443	1.2118	10	1	1	1	1	1	NS	NS
244	West Runton	Norfolk	52.9408	1.2545	15	1	1	1	1	1	NS	NS
245.1	Cromer Pier	Norfolk	52.9333	1.3011	3	1	1	1	1	1	NS	NS
245.2	Overstrand, Cromer	Norfolk	52.9198	1.3429	50	1	1	1	1	1	NS	NS
246	Trimingham	Norfolk	52.8992	1.3887	50	1	1	1	1	1	NS	NS
247	Mundesley	Norfolk	52.8763	1.4416	25	1	1	1	1	1	NS	NS
248	Hopton-on-Sea	Norfolk	52.5364	1.7378	9	1	1	1	1	1	NS	NS
249	Pakefield Cliffs south of Lowestoft	Suffolk	52.4468	1.7326	15	1	1	1	1	1	NS	NS
250	Southwold	Suffolk	52.3262	1.6813	10	1	1	1	1	1	NS	NS
251	Orford Ness Lighthouse	Suffolk	52.0843	1.5734	5	1	1	1	1	1	NS	NS
252	Hollesley Bay	Suffolk	52.0428	1.4593	3	1	1	1	1	1	NS	NS
253	Walton Pier	Essex	51.8750	1.2817	5	1	1	1	1	1	NS	NS
254	Clacton Pier	Essex	51.7833	1.1500	5	1	1	1	1	1	NS	NS
255	Southend-on-Sea Pier	Essex	51.5323	0.7164	3	1	2	1	1	1	NS	NS
256	Broadstairs	Kent	51.3564	1.4435	20	1	1	1	1	1	NS	NS
257	Dungeness Bird Observatory	Kent	50.9127	0.9775	3	1	1	1	1	1	CSW	NS
258	Fairlight Beach east of Hastings	East Sussex	50.8732	0.6690	60	1	1	1	1	1	CSW	NS
259.1	Hastings	East Sussex	50.8535	0.5928	10	1	1	1	1	1	CSW	NS
259.2	Warrior Beach, Hastings	East Sussex	50.8523	0.5690	10	1	1	1	1	1	CSW	NS
260	Holywell	East Sussex	50.7475	0.2659	75	1	1	1	1	1	CSW	NS
261	Bulverhythe Beach, Bexhill	East Sussex	50.8448	0.5087	5	1	1	1	1	1	CSW	NS
262	Birling Gap	East Sussex	50.7426	0.2021	75	1	1	1	1	1	CSW	NS
263	Brighton Marina	West Sussex	50.8123	-0.1060	5	1	1	1	1	1	CSW	NS
264	Southwick beach	West Sussex	50.8289	-0.2353	5	1	1	1	1	1	CSW	NS
265	Shoreham	West Sussex	50.8280	-0.2610	2	1	1	1	1	1	CSW	NS
266	Lancing Beach	West Sussex	50.8183	-0.3267	5	1	1	1	1	1	CSW	NS
267	Worthing	West Sussex	50.8088	-0.3710	4	1	1	1	1	1	CSW	NS
268	Southsea Castle, Portsmouth	Hants	50.7779	-1.0889	5	1	1	1	1	1	CSW	NS
269	Poole Bay	Dorset	50.6917	-1.9339	5	1	1	1	1	1	CSW	NS
270	Durlston Country Park	Dorset	50.5952	-1.9527	79	1	1	1	1	1	CSW	NS
271	Burton Bradstock Cliffs	Dorset	50.7008	-2.7310	25	1	1	1	1	1	CSW	CIS
272	Stonebarrow Cliff, Charmouth	Dorset	50.7344	-2.8867	50	1	1	1	1	1	CSW	CIS

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273	Beer Head	South Devon	50.6854	-3.0971	75	1	1	1	1	1	CSW	CIS
274	Branscombe West Cliff	South Devon	50.6880	-3.1290	100	1	1	1	1	1	CSW	CIS
275	Orcombe Point near Exmouth	South Devon	50.6071	-3.3850	30	1	1	1	1	1	CSW	CIS
276	Dawlish Warren W of Exmouth	South Devon	50.5795	-3.4647	10	1	1	1	1	1	CSW	CIS
277	Teignmouth (Public viewpoint)	South Devon	50.5489	-3.4003	5	1	1	1	1	1	CSW	CIS
278	Labrador Bay	South Devon	50.5289	-3.5046	100	1	1	1	1	1	CSW	CIS
279	Maidencombe N of Torquay	South Devon	50.5057	-3.5143	50	1	1	1	1	1	CSW	CIS
280	Berry Head near Brixham	South Devon	50.3997	-3.4835	50	1	1	1	1	1	CSW	CIS
281	Sharkham Point S of Berry Head	South Devon	50.3818	-3.4977	50	1	1	1	1	1	CSW	CIS
282	Dartmouth	South Devon	50.3435	-3.5687	50	1	4	1	1	1	CSW	CS
283	Slapton Sands	South Devon	50.2853	-3.6453	25	1	1	1	1	1	CSW	CS
284	Torcross	South Devon	50.2667	-3.6523	4	1	1	1	1	1	CSW	CIS
285	Start Point	South Devon	50.2225	-3.6420	50	1	1	1	1	1	CSW	CIS
286	Pear Tree Point W of Start Point	South Devon	50.2188	-3.6569	50	1	1	1	1	1	CSW	CIS
287	Mattiscombe Beach	South Devon	50.6592	-3.6592	30	1	1	1	1	1	CSW	CIS
288	Prawle Point	South Devon	50.2027	-3.7208	45	1	1	1	1	1	CSW	CIS
289	Bolberry W of Bolt Head	South Devon	50.2313	-3.8428	100	1	1	1	1	1	CSW	CIS
290	Bolt Head, Devon	South Devon	50.2114	-3.7881	128	1	1	1	1	1	CSW	CIS
291	Bolt Tail, Devon	South Devon	50.2418	-3.8689	50	1	1	1	1	1	CSW	CIS
292	Warren Point S of Thurlestone	South Devon	50.2640	-3.7881	50	1	1	1	1	1	CSW	CIS
293	Bantham near Bigbury	South Devon	50.2917	-3.8750	20	1	1	1	1	1	CSW	CIS
294	Burgh Island, Bigbury-on-Sea	South Devon	50.2791	-3.9003	50	1	1	1	1	1	CSW	CIS
295	Fernycombe Point, W of Bigbury	South Devon	50.2932	-3.9092	40	1	1	1	1	1	CSW	CIS
296	Mothecombe	South Devon	50.2947	-3.9114	40	1	1	1	1	1	CSW	CIS
297.1	Stoke Beach, Noss Mayo	South Devon	50.2963	-4.0218	50	1	1	1	1	1	CSW	CIS
297.2	Stoke Point	South Devon	50.2954	-4.0230	30	1	1	1	1	1	CSW	CIS
298	Blackstone Point	South Devon	50.2993	-4.0552	90	1	1	1	1	1	CSW	CIS
299	Gara Point W of Blackstone Point	South Devon	50.3050	-4.0722	60	1	1	1	1	1	CSW	CIS
300	Wembury	South Devon	50.3172	-4.0831	50	1	1	1	1	1	CSW	CIS
301	Bovisand Bay, Plymouth	South Devon	50.3360	-4.1257	30	1	1	1	1	1	CSW	CIS
302	Rame Head west of Plymouth	Cornwall (S)	50.3114	-4.2229	100	1	1	1	1	1	CSW	CIS
303	Port Wrinkle west of Plymouth	Cornwall (S)	50.3617	-4.3068	70	1	1	1	1	1	CSW	CIS
304	Polruan near Fowey	Cornwall (S)	50.3276	-4.6372	50	1	1	1	1	1	CSW	CIS
305	Charlestown near St Austell	Cornwall (S)	50.3308	-4.7569	35	1	1	1	1	1	CSW	CIS
306	Black Head south of St Austell	Cornwall (S)	50.3006	-4.7561	60	1	1	1	1	1	CSW	CIS

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307	Castle Point (near St Mawes)	Cornwall (S)	50.1555	-5.0237	30	1	1	1	1	1	CSW	CIS
308	Pendennis, S of Falmouth	Cornwall (S)	50.1529	-5.0531	18	1	1	2	2	2	CSW	CIS
309	Rosemullion Head, SW of Falmouth	Cornwall (S)	50.1101	-5.0825	40	1	1	1	1	1	CSW	CIS
310	Nare Point (Lizard Peninsula)	Cornwall (S)	50.0850	-5.0772	25	1	1	1	1	1	CSW	CIS
311	Manacles	Cornwall (S)	50.0524	-5.0621	50	1	1	1	1	1	CSW	CIS
312	Chynhal's, Coverack	Cornwall (S)	50.0152	-5.0913	22	1	1	2	2	2	CSW	CIS
313	Bass Point nr Lizard Point	Cornwall (S)	49.9636	-5.1867	40	1	1	1	1	1	CSW	CIS
314	Kynance Cove	Cornwall (S)	49.9740	-5.2300	50	1	1	1	1	1	CSW	CIS
315	Predannack Head, Lizard Peninsula	Cornwall (S)	50.0001	-5.2653	80	1	1	1	1	1	CSW	CIS
316	Mullion	Cornwall (S)	50.0162	-5.2588	50	1	1	1	1	1	CSW	CIS
317	Porthleven	Cornwall (S)	50.0808	-5.3132	18	1	1	2	2	2	CSW	CIS
318	Trewavas Head W of Porthleven	Cornwall (S)	50.0895	-5.3619	70	1	1	1	1	1	CSW	CIS
319	Rinsey Head W of Porthleven	Cornwall (S)	50.0949	-5.3726	60	1	1	1	1	1	CSW	CIS
320	Cudden Point	Cornwall (S)	50.1011	-5.4243	61	1	1	1	1	1	CSW	CIS
321	Vessacks east of Gwennap Head	Cornwall (S)	50.0378	-5.6622	50	1	1	2	1	1	CSW	CIS
322	Porthgwarra	Cornwall (S)	50.0362	-5.6693	40	1	1	1	1	1	CSW	CIS
323	Gwennap Head	Cornwall (S)	50.0370	-5.6786	47	2	1	1	1	1	CSW	CIS
324	Peninnis Head, Isles of Scilly	Cornwall (SW)	49.9033	-6.3023	30	1	1	1	1	1	CSW	CIS
325	Bishop's Rock LH, Isles of Scilly	Cornwall (SW)	49.8723	-6.4447	50	1	1	1	1	1	CSW	CIS
326	Lands End	Cornwall (W)	50.0655	-5.7138	70	1	1	1	1	1	CSW	CIS
327	Sennen Cove nr Lands End	Cornwall (W)	50.0775	-5.7035	50	1	1	1	1	1	CSW	CIS
328	Cape Cornwall	Cornwall (W)	50.1268	-5.7065	50	1	1	1	1	1	CSW	CIS
329	St. Ives Bay	Cornwall (N)	50.2184	-5.4761	24	2	1	2	2	1	CSW	CIS
330	Godrevy Point	Cornwall (N)	50.2397	-5.3946	30	1	1	1	1	1	CSW	CIS
331	Portreath south of St Agnes	Cornwall (N)	50.2638	-5.2902	40	1	1	1	1	1	CSW	CIS
332	Porthtowan	Cornwall (N)	50.2865	-5.2450	85	1	1	1	1	1	CSW	CIS
333	St Agnes Head/Tubby's Head	Cornwall (N)	50.3175	-5.2327	100	1	1	1	1	1	CSW	CIS
334	Towan Head, Newquay	Cornwall (N)	50.4253	-5.0990	33	1	1	1	1	1	CSW	CIS
335	Trenance, nr. Newquay	Cornwall (N)	50.4718	-5.0365	75	1	1	1	1	1	CSW	CIS
336	Stepper Point nr Padstow	Cornwall (N)	50.5677	-4.9438	74	1	1	1	1	1	CSW	CIS
337	Pentire Point	Cornwall (N)	50.5893	-4.7337	80	1	1	1	1	1	CSW	CIS
338	Boscastle	Cornwall (N)	50.6930	-4.6989	90	1	1	1	1	1	CSW	CIS
339.1	South end, Lundy Island	North Devon	51.1623	-4.6644	114	1	1	1	1	1	CSW	CIS
339.2	Castle Green, Lundy Island	North Devon	51.1626	-4.6596	115	1	1	1	1	1	CSW	CIS
339.3	The Battery, Lundy Island	North Devon	51.1723	-4.6793	110	1	1	1	1	1	CSW	CIS

Site No	Site	Region	Lat decimal	Long decimal	Elev (m)	No Obs	Obs Area	Optics	Obs Method	Rec method	BND MUs	HP MUs
339.4	Lundy Island	North Devon	51.1850	-4.6650	100	1	1	1	1	1	CSW	CIS
340	Welcombe Mouth	North Devon	50.9336	-4.5447	30	1	1	1	1	1	CSW	CIS
341	Hartland Point	North Devon	51.0208	-4.5225	80	1	1	1	1	1	CSW	CIS
342	Greencliff	North Devon	51.0194	-4.2700	50	1	1	1	1	1	CSW	CIS
343	Cornborough	North Devon	51.0298	-4.2636	50	1	1	1	1	1	CSW	CIS
344	Rock Nose, Westward Ho!	North Devon	51.0224	-4.2736	50	1	1	1	1	1	CSW	CIS
345	Westward Ho!	North Devon	51.0383	-4.2483	30	1	1	1	1	1	CSW	CIS
346	Northam Burrows	North Devon	51.0621	-4.2239	15	1	1	1	1	1	CSW	CIS
347	Bideford Bay	North Devon	51.0841	-4.2188	19	1	1	1	1	1	CSW	CIS
348	Appledore	North Devon	51.0574	-4.1963	10	1	3	1	1	1	CSW	CIS
349	Saunton Beach, S of Croyde Bay	North Devon	51.1090	-4.2195	50	1	1	1	1	1	CSW	CIS
350	Downend Point	North Devon	51.1213	-4.2358	50	1	1	1	1	1	CSW	CIS
351	Croyde	North Devon	51.1252	-4.2405	40	1	1	1	1	1	CSW	CIS
352	Baggy Point	North Devon	51.1440	-4.2563	90	1	1	1	1	1	CSW	CIS
353	Woolacombe	North Devon	51.1735	-4.2102	50	1	1	1	1	1	CSW	CIS
354	Grunta Beach	North Devon	51.1793	-4.2204	50	1	1	1	1	1	CSW	CIS
355	Morte Point	North Devon	51.1875	-4.2252	73	1	1	1	1	1	CSW	CIS
356	Bull Point	North Devon	51.1990	-4.1997	50	1	1	1	1	1	CSW	CIS
357	Torrs, Ilfracombe	North Devon	51.2078	-4.1352	137	1	1	1	1	1	CSW	CIS
358	Tunnels Beach, Ilfracombe	North Devon	51.2143	-4.1279	50	1	1	1	1	1	CSW	CIS
359	Capstone Point nr Ilfracombe	North Devon	51.2107	-4.1130	20	1	1	1	1	1	CSW	CIS
360.1	Ilfracombe	North Devon	51.2103	-4.1125	48	1	1	1	1	1	CSW	CIS
360.2	Ilfracombe Coastguard house	North Devon	51.2097	-4.1094	100	1	1	1	1	1	CSW	CIS
360.3	Ilfracombe Pier	North Devon	51.2118	-4.1074	10	1	1	1	1	1	CSW	CIS
361	Watermouth, W of Combe Martin	North Devon	51.2169	-4.0730	40	1	1	1	1	1	CSW	CIS
362	Burrow Nose, W of Combe Martin	North Devon	51.2186	-4.0670	30	1	1	1	1	1	CSW	CIS
363	Lester Point, Combe Martin	North Devon	51.2146	-4.0664	150	1	1	1	1	1	CSW	CIS
364	High Veer Point nr Martinhoe	North Devon	51.2297	-3.9227	150	1	1	1	1	1	CSW	CIS
365	Foreland Point	North Devon	51.2438	-3.7855	90	1	1	1	1	1	CSW	CIS
366	Hurlstone Point	North Devon	51.2316	-3.5779	109	1	1	1	1	1	CSW	CIS
367	Minehead	Somerset	51.2098	-3.4736	10	1	1	1	1	1	CSW	CIS
368	Brean Down	Somerset	51.3280	-3.0336	97	1	1	1	1	1	CSW	CIS
369	Avonmouth	Somerset	51.4969	-2.7274	10	1	1	1	1	1	CSW	CIS
370	Lavernock Point	Glamorgan	51.4065	-3.1711	15	1	1	1	1	1	CSW	CIS
371	Penry Bay, West of Rhoose	Glamorgan	51.3880	-3.4290	10	1	1	1	1	1	CSW	CIS
372	Boverton (Summerhouse Point)	Glamorgan	51.8870	-3.4427	20	1	1	1	1	1	CSW	CIS
373	Nash Point	Glamorgan	51.4010	-3.5560	40	1	1	1	1	1	CSW	CIS

Site No	Site	Region	Lat decimal	Long decimal	Elev (m)	No Obs	Obs Area	Optics	Obs Method	Rec method	BND MUs	HP MUs
374	Southerndown (Sea Watch Centre)	Glamorgan	51.4530	-3.6189	50	1	1	1	1	1	CSW	CIS
375	Ogmore-by-sea	Glamorgan	51.4613	-3.6343	50	1	1	1	1	1	CSW	CIS
376	Porthcawl Point	Glamorgan	51.4741	-3.7020	10	1	1	1	1	1	CSW	CIS
377	Port Talbot South Breakwater	Neath	51.5741	-3.8172	5	1	1	1	1	1	CSW	CIS
378	Mumbles (Tutt Head)	Gower	51.5651	-3.9818	53	1	1	1	1	1	CSW	CIS
379	Pwll Ddu	Gower	51.5585	-4.0649	55	1	1	1	1	1	CSW	CIS
380	Southgate	Gower	51.5648	-4.0909	73	1	1	1	1	1	CSW	CIS
381	Oxwich Point	Gower	51.5443	-4.1487	20	1	1	1	1	1	CSW	CIS
382	Port Eynon Point	Gower	51.5395	-4.2097	47	1	1	1	1	1	CSW	CIS
383	Paviland	Gower	51.5502	-4.2559	55	1	1	1	1	1	CSW	CS
384	Worm's Head	Gower	51.5650	-4.3268	47	1	1	1	1	1	CSW	CIS
385	Rhossili	Gower	51.5677	-4.2976	26	1	1	1	1	1	CSW	CIS
386	Burry Holms	Gower	51.6090	-4.3136	15	1	1	1	1	1	CSW	CIS
387	Limekiln Point	Gower	51.6103	-4.3070	50	1	1	1	1	1	CSW	CIS
388	Saundersfoot	Pembs (S)	51.7098	-4.6965	15	1	1	1	1	1	CSW	CIS
389	Milford Haven	Pembs (S)	51.7074	-5.0520	25	1	2	1	1	1	CSW	CIS
390.1	Skokholm Island Lighthouse	Pembs (W)	51.6933	-5.2860	50	1	1	1	1	1	CSW	CIS
390.2	Skokholm Island	Pembs (W)	51.6948	-5.2847	40	1	1	1	1	1	CSW	CIS
391.1	Mew Stone, Skomer	Pembs (W)	51.7283	-5.2908	50	1	1	1	1	1	CSW	CIS
391.2	Skomer Head	Pembs (W)	51.7331	-5.3104	60	1	1	1	1	2	CSW	CIS
391.3	Skomer Island NNR	Pembs (W)	51.7348	-5.3102	50	1	1	1	1	2	CSW	CIS
391.4	Garland Stone, Skomer	Pembs (W)	51.7437	-5.2988	60	1	1	1	1	1	CSW	CIS
392	Deer Park, Martin's Haven	Pembs (W)	51.7337	-5.2521	50	1	1	1	1	1	CSW	CIS
393	Solva	Pembs (W)	51.8720	-5.1966	40	1	1	1	1	1	CSW	CIS
394.1	S. Ramsey Sound	Pembs (W)	51.8612	-5.3167	30	1	3	1	1	1	CSW	CIS
394.2	Ramsey Bitches	Pembs (W)	51.8623	-5.3178	40	1	1	1	1	1	CSW	CIS
394.3	Ramsey Sound	Pembs (W)	51.8638	-5.3178	30	1	3	1	1	1	CSW	CIS
395	St. David's Head	Pembs (W)	51.9023	-5.3122	50	1	1	1	1	1	CSW	CIS
396	Penllechwen by St David's Head	Pembs (N)	51.9123	-5.2872	40	1	1	1	1	1	CSW	CIS
397	Castell Coch, near Abercastle	Pembs (N)	51.9603	-5.1258	30	1	1	1	1	1	CSW	CIS
398	Penbrush, Strumble Head	Pembs (N)	52.0147	-5.0875	70	1	1	1	1	1	CSW	CIS
399	Pwll Deri, S of Strumble Head	Pembs (N)	52.0069	-5.0777	100	1	1	1	1	1	CSW	CIS
400	Strumble Head	Pembs (N)	52.0293	-5.0703	40	1	1	1	1	1	CSW	CIS
401.1	Dinas Head	Pembs (N)	52.0318	-4.9062	142	1	1	1	1	1	CSW	CIS
401.2	Needle Rock, Dinas Head	Pembs (N)	52.0312	-4.8928	80	1	1	1	1	1	CSW	CIS
402	Newport Bay	Pembs (N)	52.0397	-4.8392	30	1	1	1	1	1	CSW	CIS

Site No	Site	Region	Lat decimal	Long decimal	Elev (m)	No Obs	Obs Area	Optics	Obs Method	Rec method	BND MUs	HP MUs
403	Poppit YH	Ceredigion	52.1097	-4.7130	50	1	1	1	1	1	IS	CIS
404	Cardigan Islad, headland	Ceredigion	52.1293	-4.6845	25	1	1	1	1	1	IS	CIS
405	Cardigan Island	Ceredigion	52.1313	-4.6890	35	1	1	1	1	1	IS	CIS
406.1	Aberporth A	Ceredigion	52.1340	-4.5335	25	1	2	1	1	1	IS	CIS
406.2	Aberporth B	Ceredigion	52.1358	-4.5427	6	1	2	1	1	2	IS	CIS
407	Pencestyll, W of Pen Peles	Ceredigion	52.1370	-4.6187	70	1	1	1	1	1	IS	CIS
408	Pen Peles	Ceredigion	52.1403	-4.6052	40	1	1	1	1	1	IS	CIS
409	Mwnt	Ceredigion	52.1379	-4.6427	50	1	1	1	1	2	IS	CIS
410	Llangrannog	Ceredigion	52.1606	-4.4726	150	1	1	1	1	1	IS	CIS
411	Ynys Lochtyn	Ceredigion	52.1709	-4.4663	80	1	1	1	1	1	IS	CIS
412	Caerwenfor (W of Cwmtudu)	Ceredigion	52.1800	-4.4235	125	1	1	1	1	1	IS	CIS
413.1	New Quay, Birds Rock	Ceredigion	52.2173	-4.3644	70	1	1	1	1	2	IS	CIS
413.2	Target Rock, New Quay	Ceredigion	52.2180	-4.3641	80	1	1	1	1	1	IS	CIS
413.3	Fish Factory, New Quay	Ceredigion	52.2181	-4.3629	40	1	1	1	1	1	IS	CIS
413.4	New Quay Headland	Ceredigion	52.2180	-4.3607	75	1	1	1	1	1	IS	CIS
413.5	New Quay Harbour	Ceredigion	52.2148	-4.3577	3	1	1	1	1	1	IS	CIS
414	Aberaeron	Ceredigion	52.2420	-4.2637	20	1	1	1	1	1	IS	CIS
415	Llanrhystud	Ceredigion	52.3057	-4.1621	90	1	1	1	1	1	IS	CIS
416	Monk's Cave, Llanrhystud	Ceredigion	52.3143	-4.1470	80	1	1	1	1	1	IS	CIS
417.1	Aberystwyth Harbour	Ceredigion	52.4067	-4.0916	3	1	1	1	1	1	IS	CIS
417.2	Aberystwyth	Ceredigion	52.4125	-4.0872	3	1	1	1	1	1	IS	CIS
417.3	Aberystwyth Castle	Ceredigion	52.4139	-4.0910	9	1	1	1	1	2	IS	CIS
418	Borth	Ceredigion	52.4822	-4.0492	3	1	1	1	1	1	IS	CIS
419	Ynyslas	Ceredigion	52.5170	-4.0542	8	1	1	1	1	1	IS	CIS
420	Aber Dysynni	Gwynedd	52.6102	-4.1247	5	1	1	1	1	1	IS	CIS
421	Friog Cliffs	Gwynedd	52.6197	-4.1243	10	1	1	1	1	1	IS	CIS
422	Llwgngwril	Gwynedd	52.6682	-4.0927	20	1	1	1	1	1	IS	CIS
423	Barmouth	Gwynedd	52.7280	-4.0622	10	1	1	1	1	1	IS	CIS
424	Tal-y-bont, north of Barmouth	Gwynedd	52.7493	-4.0826	6	1	1	1	1	1	IS	CIS
425	Shell Island (Tremadog Bay)	Gwynedd	52.8195	-4.1435	10	1	1	1	1	1	IS	CIS
426	Llanfair Cliffs	Gwynedd	52.8443	-4.1182	40	1	1	1	1	1	IS	CIS
427	Harlech	Gwynedd	52.8563	-4.1198	15	1	1	1	1	1	IS	CIS
428	Criccieth	Gwynedd	52.9158	-4.2318	20	1	1	1	1	1	IS	CIS
429	St Tudwals Islands (east)	Gwynedd	52.8063	-4.4613	5	2	1	1	2	2	IS	CIS
430	Trwyn y Wylfa, Llŷn Peninsula	Gwynedd	52.7930	-4.4902	50	1	1	1	3	2	IS	CIS
431	Bardsey Island	Gwynedd	52.7455	-4.8010	20	1	1	1	1	1	IS	CIS

Site No	Site	Region	Lat decimal	Long decimal	Elev (m)	No Obs	Obs Area	Optics	Obs Method	Rec method	BND MUs	HP MUs
.1												
431.2	Bardsey Island Lighthouse	Gwynedd	52.7495	-4.7995	10	1	1	1	1	1	IS	CIS
431.3	Bardsey Island, Flagstaff	Gwynedd	52.7507	-4.8002	10	1	1	1	1	1	IS	CIS
431.4	Cliff, Bardsey Island	Gwynedd	52.7589	-4.7856	60	1	1	1	2	1	IS	CIS
431.5	North End, Bardsey Island	Gwynedd	52.7667	-4.7908	37.5	1	1	1	2	1	IS	CIS
431.6	Bardsey Island, NW corner	Gwynedd	52.7677	-4.7927	10	1	1	1	1	1	IS	CIS
431.7	Pen-y-Cil, Bardsey Island	Gwynedd	52.7820	-4.7319	40	1	1	1	2	1	IS	CIS
431.8	St Mary's Well, Bardsey Island	Gwynedd	52.7922	-4.7612	50	1	1	1	2	1	IS	CIS
431.9	Mynydd Mawr, Bardsey Island	Gwynedd	52.7980	-4.7600	160	1	1	1	2	1	IS	CIS
432	Porth Dinllaen	Gwynedd	52.9375	-4.5642	30	1	1	1	1	1	IS	CIS
433	Dinas Dinlle	Gwynedd	53.0977	-4.3423	3	1	1	1	1	1	IS	CIS
434	Rhoscolyn	Anglesey	53.2461	-4.6107	7	1	1	1	1	2	IS	CIS
435	The Range	Anglesey	53.2842	-4.6850	15	1	1	1	1	2	IS	CIS
436	South Stack	Anglesey	53.3064	-4.6998	40	1	1	1	1	2	IS	CIS
437	North Stack	Anglesey	53.3222	-4.6794	95	2	1	1	2	2	IS	CIS
438	Breakwater C P	Anglesey	53.3200	-4.6677	17	1	1	1	1	2	IS	CIS
439	The Skerries (from Anglesey)	Anglesey	53.4212	-4.6080	5	1	1	1	1	2	IS	CIS
440	Skerries, Holyhead (Island)	Anglesey	53.4230	-4.6048	5	2	1	1	2	2	IS	CIS
441	Carmel Head	Anglesey	53.4029	-4.5739	22	2	1	1	2	2	IS	CIS
442	Porth y Dyfn	Anglesey	53.4043	-4.5694	13	2	1	1	2	2	IS	CIS
443	Cemlyn	Anglesey	53.4158	-4.5112	2	2	1	1	2	2	IS	CIS
444	Wylfa Head	Anglesey	53.4210	-4.4744	27	1	1	1	1	2	IS	CIS
445	Cemaes	Anglesey	53.4155	-4.4582	7	1	1	1	1	2	IS	CIS
446	Llanbadrig	Anglesey	53.4277	-4.4357	17	1	1	1	1	2	IS	CIS
447	Middle Mouse	Anglesey	53.4296	-4.4256	23	2	1	1	2	2	IS	CIS
448	Porth Wen	Anglesey	53.4252	-4.3955	15	1	1	1	1	2	IS	CIS
449	Bull Bay	Anglesey	53.4254	-4.3788	14	1	1	1	1	2	IS	CIS
450.1	Llam Carw	Anglesey	53.4176	-4.3252	12	1	1	1	1	2	IS	CIS
450.2	Amlwch Bonc	Anglesey	53.4192	-4.3399	5	1	1	1	1	2	IS	CIS
451	Point Lynas	Anglesey	53.4172	-4.2882	20	1	1	1	1	2	IS	CIS
452	Dulas	Anglesey	53.3742	-4.2736	12	1	1	1	1	2	IS	CIS
453	Lligwy	Anglesey	53.3606	-4.2520	5	1	1	1	1	2	IS	CIS
454	Nant Bychan	Anglesey	53.3470	-4.2350	18	2	1	1	2	2	IS	CIS
455	Moelfre	Anglesey	53.3531	-4.2335	8	2	1	1	2	2	IS	CIS
456	Fedw Fawr	Anglesey	53.3176	-4.0985	19	1	1	1	1	2	IS	CIS
457	Penmon	Anglesey	53.3024	-4.0574	10	1	1	1	1	2	IS	CIS
458	Whitebeach, Penmon	Anglesey	53.3079	-4.0445	8	2	1	1	2	2	IS	CIS
459	Great Orme Country	Conwy	53.3418	-3.8677	80	1	1	1	1	1	IS	CIS

Site No	Site	Region	Lat decimal	Long decimal	Elev (m)	No Obs	Obs Area	Optics	Obs Method	Rec method	BND MUs	HP MUs
	Park											
460.1	Calf of Man	Isle of Man	54.0532	-4.8280	50	1	1	1	1	1	IS	CIS
460.2	Calf East	Isle of Man	54.0630	-3.2041	70	1	1	1	1	1	IS	CIS
460.3	Calf West	Isle of Man	54.0641	-3.2062	100	1	1	1	1	1	IS	CIS
461	Cregneash	Isle of Man	54.0638	-4.7922	100	1	1	1	1	1	IS	CIS
462	Port St. Mary	Isle of Man	54.0681	-4.7347	30	1	1	1	1	1	IS	CIS
463	Glen Chass Farmhouse	Isle of Man	54.0688	-4.7522	100	1	1	1	1	1	IS	CIS
464	Arches, Port Erin	Isle of Man	54.1403	-3.5286	50	1	1	1	1	1	IS	CIS
465	Marine Drive	Isle of Man	54.1254	-4.5263	60	1	1	1	1	1	IS	CIS
466.1	Niarbyl	Isle of Man	54.1543	-4.7305	20	1	1	1	1	1	IS	CIS
466.2	Elby Point, Niarbyl	Isle of Man	54.1650	-4.7394	35	1	1	1	1	1	IS	CIS
467	Ballalhargy Farm, Dalby	Isle of Man	54.1783	-4.3867	30	1	1	1	1	1	IS	CIS
468	Ballaquane	Isle of Man	54.1783	-4.7233	60	1	1	1	1	1	IS	CIS
469	Contrary Head	Isle of Man	54.2109	-4.7194	140	1	1	1	1	1	IS	CIS
470	Peel	Isle of Man	54.2262	-3.2995	20	1	1	1	1	1	IS	CIS
471	Lynague, north of Peel	Isle of Man	54.2501	-4.6412	70	1	1	1	1	1	IS	CIS
472	Maughold Head	Isle of Man	54.3000	-4.3000	117	1	1	1	1	1	IS	CIS
473	Ballaghennie	Isle of Man	54.4111	-4.4056	30	1	1	1	1	1	IS	CIS
474	Point of Ayre	Isle of Man	54.4165	-4.3685	9	1	1	1	1	1	IS	CIS
475	Seacombe ferry terminal	Merseyside	53.4100	-3.0155	3	1	1	1	1	1	IS	CIS
476	Marine Point, New Brighton	Merseyside	53.4409	-3.0477	5	1	1	1	1	1	IS	CIS
477	Burbo Bank Windfarm, Crosby	Lancashire	53.4967	-3.0580	3	1	1	1	1	1	IS	CIS
478	Formby Point	Lancashire	53.5503	-3.0954	2	1	1	1	1	1	IS	CIS
479.1	Mirror Ball, Blackpool	Lancashire	53.7955	-3.0573	5	1	1	1	1	1	IS	CIS
479.2	South Promenade, Blackpool	Lancashire	53.7955	-3.0597	5	1	1	1	1	1	IS	CIS
479.3	Blackpool	Lancashire	53.8118	-3.0545	8	1	1	1	1	1	IS	CIS
479.4	St Chads, Blackpool	Lancashire	53.8026	-3.0560	5	1	1	1	1	1	IS	CIS
479.5	Gynn Square, Blackpool	Lancashire	53.8320	-3.0557	5	1	1	1	1	1	IS	CIS
479.6	Norbreck Castle, Blackpool	Lancashire	53.8578	-3.0488	5	1	1	1	1	1	IS	CIS
479.7	Bispham Cliffs, Blackpool	Lancashire	53.8516	-3.0531	5	1	1	1	1	1	IS	CIS
479.8	Anchorsholme	Lancashire	53.8661	-3.0490	5	1	1	1	1	1	IS	CIS
480	Rossall Point, Fleetwood	Lancashire	53.9258	-3.0223	5	1	1	1	1	1	IS	CIS
481	Knott End-on-Sea, Fleetwood	Lancashire	53.9285	-2.9972	3	1	1	1	1	1	IS	CIS
482	Heysham	Lancashire	54.0314	-2.9238	3	1	1	1	1	1	IS	CIS
483	Walney South End	Cumbria	54.0456	-3.1911	8	1	1	1	1	1	IS	CIS

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484	Morecambe Bay	Cumbria	54.1665	-2.8263	3	1	1	1	1	1	IS	CIS
485	Silecroft	Cumbria	54.2174	-3.3491	3	1	1	1	1	1	IS	CIS
486	Nethertown	Cumbria	54.4516	-3.5617	35	1	1	1	1	1	IS	CIS
487	St. Bees Head	Cumbria	54.5121	-3.6390	100	1	1	1	1	1	IS	CIS
488	Maryport	Cumbria	54.7171	-3.5087	10	1	1	1	1	1	IS	CIS
489	Silloth	Cumbria	54.8693	-3.3972	5	1	1	1	1	1	IS	CIS
490	Southerness Point	Galloway	54.8728	-3.5952	10	1	1	1	1	1	IS	CIS
491	Balcary Haugh/Balcary Point	Galloway	54.8167	-3.8167	10	1	1	1	1	1	IS	CIS
492	Abbey Head, Abbey Burnfoot	Galloway	54.7746	-3.9600	100	1	1	1	1	1	IS	CIS
493	Burrow Head	Galloway	54.6873	-4.3987	40	1	1	1	1	1	IS	CIS
494	Monreith Beach, Galloway	Galloway	54.7279	-4.5472	40	1	1	1	1	1	IS	CIS
495	Mull of Galloway Lighthouse	Galloway	54.6353	-4.8569	85	1	1	1	1	1	IS	CIS
496	Portpatrick, Dunskey Castle	Galloway	54.8410	-5.1182	40	1	1	1	1	1	IS	CIS
497	Corsewall Point	Galloway	55.0069	-5.1586	10	1	1	1	1	1	IS	CIS
498	Ardentinny, Argyll	Argyll	56.0443	-4.9081	10	1	3	1	1	1	CWSH	WS
499	Blairmore	Argyll	56.0012	-4.8969	8	1	3	1	1	1	CWSH	WS
500	Strone, Dunoon	Renfrewshire	55.9946	-4.8948	5	1	3	1	1	1	CWSH	WS
501	Innellan	Renfrewshire	55.8948	-4.9544	5	1	1	1	1	1	CWSH	WS
502	Coul Point, Islay	Argyll	55.7902	-6.4822	30	1	1	1	1	1	CWSH	WS
503.1	Salen Cemetery, Isle of Mull	Argyll	56.5208	-5.8961	10	1	3	1	1	1	CWSH	WS
503.2	Old Chapelsite, Isle of Mull	Argyll	56.5211	-5.9008	15	1	1	1	1	1	CWSH	WS
504	Calliach Point, Isle of Mull	Argyll	56.6003	-6.3200	57	1	1	1	1	1	CWSH	WS
505	Tobermory LH, Isle of Mull	Argyll	56.6371	-6.0650	40	1	1	1	1	1	CWSH	WS
506	Bloody Bay, Isle of Mull	Argyll	56.6500	-6.1167	50	1	1	1	1	1	CWSH	WS
507	Ardnamurchan Point	Argyll	56.7266	-6.2260	20	1	1	1	1	1	CWSH	WS
508	Muck Harbour	Inner Hebrides	56.8323	-6.2242	10	1	4	1	1	1	CWSH	WS
509	Isle of Eigg (Glebe)	Inner Hebrides	56.8901	-6.1350	73	1	1	2	2	1	CWSH	WS
510	Arisaig campsite	Highland	56.9929	-5.8791	15	1	1	1	1	1	CWSH	WS
511	Mallaig	Highland	57.0117	-5.8115	30	1	1	1	1	1	CWSH	WS
512	Skye Bridge	Inner Hebrides	57.2762	-5.7931	10	1	4	1	1	1	CWSH	WS
513	Neist Point, Isle of Skye	Inner Hebrides	57.4218	-6.7900	20	1	1	1	1	1	CWSH	WS
514	Waternish, Skye (Trumpan Church)	Inner Hebrides	57.5619	-6.6344	50	1	1	1	1	1	CWSH	WS
515	Gairloch	Highland	57.7205	-5.6881	5	1	1	1	1	1	CWSH	WS

Site No	Site	Region	Lat decimal	Long decimal	Elev (m)	No Obs	Obs Area	Optics	Obs Method	Rec method	BND MUs	HP MUs
516.1	Melvaig Inn, Gairloch	Highland	57.8075	-5.8058	18	1	1	2	2	1	CWSH	WS
516.2	Melvaig, Gairloch	Highland	57.8115	-5.8071	20	1	1	2	2	1	CWSH	WS
517	Rua Reidh Lighthouse, Gairloch	Highland	57.8588	-5.8108	23	1	1	2	2	1	CWSH	WS
518	Loch Broom, Ullapool	Highland	57.8967	-5.1617	10	1	4	1	1	1	CWSH	WS
519	Clachtoll	Sutherland	58.1889	-5.3332	15	1	1	1	1	1	CWSH	WS
520	Raffin, Stoer Head	Sutherland	58.2328	-5.3822	50	1	1	1	1	1	CWSH	WS
521	Stoer Head Lighthouse	Sutherland	58.2379	-5.4010	33	1	1	1	1	1	CWSH	WS
522	Culkein, Stoer	Sutherland	58.2505	-5.3396	10	1	1	1	1	1	CWSH	WS
523	Kylesku	Sutherland	58.2515	-5.0509	20	1	4	1	1	1	CWSH	WS
524	Scourie Bay	Sutherland	58.3530	-5.1659	10	1	2	1	1	1	CWSH	WS
525.1	Handa Island (Geodh Dearg)	Sutherland	58.3769	-5.2085	50	1	1	1	1	1	CWSH	WS
525.2	Handa Island (Meall a Bhodha)	Sutherland	58.3769	-5.2085	50	1	1	1	1	1	CWSH	WS
525.3	Handa Island	Sutherland	58.3793	-5.2028	30	1	1	1	1	1	CWSH	WS
526	Faraid Head	Sutherland	58.6026	-4.7746	80	1	1	1	1	1	CWSH	WS
527	Strathy Point	Sutherland	58.5988	-4.0179	30	1	1	1	1	1	CWSH	WS
528	Garrynamonie, South Uist	Western Isles	57.1213	-7.3911	8	1	1	2	2	1	CWSH	WS
529	Kildonan, South Uist	Western Isles	57.2230	-7.4291	8	1	1	2	2	1	CWSH	WS
530	Airport Mound, Benbecula	Western Isles	57.4742	-7.3796	8	1	1	2	2	1	CWSH	WS
531	Balranald Reserve, North Uist	Western Isles	57.6057	-7.5175	6	1	1	2	2	1	CWSH	WS
532	Berneray (East Beach), North Uist	Western Isles	57.7218	-7.1533	5	1	1	2	2	1	CWSH	WS
533	Rodel, Harris	Western Isles	57.7388	-6.9533	35	1	2	2	2	1	CWSH	WS
534	Berneray (North), North Uist	Western Isles	57.7389	-7.1709	5	1	1	2	2	1	CWSH	WS
535	Quidinish Point, Harris	Western Isles	57.7734	-6.8727	28	1	1	2	2	1	CWSH	WS
536	Tiumpan Head East, Lewis	Western Isles	58.2602	-6.1415	65	1	1	2	2	1	CWSH	WS
537	Butt of Lewis	Western Isles	58.5147	-6.2620	30	1	1	1	1	1	CWSH	WS
538	Alderney	Channel Isles	57.6079	-6.6339	5	1	1	1	1	1	CSW	CIS
539	La Crete Point, Jersey	Channel Isles	49.2091	-2.0201	3	1	1	1	1	1	CSW	CIS
540	Le Hurel Slip, Grouville Bay, Jersey	Channel Isles	49.1744	-2.0303	3	1	1	1	1	1	CSW	CIS
541	Magilligan Point	Co. Derry	55.1922	-6.9568	3	1	3	1	1	1	CWSH	CIS
542	Rathlin Island	Co. Antrim	55.2984	-6.1913	50	1	1	1	1	1	CWSH	WS
543	Portaneevey, near Carrickarede Is.	Co. Antrim	55.2371	-6.3308	45	1	1	1	1	1	CWSH	WS
544	Ramore Head	Co. Antrim	55.2116	-6.6574	2	1	1	1	1	1	CWS	WS

Site No	Site	Region	Lat decimal	Long decimal	Elev (m)	No Obs	Obs Area	Optics	Obs Method	Rec method	BND MUs	HP MUs
											H	
545	Torr Head	Co. Antrim	55.1965	-6.0639	35	1	1	1	1	1	CWSH	WS
546	Portmuck, Island Magee	Co. Antrim	54.8479	-5.7262	6	1	1	1	1	1	IS	CIS
547	Black Head	Co. Antrim	54.7668	-5.6887	10	1	1	1	1	1	IS	CIS
548	Grey Point, Belfast Lough	Co. Down	54.6766	-5.7410	16	1	1	1	1	1	IS	CIS
549	Ballyquintin Point, Ards Peninsula	Co. Down	54.3339	-5.5008	4	1	1	1	1	1	IS	CIS
550	Killard Point	Co. Down	54.3125	-5.5263	7	1	1	1	1	1	IS	CIS
551	St. John's Point	Co. Down	54.2261	-5.6592	3	1	1	1	1	1	IS	CIS
552	Bloody Bridge, Newcastle	Co. Down	54.1735	-5.8743	21	1	1	1	1	1	IS	CIS
553	Cranfield Point, Carlingford Lough	Co. Down	54.0233	-6.0624	2	1	1	1	1	1	IS	CIS

Table A1. 2. List of sites with details of effort.

Site No	Site	Region	Total Effort	No of years	Year span	BND MUs	HP MUs
1	Lamba Ness, Unst	Shetland	60	1	2013	NS	NS
2	Westing, Unst	Shetland	80	1	2013	NS	NS
3	Papil VP, Yell, Bluemull Sound	Shetland	1778	2	2011-12	NS	NS
4	Bluemull VP, Unst, Bluemull Sound	Shetland	169	1	2012	NS	NS
5	The Ness VP, Yell, Bluemull Sound	Shetland	2379	2	2011-12	NS	NS
6	Wadbister VP, Unst, Bluemull Sound	Shetland	56	1	2012	NS	NS
7	Muness, Unst	Shetland	65	1	2013	NS	NS
8	Belmont VP, Unst, Bluemull Sound	Shetland	119	1	2012	NS	NS
9	Gutcher VP, Yell, Bluemull Sound	Shetland	2299	2	2011-12	NS	NS
10	Ness of Sound, Yell	Shetland	360	1	1995	NS	NS
11	Fethaland	Shetland	900	1	1995	NS	NS
12	Tresta, Fetlar	Shetland	360	1	1995	NS	NS
13	Funzie Bay, Fetlar	Shetland	320	1	1995	NS	NS
14	Head of Brough, Yell	Shetland	360	1	1995	NS	NS
15	Burra Voe (from North Voe)	Shetland	620	6	1990-95	NS	NS
16	Collafirth	Shetland	460	5	1990-94	NS	NS
17	Ronas Voe	Shetland	460	5	1990-94	NS	NS
18	Eshaness	Shetland	440	5	1990-94	NS	NS
19	Braewick, nr Eshaness	Shetland	350	4	1990-93	NS	NS
20	Brough (Toft) - actually Toft Ness	Shetland	711	6	1990-95	NS	NS
21	Hillswick	Shetland	1646	6	1990-93	NS	NS
22	Lunna Ness	Shetland	1680	6	1990-95	NS	NS
23	Gunnister Voe	Shetland	470	5	1990-94	NS	NS
24	Sullom Voe from Sullom	Shetland	460	5	1990-94	NS	NS
25	Dales Voe	Shetland	920	5	1990-94	NS	NS
26	Mangaster Voe	Shetland	460	5	1990-94	NS	NS
27	Skaw, Whalsay	Shetland	1560	1	1995	NS	NS
28	Vidlin/Gunna Voe	Shetland	460	5	1990-94	NS	NS
29	Lunning Sound from Lunning	Shetland	560	6	1990-95	NS	NS
30	Wethersta overlooking Olna Firth	Shetland	530	5	1990-94	NS	NS
31	Marrister, Whalsay	Shetland	1430	1	1995	NS	NS
32	Dury Voe	Shetland	580	5	1990-94	NS	NS
33	Muckle Roe overlooking Swarbacks Minn	Shetland	560	6	1990-95	NS	NS
34	Aithvoe from East Burrafirth	Shetland	660	5	1990-94	NS	NS
35	Melby	Shetland	1820	6	1990-95	NS	NS
36	Huxter	Shetland	460	1	1995	NS	NS
37	West Burrafirth	Shetland	430	4	1990-94	NS	NS
38	South Nesting Voe	Shetland	1180	6	1990-2005	NS	NS
39	Voe of Dale	Shetland	460	5	1990-94	NS	NS
40	Gletness	Shetland	560	6	1990-95	NS	NS
41	Wadbister Voe from Girlsta	Shetland	500	5	1990-94	NS	NS

Site No	Site	Region	Total Effort	No of years	Year span	BND MUs	HP MUs
42	Sandsound Voe	Shetland	460	5	1990-94	NS	NS
43	Burrastow/Vaila Sound from Stapness	Shetland	560	6	1990-95	NS	NS
44	Laxfirth	Shetland	100	1	1992	NS	NS
45	Sandvoe/Kirkaness	Shetland	360	4	1990-93	NS	NS
46	Beosetter/Gunnista	Shetland	460	5	1990-94	NS	NS
47	Whiteness Voe	Shetland	500	5	1990-94	NS	NS
48	Westerwick	Shetland	466	5	1990-94	NS	NS
49	Cullingsburgh	Shetland	460	5	1990-94	NS	NS
50	Scarvister	Shetland	560	6	1990-95	NS	NS
51	Bressay Broch	Shetland	820	2	1991-92	NS	NS
52	Mansies Berg, Noss	Shetland	230	2	1991-2000	NS	NS
53.1	Cols Ness, Noss	Shetland	130	1	2000	NS	NS
53.2	Noss Head, Noss	Shetland	8550	2	1992-2010	NS	NS
53.3	Noss Sound from Noss	Shetland	21438	9	1990-2013	NS	NS
54	Big Ness, Noss	Shetland	130	1	2000	NS	NS
55	Turr Ness, Noss	Shetland	1790	2	1991-92	NS	NS
56	Heogatoug, Noss	Shetland	30	1	2000	NS	NS
57	The Knab, Lerwick	Shetland	2155	2	2005-06	NS	NS
58	Brei Wick	Shetland	660	5	1990-94	NS	NS
59	Gulberwick	Shetland	760	6	1990-95	NS	NS
60	Bressay LH (Kirkabister Ness), Bressay	Shetland	15	1	2013	NS	NS
61	Hamnavoe	Shetland	2505	6	1990-95	NS	NS
62	Wester Quarff	Shetland	500	5	1990-94	NS	NS
63	Easter Quarff (East Voe of Quarff)	Shetland	560	6	1990-95	NS	NS
64	Fladdabister	Shetland	760	6	1990-95	NS	NS
65	East Burra from Houss to Clift Sound	Shetland	460	5	1990-94	NS	NS
66	Aithwick	Shetland	400	4	1990-95	NS	NS
67.1	Mousa North Site	Shetland	28076	5	1990-99	NS	NS
67.2	Mousa Sound Central Site	Shetland	29069	8	1990-2010	NS	NS
67.3	Mousa South Site	Shetland	4995	3	1992-94	NS	NS
67.4	Mousa Island	Shetland	60	1	1992	NS	NS
68	Sandwick	Shetland	400	4	1990-93	NS	NS
69	Channerwick/Levenwick	Shetland	600	6	1990-95	NS	NS
70	Noness	Shetland	300	2	1994-95	NS	NS
71	St. Ninians Isle	Shetland	3247	8	1990-2013	NS	NS
72	Scousburgh	Shetland	600	6	1990-95	NS	NS
73	Boddam (OutVoe)	Shetland	2410	6	1990-95	NS	NS
74	Quendale Bay	Shetland	6070	6	1990-95	NS	NS
75	Sumburgh Head	Shetland	10980	12	1990-2013	NS	NS
76	Fair Isle (Buness)	Shetland	120	1	2011	NS	NS
77.1	Marwick Head	Orkney	240	1	2012	ECS	NS
77.2	Kitchener Memorial, Marwick Head	Orkney	120	1	2013	ECS	NS

Site No	Site	Region	Total Effort	No of years	Year span	BND MUs	HP MUs
78	Billia Croo	Orkney	265725	5	2009-13	ECS	NS
79	Hundland, Papa Westray	Orkney	1606	2	2006-10	ECS	NS
80.1	Clay Face, Sanday	Orkney	60	1	1996	ECS	NS
80.2	Warsetter, Sanday	Orkney	75	1	1996	ECS	NS
81.1	Whalepoint, Sanday	Orkney	210	1	1996	ECS	NS
81.2	Whitemill Bay, Sanday	Orkney	75	1	1996	ECS	NS
82.1	Doun Helzie, Sanday	Orkney	60	1	1996	ECS	NS
82.2	Loth Pier, Sanday	Orkney	30	1	1996	ECS	NS
83	Hoxa Head, South Ronaldsay	Orkney	2727	7	2001-13	ECS	NS
84	Herston Head, South Ronaldsay	Orkney	625	3	2005-11	ECS	NS
85	Cantick Head, South Walls	Orkney	100	1	1988	ECS	NS
86	Barswick/Barth Head, South Ronaldsay	Orkney	270	1	2006	ECS	NS
87	Bur Wick, South Ronaldsay	Orkney	120	1	2006	ECS	NS
88	The Wing, South Ronaldsay	Orkney	60	1	2001	ECS	NS
89	Portskerra	Sutherland	75	1	2006	ECS	NS
90	Ushat Head	Caithness (N)	120	1	2013	ECS	NS
91	Holborn Head, Thurso	Caithness (N)	480	2	2011-12	ECS	NS
92	Scrabster Lighthouse	Caithness (N)	590	3	2011-13	ECS	NS
93.1	Thurso Bay	Caithness (N)	120	1	2010	ECS	NS
93.2	Thurso caravan park	Caithness (N)	120	1	2008	ECS	NS
93.3	Thurso	Caithness (N)	1765	4	2001-13	ECS	NS
94	Castletown, Dunnet Bay	Caithness (N)	10	1	2001	ECS	NS
95.1	Dunnet Head (West)	Caithness (N)	2320	3	2010-13	ECS	NS
95.2	Dunnet Head	Caithness (N)	120	2	2001-05	ECS	NS
95.3	Dunnet Head (East)	Caithness (N)	2280	2	2012-13	ECS	NS
96.1	St. John's Point, Gill's Bay	Caithness (N)	810	3	2002-05	ECS	NS
96.2	Gill's Bay	Caithness (N)	780	5	2004-13	ECS	NS
97	Duncansby Head	Caithness (N)	11776	6	2004-13	ECS	NS
98	Noss Head, Wick	Caithness (E)	1605	2	2012-13	ECS	NS
99.1	Wick	Caithness (E)	60	1	2012	ECS	NS
99.2	Trinkie, Wick	Caithness (E)	960	4	2010-13	ECS	NS
100	Whaligoe	Caithness (E)	5543	9	2003-13	ECS	NS
101.1	Shelligoe Clifftop	Caithness (E)	435	1	2004	ECS	NS
101.2	Lybster Viewpoint	Caithness (E)	30195	12	2002-13	ECS	NS
102	Forse	Caithness (E)	1507	2	2010-11	ECS	NS
103	Latheronwheel	Caithness (E)	420	4	2008-12	ECS	NS
104	Badbea	Caithness (E)	60	1	2004	ECS	NS
105	Ousdale nr Badbea	Caithness (E)	10	1	2004	ECS	NS
106	Avoch	Highland	180	1	1996	ECS	NS
107	Brora	Highland	1715	5	2001-06	ECS	NS
108.1	Dunrobin Point, Golspie	Highland	40	1	2001	ECS	NS
108.2	Strathsteven, near Brora	Highland	1021	4	2001-04	ECS	NS

Site No	Site	Region	Total Effort	No of years	Year span	BND MUs	HP MUs
109.1	Golspie, Iain Macdonald's house	Highland	645	4	2001-04	ECS	NS
109.2	Golspie Pier	Highland	20	1	2001	ECS	NS
109.3	Road to Golspie	Highland	15	1	2001	ECS	NS
109.4	Golspie go cart track	Highland	240	1	2001	ECS	NS
110	Embo	Highland	120	3	2001-04	ECS	NS
111	Dornoch	Highland	225	4	2001-04	ECS	NS
112	Tarbat Ness	Highland	1935	4	2001-04	ECS	NS
113	Portmahomack	Highland	65	2	2001-04	ECS	NS
114	Rockfield	Highland	324	3	2001-04	ECS	NS
115	Balintore Harbour	Highland	6077	5	1996-2004	ECS	NS
116	Nigg (near Cromarty)	Highland	405	2	2001-04	ECS	NS
117	Cromarty	Highland	955	4	1992-2005	ECS	NS
118	South Sutor, Cromarty	Highland	3185	9	2000-13	ECS	NS
119	Balblair, By Cromarty	Highland	120	1	1996	ECS	NS
120	Castlecraig	Highland	2880	1	1993	ECS	NS
121	Rosemarkie	Highland	630	2	1996-2001	ECS	NS
122	Fort George	Highland	15952	14	1992-2013	ECS	NS
123	Fortrose	Highland	15	1	2003	ECS	NS
124	Chanonry Point	Highland	87256	19	1991-2013	ECS	NS
125	Kilmuir, Black Isle	Highland	60	1	2001	ECS	NS
126.1	North Kessock	Highland	240	7	1996-2013	ECS	NS
126.2	Kessock bridge (north)	Highland	748	1	1996	ECS	NS
126.3	Kessock Bridge, Inverness	Highland	120	7	1994-2010	ECS	NS
126.4	Kessock bridge (south)	Highland	12303	1	1996	ECS	NS
126.5	South Kessock	Highland	7694	2	1992-93	ECS	NS
127	Ardersier	Moray	165	3	2001-06	ECS	NS
128	Nairn	Moray	120	1	1996	ECS	NS
129	Nairn Harbour	Moray	2933	4	1996-2013	ECS	NS
130	Culbin Sands	Moray	240	1	1991	ECS	NS
131	Findhorn Bay	Moray	3286	8	1991-2006	ECS	NS
132	Kinloss	Moray	100	1	1996	ECS	NS
133.1	Burghead Harbour	Moray	2160	2	1990-91	ECS	NS
133.2	Burghead Point	Moray	260	2	1995-96	ECS	NS
133.3	Burghead (near Fort)	Moray	210	2	1990-91	ECS	NS
133.4	Burghead Bay	Moray	340	1	1996	ECS	NS
133.5	Burghead Beach	Moray	285	2	1992-93	ECS	NS
133.6	Burghead East	Moray	240	2	1991-96	ECS	NS
133.7	Burghead	Moray	19859	18	1990-2013	ECS	NS
133.8	Burghead (near Red Craig)	Moray	120	1	1990	ECS	NS
134	Cummingston	Moray	560	3	1994-2003	ECS	NS
135.1	Hopeman Beach	Moray	660	2	1995-96	ECS	NS
135.2	Hopeman	Moray	4045	8	1990-2011	ECS	NS
135.3	Hopeman East Beach	Moray	150	1	1996	ECS	NS

Site No	Site	Region	Total Effort	No of years	Year span	BND MUs	HP MUs
135.4	Hopeman Caves	Moray	60	1	1992	ECS	NS
135.5	Clasach Cove	Moray	120	1	1995	ECS	NS
136.1	Covesea Coastguard Station	Moray	470	3	1981-96	ECS	NS
136.2	Covesea	Moray	1795	9	1993-2013	ECS	NS
136.3	Covesea Lighthouse (Lossiemouth LH)	Moray	120	1	1991	ECS	NS
136.4	Covesea Cliffs	Moray	100	1	1995	ECS	NS
137.1	Lossiemouth West Beach	Moray	405	1	1993	ECS	NS
137.2	Lossiemouth Coastguard Station	Moray	210	2	1991-93	ECS	NS
137.3	Lossiemouth Harbour	Moray	805	3	1990-93	ECS	NS
137.4	Lossiemouth Prospect Terrace	Moray	155	1	1992	ECS	NS
137.5	Lossiemouth East End Shore St	Moray	168	1	1992	ECS	NS
137.6	Lossiemouth Pier	Moray	9583	2	1995-96	ECS	NS
137.7	Lossiemouth East Beach	Moray	330	2	1991-92	ECS	NS
137.8	Lossiemouth	Moray	1930	12	1990-2008	ECS	NS
138	Kingston by River Spey	Moray	120	1	2002	ECS	NS
139	Spey Bay	Moray	149884	18	1991-2013	ECS	NS
140	Portgordon	Moray	3930	5	1992-96	ECS	NS
141	Buckie	Moray	4475	6	1991-2003	ECS	NS
142	Portessie	Moray	10650	7	1991-2006	ECS	NS
143	Craig Head west of Findochty	Moray	380	2	1991-92	ECS	NS
144.1	Findochty Harbour	Moray	3405	1	1992	ECS	NS
144.2	Findochty	Moray	49242	16	1990-2013	ECS	NS
145.1	W of Portnockie Harbour	Moray	6295	3	1993-95	ECS	NS
145.2	N of Portknockie Harbour	Moray	13985	3	1991-93	ECS	NS
145.3	Green Castle Rock, Portknockie	Moray	60	1	1994	ECS	NS
145.4	Portknockie cliffs	Moray	90	1	1992	ECS	NS
145.5	Portknockie	Moray	3065	14	1992-2013	ECS	NS
145.6	Bow Fiddle, Portnockie	Moray	450	3	2001-12	ECS	NS
146.1	Cullen Bay near Scar Nose	Moray	4950	5	1990-95	ECS	NS
146.2	Cullen Bay	Moray	115	1	1995	ECS	NS
146.3	Cullen (east of harbour)	Moray	50	1	1995	ECS	NS
146.4	Cullen	Moray	10040	8	1996-2013	ECS	NS
147	Between Cullen & Sandend Bay	Moray	120	1	1993	ECS	NS
148	Findlater Castle	Aberdeenshire	35	1	1992	ECS	NS
149	Sandend	Aberdeenshire	120	1	1996	ECS	NS
150	Portsoy	Aberdeenshire	1155	4	1994-2010	ECS	NS
151.1	Banff Harbour	Aberdeenshire	790	4	1999-2004	ECS	NS
151.2	Banff	Aberdeenshire	630	1	1996	ECS	NS
152	Troup Head	Aberdeenshire	540	4	1992-2008	ECS	NS
153	Crovie N of Gardenstown	Aberdeenshire	120	1	1996	ECS	NS
154	Sandhaven	Aberdeenshire	45	1	2001	ECS	NS
155	Fraserburgh	Aberdeenshire	510	4	1996-2011	ECS	NS

Site No	Site	Region	Total Effort	No of years	Year span	BND MUs	HP MUs
156	Kinnaird Head, By Fraserburgh	Aberdeenshire	1800	4	1992-2010	ECS	NS
157.1	Macduff	Aberdeenshire	120	1	1996	ECS	NS
157.2	Macduff Marine Aquarium	Aberdeenshire	2320	4	2010-13	ECS	NS
157.3	Boyndie Bay E of Whitehills	Aberdeenshire	30	1	1992	ECS	NS
157.4	Macduff, Gellymill	Aberdeenshire	17840	3	2011-13	ECS	NS
158	St Combs S of Inverallochy	Aberdeenshire	460	4	2010-13	ECS	NS
159	Rattray Head, Buchan	Aberdeenshire	600	4	1992-2012	ECS	NS
160	Peterhead	Aberdeenshire	81598	26	1981-2013	ECS	NS
161.1	Buchan	Aberdeenshire	2130	6	1993-2013	ECS	NS
161.2	Longhaven Cliffs N of Bullers of Buchan	Aberdeenshire	480	3	1994-2013	ECS	NS
162	Slains Castle S of Bullers of Buchan	Aberdeenshire	735	6	1999-2013	ECS	NS
163	Cruden Bay	Aberdeenshire	300	2	2004-13	ECS	NS
164	Whinnyfold S of Cruden Bay	Aberdeenshire	475	4	1992-2010	ECS	NS
165	Collieston N of Newburgh	Aberdeenshire	6525	12	1992-2013	ECS	NS
166	Hackley Bay	Aberdeenshire	540	2	2010-12	ECS	NS
167.1	Sands of Forvie	Aberdeenshire	420	3	1999-2011	ECS	NS
167.2	Ythan river mouth	Aberdeenshire	120	1	2011	ECS	NS
167.3	Newburgh	Aberdeenshire	315	2	1999-2012	ECS	NS
168	Balmedie Beach	Aberdeenshire	2730	8	1992-2013	ECS	NS
169	Blackdog, Aberdeen	Aberdeenshire	180	1	2007	ECS	NS
170.1	Donmouth	Aberdeenshire	4845	8	1996-2013	ECS	NS
170.2	Aberdeen Beach	Aberdeenshire	4100	13	1991-2013	ECS	NS
170.3	Aberdeen Harbour	Aberdeenshire	13798	13	1995-2012	ECS	NS
170.4	Aberdeen Torry Battery	Aberdeenshire	25406	12	2001-13	ECS	NS
171	Girdleness	Aberdeenshire	14803	19	1990-2013	ECS	NS
172	Nigg Bay	Aberdeenshire	1080	6	2000-06	ECS	NS
173	North Broad Craig	Aberdeenshire	115	1	2000	ECS	NS
174	Doonies Farm	Aberdeenshire	480	4	2000-05	ECS	NS
175.1	Souter Head, Cove	Aberdeenshire	5860	8	1992-2013	ECS	NS
175.2	Cove Bay harbour	Aberdeenshire	240	1	2010	ECS	NS
176	Findon Ness N of Portlethen	Aberdeenshire	120	1	2004	ECS	NS
177	Portlethen	Aberdeenshire	240	1	2011	ECS	NS
178	Newtonhill	Aberdeenshire	2474	3	1987-2006	ECS	NS
179	Muchalls S of Newtonhill	Aberdeenshire	120	1	1999	ECS	NS
180.1	Stonehaven	Aberdeenshire	39700	7	1993-2007	ECS	NS
180.2	Downie Point, Stonehaven	Aberdeenshire	165	1	2010	ECS	NS
180.3	Dunnottar Castle, Stonehaven	Aberdeenshire	30	1	2006	ECS	NS
181	Fowlsheugh	Aberdeenshire	1335	6	1993-2007	ECS	NS
182	Crawton Ness N of Catterline	Aberdeenshire	50	1	2006	ECS	NS
183.1	Catterline S of Stonehaven	Aberdeenshire	41	1	2002	ECS	NS
183.2	Todhead Point, N of Inverbervie	Aberdeenshire	300	1	2006	ECS	NS
184	Inverbervie S of Stonehaven	Aberdeenshire	45	1	2007	ECS	NS

Site No	Site	Region	Total Effort	No of years	Year span	BND MUs	HP MUs
185	Johnshaven S of Inverbervie	Aberdeenshire	120	1	2007	ECS	NS
186	St Cyrus	Aberdeenshire	2796	9	1993-2013	ECS	NS
187	Montrose	Angus	380	3	2005-07	ECS	NS
188	Scurdie Ness	Angus	120	1	2006	ECS	NS
189	Auchmithie, Lud Castle N of Arbroath	Angus	1620	2	2012-13	ECS	NS
190.1	Three Storey Hoose, Arbroath	Angus	1650	3	2012-13	ECS	NS
190.2	Arbroath	Angus	19560	2	2011-13	ECS	NS
191	Elliot Links, S of Arbroath	Angus	31020	3	2011-13	ECS	NS
192	St. Andrews	Fife	840	2	2005-12	ECS	NS
193	East Wemyss N of Kirkcaldy	Fife	440	2	2012-13	ECS	NS
194	Musselburgh	East Lothian	50	1	2006	ECS	NS
195	North Berwick	East Lothian	60	1	2006	ECS	NS
196	St. Abb's Head	Berwickshire	2040	7	1992-2013	ECS	NS
197	Lindisfarne (Holy Island)	Northumberland	250	1	2013	NS	NS
198	Farne Islands (Inner Farne LH)	Northumberland	1320	1	2009	NS	NS
199	Bamburgh	Northumberland	495	2	2003-13	NS	NS
200	Seahouses	Northumberland	75	1	2003	NS	NS
201	Beadnell	Northumberland	270	1	2013	NS	NS
202	Dunstanburgh Castle, Craster	Northumberland	1182	2	2011-13	NS	NS
203	Cullernose Point S of Craster	Northumberland	634	2	1992-2013	NS	NS
204	Boulmer	Northumberland	90	1	1992	NS	NS
205.1	Amble Sand Dunes / opp. Coquet Island	Northumberland	120	1	2002	NS	NS
205.2	Low Hauxley	Northumberland	225	1	2013	NS	NS
205.3	Hauxley Nature Reserve	Northumberland	90	1	2013	NS	NS
206	Druridge Bay S of Amble	Northumberland	240	2	2002-03	NS	NS
207	Cresswell	Northumberland	4495	4	2002-13	NS	NS
208	Newbiggin-by-the-Sea (Church Point)	Northumberland	690	1	2013	NS	NS
209	Blyth	Northumberland	1165	2	2002-05	NS	NS
210	Rocky Island, Seaton Sluice	Northumberland	2569	3	2004-13	NS	NS
211	St. Mary's Lighthouse	Northumberland	1453	3	1992-2013	NS	NS
212	Cullercoats	Tyne and Wear	90	1	2003	NS	NS
213.1	King Edward's Bay, Tynemouth	Tyne and Wear	540	1	2003	NS	NS
213.2	Spanish Battery, Tynemouth	Tyne and Wear	2065	2	2003-04	NS	NS
213.3	Tynemouth North Pier	Tyne and Wear	2430	3	2001-13	NS	NS
214	Marsden Lea N, Car Park, South Shields	Tyne and Wear	1980	2	2002-03	NS	NS
215	Lizard Point, Mardsen	Tyne and Wear	165	2	2013	NS	NS
216.1	Souter Lighthouse B, Sunderland	Tyne and Wear	2464	2	2004-13	NS	NS
216.2	The Wherry, Whitburn	Tyne and Wear	180	1	2001-12	NS	NS
216.3	Souter Lighthouse A, Sunderland	Tyne and Wear	2310	2	2003-13	NS	NS
217	Seaham	Durham	300	2	2002-03	NS	NS
218	Crimdon Dene, nr. Hartlepool	Durham	90	1	2003	NS	NS

Site No	Site	Region	Total Effort	No of years	Year span	BND MUs	HP MUs
219	Saltburn Top	Yorkshire	531	1	2013	NS	NS
220	Staithes	Yorkshire	120	1	2013	NS	NS
221	Long Nab, Burniston, N of Scarborough	Yorkshire	75	1	2013	NS	NS
222.1	Marine Drive, Scarborough	Yorkshire	285	4	2000-05	NS	NS
222.2	Scarborough	Yorkshire	110	5	2012-13	NS	NS
222.3	East Pier, Scarborough	Yorkshire	375	2	2000-01	NS	NS
222.4	Scarborough, Holbeck Bay	Yorkshire	42247	2	2009-13	NS	NS
223	Filey Brigg	Yorkshire	840	5	2000-13	NS	NS
224	Filey Bay	Yorkshire	220	1	2000	NS	NS
225	Bridlington Bay	Yorkshire	181	1	2013	NS	NS
226	Bempton Cliffs	Yorkshire	4856	4	2002-13	NS	NS
227	Flamborough Head	Yorkshire	2520	6	2004-13	NS	NS
228	Mappleton S of Hornsea	Yorkshire	90	1	2004	NS	NS
229.1	Spurn Head	Yorkshire	115220	16	1965-2006	NS	NS
229.2	Spurn Head Bird Observatory	Yorkshire	953645	28	1965-1994	NS	NS
230	The Deep, Hull	Humberside	615	3	2004-08	NS	NS
231	Humber Bridge, Hull	Humberside	95	1	2006	NS	NS
232	Theddlethorpe Beach N of Mablethorpe	Lincolnshire	1650	2	2011-13	NS	NS
233	Mablethorpe	Lincolnshire	120	1	2013	NS	NS
234	Huttoft Car Terrace N of Anderby Creek	Lincolnshire	460	1	2013	NS	NS
235	Anderby Creek south of Mablethorpe	Lincolnshire	8630	3	2011-13	NS	NS
236	Chapel Point N of Chapel St Leonards	Lincolnshire	60	1	2013	NS	NS
237.1	Winthorpe Tower, Skegness	Lincolnshire	3855	3	2011-13	NS	NS
237.2	Skegness Pier	Lincolnshire	2472	2	2012-13	NS	NS
238	Gibraltar Point NNR	Lincolnshire	22885	3	2011-13	NS	NS
239	Hunstanton	Norfolk	360	2	2009-10	NS	NS
240	Blakeney Point	Norfolk	1050	2	2002-12	NS	NS
241	Cley next the Sea	Norfolk	180	3	2009-13	NS	NS
242	Weybourne	Norfolk	3270	3	1987-2009	NS	NS
243	Sheringham	Norfolk	8195	4	1988-91	NS	NS
244	West Runton	Norfolk	190	1	1987	NS	NS
245.1	Cromer Pier	Norfolk	2022	1	2012-13	NS	NS
245.2	Overstrand, Cromer	Norfolk	360	2	2010	NS	NS
246	Trimingham	Norfolk	120	1	2013	NS	NS
247	Mundesley	Norfolk	1170	2	2010-11	NS	NS
248	Hopton-on-Sea	Norfolk	540	3	2009-13	NS	NS
249	Pakefield Cliffs S of Lowestoft	Suffolk	235	1	2006	NS	NS
250	Southwold	Suffolk	330	1	2006	NS	NS
251	Orford Ness Lighthouse	Suffolk	2655	3	2004-07	NS	NS
252	Hollesley Bay	Suffolk	210	1	2001	NS	NS

Site No	Site	Region	Total Effort	No of years	Year span	BND MUs	HP MUs
253	Walton Pier	Essex	885	2	2000-2001	NS	NS
254	Clacton Pier	Essex	180	1	2002	NS	NS
255	Southend-on-Sea Pier	Essex	122	1	2011	NS	NS
256	Broadstairs	Kent	120	1	2013	NS	NS
257	Dungeness Bird Observatory	Kent	211	2	2006-12	CSW	NS
258	Fairlight Beach E of Hastings	East Sussex	11635	5	1990-94	CSW	NS
259.1	Hastings	East Sussex	5745	4	1990-94	CSW	NS
259.2	Warrior Beach, Hastings	East Sussex	9808	4	1991-94	CSW	NS
260	Holywell	East Sussex	1160	1	2010	CSW	NS
261	Bulverhythe Beach, Bexhill	East Sussex	480	1	1994	CSW	NS
262	Birling Gap	East Sussex	1920	2	2010-13	CSW	NS
263	Brighton Marina	West Sussex	1950	3	2000-06	CSW	NS
264	Southwick beach W of Portslade-by-Sea	West Sussex	45	1	2013	CSW	NS
265	Shoreham	West Sussex	195	1	2006	CSW	NS
266	Lancing Beach	West Sussex	165	1	2001	CSW	NS
267	Worthing	West Sussex	990	1	2001	CSW	NS
268	Southsea Castle, Portsmouth	Hants	1280	1	2013	CSW	NS
269	Poole Bay	Dorset	255	1	2010	CSW	NS
270	Durlston Country Park	Dorset	1121	3	2004-13	CSW	NS
271	Burton Bradstock Cliffs	Dorset	120	1	2010	CSW	CIS
272	Stonebarrow Cliff, Charmouth	Dorset	180	1	2010	CSW	CIS
273	Beer Head	South Devon	4205	3	2005-07	CSW	CIS
274	Branscombe West Cliff	South Devon	375	1	2008	CSW	CIS
275	Orcombe Point near Exmouth	South Devon	2315	3	2005-07	CSW	CIS
276	Dawlish Warren W of Exmouth	South Devon	1110	2	2006-09	CSW	CIS
277	Teignmouth (Public viewpoint)	South Devon	70	1	2009	CSW	CIS
278	Labrador Bay	South Devon	135	1	2009	CSW	CIS
279	Maidencombe N of Torquay	South Devon	3202	2	2009-10	CSW	CIS
280	Berry Head near Brixham	South Devon	15032	6	1994-2012	CSW	CIS
281	Sharkham Point S of Berry Head	South Devon	180	1	1994	CSW	CIS
282	Dartmouth	South Devon	210	1	1997	CSW	CS
283	Slapton Sands	South Devon	175	1	2001	CSW	CS
284	Torcross	South Devon	75	1	2002	CSW	CIS
285	Start Point	South Devon	4379	11	1994-2009	CSW	CIS
286	Pear Tree Point W of Start Point	South Devon	60	1	1994	CSW	CIS
287	Mattiscombe Beach W of PearTree Point	South Devon	240	1	1994	CSW	CIS
288	Prawle Point	South Devon	66120	6	1993-2003	CSW	CIS
289	Bolberry W of Bolt Head	South Devon	120	1	1997	CSW	CIS
290	Bolt Head, Devon	South Devon	245	2	2009-10	CSW	CIS
291	Bolt Tail, Devon	South Devon	60	1	2009	CSW	CIS
292	Warren Point S of Thurlestone	South Devon	860	1	2009	CSW	CIS
293	Bantham N of Thurlestone	South Devon	215	1	2006	CSW	CIS

Site No	Site	Region	Total Effort	No of years	Year span	BND MUs	HP MUs
294	Burgh Island, Bigbury-on-Sea	South Devon	130	1	2009	CSW	CIS
295	Fernycombe Point, W of Bigbury	South Devon	245	1	2009	CSW	CIS
296	Mothecombe	South Devon	840	1	2010	CSW	CIS
297.1	Stoke Beach, Noss Mayo	South Devon	240	2	2006-09	CSW	CIS
297.2	Stoke Point	South Devon	120	1	2006	CSW	CIS
298	Blackstone Point	South Devon	660	2	2006-07	CSW	CIS
299	Gara Point west of Blackstone Point	South Devon	4055	2	2006-07	CSW	CIS
300	Wembury	South Devon	1260	4	2008-13	CSW	CIS
301	Bovisand Bay, Plymouth	South Devon	115	1	2005	CSW	CIS
302	Rame Head west of Plymouth	Cornwall (south)	570	2	2001-13	CSW	CIS
303	Port Wrinkle west of Plymouth	Cornwall (south)	2820	2	2010-11	CSW	CIS
304	Polruan near Fowey	Cornwall (south)	960	2	2012-13	CSW	CIS
305	Charlestown near St Austell	Cornwall (south)	60	1	2013	CSW	CIS
306	Black Head south of St Austell	Cornwall (south)	4965	4	2010-13	CSW	CIS
307	Castle Point (near St Mawes)	Cornwall (south)	105	1	2013	CSW	CIS
308	Pendennis, S of Falmouth	Cornwall (south)	180	1	2006	CSW	CIS
309	Rosemullion Head, SW of Falmouth	Cornwall (south)	105	1	2013	CSW	CIS
310	Nare Point (Lizard Peninsula)	Cornwall (south)	630	1	2013	CSW	CIS
311	Manacles	Cornwall (south)	2100	3	2010-12	CSW	CIS
312	Chynhal's, Coverack	Cornwall (south)	420	2	2006-07	CSW	CIS
313	Bass Point nr Lizard Point	Cornwall (south)	990	2	2012-13	CSW	CIS
314	Kynance Cove	Cornwall (south)	240	1	2013	CSW	CIS
315	Predannack Head, Lizard Peninsula	Cornwall (south)	330	1	2013	CSW	CIS
316	Mullion	Cornwall (south)	3960	3	2010-12	CSW	CIS
317	Porthleven	Cornwall (south)	3750	2	2006-07	CSW	CIS
318	Trewavas Head W of Porthleven	Cornwall (south)	120	1	2013	CSW	CIS
319	Rinsey Head W of Porthleven	Cornwall (south)	4500	2	2010-11	CSW	CIS
320	Cudden Point	Cornwall (south)	285	1	2013	CSW	CIS
321	Vessacks E of Gwennap Head	Cornwall (south)	120	1	2001	CSW	CIS
322	Porthgwarra	Cornwall (south)	75	1	1994	CSW	CIS
323	Gwennap Head	Cornwall (south)	260745	8	2001-13	CSW	CIS
324	Peninnis Head, Isles of Scilly	Cornwall (SW)	180	2	1996-2010	CSW	CIS
325	Bishop's Rock Lighthouse, Isles of Scilly	Cornwall (SW)	31320	1	1986	CSW	CIS
326	Lands End	Cornwall (west)	3748	2	1992-2007	CSW	CIS
327	Sennen Cove nr Lands End	Cornwal (west)	1920	1	2013	CSW	CIS
328	Cape Cornwall	Cornwall (west)	226440	9	1990-98	CSW	CIS
329	St. Ives Bay	Cornwall (north)	34380	4	2010-13	CSW	CIS
330	Godrevy Point	Cornwall (north)	450	3	2010-13	CSW	CIS
331	Portreath south of St Agnes	Cornwall (north)	330	1	1994	CSW	CIS
332	Porthtowan	Cornwall (north)	480	1	2013	CSW	CIS
333	St Agnes Head/Tubby's Head	Cornwall (north)	5365	5	1993-2013	CSW	CIS
334	Towan Head, Newquay	Cornwall (north)	120	1	2013	CSW	CIS

Site No	Site	Region	Total Effort	No of years	Year span	BND MUs	HP MUs
335	Trenance, nr. Newquay	Cornwall (north)	105	1	1999	CSW	CIS
336	Stepper Point nr Padstow	Cornwall (north)	195	1	2007	CSW	CIS
337	Pentire Point	Cornwall (north)	255	1	2006	CSW	CIS
338	Boscastle	Cornwall (north)	9735	4	2010-13	CSW	CIS
339.1	South end, Lundy Island	North Devon	1271	3	2011-13	CSW	CIS
339.2	Castle Green, Lundy Island	North Devon	412	2	2011-13	CSW	CIS
339.3	The Battery, Lundy Island	North Devon	120	1	2013	CSW	CIS
339.4	Lundy Island	North Devon	3565	6	2006-13	CSW	CIS
340	Welcombe Mouth	North Devon	60	1	2006	CSW	CIS
341	Hartland Point	North Devon	4556	10	1993-2013	CSW	CIS
342	Greencliff	North Devon	90	1	2008	CSW	CIS
343	Cornborough	North Devon	60	1	2006	CSW	CIS
344	Rock Nose, Mermaid's Pool, Westward Ho!	North Devon	980	3	2006-08	CSW	CIS
345	Westward Ho!	North Devon	1160	6	2003-10	CSW	CIS
346	Northam Burrows	North Devon	120	1	2006	CSW	CIS
347	Bideford Bay	North Devon	60	1	2006	CSW	CIS
348	Appledore	North Devon	60	1	2006	CSW	CIS
349	Saunton Beach, S of Croyde Bay	North Devon	750	4	2005-08	CSW	CIS
350	Downend Point	North Devon	17974	8	2006-13	CSW	CIS
351	Croyde	North Devon	60	1	2006	CSW	CIS
352	Baggy Point	North Devon	21134	13	1992-2013	CSW	CIS
353	Woolacombe	North Devon	120	1	1992	CSW	CIS
354	Grunta Beach	North Devon	2940	3	2007-13	CSW	CIS
355	Morte Point	North Devon	24115	11	1992-2013	CSW	CIS
356	Bull Point	North Devon	29650	11	1992-2013	CSW	CIS
357	Torrs, Ilfracombe	North Devon	2310	2	2005-06	CSW	CIS
358	Tunnels Beach, Ilfracombe	North Devon	120	1	2009	CSW	CIS
359	Capstone Point nr Ilfracombe	North Devon	61337	8	2006-13	CSW	CIS
360.1	Ilfracombe	North Devon	1400	2	2006-13	CSW	CIS
360.2	Ilfracombe Coastguard house	North Devon	320	1	2013	CSW	CIS
360.3	Ilfracombe Pier	North Devon	90	1	2013	CSW	CIS
361	Watermouth, W of Combe Martin	North Devon	720	1	2006	CSW	CIS
362	Burrow Nose W of Combe Martin	North Devon	375	2	2005-11	CSW	CIS
363	Lester Point, Combe Martin	North Devon	240	1	2013	CSW	CIS
364	High Veer Point nr Martinhoe	North Devon	120	1	1993	CSW	CIS
365	Foreland Point	North Devon	1870	5	1993-2010	CSW	CIS
366	Hurlstone Point	North Devon	885	3	2007-13	CSW	CIS
367	Minehead	Somerset	1095	2	2006-07	CSW	CIS
368	Brean Down	Somerset	270	1	2010	CSW	CIS
369	Avonmouth	Somerset	120	1	2009	CSW	CIS
370	Lavernock Point	Glamorgan	4590	1	2013	CSW	CIS
371	Penry Bay, West of Rhoose	Glamorgan	90	1	2005	CSW	CIS

Site No	Site	Region	Total Effort	No of years	Year span	BND MUs	HP MUs
372	Boverton (Summerhouse Point)	Glamorgan	125	2	2010-11	CSW	CIS
373	Nash Point	Glamorgan	105	1	2005	CSW	CIS
374	Southerndown (Sea Watch Centre)	Glamorgan	65	1	2008	CSW	CIS
375	Ogmore-by-sea	Glamorgan	68	1	1987	CSW	CIS
376	Porthcawl Point	Glamorgan	1933	1	2006	CSW	CIS
377	Port Talbot South Breakwater	Neath	6605	5	2001-13	CSW	CIS
378	Mumbles (Tutt Head)	Gower	12031	3	2011-13	CSW	CIS
379	Pwll Ddu	Gower	3407	4	2011-14	CSW	CIS
380	Southgate	Gower	10259	3	2011-13	CSW	CIS
381	Oxwich Point	Gower	1084	3	1996-2012	CSW	CIS
382	Port Eynon Point	Gower	11320	7	2000-13	CSW	CIS
383	Paviland	Gower	150	1	2002	CSW	CS
384	Worm's Head	Gower	7205	5	2011-13	CSW	CIS
385	Rhossili	Gower	42835	3	1995-2012	CSW	CIS
386	Burry Holm	Gower	4110	4	1996-2000	CSW	CIS
387	Limekiln Point	Gower	1864	11	2002-12	CSW	CIS
388	Saundersfoot	Pembs (south)	50	1	1987	CSW	CIS
389	Milford Haven	Pembs (south)	1039	1	2006	CSW	CIS
390.1	Skokholm Island Lighthouse	Pembs (west)	2824	4	1996-2005	CSW	CIS
390.2	Skokholm Island	Pembs (west)	11435	4	1987-90	CSW	CIS
391.1	Mew Stone, Skomer	Pembs (west)	805	3	1994-2013	CSW	CIS
391.2	Skomer Head	Pembs (west)	150	1	2013	CSW	CIS
391.3	Skomer Island NNR	Pembs (west)	90	2	1991-2004	CSW	CIS
391.4	Garland Stone, Skomer	Pembs (west)	1147	3	1993-2013	CSW	CIS
392	Deer Park, Martin's Haven	Pembs (west)	75	1	2002	CSW	CIS
393	Solva	Pembs (west)	90	1	1987	CSW	CIS
394.1	S. Ramsey Sound	Pembs (west)	23390	7	1992-98	CSW	CIS
394.2	Ramsey Bitches	Pembs (west)	1890	4	1991-97	CSW	CIS
394.3	Ramsey Sound	Pembs (west)	2430	1	1992	CSW	CIS
395	St. David's Head	Pembs (west)	1070	5	1987-98	CSW	CIS
396	Penllechwen by St David's Head	Pembs (north)	45	1	1997	CSW	CIS
397	Castell Coch, near Abercastle	Pembs (north)	120	1	1987	CSW	CIS
398	Penbrush, Strumble Head	Pembs (north)	500	2	1994-97	CSW	CIS
399	Pwll Deri, S of Strumble Head	Pembs (north)	120	1	1987	CSW	CIS
400	Strumble Head	Pembs (north)	38311	15	1987-2012	CSW	CIS
401.1	Dinas Head	Pembs (north)	1050	3	1990-92	CSW	CIS
401.2	Needle Rock, Dinas Head	Pembs (north)	160	1	1998	CSW	CIS
402	Newport Bay	Pembs (north)	660	2	1989-90	CSW	CIS
403	Poppit YH	Ceredigion	510	1	1991	IS	CIS
404	Clumyr Ynys (Cardigan Is., headland)	Ceredigion	790	2	1991-92	IS	CIS
405	Cardigan Island	Ceredigion	360	2	1992-2000	IS	CIS
406.1	Aberporth A	Ceredigion	4645	4	1990-2010	IS	CIS
406.2	Aberporth B	Ceredigion	40415	6	2004-09	IS	CIS

Site No	Site	Region	Total Effort	No of years	Year span	BND MUs	HP MUs
407	Pencestyll, W of Pen Peles	Ceredigion	60	1	1991	IS	CIS
408	Pen Peles	Ceredigion	90	1	2009	IS	CIS
409	Mwnt	Ceredigion	94146	16	1991-2013	IS	CIS
410	Llangrannog	Ceredigion	1060	1	2000	IS	CIS
411	Ynys Lochtyn	Ceredigion	21615	9	1990-2009	IS	CIS
412	Caerwenfor (W of Cwmtudu)	Ceredigion	3635	2	2010-13	IS	CIS
413.1	New Quay, Birds Rock	Ceredigion	1260	1	2011	IS	CIS
413.2	Target Rock, New Quay	Ceredigion	90	1	2011	IS	CIS
413.3	Fish Factory, New Quay	Ceredigion	75	1	2013	IS	CIS
413.4	New Quay Headland	Ceredigion	125866	17	1988-2010	IS	CIS
413.5	New Quay Harbour	Ceredigion	1260	5	1991-2013	IS	CIS
414	Aberaeron	Ceredigion	540	1	1990	IS	CIS
415	Llanrhystud	Ceredigion	1020	1	1990	IS	CIS
416	Monk's Cave, Llanrhystud	Ceredigion	240	1	1990	IS	CIS
417.1	Aberystwyth Harbour	Ceredigion	525	1	1990-2010	IS	CIS
417.2	Aberystwyth	Ceredigion	13223	7	2011-2013	IS	CIS
417.3	Aberystwyth Castle	Ceredigion	700	2	2012	IS	CIS
418	Borth	Ceredigion	930	1	1990	IS	CIS
419	Ynyslas	Ceredigion	5461	2	1990-93	IS	CIS
420	Aber Dysynni	Gwynedd	550	1	1990	IS	CIS
421	Friog Cliffs	Gwynedd	500	2	2000-01	IS	CIS
422	Llwgngwril	Gwynedd	10	1	1990	IS	CIS
423	Barmouth	Gwynedd	1365	2	1990-2013	IS	CIS
424	Tal-y-bont, north of Barmouth	Gwynedd	1087	1	2011	IS	CIS
425	Shell Island (Tremadog Bay)	Gwynedd	140	1	2005	IS	CIS
426	Llanfair Cliffs	Gwynedd	555	1	1990	IS	CIS
427	Harlech	Gwynedd	30	1	1990	IS	CIS
428	Criccieth	Gwynedd	1260	2	1990-94	IS	CIS
429	St Tudwals Islands (east)	Gwynedd	120	1	2009	IS	CIS
430	Trwyn y Wylfa, Llŷn Peninsula	Gwynedd	135	1	1990	IS	CIS
431.1	Bardsey Island	Gwynedd	4650	3	1990-97	IS	CIS
431.2	Bardsey Island Lighthouse	Gwynedd	1200	1	1998	IS	CIS
431.3	Bardsey Island, Flagstaff	Gwynedd	14071	2	1997-98	IS	CIS
431.4	Cliff, Bardsey Island	Gwynedd	1819	2	2011-12	IS	CIS
431.5	North End, Bardsey Island	Gwynedd	8419	3	2010-12	IS	CIS
431.6	Bardsey Island, NW corner	Gwynedd	180	1	1997	IS	CIS
431.7	Pen-y-Cil, Bardsey Island	Gwynedd	2141	1	2010	IS	CIS
431.8	St Mary's Well, Bardsey Island	Gwynedd	2345	1	2010	IS	CIS
431.9	Mynydd Mawr, Bardsey Island	Gwynedd	339	1	2010	IS	CIS
432	Porth Dinllaen	Gwynedd	1500	1	2010	IS	CIS
433	Dinas Dinlle	Gwynedd	120	1	2013	IS	CIS
434	Rhoscolyn	Anglesey	660	3	2007-10	IS	CIS
435	The Range	Anglesey	1710	4	2005-08	IS	CIS

Site No	Site	Region	Total Effort	No of years	Year span	BND MUs	HP MUs
436	South Stack	Anglesey	7770	10	1991-2010	IS	CIS
437	North Stack	Anglesey	3880	7	2001-08	IS	CIS
438	Breakwater C P	Anglesey	510	2	2005-08	IS	CIS
439	The Skerries (from Anglesey mainland)	Anglesey	1140	2	2005-07	IS	CIS
440	Skerries, Holyhead (Island)	Anglesey	1650	4	1983-95	IS	CIS
441	Carmel Head	Anglesey	5015	8	2001-09	IS	CIS
442	Porth y Dyfn	Anglesey	140	1	2009	IS	CIS
443	Cemlyn	Anglesey	1890	5	2001-08	IS	CIS
444	Wylfa Head	Anglesey	180	2	2005-06	IS	CIS
445	Cemaes	Anglesey	60	1	2006	IS	CIS
446	Llanbadrig	Anglesey	2200	8	2001-11	IS	CIS
447	Middle Mouse	Anglesey	6330	7	2001-09	IS	CIS
448	Porth Wen	Anglesey	720	2	2006-08	IS	CIS
449	Bull Bay	Anglesey	8350	13	2001-13	IS	CIS
450.1	Llam Carw	Anglesey	11180	8	2001-08	IS	CIS
450.2	Amlwch Bonc	Anglesey	360	1	2005	IS	CIS
451	Point Lynas	Anglesey	126701	27	1976-2013	IS	CIS
452	Dulas	Anglesey	60	1	2005	IS	CIS
453	Lligwy	Anglesey	180	2	2005-06	IS	CIS
454	Nant Bychan	Anglesey	211	1	2002	IS	CIS
455	Moelfre	Anglesey	660	3	2006-08	IS	CIS
456	Fedw Fawr	Anglesey	720	3	2006-08	IS	CIS
457	Penmon	Anglesey	90	1	2005	IS	CIS
458	Whitebeach, Penmon	Anglesey	75	1	2002	IS	CIS
459	Great Orme Country Park	Conwy	1155	1	1991	IS	CIS
460.1	Calf of Man	Isle of Man	1050	1	2007	IS	CIS
460.2	Calf East	Isle of Man	13125	7	2007-13	IS	CIS
460.3	Calf West	Isle of Man	6315	7	2007-13	IS	CIS
461	Cregneash	Isle of Man	150	1	2007	IS	CIS
462	Port St. Mary	Isle of Man	13710	8	2006-13	IS	CIS
463	Glen Chass Farmhouse	Isle of Man	270	1	2006	IS	CIS
464	Arches, Port Erin	Isle of Man	3015	2	2008-09	IS	CIS
465	Marine Drive	Isle of Man	9660	4	2010-13	IS	CIS
466.1	Niarbyl	Isle of Man	17040	8	2006-13	IS	CIS
466.2	Elby Point, Niarbyl	Isle of Man	315	1	2006	IS	CIS
467	Ballalhargy Farm, Dalby	Isle of Man	4050	2	2006-07	IS	CIS
468	Ballaquane	Isle of Man	13185	3	2004-06	IS	CIS
469	Contrary Head	Isle of Man	120	1	2007	IS	CIS
470	Peel	Isle of Man	4050	5	2007-12	IS	CIS
471	Lynague, north of Peel	Isle of Man	2145	3	2010-12	IS	CIS
472	Maughold Head	Isle of Man	2820	1	2006	IS	CIS
473	Ballaghennie	Isle of Man	182	1	2006	IS	CIS

Site No	Site	Region	Total Effort	No of years	Year span	BND MUs	HP MUs
474	Point of Ayre	Isle of Man	285	2	2006-12	IS	CIS
475	Seacombe ferry terminal	Merseyside	180	1	2012	IS	CIS
476	Marine Point, New Brighton	Merseyside	180	1	2012	IS	CIS
477	Burbo Bank Windfarm, Crosby	Lancashire	120	1	2010	IS	CIS
478	Formby Point	Lancashire	660	1	2010	IS	CIS
479.1	Mirror Ball, Blackpool	Lancashire	1260	2	2010-13	IS	CIS
479.2	South Promenade, Blackpool	Lancashire	540	2	2004-08	IS	CIS
479.3	Blackpool	Lancashire	2035	2	2006-12	IS	CIS
479.4	St Chads, Blackpool	Lancashire	240	1	2010	IS	CIS
479.5	Gynn Square, Blackpool	Lancashire	965	3	2011-13	IS	CIS
479.6	Norbreck Castle, Blackpool	Lancashire	1770	1	2013	IS	CIS
479.7	Bispham Cliffs, Blackpool	Lancashire	1020	4	2008-13	IS	CIS
479.8	Anchorsholme	Lancashire	240	1	2013	IS	CIS
480	Rossall Point, Fleetwood	Lancashire	230	1	2013	IS	CIS
481	Knott End-on-Sea, Fleetwood	Lancashire	90	1	2008	IS	CIS
482	Heysham	Lancashire	625	2	2012-13	IS	CIS
483	Walney South End	Cumbria	405	3	2007-13	IS	CIS
484	Morecambe Bay	Cumbria	120	1	2007	IS	CIS
485	Silecroft	Cumbria	180	1	2008	IS	CIS
486	Nethertown	Cumbria	55	1	2008	IS	CIS
487	St. Bees Head	Cumbria	2440	5	1994-2013	IS	CIS
488	Maryport	Cumbria	347	1	2007-13	IS	CIS
489	Silloth	Cumbria	240	4	2012	IS	CIS
490	Southerness Point	Galloway	60	1	2004	IS	CIS
491	Balcary Haugh/Balcary Point	Galloway	1455	2	2003-06	IS	CIS
492	Abbey Head, Abbey Burnfoot	Galloway	690	2	2006-10	IS	CIS
493	Burrow Head	Galloway	500	1	2006-07	IS	CIS
494	Monreith Beach, Galloway	Galloway	1425	1	1994-2012	IS	CIS
495	Mull of Galloway Lighthouse	Galloway	120	2	2012	IS	CIS
496	Portpatrick, Dunskey Castle	Galloway	585	2	2006	IS	CIS
497	Corsewall Point	Galloway	690	2	2012-13	IS	CIS
498	Ardentinny, Argyll	Argyll	810	1	1996	CWSH	WS
499	Blairmore	Argyll	1215	2	2010-11	CWSH	WS
500	Strone, Dunoon	Renfrewshire	2120	3	2009-11	CWSH	WS
501	Innellan	Renfrewshire	120	1	2011	CWSH	WS
502	Coul Point, Islay	Argyll	20	1	2011	CWSH	WS
503.1	Salen Cemetery car park, Isle of Mull	Argyll	630	1	1994	CWSH	WS
503.2	Old Chapelsite, Isle of Mull	Argyll	90	1	2003	CWSH	WS
504	Calliach Point, Isle of Mull	Argyll	180	1	2006	CWSH	WS
505	Tobermory Lighthouse, Isle of Mull	Argyll	90	1	2002	CWSH	WS
506	Bloody Bay, Isle of Mull	Argyll	382	2	2001-03	CWSH	WS
507	Ardnamurchan Point	Argyll	100035	9	1999-2013	CWSH	WS
508	Muck Harbour	Inner Hebrides	100	1	2013	CWSH	WS

Site No	Site	Region	Total Effort	No of years	Year span	BND MUs	HP MUs
509	Isle of Eigg (Glebe)	Inner Hebrides	240	1	2004	CWSH	WS
510	Arisaig campsite	Highland	120	1	2002	CWSH	WS
511	Mallaig	Highland	110	1	2006	CWSH	WS
512	Skye Bridge	Inner Hebrides	90	1	2002	CWSH	WS
513	Neist Point, Isle of Skye	Inner Hebrides	150	1	2011	CWSH	WS
514	Waternish, Skye (Trumpan Church)	Inner Hebrides	60	1	2013	CWSH	WS
515	Gairloch	Highland	630	2	1994-2012	CWSH	WS
516.1	Melvaig Inn, Gairloch	Highland	200	3	2010-12	CWSH	WS
516.2	Melvaig, Gairloch	Highland	12894	4	2008-11	CWSH	WS
517	Rua Reidh Lighthouse, Gairloch	Highland	520	4	2010-13	CWSH	WS
518	Loch Broom, Ullapool	Highland	60	1	1990	CWSH	WS
519	Clachtoll	Sutherland	30	1	2003	CWSH	WS
520	Raffin, Stoer Head	Sutherland	60	1	2004	CWSH	WS
521	Stoer Head Lighthouse	Sutherland	4761	9	1999-2013	CWSH	WS
522	Culkein, Stoer	Sutherland	485	5	1999-2004	CWSH	WS
523	Kylesku	Sutherland	195	1	2004	CWSH	WS
524	Scourie Bay	Sutherland	360	1	2004	CWSH	WS
525.1	Handa Island (Geodh Dearg)	Sutherland	138	1	1995	CWSH	WS
525.2	Handa Island (Meall a Bhodha)	Sutherland	637	1	1995	CWSH	WS
525.3	Handa Island	Sutherland	9657	11	1994-2012	CWSH	WS
526	Faraid Head	Sutherland	1020	1	2001	CWSH	WS
527	Strathy Point	Sutherland	8826	10	2002-13	CWSH	WS
528	Garrynamonie, South Uist	Western Isles	363	2	2011-12	CWSH	WS
529	Kildonan, South Uist	Western Isles	150	2	2011-12	CWSH	WS
530	Airport Mound, Benbecula	Western Isles	130	1	2012	CWSH	WS
531	Balranald Nature Reserve, North Uist	Western Isles	460	4	2010-13	CWSH	WS
532	Berneray (East Beach), North Uist	Western Isles	500	4	2010-13	CWSH	WS
533	Rodel, Harris	Western Isles	1250	2	2012-13	CWSH	WS
534	Berneray (North), North Uist	Western Isles	490	4	2010-13	CWSH	WS
535	Quidinish Point, Harris	Western Isles	240	1	2012	CWSH	WS
536	Tiumpan Head East, Lewis	Western Isles	11976	7	1990-2013	CWSH	WS
537	Butt of Lewis	Western Isles	1045	2	1990-2010	CWSH	WS
538	Alderney	Channel Islands	360	1	2013	CSW	CIS
539	La Crete Point, Jersey	Channel Islands	435	1	2002	CSW	CIS
540	Le Hurel Slip, Grouville Bay, Jersey	Channel Islands	240	1	2010	CSW	CIS
541	Magilligan Point	Co. Derry	5315	6	2008-13	CWSH	CIS
542	Rathlin Island	Co. Antrim	4390	7	2004-13	CWSH	WS
543	Portaneevey, Nr. Carrickarede Island	Co. Antrim	3930	5	2009-13	CWSH	WS
544	Ramore Head	Co. Antrim	17823	10	2004-13	CWSH	WS
545	Torr Head	Co. Antrim	3820	7	2007-13	CWSH	WS
546	Portmuck, Island Magee	Co. Antrim	11520	11	2003-13	IS	CIS
547	Black Head	Co. Antrim	13498	12	1994-2013	IS	CIS
548	Grey Point, Belfast Lough	Co. Down	11240	10	2003-12	IS	CIS

Site No	Site	Region	Total Effort	No of years	Year span	BND MUs	HP MUs
549	Ballyquintin Point, Ards Peninsula	Co. Down	3985	6	2008-13	IS	CIS
550	Killard Point	Co. Down	3295	7	2005-13	IS	CIS
551	St. John's Point	Co. Down	5298	6	2005-12	IS	CIS
552	Bloody Bridge, Newcastle	Co. Down	22445	11	2003-13	IS	CIS
553	Cranfield Point, Carlingford Lough	Co. Down	2835	6	2008-13	IS	CIS

Appendix 2: Geographical distribution of sighting rates

Bottlenose dolphin
Figure A2.1 shows sighting rates at particular sites partitioned by different levels of observational effort. All four maps show similar patterns, with sightings concentrated in the Moray Firth and Cardigan Bay, but also revealed is the importance of the outer Moray Firth as far north as the Dornoch Firth and the east Grampian coast south towards the Firth of Forth in eastern Scotland; and the North Wales coast and Isle of Anglesey, in Wales. Six sites in south-west England with reasonable levels of effort (>5h watch effort overall) have moderately high sightings rates (0.2 sighting/hour): Blackstone Point, south Devon; Bass Point and Predannack Head on the Lizard Peninsula in south Cornwall; Land's End, west Cornwall; St Ives Bay, north Cornwall; and around Croyde Bay in north Devon. The resident bottlenose dolphin population that inhabits waters around Jersey, Channel Islands, is revealed despite the relatively small amount of effort there.

Harbour Porpoise
Figure A2.2 shows sighting rates at particular sites partitioned by different levels of effort. The four maps reveal similar patterns for those locations where there has been variable effort. Table 4 details those sites with more than 5h of effort and high sightings rates. The east side of Shetland, particularly around the islands of Whalsay, Noss, Mousa, and both sides of the southern mainland peninsula have the highest sighting rates (1.2-6.5 sightings/h). Two sites in Orkney also have high sighting rates: Herston Head (1.1 sightings/h) and The Wing (3.0 sightings/h) in South Ronaldsay. In north Caithness, moderately high sighting rates (0.6-2.0 sightings/h) were observed at Scrabster Lighthouse, Thurso, and Gills Bay. In east Caithness, high sighting rates (1.8-5.6 sightings/h) occurred at Shelligoe Clifftop near Lybster, and then around the Dornoch Firth at sites from Brora to Dornoch on the north side, and at Tarbat Ness (0.5 sighting/h) and Rockfield (3.1 sighting/h) on the south side. Sighting rates were then relatively low (<1.0 sighting/h) in the inner Moray Firth, southern shores of the outer Moray Firth and Aberdeenshire, with moderate rates (0.6-1.5 sightings/h) only at Whinnyfold, Collieston, Newburgh, Balmedie, Cove, and Downie Point, Stonehaven.

Further south, sighting rates remain low (<0.5 sightings/h) until King Edward's Bay in Tynemouth and Marsden Lea in South Shields (both *ca*0.5 sightings/h), and at Souter Lighthouse, Tyne & Wear (1.0 sighting/h). Sighting rates then increase along the North Yorkshire coast, ranging from 1.1-4.9 sightings/h at Scarborough and Filey Bay, and 0.6-0.9 sightings/h at Bempton (80h effort), and Flamborough Head (>40h effort) in East Riding.

Sighting rates are low (<0.5 sightings/h) at all sites from Humberside and the Wash south to the Thames Estuary (although low elevation at most watch points may contribute to this) until Dungeness Bird Observatory (1.1 sighting/h). Along areas of the south-east and south-west coast of England (Sussex, Hants, and Dorset), sighting rates remain low (<0.5 sightings/h) until Start Point and Bolt Head (0.5-0.6 sightings/h) in south Devon. Most of Cornwall has low sighting rates (<0.5 sightings/h) until the north Cornish coast at Trenance near Newquay and Stepper Point near Padstow (sighting rates 0.9-1.1/h), but these are both based on low effort (<3h). Lundy Island has intermediate sighting rates (0.4-0.5/h) based on moderate effort (*c*20h effort). Several sites in north Devon have similar sighting rates: Hartland Point, Greencliff, Westward Ho!, Baggy Point, Grunta Beach, Morte Point, and Bull Point (all ranging between 0.4-1.3 sighting/h). Further into the Bristol Channel, sighting rates at Ilfracombe, Foreland Point, High Veer Point, Hurlstone Point, and Minehead ranged from 0.4-1.1/h.

Along the south Wales coast, moderate sighting rates (0.4-1.6/h) occur at several locations around the Gower Peninsula and in Swansea Bay: Port Talbot, Mumbles, Pwll Du (>50h effort), Port Eynon Point, Paviland, Limekiln Point, Worm's Head, and Burry Holm.

In west Pembrokeshire, sighting rates at Skokholm and Skomer Islands ranged from 0.4-0.8 sightings/h, increasing in Ramsey Sound to 1.3 sightings/h. At Strumble Head, the sighting rate was 0.4/h and at Dinas Head up to 1.9/h, although the former figure is based upon >500h of effort whereas the latter is based on <3h effort. Sighting rates are then low (<0.3/h) along the coast of Cardigan Bay until the west end of the Llŷn Peninsula, where they increase a little at Trwyn y Wylfa (0.4/h but based on <3h effort) and then significantly at Bardsey Island (1.2-5.4/h).

In North Wales, sighting rates were low until north-west Anglesey where sighting rates of 0.6-1.2/h occur at South Stack and North Stack respectively. Eastwards along the north coast, sighting rates ranged from 0.5-1.2/h at Carmel Head (>80h effort), Llanbadrig (>35h effort), Middle Mouse (>100h effort), Bull Bay (>100h effort), and Point Lynas (>2,000h effort). The east side of Anglesey and north-east mainland coast of Wales have low sighting rates (<0.5/h) although based on relatively limited coverage.

Sighting rates at sites in the Isle of Man are relatively high, mainly between 0.4-0.8/h but with rates of 2.1-659/h at Elby Point (Niarbyl), Ballaghenie, and Point of Ayre (although effort at these three sites is <5h).

Sites in Lancashire and Cumbria have low sighting rates (<0.5/h) until one reaches St Bees Head (where it is 0.6/h with >40h effort). In south-west Scotland, sighting rates of 0.5-1.0/h occur at Corsewall Point (>40h effort), Galloway, Strone near Dunoon (>30h effort), and Blairmore (*c*20h effort).

Further north in west Scotland, there are very few sites with much land watching. Relatively high sighting rates (0.5-2.7/h) occur at several sites on the Isle of Mull (but generally based upon less than 5h effort per site), the Isle of Muck (but only 2h effort), and Mallaig (only 1.5h effort), as well as Culkein (8h effort), Kylesku (3h effort) and Stoer Head (79h effort). On the north Sutherland coast, a moderate sighting rate (0.6/h) occurs at Strathy Point (*c*150h effort).

In the Outer Hebrides, sighting rates were 0.9/h at Berneray, North Uist (*c*8h effort), 1.1/h at Rodel, Harris (*c*20h effort), and 0.5/h at Tiumpan Head, Isle of Lewis (*c*200h effort).
In Northern Ireland, moderate sighting rates occur at Black Head (0.4/h with >200h effort), 0.6/h at Portmuck, Island Magee, 0.4/h at Ramore Head, and 0.4/h at Magilligan Point. All these sites had >50h of effort. Sightings rates in the Channel Islands are zero (although effort is limited – totalling *c*17h at three sites), and incidental sightings are also rare around these islands.

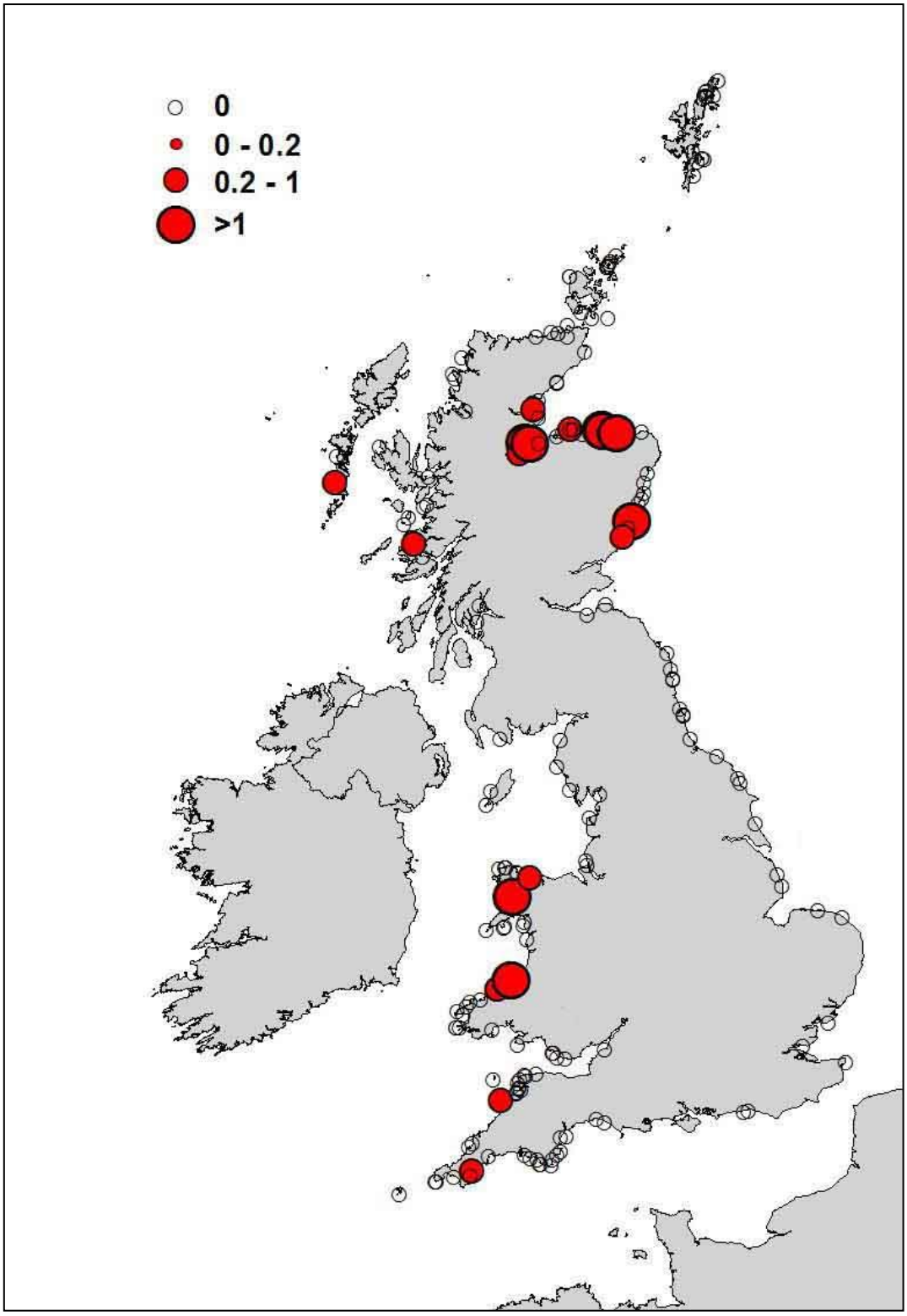


Figure A2.1 a. Map of bottlenose dolphin sighting rates (number of sightings per hour effort) by site (for watches with <3h total effort).

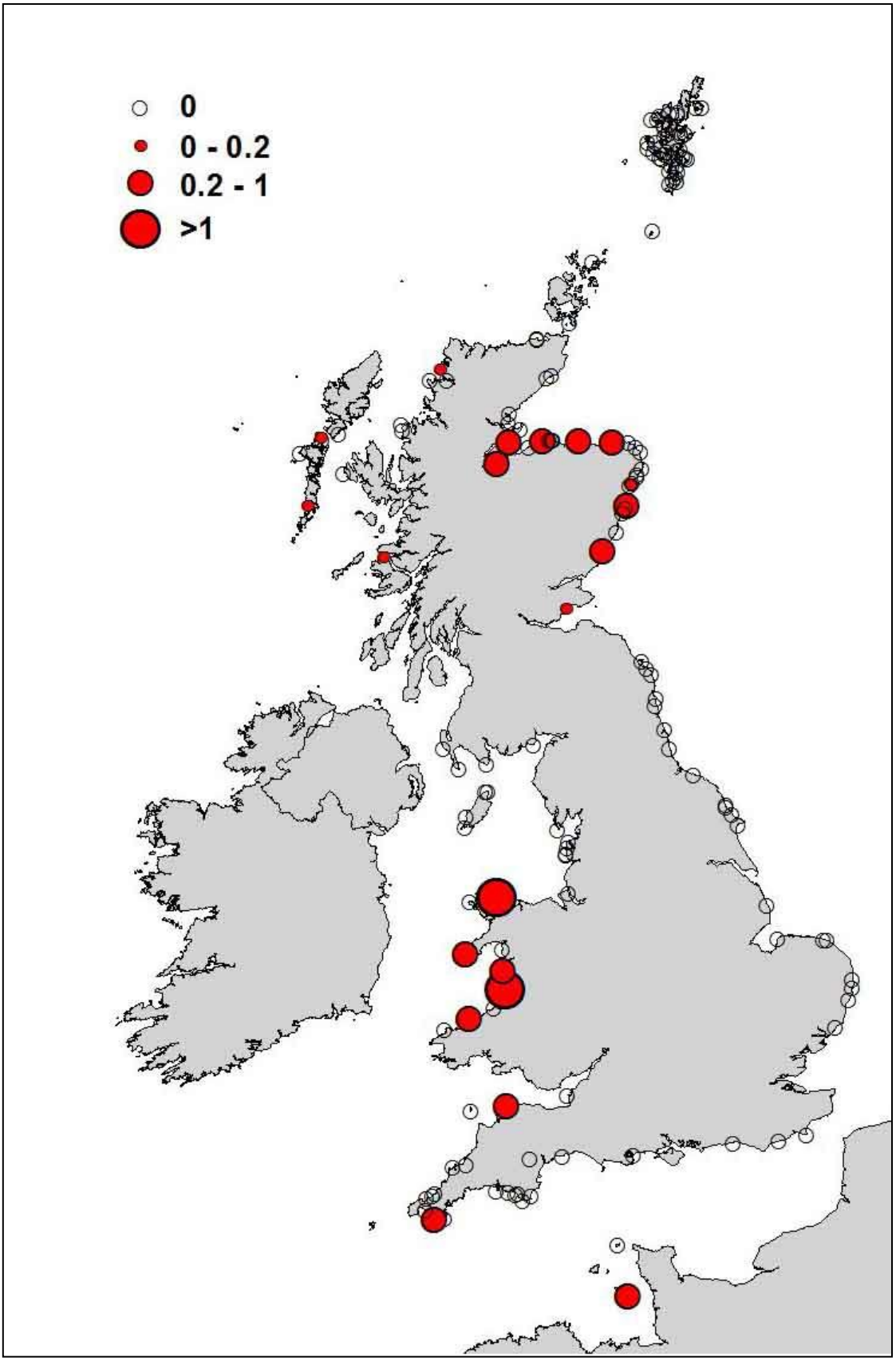


Figure A2.1 b. Map of bottlenose dolphin sighting rates (number of sightings per hour effort) by site (for watches with 3-10h total effort).

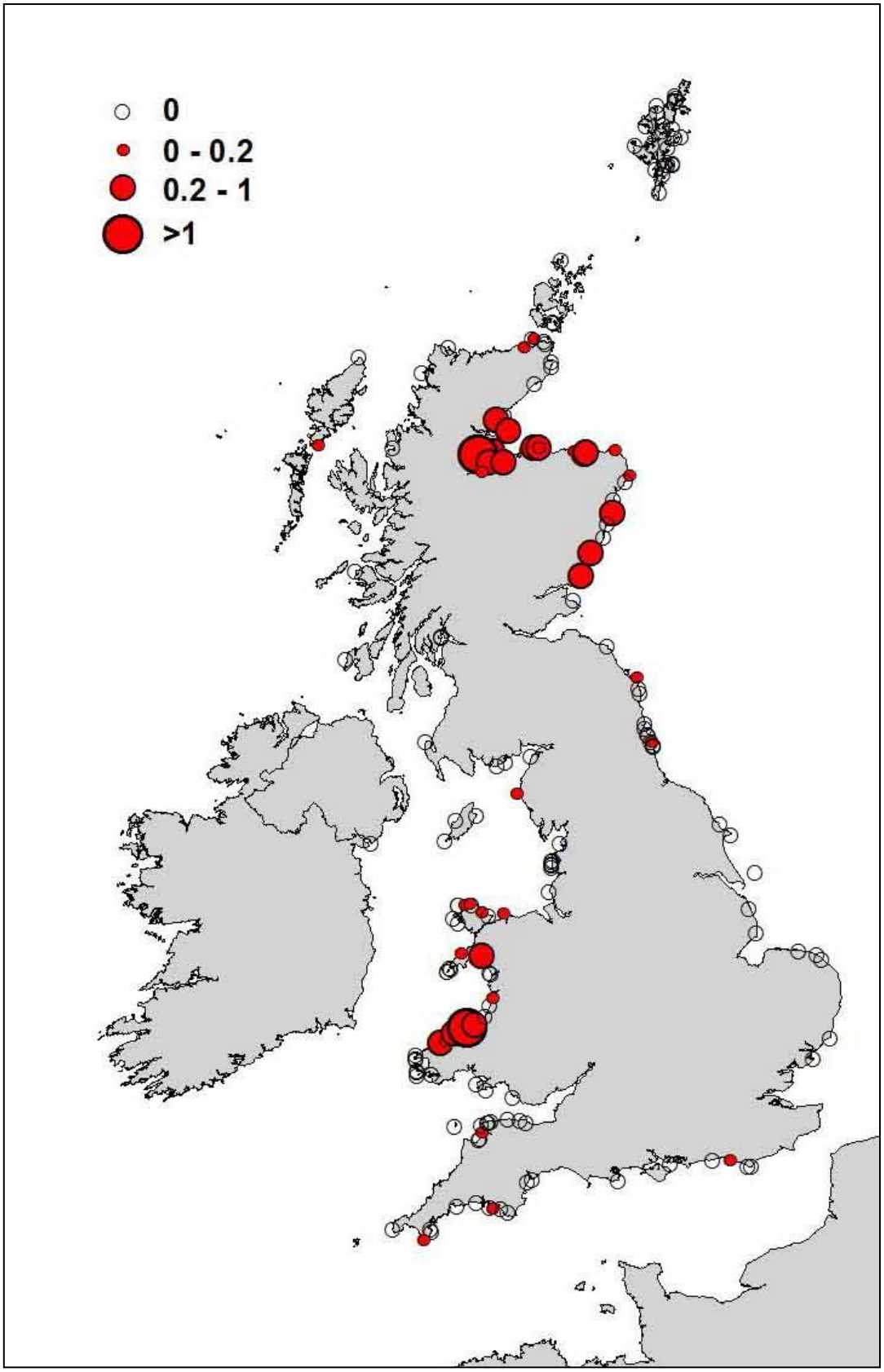


Figure A2.1 c. Map of bottlenose dolphin sighting rates (number of sightings per hour effort) by site (for watches with 10-50h total effort).

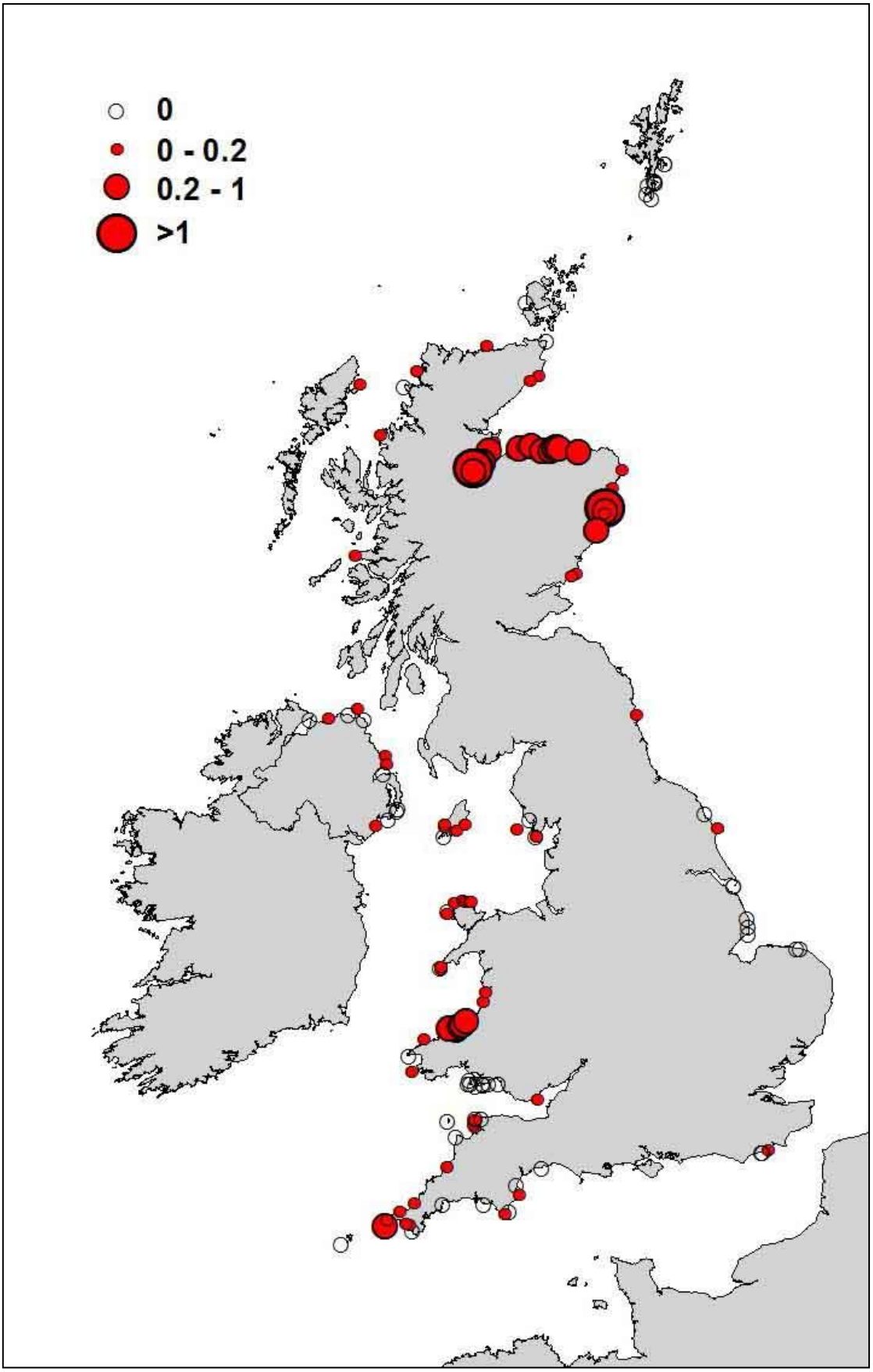


Figure A2.1 d. Map of bottlenose dolphin sighting rates (number of sightings per hour effort) by site (for watches with >50h total effort).

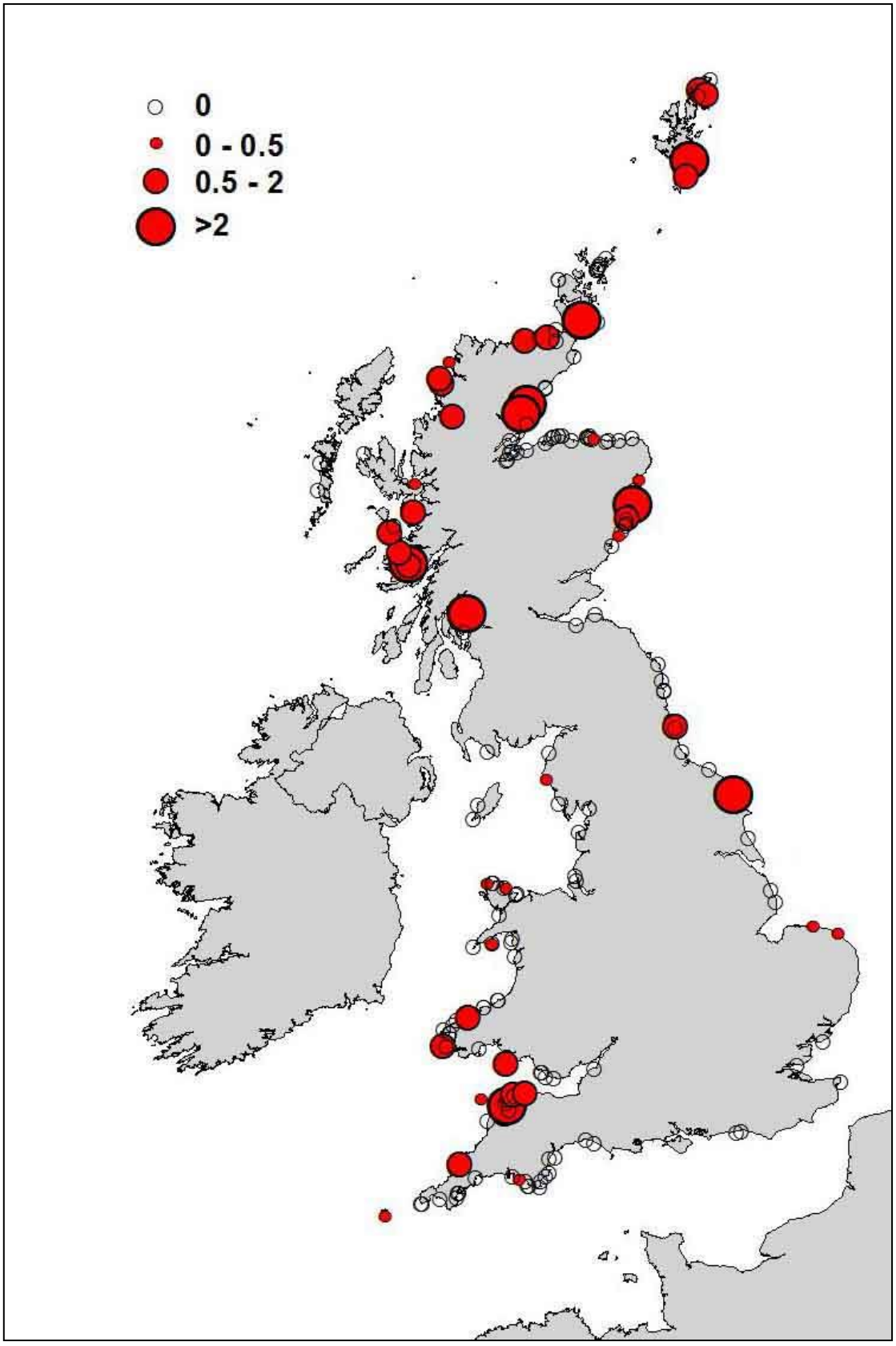


Figure A2.2 a. Map of harbour porpoise sighting rates (number of sightings per hour effort) by site (for watches with <3h total effort).

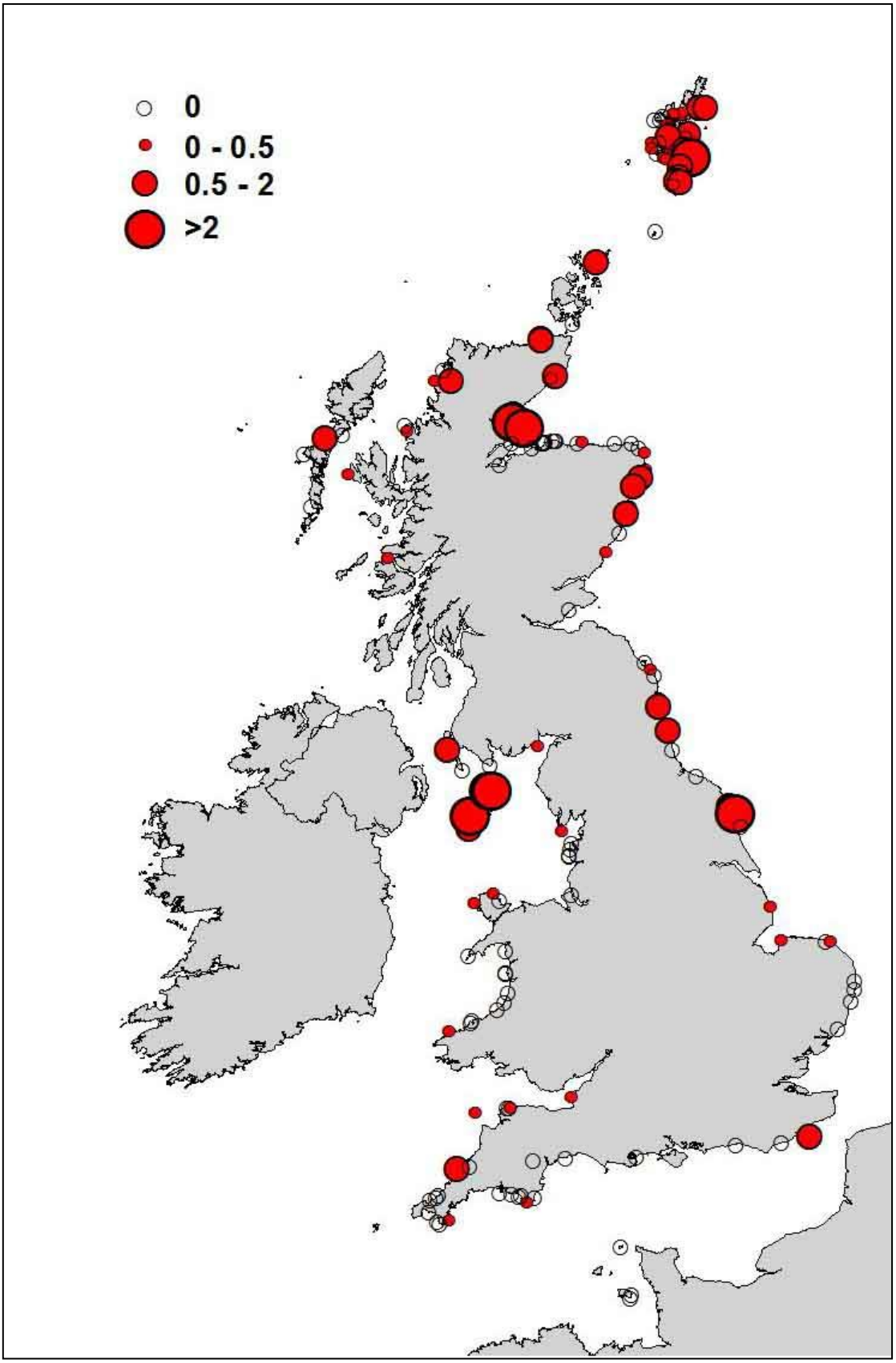


Figure A2.2 b. Map of harbour porpoise sighting rates (number of sightings per hour effort) by site (for watches with 3-10h total effort).

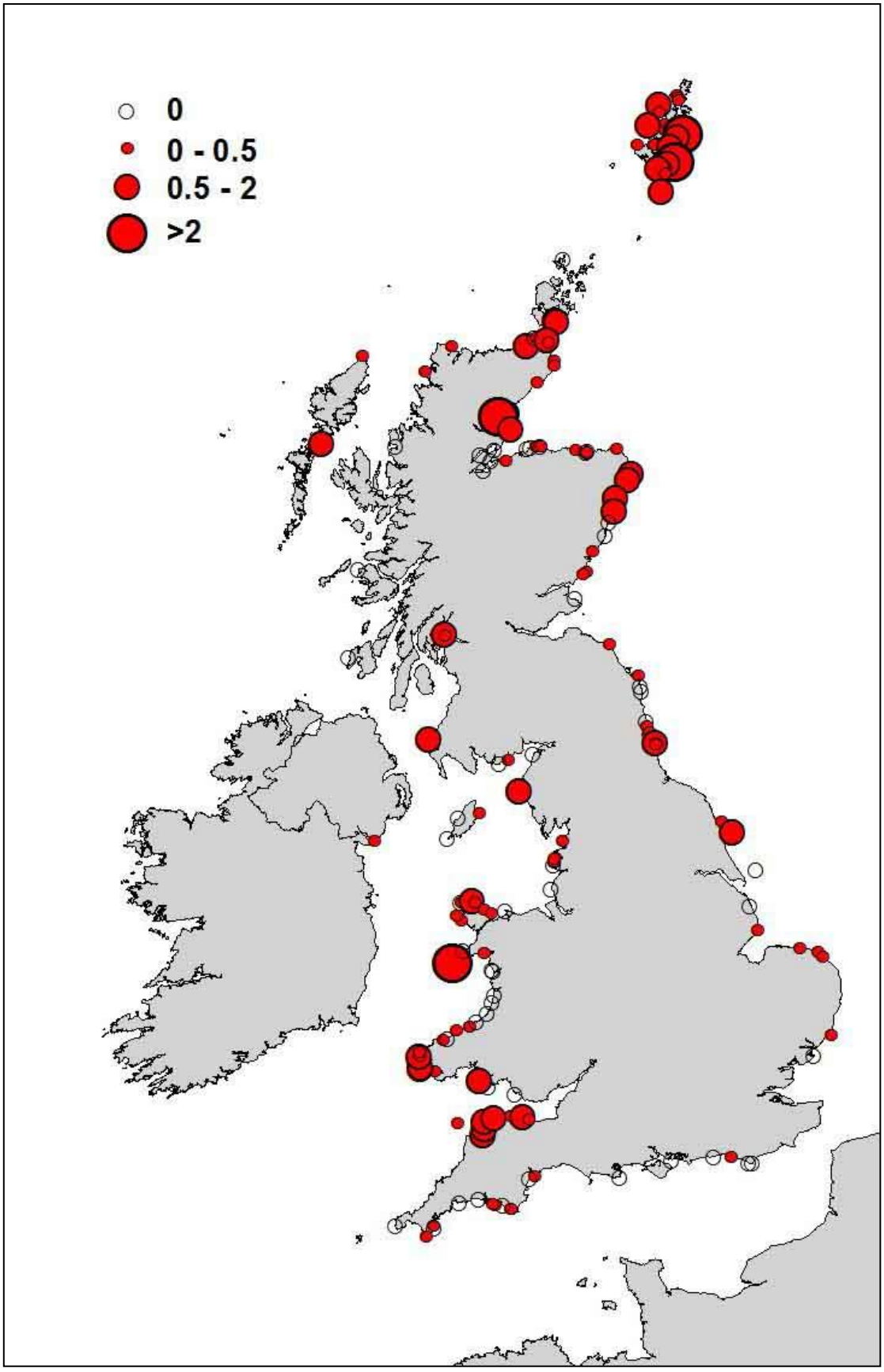


Figure A2.2 c. Map of harbour porpoise sighting rates (number of sightings per hour effort) by site (for watches with 10-50h total effort).

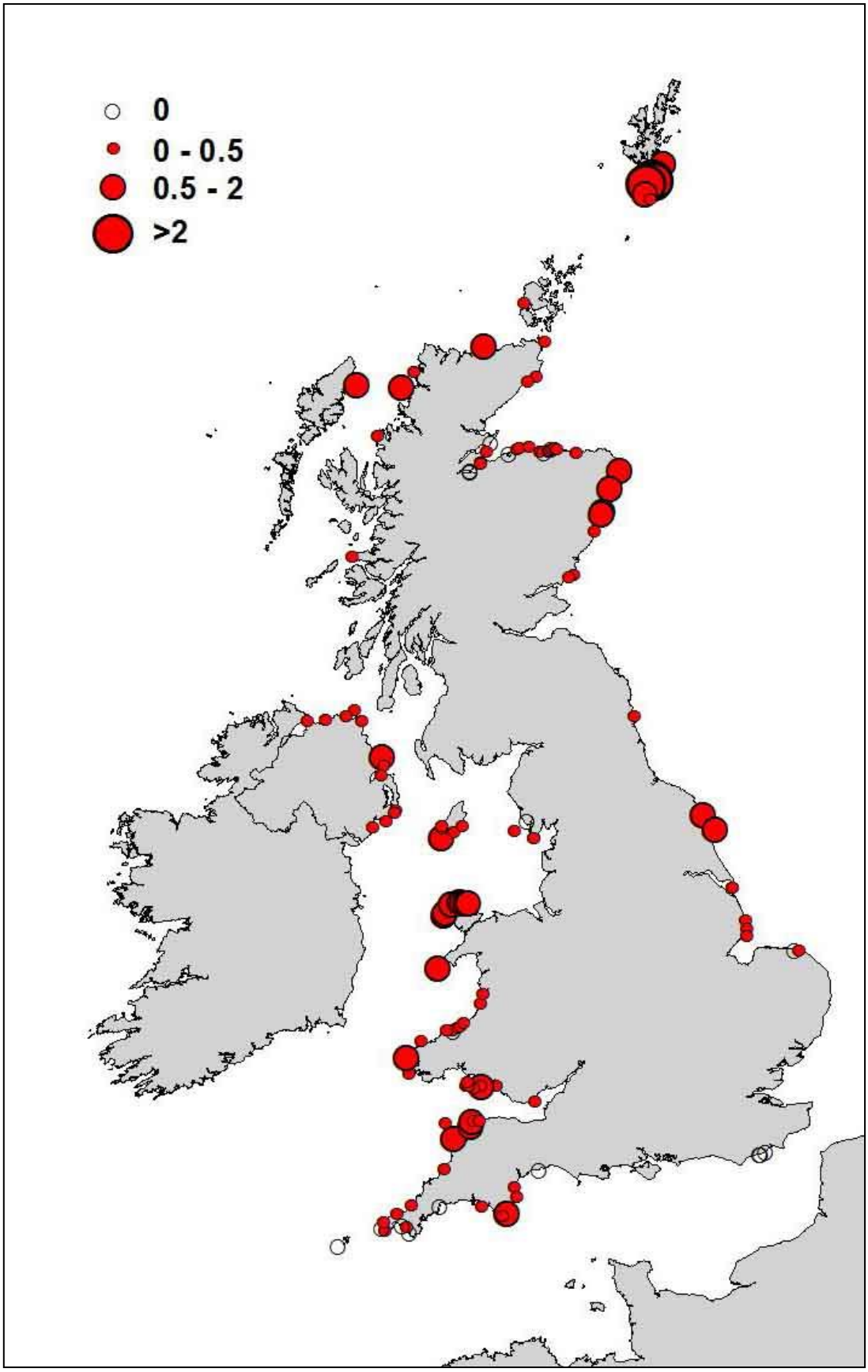


Figure A2.2 d. Map of harbour porpoise sighting rates (number of sightings per hour effort) by site (for watches with >50h total effort).

Appendix 3: Persistence tables

There are eight tables (five for bottlenose dolphin and three for harbour porpoise), arranged by Management Unit (MU). These provide full details of effort and count rates by year from 1965 to the present, for each site within that management unit. Any entry in blue indicates effort in that year without any sightings of that species. Entries in yellow indicate positive sightings and provide the count rates for that year. Count rates are expressed as numbers of animals per minute of observation. At the end of the matrix is the sum of years for which there was watch effort from 1965 onwards, and then since 2000.

Inevitably, with many sites and years, it is a very large table so is **presented in pdf form enabling one to zoom in as needed, to see the fine detail.**

Table A3. 1. List of tables provided separately for Appendix 3.

Yearly persistence for bottlenose dolphin: ECS (East Coast Scotland) management unit
Yearly persistence for bottlenose dolphin: NS (North Sea) management unit
Yearly persistence for bottlenose dolphin: CSW (Channel & Southwest England) management unit
Yearly persistence for bottlenose dolphin: IS (Irish Sea) management unit
Yearly persistence for bottlenose dolphin: WCS (West Coast Scotland) & OS (Offshore) management units
Yearly persistence for harbour porpoise: NS (North Sea) management unit
Yearly persistence for harbour porpoise: CIS (Celtic & Irish Seas) management unit
Yearly persistence for harbour porpoise: WS (West Scotland) management unit

Appendix 4: Summary of GAM and GAMM models

This appendix provides a brief narrative and details of selected model output to support the main text. All models presented are binomial General Additive Model (GAM) or Mixed Models (GAMM) (of presence-absence) based on data units of site-days. As mentioned in the main text, properties of sightings rates variables preclude their use for modelling (i.e. they do not fit standard distributions) while count data are very overdispersed (high numbers of zeroes) so that assumptions of Poisson or negative binomial models are normally not met. Quasi-Poisson models (allowing over-dispersion) may be suitable for some subsets of the data.

The models presented here are therefore binomial models, fitted with a logit link function. Significance of the explanatory variables is coded as follows:

'***' p<0.001, '**' p<0.01, '*' p<0.05, '.' P<0.1, ' ' p>≥0.1

Table A4. 1. List of models run for each time period and species combination. The symbol "6-m" indicates that models were run also for the subset of sightings recorded in the central part of the year (the months from, and including, April to September). Lat=Latitude; Long= Longitude, Site No = Site number; 2-d= 2-d smooth; and, MM = mixed model

Species/model	(1) Lat x Lon 2-d	(2) Site No	(3) Site No GAMM	(4) Site No x Year 2-d	(5) Site x Yr MM
BND 1994-2003	Yes	Yes	Yes	Yes	-
BND 2004-2014	Yes	Yes	-	Yes	-
BND 1994-2014	Yes	Yes	-	Yes	-
BND 1965-1993	Yes	Yes	-	Yes	-
HP 1994-2003	Yes	Yes	Yes	Yes	Yes
HP 2004-2014	Yes	Yes	-	Yes	-
HP 1994-2014	Yes+6-m	Yes+6-m	-	Yes + 6-m	-
HP 1965-1993	Yes	Yes	-	Yes	-

Note: many GAMMs could not be run. For the more complex GAMMs, there was either insufficient data to also estimate the random component or models do not converge. Model runs were normally discontinued after 12-18 hours if no convergence was reached.

Model fitting used backwards selection, referring to Akaike Information Criterion (AIC) values and significance of individual terms, employing an Analysis of Variance (ANOVA) to compare nested models when necessary. Only final models are presented. Validation included looking for influential data points and checking residual plots. GAMMs were based on assuming autocorrelation existed within runs of consecutive days of data and using an AR1 correlation structure. The authors have included illustrations of smoothers for some of the models

Bottlenose dolphin

Models 1.BND 1994-2003

Model 1.1 Using Latitude and Longitude 2-d smoother

There were only 4124 records in this subset. The final model has fewer terms since EffType, Seastate, Hour, Year and Yearfrac all dropped out.

```
Formula: BND_Presence ~ s(SumDuration, k = 4) + s(SiteLat, SiteLon, k = 80) +
as.factor(Area)

Parametric coefficients:
Estimate Std. Error z value Pr(>|z|)
(Intercept)      -3.691e+00  5.220e-01  -7.071 1.54e-12 ***
as.factor(Area)2  1.491e+00  2.957e-01   5.044 4.57e-07 ***
as.factor(Area)3  5.650e-01  5.644e-01   1.001    0.317
as.factor(Area)4 -1.265e+02  1.151e+07   0.000    1.000
---
Approximate significance of smooth terms:
edfRef.dfChi.sq  p-value
s(SumDuration)      2.536  2.835  66.94 4.09e-14 ***
s(SiteLat,SiteLon) 32.405 39.590 413.20  < 2e-16 ***
---
R-sq.(adj) =  0.333   Deviance explained =   37%
UBRE score = -0.49969  Scale est. = 1         n = 4124
```

Model 1.2 Substituting Latitude and longitude with Site Number

```
Formula: BND_Presence ~ s(SumDuration, k = 4) + s(Site_No, k = 20) + as.factor(Area)

Parametric coefficients:
                  Estimate Std. Error z value Pr(>|z|)
(Intercept)      -5.256e+00  3.872e+00  -1.357    0.175
as.factor(Area)2  1.916e+00  2.461e-01   7.784 7.05e-15 ***
as.factor(Area)3  1.808e+00  3.889e-01   4.649 3.33e-06 ***
as.factor(Area)4 -1.161e+02  1.151e+07   0.000    1.000
---
Approximate significance of smooth terms:
edfRef.dfChi.sq  p-value
s(SumDuration)  2.472   2.79  73.74 1.86e-15 ***
s(Site_No)     15.830  16.12 340.36  < 2e-16 ***
---
R-sq.(adj) =  0.314   Deviance explained = 35.3%
UBRE score = -0.49847  Scale est. = 1         n = 4124
```

Model 1.3 Mixed model with Site number

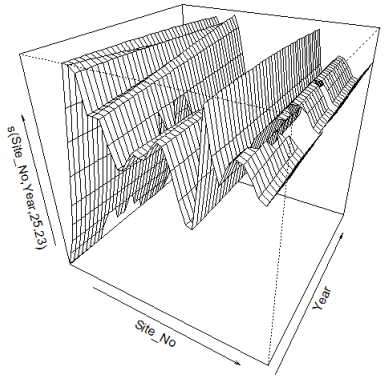
```
Linear mixed-effects model fit by maximum likelihood
Data: data
       AIC      BIC    logLik
  35896.49 35966.06 -17937.25

Random effects:
 Formula: ~Xr - 1 | g
 Structure: pdIdnot
             Xr1      Xr2
StdDev: 104.0379 104.0379

 Formula: ~Xr.0 - 1 | g.0 %in% g
 Structure: pdIdnot
          Xr.01    Xr.02    Xr.03    Xr.04    Xr.05    Xr.06    Xr.07    Xr.08
StdDev: 1942.829 1942.829 1942.829 1942.829 1942.829 1942.829 1942.829 1942.829
          Xr.09   Xr.010   Xr.011   Xr.012   Xr.013   Xr.014   Xr.015   Xr.016
StdDev: 1942.829 1942.829 1942.829 1942.829 1942.829 1942.829 1942.829 1942.829
         Xr.017   Xr.018
StdDev: 1942.829 1942.829

 Formula: ~1 | Run_ID %in% g.0 %in% g
```

```
        (Intercept)  Residual
StdDev:     3.06043 0.4012411

Correlation Structure: AR(1)
 Formula: ~1 | g/g.0/Run_ID
 Parameter estimate(s):
       Phi
-0.1333945
Variance function:
 Structure: fixed weights
 Formula: ~invwt
Fixed effects: list(fixed)
                      Value Std.Error   DF   t-value p-value
X(Intercept)         -7.0100         2 2680 -3.661395  0.0003
Xas.factor(Area)2     3.5405         0 2680  8.281269  0.0000
Xas.factor(Area)3     2.8465         1 2680  4.219980  0.0000
Xas.factor(Area)4  -968.7622   4621277 2680 -0.000210  0.9998
Xs(SumDuration)Fx1    1.0003         0 1438  4.008352  0.0001
Xs(Site_No)Fx1       33.1172        69 2680  0.476553  0.6337
 Correlation:
X(Int) X.(A)2 X.(A)3 X.(A)4 X(SD)F
Xas.factor(Area)2  -0.062
Xas.factor(Area)3   0.152  0.090
Xas.factor(Area)4   0.000  0.000  0.000
Xs(SumDuration)Fx1  0.002  0.008 -0.001  0.000
Xs(Site_No)Fx1     -0.706  0.007 -0.062  0.000 -0.001

Standardized Within-Group Residuals:
         Min           Q1          Med           Q3          Max
-9.348358216 -0.240153354 -0.107022878 -0.001679262 15.166169729

Number of Observations: 4124
Number of Groups:
g             g.0 %in% g Run_ID %in% g.0 %in% g
                    1                     1                  2685

Formula: BND_Presence ~ s(SumDuration, k = 4) + s(Site_No, k = 20) + as.factor(Area)

Parametric coefficients:
                  Estimate Std. Error t value Pr(>|t|)
(Intercept)      -7.010e+00  1.914e+00  -3.662 0.000253 ***
as.factor(Area)2  3.541e+00  4.274e-01   8.283  < 2e-16 ***
as.factor(Area)3  2.846e+00  6.744e-01   4.221 2.48e-05 ***
as.factor(Area)4 -9.688e+02  4.753e+06   0.000 0.999837
---
Approximate significance of smooth terms:
edfRef.df     F p-value
s(SumDuration)  2.847  2.847 49.38  <2e-16 ***
s(Site_No)     14.462 14.462 19.80  <2e-16 ***
---
R-sq.(adj) =   0.28  Scale est. = 0.16099   n = 4124
```

Model 1.4 Using Site Number by Year 2-d smoother

```
Formula: BND_Presence ~ s(SumDuration, k = 4) + s(Site_No, Year, k = 50) +
as.factor(Area)

Parametric coefficients:
Estimate Std. Error z value Pr(>|z|)
(Intercept)      -3.635e+00  3.250e-01 -11.186  < 2e-16 ***
as.factor(Area)2  1.507e+00  3.073e-01   4.905 9.34e-07 ***
as.factor(Area)3  1.252e+00  4.533e-01   2.762  0.00574 **
as.factor(Area)4 -1.267e+02  1.151e+07   0.000  0.99999
---
Approximate significance of smooth terms:
edfRef.dfChi.sq  p-value
s(SumDuration)   2.445   2.77  58.29 2.77e-12 ***
s(Site_No,Year) 25.230  30.20 446.37  < 2e-16 ***
---
R-sq.(adj) =   0.34   Deviance explained = 37.3%
```

```
UBRE score = -0.50709  Scale est. = 1         n = 4124
```



Models 2.BND 2004-2014

Model 2.1 Using Latitude and Longitude 2-d smoother

Use binomial and gamma=1.4.

```
Formula: BND_Presence ~ s(SumDuration, k = 4) + s(SiteLat, SiteLon, k = 85) +
s(SeaState) + as.factor(EffType) + as.factor(Area) + s(Elev, k = 4) + s(MinHour) +
s(Year) + s(Yearfrac)

Parametric coefficients:
                      Estimate Std. Error   z value Pr(>|z|)
(Intercept)         -9.396e+00  3.288e+00    -2.858  0.00426 **
as.factor(EffType)2 -7.240e-01  2.508e-01    -2.886  0.00390 **
as.factor(Area)2     8.357e-01  2.142e-01     3.901 9.57e-05 ***
as.factor(Area)3    -1.082e+00  7.786e-01    -1.389  0.16474
as.factor(Area)4    -1.480e+11  2.237e+07 -6614.426  < 2e-16 ***
---
Approximate significance of smooth terms:
edfRef.dfChi.sq  p-value
s(SumDuration)      2.888  2.989  219.12  < 2e-16 ***
s(SiteLat,SiteLon) 75.063 76.319 1451.41  < 2e-16 ***
s(SeaState)         2.133  2.706   62.18 4.80e-13 ***
s(Elev)             2.429  2.759   19.19 0.000232 ***
s(MinHour)          8.468  8.843   65.17 1.38e-10 ***
s(Year)             4.375  5.361   69.75 3.50e-13 ***
s(Yearfrac)         7.858  8.646  167.09  < 2e-16 ***
---
R-sq.(adj) =  0.423   Deviance explained = 43.3%
UBRE score = -0.48021  Scale est. = 1         n = 17567
```

Model 2.2 Substituting Latitude and longitude with Site Number

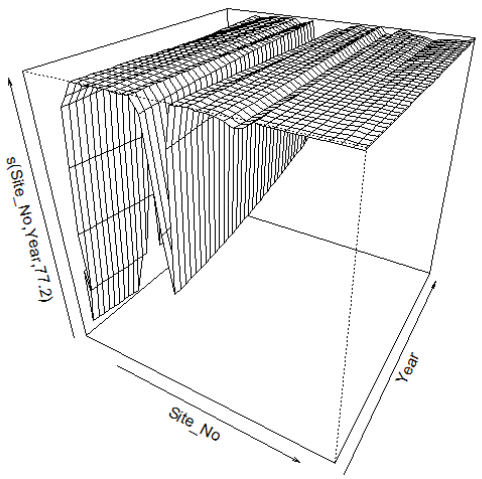
```
Formula:BND_Presence ~ s(SumDuration, k = 4) + s(Site_No, k = 45) + s(SeaState) +
as.factor(Area) + s(MinHour) + s(Year) + s(Yearfrac)

Parametric coefficients:
                    Estimate Std. Error z value Pr(>|z|)
(Intercept)      -3.857e+00  4.066e+00  -0.948    0.343
as.factor(Area)2  1.222e+00  2.000e-01   6.108 1.01e-09 ***
as.factor(Area)3  1.795e+00  2.518e-01   7.130 1.00e-12 ***
as.factor(Area)4 -1.188e+02  2.237e+07   0.000    1.000
---
Approximate significance of smooth terms:
edfRef.dfChi.sq  p-value
s(SumDuration)  2.896  2.991  242.68  < 2e-16 ***
s(Site_No)     39.720 40.645 1694.90  < 2e-16 ***
s(SeaState)     2.259  2.860   74.12 1.23e-15 ***
```

```
s(MinHour)       6.956  7.867   95.46  < 2e-16 ***
s(Year)          4.151  5.102   79.42 1.66e-15 ***
s(Yearfrac)      7.885  8.661  168.71  < 2e-16 ***
---
R-sq.(adj) =  0.406   Deviance explained = 41.6%
UBRE score = -0.47186  Scale est. = 1         n = 17567
```

Model 2.4 Using Site Number x Year 2-d smoother

```
Family: binomial
Link function: logit

Formula:
BND_Presence ~ s(SumDuration, k = 4) + s(SiteLat, SiteLon, k = 80) +
    s(SeaState) + as.factor(EffType) + as.factor(Area) + s(MinHour) +
    s(Year, k = 15) + s(Yearfrac) + s(Elev, k = 4)

Parametric coefficients:
                      Estimate Std. Error z value Pr(>|z|)
(Intercept)         -9.083e+00  5.577e+00  -1.629   0.1034
as.factor(EffType)2 -4.952e-01  1.961e-01  -2.526   0.0115 *
as.factor(Area)2     6.221e-01  1.513e-01   4.113 3.91e-05 ***
as.factor(Area)3    -4.931e-01  4.406e-01  -1.119   0.2631
as.factor(Area)4    -1.061e+02  1.023e+07   0.000   1.0000
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Approximate significance of smooth terms:
                     edf Ref.df  Chi.sq  p-value
s(SumDuration)     2.920  2.995  355.54  < 2e-16 ***
s(SiteLat,SiteLon) 75.305 76.579 1792.22  < 2e-16 ***
s(SeaState)        1.945  2.464   51.62 5.09e-11 ***
s(MinHour)         7.601  8.398   58.34 1.91e-09 ***
s(Year)           11.680 13.012   97.95 4.23e-15 ***
s(Yearfrac)        7.359  8.328  147.68  < 2e-16 ***
s(Elev)            1.002  1.005   19.84 8.62e-06 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

R-sq.(adj) =  0.398   Deviance explained = 41.2%
UBRE score = -0.47853  Scale est. = 1         n = 21691
```

‘Smoother’ for year by site interaction:



Models 3. BND 1994-2014

Model 3.1 Using Latitude and Longitude 2-d smoother

```
Formula: BND_Presence ~ s(SumDuration, k = 4) + s(SiteLat, SiteLon, k = 80) +
s(SeaState) + as.factor(EffType) + as.factor(Area) + s(MinHour) + s(Year, k = 15) +
s(Yearfrac) + s(Elev, k = 4)

Parametric coefficients:
                     Estimate Std. Error z value Pr(>|z|)
(Intercept)         -9.083e+00  5.577e+00  -1.629   0.1034
as.factor(EffType)2 -4.952e-01  1.961e-01  -2.526   0.0115 *
as.factor(Area)2     6.221e-01  1.513e-01   4.113 3.91e-05 ***
as.factor(Area)3    -4.931e-01  4.406e-01  -1.119   0.2631
as.factor(Area)4    -1.061e+02  1.023e+07   0.000   1.0000
---
Approximate significance of smooth terms:
edfRef.dfChi.sq  p-value
s(SumDuration)      2.920  2.995  355.54  < 2e-16 ***
s(SiteLat,SiteLon) 75.305 76.579 1792.22  < 2e-16 ***
s(SeaState)         1.945  2.464   51.62 5.09e-11 ***
s(MinHour)          7.601  8.398   58.34 1.91e-09 ***
s(Year)            11.680 13.012   97.95 4.23e-15 ***
s(Yearfrac)         7.359  8.328  147.68  < 2e-16 ***
s(Elev)             1.002  1.005   19.84 8.62e-06 ***
---
R-sq.(adj) =  0.398   Deviance explained = 41.2%
UBRE score = -0.47853  Scale est. = 1         n = 21691
```

Model 3.2 Substituting Latitude and longitude with Site Number

The final model excludes Optics and Effort type.

```
Formula: BND_Presence ~ s(SumDuration, k = 4) + s(Site_No, k = 40) + s(SeaState) +
as.factor(Area) + s(MinHour) + s(Year, k = 15) + s(Elev, k = 4) + s(Yearfrac)

Parametric coefficients:
Estimate Std. Error z value Pr(>|z|)
(Intercept)      -3.769e+00  7.552e-01  -4.991 6.00e-07 ***
as.factor(Area)2  9.752e-01  1.433e-01   6.807 9.97e-12 ***
as.factor(Area)3  1.579e+00  2.086e-01   7.568 3.78e-14 ***
as.factor(Area)4 -1.228e+02  1.023e+07   0.000        1
---
Approximate significance of smooth terms:
edfRef.dfChi.sq  p-value
s(SumDuration)  2.973  2.998  388.41  < 2e-16 ***
s(Site_No)     32.964 34.553 1948.95  < 2e-16 ***
s(SeaState)     2.124  2.685   65.57 9.99e-14 ***
s(MinHour)      7.475  8.306   94.13  < 2e-16 ***
s(Year)        10.680 12.212  102.64 2.63e-16 ***
s(Elev)         2.712  2.934   12.14  0.00665 **
s(Yearfrac)     7.478  8.411  136.45  < 2e-16 ***
---
R-sq.(adj) =  0.383   Deviance explained = 39.5%
UBRE score = -0.46929  Scale est. = 1         n = 21691
```

Model 3.4 Using Site Number x Year 2-d smoother

```
Formula: BND_Presence ~ s(SumDuration, k = 4) + s(Site_No, Year, k = 60) + s(SeaState) +
as.factor(Area) + s(MinHour) + s(Yearfrac)

Parametric coefficients:
                   Estimate Std. Error z value Pr(>|z|)
(Intercept)      -4.558e+00  9.761e-01  -4.670 3.02e-06 ***
as.factor(Area)2  6.932e-01  1.562e-01   4.437 9.14e-06 ***
as.factor(Area)3  1.823e+00  2.180e-01   8.362  < 2e-16 ***
as.factor(Area)4 -1.135e+02  1.023e+07   0.000        1
---
Approximate significance of smooth terms:
edfRef.dfChi.sq  p-value
s(SumDuration)   2.961  2.998  315.25  < 2e-16 ***
s(Site_No,Year) 56.107 56.974 2028.41  < 2e-16 ***
s(SeaState)      2.337  2.949   68.01 1.53e-14 ***
```

```
s(MinHour)       6.036  7.123   84.13 2.84e-15 ***
s(Yearfrac)      7.545  8.456  146.37  < 2e-16 ***
---
R-sq.(adj) =   0.39   Deviance explained = 40.2%
UBRE score = -0.47432  Scale est. = 1         n = 21691
```

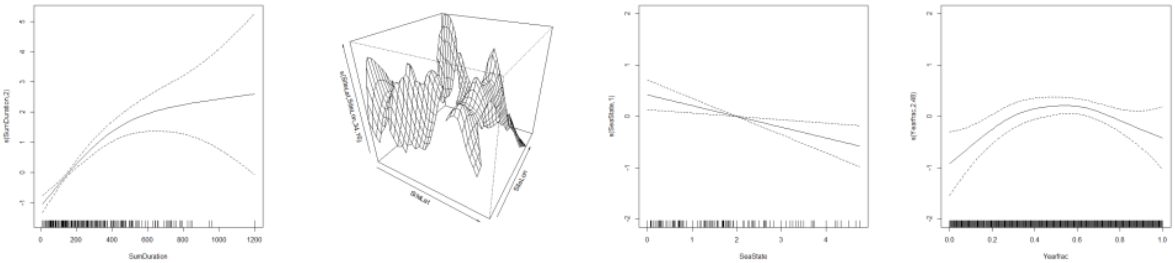
Models 4. BND 1967-1993

There are only 2853 records here; the final models have fewer terms since many variables ended up been dropped.

Model 4.1 Using Latitude and Longitude 2-d smoother

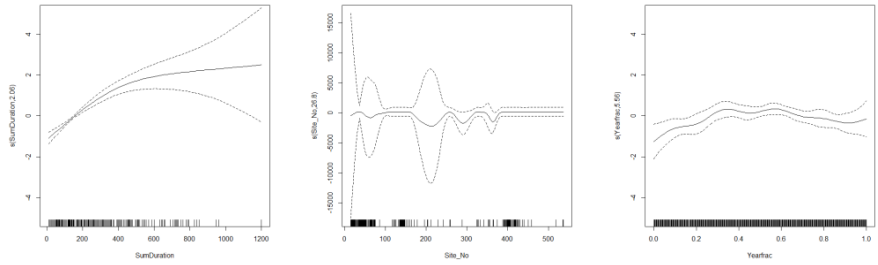
```
Formula: BND_Presence ~ s(SumDuration, k = 4) + s(SiteLat, SiteLon, k = 80) + s(SeaState) +
s(Yearfrac)

Parametric coefficients:
            Estimate Std. Error z value Pr(>|z|)
(Intercept)   -5.107      4.745  -1.076    0.282

Approximate significance of smooth terms:
                      edf Ref.df  Chi.sq  p-value
s(SumDuration)      2.003  2.398  72.518 2.49e-15 ***
s(SiteLat,SiteLon) 34.156 40.244 275.073  < 2e-16 ***
s(SeaState)         1.000  1.001   8.398  0.00376 **
s(Yearfrac)         2.475  3.098  12.361  0.00700 **
---
R-sq.(adj) =  0.568   Deviance explained = 56.4%
UBRE score = -0.57983  Scale est. = 1         n = 2853
```

Smoothers: It can be seen that bottlenose dolphins presence increased for longer observation periods. Sea state had a negative effect on sightings and more sightings took place in middle of the year



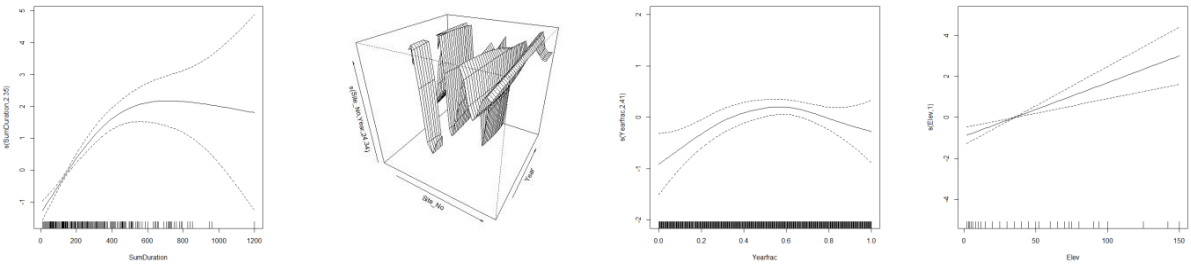
Model 4.2 Substituting Latitude and longitude with Site Number

```
Formula: BND_Presence ~ s(SumDuration, k = 4) + s(Site_No, k = 40) + s(Yearfrac)

Parametric coefficients:
            Estimate Std. Error z value Pr(>|z|)
(Intercept)   -187.0      365.4  -0.512    0.609

Approximate significance of smooth terms:
                  edf Ref.df Chi.sq  p-value
s(SumDuration)  2.059  2.453  74.65 1.12e-15 ***
s(Site_No)     26.801 27.369 101.15 2.29e-10 ***
s(Yearfrac)     5.557  6.172  16.97   0.0107 *
---
R-sq.(adj) =  0.555   Deviance explained = 55.3%
UBRE score = -0.57535  Scale est. = 1         n = 2853

Smoothers:
```



Model 4.4 Using Site Number x Year 2-d smoother

```
Formula: BND_Presence ~ s(SumDuration, k = 4) + s(Site_No, Year, k = 40) + s(Yearfrac) +
s(Elev, k = 4)

Parametric coefficients:
            Estimate Std. Error z value Pr(>|z|)
(Intercept)   -5.942      6.825  -0.871    0.384

Approximate significance of smooth terms:
                   edf Ref.df Chi.sq  p-value
s(SumDuration)   2.354  2.714  99.13  < 2e-16 ***
s(Site_No,Year) 24.340 26.729 129.78 1.94e-15 ***
s(Yearfrac)      2.412  3.024  12.74  0.00539 **
s(Elev)          1.004  1.007  18.37 1.88e-05 ***
---
R-sq.(adj) =  0.542   Deviance explained = 54.8%
UBRE score = -0.57461  Scale est. = 1         n = 2853

Smoothers:
```



Harbour porpoise

Models 5.HP 1994-2003

For this subset of the data, there are 4124 records.

Model 5.1 Using Latitude and Longitude 2-d smoother

```
Formula: HP_Presence ~ s(SumDuration, k = 4) + s(SiteLat, SiteLon, k = 80) + s(SeaState)
+ as.factor(Area) + s(Year) + s(Elev)

Parametric coefficients:
                Estimate Std. Error z value Pr(>|z|)
(Intercept)      -1.60575    0.09417 -17.051   <2e-16 ***
as.factor(Area)2 -0.31596    0.27044  -1.168   0.2427
as.factor(Area)3  0.13050    0.35291   0.370   0.7116
as.factor(Area)4  0.98964    0.52859   1.872   0.0612 .
---
Approximate significance of smooth terms:
                     edf Ref.df  Chi.sq  p-value
s(SumDuration)     2.698  2.929  98.467  < 2e-16 ***
s(SiteLat,SiteLon) 52.621 62.825 942.526  < 2e-16 ***
s(SeaState)         3.012  3.686  89.251  < 2e-16 ***
s(Year)             7.417  8.369  31.052 0.000194 ***
s(Elev)             2.482  3.079   7.967 0.049759 *
---
R-sq.(adj) =  0.497   Deviance explained =   46%
UBRE score = -0.28217  Scale est. = 1         n = 4124
```

Model 5.2 Substituting Latitude and longitude with Site Number

```
Formula: HP_Presence ~ s(SumDuration, k = 4) + s(Site_No, k = 40) + s(SeaState) +
as.factor(Area) + s(Year) + s(Elev)

Parametric coefficients:
                Estimate Std. Error z value Pr(>|z|)
(Intercept)      -1.58272    0.08058 -19.643   <2e-16 ***
as.factor(Area)2 -0.43417    0.24453  -1.776   0.0758 .
as.factor(Area)3  0.61188    0.26132   2.341   0.0192 *
as.factor(Area)4  0.36884    0.46741   0.789   0.4300
---
Approximate significance of smooth terms:
                  edf Ref.df  Chi.sq  p-value
s(SumDuration)  2.765  2.955  81.211  < 2e-16 ***
s(Site_No)     30.112 34.012 903.046  < 2e-16 ***
s(SeaState)     3.188  3.876  90.924  < 2e-16 ***
s(Year)         7.356  8.328  33.508 6.96e-05 ***
s(Elev)         2.233  2.807   6.305   0.0849 .
---
R-sq.(adj) =  0.465   Deviance explained = 42.9%
UBRE score = -0.25954  Scale est. = 1         n = 4124
```

Model 5.3 Mixed model with Site number

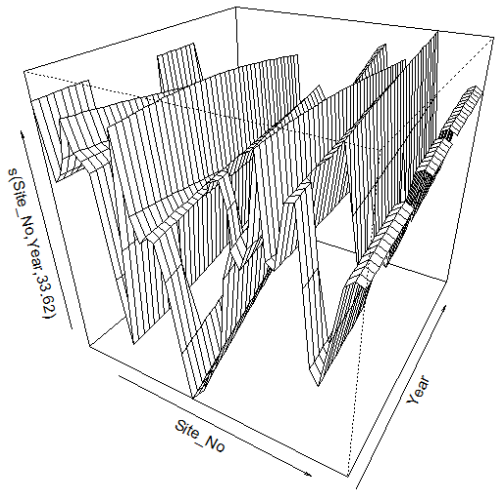
```
Linear mixed-effects model fit by maximum likelihood
 Data: data
       AIC      BIC    logLik
  25188.91 25296.43 -12577.46

Random effects:
 Formula: ~Xr - 1 | g
 Structure: pdIdnot
             Xr1      Xr2
StdDev: 94.63016 94.63016

 Formula: ~Xr.0 - 1 | g.0 %in% g
 Structure: pdIdnot
          Xr.01    Xr.02    Xr.03    Xr.04    Xr.05    Xr.06    Xr.07    Xr.08    Xr.09   Xr.010
StdDev: 945.8643 945.8643 945.8643 945.8643 945.8643 945.8643 945.8643 945.8643 945.8643 945.8643
         Xr.011   Xr.012   Xr.013   Xr.014   Xr.015   Xr.016   Xr.017   Xr.018   Xr.019   Xr.020
StdDev: 945.8643 945.8643 945.8643 945.8643 945.8643 945.8643 945.8643 945.8643 945.8643 945.8643
         Xr.021   Xr.022   Xr.023   Xr.024   Xr.025   Xr.026   Xr.027   Xr.028   Xr.029   Xr.030
StdDev: 945.8643 945.8643 945.8643 945.8643 945.8643 945.8643 945.8643 945.8643 945.8643 945.8643
```

```
         Xr.031   Xr.032   Xr.033   Xr.034   Xr.035   Xr.036   Xr.037   Xr.038
StdDev: 945.8643 945.8643 945.8643 945.8643 945.8643 945.8643 945.8643 945.8643

 Formula: ~Xr.1 - 1 | g.1 %in% g.0 %in% g
 Structure: pdIdnot
           Xr.11    Xr.12    Xr.13    Xr.14    Xr.15    Xr.16    Xr.17    Xr.18
StdDev: 29.52051 29.52051 29.52051 29.52051 29.52051 29.52051 29.52051 29.52051

 Formula: ~Xr.2 - 1 | g.2 %in% g.1 %in% g.0 %in% g
 Structure: pdIdnot
            Xr.21       Xr.22       Xr.23       Xr.24       Xr.25       Xr.26       Xr.27       Xr.28
StdDev: 0.004169874 0.004169874 0.004169874 0.004169874 0.004169874 0.004169874 0.004169874 0.004169874

 Formula: ~Xr.3 - 1 | g.3 %in% g.2 %in% g.1 %in% g.0 %in% g
 Structure: pdIdnot
           Xr.31    Xr.32    Xr.33    Xr.34    Xr.35    Xr.36    Xr.37    Xr.38
StdDev: 6.856426 6.856426 6.856426 6.856426 6.856426 6.856426 6.856426 6.856426

 Formula: ~1 | Run_ID %in% g.3 %in% g.2 %in% g.1 %in% g.0 %in% g
        (Intercept)  Residual
StdDev:    2.762834 0.5018015

Correlation Structure: AR(1)
 Formula: ~1 | g/g.0/g.1/g.2/g.3/Run_ID
 Parameter estimate(s):
        Phi
-0.01410303
Variance function:
 Structure: fixed weights
 Formula: ~invwt
Fixed effects: list(fixed)
                       Value Std.Error   DF    t-value p-value
X(Intercept)        -2.19156  0.117513 2679 -18.649425  0.0000
Xas.factor(Area)2   -0.77218  0.374709 2679  -2.060738  0.0394
Xas.factor(Area)3    0.91036  0.403762 2679   2.254705  0.0242
Xas.factor(Area)4    0.56793  0.718308 2679   0.790652  0.4292
Xs(SumDuration)Fx1   1.46161  0.227872 1436   6.414192  0.0000
Xs(Site_No)Fx1     -38.98899 19.135783 2679  -2.037491  0.0417
Xs(SeaState)Fx1     -0.03723  0.553404 1436  -0.067273  0.9464
Xs(Year)Fx1          0.40536  0.133485 1436   3.036726  0.0024
Xs(Elev)Fx1         -0.26062  0.198014 2679  -1.316192  0.1882
 Correlation:
                    X(Int) X.(A)2 X.(A)3 X.(A)4 X(SD)F X(S_N) X(SS)F X(Y)F1
Xas.factor(Area)2   -0.350
Xas.factor(Area)3   -0.393  0.388
Xas.factor(Area)4   -0.177  0.205  0.242
Xs(SumDuration)Fx1 -0.041 -0.013 -0.012  0.003
Xs(Site_No)Fx1     -0.024  0.076 -0.003 -0.006  0.005
Xs(SeaState)Fx1     0.007  0.000 -0.009 -0.007 -0.027  0.001
Xs(Year)Fx1        -0.067 -0.014  0.010  0.004  0.030 -0.041 -0.008
Xs(Elev)Fx1        -0.072  0.098  0.108  0.034 -0.007  0.012 -0.001 -0.057

Standardized Within-Group Residuals:
       Min         Q1        Med         Q3        Max
-9.7328755 -0.3010201 -0.1050134  0.3154913  8.0013506

Number of Observations: 4124
Number of Groups:
                                                 g                                      g.0 %in% g
                                                 1                                                1
                                g.1 %in% g.0 %in% g                  g.2 %in% g.1 %in% g.0 %in% g
                                                 1                                                1
       g.3 %in% g.2 %in% g.1 %in% g.0 %in% g Run_ID %in% g.3 %in% g.2 %in% g.1 %in% g.0 %in% g
                                                 1                                             2685


Formula: HP_Presence ~ s(SumDuration, k = 4) + s(Site_No, k = 40) + s(SeaState) +
as.factor(Area) + s(Year) + s(Elev)

Parametric coefficients:
                  Estimate Std. Error t value Pr(>|t|)
(Intercept)        -2.1916     0.1174 -18.661   <2e-16 ***
as.factor(Area)2   -0.7722     0.3745  -2.062   0.0393 *
as.factor(Area)3    0.9104     0.4035   2.256   0.0241 *
as.factor(Area)4    0.5679     0.7179   0.791   0.4289
---
Approximate significance of smooth terms:
```

```
                  edf Ref.df      F p-value
s(SumDuration)  2.862  2.862 82.518 < 2e-16 ***
s(Site_No)     28.243 28.243 27.832 < 2e-16 ***
s(SeaState)     4.724  4.724 37.113 < 2e-16 ***
s(Year)         1.000  1.000  9.233 0.00239 **
s(Elev)         1.637  1.637  3.370 0.04449 *
---
R-sq.(adj) =  0.438  Scale est. = 0.2518    n = 4124
```

Model 5.4 Using Site Number x Longitude 2-d smoother

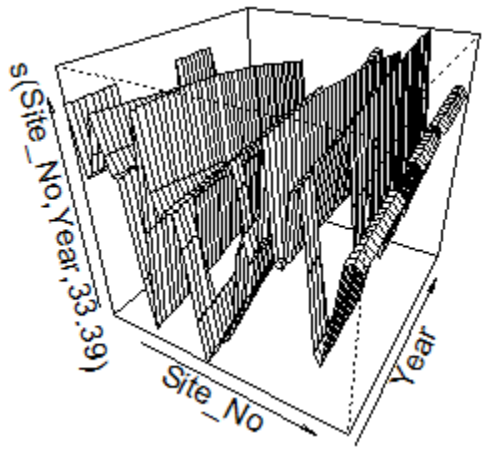
```
Formula: HP_Presence ~ s(SumDuration, k = 4) + s(Site_No, Year, k = 40) + s(SeaState) +
as.factor(Area)

Parametric coefficients:
                Estimate Std. Error z value Pr(>|z|)
(Intercept)      -1.65252    0.09012 -18.337   <2e-16 ***
as.factor(Area)2 -0.48774    0.23608  -2.066   0.0388 *
as.factor(Area)3  0.47296    0.24314   1.945   0.0517 .
as.factor(Area)4  0.31776    0.43623   0.728   0.4664
---
Approximate significance of smooth terms:
                   edf Ref.df Chi.sq p-value
s(SumDuration)   2.826  2.976  92.35  <2e-16 ***
s(Site_No,Year) 33.967 37.386 929.04  <2e-16 ***
s(SeaState)      3.406  4.109  94.73  <2e-16 ***
---
R-sq.(adj) =  0.466   Deviance explained =   43%
UBRE score = -0.26443  Scale est. = 1         n = 4124
```



Model 5.5 Mixed model with Site Number x Longitude 2-d smoother

```
Linear mixed-effects model fit by maximum likelihood
 Data: data
      AIC      BIC   logLik
  25787.8 25876.34 -12879.9

Random effects:
 Formula: ~Xr - 1 | g
 Structure: pdIdnot
             Xr1      Xr2
StdDev: 97.58165 97.58165

 Formula: ~Xr.0 - 1 | g.0 %in% g
 Structure: pdIdnot
          Xr.01    Xr.02    Xr.03    Xr.04    Xr.05    Xr.06    Xr.07    Xr.08    Xr.09   Xr.010
StdDev: 461.9909 461.9909 461.9909 461.9909 461.9909 461.9909 461.9909 461.9909 461.9909 461.9909
          Xr.011   Xr.012   Xr.013   Xr.014   Xr.015   Xr.016   Xr.017   Xr.018   Xr.019   Xr.020
StdDev: 461.9909 461.9909 461.9909 461.9909 461.9909 461.9909 461.9909 461.9909 461.9909 461.9909
          Xr.021   Xr.022   Xr.023   Xr.024   Xr.025   Xr.026   Xr.027   Xr.028   Xr.029   Xr.030
```

```
StdDev: 461.9909 461.9909 461.9909 461.9909 461.9909 461.9909 461.9909 461.9909 461.9909 461.9909
         Xr.031   Xr.032   Xr.033   Xr.034   Xr.035   Xr.036   Xr.037
StdDev: 461.9909 461.9909 461.9909 461.9909 461.9909 461.9909 461.9909

 Formula: ~Xr.1 - 1 | g.1 %in% g.0 %in% g
 Structure: pdIdnot
           Xr.11    Xr.12    Xr.13    Xr.14    Xr.15    Xr.16    Xr.17    Xr.18
StdDev: 32.27377 32.27377 32.27377 32.27377 32.27377 32.27377 32.27377 32.27377

 Formula: ~1 | Run_ID %in% g.1 %in% g.0 %in% g
        (Intercept)  Residual
StdDev:    2.767639 0.4996185

Correlation Structure: AR(1)
 Formula: ~1 | g/g.0/g.1/Run_ID
 Parameter estimate(s):
        Phi
-0.01827909
Variance function:
 Structure: fixed weights
 Formula: ~invwt
Fixed effects: list(fixed)
                         Value Std.Error   DF    t-value p-value
X(Intercept)        -2.3600409 0.1300543 2681 -18.146586  0.0000
Xas.factor(Area)2   -0.5630270 0.3781362 2681  -1.488953  0.1366
Xas.factor(Area)3    0.9650515 0.3904668 2681   2.471533  0.0135
Xas.factor(Area)4    0.6420176 0.6948823 2681   0.923923  0.3556
Xs(SumDuration)Fx1   1.4952684 0.2295833 1435   6.512967  0.0000
Xs(Site_No,Year)Fx1 -2.7898959 1.7111669 1435  -1.630405  0.1032
Xs(Site_No,Year)Fx2  0.5405672 0.1694335 1435   3.190439  0.0015
Xs(SeaState)Fx1      0.0113335 0.5883250 1435   0.019264  0.9846
 Correlation:
                    X(Int) X.(A)2 X.(A)3 X.(A)4 X(SD)F X(S_N,Y)F1 X(S_N,Y)F2
Xas.factor(Area)2   -0.303
Xas.factor(Area)3   -0.328  0.375
Xas.factor(Area)4   -0.152  0.203  0.217
Xs(SumDuration)Fx1  -0.048 -0.003 -0.004  0.006
Xs(Site_No,Year)Fx1 -0.021  0.124  0.020  0.014 -0.001
Xs(Site_No,Year)Fx2 -0.185  0.023  0.030  0.020  0.039 -0.163
Xs(SeaState)Fx1      0.008 -0.002 -0.011 -0.008 -0.027  0.000     -0.006

Standardized Within-Group Residuals:
        Min          Q1         Med          Q3         Max
-9.70791048 -0.30514428 -0.08723731  0.30527125  8.47764256

Number of Observations: 4124
Number of Groups:
                          g                   g.0 %in% g            g.1 %in% g.0 %in% g
                          1                           1                              1
Run_ID %in% g.1 %in% g.0 %in% g
                       2685

Formula: HP_Presence ~ s(SumDuration, k = 4) + s(Site_No, Year, k = 40) + s(SeaState) +
as.factor(Area)

Parametric coefficients:
                Estimate Std. Error t value Pr(>|t|)
(Intercept)       -2.3600     0.1300 -18.155   <2e-16 ***
as.factor(Area)2  -0.5630     0.3780  -1.490   0.1364
as.factor(Area)3   0.9651     0.3903   2.473   0.0134 *
as.factor(Area)4   0.6420     0.6945   0.924   0.3553
---
Approximate significance of smooth terms:
                   edf Ref.df     F p-value
s(SumDuration)   2.868  2.868 85.39  <2e-16 ***
s(Site_No,Year) 33.388 33.388 23.26  <2e-16 ***
s(SeaState)      4.882  4.882 35.76  <2e-16 ***
---
R-sq.(adj) =  0.445  Scale est. = 0.24962   n = 4124
```

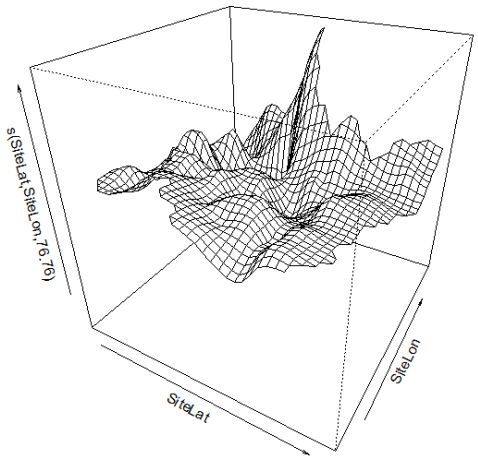


Models 7.HP 1994-2014

The models for these time period were run also for the central part of the year, i.e. months of April to September. Results are presented for both sets of models.

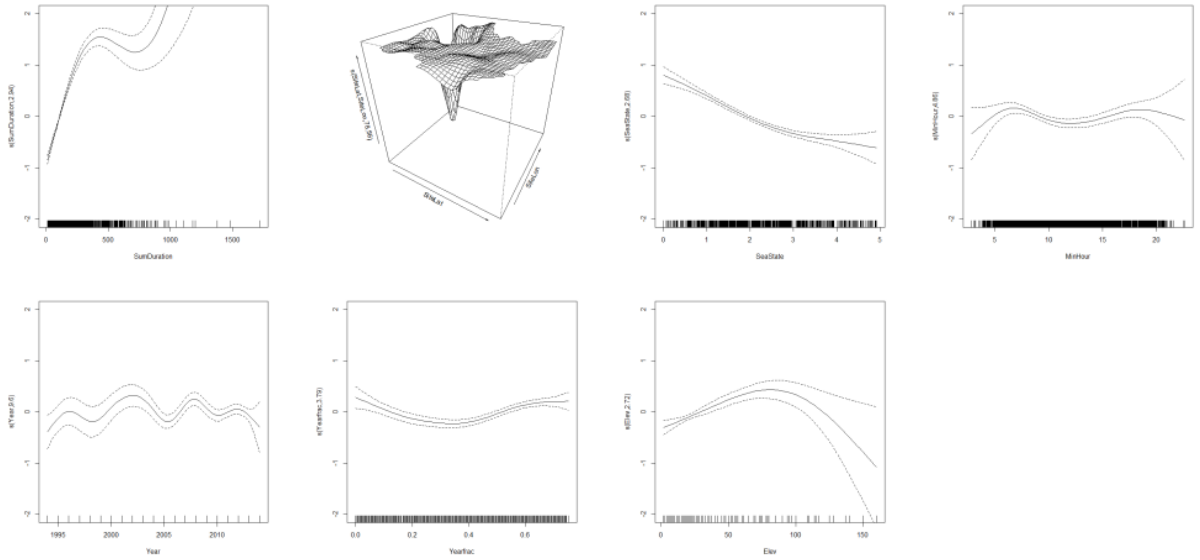
Model 7.1a Using Latitude and Longitude 2-d smoother for all months

```
Formula: HP_Presence ~ s(SumDuration, k = 4) + s(SiteLat, SiteLon, k = 80) + s(SeaState)
+ as.factor(EffType) + as.factor(Area) + s(MinHour) + s(Year, k = 15) + s(Yearfrac) +
s(Elev, k = 4) + as.factor(Optics)

Parametric coefficients:
                    Estimate Std. Error z value Pr(>|z|)
(Intercept)         -1.68327    0.05051 -33.327  < 2e-16 ***
as.factor(EffType)2 -0.61966    0.16767  -3.696 0.000219 ***
as.factor(Area)2    -0.43585    0.14122  -3.086 0.002027 **
as.factor(Area)3     0.20866    0.18482   1.129 0.258887
as.factor(Area)4     0.89690    0.40786   2.199 0.027876 *
as.factor(Optics)2  -1.22296    0.26148  -4.677 2.91e-06 ***
---
Approximate significance of smooth terms:
                       edf Ref.df  Chi.sq  p-value
s(SumDuration)       2.632  2.729  524.82  < 2e-16 ***
s(SiteLat,SiteLon) 76.761 77.562 3276.79  < 2e-16 ***
s(SeaState)          5.438  5.942  279.04  < 2e-16 ***
s(MinHour)           5.932  6.987   32.89 2.77e-05 ***
s(Year)              9.683 10.932   72.05 5.03e-11 ***
s(Yearfrac)          5.005  6.026   71.63 2.05e-13 ***
s(Elev)              2.775  2.961   25.18 1.45e-05 ***
---
R-sq.(adj) =  0.356   Deviance explained = 34.1%
UBRE score = -0.22846  Scale est. = 1         n = 21691
```



Model 7.1b Using Latitude and Longitude 2-d smoother for April-September

```
Formula: HP_Presence ~ s(SumDuration, k = 4) + s(SiteLat, SiteLon, k = 80) +
s(SeaState) + as.factor(EffType) + as.factor(Area) + s(MinHour) + s(Year, k = 15) +
s(Yearfrac) + s(Elev, k = 4) + as.factor(Optics)

Parametric coefficients:
                    Estimate Std. Error z value Pr(>|z|)
(Intercept)         -1.97839    0.08693 -22.759  < 2e-16 ***
as.factor(EffType)2 -0.77135    0.18241  -4.229 2.35e-05 ***
as.factor(Area)2    -0.29950    0.15211  -1.969  0.04896 *
as.factor(Area)3     0.45175    0.20138   2.243  0.02488 *
as.factor(Area)4     0.88811    0.40638   2.185  0.02886 *
as.factor(Optics)2  -1.12116    0.30937  -3.624  0.00029 ***
---
Approximate significance of smooth terms:
                       edf Ref.df  Chi.sq  p-value
s(SumDuration)       2.935  2.996  438.22  < 2e-16 ***
s(SiteLat,SiteLon) 78.562 78.882 2751.94  < 2e-16 ***
s(SeaState)          2.685  3.359  230.00  < 2e-16 ***
s(MinHour)           4.857  5.958   19.74  0.00302 **
s(Year)              9.600 11.274   42.36 1.81e-05 ***
s(Yearfrac)          3.789  4.702   55.49 1.24e-10 ***
s(Elev)              2.725  2.942   32.70 4.03e-07 ***
---
R-sq.(adj) =  0.353   Deviance explained =   34%
UBRE score = -0.23003  Scale est. = 1         n = 18156

Smoothers:
```

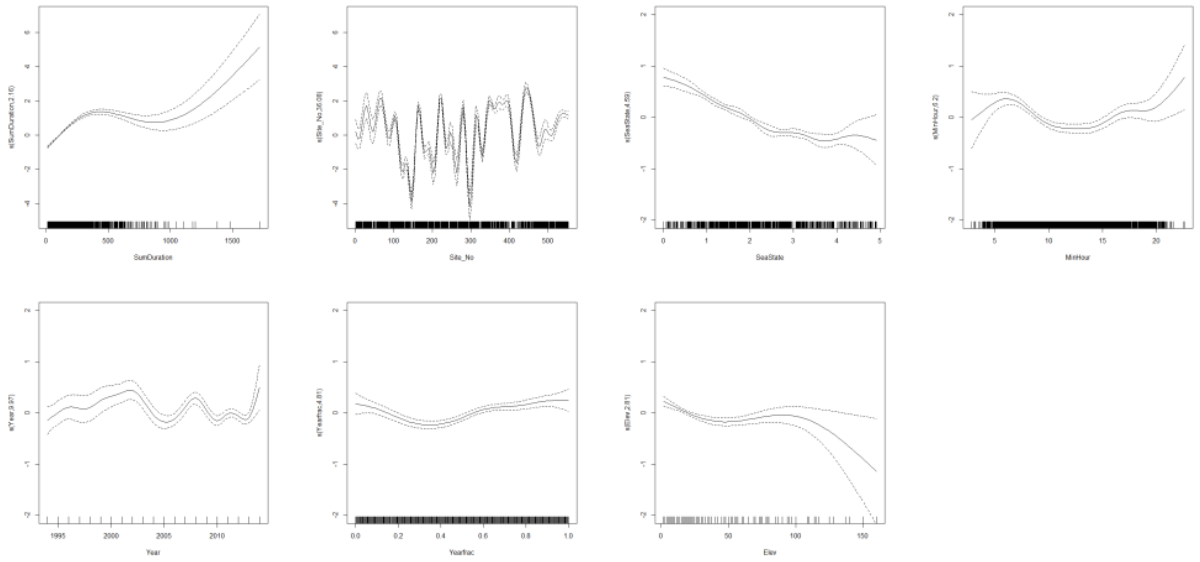


Model 7.2a Substituting Latitude and longitude with Site Number for all months

```
Formula: HP_Presence ~ s(SumDuration, k = 4) + s(Site_No, k = 40) + s(SeaState) +
as.factor(EffType) + as.factor(Area) + s(MinHour) + s(Year, k = 15) + s(Yearfrac) +
s(Elev, k = 4) + as.factor(Optics)

Parametric coefficients:
                    Estimate Std. Error z value Pr(>|z|)
(Intercept)         -1.61372    0.03678 -43.878  < 2e-16 ***
as.factor(EffType)2 -0.97643    0.13118  -7.444 9.79e-14 ***
as.factor(Area)2    -0.66898    0.12427  -5.383 7.32e-08 ***
as.factor(Area)3     0.43805    0.15008   2.919  0.00352 **
as.factor(Area)4     0.55312    0.37914   1.459  0.14460
as.factor(Optics)2  -0.73312    0.12280  -5.970 2.38e-09 ***
---
Approximate significance of smooth terms:
                  edf Ref.df  Chi.sq  p-value
```

```
s(SumDuration)  2.160  2.274  465.94  < 2e-16 ***
s(Site_No)     36.084 36.705 3060.76  < 2e-16 ***
s(SeaState)     4.590  4.998  274.49  < 2e-16 ***
s(MinHour)      6.198  7.155   67.65 6.39e-12 ***
s(Year)         9.974 11.430   65.32 1.68e-09 ***
s(Yearfrac)     4.805  5.827   61.60 2.46e-11 ***
s(Elev)         2.807  2.970   24.66 1.85e-05 ***
---
R-sq.(adj) =  0.328   Deviance explained =   31%
UBRE score = -0.19688  Scale est. = 1         n = 21691
```

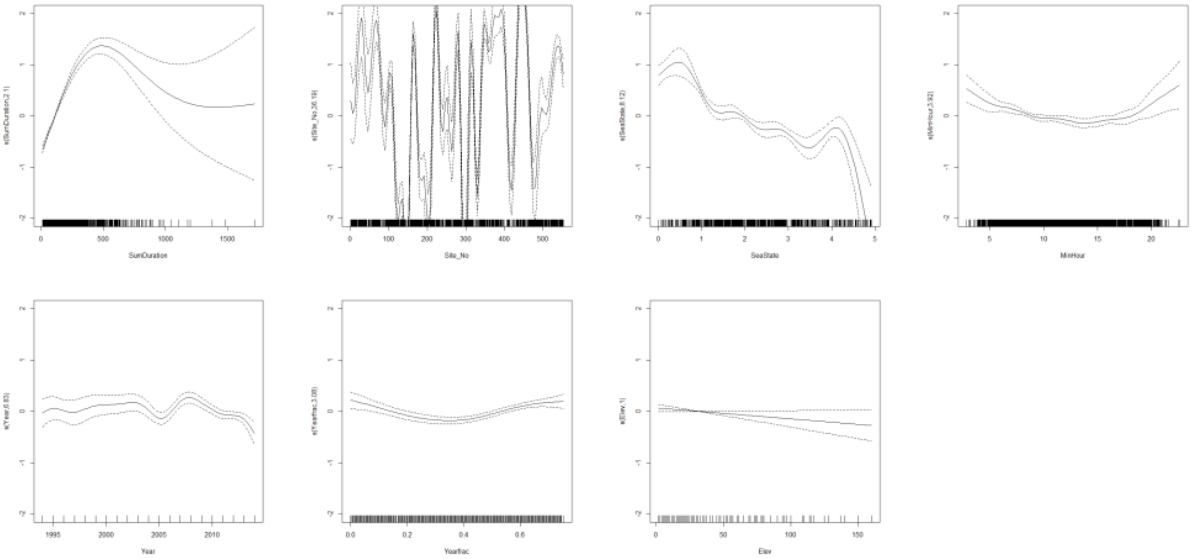
Smoothers:



Model 7.2b Substituting Latitude and longitude with Site Number for April-September

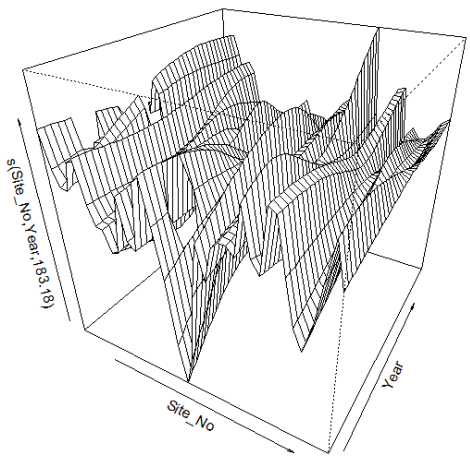
```
Formula: HP_Presence ~ s(SumDuration, k = 4) + s(Site_No, k = 40) + s(SeaState) +
as.factor(EffType) + as.factor(Area) + s(MinHour) + s(Year, k = 15) + s(Yearfrac) +
s(Elev, k = 4) + as.factor(Optics)

Parametric coefficients:
                   Estimate Std. Error z value Pr(>|z|)
(Intercept)         -1.55128    0.03809 -40.728  < 2e-16 ***
as.factor(EffType)2 -1.20334    0.14149  -8.505  < 2e-16 ***
as.factor(Area)2    -0.58801    0.13242  -4.440 8.98e-06 ***
as.factor(Area)3     0.37851    0.15979   2.369   0.0178 *
as.factor(Area)4     0.36531    0.37420   0.976   0.3289
as.factor(Optics)2  -0.79255    0.13167  -6.019 1.75e-09 ***
---
Approximate significance of smooth terms:
                edf Ref.df  Chi.sq  p-value
s(SumDuration)  2.096  2.180  343.89  < 2e-16 ***
s(Site_No)     36.190 36.676 2612.20  < 2e-16 ***
s(SeaState)     8.118  8.707  295.83  < 2e-16 ***
s(MinHour)      3.925  3.990   20.30 0.000435 ***
s(Year)         6.831  8.245   42.38 1.58e-06 ***
s(Yearfrac)     3.079  3.809   40.55 3.82e-08 ***
s(Elev)         1.002  1.004    3.31 0.069251 .
---
R-sq.(adj) =  0.314   Deviance explained = 29.9%
UBRE score = -0.19009 Scale est. = 1         n = 18156
```

Smoothers:



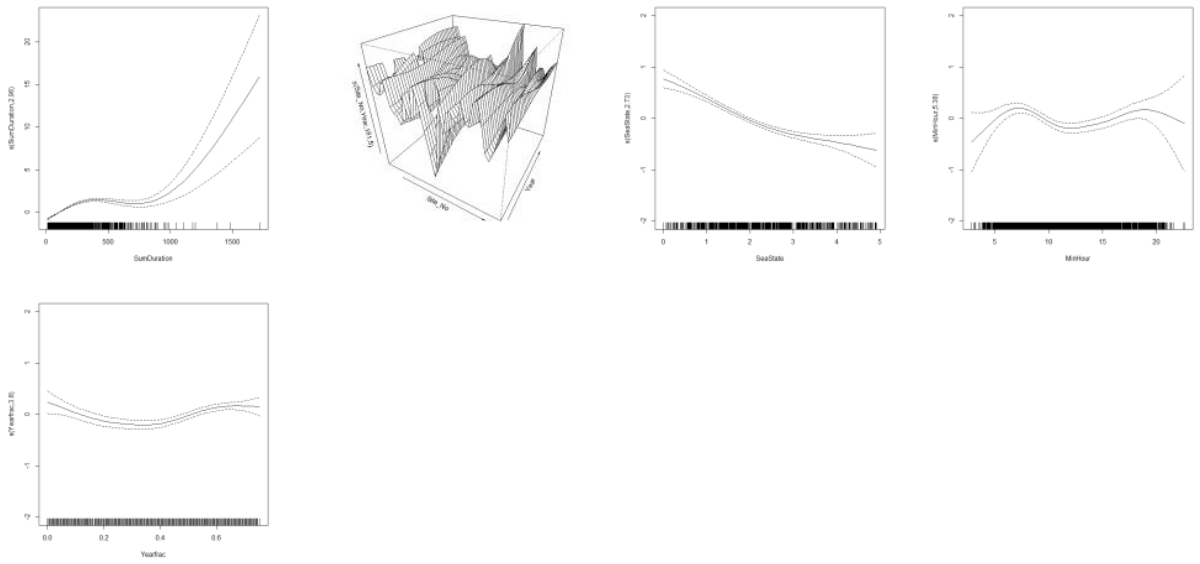
Model 7.4a Using Site Number x Year 2-d smoother for all months

```
Formula: HP_Presence ~ s(SumDuration, k = 4) + s(Site_No, Year, k = 200) + s(SeaState) +
as.factor(EffType) + as.factor(Area) + s(MinHour) + s(Yearfrac) + as.factor(Optics)

Parametric coefficients:
                    Estimate Std. Error z value Pr(>|z|)
(Intercept)         -1.87881    0.07183 -26.156  < 2e-16 ***
as.factor(EffType)2 -0.60602    0.19048  -3.181  0.00147 **
as.factor(Area)2    -0.67262    0.16158  -4.163 3.14e-05 ***
as.factor(Area)3     0.22429    0.22556   0.994  0.32006
as.factor(Area)4     0.20378    0.46524   0.438  0.66138
as.factor(Optics)2  -1.64303    0.25169  -6.528 6.67e-11 ***
---
Approximate significance of smooth terms:
                    edf  Ref.df  Chi.sq  p-value
s(SumDuration)    2.959   2.998  375.75  < 2e-16 ***
s(Site_No,Year) 183.183 194.493 2960.57  < 2e-16 ***
s(SeaState)       2.973   3.690  223.78  < 2e-16 ***
s(MinHour)        5.383   6.508   34.62 9.82e-06 ***
s(Yearfrac)       5.517   6.670   56.93 6.10e-10 ***
---
R-sq.(adj) =  0.391   Deviance explained = 38.2%
UBRE score = -0.26123  Scale est. = 1         n = 21691
```



Model 7.4b Using Site Number x Year 2-d smoother for April-September

```
Formula: HP_Presence ~ s(SumDuration, k = 4) + s(Site_No, Year, k = 200) + s(SeaState) +
as.factor(EffType) + as.factor(Area) + s(MinHour) + s(Yearfrac) + as.factor(Optics)

Parametric coefficients:
                    Estimate Std. Error z value Pr(>|z|)
(Intercept)         -1.88984    0.07653 -24.695  < 2e-16 ***
as.factor(EffType)2 -0.78794    0.20471  -3.849 0.000119 ***
as.factor(Area)2    -0.54527    0.17527  -3.111 0.001865 **
as.factor(Area)3     0.18289    0.23851   0.767 0.443204
as.factor(Area)4     0.25048    0.47220   0.530 0.595794
as.factor(Optics)2  -1.59039    0.27492  -5.785 7.26e-09 ***
---
Approximate significance of smooth terms:
                    edf  Ref.df  Chi.sq  p-value
s(SumDuration)    2.960   2.998  325.41  < 2e-16 ***
s(Site_No,Year) 181.502 193.804 2489.29  < 2e-16 ***
s(SeaState)       2.734   3.416  195.44  < 2e-16 ***
s(MinHour)        5.382   6.513   29.79 7.71e-05 ***
s(Yearfrac)       3.801   4.718   40.00 1.50e-07 ***
---
R-sq.(adj) =  0.388   Deviance explained = 38.2%
UBRE score = -0.26334  Scale est. =1         n = 18156

Smoothers:
```



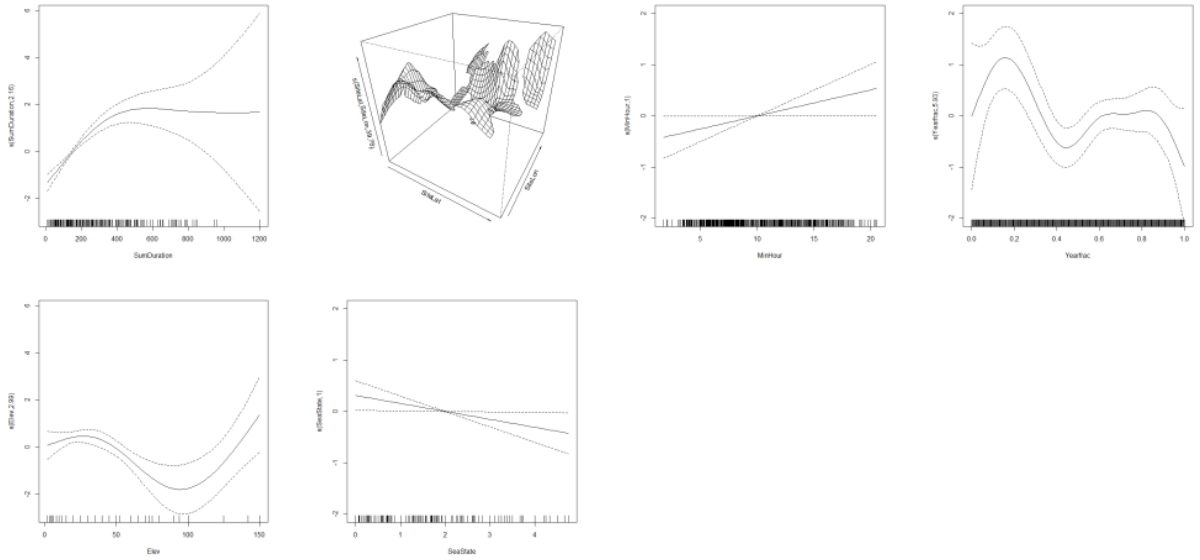
Models 8.HP 1965-1993

Model 8.1 Using Latitude and Longitude 2-d smoother

```
Formula: HP_Presence ~ s(SumDuration, k = 4) + s(SiteLat, SiteLon, k = 80) + s(MinHour)
+ s(Yearfrac) + s(Elev, k = 4) + s(SeaState)

Parametric coefficients:
            Estimate Std. Error z value Pr(>|z|)
(Intercept)   -2.892      0.459    -6.3 2.97e-10 ***
---
Approximate significance of smooth terms:
                      edf Ref.df  Chi.sq  p-value
s(SumDuration)      2.156  2.488  61.451 5.61e-13 ***
s(SiteLat,SiteLon) 39.785 49.031 613.911  < 2e-16 ***
s(MinHour)          1.000  1.001   4.185  0.04083 *
s(Yearfrac)         5.927  7.069  22.227  0.00246 **
s(Elev)             2.993  2.999  15.553  0.00140 **
```

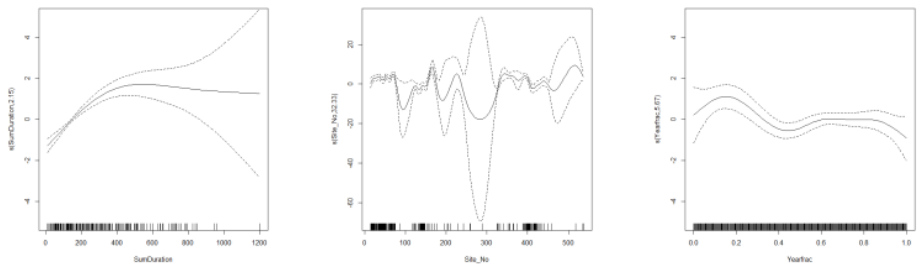
```
s(SeaState)         1.002  1.004   4.565  0.03283 *
---
R-sq.(adj) =  0.674   Deviance explained = 63.9%
UBRE score = -0.54537  Scale est. = 1         n = 2853
```

Smoothers:



Model 8.2 Substituting Latitude and longitude with Site Number

```
Formula: HP_Presence ~ s(SumDuration, k = 4) + s(Site_No, k = 40) + as.factor(Area) +
s(Yearfrac)

Parametric coefficients:
                Estimate Std. Error z value Pr(>|z|)
(Intercept)      -2.93347    0.54468  -5.386 7.22e-08 ***
as.factor(Area)2 -0.17088    0.34593  -0.494 0.621315
as.factor(Area)3  0.05045    0.32711   0.154 0.877431
as.factor(Area)4 -1.85350    0.52133  -3.555 0.000378 ***
---
Approximate significance of smooth terms:
                 edf Ref.df Chi.sq  p-value
s(SumDuration)  2.149   2.48  62.23 3.84e-13 ***
s(Site_No)     32.332  35.00 591.89  < 2e-16 ***
s(Yearfrac)     5.666   6.81  21.07  0.00333 **
---
R-sq.(adj) =  0.661   Deviance explained = 62.3%
UBRE score = -0.53673  Scale est. = 1         n = 2853

Smoothers:
```



Model 8.4 Using Site Number x Year 2-d smoother

```
Formula: HP_Presence ~ s(SumDuration, k = 4) + s(Site_No, Year, k = 200) + s(SeaState) +
as.factor(Area) + s(MinHour) + s(Yearfrac)

Parametric coefficients:
                 Estimate Std. Error z value Pr(>|z|)
(Intercept)       -2.8438     0.2673 -10.638  < 2e-16 ***
as.factor(Area)2  -0.1002     0.4041  -0.248 0.804079
as.factor(Area)3  -0.2774     0.3819  -0.726 0.467708
as.factor(Area)4  -2.0069     0.5711  -3.514 0.000441 ***
---
Approximate significance of smooth terms:
                   edf Ref.df  Chi.sq  p-value
s(SumDuration)   2.007  2.320  49.409 9.34e-11 ***
s(Site_No,Year) 59.867 78.106 571.634  < 2e-16 ***
s(SeaState)      1.046  1.089   5.498  0.02225 *
s(MinHour)       1.000  1.001   3.311  0.06890 .
s(Yearfrac)      6.046  7.180  21.388  0.00372 **
---
R-sq.(adj) =  0.706   Deviance explained = 67.9%
UBRE score = -0.56978  Scale est. = 1         n = 2853

Smoothers:
```