BTO RESEARCH REPORT 744

A review of the BTO/RSPB/JNCC Wetland Bird Survey (WeBS) Low Tide Counts scheme with recommendations for its future operation.

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BTO
Inspired by birds, informed by science

ACKNOWLEDGEMENTS: WeBS is a partnership jointly funded by the BTO, RSPB and JNCC, in association with WWT, with fieldwork conducted by volunteers. This scheme relies on the dedication all the volunteer observers and local coordinators as well as receiving important contributions from statutory nature conservation agency staff: Natural England, Natural Resources Wales, NatureScot and the Department of Agriculture, Environment and Rural Affairs, Northern Ireland. Thanks go to the WeBS Steering Committee for their continued guidance on the scheme. We are also extremely grateful for all those individuals who responded to the questionnaire distributed as part of this review and who attended the virtual workshop and provided valuable feedback on user requirements.

A review of the BTO/RSPB/JNCC Wetland Bird Survey (WeBS) Low Tide Counts scheme with recommendations for its future operation.

Report of work carried out by the British Trust for Ornithology on behalf of the Wetland Bird Survey Partnership

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BTO Research Report 744

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ISBN 978-1-912642-35-9

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EXECUTIVE SUMMARY

1. The British Trust for Ornithology (BTO)/Royal Society for the Protection of Birds (RSPB)/Joint Nature Conservation Committee (JNCC) Wetland Bird Survey (WeBS) Low Tide Counts scheme, which was initiated in the winter of 1992/93, aims to monitor, assess and regularly update information on the relative importance of intertidal feeding areas of UK estuaries for wintering waterbirds. Counts are made mostly by volunteer observers across multiple sectors within a site between the months of November and February. The data gathered contribute greatly to the conservation of waterbirds by providing supporting information for the establishment and management of the UK network of Ramsar sites and Special Protection Areas, other site designations and whole estuary conservation plans.

2. We carried out a review of the WeBS Low Tide Counts scheme to: i) review the methods and coverage since the scheme began, ii) improve our understanding of temporal variability of within-site species distributions, and iii) improve our understanding of user requirements to be able to make recommendations to improve the value of the data collected. We used a combination of analysis of WeBS Low Tide Counts scheme data and a stakeholder questionnaire and workshop to address these aims.

3. Site coverage has been good with data collected from 87 estuaries across the UK and, for most of these sites, data were first recorded within the first 10 years of the scheme. Over the 28 years of the scheme from 1992/93 to 2019/20, sites have most frequently been covered on three occasions, although data for eight sites cover a single winter only. Time-series of >20 years of data are available for five sites. The current method suggests that sites should be revisited every six years; however, this has only been achieved at 12 sites often due to capacity of counters. Within-winter and spatial coverage of sites have generally been high (across the years they have been surveyed) with 75% coverage of sectors being achieved at approximately 75% of sites and at least three monthly visits being achieved across the winter at an average of 88% of sites.

4. Waterbird distributions within an estuary reflect the specific resources that species exploit and thus are unlikely to change considerably unless there are wider changes in the system which affect the quality or location of those resources. For a selected number of sites and species, for which long time-series of data were available, using generalised additive models, we explored the variation in sector counts against the site mean, subsampling different time periods. However, this approach was found to be limited with very poor model fit to the data. An alternative non-parametric approach ranking individual sector counts and changes over time was also considered and although this was not able to directly inform whether the six year coverage target should be amended, it provided a potentially valuable and simple metric for comparing variability in within-site distributions between sites.

5. User requirements were considered through an appraisal of data requests, a stakeholder questionnaire, and a subsequent workshop attended by representatives from the country agencies, non-governmental organisations (NGOs) and consultancies. Requests for WeBS Low Tide Counts data come from partners (20.6% of requests), volunteers or research organisations (11.9%) and as standard data requests (67.6%). It is apparent that data are most widely used for site specific projects, with data often requested for only a selection of sectors, usually to inform casework around new developments or activities which may cause disturbance. Responses received through the questionnaire and workshop highlighted a strong desire for more frequent annual coverage of sites, as well as for data collected outside of the core winter period, especially for sites which hold important numbers of species during autumn and spring passage periods.

6. Key recommendations from this review are to:

    - increase the number of sites which achieve annual coverage at least once every six years, particularly in Scotland, Wales and northern England.
    - facilitate more flexibility in the months in which WeBS Low Tide Counts data are collected to include passage periods, as an addition to but not replacement of winter visits, and distribute a list of priority sites and species where this would be most relevant.
    - ensure that for winter counts, preferably at least three monthly visits are carried out during any winter a site is covered and single visits are avoided where at all possible, to better capture within-winter variation.
    - engage with ecology staff, especially within consultancies, more proactively to see if data are available from professional surveys which could be submitted to and made available within the WeBS Low Tide Counts scheme to fill temporal and spatial data gaps.

1. INTRODUCTION

1.1. Background

The Wetland Bird Survey (WeBS) monitors non-breeding waterbirds in the UK, relying on the dedication of volunteer observers. WeBS is a partnership scheme of the British Trust for Ornithology (BTO), Royal Society for the Protection of Birds (RSPB) and the Joint Nature Conservation Committee (JNCC) and in association with the Wildfowl & Wetlands Trust (WWT).

The WeBS Core Counts scheme is the principal scheme of WeBS with over 3,000 volunteer counters contributing to the survey, making over 40,000 monthly visits each year to over 2,900 wetland sites of all habitats. Core Count data are primarily used to assess species abundance and population trends.

Despite involving only a relatively small number of sites, estuaries collectively represent the most important habitat for wintering waterbirds in the UK (Frost *et al.* 2021). They are also inherently different from the thousands of inland sites counted for WeBS. The influence of the tide means that the birds have to be much more mobile, both within and between sites. Estuarine sites are well represented within the Core Counts scheme, with counts, in general, being based around high tide roosts. Although important in themselves and useful for determining the abundance of species present at the site, roost sites are usually secondary in importance to the manner in which waterbirds make use of a site for feeding. Therefore, information gathered about these sites at high tide will only provide part of the picture.

The WeBS Low Tide Counts scheme, which was initiated in the winter of 1992/93, aims to monitor, assess and regularly update information on the relative importance of intertidal feeding areas of UK estuaries for wintering waterbirds and thus to complement the information gathered by Core Counts on estuaries. Low Tide Counts provide information needed to assess the potential impacts on waterbird populations of a variety of human activities which affect the extent or value of intertidal habitats, such as dock developments, proposals for recreational activities, tidal power barrages, marinas and housing schemes. The data gathered contribute greatly to the conservation of waterbirds by providing supporting information for the establishment and management of the UK network of Ramsar sites and Special Protection Areas (SPAs), other site designations and whole estuary conservation plans. In addition, WeBS Low Tide Counts enhance our knowledge of the low tide distribution of waterbirds and provide data that highlight regional variations in habitat use.

An earlier review of the first seven years of the WeBS Low Tide Counts scheme was carried out by Musgrove *et al.* (2003), and provided detailed site accounts for the 62 sites covered in the initial years of the scheme.

Much of the data collected under the scheme is now publicly available as part of the WeBS annual report *Waterbirds in the UK* comprising a summary report and statistics, maps and plots accessible through an online interface (e.g. Frost *et al.* 2021).

1.2. Aims

The WeBS Low Tide Counts scheme has been in operation for nearly 30 years. The purpose of this review is to better understand existing coverage over this period and the outputs and user requirements so that recommendations can be made to help improve the value of the data being collected.

Specific aims of the review were to:

1. summarise the existing methods, site coverage and the frequency of coverage of WeBS Low Tide Counts between 1992/93 and 2019/20.
2. improve our understanding of temporal (annual and within-winter) variability of within-site species distributions.
3. develop a clearer understanding of the use of Low Tide Counts scheme data by stakeholders and investigate the potential for capturing data being collected outwith the scheme.

1.3. Approach

In order to achieve aim 1) we carried out descriptive analyses of the entire Low Tide Counts dataset and reviewed the current guidance materials available to observers. A literature review and an analysis of data from a selected sample of sites and species were used to address aim 2). All data handling and analyses was carried out using R v3.6.1 (R Core Team 2019). Aim 3) was addressed using a combination of a targeted questionnaire and an online workshop with a variety of stakeholders, to capture user requirements and discuss options for improving the value of the data collected. Specific methods are detailed below in subsequent chapters.

2. OVERVIEW OF THE WEBS LOW TIDE COUNTS SCHEME

2.1. Methodology

2.1.1. Current methods

WeBS Low Tide Counts are made using a so-called 'look-see' methodology (Bibby *et al.* 2000), whereby the observer, familiar with the species involved, surveys the whole of predefined count sectors. Numbers of all waterbird species, as defined by Wetlands International (Rose & Scott 1997), are recorded. In the UK, this

includes divers, grebes, cormorants, herons, Spoonbill, swans, geese, ducks, rails, cranes, waders and Kingfisher. Counts of gulls and terns are optional. In line with the recommendations of Vinicombe *et al*. (1993), records of all species recorded by WeBS, including escapes, are collected to contribute to the proper assessment of naturalised populations and escaped birds.

The Low Tide Counts scheme provides information on the numbers of waterbirds feeding on subdivisions (sectors) of the intertidal habitat within estuaries. Given the extra work that Low Tide Counts entail, often to the same volunteer counters that carry out the Core Counts, the Low Tide Counts scheme aims to cover most individual estuaries about once every six years, although on some sites more frequent counts are made.

Ideally, counts are carried out on each sector in each month from November to February during the two hours either side of low tide, with co-ordination between counters on different sectors. However, this is often not feasible given conditions at the site and counter capacity, leading to partial coverage as detailed below (see Section 2.2). Counts are typically made by volunteer observers from the high tide mark; however, some professional surveys have employed different approaches (see Section 2.1.3).

The WeBS Low Tide Counts methods were included in Chapter 2 of Musgrove *et al.* (2003) and has been reproduced in Appendix 1. Counters are encouraged to submit data via the WeBS Online system (Appendix 2) although paper count forms (Appendix 3) are also available if preferred.

There have been some recent changes to the guidance provided to counters on the data to be collected, updating some of the information in Appendix 1. Data on factors causing disturbance (e.g. presence of raptors or various human activities) are no longer required to be collected, as they only represent a snapshot and not considered to be representative of wider activity. Counters can still indicate, however, whether the bird counts are likely to be low if impacted by disturbance, but do not need to necessarily record the nature of the disturbance. Additionally, counts of feeding and roosting birds are no longer separated, as such an assignment of behaviour proved unreliable across counters and sites, particularly as birds may readily switch between behaviours during a count.

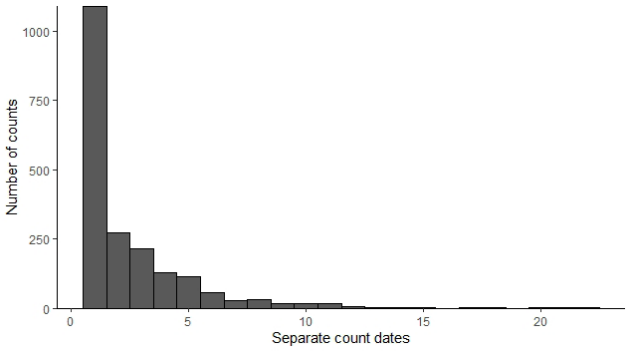
2.1.2. Coordination of counts

The primary purpose of the Low Tide Counts scheme is to investigate the relative distribution of species within sites, averaged over several dates, and not to determine overall population sizes. Therefore, in contrast to Core Counts, observers may take more than one day to cover all sectors within a monthly visit. Also, conditions of fog, rain or strong winds make the counting of birds on distant mudflats particularly difficult and so flexibility in count dates makes it possible to make best use of suitable counting conditions. This is justified in that if a sector is important for birds at low tide, it does not matter if a flock of Dunlin, for example, recorded there was also recorded elsewhere – the outcome is that we know both areas to be important. However, understanding the prevalence of non-simultaneous counts within the scheme is important if the data are used differently to the primary intention.

In the period 1992/93 to 2019/20, 2,027 WeBS Low Tide Counts were made on 87 sites (see Section 2.2.2). In 46% of these cases, the counts for a given month were made on multiple visit dates, with counts made across five or fewer dates in 90% of cases (Fig. 2.1). There were some exceptional cases, however, where data submitted for a given month came from 20 or more distinct dates.

In the majority of instances, individual sectors were only counted once in a given month; however, for 4% of site visits, duplicate counts of individual sectors were also submitted. A total of 351 (0.7%) of the overall number of unique site/sector/year/month counts (50,568) contained duplicate counts. Where duplicates do exist, the maximum count is assigned as the nominate count and used for WeBS analysis.

Figure 2.1. The number of days over which site-level WeBS Low Tide Counts were made in a given month (data from 2,207 counts of 87 sites, made between 1992/93 and 2019/20).



Averaging the number of discrete visit dates within a site level count across all years and months gives an idea of site level variability. The median and mean number of days over which site-level WeBS Low Tide Counts were made in a given month were 1.8 and 2.7, respectively. The maximum mean for any site was 12.6 days and a total of seven sites may be considered outliers based on the boxplot shown in Fig. 2.2. These sites included large or complex sites such as the Severn Estuary, Humber Estuary, North Norfolk Coast or the Solway Firth.

Figure 2.2. Site (n = 87) variability in the number of days over which site-level WeBS Low Tide Counts were made in a given month (data from 2,207 counts of 87 sites, made between 1992/93 and 2019/20).

2.1.3. Alternative methods

The Wash has been treated differently within the Low Tide Count scheme and has been periodically surveyed under professional contract due to the extensiveness of its intertidal areas, where identifying all individuals from the high tide mark is not feasible (Yates *et al.* 2004; Garbutt *et al*. 2010). At this site, surveys have been undertaken by observers walking set transects across the intertidal area, recording and mapping the numbers of birds in flocks. These data have yet to be incorporated into the WeBS Low Tide Counts main database.

There have been various trials of alternative methods to conduct bird surveys around low tide, principally using aerial surveys, both visual (a 'look-see' approach from the air) and digital (photographic material to be processed after field visits) and there are examples of long-term aerial surveys being used for monitoring waterbirds outside of the UK (e.g. Rendón *et al.* 2008, Kingsford & Porter 2009). A comparison of both visual aerial and ground methods from Australia found that counts from visual aerial surveys were less precise for some abundance classes and tended to underestimate counts for species present in very small (<10) or large (>5,000) numbers (Kingsford 1999). Kingsford also reported that more species were detected during the ground surveys although in this remote Australian site context aerial surveys were much cheaper and quicker to carry out, but this may not be true for other sites.

A visual aerial survey of Morecambe Bay was carried out using a low-flying aircraft across multiple visits during the 2005/06 winter (Musgrove *et al*. 2007). Given the extent of this site (over 36,000 ha), observation of the intertidal mudflats from the high tide mark is limited and thus aerial surveys have the potential to provide more complete coverage. However, species identification was problematic and generally only the distributions of larger, more distinctive species, such as Oystercatcher and Shelduck, were effectively surveyed. It wasn't possible to identify many of the smaller species and as a result, concentrations of mixed flocks were instead identified to highlight key areas.

Since the Morecambe Bay aerial survey, advances have been made in digital aerial surveys (Buckland *et al*. 2012) and these have largely replaced visual surveys for marine birds at sea. Surveys use either digital video or stills, at a resolution sufficient to identify the majority of marine birds to species (Johnston *et al.* 2015), and which can be conducted from aircraft flying sufficiently high to avoid disturbance. Digital aerial surveys, however, have been less frequently employed for surveys of intertidal waterbirds.

A recent pilot study was carried out on The Wash using aircraft to carry out a single high resolution digital aerial survey simultaneously with traditional ground-based survey methods (APEM 2018). A greater number of individuals and range of species were detected from the aerial imagery survey compared with the ground survey; however, the two methods were not directly comparable due to differences in the areas surveyed. Improvements in the quality of the imagery obtained, however, did lead to high rates of positive species identification with 87% of all birds identified to species, increasing to 94% if the small waders category (of which only 43% could be positively identified) was excluded. Calibrating results against ground-based surveys will be important if digital aerial surveys are to be more widely used in the future.

There is expected to be a continuing interest in exploring options for aerial surveys, both from aircraft and also from drones, particularly for extensive estuary systems. The potential for drone-based aerial surveys to cause disturbance and thus impact counts is likely to be much higher (Jarrett *et al.* 2020) compared with aircraft based methods, but requires continued investigation.

2.2. Data coverage

WeBS Low Tide Counts data have been collected for 87 sites across the UK since the winter of 1992/93 (Fig. 2.3), albeit with varying temporal coverage, amounting to c.500,000 species counts and a total of over 36 million individuals counted.

2.2.1.Species coverage

A total of 138 species of waterbird have been recorded by the WeBS Low Tide Counts scheme between 1992/93 and 2019/20 and the top 30 most commonly encountered and abundant species are outlined in Table 2.1 (scientific names for all species in this report are provided in Appendix 4). Fewer than 30 records have been obtained for 51 species, which includes both rare and non-native species. While such records may be excluded from some analyses, they are nevertheless passed on to other relevant recorders and included in the WeBS Report Online tables.

Table 2.1. The top 30 species recorded by the WeBS Low Tide Counts scheme between 1992/93 and 2019/20 ranked by: i) the percentage of individual sector visits on which the species was recorded and ii) the percentage of the total number of individuals recorded.

	i) % of visits on which recorded		ii) % of total numbers recorded	
Rank	Species	%	Species	%
1	Curlew	63.50	Dunlin	21.66
2	Redshank	61.25	Oystercatcher	10.93
3	Oystercatcher	56.96	Knot	7.68
4	Shelduck	38.68	Lapwing	7.40
5	Black-headed Gull*	35.97	Wigeon	6.75
6	Dunlin	33.62	Black-headed Gull*	6.63
7	Herring Gull*	31.52	Golden Plover	5.41
8	Mallard	27.41	Redshank	4.34
9	Wigeon	25.69	Brent Goose**	4.23
10	Brent Goose**	23.22	Shelduck	3.38
11	Grey Plover	22.82	Teal	3.14
12	Cormorant	22.73	Curlew	2.95
13	Lapwing	22.07	Herring Gull*	2.51
14	Teal	20.62	Black-tailed Godwit	1.33
15	Common Gull*	18.45	Grey Plover	1.22
16	Grey Heron	17.59	Mallard	1.16
17	Turnstone	16.99	Common Gull*	1.15
18	Great Black-backed Gull*	16.26	Bar-tailed Godwit	1.14
19	Little Egret	15.51	Eider	0.80
20	Red-breasted Merganser	14.36	Pintail	0.71
21	Black-tailed Godwit	14.01	Canada Goose	0.45
22	Bar-tailed Godwit	12.86	Turnstone	0.43
23	Ringed Plover	11.73	Avocet	0.43
24	Great Crested Grebe	10.97	Pink-footed Goose	0.34
25	Knot	10.49	Ringed Plover	0.33
26	Mute Swan	10.20	Barnacle Goose**	0.33
27	Goldeneye	10.19	Greylag Goose	0.29
28	Little Grebe	8.60	Cormorant	0.27
29	Lesser Black-backed Gull*	8.18	Sanderling	0.27
30	Pintail	7.54	Great Black-backed Gull*	0.24

* Gulls were counted optionally so the tabulated percentages shown are always minima.
** The values shown for Brent Goose and Barnacle Goose include all sub-species (when specified) aggregated together.

Counts have been recorded at the sub-species or population level for some goose species (Barnacle Goose, Bean Goose, Brent Goose, Greylag Goose and White-fronted Goose). However, recording at this level was not ubiquitous across the scheme so all taxonomic groupings have been aggregated at the species level in this review. Any individuals recorded but not identified to at least species level were excluded from the dataset for this review.

For some species, the typical month of peak occurrence in the UK is outside of the period when WeBS Low Tide Counts are usually undertaken, i.e. November to February, notably those that largely occur on passage and which may be specifically included as designated features of SPAs due to the importance of their numbers at these times (Stroud *et al.* 2001, Stroud *et al.* 2016). Additional data from other times of year could thus be valuable both in understanding variation in distributions across the year and in providing information for species that are typically not present in winter, including some waders and terns.

Outlined in Table 2.2 are the species listed in Stroud *et al.* (2016) which peak in number outside the main winter period and the estuarine SPA sites that they are features (or proposed features) of as non-breeding species, and the

Table 2.2. Species listed in Stroud *et al*. (2016) which typically have peak counts outside November to February and the estuarine Special Protection Areas (SPAs) that they are features of. Additionally, for Redshank and Ringed Plover, which at some sites may have peak counts during winter, sites listed in Stroud *et al*. (2001) as designated for the numbers they support on passage are also shown.

Species	Peak month	SPA sites
Goosander	August	Inner Moray Firth, Firth of Tay and Eden Estuary
Greenshank	August	NA
Whimbrel	August	NA
Black-tailed Godwit	September	Ribble and Alt Estuaries, Mersey Estuary, Humber Estuary, The Wash, Stour and Orwell Estuaries, Hamford Water, Blackwater Estuary, Exe Estuary, Poole Harbour, Portsmouth Harbour, Solent and Southampton Water, Thames Estuary and Marshes, The Dee Estuary, Belfast Lough, Morecambe Bay and Duddon Estuary, Firth of Tay and Eden Estuary
Little Egret	October	Poole Harbour, Tamar Estuaries Complex, Morecambe Bay and Duddon Estuary
Barnacle Goose (Svalbard population)	October	Upper Solway Flats and Marshes
Light-bellied Brent Goose (Canadian population)	October	Gruinart Flats (Islay)
Greenland White-fronted Goose	March	Dyfi Estuary / Aber Dyfi, Gruinart Flats (Islay)
Barnacle Goose (Greenland population)	March	Gruinart Flats (Islay)
Sanderling	May	Ribble and Alt Estuaries, Lindisfarne, The Wash, Chichester and Langstone Harbours, Morecambe Bay and Duddon Estuary, Firth of Tay and Eden Estuary
Redshank	August	Foulness, Humber Flats, Marshes and Coast, Teesmouth and Cleveland Coast, The Dee Estuary
Ringed Plover	August	Blackwater Estuary, Chichester and Langstone Harbours, Duddon Estuary, Hamford Water, Humber Flats, Marshes and Coast, Medway Estuary and Marshes, Mersey Estuary, Morecambe Bay, North Norfolk Coast, Ribble and Alt Estuaries, Severn Estuary,Teesmouth and Cleveland Coast, Thames Estuary and Marshes, The Swale, The Wash, Upper Solway Flats and Marshes

species in Stroud *et al.* (2001) for which SPA suite totals are also given explicitly for the passage periods.

2.2.2. Site coverage

Between the winters of 1992/93 to 2019/20, data are available for a total of 87 sites across the UK from the WeBS Low Tide Counts scheme (Table 2.3 & Fig. 2.4); the vast majority of these sites were surveyed for the first time within the first 10 years of the scheme (Fig. 2.5).

In addition to the standard Low Tide Counts, some supplementary count data are included in the database. These mostly refer to a short targeted survey around the Greater Solent on the south coast of England in the late 1990s, which overlapped with other named sites in the area but also included counts of some additional sectors of the open coast. These supplementary counts are not included in this review but may be of relevance to any data requests for any of the sites near the Solent.

As noted above, due to the extensiveness of its intertidal areas, The Wash has been treated differently within the Low Tide Count scheme and has been periodically surveyed under professional contract (Yates *et al.* 2004; Garbutt *et al*. 2010). Those data are provided to the BTO and are available for data requests, although have been collected under different protocols (see Section 2.1.3 above) and thus are not included in the summaries in this report. Morecambe Bay similarly is an extensive and difficult site to survey. Five discrete sites within Morecambe Bay, based around different river systems feeding into the estuary, have been covered by the WeBS Low Tide Counts scheme, with some counts made at mid-tide (c.3 hours after high tide). On occasion, data collected from other large sites have also been facilitated by additional funding and professional staff to complement volunteer observers.

Figure 2.3. Summary map of sites covered in the WeBS Low Tide Counts scheme between 1992/93 and 2019/20. Larger circles represent sites with more winters' coverage. Sites with data available at least once every six years are shown in blue whereas sites with any coverage gaps of six years or greater are shown in red.

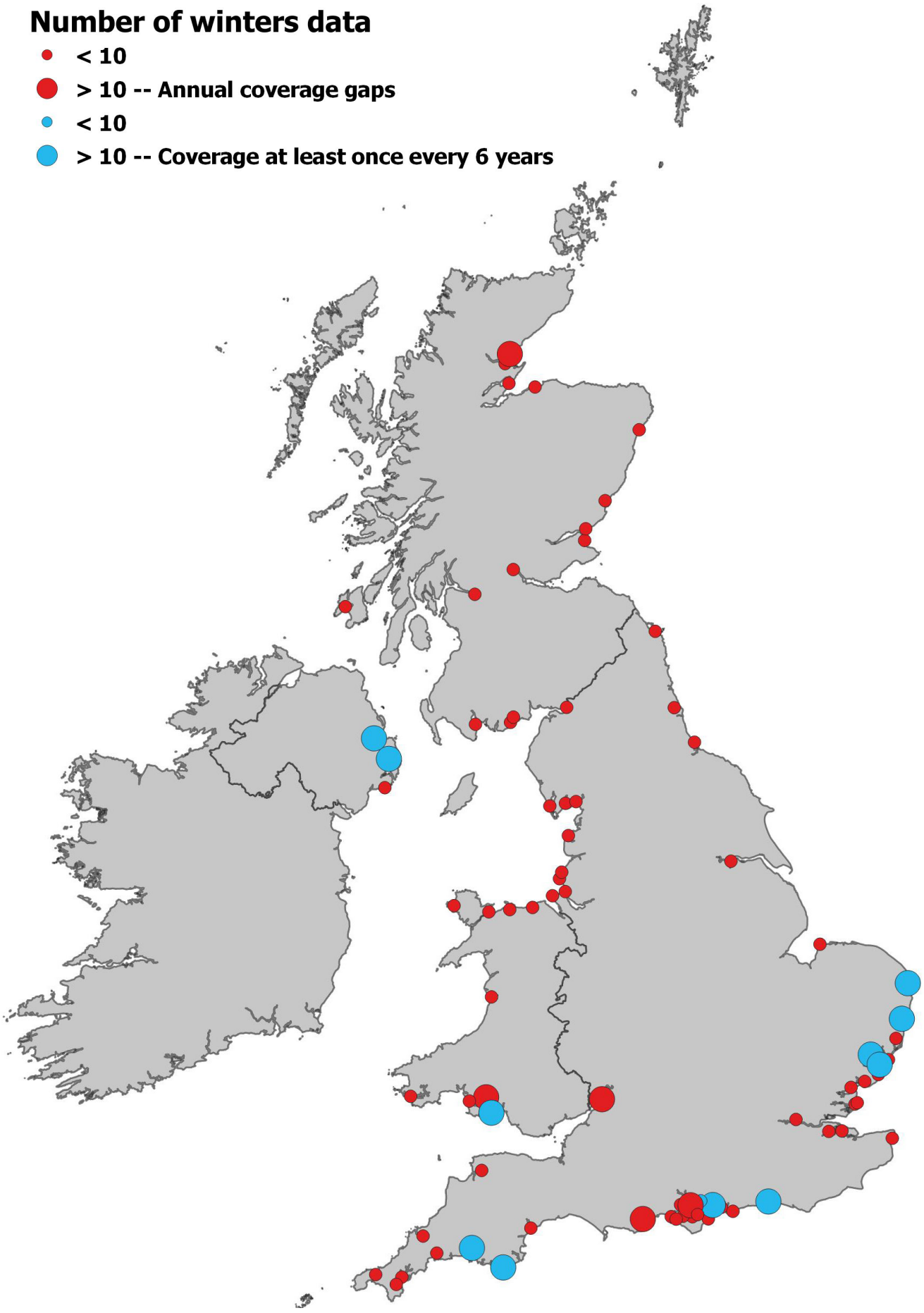


Table 2.3. List of all sites within the UK covered under the WeBS Low Tide Counts scheme between 1992/93 and 2019/20 and the total number of winters' data available for each, with first winter shown in brackets.

Site ID	Site	No. winters (1st)
England		
1	Adur Estuary	18 (1998/99)
2	Alde Complex	3 (2001/02)
3	Alt Estuary	5 (1996/97)
5	Beaulieu Estuary	2 (1996/97)
7	Bembridge Harbour	5 (1996/97)
8	Blackwater Estuary	5 (1994/95)
9	Blyth Estuary - Northumberland	1 (2013/14)
10	Blyth Estuary - Suffolk	19 (1997/98)
11	Breydon Water	22 (1998/99)
13	Camel Estuary	2 (1992/93)
15	Chichester Harbour	9 (1992/93)
18	Colne Estuary	2 (1994/95)
21	Crouch/Roach Estuary	5 (1995/96)
22	Deben Estuary	3 (1998/99)
24	Dengie Flats	3 (1992/93)
26	Duddon Estuary	7 (1992/93)
30	Exe Estuary	3 (1993/94)
31	Fal Complex	5 (1995/96)
35	Fowey Estuary	3 (1995/96)
37	Hamford Water	5 (1992/93)
38	Hayle Estuary	5 (1998/99)
39	Helford Estuary	9 (2010/11)
40	Humber Estuary	5 (1998/99)
44	Kingsbridge Estuary	26 (1993/94)
45	Langstone Harbour	19 (1993/94)
47	Lindisfarne	9 (1992/93)
50	Medina Estuary	2 (1995/96)
51	Medway Estuary	4 (1996/97)
52	Mersey Estuary	7 (1996/97)
55	Morecambe - Kent Estuary	2 (2005/06)
56	Morecambe - Leven Estuary	1 (2005/06)
57	Morecambe - Lune Estuary	1 (2005/06)
58	Morecambe - Wyre Estuary	2 (2005/06)
59	Morecambe Bay (West)	7 (1999/00)
60	Newtown Harbour	2 (1999/00)
61	North-west Solent	8 (1992/93)
62	North Norfolk Coast	4 (1997/98)
63	Orwell Estuary	23 (1994/95)
64	Pagham Harbour	9 (1995/96)
65	Pegwell Bay	3 (1994/95)
66	Poole Harbour	16 (1993/94)
67	Portland Harbour	1 (2009/10)
68	Portsmouth Harbour	5 (1992/93)
69	Ribble Estuary	3 (1997/98)
73	Southampton Water	12 (1994/95)
74	Stour Estuary	19 (1996/97)
76	Swale Estuary	3 (1992/93)
78	Tamar Complex	18 (1997/98)
79	Taw/Torridge Estuary	3 (1994/95)
80	Tees Estuary	4 (1996/97)
81	Thames Estuary	5 (1993/94)
82	Tyne Estuary	3 (1998/99)
83	Wear Estuary	1 (1995/96)
84	Western Yar Estuary	2 (1996/97)
86	Wootton Estuary	2 (1996/97)
Northern Ireland		
6	Belfast Lough	26 (1994/95)
27	Dundrum Bay	1 (1996/97)
43	Killough Harbour	6 (2001/02)
75	Strangford Lough	27 (1992/93)
Scotland		
4	Auchencairn Bay	2 (2005/06)
20	Cromarty Firth	3 (1999/00)
25	Dornoch Firth	3 (2000/01)
29	Eden Estuary	4 (1992/93)
32	Firth of Clyde	3 (1999/00)
33	Firth of Forth	3 (1992/93)
34	Firth of Tay	5 (1993/94)
42	Irvine/Garnock Estuary	1 (1998/99)
48	Loch Fleet	13 (2000/01)
49	Loch Indaal	2 (2010/11)
53	Montrose Basin	4 (1992/93)
54	Moray Firth	4 (1996/97)
70	Rough Firth	2 (2004/05)
85	Wigtown Bay	3 (1992/93)
87	Ythan Estuary	4 (1997/98)
Wales		
12	Burry Inlet	13 (1996/97)
14	Carmarthen Bay	9 (1999/00)
16	Cleddau Estuary	5 (1997/98)
17	Clwyd Estuary	2 (1992/93)
19	Conwy Estuary	3 (1996/97)
28	Dyfi Estuary	3 (2001/02)
36	Glaslyn Estuary	1 (2011/12)
41	Inland Sea	3 (1995/96)
46	Lavan Sands	4 (1995/96)
77	Swansea Bay	13 (2003/04)
England/Wales border		
23	Dee Estuary	8 (1996/97)
71	Severn Estuary	11 (1998/99)
England/Scotland border		
72	Solway Firth	7 (1998/99)

Figure 2.4. Location of all sites covered in the WeBS Low Tide Counts scheme between 1992/93 and 2019/20. Site ID numbers are listed in Table 2.3.

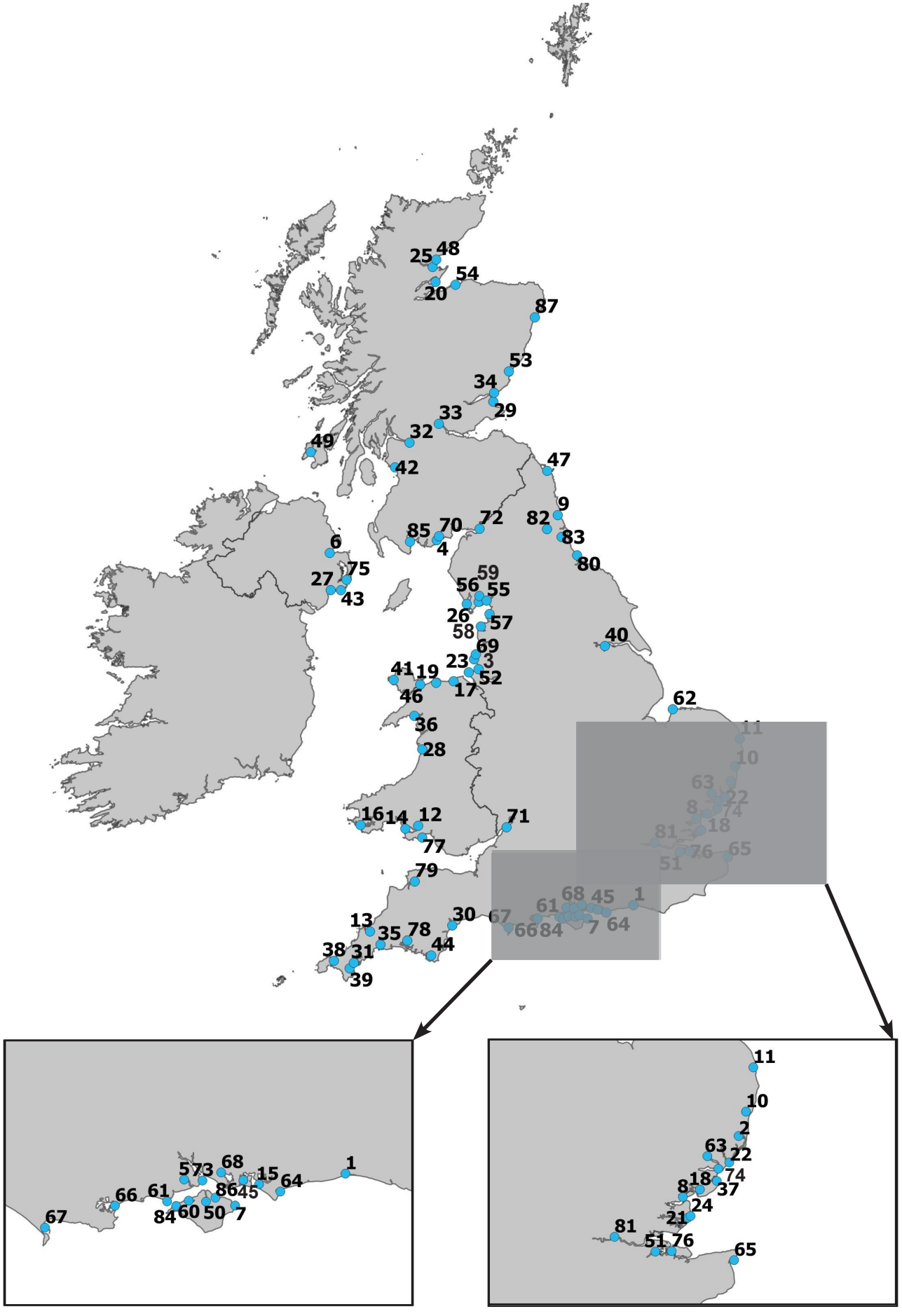
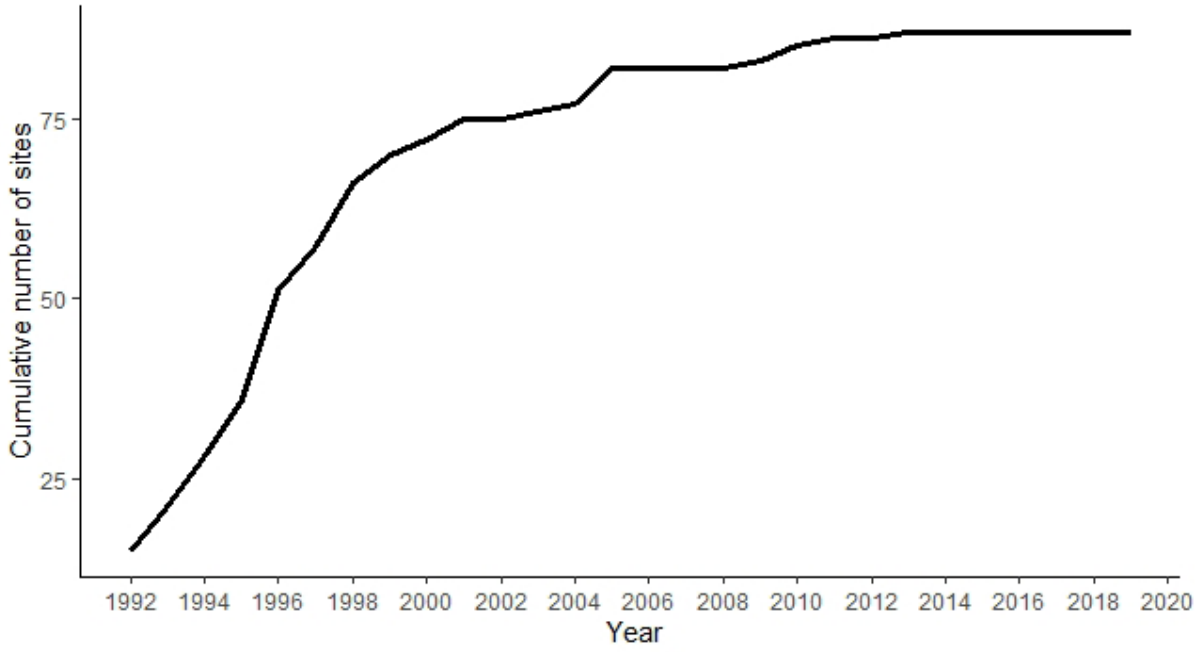


Figure 2.5. The cumulative number of estuarine sites surveyed at least once as part of the WeBS Low Tide Counts scheme between 1992/93 and 2019/20. Year 1992 = 1992/93, etc.



The majority of sites have been surveyed more than once, with data for three winters being most common (Fig. 2.6), while over 20 years of data are available for five sites (Belfast Lough, Breydon Water, Kingsbridge Estuary, Orwell Estuary and Strangford Lough). A total of 12 of the sites covered by the Low Tide Count scheme have been surveyed at least once every six years between 1992/93 or the first year of data collection at that site and 2019/20 but the majority of sites have at least one gap in their time series of six years or more (Fig. 2.7).

Figure 2.6. The frequency of coverage of sites included in the WeBS Low Tide Counts scheme between 1992/93 and 2019/20

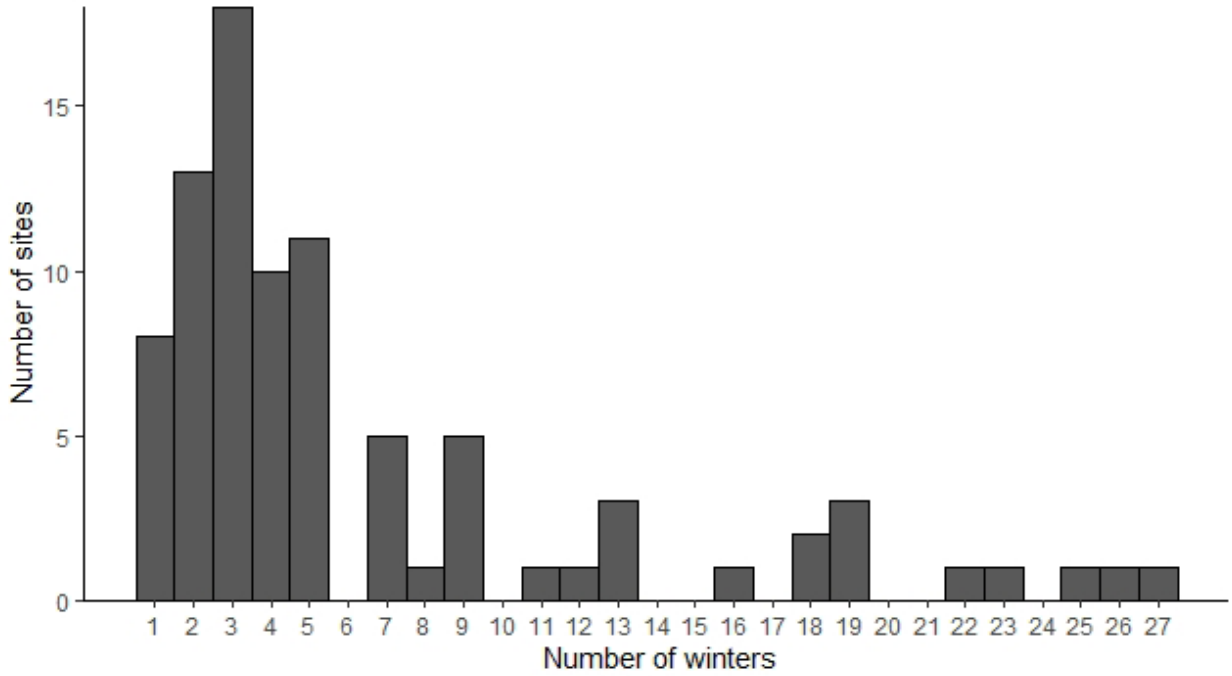
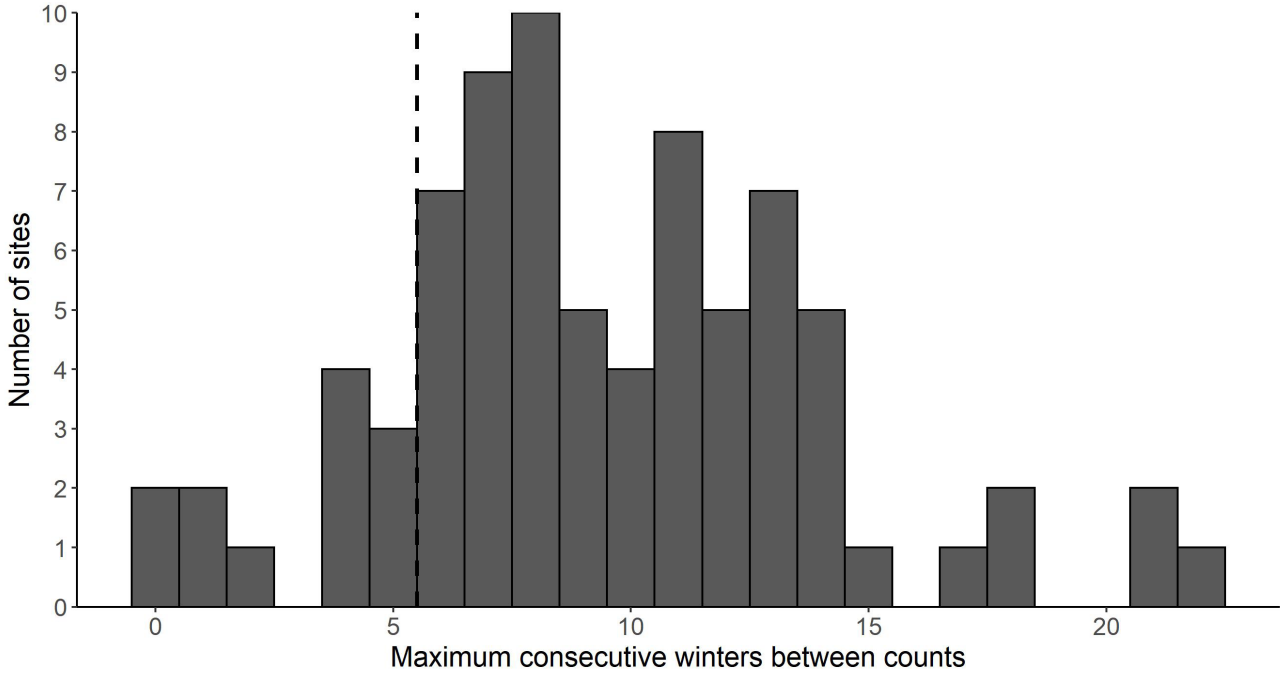


Figure 2.7. The number of years between consecutive surveys for sites (with two or more years' coverage, n = 79) included in the WeBS Low Tide Counts scheme between 1992/93 and 2019/20. The dashed line indicates the current guidance for the preferred maximum gap in coverage (sites visited at least once every six years).



2.2.3. Annual coverage

Nationally, an average of 20 sites a year has been surveyed as part of the Low Tide Counts scheme (Fig. 2.8). This ranged from a low of nine sites in 1993/94, when fewer sites had registered for the scheme overall, to a high of 28 in 2005/06 and 2010/11.

The levels of sector coverage within sites have also varied between years (Fig. 2.9). Spatial coverage of sites (across the years they have been surveyed) has generally been high, with 75% or more coverage of sectors being achieved at approximately 75% of sites. It should be noted though that any evaluation of general sector coverage between years is likely to be indicative only. For many sites, the specific boundaries of sectors may have been altered and others either aggregated or split following feedback from counters and coordinators. There is an audit of sector relationships available for some sites but not all across the Low Tide Count scheme.

Figure 2.8. The number of sites surveyed as part of the WeBS Low Tide Counts scheme (irrespective of seasonal or sector coverage) each year between 1992/93 and 2019/20. Year 1992 = 1992/93, etc.

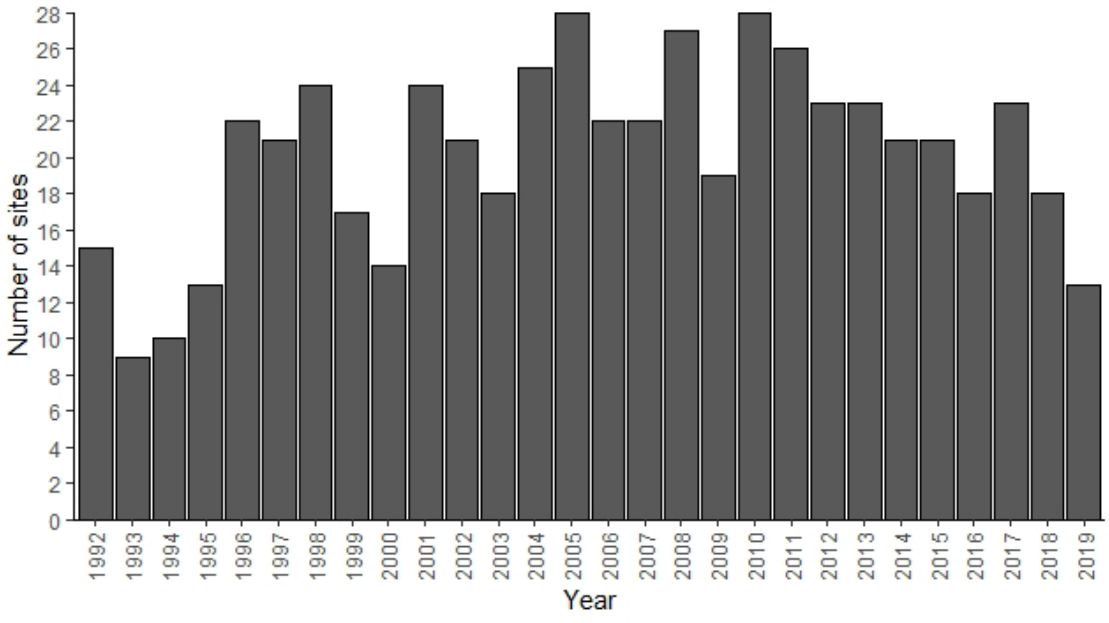
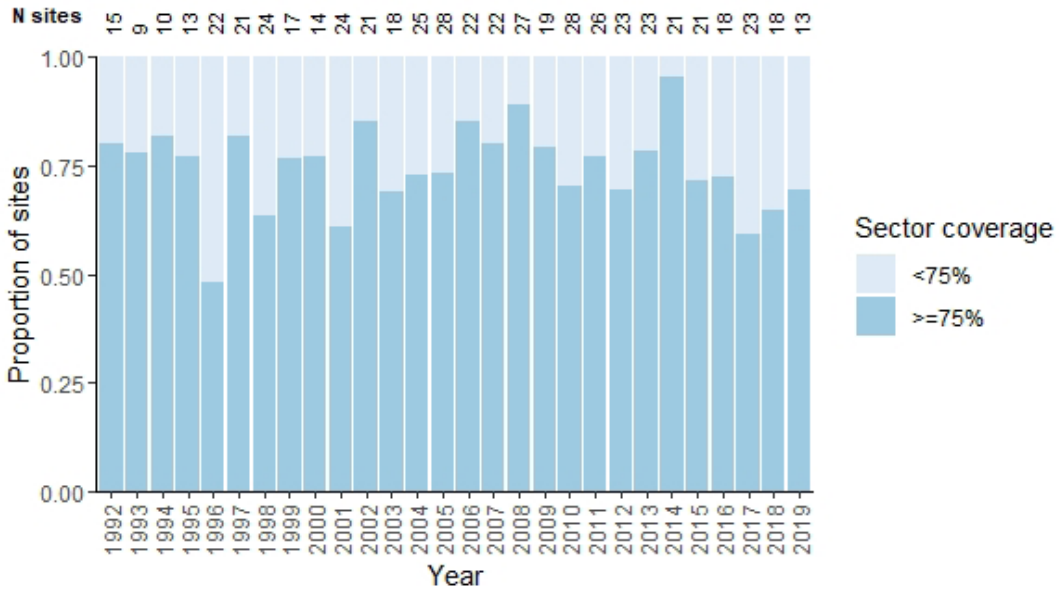


Figure 2.9. The proportion of sites where either less than 75% or 75% or more of sectors were surveyed (cumulatively across all months), within sites surveyed as part of the WeBS Low Tide Counts scheme each winter between 1992/93 and 2019/20. The total number of sites for which data are held in the database is shown above each bar. Year 1992 = 1992/93, etc.

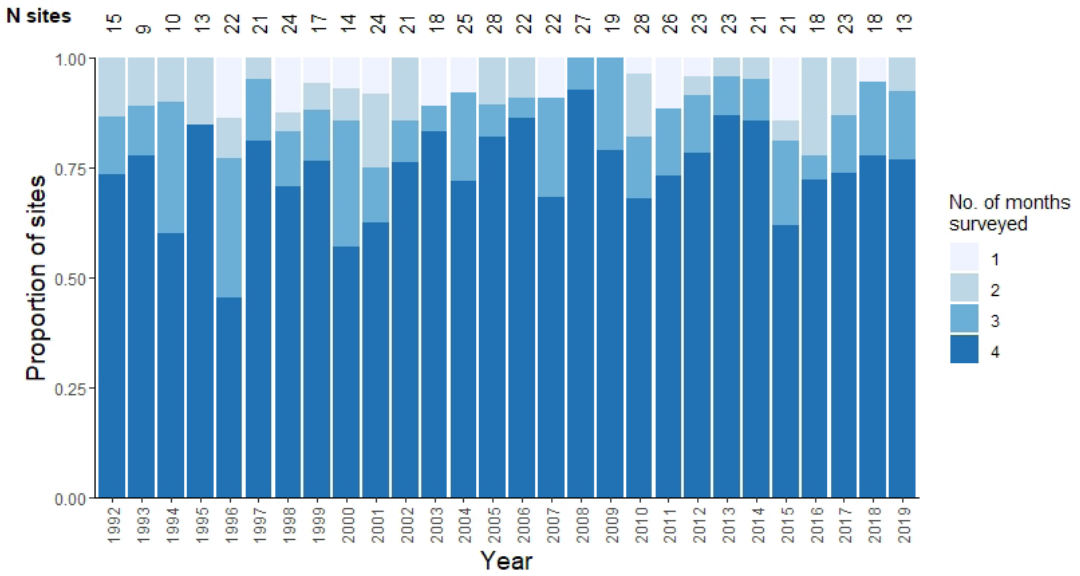


2.2.4. Within-winter and seasonal coverage

The current WeBS Low Tide Counts methods suggest four monthly visits between November and February, when waterbird numbers are at their most stable, in any given winter to allow the calculation of densities averaged across multiple visits. There are data available for more than one month within a winter for the vast majority of sites and across all years, with visits being achieved for at least three months across the winter at an average of 88% of sites (Fig. 2.10). There does not appear to be any considerable bias in which of the winter months have been covered, with the lowest coverage being in February with a total of 498 counts, compared to the highest coverage in December with a total of 515 counts. However, within individual sites there are more likely to be systematic biases in which months are included or not due to specific situations and volunteer capacity.

A small number of counts have also been submitted for months outside of the core winter period, from a total of 30 different sites across all years. These include an additional 53 site/year counts submitted from March, followed by 34 and 22 for October and September, respectively, and <10 from June to August.

Figure 2.10. The relative monthly coverage of sites surveyed as part of the WeBS Low Tide Counts scheme in each winter between 1992/93 and 2019/20. The total number of sites in each winter included in the database is shown above each bar. Year 1992 = 1992/93, etc.



3. IMPROVING UNDERSTANDING OF VARIABILITY IN SPECIES DISTRIBUTION

3.1. Relevant literature

Individual waterbirds are rarely evenly distributed across estuarine sites. Clark & Prys-Jones (1994), for example, counted waterbirds at low tide on 162 sectors of the Severn Estuary on 12 occasions during winter 1987/88: on average, 50% of birds present at low tide utilised just 13 sectors (12% of the total intertidal area) and 90% of birds occurred on only 56 sectors, with large expanses of intertidal sand virtually devoid of birdlife. Similar variation in usage can be seen across the UK's estuaries (Musgrove *et al.* 2003). This variation in within-site distribution reflects the variation in habitats in estuaries and thus the resources available to species, as well as other abiotic factors. Varying densities within sites will reflect different species' foraging niches (Burton 1974), with the availability of preferred resources being influenced by factors such as position of freshwater flows within a site (Ravenscroft & Beardall 2003). Other abiotic factors that may affect distributions include the size and isolation of the site (Paracuellos & Telleria 2004) or features likely to cause disturbance such as footpaths or railways (Burton *et al.* 2002).

For the distributions of waterbirds recorded within the WeBS Low Tide Counts scheme to be informative, it is important to understand the variability of distributions across different time scales. Burton *et al.* (2004) determined, using hourly counts through the tidal cycle describing the distribution for six waterbird species at a range of intertidal sites, that no single count frequency was ideal for all species. However, counts made at low tide were representative of the average usage of the study sites in 75% of cases, while examination of species' feeding activity also indicated that low tide was the best time for recording the feeding distributions of many waders, but that ebb and flood tides may be more suitable for assessing the usage of sites for some wildfowl. Particularly for species that follow the tide line to feed, Dias *et al.* (2006) recommended that extending the counting period to both low and mid-tides provided more accurate estimates of distribution compared with counts made at low tide alone.

Similarly, changes in feeding behaviour within the year may influence fine scale distribution. A study of Dunlin near Sylt, Germany, found that there was a difference in proximity to the tide line between spring and autumn, as birds switched between polychaete and shrimp prey. Again it was recommended that a single low tide count may not be representative without wider knowledge of the species and site (Nehls & Tiedermann 1993). An analysis of WeBS Low Tide Counts data collected from Lindisfarne National Nature Reserve between 1993/94 and 2018/19 also reported that within-winter count variability was high, and recommended that multiple counts each winter were valuable to identify changes in trends (Austin *et al.* 2020). Bird distributions on estuaries may also show short-term changes in response to cold weather events (Clark & Prys-Jones 1994) where low temperatures and high winds can cause increased metabolic rates (Wiersma & Piersma 1994) and reduced access to invertebrate prey (Pienkowski 1983).

It would be unfeasible to design a large scale citizen science monitoring programme which could effectively capture the within-tidal cycle and within-winter variations in distributions that occur across all species and sites. However, the current WeBS Low Tide Counts methods, that recommend multiple counts each winter within two hours either side of low tide, remain suitable for collecting representative and comparable data across most estuaries.

It may be expected that species' relative distributions would also remain similar between years, provided the conditions and resources they rely upon also remain stable. Evans (1995) compared the distribution of waterbird species on the Duddon Estuary and Southampton Water over three winters between 1992 and 1995. There were no significant differences in the distributions of four out of five species on the Duddon Estuary over the study period considered despite the sediments on the site being mobile, and resulting in structural change to the system. Distributions of species in Southampton Water were also similar between years for most species except for Dunlin, Teal and Black-tailed Godwit.

However, in the longer term, estuarine systems are dynamic and changes to the physical structure (Granadeiro *et al.* 2007), vegetation, foraging resources (Atkinson *et al.* 2003) and human pressures (Rosa *et al.* 2003) can all result in changes in distributions between years. Another analysis of WeBS Low Tide Counts data for the Humber Estuary in 2011/12 described how the distribution of some species had changed since the previous survey in 2003/04 due to novel area use of newly-created suitable habitat (Calbrade 2013). An important aim of long-term monitoring is to be able to detect population responses to such environmental changes. Using monthly visual aerial counts between 1978 and 2005, Rendón *et al.* (2008) analysed the abundance and distribution of 21 wintering waterbird species. They reported that while different species groups did have general habitat preferences within the site, there was a significant interaction with year indicating distributions varied over time. Density-dependent competition will also affect the relative densities within and between sites, with low-quality sites used relatively more when population levels are high (Goss-Custard 1977, 1985, Gill *et al.* 2001). A better understanding of the variability observed in waterbird distribution counts between and within years may thus be helpful to consider what frequency of sampling is appropriate to detect changes at broad scales across sites and species.

3.2. Impact of variability of within-winter coverage

We carried out an assessment of: i) the variability in counts between months and ii) the effect of reducing the number of months coverage within a year on the variability in counts between sectors for a selected group of sites and species. Curlew, Dunlin, Shelduck and Wigeon were selected as they were the most frequently recorded and most abundant wader and wildfowl species recorded within the Low Tide Count scheme. For this initial assessment only sites with long time-series of data and near complete monthly coverage each year were considered. Strangford Lough was selected to represent a larger estuary system and the Stour and Orwell Estuaries, which are adjacent to each other, as smaller more linear sites.

3.2.1 . Variability in site level counts between months

Mean monthly counts of Curlew, Dunlin, Shelduck and Wigeon (summed across all sectors covered), and the standard errors about these means, across the four months surveyed are shown in Fig. 3.1 for each site. There was variation between years in the amount of monthly count variation observed.

Standard errors of monthly counts were relatively small for the wader species at Strangford Lough for most years since 2000 but varied more in the years before then. Counts were generally more variable within the year for Shelduck at Strangford Lough, but more consistent for Wigeon.

Despite being adjacent sites, there were contrasts in the variability of counts for the two wader species between the Stour and Orwell Estuaries, with wider variability more regularly recorded on the Stour. Counts of Shelduck were also more variable than those of other species at these sites, consistent with the pattern from Strangford Lough. As at Strangford Lough, Wigeon count variability at the Orwell Estuary was also low, with counts showing a relatively small amount of error around the mean, apart from in a few exceptional years. Counts of Wigeon were more variable on the Stour, however.

3.2.2. The effect of reducing the number of months coverage within a year on the variability in counts between sectors

We next looked to investigate how missing monthly counts might impact our overall understanding of the distribution of species across the site. Using the same datasets, we considered how the number of monthly visits affected apparent spatial variability in counts within a site. Figure 3.2 presents the mean sector count in each winter derived from either the complete (November–February) coverage for these selected sites and species or a randomly selected sample of one to three of the months (Fig. 3.2).

We calculated the mean and standard error of these different sets of sector counts. In most instances, as would be expected, the standard error across sector counts was larger when individual sectors had fewer months covered; with only a single month included the mean was also more likely to deviate from those calculated using data from multiple months. Variability in species distribution at a site (i.e. standard error of mean of sectors) was noticeably less when based on four or three months of data than when based on samples of just two months.

It should be noted, however, that the sector means used in the main WeBS Low Tide Counts scheme outputs are not calculated as they are here using all raw monthly counts, i.e. with a different sample size of count data depending on monthly coverage. Instead they are derived from the sum of all monthly counts divided by the number of months covered; thus, much of the monthly variation is averaged away before being used in the scheme outputs.

Figure 3.1. Mean (± SE) monthly counts (summed across all sectors covered) from November to February in each winter for four species across three sites covered in the WeBS Low Tide Counts scheme. Year 1992 = 1992/93, etc.

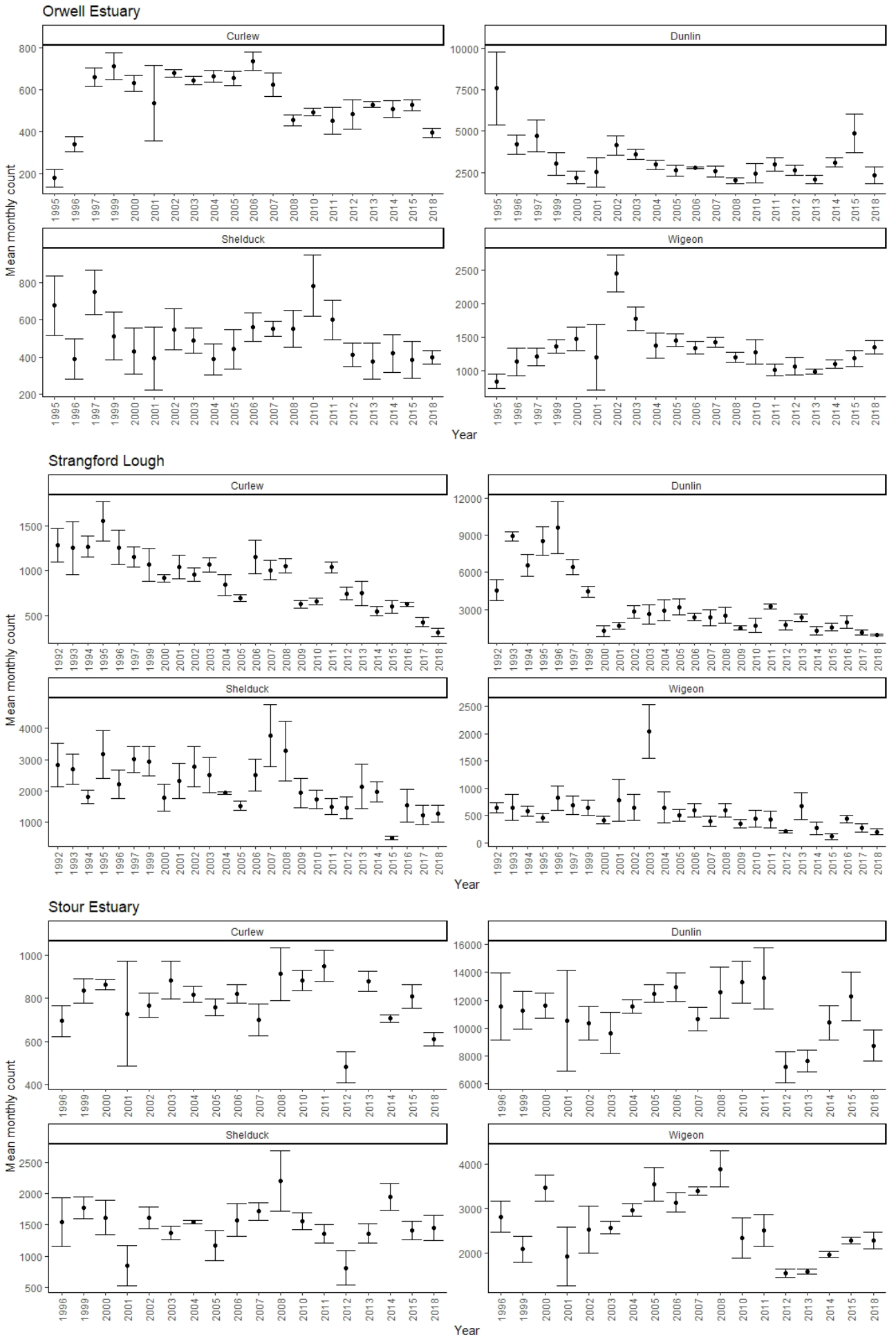
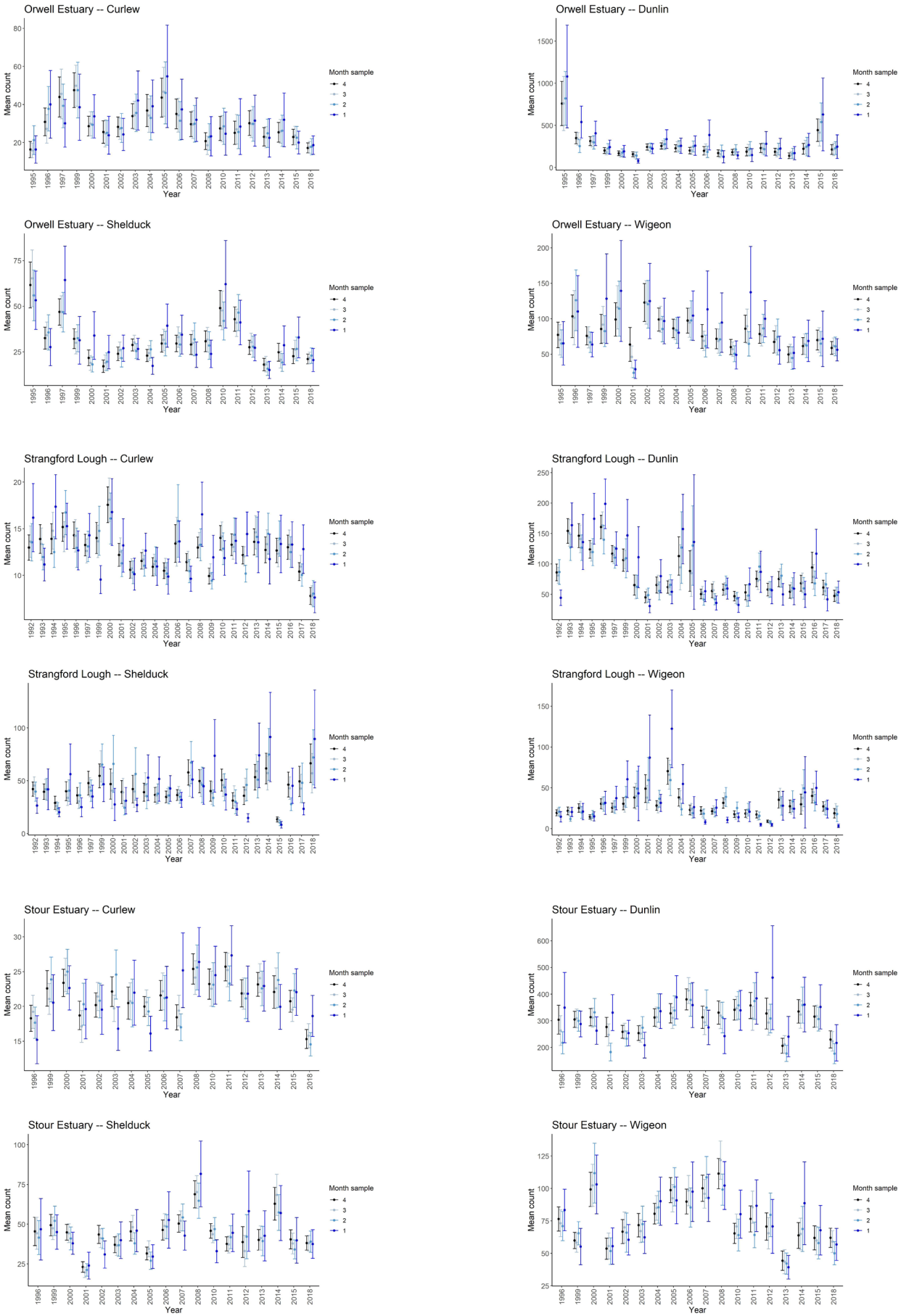


Figure 3.2. Mean (± SE) sector counts for four species across three sites in each winter they were covered in the WeBS Low Tide Counts scheme, derived from either all (four) monthly counts between November and February or a randomly selected sample of one to three months. The minimum and maximum numbers, respectively, of sectors included across years were: Orwell – 11 and 23, Strangford – 58 and 115, Stour – 37 and 40. Year 1992 = 1992/93, etc.



3.3. Variability of within-site species distributions between years

Annual variability in distribution was initially investigated for the same subset of wader (Curlew and Dunlin) and wildfowl (Shelduck and Wigeon) species considered in section 3.2. The Stour Estuary was selected as an example site as it had near complete spatial coverage of sectors during the winters surveyed.

We used generalised additive models (GAMs) separately for each species to assess relative sector use, similar to an approach used previously to produce trends in WeBS Low Tide Counts data (Austin *et al.* 2020). The mean sector count (averaged across all within-winter counts) was modelled as a function of sector, with a Poisson error distribution and log-link function. The earliest calendar year of the winter period was included as a smooth term to account for autocorrelation in trends of counts over time, and the log of sector area included as an offset. The significance of the relative utilisation of sectors was assessed by testing the deviance of the modelled count against the site mean.

The GAMs were then applied to subsets of the data using either a random sample of five years or an early (1999–2006) or late (2008–2015) run of years in the datasets to investigate whether the relative importance of sectors differed according to the frequency of counts or between different time periods.

The predicted mean counts for each sector across the different subsamples are shown in Fig. A5.1 in Appendix 5. Considering Curlew as an example, comparing the predictions using all available data or using a random sample of years did not drastically change the interpretation of which sectors were consistently used more or less than the site average. The relative importance of only two of 39 sectors differed in significance when a random subset of five years of data was considered in comparison to the full dataset; the relative importance of all other sectors was consistent in significance and direction. Comparison between early and recent annual samples indicated more differences in the relative importance of sectors, with the relative importance of four and eight of the 39 sectors, respectively, differing in significance compared with the full dataset. Some sectors also showed changes in the direction of difference from the mean, e.g. CU002, albeit very small changes.

The approach of using GAMs to assess variability in counts across WeBS Low Tide Count sectors had limited success. Assessing the GAMs using the DHARMa package (Hartig 2021) indicated poor model fit and that there was a large discrepancy between predicted and observed counts (Fig. 3.3). This is likely due to the failure of the model to account for the large amount of dispersion in the data. Previous modelling of WeBS data (Austin *et al.* 2020) suggests that model fit may be improved with the inclusion of observation-level random effects to accommodate overdispersion, but generally inference of parametric modelling of highly variable waterbird counts is challenging, susceptible to missing temporal or spatial coverage, and may require site-specific model designs. The modelling approach was therefore considered unsuitable for providing a robust understanding of annual variation in waterbird distributions across the wide range of WeBS Low Tide Counts sites.

Given the poor model fit using the GAM approach, an alternative non-parametric approach was also used to consider variation in sector utilisation over time. The mean sector counts (averaged across all within-winter counts) each year were ranked. Again using Curlew from the Stour Estuary as an example, the raw mean count ranks (Fig. 3.4) may be used to visualise variability in rank over time. Some sectors were consistently ranked highly (e.g. CU017) or were initially ranked highly but became more variable over time (e.g. CU019).

Mean sector ranks can be useful to identify sectors of particular importance for a given species but also can help inform sector use variability between sites through comparison of the standard errors around those mean ranks for individual sectors (Fig. 3.5). Table 3.1 shows the site level mean (± SE) of the standard error around mean sector ranks over time for all sites with at least three winters' data. This provides a single averaged site level metric of variability which can be used as a coarse indicator of how likely sector rank may change at a given site, for example the mean standard error for the Severn Estuary was approximately double that of the similarly sized Strangford Lough (in terms of number of sectors) suggesting it is a more dynamic site for Curlew distribution over time. This metric may be sensitive to changes in sample size, however, so may need further exploration to understand how transferable it is between sites, especially of different physical size or temporal coverage.

The comparisons between individual species and sites can be extended by calculating the Spearman's rank correlation coefficient for sector rank against year (Appendix 6) and summarising the number of sectors with significant differences in rank important over time as a metric to compare sector use variability between sites (Table 3.2). Taking the Stour Estuary as an example again, the number of sectors which significantly increased or decreased in rank importance between 1996/97 and 2018/19 was balanced, with a significant change in rank over time occurring for approximately 20–25% of all sectors for Curlew, Dunlin and Wigeon, and for 41% for Shelduck. At the Orwell Estuary, in comparison, depending on the species, 31–61% of sectors changed significantly in rank over time and, for Curlew, a slightly higher number of sectors were significantly lower ranked over time compared with the number of sectors becoming more highly ranked.

Figure 3.3. Mean sector-level counts of Curlew on the Stour Estuary based on WeBS Low Tide Counts scheme data from 1996/97 to 2018/19; black – observed, blue – predicted using generalised additive models.

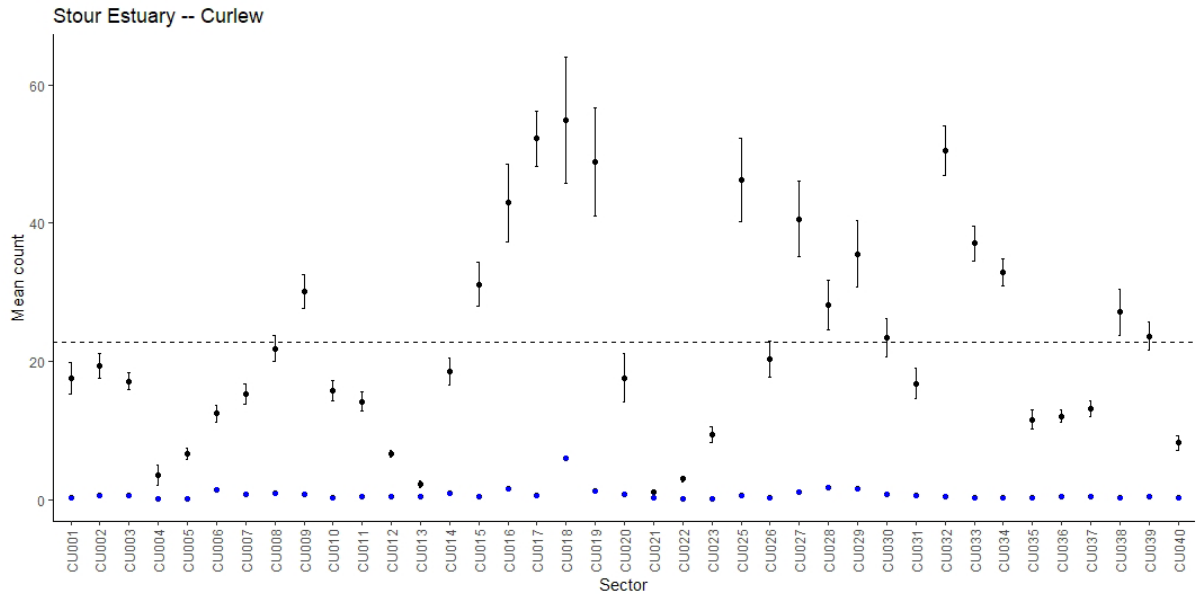


Figure 3.4. Mean counts of Curlew for each sector of the Stour Estuary ranked for each winter, based on WeBS Low Tide Counts scheme data from 1996/97 to 2018/19, with the sector ranked 1 holding the highest number of birds. Year 1992 = 1992/93, etc.

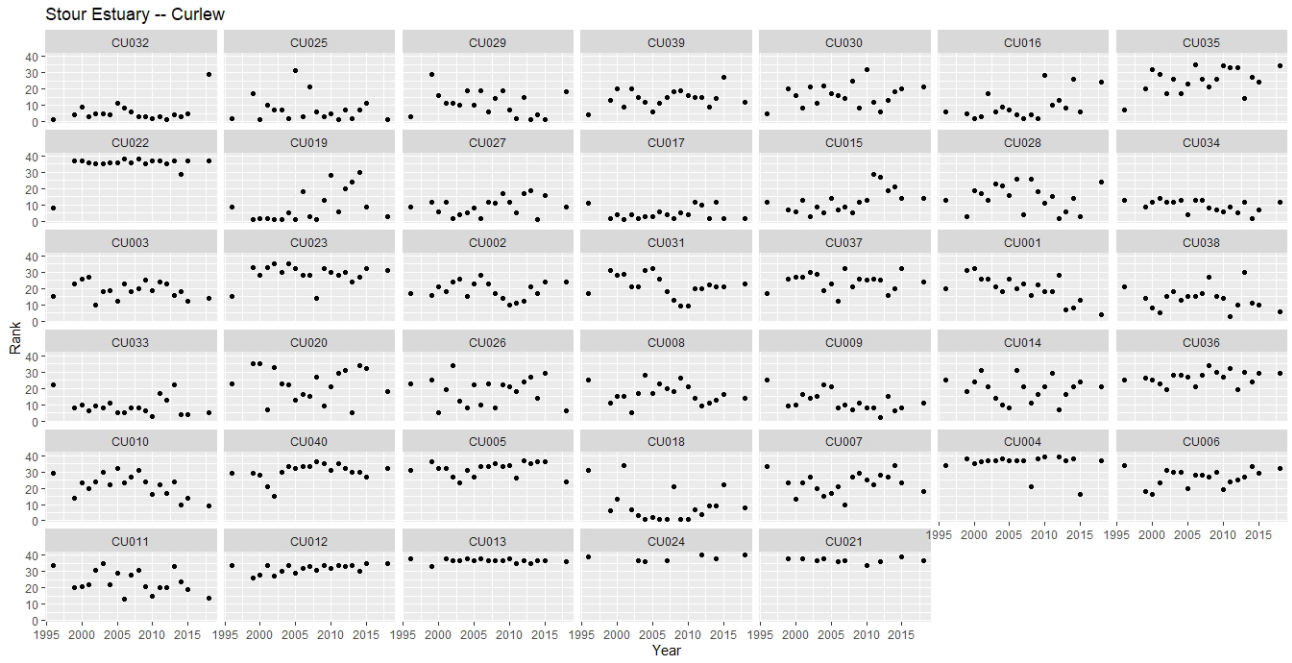


Figure 3.5. Mean (± SE) rank for each WeBS Low Tide Counts sector over time at the Stour Estuary (n = 19 years) Orwell (n = 23 years) and Strangford Lough (n = 27 years) sites for winter counts of Curlew, with the sector ranked 1 holding the highest number of birds.

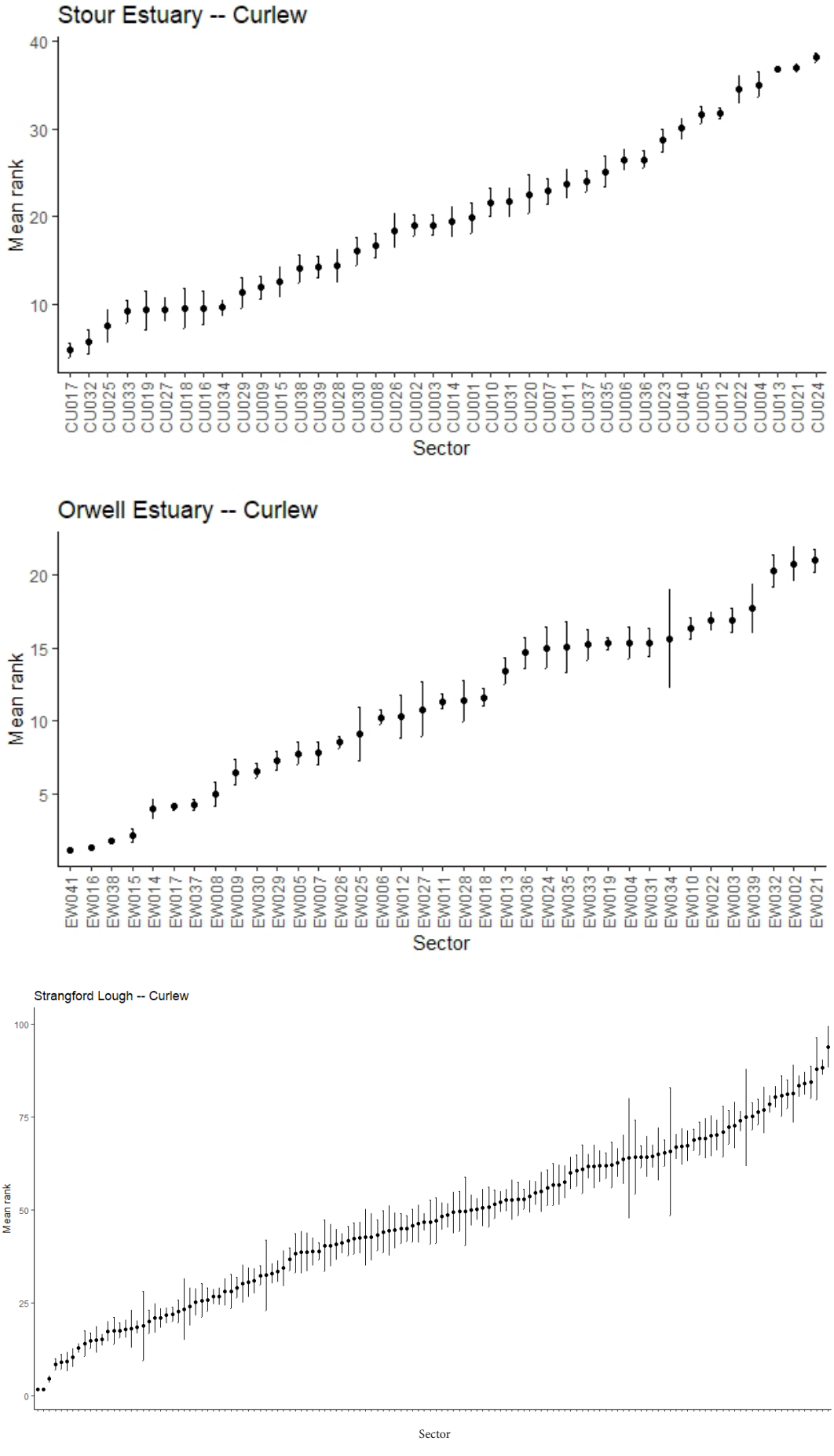


Table 3.1. Site level means (± SE) of the standard errors around mean sector rank over time (such as presented in error bars in Fig. 3.5 and with the sector ranked 1 holding the highest number of birds) for counts of Curlew from WeBS Low Tide Counts scheme data. Only sites with at least three years of data were included.

Site	Mean (± SE)	N sectors
Severn Estuary	9.55 ± 0.52	133
Solway Firth	5.25 ± 0.39	60
North Norfolk Coast	5.23 ± 0.31	84
Cleddau Estuary	5.05 ± 0.38	50
Dee Estuary	4.84 ± 0.37	54
Crouch/Roach Estuary	4.51 ± 0.37	38
Strangford Lough	4.45 ± 0.21	136
Humber Estuary	4.22 ± 0.41	48
Lavan Sands	4.02 ± 0.30	34
Blackwater Estuary	3.84 ± 0.20	45
Chichester Harbour	3.71 ± 0.26	60
Duddon Estuary	3.33 ± 0.29	34
Montrose Basin	3.22 ± 0.28	25
Lindisfarne	3.21 ± 0.24	46
Hamford Water	2.94 ± 0.31	30
Swale Estuary	2.89 ± 0.28	31
Firth of Tay	2.84 ± 0.29	25
Alde Complex	2.80 ± 0.31	24
Langstone Harbour	2.30 ± 0.21	37
Firth of Clyde	2.25 ± 0.19	26
Cromarty Firth	2.19 ± 0.29	22
Exe Estuary	2.02 ± 0.25	21
Wigtown Bay	2.00 ± 0.27	15
Mersey Estuary	1.92 ± 0.15	27
Tees Estuary	1.58 ± 0.23	16
Deben Estuary	1.54 ± 0.20	16
North-west Solent	1.48 ± 0.14	17
Burry Inlet	1.46 ± 0.12	26
Carmarthen Bay	1.46 ± 0.17	17
Pagham Harbour	1.46 ± 0.16	23
Stour Estuary	1.40 ± 0.07	40
Dyfi Estuary	1.32 ± 0.18	15
Poole Harbour	1.30 ± 0.12	29
Alt Estuary	1.22 ± 0.17	14
Conwy Estuary	1.21 ± 0.21	11
Taw/Torridge Estuary	1.17 ± 0.23	10
Southampton Water	1.12 ± 0.10	33
Portsmouth Harbour	1.12 ± 0.14	24
Fal Complex	1.11 ± 0.20	12
Medway Estuary	1.02 ± 0.19	9
Belfast Lough	1.01 ± 0.10	32
Morecambe Bay (West)	0.98 ± 0.14	14
Dengie Flats	0.93 ± 0.24	7
Orwell Estuary	0.92 ± 0.10	37
Ythan Estuary	0.88 ± 0.22	9
Swansea Bay	0.83 ± 0.08	16
Inland Sea	0.78 ± 0.20	9
Breydon Water	0.71 ± 0.10	15
Loch Fleet	0.70 ± 0.07	21
Kingsbridge Estuary	0.47 ± 0.07	18
Helford Estuary	0.40 ± 0.08	7
Hayle Estuary	0.39 ± 0.09	7
Tamar Complex	0.35 ± 0.06	12
Eden Estuary	0.32 ± 0.15	8
Blyth Estuary - Suffolk	0.24 ± 0.01	4
Ribble Estuary	0.22 ± 0.11	3
Thames Estuary	0.22 ± 0.11	3
Adur Estuary	0.14 ± 0.14	2

Table 3.2. Direction of the Spearman's rank correlation between the mean sector rank (of mean counts) and year, based on WeBS Low Tide Counts scheme data from 1996/97 to 2018/19 for the Stour and Orwell Estuaries. Significant positive change indicates that sectors were less likely to be ranked highly for counts over time and negative change indicates sectors were more likely to have high ranking counts.

		Sector rank change			
Site	Species	Positive	Not Significant	Negative	Total sectors
Stour	Curlew	5	29	5	39
	Dunlin	4	31	4	39
	Shelduck	8	23	8	39
	Wigeon	5	30	4	39
Orwell	Curlew	11	16	7	34
	Dunlin	6	9	8	23
	Shelduck	6	16	6	28
	Wigeon	6	20	3	29

4. IMPROVING OUR UNDERSTANDING OF USER REQUIREMENTS

4.1. Within WeBS

In addition to their main purpose in providing information on the relative importance of intertidal feeding areas of UK estuaries for wintering waterbirds, WeBS Low Tide Counts also, in some instances, contribute to the WeBS Core Count scheme, where it is not feasible to carry out counts at high tide. The reasons behind this may vary but are most commonly because the main roost areas within a site are not visible at high tide.

Between 1992/93 and 2019/20, counts from Core Counts carried out at low tide were fed into both schemes at five sites (Table. 4.1) for between ten and 13 years. The methodology for Low Tide Counts does not require all sectors within a site to be visited on a single date and, therefore, there is the possibility of double counting. Consequently, the data collected are less suitable for calculating abundance. This is likely to only affect two sites, the Helford Estuary and the Tamar Complex, where the majority of counts were conducted over multiple days.

4.2. Data requests

Data requests that include WeBS Low Tide Counts scheme data make up about a fifth of data requests received each year. Most approaches for WeBS Low Tide Counts data come from commercial requests by ecological consultancies (Table 4.2), often to inform Appropriate Assessments and Environmental Impact Assessments, either providing historical data to complement ongoing surveys being carried out by the consultants or for desk studies where WeBS Low Tide Counts are the only available source of data for their site. Most of these requests for commercial use are for data from selected sectors within a site where a development is to take place rather than for data on an estuary-wide basis, though peak counts for the whole site in each month are included in the standard Low Tide Count data request output. Dot density distribution maps and peak and average counts for each site and year are freely available in the WeBS Online Report if more context is needed. WeBS Partner organisations and country conservation agencies, also use WeBS Low Tide Counts scheme data for casework on issues such as coastal footpath development, wildfowling consents and designated site assessments. Depending on the nature of the work, requests from Partner organisations may be for data from a selection of sectors or all sectors of an estuary. Many individuals and teams within Partner organisations have direct access to WeBS Low Tide Counts scheme data through WeBS Online and so some use would not get recorded in the data request system. Further requests come from volunteers and researchers.

Within WeBS Online is an 'Explore Data' facility where raw counts can be downloaded directly. WeBS Partners and country agencies can access both WeBS Core and Low Tide Counts data for all sites; County Recorders and Low Tide Local Organisers can have access to sites in their specific county or region; and WeBS Volunteers can download data from their own site(s). The download facility in WeBS Online and auditing of usage was improved in June 2019, making analysis of Low Tide Counts scheme data downloads possible. For July–December 2019, volunteers completed 20 downloads for 53 count sectors and partners five downloads for 190 count sectors. In 2020, volunteers completed 53 downloads for 937 count sectors, and partners 10 downloads for 2,890 count sectors (Fig. 4.1). There has been a slight decline in the number of data requests received directly per year, which is likely to be related to the publishing of site level data on WeBS Report Online as Open Data and the improved access for Partner organisations and volunteers to additional count sector data through the WeBS Online database, reducing the need for bespoke requests. However, as a record is not available of how many downloads were carried out prior to June 2019, it is not possible to quantify this.

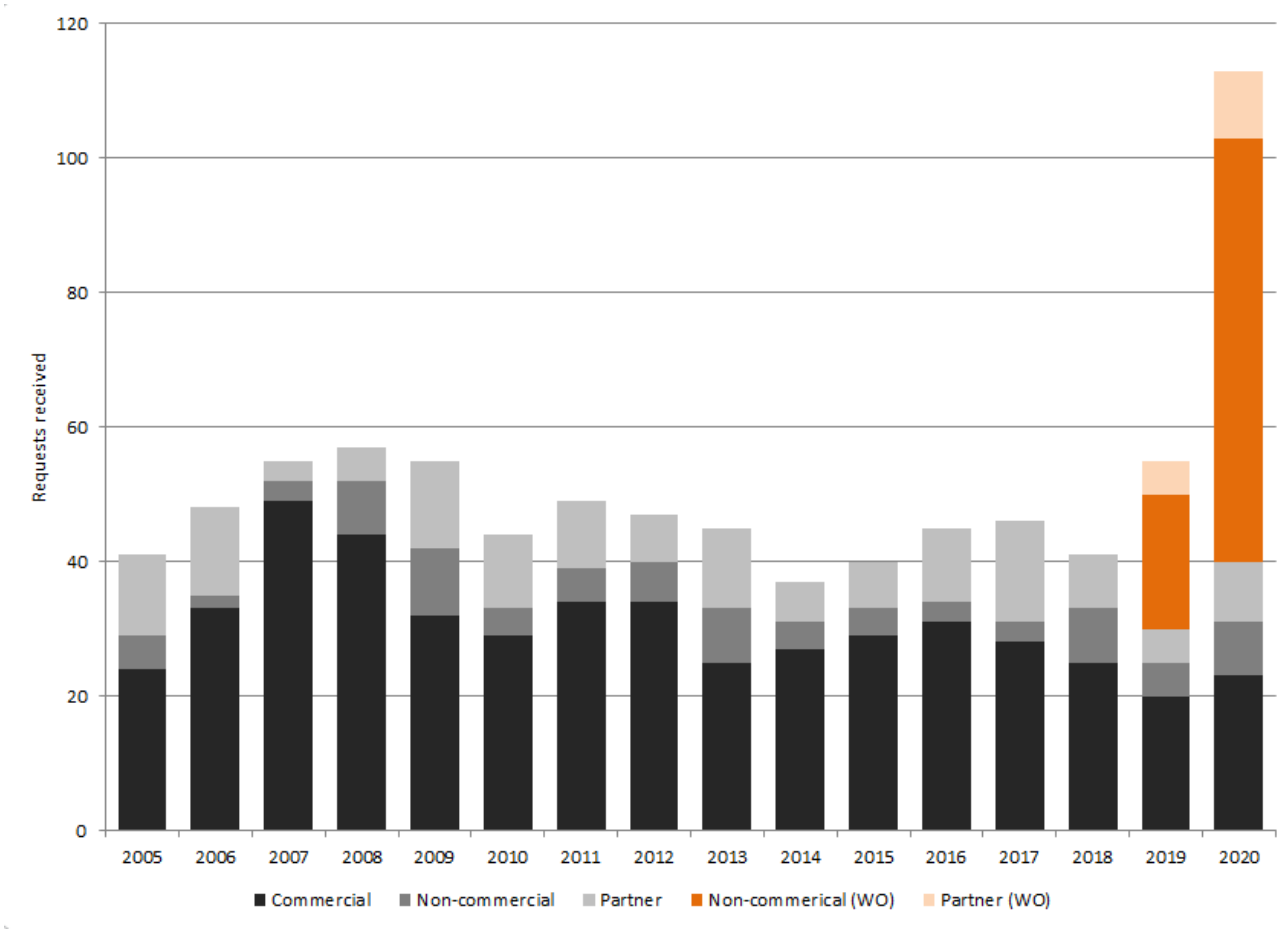
Table 4.1 Site and years in which WeBS Low Tide Counts have been used in the place of standard high tide counts in the WeBS Core Counts scheme. The number of counts that took place across multiple dates within a month (relative to the total number of monthly counts) is shown as an indication of the likelihood of double counting.

		Year															
Site	Monthly counts with multiple dates (total)	1992/93–2003/04	2004/05	2005/06	2006/07	2007/08	2008/09	2009/10	2010/11	2011/12	2012/13	2013/14	2014/15	2015/16	2016/17	2017/18	2018/19	2019/20
Blyth Estuary	0 (30)						Y	Y	Y	Y	Y	Y	Y	Y	Y	Y		
Helford Estuary	22 (34)								Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Kingsbridge Estuary	4 (47)					Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Poole Harbour	6 (51)		Y			Y	Y	Y	Y	Y	Y	Y	Y	Y		Y	Y	Y
Tamar Complex	44 (44)						Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y

Table 4.2. Summary of data requests to the WeBS Low Tide Counts scheme since 2005.

	Category			
Year	Partner	Standard	Volunteer/ Research/Education	Total
2005	12	24	5	41
2006	13	33	2	48
2007	3	49	3	55
2008	5	40	7	52
2009	13	32	10	55
2010	11	29	4	44
2011	10	34	5	49
2012	7	34	6	47
2013	12	25	8	45
2014	6	27	4	37
2015	7	29	4	40
2016	11	31	3	45
2017	15	28	3	46
2018	8	25	8	41
2019	5	20	5	30
2020	9	23	8	40
Total	**147 (20.6%)**	**483 (67.6%)**	**85 (11.9%)**	**715**

Figure 4.1. Summary of bespoke data requests to the WeBS Low Tide Counts scheme since 2005, plus recent download statistics from WeBS Online (WO). Download statistics prior to 2019 are not available.



4.3. Stakeholder questionnaire

An online questionnaire using Google Forms (Appendix A7) was produced and distributed in January 2021 to an initial list of 77 individuals identified as key users of WeBS Low Tide Counts data, based on data requests submitted to the BTO between 2018 and 2020. Responses could be returned anonymously or with contact details to allow feedback, while sharing the questionnaire to other interested parties in the recipient's contact network was encouraged. The aims of the questionnaire were to: i) improve our understanding of how the WeBS Low Tide Counts scheme data are currently being used; ii) identify what additional data may be of value to users to form the basis of discussion at the stakeholder workshop; and iii) investigate the potential to capture within the scheme additional data being collected as part of professional surveys.

In total, 18 responses were received to the questionnaire (Appendix A7), all from respondents who had previously known about the scheme and who indicated that the current outputs and reporting largely suited their requirements. Respondents who did identify themselves were mostly from country agencies with a few individuals from consultancies and non-governmental organisations (NGOs). The most common primary use of WeBS Low Tide Counts data was to consider species distribution and densities at a particular site and c. 75% of the respondents indicated that they used data from specific sites rather than for comparisons between multiple sites.

There was also more interest for data from specific sectors than for whole sites, although this was also likely to vary case by case (Fig. 4.2). The fact that sector counts may not be synchronous was generally not considered to be an issue although five of 18 respondents (28%) indicated it potentially could be for their applications.

The majority of responses indicated site coverage nationally has been adequate for their needs (Fig. 4.3). Stakeholders were more likely than not to use data from adjacent sites (six responses) to infer something about an area if data from the specific site of interest were not available (two responses). Stakeholders indicated a strong preference for more frequent annual coverage if additional survey effort was put into the scheme (Fig. 4.4). If the scheme was to be extended outside the core winter months then both the spring and autumn periods were indicated as valuable (Fig. 4.5).

Figure 4.2. Response to WeBS Low Tide Counts stakeholder questionnaire question "Do you mostly use data from whole sites or specific sectors?"

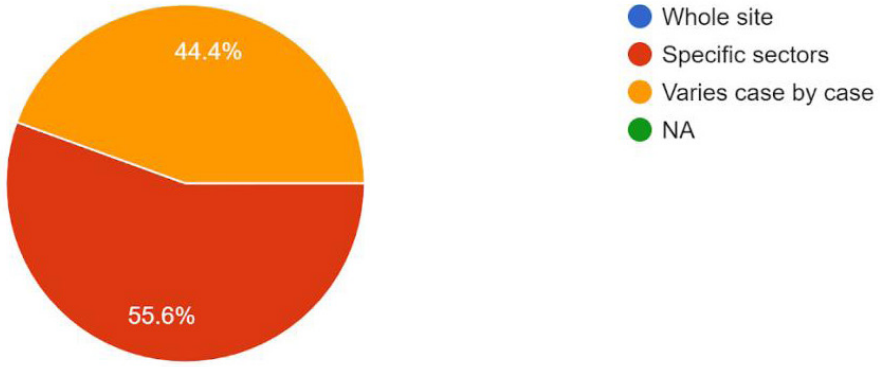


Figure 4.3. Response to WeBS Low Tide Counts stakeholder questionnaire question "Has site coverage been suitable for your requirements?"

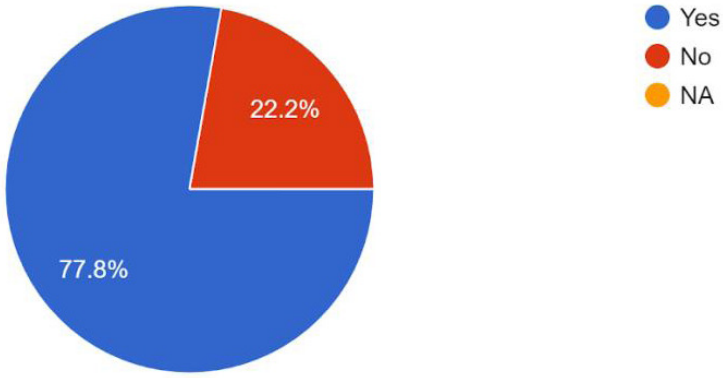
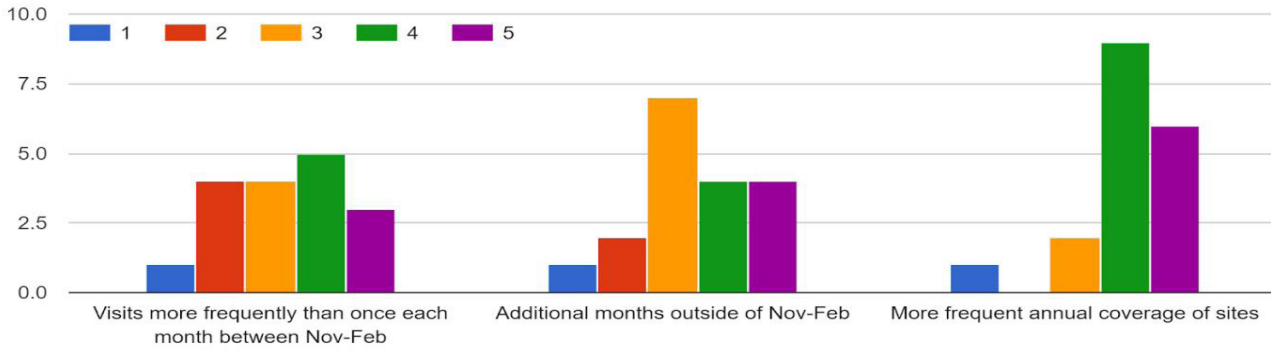


Figure 4.4. Response to WeBS Low Tide Counts stakeholder questionnaire question "If capacity within the scheme were to be increased or redistributed, which of the following options would be valuable to you? 1 (Not valuable at all) – 5 (Extremely valuable for my requirements)".



Seven (39%) of 18 respondents indicated that their organisations had undertaken independent counts of birds at low tide, mostly following the same protocols as WeBS Low Tide Counts, for specific projects. Three of these respondents also indicated that at least some of these data may be freely available for inclusion in the Low Tide Counts (Fig. 4.6), although that would likely vary depending on the specific details of each project. The most commonly requested additional data for the scheme to record was information on disturbance and species activity/behaviour at the time of the count.

Figure 4.5. Response to WeBS Low Tide Counts stakeholder questionnaire question "would Low Tide Count data from other times of year also be of value? 1 (Not valuable at all) – 5 (Extremely valuable for my requirements)".

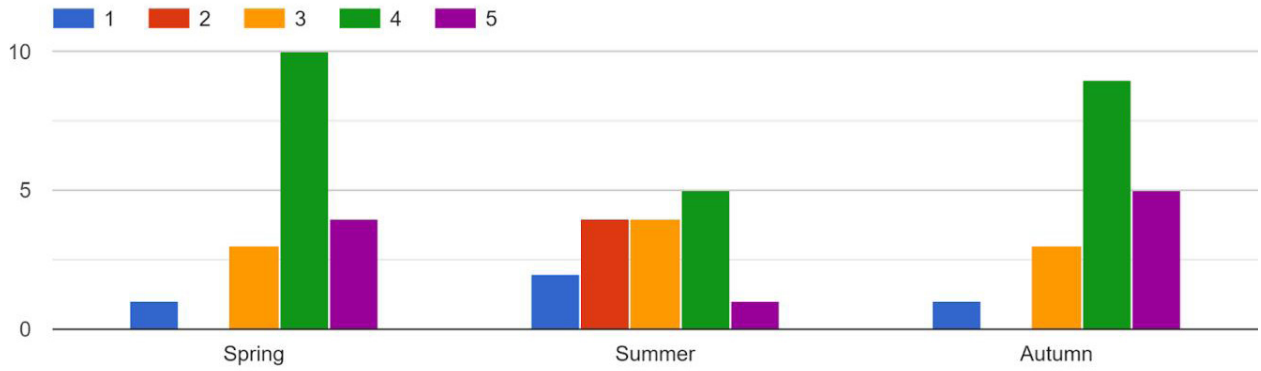
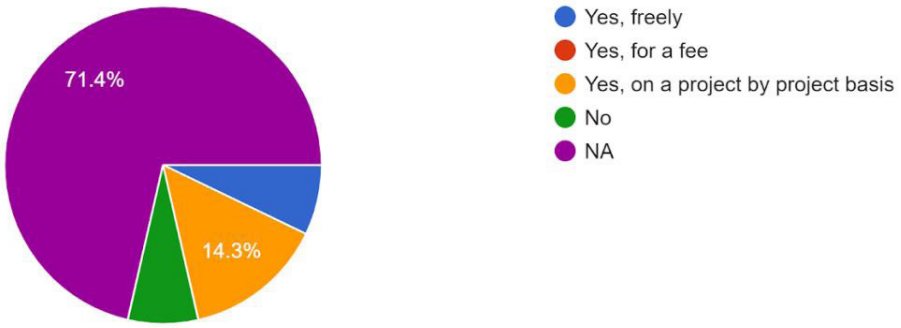


Figure 4.6. Response to WeBS Low Tide Counts stakeholder questionnaire question "If your organisation has carried out their own counts of birds at low tide, would any or all of those data be available to be included in the WeBS Low Tide Counts scheme?" n = 14 responses.



4.4. Stakeholder workshop

A virtual workshop was held in February 2021 to improve understanding of user requirements and discuss options for recommendations for improvements within the WeBS Low Tide Counts scheme based on individual experiences and initial results from the questionnaire circulated beforehand (see Section 4.3) and of the review of data coverage (Section 2.2). A total of 15 individuals attended the workshop representing the following stakeholders: ABPmer, BTO, JNCC, Natural England, Natural Resources Wales, NatureScot, Northern Ireland Environment Agency, RSPB and UK Centre for Ecology & Hydrology (UKCEH). All individuals were able to provide feedback to each agenda item during the workshop and via email following the workshop.

The agenda and the main topics discussed were:

1. WeBS Low Tide Counts scheme review – Objectives

i) Methods and coverage since 1992/93 for context

This included a presentation of some of the coverage summaries from Section 2.2 of this report.

2. Understanding user requirements

i) Data requests to BTO

The WeBS Low Tide Counts organiser gave a summary of data requests for the scheme as outlined in Section 4.2.

ii) Questionnaire

Preliminary responses to the stakeholder questionnaire were shared with the workshop attendees. There was support for bespoke recording priorities depending on the site and any designations or features as well as data collection outside of the winter period.

The questionnaire responses and workshop discussion also highlighted the value of collecting data at a finer spatial resolution and additional data on disturbance or behaviour to some users.

3. Understanding additional data sources
i) Availability of additional existing data

The potential for capturing additional count data from professional surveys to supplement or fill gaps in the WeBS Low Tide Counts dataset was discussed. The responses to the questionnaire suggest that these data may be available, and were collected using the same or similar methodology. However, it was raised that in the majority of cases, especially when collected for Environmental Impact Assessments, data would be confidential, at least until findings were published. It was not, therefore, considered to be a considerable source of new up-to-date data for the Low Tide Counts scheme although it could help fill historical gaps. It was also noted that the spatial survey units of professional surveys would often differ from those used in the WeBS Low Tide Counts scheme but making the sector boundaries used in the scheme available, publicly or directly to professional ecologists (likely during any data requests submitted to the BTO), may encourage the collection of more comparable data if it is also feasible to be included in the scheme.

ii) Non-standard sites – e.g. The Wash

UKCEH provided an overview of the transect approaches used on The Wash for low tide counts (e.g. Garbutt *et al.* 2010) which have been effective for this extensive site, but are labour intensive. There was particular interest around the use digital aerial imagery surveys, such as those trialled on The Wash (APEM 2018). The trade-offs between wider spatial coverage and accuracy in identification were discussed as well as the importance of shade and light conditions in species identification, not just the image resolution. The potential to use drones instead of low flying aircraft was also discussed but was generally thought that the validity of counts may be reduced using current options due to disturbance caused by the drone, as has been reported in published studies (Jarrett *et al.* 2020).

iii) Volunteer/professional/combination models for filling data gaps

Examples of sites which have benefited from funding, especially from country agencies, to ensure complete coverage of extensive areas or to collect supplementary data from other times of year were also discussed. There is annual contact both at a national and local level between the WeBS Low Tide Counts scheme organiser and country agencies to prioritise sites to be covered each year, taking into account urgency, and the feasibility of undertaking counts in that year. On the basis of this process of identifying higher priorty sites in a given year, funding may then be sought to supplement and support counts at those sites. The importance of being aware of volunteer capacity in different areas and the constraints this may place on additional coverage was particularly highlighted.

Ideally data are collected at the whole site level and not restricted to areas of particular interest (i.e. development potential) although if volunteer capacity is limited partial site coverage is preferred to nothing.

4. Gaining insights from scheme update
i) Methodology

ii) Understanding changes in distributions

Proposed methods from Section 3 were presented, although no results from the analysis were available at the time of the workshop. The discussion focused on previous points about understanding and prioritising user requirements, and whether understanding of the current variability in data collected might have implications for expanded or targeted data collection in the future (e.g. additional months or priority sites).

5. Recommendations/future actions
It was agreed that broad uniform recommendations for any new data collection efforts across the entire scheme should be followed where possible. However, some recommendations may need to be implemented with flexibility at local level to reflect site or species priorities.

6. AOB
Recent improvements in online reporting were discussed and attendees were positive that they help meet their needs.

It was noted that the dot density maps may be misinterpreted as showing the exact locations of birds if figure descriptions are not read.

The benefit of passing on qualitative information about particular sites from knowledgeable local observers to users making data requests, which may help with interpretation of data or planning additional professional coverage, was also noted.

5. DISCUSSION

5.1. Summary

Generally, spatial coverage within the WeBS Low Tide Counts scheme has been good, with data collected from 87 estuaries across the UK; for most of these sites, data were first recorded within the first 10 years of the scheme. Over the 28 years of the scheme from 1992/93 to 2019/20, sites have most frequently been covered on three occasions, although data for eight sites cover a single winter only. There are, however, relatively few sites (five) with long-term time series (>20 years) and site coverage meeting the recommended frequency of at least once every six years is poor, especially in Wales, Scotland and Northern England. However, for years when sites are covered, within-winter coverage is good with at least three monthly visits being achieved across the winter at an average of 88% of sites, which this review confirmed as an important objective in order to collect representative data.

Studies in the literature highlight that waterbird distributions within an estuary may change temporally, over the tidal cycle, within and between years. In the longer term, broad-scale distributions reflect the specific resources that species exploit and thus are unlikely to change considerably unless there are wider changes in the system which affect the quality or location of those resources. However, estuarine systems are dynamic and may also be impacted by human pressures. For a selected number of sites and species, for which long time-series of data were available, we explored the variation in sector counts over time using GAMs, subsampling to investigate the effect of frequency in coverage. Unfortunately, this approach was found to be limited with very poor model fit to the data and it was therefore considered unsuitable for providing a robust understanding of annual variation in waterbird distributions across the wide range of WeBS Low Tide Counts sites. An alternative non-parametric approach ranking individual sector counts and changes over time was consequently also considered and although it was not able to directly inform whether the six-year coverage target should be amended, it provided a potentially valuable and simple metric for comparing variability in within-site distributions between sites. For the example sites and species considered, the majority of sectors were relatively stable in their ranked importance for species over time, suggesting that distributions were relatively stable as well. Nevertheless, the example of Curlew did show that the relative importance of sectors over time may vary between sites and thus that some sites could benefit from more frequent coverage.

User requirements were considered through an appraisal of data requests, a questionnaire and a subsequent workshop attended by representatives from the country conservation agencies, NGOs and consultancies. Requests for WeBS Low Tide Counts data come from partners and country agencies (20.6% of requests), volunteers or research organisations (11.9%) and as standard data requests (67.6%). It is apparent that data are most widely used for site-specific projects, with data often requested for only a selection of sectors, usually to inform casework around new developments or activities which may cause disturbance. Responses received through the questionnaire and workshop highlighted a strong desire for more frequent annual coverage of sites, as well as for data collected outside of the core winter period, especially for sites which hold important numbers of species during autumn and spring passage periods.

It is also important to consider site practicalities with any longer-term planning and large sites such as the North Norfolk Coast, Firth of Forth, Severn Estuary and Humber Estuary are likely to only get counted with the help of funding to support gap-filling by professional fieldworkers due to the number of sectors and the number of counters and organisers involved. Many of the Scottish estuaries, such as the Moray, Dornoch and Cromarty Firths, have limited available counters and, again, funding may be needed for repeat counts. Such an approach has been used elsewhere, e.g. on the Colne Estuary, where more frequent counts have been required to inform local casework.

Other relatively small sites have also been very infrequently counted for the Low Tide Counts scheme, such as Blyth Estuary – Northumberland, Dundrum Bay, Glaslyn Estuary, Irvine/Garnock Estuary, Portland Harbour and Wear Estuary. Sites such as these have had lower priority in arranging counters and may continue to struggle to meet the recommended coverage targets but nonetheless still can provide some data so should continue to be encouraged in the Low Tide Counts scheme wherever possible.

5.2. Recommendations

Depending on the limitations of the current volunteer network, we make the following recommendations which could improve the value of WeBS Low Tide Counts data to users:

- To continue to support the delivery of the WeBS Low Tide Counts scheme outputs including summaries in the WeBS annual report and WeBS Report Online interface (Frost *et al.* 2021) which users can explore directly.
- To encourage observers to survey a larger sample of sites at least once every six years. This would be especially beneficial across Scotland, Wales and northern England where annual data gaps were more common (Fig. 2.3).
- To encourage WeBS Local Organisers and counters to use the "no count carried out" option

for sectors that weren't covered in a month, or "no waterbirds present" if a sector was visited and no birds were present, to reduce ambiguity on sector coverage.

- To allow wider flexibility for the months that Low Tide Counts may be carried out, as additional counts but not a replacement of November–February counts, and to communicate with the WeBS volunteer network regarding where additional months are likely to be most valuable. For example, for species whose abundance may peak outside of November–February or where they are listed as features of SPA sites. We would recommend, however, that the current outputs from the scheme still focus on the main winter period to ensure consistency with previously published data and to reduce the need for investment in new reporting features. Data from outside the main winter period could then be made available for users as part of data requests and WeBS Online *Explore Data* downloads. It should be made clear on the WeBS website that data for extra months is available via data requests.

- To communicate that, if effort is reduced during the main winter period for any reason, it would be preferable that at least three of the core winter months are still covered and single month coverage within a winter should be avoided where possible.

- To engage with consultants and agencies more proactively to see if data are available from professional surveys which could be available to be submitted to and made available within the WeBS Low Tide Counts scheme where appropriate. This may be through direct communication with larger industry organisations or as part of the data request process.

- Ensure that sufficient information regarding the sector coverage and coordination of multiple visits within a given month are provided with data requests to allow full interpretation of the data. Interpretation and guidance notes for appropriate use of Low Tide Count data should also be updated to refer to this review and highlight the challenges and limitations of parametric modelling approaches with Low Tide Count scheme data for most sites.

6. REFERENCES

APEM. (2018). Digital Aerial Imagery Proof of Concept Surveys – The Wash SPA. *APEM Scientific Report P00002312*. Natural England, May 2018, v4.0.

Atkinson, P.W., Clark, N.A., Bell, M.C., Dare, P.J., Clark, J.A. & Ireland, P.L. (2003). Changes in commercially fished shellfish stocks and shorebird populations in the Wash, England. *Biological Conservation* **114**: 127–141.

Austin, G.E., Boersch-Supan, P.H., Calbrade, N.A. & Ross-Smith, V. (2020). Analysis of Wetland Bird Survey (WeBS) Data for Lindisfarne National Nature Reserve: site and count sector-level trends winter 1993/94 to 2018/19. *BTO Research Report* **729**. British Trust for Ornithology, Thetford.

Bibby, C.J., Burgess, N.D., Hill, D.A. & Mustoe, S. (2000). *Bird Census Techniques*. Elsevier, London.

Buckland, S.T., Burt, M.L., Rexstad, E.A., Mellor, M., Williams, A.E. & Woodward, R. (2012). Aerial surveys of seabirds: the advent of digital methods. *Journal of Applied Ecology* **49**: 960–967.

Burton, P. J. K. (1974) *Feeding and feeding apparatus in waders*. British Museum (Natural History), London.

Burton, N.H., Armitage, M.J., Musgrove, A.J. & Rehfisch, M.M. (2002). Impacts of man-made landscape features on numbers of estuarine waterbirds at low tide. *Environmental Management* **30**: 0857–0864.

Burton, N.H., Musgrove, A.J. & Rehfisch, M.M. (2004). Tidal variation in numbers of waterbirds: how frequently should birds be counted to detect change and do low tide counts provide a realistic average? *Bird Study* **51**: 48–57.

Calbrade, N.A. (2013). Humber Estuary Low Tide Programme 2011/2012. *BTO Research Report* **642**. British Trust for Ornithology, Thetford.

Clark, N.A. & Prys-Jones, R.P. (1994). Low tide distribution of wintering waders and shelduck on the Severn Estuary in relation to the proposed tidal barrage. *Biological Journal of the Linnean Society* **51**: 199–217.

Dias, M.P., Granadeiro, J.P., Martins, R.C. & Palmeirim, J.M. (2006). Estimating the use of tidal flats by waders: inaccuracies due to the response of birds to the tidal cycle. *Bird Study* **53**: 32–38.

Evans, J. (1995). The use of WeBS low-tide counts in predicting the effects of habitat loss. In: *Effect of habitat loss and change on waterbirds*. pp.29-34. Eds: Goss-Custard, JD, Rufino, R. & Luis, A. The Stationary Office.

Frost, T.M., Calbrade, N.A., Birtles, G.A., Hall, C., Robinson, A.E., Wotton, S.R., Balmer, D.E. and Austin, G.E. 2021. *Waterbirds in the UK 2019/20: The Wetland Bird Survey*. BTO/RSPB/JNCC. Thetford.

Garbutt, A., Yates, M., Rispin, E. & Norris, D. (2010). Low tide survey of The Wash Special Protection Area. Final report of the winter 2009–10 shorebird survey. A NERC Centre for Ecology and Hydrology project on behalf of Natural England. *NERC CEH Project No.* C03788.

Gill, J.A., Norris, K., Potts, P.M., Gunnarson, T.G., Atkinson, P.W. & Sutherland, W.J. (2001). The buffer effect and large-scale population regulation in migratory birds. *Nature* **412**: 436–438.

Goss-Custard, J.D. (1977). The ecology of the Wash. III. Density-related behaviour and the possible effects of a loss of feeding grounds on wading birds (Charadrii). *Journal of Applied Ecology* **14**: 721–739.

Goss-Custard, J.D. (1985). Foraging behaviour of wading birds and the carrying capacity of estuaries. In: *Behavioural ecology: ecological consequences of adaptive behaviour.* pp.169–188. Eds: Sibly, R.M. & Smith, R.H. Blackwell Scientific, Oxford.

Granadeiro, J.P., Santos, C.D., Dias, M.P. & Palmeirim, J.M. (2007). Environmental factors drive habitat partitioning in birds feeding in intertidal flats: implications for conservation. *Hydrobiologia* **587**: 291–302.

Hartig, F. (2021). DHARMa: Residual Diagnostics for Hierarchical (Multi-Level / Mixed) Regression Models. R package version 0.4.3. https://CRAN.R-project.org/package=DHARMa

Jarrett, D., Calladine, J., Cotton, A., Wilson, M.W. & Humphreys, E. (2020). Behavioural responses of non-breeding waterbirds to drone approach are associated with flock size and habitat. *Bird Study* **67**: 190–196.

Johnston, A., Thaxter, C.B., Austin, G.E., Cook, A.S., Humphreys, E.M., Still, D.A., Mackay, A., Irvine, R., Webb, A. & Burton, N.H. (2015). Modelling the abundance and distribution of marine birds accounting for uncertain species identification. *Journal of Applied Ecology* **52**: 150–160.

Kingsford, R.T. & Porter, J.L. (2009). Monitoring waterbird populations with aerial surveys – what have we learnt? *Wildlife Research* **36**: 29–40.

Kingsford, R.T. (1999). Aerial survey of waterbirds on wetlands as a measure of river and floodplain health. *Freshwater Biology* **41**: 425–438.

Musgrove, A.J., Langston, R.H.W., Baker, H. & Ward, R.M. (eds). (2003). *Estuarine Waterbirds at Low Tide: the WeBS Low Tide Counts 1992/93 to 1998/99.* WSG/BTO/WWT/RSPB/JNCC, Thetford.

Musgrove, A.J., Collier, M.P., Banks, A.N., Calbrade, N.A., Hearn, R.D. & Austin, G.E. (2007). *Waterbirds in the UK 2005/06: the wetland bird survey.* BTO, WWT, RSPB and JNCC, Thetford.

Nehls, G. & Tiedemann, R. (1993). What determines the densities of feeding birds on tidal flats? A case study on Dunlin, *Calidris alpina*, in the Wadden Sea. Netherlands *Journal of Sea Research* **31**: 375–384.

Paracuellos, M. & Tellería, J.L. (2004). Factors affecting the distribution of a waterbird community: the role of habitat configuration and bird abundance. *Waterbirds* **27**: 446–453.

Pienkowski, M.W. (1983). The effect of environmental conditions on feeding rates and prey selection of shore plovers. *Ornis Scandinavica* **14**: 227–238.

R Core Team. (2019). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria.

Ravenscroft, N.O.M. & Beardall, C.H. (2003). The importance of freshwater flows over estuarine mudflats for wintering waders and wildfowl. *Biological Conservation* **113**: 89–97.

Rendón, M.A., Green, A.J., Aguilera, E. & Almaraz, P. (2008). Status, distribution and long-term changes in the waterbird community wintering in Doñana, south–west Spain. *Biological Conservation* **141**: 1371–1388.

Rosa, S., Palmeirim, J.M. & Moreira, F. (2003). Factors affecting waterbird abundance and species richness in an increasingly urbanized area of the Tagus estuary in Portugal. *Waterbirds* **26**: 226–232.

Rose, P.M. & Scott, D.A. (1997). *Waterfowl Populations Estimates* 2nd ed. Wetlands International, Wageningen.

Stroud, D. A., Chambers, D., Cook, S., Buxton, N., Fraser, B., Clement, P., Lewis, P., McLean, I., Baker, H. & Whitehead, S. (Eds.). (2001). *The UK SPA network: Its Scope and Content*. JNCC, Peterborough.

Stroud, D.A., Bainbridge, I.P., Maddock, A., Anthony, S., Baker, H., Buxton, N., Chambers, D., Enlander, I., Hearn, R.D., Jennings, K.R, Mavor, R., Whitehead, S. & Wilson, J.D. – on behalf of the UK SPA & Ramsar Scientific Working Group (eds). (2016). *The status of UK SPAs in the 2000s: the Third Network Review.* JNCC, Peterborough.

Vinicombe, K., Marchant, J. & Knox, A. (1993). Review of status and categorisation of feral birds on the British List. *British Birds* **86**: 605–614.

Wiersma, P. & Piersma, T. (1994). Effects of microhabitat, flocking, climate and migratory goal on energy expenditure in the annual cycle of Red Knots. *Condor* **96**: 257–279.

Yates, M.G., Garbutt, A., Rispin, E. & Brown, N. (2004). Low tide survey of The Wash Special Protection Area. Final Report of the winter 2002–2003 shorebird survey. *Natural England Research Report* No. **589**.

APPENDICES

APPENDIX 1. Current WeBS Low Tide Counts scheme methodology taken from Chapter 2 of Musgrove *et al.* (2003) which is available on the BTO website as a pdf.

SITE SELECTION

The scope of the WeBS Low Tide Counts (LTCs) is estuarine sites throughout the United Kingdom. When the LTCs were originally planned, the aim was to 'systematically census each of the 59 main UK estuaries (defined as those supporting more than 5,000 wintering waders) on a five-year rotational basis using standardised methods'. However, this initial plan was modified in subsequent years, for a number of reasons. The waders-only emphasis was removed and monitoring of all waterbirds (notably including ducks and Brent Geese) was considered equally important. Also, as well as the main sites initially chosen, a number of smaller sites were also covered, due to local enthusiasm by counters or local management plans and/or development pressures on those sites leading to a requirement for data. The five-year rotation was extended to a seven year cycle, to permit coverage of several sites where there were logistical difficulties in establishing a new counting scheme within the original time allocation and to cover an increased number of sites. Conversely, at a number of sites repeat counts were carried out on the initiative of the local counters, some even instigating LTCs on an annual basis.

It was always recognised that several very large sites (notably the Wash and Morecambe Bay) would be difficult to count. The problem with large estuaries (or rather, wide expanses of intertidal habitat) is that many birds may be present at very great distances, thus reducing an observer's ability to accurately determine the number and identity of birds present on the count section. Safety of counters has to be paramount and so they are discouraged from venturing out on to potentially dangerous intertidal habitats to record more distant birds. Although covering large sites requires the recruitment and co-ordination of large numbers of volunteers, this is not always an insurmountable obstacle. For example, excellent counts of the Moray Firth and Firth of Forth were achieved, both of which are large but relatively linear in shape. The potential of using aerial counts for counting waterbirds on estuaries like the Wash at low tide was examined (Musgrove & Holloway 1997). However, the conclusions were that any attempts to count large estuaries from the air were likely to lead to results which were not comparable with shore-based counts, owing to the possibility of missing a very large proportion of the numbers of some species. The WeBS Partners are reviewing how to tackle LTCs of large intertidal areas, including reconsideration of aerial survey techniques.

SPECIES COVERAGE

The principal groups of waterbirds of interest for the LTCs are waders and wildfowl, along with additional species characteristic of wetland habitats such as divers, grebes, cormorants, herons, rails, gulls, terns and Kingfisher. The species involved are discussed individually in the Species Accounts. As well as recording at the species level, separation at subspecific level is requested of counters for Brent Goose and White-fronted Goose. Recording the presence or absence of raptors is also requested, although treated as a category of 'activity/disturbance' (see below) as opposed to a bird count. Although data collection for all waterbird species is encouraged, recording of gulls and terns is optional at the discretion of the individual counter, as they are not priority species for the survey. This is because the counting and identification of gulls can be very time-consuming and consequently may compromise the quality of counts of the priority LTC species. Numbers of gulls on most estuaries vary more with the time of the day than with the state of the tide and many estuaries support important night-time roosts (Burton *et al.* 2002c). Since the LTCs take place between November and February very few terns are recorded.

COUNTERS AND LOCAL ORGANISERS

Most LTCs are carried out by volunteers with a keen interest in and knowledge of their local estuary. Many of these counters also take part in WeBS Core Counts at the same site. Each counter takes responsibility for a number of count sections, depending on the amount of time they can commit to the survey. To enable efficient administration of the survey, a 'Local Organiser' is selected to co-ordinate the counts at the site level and to provide a single point of contact for the national organiser. At the end of a winter, counters are requested to return their forms to their local organiser who can then check for completeness and for any obvious mistakes before returning them to the national organiser. In some cases, the local organiser is a local professional ornithologist, often a reserve warden, although many local organisers work purely in a voluntary capacity. At some sites, local nature reserve staff are among the counters. This has been especially helpful in situations where special equipment (such as boats) has been required or where public access is generally restricted. The co-ordinated network of volunteer fieldworkers forms the backbone of UK bird monitoring and is widely envied in other countries. Counters are experienced and skilled local birdwatchers and include many individuals possessing the most in depth knowledge of the birds using UK estuaries. The LTCs appear to have been a generally popular survey, partly because the local counters could see the obvious value of the counts and partly because the plan was to count each site at low tide only on a periodic basis, thereby time limiting the substantial commitment required.

SUBDIVISION OF SITES

The LTCs are organised around recognisable sites, which are then subdivided into smaller sections, leading to a two-tier count-unit hierarchy. Given their differing methodologies, a site counted for the Core Counts is not considered an identical entity to the same broad geographical site counted for the LTCs (although, clearly, there is a close relationship between the two). The principal distinction between Core Count and LTC site boundaries is their downshore limit. LTC sites are, by their very nature, precisely defined in terms of intertidal habitat, much of which may not be visible during Core Counts if the latter take place at high tide. WeBS Core Count site boundaries on estuaries are more likely to incorporate adjacent nontidal habitats, especially where these are important roost sites. Such nontidal habitats are also frequently surveyed during LTCs, especially where the area is used by waterbirds during the low tide period. Additionally, at low tide some estuarine species, such as grebes and diving ducks, are present on the water below the tideline. Counters are encouraged to record these species and to assign such counts to the nearest section. In general, the subdivision of a site into sections has been determined by local geography, identifiable features (natural and man-made), accessibility, ease of counting and existing Core Count sections, with a broad stipulation that sections should be relatively similar in size to one another. Generally, sections have been selected by the local organiser and counters themselves. A map of the subdivisions is then discussed with the national organiser. It is stressed that the same count sections should be used in subsequent count years. However, in a few cases, the experience gained from the first winter's survey led to the splitting of larger sections into several smaller ones, or vice versa, or sometimes to the addition of new count sections. Such details are fully described within the Site Accounts.

COUNT DATES AND TIMES

The LTCs take place during the four months of November to February inclusive and counters are asked to make one visit per month during this period. The mid-winter period was chosen partly because waterbird numbers on estuaries are at their highest then, partly to minimise between month variation in counts and partly because this is the time of year when feeding constraints are likely to be at their greatest. Although three dates were initially considered to be satisfactory, it was

decided that using four would allow for a certain amount of redundancy for missing counts due to factors such as poor weather. Although only one visit per month is requested, some counters do carry out more. In such cases, care is taken to select one count only in an unbiased fashion (i.e. without examining the actual numbers of birds counted). In most cases where multiple visits are made to a count section in a particular month, the visit on the date most consistent with the counts on neighbouring sections is taken to be the visit to use for analysis. Unlike the WeBS Core Counts, no pre-determined count dates are set at a national level but are decided upon by local organisers. Additionally, although simultaneous counts of all sections within a site are preferable, they are not compulsory. The principal reason for this is that the primary purpose of the scheme is to investigate relative distribution, averaged over several dates, and not to determine overall population sizes. Secondly, although weather conditions can affect the ease of carrying out any bird monitoring, conditions of fog, rain or strong winds make the counting of birds on distant mudflats particularly difficult and so the flexibility in count dates makes it possible to make best use of suitable counting conditions. Finally, given that most LTC participants also take part in the WeBS Core Counts which do occur on a predetermined date each month, it was thought useful to allow a degree of flexibility to encourage a high level of participation. LTC participants are asked to count during the two hours either side of low tide. There were several reasons for low tide being selected as the counting period. A key objective of the scheme is to record feeding distributions and studies have shown that for many of the specialist estuarine species, a high proportion of birds feed during this period (although this proportion varies between species – see Discussion). Also, since the position of the tideline (and thus the availability of food) is relatively stable during this period, changes in the numbers and distribution of waterbirds are consequently relatively small. Although the tideline varies between neap tides and spring tides, the fact that a mean low water (and high water) mark is shown on Ordnance Survey maps means that a standardised, repeatable measurement of area can be achieved. Finally, it is easiest to assign birds in the field to pre-defined count sections when all the features of the intertidal area are visible.

FIELD METHODS AND THE RECORDING FORM

Counters are provided with pre-prepared count forms on which to record counts of feeding and roosting birds, along with the date, section code and the start and finish times of the count. Additional details on count accuracy, weather, human activities, raptors and disturbance are also requested. The count forms include the basic instructions on how to carry out the survey. Some counters use their forms in the field whereas others record counts in their notebooks and transfer details to the form later.

DATA STORAGE AND VALIDATION

Once the count forms for a site over a winter have been received, they are checked for completeness and any apparent irregularities are discussed with the local organiser. The data from all forms are then input independently by two different people, using a customised inputting form. The two resulting sets of digital data are then checked against one another by computer and any

discrepancies are flagged, investigated and resolved. This ensures the virtual elimination of errors in the dataset due to inputting mistakes, since the chances of both people making the same inputting error are very small. Once both sets of data are the same, one set is loaded into the purpose-built LTC database.

Double-inputting, whilst effectively eliminating keyboard errors, cannot pick out other types of error. The most common of these are when a counter records a count against the wrong species (usually that adjacent on the count form to the intended target). Such errors can be easy to spot if, for example, an abnormally high count of an unlikely species occurs (e.g. a count of 50 Ringed Plovers mistakenly recorded as 50 Little Ringed Plovers). However, other mistakes in recording

can be much less obvious and in some cases are probably undetectable (e.g. a count of 20 Mallards mistakenly recorded as 20 Teal). The only chance of discovering such errors is to create tables of summary data and distribution maps of each species on the site (as discussed below) and to return these to the local organiser and counters for checking, which generally identifies any gross errors outstanding. At the end of the process of checking, inputting, validation and loading, the end result is a rigorously-derived definitive dataset.

AREAS AND DENSITIES

Whilst the collection of LTC data is concerned with making counts of birds, further presentation and analysis of results is based mostly around bird densities, for the simple reason that count sections are not of equal size. To calculate a density, it is clearly necessary to have an area measurement to divide a count by. Throughout the LTCs, areas are measured in hectares (1 ha = 100 m x 100 m) and consequently densities are given as birds per hectare (b/ha). To derive the areas of count sections, a map of the site is drawn carefully onto a photocopy of a 1:25,000 map of the area, although for Northern Ireland only maps at the 1:50,000 scale are available. A digitising tablet is then used to transfer the relevant features of each paper map into digital form for incorporation into a Geographical Information System (GIS). One of the many advantages of the use of a GIS for storing and manipulating maps is that the area of each section can be calculated automatically. This is not only far faster than using traditional methods, but is also less prone to error and, importantly, completely repeatable.

For the purposes of determining useful area measurements, each count section is subdivided into up to three zones. The intertidal zone is that situated between mean low water and mean high water, the subtidal zone is below mean low water (both in creeks and 'offshore') and the nontidal zone is found above mean high water – often saltmarsh (so strictly not entirely lacking a tidal influence) but sometimes grazing marshes, higher areas of sandflats, adjacent freshwater reserves, etc. It is important to note that these definitions apply only within the context of the LTCs and these terms may (and do) have different meanings elsewhere. Although it is usually straightforward to define the intertidal and nontidal extent of a count section on a map, the subtidal zone being surveyed is less readily delineated. It is taken throughout that the subtidal zone of a count section extends half way across a channel or, where the channel is wide or the section has a more 'open-coast' aspect, the subtidal zone is taken to extend an arbitrary 500m offshore. The area of each zone of each section is calculated separately by the GIS. To achieve this, the mean low water and mean high water marks around each site are also digitised. It should be noted, however, that on Ordnance Survey maps, whereas mean low water and mean high water are mapped for England and Wales, for Scotland the equivalent lines on the maps represent mean low water springs and mean high water springs. Thus, for the same actual area of intertidal habitat, a larger area will be depicted on a Scottish map than on an English or Welsh one. Unfortunately, there is no straightforward conversion factor, the difference between the two depending upon the gradient of the substrate between the two lines. Estuaries are mobile systems and although intertidal flats, saltmarshes and channels are often of relatively stable shape between years, at some sites major changes occur. This means that commercially available maps may diverge increasingly from reality over the years. Although a

counter can inform the national organiser that, for example, a particular saltmarsh has decreased in extent by 50% compared to that mapped, it is not straightforward to incorporate such information in a systematic fashion. Therefore, the commercial maps have to be taken as a standard, even where divergences are known to occur. This issue is discussed within the Site Accounts for those individual sites most affected. Aerial photographs have been suggested as a way to counteract this problem but in reality these are seldom taken frequently enough to allow a systematic determination of a mean low water mark. Although the density of birds on a count section is expressed as a count divided by an area, with a

basic knowledge of the ecological differences between species it is clear that it is not sensible to use the same area measurement for all species. For example, consider a count section of 100 ha in size, composed half of open mudflat and half of saltmarsh, on which a flock of 100 Knot was present. One might make the assumption that the Knot were evenly distributed over that count section, leading to a density of 1 b/ha. However, a basic knowledge of the feeding habits of Knot would tell us that they are seldom found feeding in saltmarsh and all or the majority would have been present on the mudflat, suggesting that the real density should be 2 b/ ha. Throughout this book, densities have been calculated in such a way so as to take into account such species specific habitat associations.

DISTRIBUTION MAPS

When data can be assigned to well-defined geographical areas, as is the case with the LTCs, the presentation of results in map form has many advantages over a simple tabulation of statistics since it enables an appreciation of the relationship between different count sections. The production of maps depicting bird distribution has been a major theme from the beginning of the LTCs, with GIS technology providing great versatility in the range of presentational options available. After examining the possibilities, 'dot density' maps were chosen as the preferred means of presentation. To create a dot-density map, the GIS is instructed to take a number of dots equal to the mean number of individuals of a species present in a count section and to place them randomly within the polygon representing the count section. Although the information presented is actually a number of dots, the fact that the number is spread across an area makes it equivalent to a density.

It is thus immediately apparent to anyone examining the map how the species is distributed across the site at low tide. Since the actual mean numbers are used for the display there is a continuous, not discrete, depiction of densities. The main potential misunderstanding arising from dot-density maps is that there is a tendency to equate the precise position of each dot with the precise position of a bird, whereas no conclusions should actually be drawn at a resolution greater than that of the count section. The higher the number of birds present, the less this is an issue. Ideally, one would distribute dots evenly within a count section, rather than randomly, but this has not been possible to date with the available software. On some distribution maps, there appear to be artificially sharp boundaries between the dots representing one count section and those representing a neighbouring one. Clearly, these sharp demarcations are a product of the count sections selected and, in many cases, the change from a high density to a low density would be far less marked in reality.

However, such marked changes in density may be realistic where there is a distinct change in habitat (such as with an isolated mussel scar, for example). It is thus important to assess maps on a case-by-case basis, with reference to any other available sources of information. In some cases, slight modifications have to be made. For example, there may be such large numbers of a species (e.g. Dunlin) on many count sections that it is not possible to differentiate between densities. In such a case, either the size of the individual dots can be reduced or else the GIS can be instructed to display, for example, one dot for every ten Dunlin. As with the calculation of densities discussed above, species-specific habitat associations have been applied in production of distribution maps and so, for example, Knot are plotted only on intertidal parts of a count section. Similarly, Great Crested Grebes would be plotted in the subtidal zone. Other species, less specialised in habitat use, have been assigned to more than one zone for mapping purposes (e.g. Curlew on both saltmarsh and mudflats).

Appendix 2. WeBS Online guidance

WeBS Core Counts

3 Guide to WeBS Online

After carrying out your counts, it is important to ensure that your records are transferred clearly either to WeBS Online or, if you don't have internet access, to a recording form (please see ***3a Completing a recording form***). Accuracy at this stage is equally as important as during your counts. Whilst we will notice obvious mistakes, e.g. a large count listed for the wrong species, there is little chance that we will spot smaller-scale errors, so please follow the instructions below carefully and check against your notebook to ensure you have transcribed your counts correctly. WeBS Online allows any counter with access to the internet to enter their WeBS counts themselves, removing the need for them to use the paper forms. Moreover, WeBS Online allows users access to past counts for their sites. Counters can also see their count section boundary map.

Use of WeBS Online is not compulsory. Whilst we are obviously keen that as many counters as possible benefit from the advantages of the system, we are fully aware that some counters do not have internet access and will be unable to use WeBS Online. In which case paper forms can be made available. Just let your Local Organiser know whether to expect paper or online returns from you.

Getting started

Registering for WeBS Online

Your way into WeBS Online is through the WeBS homepage at www.bto.org/webs. You have two options, depending upon whether or not you already use any of the BTO's other online surveys (such as BirdTrack, Breeding Bird Survey Online or Garden BirdWatch Online).

I have a BTO online account already

If you are an existing online user for one of BTO's other surveys, go to https://app.bto.org/websonline and select '***Existing BTO account- Sign up for WeBS Online***'. This will take you to your MyBTO page, where you can select ***'Sign Up'*** for WeBS. The WeBS Terms and Conditions will appear as a pop-up on screen; please read through and agree to the Terms and Conditions in order to complete your WeBS registration.

If you are not automatically redirected to the WeBS Data Home page, go to the WeBS hompage (www.bto.org/webs) and click on the orange ***'Go to Data Entry'*** button and log into WeBS online. You are now ready to start!

I don't have a BTO online account

If you are totally new to BTO online surveys, you will first need to create a MyBTO online account. Visit the BTO homepage (https://www.bto.org/) and select '***MyBTO***' in the top right hand corner. Press on ***'Register an Account start using My BTO today'*** where you will then be asked to create a username and password and fill in personal details. This password needs to be at least eight characters long, it must contain both upper and lower-case letters, a number and a punctuation/special character. You will see prompts on the page if any of these are missing from your chosen password, but please don't use any passwords you already use for internet banking or similarly sensitive ones. You need to remember this username and password to be able to use WeBS Online. Once you have completed all the boxes and agreed to the Terms and Conditions, please click on ***'Create New Account'***.

You will then be directed to your MyBTO homepage, where you will see a list of projects under ***'Sign Up for Projects'***. Select '***Sign Up***' for WeBS. The WeBS Terms and Conditions will appear as a pop up on screen; please read through and agree to the Terms and Conditions in order to complete your WeBS registration. Once you have agreed to the Terms and Conditions, the WeBS project will appear under the ***'My Current Projects'*** header (you may need to refresh the screen). Please click on the orange "***Go To Project***" button below the WeBS logo and log into WeBS online. You are now ready to start!

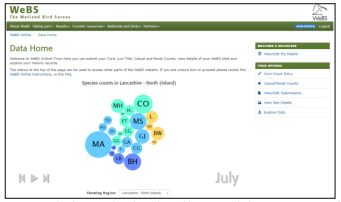
Once you're an active user

On subsequent visits simply go to the WeBS home page at www.bto.org/webs and click on the orange ***'Go to Data Entry'*** button from the options on the right-hand side of the page. You may need to enter your username and password to login to the system. You can also bookmark the data homepage itself: https://app.bto.org/websonline/

The Wetland Bird Survey (WeBS) is the monitoring scheme for non-breeding waterbirds in the UK which aims to provide the principal data for the conservation of their populations and wetland habitats. WeBS is a partnership, jointly funded by BTO, RSPB, JNCC, in association with WWT, with fieldwork conducted by volunteers.

WeBS Data Home

When you go into WeBS Online, you will find yourself at a page called ***WeBS Data Home***. From here, you can access all the different functions of WeBS Online that are available to you. You can also see a video visualisation of monthly species counts in your WeBS region (and other regions by selecting from the drop down). Hover over a circle to see the species name and count.



The following instructions aim to cover the main features, but note that instructions are also accessible online from this page. Most counters will have the same set of options open to them. However WeBS Local Organisers have additional functions to manage their local teams of counters; review any counts being submitted online; and input counts for any of the sections in their area. The ***'View/Edit My Details'*** option can be used to set your preferences.

Entering your counts into WeBS Online

Submitting Core & Low Tide Counts

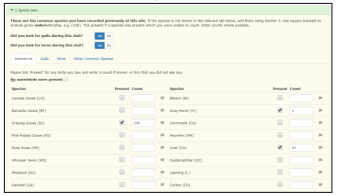
For standard WeBS counts, click on ***'Core & LT Count Entry'***.

First you will be asked to specify whether you are recording for a Core or Low Tide Count. Press the correct option. Record the visit details for the count in ***'1. Visit Details'***. Select the count section at which you recorded the count. If you want to record a count for a site that does not appear on the drop-down list then please contact the WeBS Office.

The date of the count must also be recorded and, ideally, the approximate start and end time, as well as ice cover and (for coastal sites) tidal state. Importantly, if you feel that your count did not accurately represent the true number of birds present, please record a count accuracy of ***'Low'*** and tell us why this was. There is also a facility to record extra details (e.g. additional counters, flooding, etc). Once you have completed this page, please scroll down to '***2. Species Seen***'.

If you are entering the first/only count for a site for a month (which will usually be the case), then this count will be treated as the ***"primary"*** count for that month. However, if you wish to add subsequent counts within a given month, you will be given the opportunity to specify which should be treated as the primary count. You can then enter your species counts.

The number of species you see on the form may vary depending upon your user preferences. To reduce the size of the form you have to look through, we have set WeBS Online to show you only those species previously recorded at that site. However, if there are less than 20 species recorded for a site, you will see the original full set of species from the paper recording form. However, you can change this by reducing the '**Preferred species list form size limiter**' in ***'View/Edit My Details'***.



To record your count, simply enter the count of each species you saw in the relevant box. If you recorded a species but were unable to make a count for some reason (e.g. insufficient time, birds flushed before you could count them, etc.) then simply tick the ***'Present'*** box. Please make a count wherever possible.

You can use the tab key to move from one species to the next. When you type a number, the ***'Present'*** box is automatically ticked for you. If you accidentally enter a count next to a species that was not present, please delete the number **and** untick the ***'Present'*** box.

If you feel your count was a significant underestimate of the numbers you would have been able to count under ideal conditions then please use [square brackets] to show this. Note however that if you have recorded an approximate count (e.g. circa 1500 Dunlin) then this does not need any brackets or additional notation.

If you do want to record any specific comments about a particular species then there is a comments box to click on against each species.

Important: If you visit your section and see no herons, rails, wildfowl or waders then please tick the box at the top to say "No waterbirds were present".

Gulls and terns are included as separate groups, with their own tabs at the top of this section. As has been the case with WeBS in the past, recording of these groups is optional, but we would encourage all WeBS counters to count gulls and terns unless they have a particularly good reason not to do so. The online system will automatically mark ***'Did you look for gulls/ terns during this visit?'*** at the top of this section as ***'Yes'*** unless you have changed your preferences in ***'View/Edit My Details'***. If you did not look for gulls/ terns, please change these to ***'No'*** by clicking on the option. Approximate counts or even just a ***'Present'*** tick are better than no counts at all. If you would have recorded gulls and terns but encountered none during your count, then please tick the box at the top of the gull tab and the terns tab to say ***'No gulls/terns were present'***.

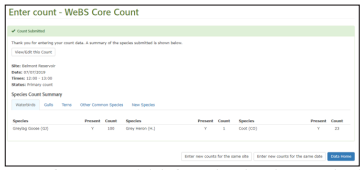
Important: if you have recorded no gulls or terns, it is crucial that we can determine whether a) these birds were truly absent (No gulls/terns were present), or b) these birds may have been present but you weren't recording them (*'No'* is selected for whether you looked for gulls/terns). The online system will therefore prompt you if you do not either enter a count, or select one of these, for both gulls and terns.

You can optionally record non-waterbird species commonly found at wetlands, such as Dipper, Reed Bunting or Marsh Harrier, in the ***'Other Common Species'*** tab if you wish.

If you come across a species not on the main list, simply scroll down to ***'3. New Species Seen'*** and on a new row, start typing or scroll through the list of additional species, and click on the species you want. It will then appear and you can enter the number present.

If there are not enough rows to cover all the additional species present, then click on the green ***'Add Row'*** at the bottom. Alternately, if you wish to clear a species added by mistake, click on the corresponding red bin button to the right of the species count and comment.

Once you've finished entering all the counts, click on ***'Submit Count'***. This will take you to a validation page, where a summary of your entered counts is shown for you to look at and make sure you haven't typed in a count for the wrong species, or added an extra zero to a number by mistake. The same tab sections are used here, so you will need to select the ***Waterbirds / Gulls / Terns / Other Common Species / New Species*** tabs to see all the species data that you entered.



If any essential information has been omitted, such as the date, ice cover or whether you recorded gulls, these will be highlighted as an error in red at the top of the page. **These must be addressed before the count can be submitted otherwise your count will not be saved.**

To try to help you spot inputting errors, you will sometimes be prompted by comments about the species, the numbers recorded or that you have only recorded a species as present and not given a count, with a validation warning in amber at the top of the page**. These warnings are an advisory check only and can often be disregarded.** However, they should hopefully reduce the number of midwinter Little Ringed Plover records that should have been entered in the Ringed Plover box!

From the Enter Count page, you can go back to make any corrections by pressing ***'View/Edit this Count'***. If you are satisfied you have recorded everything correctly, then the count has been submitted on the online database and you can close the page, or alternatively return to the WeBS ***'Data Home'*** or ***'Enter new counts for the same site'*** or ***'Enter new counts for the same date'*** if you have more data to input.

Submitting Casual & Roost Counts

From the WeBS Data home, the option to submit ***'Casual/Roost counts'*** is for incomplete counts when some species have been counted, but not necessarily all. Examples could be an evening gull roost count, or daily counts of Whimbrels at key passage sites. Such additional information can be of great use in supplementing the main counts. **NOTE** if you want to submit a second complete count (i.e. all species have been recorded) for a month, this should be done by clicking on ***'Core & LT Count Entry'***.

When submitting casual/roost counts, there are only two differences compared to the submission of standard counts. Firstly, you are asked to specify whether you are entering a casual daytime count, or a specifically targeted roost count (either dawn or dusk – enter the count times for us to know which). Secondly, you will see no pre-selected species names, but instead need to select any individual species

concerned from the dropdown box.

Viewing & editing past records

By clicking on ***'View/Edit Submissions'*** counters will be able to select the survey type and the site, which will then bring up a list of all the visits made to that site. By clicking on '***View/Edit'***, counters can view that count in more detail.

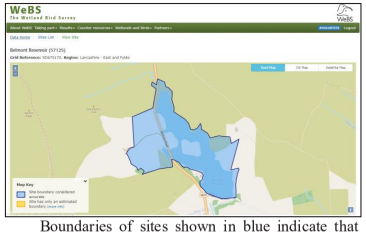
If you happen to carry out a core count of a section of a larger site, then you will also be able to view the consolidated total counts for the larger site. These totals are calculated annually, once data for all sections have been received (from online and paper form submissions), so you will not be able to see consolidated totals for the most recent year.

For individual count sections, you will be able to edit or delete a count only if a) you are the counter who made the count, and b) if the count has only been entered recently and has not been processed for annual reporting. If the record is editable, the relevant buttons are shown at the top of the page. If you can't edit a count, but notice an error, you can click on a link to send an email to the WeBS Team.

The BTO keeps a track of all edited or deleted data in case of mishaps.

Viewing your sites

Clicking on ***'View Site Details'*** brings up a list of all the sites you are connected with, either through counting or viewing those counts as part of 'complex sites'. You can view a UK map showing the position of your sites by using the ***'View Sites Map'*** button. More usefully, you can look at the boundaries of any of your count sites by clicking on the site name. This will show the boundary of the site, which can be viewed as a traditional 'road atlas' type map or a satellite map. The maps can be zoomed in and out of, and panned around using the onscreen arrows and zoom tools.



Boundaries of sites shown in blue indicate that the map is based on information received from WeBS counters. For some sites, boundaries have not yet been provided by counters and in many of these instances an approximate 'best guess' boundary has been provided; such approximate site boundaries are displayed in yellow.

If you have a site with a yellow or missing boundary then please send a map of the correct boundary to the WeBS office.

Summaries

Two facilities for summarising WeBS data are available for counters. The first, ***'Site Summary'***, provides the ability to compare the counts for a site across a range of years, or months within a particular year.

The second option, ***'Explore Data'***, allows counters to interrogate their data in any way they wish by downloading a dataset. You can select one or all sites, one or all species, and a variety of dates or date ranges. You will be given a summary of the data available to download and the option to download the result as a separate file in csv or xlsx format (e.g. for use in Excel or other packages). Further help is available for this facility within WeBS Online.

When to submit your counts

We recommend that you submit your counts as soon as possible after each count but not necessarily all. Examples could be an evening gull roost count, or daily counts of Whimbrels at key passage sites. Such additional information can be of great use in supplementing the main counts. **NOTE** if you want to submit a second complete count (i.e. all species have been recorded) for a month, this should be done by clicking on ***'Core & LT Count Entry'***.

When submitting casual/roost counts, there are only two differences compared to the submission of standard counts. Firstly, you are asked to specify whether you are entering a casual daytime count, or a specifically targeted roost count (either dawn or dusk – enter the count times for us to know which). Secondly, you will see no pre-selected species names, but instead need to select any individual species

promptly after the June count **but before the end of September of each year.** Thus, counts from July 2018 to June 2019 need to be submitted by the end of September 2019, and so on. We cannot guarantee that any data submitted after the end of September will be included in the annual report.

Appendix 3. WeBS Low Tide Counts scheme recording form.

LOW TIDE COUNT FORM

Site name can be provided here if useful for your filing purposes

This form is for recording numbers of waterbirds on estuaries at low tide, as part of the Wetland Bird Survey Low Tide Count scheme. Numbered sections below refer to those on the following pages. **Please use a new form for each month counted.** If you count more than five different sections in a month, please use more forms. Counting of gulls is optional but please specify whether or not these species are counted. Scarce waterbirds can be added to this form where necessary. If you wish to count species other than waterbirds (e.g. raptors, passerines), please submit these records to BirdTrack, as instructed on the back page of this form. Please conduct all counts within two hours either side of low tide.

1 **COUNTER CODE:** Please enter your counter code in the box provided. If you do not know your code, or if your address has changed, please provide your full name and address. Space is provided on the back page of the form for details of anyone else who assisted with the counts.

2 **SITE AND MONTH:** Please enter the name of the estuary you are counting and the month of the count..

3 **VISIT DETAILS:** For each section visited, please enter the section number, the date and the approximate start and end times of the count. Please use 24 hr clock for the times (e.g. 0900, 1300). Please consult your local organiser if you are unsure of the section number.

4 **WATERBIRD COUNTS:** Please stick to pre-defined count section boundaries and do not alter these without discussion with the Local Organiser or National Organiser. Where appropriate, include birds sitting on water out to a distance of about 500 offshore. Please count all waterbirds (i.e. grebes, divers, herons, wildfowl, rails and waders, including non-native birds and free-flying exotics, hybrids and escapes) and Kingfisher present within your count area during the visit. Recording of gulls and terns is optional. Please enter the number of each species counted in the appropriate box (do not separate counts of male and female birds). Blank lines are provided to record additional species not listed on the form.

- Use brackets to enclose gross UNDERestimates, e.g. [100].
- Write "NC" (No Count) in the appropriate box if a species was present which you were unable to count.
- Birds flying overhead should be excluded unless obviously using your count area.
- Please tick the box at the top of the section if you looked for those species but none was present. This will allow us to distinguish Nil Returns (no birds present) from No Counts (birds present but not counted), particularly in the case of gulls and terns since recording these groups is optional.
- Circle counts of Bean, Brent or White-fronted Geese if you could not identify the race involved, e.g. (80).
- Movements of birds between count sections often occur. Please record the birds present on a section while you are recording it, regardless of whether you suspect they have moved from another section. It is the relative importance of different parts of the site that is being recorded rather than an overall quantification of numbers on the whole site. However, it would also be useful if you could make a note in the 'Additional Information' section if you feel birds may have been double-counted.

5 **COUNT CONDITIONS:** Please give an approximate value for the percentage of the water area within your count area covered by ice.

6 **COVERAGE:** Recording of coverage is essential if we are to interpret your counts properly. Please circle whether you feel the counts provide a reasonably accurate reflection of the bird numbers in the count area at the time of your visit (OK) or if other factors prevented you from recording a significant number of the birds present (LOW). If your count was LOW, please tick the appropriate box(es) to indicate the factors which affected your count.

7 **ADDITIONAL INFORMATION:** Please provide any additional information you feel is relevant, particularly where you feel birds may have been double-counted or where you have made more than one visit during a month. You can also use this space to list any additional counters who took part.

Please return completed forms promptly to your WeBS Low Tide Counts Local Organiser

THANK YOU FOR YOUR HELP

BTO WWT RSPB JOINT NATURE CONSERVATION COMMITTEE

WeBS Office, BTO, The Nunnery, Thetford, Norfolk, IP24 2PU

1 COUNTER CODE						-					

If you have changed address or do not know your counter code, please provide your full name and address below

2 **ESTUARY NAME:**

MONTH (e.g. Nov-03):

If you are unsure how to complete any part of this form, full instructions for each numbered section are given on the front page.

3 COUNT SECTION						
Leave blank for office use						
DATE (e.g. 13/10/97)	/ /	/ /	/ /	/ /	/ /	
TIME (use 24 hour clock) Start (e.g. 0900)						
Finish (e.g. 1400)						

4 WATERBIRDS							
Please ✓ box if NO waterbirds were present	XX	❑	❑	❑	❑	❑	XX
Red-throated Diver	RH						RH
Black-throated Diver	BV						BV
Great Northern Diver	ND						ND
Little Grebe	LG						LG
Great Crested Grebe	GG						GG
Red-necked Grebe	RX						RX
Slavonian Grebe	SZ						SZ
Black-necked Grebe	BN						BN
Cormorant	CA						CA
Shag	SA						SA
Bittern	BI						BI
Little Egret	ET						ET
Grey Heron	H.						H.
Spoonbill	NB						NB
Mute Swan	MS						MS
Bewick's Swan	BS						BS
Whooper Swan	WS						WS
Taiga Bean Goose	XF						XF
Tundra Bean Goose	XR						XR
Pink-footed Goose	PG						PG
European White-fronted Goose	EW						EW
Greenland White-fronted Goose	NW						NW
Greylag Goose	GJ						GJ
Canada Goose	CG						CG
Barnacle Goose	BY						BY
Dark-bellied Brent Goose	DB						DB
Light-bellied Brent Goose	PB						PB
Egyptian Goose	EG						EG
Mandarin	MN						MN
Shelduck	SU						SU
Wigeon	WN						WN
Gadwall	GA						GA
Teal	T.						T.
Mallard	MA						MA
Pintail	PT						PT
Shoveler	SV						SV
Red-crested Pochard	RQ						RQ
Pochard	PO						PO
Tufted Duck	TU						TU
Scaup	SP						SP
Eider	E.						E.
Long-tailed Duck	LN						LN
Common Scoter	CX						CX
Velvet Scoter	VS						VS
Goldeneye	GN						GN
Smew	SY						SY

DATE	/ /	/ /	/ /	/ /	/ /	

4 WATERBIRDS (continued...)							
Red-breasted Merganser	RM						RM
Goosander	GD						GD
Ruddy Duck	RY						RY
Water Rail	WA						WA
Moorhen	MH						MH
Coot	CO						CO
Oystercatcher	OC						OC
Avocet	AV						AV
Ringed Plover	RP						RP
Golden Plover	GP						GP
Grey Plover	GV						GV
Lapwing	L.						L.
Knot	KN						KN
Sanderling	SS						SS
Little Stint	LX						LX
Curlew Sandpiper	CV						CV
Purple Sandpiper	PS						PS
Dunlin	DN						DN
Ruff	RU						RU
Jack Snipe	JS						JS
Snipe	SN						SN
Woodcock	WK						WK
Black-tailed Godwit	BW						BW
Bar-tailed Godwit	BA						BA
Whimbrel	WM						WM
Curlew	CU						CU
Spotted Redshank	DR						DR
Redshank	RK						RK
Greenshank	GK						GK
Green Sandpiper	GE						GE
Common Sandpiper	CS						CS
Turnstone	TT						TT
Kingfisher	KF						KF

GULLS: OPTIONAL SECTION							
Please ✓ box if NO gulls were present	XG	❑	❑	❑	❑	❑	XX
Mediterranean Gull	MU						MU
Black-headed Gull	BH						BH
Common Gull	CM						CM
Lesser Black-backed Gull	LB						LB
Herring Gull	HG						HG
Great Black-backed Gull	GB						GB
Kittiwake	KI						KI

COUNT SECTION						
DATE	/ /	/ /	/ /	/ /	/ /	

5 COUNT CONDITIONS

% of water area in count unit covered by ice						

6 COVERAGE

Do you feel your counts of waterbirds were reasonably accurate (circle 'OK') or did other factors (e.g. weather or disturbance) prevent you from recording a significant number of the birds present (circle 'LOW')?

Count accuracy	OK / LOW	OK / LOW	OK / LOW	OK / LOW	OK / LOW
If 'LOW', which of the following affected your count (please ✓ the appropriate box/boxes)?					
I did not cover all of my count area	❑	❑	❑	❑	❑
Poor visibility (due to fog, glare, heavy rain etc.)	❑	❑	❑	❑	❑
High levels of disturbance	❑	❑	❑	❑	❑

7 ADDITIONAL INFORMATION

Additional Counters: Please list the counter codes (or names and addresses) of any other observers who assisted with the counts.

FOR ALL RECORDS OF NON-WATERBIRDS (E.G. PASSERINES, RAPTORS, ETC)
PLEASE MAKE USE OF BIRDTRACK.

This is an online scheme designed to increase the personal, local and national value of your sightings.
Go to www.bto.org/birdtrack/index.htm to find out more.

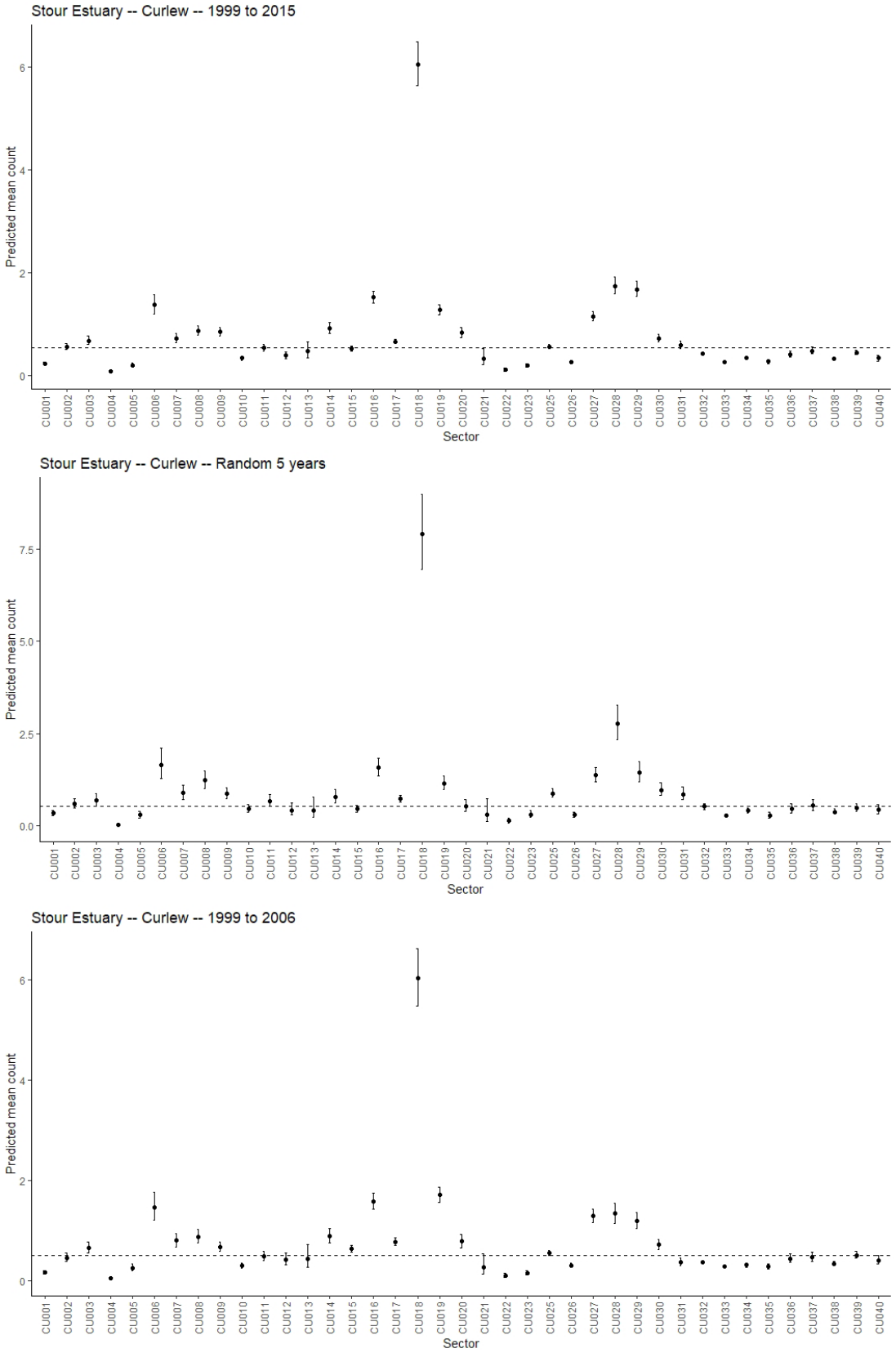
Appendix 4. Scientific names for all species listed in this report

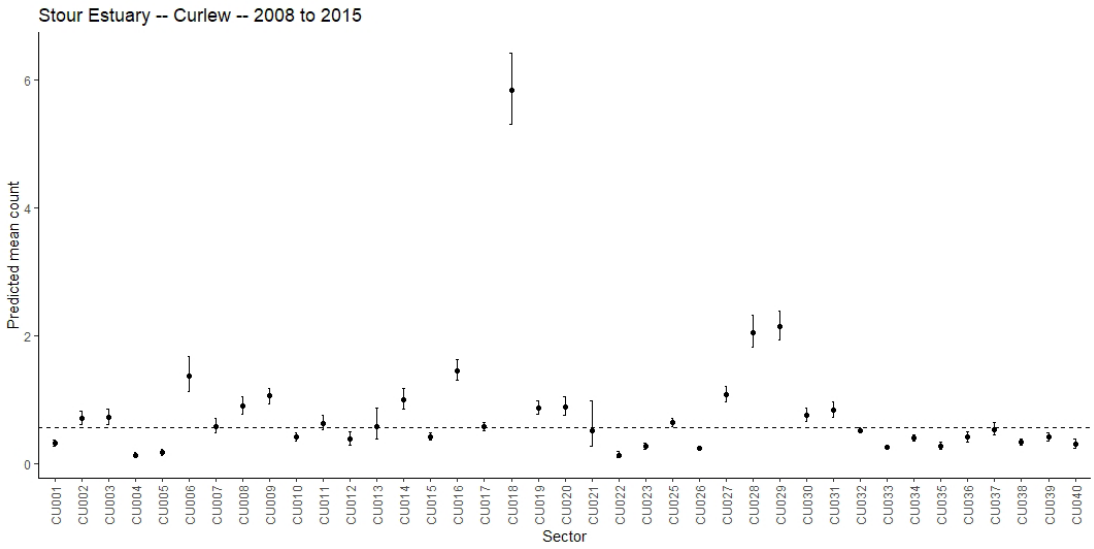
Common name	Scientific name
Avocet	*Recurvirostra avosetta*
Barnacle Goose	*Branta leucopsis*
Bar-tailed Godwit	*Limosa lapponica*
Black-headed Gull	*Chroicocephalus ridibundus*
Black-tailed Godwit	*Limosa limosa*
Brent Goose	*Branta bernicla*
Canada Goose	*Branta canadensis*
Common Gull	*Larus canus*
Cormorant	*Phalacrocorax carbo*
Curlew	*Numenius arquata*
Dunlin	*Calidris alpina*
Eider	*Somateria mollissima*
Golden Plover	*Pluvialis apricaria*
Goldeneye	*Bucephala clangula*
Great Black-backed Gull	*Larus marinus*
Great Crested Grebe	*Podiceps cristatus*
Grey Heron	*Ardea cinerea*
Grey Plover	*Pluvialis squatarola*
Greylag Goose	*Anser anser*
Herring Gull	*Larus argentatus*
Knot	*Calidris canutus*
Lapwing	*Vanellus vanellus*
Lesser Black-backed Gull	*Larus fuscus*
Little Egret	*Egretta garzetta*
Little Grebe	*Tachybaptus ruficollis*
Mallard	*Anas platyrhynchos*
Mute Swan	*Cygnus olor*
Oystercatcher	*Haematopus ostralegus*
Pink-footed Goose	*Anser brachyrhynchus*
Pintail	*Anas acuta*
Red-breasted Merganser	*Mergus serrator*
Redshank	*Tringa tetanus*
Ringed Plover	*Charadrius hiaticula*
Sanderling	*Calidris alba*
Shelduck	*Tadorna tadorna*
Teal	*Anas crecca*
Turnstone	*Arenaria interpres*
Wigeon	*Mareca penelope*

Appendix 5. Predicted mean sector counts of Curlew at the Stour Estuary from generalised additive models (GAMs), based on sampling WeBS Low Tide Counts scheme data from 1996/97 to 2018/19.

The mean sector count (averaged across all within winter counts) was modelled as a function of sector with a Poisson error distribution and log-link function. Year was included as a smoothing parameter to account for autocorrelation in trends of counts over time and the log of sector area included as an offset.

Figure A5.1. Predicted mean sector counts of Curlew at the Stour Estuary from generalised additive models (GAMs), based on sampling WeBS Low Tide Counts scheme data from 1996/97 to 2018/19.




Stour Estuary -- Curlew -- 2008 to 2015
Predicted mean count
0
2
4
6
CU001
CU002
CU003
CU004
CU005
CU006
CU007
CU008
CU009
CU010
CU011
CU012
CU013
CU014
CU015
CU016
CU017
CU018
CU019
CU020
CU021
CU022
CU023
CU025
CU026
CU027
CU028
CU029
CU030
CU031
CU032
CU033
CU034
CU035
CU036
CU037
CU038
CU039
CU040
Sector

Appendix 6. Spearman's rank correlation tests between the mean sector rank (of mean counts) and year, based on WeBS Low Tide Counts scheme data from 1996/97 to 2018/19 for the Stour and Orwell Estuaries, used to produce Table 3.2 in main document.

Site	Species	Sector	Estimate	Statistic	p.value
Stour	Curlew	CU019	0.746184	207.114	0.000582
Stour	Curlew	CU001	-0.72168	1404.894	0.001074
Stour	Curlew	CU015	0.690845	252.2702	0.002136
Stour	Curlew	CU029	-0.63139	1331.215	0.00656
Stour	Curlew	CU012	0.556925	361.5496	0.02022
Stour	Curlew	CU034	-0.54211	1258.358	0.024575
Stour	Curlew	CU009	-0.53211	1250.205	0.0279
Stour	Curlew	CU031	-0.52997	1248.459	0.028655
Stour	Curlew	CU007	0.497543	410.0049	0.042132
Stour	Curlew	CU005	0.4923	414.2832	0.044698
Stour	Curlew	CU023	-0.47398	1202.769	0.054594
Stour	Curlew	CU032	-0.41652	1155.882	0.096284
Stour	Curlew	CU016	0.403447	486.7874	0.108301
Stour	Curlew	CU017	0.356321	525.2418	0.16037
Stour	Curlew	CU028	-0.35583	1106.356	0.16099
Stour	Curlew	CU036	0.350772	529.7697	0.16745
Stour	Curlew	CU027	0.300195	571.0409	0.241717
Stour	Curlew	CU006	0.297665	573.1054	0.245901
Stour	Curlew	CU040	0.292237	577.5343	0.255031
Stour	Curlew	CU003	-0.28114	1045.41	0.274345
Stour	Curlew	CU010	-0.25231	1021.885	0.328573
Stour	Curlew	CU026	0.242945	617.7569	0.347437
Stour	Curlew	CU037	-0.24246	1013.85	0.348423
Stour	Curlew	CU004	0.236639	622.9028	0.360479
Stour	Curlew	CU002	-0.23587	1008.472	0.362081
Stour	Curlew	CU013	-0.2131	989.8905	0.411527
Stour	Curlew	CU021	0.183406	666.341	0.481051
Stour	Curlew	CU011	-0.16739	952.5871	0.520784
Stour	Curlew	CU035	0.148833	694.5527	0.568609
Stour	Curlew	CU033	-0.13713	927.8949	0.599715
Stour	Curlew	CU039	0.134572	706.1896	0.606593
Stour	Curlew	CU025	-0.1186	912.774	0.650302
Stour	Curlew	CU020	-0.11649	911.0583	0.65614
Stour	Curlew	CU018	0.064602	763.2845	0.805427
Stour	Curlew	CU014	-0.063	867.4112	0.810158
Stour	Curlew	CU030	-0.05893	864.0885	0.822237
Stour	Curlew	CU008	-0.02824	839.0424	0.914328
Stour	Curlew	CU022	-0.01905	831.5428	0.942157
Stour	Curlew	CU038	-0.00741	822.0446	0.97749
Stour	Dunlin	CU025	0.689664	253.2346	0.002189
Stour	Dunlin	CU019	0.62362	307.1257	0.007473
Stour	Dunlin	CU035	-0.57319	1283.723	0.016159
Stour	Dunlin	CU010	-0.52009	1240.394	0.032348
Stour	Dunlin	CU016	-0.51336	1234.906	0.035062
Stour	Dunlin	CU027	0.50889	400.7455	0.036962

Site	Species	Sector	Estimate	Statistic	p.value
Stour	Dunlin	CU014	-0.49785	1222.247	0.041985
Stour	Dunlin	CU018	0.489872	416.2645	0.045925
Stour	Dunlin	CU003	-0.48734	1213.672	0.04723
Stour	Dunlin	CU026	0.448128	450.3272	0.07123
Stour	Dunlin	CU029	-0.44404	1178.335	0.074169
Stour	Dunlin	CU031	-0.41931	1158.159	0.093849
Stour	Dunlin	CU009	0.404447	485.9715	0.107346
Stour	Dunlin	CU032	-0.38807	1132.667	0.123744
Stour	Dunlin	CU015	0.382251	504.0829	0.129974
Stour	Dunlin	CU030	-0.35323	1104.239	0.164283
Stour	Dunlin	CU033	0.315666	558.4168	0.217111
Stour	Dunlin	CU039	-0.30098	1061.603	0.240422
Stour	Dunlin	CU022	-0.2463	1016.98	0.340611
Stour	Dunlin	CU034	-0.217	993.0737	0.402812
Stour	Dunlin	CU006	0.214421	641.0324	0.408567
Stour	Dunlin	CU021	-0.20338	981.9592	0.433671
Stour	Dunlin	CU008	0.188543	662.1492	0.468631
Stour	Dunlin	CU023	0.18316	666.5414	0.481648
Stour	Dunlin	CU004	-0.1656	951.1292	0.525307
Stour	Dunlin	CU036	-0.15461	942.165	0.553507
Stour	Dunlin	CU002	-0.14862	937.2699	0.569181
Stour	Dunlin	CU038	-0.12308	916.4317	0.637922
Stour	Dunlin	CU020	0.114251	722.7712	0.662385
Stour	Dunlin	CU001	-0.10449	901.2616	0.689825
Stour	Dunlin	CU040	0.09822	735.8525	0.707636
Stour	Dunlin	CU007	-0.09735	895.4393	0.710113
Stour	Dunlin	CU037	0.081534	749.4679	0.755735
Stour	Dunlin	CU013	-0.07296	875.5346	0.780801
Stour	Dunlin	CU005	-0.06107	865.8314	0.815896
Stour	Dunlin	CU012	-0.05436	860.3547	0.835855
Stour	Dunlin	CU028	0.019741	799.8911	0.940054
Stour	Dunlin	CU011	-0.01351	827.0271	0.958946
Stour	Dunlin	CU017	0.001241	814.9875	0.996229
Stour	Wigeon	CU036	-0.87016	1526.052	5.61E-06
Stour	Shelduck	CU039	0.745699	207.5092	0.000589
Stour	Wigeon	CU015	0.733221	217.6914	0.000811
Stour	Wigeon	CU017	0.729196	220.9758	0.000896
Stour	Wigeon	CU027	0.715526	232.1308	0.00124
Stour	Wigeon	CU014	-0.70805	1393.773	0.00147
Stour	Shelduck	CU011	0.701909	243.2425	0.001685
Stour	Wigeon	CU037	-0.68065	1371.414	0.002635
Stour	Shelduck	CU013	-0.62614	1326.933	0.007166
Stour	Wigeon	CU031	-0.61662	1319.163	0.008381
Stour	Shelduck	CU019	-0.60383	1308.725	0.010265
Stour	Shelduck	CU040	-0.59125	1298.46	0.012431

Site	Species	Sector	Estimate	Statistic	p.value
Stour	Wigeon	CU029	0.573899	347.6988	0.015998
Stour	Shelduck	CU030	-0.56687	1278.567	0.017652
Stour	Shelduck	CU001	0.535223	379.2577	0.02683
Stour	Wigeon	CU025	0.494468	412.5139	0.043623
Stour	Wigeon	CU038	-0.47192	1201.086	0.055803
Stour	Shelduck	CU028	-0.47146	1200.708	0.056078
Stour	Shelduck	CU029	-0.46654	1196.7	0.059047
Stour	Shelduck	CU010	0.45662	443.3984	0.065403
Stour	Shelduck	CU007	-0.4372	1172.753	0.07928
Stour	Shelduck	CU038	0.414685	477.6174	0.097913
Stour	Shelduck	CU018	-0.40025	1142.601	0.111397
Stour	Shelduck	CU031	-0.38794	1132.556	0.123888
Stour	Wigeon	CU034	0.383766	502.8466	0.128332
Stour	Shelduck	CU009	0.372543	512.0049	0.140843
Stour	Shelduck	CU033	0.368459	515.3373	0.145596
Stour	Wigeon	CU035	-0.36152	1111.004	0.153918
Stour	Shelduck	CU002	0.361289	521.188	0.154205
Stour	Wigeon	CU003	-0.35749	1107.716	0.158899
Stour	Wigeon	CU040	-0.35468	1105.422	0.162437
Stour	Shelduck	CU016	0.337631	540.4931	0.185047
Stour	Wigeon	CU033	-0.3317	1086.667	0.193376
Stour	Shelduck	CU012	-0.27845	1043.215	0.279157
Stour	Shelduck	CU025	-0.26531	1032.494	0.303396
Stour	Shelduck	CU022	-0.25986	1028.042	0.313818
Stour	Shelduck	CU032	0.251407	610.8518	0.330366
Stour	Wigeon	CU021	-0.24375	1014.902	0.345787
Stour	Wigeon	CU028	-0.24216	1013.606	0.349036
Stour	Wigeon	CU019	0.235873	623.5277	0.362081
Stour	Wigeon	CU020	0.214024	641.3567	0.409457
Stour	Wigeon	CU013	-0.20112	980.1099	0.438921
Stour	Wigeon	CU018	0.200123	652.6995	0.441229
Stour	Shelduck	CU020	-0.19323	973.6778	0.457434
Stour	Shelduck	CU014	-0.19089	971.7654	0.463012
Stour	Wigeon	CU005	0.189247	661.5741	0.46694
Stour	Wigeon	CU010	0.188077	662.5291	0.46975
Stour	Wigeon	CU004	0.181573	667.8362	0.485519
Stour	Wigeon	CU002	-0.17701	960.4432	0.496725
Stour	Wigeon	CU012	-0.17345	957.5378	0.50556
Stour	Shelduck	CU036	0.168035	678.8832	0.519145
Stour	Wigeon	CU026	0.160399	685.1148	0.538575
Stour	Shelduck	CU023	-0.15951	946.1596	0.540859
Stour	Wigeon	CU023	-0.15252	940.4584	0.55895
Stour	Wigeon	CU007	-0.14911	937.6729	0.567883
Stour	Shelduck	CU005	0.147377	695.7407	0.57244
Stour	Shelduck	CU003	0.141278	700.7171	0.588604
Stour	Wigeon	CU030	0.136532	704.5896	0.601311
Stour	Shelduck	CU034	-0.12223	915.7361	0.640269
Stour	Shelduck	CU004	0.111582	724.9487	0.669846
Stour	Wigeon	CU008	-0.11002	905.7734	0.674238

Site	Species	Sector	Estimate	Statistic	p.value
Stour	Shelduck	CU008	-0.10578	902.3179	0.686165
Stour	Shelduck	CU035	0.105717	729.7353	0.686349
Stour	Wigeon	CU016	-0.09883	896.645	0.705896
Stour	Shelduck	CU037	0.087494	744.6052	0.738448
Stour	Wigeon	CU006	-0.0773	879.0773	0.768083
Stour	Wigeon	CU022	0.073938	755.6664	0.777928
Stour	Shelduck	CU026	0.071341	757.7856	0.785554
Stour	Wigeon	CU001	0.059669	767.3098	0.820046
Stour	Shelduck	CU021	-0.04597	853.5091	0.860936
Stour	Wigeon	CU011	-0.02589	837.1299	0.921417
Stour	Shelduck	CU027	-0.02349	835.1651	0.928706
Stour	Shelduck	CU015	0.020885	798.9582	0.936588
Stour	Wigeon	CU039	0.019705	799.921	0.940165
Stour	Wigeon	CU009	-0.01481	828.0817	0.955024
Stour	Wigeon	CU032	-0.01356	827.068	0.958794
Stour	Shelduck	CU006	0.012285	805.9754	0.962676
Stour	Shelduck	CU017	-0.00743	822.0635	0.977419
Orwell	Curlew	EW015	0.990947	13.94161	4.91E-18
Orwell	Curlew	EW005	0.66624	39210.07	1.04E-12
Orwell	Curlew	EW037	0.672323	17168.32	3.43E-10
Orwell	Curlew	EW003	0.674596	11711.3	3.43E-09
Orwell	Curlew	EW011	0.508413	52105.78	5.81E-07
Orwell	Curlew	EW016	-0.8057	2401.579	1.81E-05
Orwell	Curlew	EW030	-0.51498	57296.51	2.17E-05
Orwell	Curlew	EW006	-0.40693	149127.1	0.000101
Orwell	Curlew	EW010	0.417516	30518.67	0.000397
Orwell	Curlew	EW004	0.728027	310.0487	0.00041
Orwell	Curlew	EW017	-0.35918	154353.5	0.000589
Orwell	Curlew	EW032	0.806297	70.5078	0.000871
Orwell	Curlew	EW009	-0.66539	2214.972	0.001366
Orwell	Curlew	EW029	-0.41581	33166.76	0.002172
Orwell	Curlew	EW024	-0.58038	2101.9	0.007299
Orwell	Curlew	EW028	0.43118	2556.848	0.017364
Orwell	Curlew	EW013	0.636364	104	0.026097
Orwell	Curlew	EW036	0.72394	23.18904	0.042307
Orwell	Curlew	EW022	-0.26463	31367.9	0.055506
Orwell	Curlew	EW014	-0.41121	2173.271	0.064035
Orwell	Curlew	EW026	-0.18201	54088.89	0.146749
Orwell	Curlew	EW035	-0.27784	2263.059	0.210587
Orwell	Curlew	EW008	-0.3211	898.3486	0.225262
Orwell	Curlew	EW027	0.280787	956.5531	0.23046
Orwell	Curlew	EW002	0.7	6	0.233333
Orwell	Curlew	EW039	0.382114	135.935	0.246163
Orwell	Curlew	EW031	-0.15169	25452.37	0.287964
Orwell	Curlew	EW019	0.123939	36500.2	0.333156
Orwell	Curlew	EW041	-0.06299	55694.51	0.609814
Orwell	Curlew	EW038	0.062994	49093.49	0.609814
Orwell	Curlew	EW033	0.060455	22009.78	0.670296
Orwell	Curlew	EW018	-0.04545	99614.32	0.683296

Site	Species	Sector	Estimate	Statistic	p.value
Orwell	Curlew	EW025	0.087619	1213.467	0.713379
Orwell	Curlew	EW007	-0.05711	862.6055	0.82764
Orwell	Dunlin	EW037	-0.83183	91803.98	2.83E-18
Orwell	Dunlin	EW030	-0.83387	69357.02	7.29E-17
Orwell	Dunlin	EW019	-0.91711	10459.76	1.63E-13
Orwell	Dunlin	EW006	-0.55159	147841.4	6.50E-08
Orwell	Dunlin	EW018	0.652865	8610.328	1.17E-07
Orwell	Dunlin	EW017	0.514569	27744.83	5.19E-06
Orwell	Dunlin	EW005	0.473719	38497.43	1.54E-05
Orwell	Dunlin	EW031	-0.6875	6166.127	5.30E-05
Orwell	Dunlin	EW003	0.534471	3323.88	0.000942
Orwell	Dunlin	EW033	-0.92593	161.7778	0.00096
Orwell	Dunlin	EW016	-0.67451	2227.097	0.001106
Orwell	Dunlin	EW011	0.306633	70959.21	0.004314
Orwell	Dunlin	EW026	-0.35747	41886.07	0.006336
Orwell	Dunlin	EW008	0.564246	244.0223	0.028446
Orwell	Dunlin	EW010	-0.24936	23018.2	0.087416
Orwell	Dunlin	EW038	-0.16843	61218.74	0.169754
Orwell	Dunlin	EW014	-0.30012	1729.159	0.19857
Orwell	Dunlin	EW004	0.316636	662.1801	0.200484
Orwell	Dunlin	EW015	0.290656	1092.39	0.201178
Orwell	Dunlin	EW009	-0.27799	1699.728	0.235333
Orwell	Dunlin	EW022	-0.11476	4525.928	0.553325
Orwell	Dunlin	EW007	-0.13057	768.7865	0.62982
Orwell	Dunlin	EW041	-0.02505	49104.95	0.841763
Orwell	Shelduck	EW008	0.917431	56.14679	5.63E-07
Orwell	Shelduck	EW011	-0.506	133371.2	1.44E-06
Orwell	Shelduck	EW019	-0.56387	45758.75	6.03E-06
Orwell	Shelduck	EW002	0.573792	7371.7	2.48E-05
Orwell	Shelduck	EW037	0.504115	20660.54	2.53E-05
Orwell	Shelduck	EW018	0.412672	29434.51	0.00052
Orwell	Shelduck	EW009	-0.70732	1946.341	0.000707
Orwell	Shelduck	EW003	0.386554	32140.91	0.00113
Orwell	Shelduck	EW012	-0.70098	619.1566	0.007601
Orwell	Shelduck	EW010	-0.35561	31756.56	0.009676
Orwell	Shelduck	EW017	0.267457	80386.29	0.012266
Orwell	Shelduck	EW030	0.281286	15883.59	0.045548
Orwell	Shelduck	EW014	-0.37403	1827.465	0.104242
Orwell	Shelduck	EW016	-0.33705	1778.274	0.146171
Orwell	Shelduck	EW005	-0.15251	130884.2	0.156024
Orwell	Shelduck	EW021	0.235493	6449.383	0.160586
Orwell	Shelduck	EW026	0.19091	17880.88	0.179611
Orwell	Shelduck	EW007	-0.38857	505.44	0.189473
Orwell	Shelduck	EW033	-0.10912	44044.41	0.398513
Orwell	Shelduck	EW029	-0.42857	50	0.419444
Orwell	Shelduck	EW006	0.086245	80922.14	0.443933
Orwell	Shelduck	EW022	-0.11647	6091.474	0.525545
Orwell	Shelduck	EW015	-0.1237	1494.521	0.603353
Orwell	Shelduck	EW041	-0.06111	55595.97	0.620549

Site	Species	Sector	Estimate	Statistic	p.value
Orwell	Shelduck	EW004	-0.10537	1957.611	0.640726
Orwell	Shelduck	EW038	0.045599	50004.89	0.71195
Orwell	Shelduck	EW031	-0.05653	8912.883	0.739648
Orwell	Shelduck	EW013	0.016216	1121.514	0.947465
Orwell	Wigeon	EW011	0.645671	31379.38	7.61E-11
Orwell	Wigeon	EW037	-0.64726	82554.21	3.24E-09
Orwell	Wigeon	EW006	0.519597	36547.1	1.28E-06
Orwell	Wigeon	EW026	0.54024	21038.61	3.40E-06
Orwell	Wigeon	EW014	-0.78042	2367.961	4.92E-05
Orwell	Wigeon	EW041	0.409836	28271.81	0.000632
Orwell	Wigeon	EW019	-0.36331	42066.24	0.005474
Orwell	Wigeon	EW027	0.554172	363.7958	0.02098
Orwell	Wigeon	EW030	0.306947	16235.47	0.026874
Orwell	Wigeon	EW015	0.392265	340.3315	0.148132
Orwell	Wigeon	EW002	-0.44308	238.108	0.199678
Orwell	Wigeon	EW025	0.384251	176.1041	0.217493
Orwell	Wigeon	EW007	-0.30357	1063.714	0.236203
Orwell	Wigeon	EW017	-0.10221	108864.9	0.354899
Orwell	Wigeon	EW033	0.109834	42643.39	0.379993
Orwell	Wigeon	EW012	-0.1124	29183.69	0.418414
Orwell	Wigeon	EW009	-0.22299	556.4598	0.443507
Orwell	Wigeon	EW022	-0.1021	21601.11	0.48514
Orwell	Wigeon	EW008	0.170693	563.929	0.527353
Orwell	Wigeon	EW003	-0.09266	12543.75	0.564472
Orwell	Wigeon	EW018	0.076948	25587.01	0.576584
Orwell	Wigeon	EW021	-0.15363	419.9204	0.616307
Orwell	Wigeon	EW005	0.054215	77705.72	0.635115
Orwell	Wigeon	EW038	-0.03715	47459.93	0.768915
Orwell	Wigeon	EW016	0.057187	1253.941	0.810736
Orwell	Wigeon	EW004	0.036214	2505.844	0.863551
Orwell	Wigeon	EW028	0.058824	32.94118	0.911866
Orwell	Wigeon	EW029	-0.02326	225.1163	0.94589
Orwell	Wigeon	EW010	0.010604	7687.608	0.951057

Appendix 7. Stakeholder questionnaire

Wetland Bird Survey - Low Tide Counts scheme Stakeholder questionnaire

The Wetland Bird Survey (WeBS) monitors non-breeding waterbirds in the UK and is jointly funded by BTO, RSPB and JNCC, in association with WWT, with fieldwork conducted by volunteers.

The BTO are currently carrying out a review of the WeBS Low Tide Counts scheme, which is undertaken on selected estuaries annually with the aim of identifying key areas used during the low tide period, principally by feeding birds. As part of this review, we wish to gain a better understanding of how various stakeholders currently use WeBS Low Tide Count data.

More information about the scheme can be found here - https://bit.ly/3srYXeP

We would be grateful if you could spare the time to complete the following questionnaire and if possible respond before 5th Feb so we may include this feedback in a virtual workshop we are holding, however we are still able to receive any responses up until the end of Feb.

Feel free to forward the link to this questionnaire to anyone you think may be interested among your contacts.

If you have any questions please contact -
gary.clewley@bto.org

1. Please provide your name, organisation and an email address if you would like feedback from this review. Responses may be submitted anonymously (leave this question blank).

_____

_____

_____

_____

_____

2. Are you aware of the WeBS Low Tide Count Scheme and/or previously made use of the data in any way?

Mark only one oval.

- ◯ Yes
- ◯ No

3. What have you used WeBS Low Tide Counts data for primarily?

Mark only one oval.

- ◯ Species distribution within a site
- ◯ Species densities within a site
- ◯ Species presence/absence within a site
- ◯ Species densities between sites
- ◯ Species presence/absence between sites
- ◯ NA
- ◯ Other: _____

4. Do you mostly use data from whole sites or specific sectors?

Mark only one oval.

- ◯ Whole site
- ◯ Specific sectors
- ◯ Varies case by case
- ◯ NA

5. Counts of specific sectors within a site may not be conducted synchronously, is this problematic for your requirements?

_____

6. Has site coverage been suitable for your requirements?

Mark only one oval.

- ◯ Yes
- ◯ No
- ◯ NA

7. If not, have you used data from nearby sites to infer anything about your area of interest?

Mark only one oval.

- ◯ Yes
- ◯ No
- ◯ NA

8. Currently WeBS Low Tide Counts are made on a rolling basis with each site ideally covered around every six years. If capacity within the scheme were to be increased or redistributed, which of the following options would be valuable to you? 1 (Not valuable at all) - 5 (Extremely valuable for my requirements)

Mark only one oval per row.

	1	2	3	4	5
Visits more frequently than once each month between Nov-Feb	◯	◯	◯	◯	◯
Additional months outside of Nov-Feb	◯	◯	◯	◯	◯
More frequent annual coverage of sites	◯	◯	◯	◯	◯

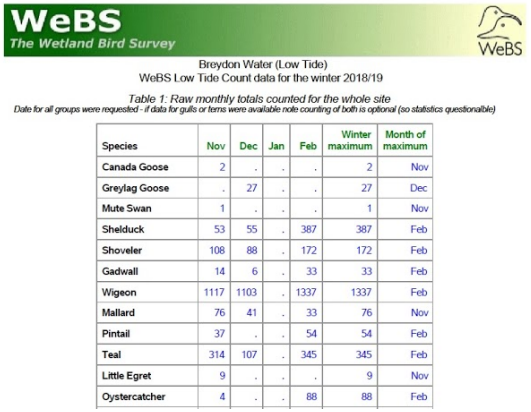
9. WeBS Low Tide Counts are presently focused on winter months when numbers of most waterbird species are at their highest and stable. Although species assemblages, abundance and turnover are very different, would Low Tide Count data from other times of year also be of value? 1 (Not valuable at all) - 5 (Extremely valuable for my requirements)

Mark only one oval per row.

	1	2	3	4	5
Spring	◯	◯	◯	◯	◯
Summer	◯	◯	◯	◯	◯
Autumn	◯	◯	◯	◯	◯

10. Results of the WeBS Low Tide Counts scheme are reported annually as part of the WeBS Report Online: (https://bit.ly/3oQc3Ao). Are there additional features in the online reporting that would be of value?

11. Do the outputs provided through the data request scheme meet your needs or are there additional outputs that would be of value?



WeBS
The Wetland Bird Survey

Breydon Water (Low Tide)
WeBS Low Tide Count data for the winter 2018/19

Table 1: Raw monthly totals counted for the whole site
Date for all groups were requested - if data for gulls or terns were available note counting of both is optional (so statistics questionable)

Species	Nov	Dec	Jan	Feb	Winter maximum	Month of maximum
Canada Goose	2	.	.	.	2	Nov
Greylag Goose	.	27	.	.	27	Dec
Mute Swan	1	.	.	.	1	Nov
Shelduck	53	55	.	387	387	Feb
Shoveler	108	88	.	172	172	Feb
Gadwall	14	6	.	33	33	Feb
Wigeon	1117	1103	.	1337	1337	Feb
Mallard	76	41	.	33	76	Nov
Pintail	37	.	.	54	54	Feb
Teal	314	107	.	345	345	Feb
Little Egret	9	.	.	.	9	Nov
Oystercatcher	4	.	.	88	88	Feb

Example of raw count table provided as part of standard data requests

12. Have you or your organisation undertaken your own Low Tide Counts for specific projects?

Mark only one oval.

- ◯ Yes
- ◯ No
- ◯ Prefer not to say

13. If yes, do the methods used for these counts follow those of the WeBS Low Tide Counts Scheme (count frequency, species counted, separation of behaviour, count units)?

Mark only one oval.

- ◯ Yes
- ◯ No
- ◯ NA

14. If yes, would any or all of those data be available to be included in the WeBS Low Tide Counts Scheme?

Mark only one oval.

- ◯ Yes, freely
- ◯ Yes, for a fee
- ◯ Yes, on a project by project basis
- ◯ No
- ◯ NA

15. Are there any additional data you would wish to see recorded within the WeBS Low Tide Counts scheme? E.g. species coverage, species activity or disturbance? Please provide details

16. Any other comments?

_____

_____

_____

_____

_____

Cover image: Sanderling by Liz Cutting/BTO. Back cover: Knot by Liz Cutting/BTO.

A review of the BTO/RSPB/JNCC Wetland Bird Survey (WeBS) Low Tide Counts scheme with recommendations for its future operation.

The BTO/RSPB/JNCC Wetland Bird Survey (WeBS) Low Tide Counts scheme, which was initiated in the winter of 1992/93, aims to monitor, assess and regularly update information on the relative importance of intertidal feeding areas of UK estuaries for wintering waterbirds. Counts are made mostly by volunteer observers across multiple sectors within a site between the months of November and February. The data gathered contribute greatly to the conservation of waterbirds by providing supporting information for the establishment and management of the UK network of Ramsar sites and Special Protection Areas, other site designations and whole estuary conservation plans.

We carried out a review of the WeBS Low Tide Counts scheme to: i) review the methods and coverage since the scheme began, ii) improve our understanding of temporal variability of within-site species distributions, and iii) improve our understanding of user requirements to be able to make recommendations to improve the value of the data collected. We used a combination of analysis of WeBS Low Tide Counts scheme data and a stakeholder questionnaire and workshop to address these aims.

Clewley, G.D., Calbrade, N.A., Austin, G.E., Frost, T.M. & Burton, N.H.K. (2022). A review of the BTO/RSPB/JNCC Wetland Bird Survey (WeBS) Low Tide Counts Scheme with recommendations for its future operation. *BTO Research Report* **744**, BTO, Thetford, UK.

ISBN 978-1-912642-35-9

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