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Notes on the WeBS-Defra Annual Cormorant Index

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CONTENTS

List of Figures

Aims of this document

A detailed description of the WeBS-Defra Annual Cormorant Index (hereafter the WeBS-Defra Index) can be found in Chamberlain *et al*. (2012 & 2013).

This document provides an overview of that index, how it differs from the standard WeBS Annual Cormorant Index" (hereafter the WeBS Index), assumptions of the analysis, its strengths and weaknesses, and suggestions of how it might be improved. The WeBS-Defra Index is the enhanced index supplied annually to Fera.

Although this report dwells heavily on potential weaknesses of the WeBS-Defra Index and makes suggestions on how it might be further improved, it is important to stress that as it stands, this approach is still considered to be a substantial improvement over the standard WeBS index and other published bird indices in general. The WeBS-Defra index makes allowance for bias in habitat coverage by incorporating data from other surveys independent of the WeBS Core Count Survey and, furthermore, unlike other bird indices which by definition give relative change in numbers, the WeBS-Defra Index produces an annual population estimate.

1.   Background

The Wetland Bird Survey (WeBS) Core Count scheme and its progenitor schemes, the National Wildfowl Counts and the Birds of Estuaries Enquiry, have been monitoring the UK's waterbirds since the 1940s. Originally concentrating on wildfowl and waders, other waterbird groups have been introduced into the survey over time, and Cormorant *Phalacrocorax carbo* has been included since 1987. WeBS is the scheme which monitors non-breeding waterbirds in the UK. The principal aims of the WeBS Core Counts are to derive population sizes, determine trends in numbers and distribution and to identify important sites for waterbirds (WeBS home page). WeBS Core Counts cover over 2,400 wetland sites throughout the UK (Figure 1) through its network of over 3,500 volunteer organisers and surveyors. In addition to the annual reporting, WeBS undertakes an assessment of protected sites (Special Protected Areas and Sites of Special Scientific Interest on a three-year cycle (WeBS Alerts). Further to the Core Counts, WeBS also monitors use of intertidal habitats on estuaries through the Low Tide Count scheme, and organises a number of intermittent surveys – the Dispersed Waterbirds Survey (DWS) and the Non-estuarine Waterbird Survey (NEWS) to supplement out understanding of waterbird numbers and distribution outside of the wetland sites monitored by the Core Count Survey.

Each year, WeBS reports annual indices for the majority of widespread and more numerous waterbirds including that for Cormorant (WeBS report Cormorant). These are reported for the UK, its constituent countries and Great Britain.

The standard WeBS Annual Indices (hereafter WeBS Indices) are based on the Underhill Indexing Method (Underhill & Prŷs-Jones 1994). An important aspect of this or any indexing method is that the trend obtained is representative of the average trend across all the contributory sites and represent changes in relative abundance rather than numbers within a population. It follows that for species that inhabits a variety of habitats, for the index to be truly representative of population trend for that species, data should be obtained from all those habitat types and differences in relative coverage of those habitats controlled for. This is important because trends on different habitat types may be following different trajectories; bias in coverage will manifest itself as bias in the overall trajectory. For the majority of species for which WeBS reports annual indices, this is not considered to be an issue. WeBS counts are obtained from all estuaries within the UK, the majority of larger inland waterbodies, a substantial proportion of medium sized waterbodies and a large sample of smaller waterbodies. Thus for species that are primarily found on estuarine habitats and/or medium to larger waterbodies WeBS is monitoring a substantial proportion of individuals over-wintering in the UK and although a small proportion of a given species on marginal habitats may be following different trends the objective of describing the overall trend of the over-wintering population is not compromised.

However, WeBS recognises that for some of the more ubiquitous species which occur away from the main wetland sites, WeBS may be underestimating population sizes and reporting trends biased towards particular habitats. To address this issue WeBS runs several intermittent surveys aimed at 'plugging the gaps' in coverage by the WeBS Core Counts. Thus NEWS conducts periodic surveys of the open coast, a habitat under-represented within the Core Count scheme but important for several species of wader. Primarily used to support population estimates, NEWS data also contribute to the Scottish Waterbird Indicator (Scottish Government Waterbird Indicator, SNH Waterbird Indicator Report) and indicators being developed under the Marine Strategy Framework Directive. Of particular relevance to Cormorants, WeBS also conducted a one-off Dispersed Waterbird Survey (Jackson *et al*. 2006) during Winter 2002/03, a prime objective of which was to understand how well waterbird species that are dispersed across the wider countryside are being monitored by WeBS. DWS employed randomised one-km^2 quadrats (based on the Ordinance Survey

British National Grid) to sample waterbird numbers across all habitats in the wider countryside. The primary target species of DWS were those such as Little Grebe, Mallard, Tufted Duck and Moorhen that typically occur in habitats relatively poorly monitored by WeBS, such as smaller rivers and streams, farm reservoirs, drainage ditches, and smaller ponds and pools. Although not considered to be one of the principal species targeted by the DWS, as it was considered to be reasonably well monitored by the WeBS Core Count scheme, Cormorant was one of the species for which sufficient data were obtained to compare population size estimates derived from the DWS and WeBS Core Count methodologies.

2. Development of the WeBS-Defra Annual Cormorant Index

Prior to 2013, the model used to assess the impact of culling on the national Cormorant population on behalf of Defra (Smith *et al*. 2008: hereafter the Fera model), was supported by the standard WeBS annual Cormorant Index. However, this had attracted criticism because confidence limits cannot be attached to that index (because there is no standard sized sampling unit) and because of potential habitat bias (Green 2008). Furthermore, by definition indices represent changes in relative numbers, not actual numbers in the population. Thus an action point arising from a meeting held between Defra, government agencies and NGOs on Cormorants (9 January 2009) was to consider the possibility of incorporating data from the DWS to inform the WeBS Index for Cormorant to allow confidence limits to be fitted to actual annual population estimates. As a result of discussion at a meeting informing Defra's recent review of the culling of fish-eating birds (5 October 2011), the necessary work was funded by Defra and a new methodology published (Chamberlain *et al*. 2012, Chamberlain *et al*. 2013). Subsequently, the new WeBS-Defra Index has been supplied to inform the Fera model in preference to the standard WeBS Cormorant Index.

The methods of Chamberlain *et al*. (2012 &2013) essentially take the data used for the WeBS Index and apply a correction to allow for relative numbers of birds recorded under the WeBS Core Counts and what would be expected by a survey covering all habitats across the wider countryside. When undertaken using random sampling with replacement from the DWS dataset within a boot-strap simulation i.e. producing a large number of realisations of the index, this allows an index with confidence limits to be reported. Furthermore, the values underpinning the index (i.e. before being standardised relative to a base year) now represent an annual estimate of population size rather than numbers on a sample of sites.

3. Assumptions of the WeBS-Defra Annual Cormorant Index

Whereas the standard WeBS Index is based on the assumption that the sites covered by the Core Count scheme are proportionally representative of the habitats frequented by the species in question and that numbers on poorly or uncovered habitats will follow the same trend, the enhanced WeBS-Defra Index allows for the fact that this may not be the case. However, this is based on DWS data obtained during the single winter of 2002/03. There are, therefore, a number of implicit assumptions behind the WeBS-Defra index. Firstly, that the relative habitat coverage of the WeBS Core Count scheme to the wider countryside remains constant between winters and secondly, that the relative use of different habitats by Cormorants across the wider-countryside remains constant.

The first of these two assumptions, that the relative habitat coverage of the WeBS Core Count scheme remains constant, is defensible. Before data from a site monitored by WeBS can be included in the indexing process a long time series of data must exist and historically WeBS only included sites with data from at least 50% of possible visits in index calculations as recommended by Underhill & Prŷs-Jones (1994). Having adopted recommendations from Frost (2010), this rule has recently been

relaxed more recently to ensure important sites are not excluded even if they do not meet the '50% rule'. However, this essentially excludes sites introduced into the scheme in recent winters that might have by chance shifted the balance of habitat coverage. Furthermore, although WeBS welcomes the inclusion of newly monitored sites from any wetland habitat, no effort has been made since 2002/03 to recruit new sites of any particular habitat type.

The second of these two assumptions, that the relative habitat use by Cormorants across the wider countryside remains constant is more difficult to justify, principally because data for other than the winter of 2002/03 do not exist. Ideally, this would be addressed by repeating the DWS intermittently in a similar manner to NEWS. This would allow WeBS to track shifts in habitat usage by Cormorants (and other species) and further enhance the WeBS-Defra index to reflect such shifts.

A third assumption of the WeBS-Defra index, must also be considered. The enhanced index is based on the assumption that the DWS was representative of the whole of England and Wales with respect to relative habitat use by Cormorants. Despite a substantial input by professional counters, the coverage obtained during the DWS was less than 50% of what was targeted, and this left gaps in coverage for some extensive areas. Thus, from Figure 2, it is apparent that there was poor coverage of much of Northern England, no coverage of the West Midlands, and poor coverage in central Southern England. If the distribution of habitats and/or the relative use of different habitats by Cormorants in parts of the country that were covered differs substantially from those in those parts of the country that were not covered, then this assumption will not be met. Again, no data are available to test this assumption.

4. Potential improvements to the WeBS-Defra Annual Cormorant Index

There are two principal means of improving the enhanced WeBS-Defra Index further. The first would be to increase routine monitoring of habitats not well covered by the WeBS Core Count scheme, such as smaller rivers and streams, and smaller ponds and pools which may be frequented by Cormorants. However, if these were targeted directly, unless records for past winters were available, there would necessarily be a long lag until data for a sufficiently long time-series would be accumulated and so allow these sites to contribute to the WeBS Core Count data being used. An approach that would bring more immediate benefits would be the introduction of a randomised element into the annual monitor of waterbirds based on standard sampling quadrats of the wider countryside (akin to an annual mini-DWS).

The collection of further data using DWS protocols, whether as part of a repeat DWS or by its introduction as an annual element of WeBS, has the potential to address a number of aspects which in turn may lead to desirable improvement in the reported WeBS-Defra Cormorant Index.

- Because of the gaps in coverage during the DWS detailed above, there remains a query over how representative that survey was of Cormorants across the wider countryside. Increasing the geographic coverage across England and Wales to fill those gaps would ensure that the WeBS-Defra Cormorant Index would be considered representative across the whole of England and Wales.

- Because of the considerable shortfall to the target sample size obtained for the DWS, the confidence limits remain wider than they might otherwise have been. If a repeat DWS was undertaken then additional effort to obtain a sample size nearer that originally envisaged for the 2002/03 DWS should be a priority.

- Because the DWS has only been undertaken on one occasion we have no knowledge of how changes in Cormorant distribution across the wider countryside over time may affect the WeBS-Defra Index. If the DWS was to be repeated on an intermittent basic, ideally with more comprehensive coverage than was obtained during winter 2002/03, this would allow any shifts in habitat usage to be incorporated into the modelling.

Aside from an ongoing request to volunteers to bring new sites into the WeBS Core Count scheme, currently there are no plans in place for these initiatives. The sampling of randomised, standard sampling units would inevitably be 'hard to sell' to the volunteer workforce, reluctant to commit to sites on which they may expect to record relatively few, if any, waterbirds. This means that without a high degree of professional coverage, meeting the required level of sampling would be impossible to guarantee. It would be particularly challenging to put in place funding for professional coverage on a long-term annual basis, while a repeat of the full DWS would likely to cost in the region of £100,000.

It's difficult to assess the relative merits of the data that an annual DWS element would provide compared to a periodic repeat of a full DWS. If it proved possible to accomplish a full survey then we would still only have two points in time where we have estimates of cormorant use of the wider-countryside relative to WeBS counts and so would still have to extrapolate over the intervening years assuming linear change over time. Employing an annual mini-DWS the data would have the potential to track annual differences in that relationship and so avoid this issue in the future. However, the problem we had obtaining representative geographical coverage from the full DWS would be magnified many times over in an annual mini survey. Given the experience of analysing the data from the 2002/03 DWS, an annual mini-DWS would still be aiming to obtain a substantial sample, probably in the range of 400-500 grid squares. Given the substantial shortfall in targeted coverage during the 2002/03 DWS (target 1500 grid squares; actually number 700 grid squares, and then only with a substantial input from professional counters, an annual mini-survey would probably be unsustainable using the WeBS volunteer workforce.

To finish on a word of caution, a narrowing of the confidence limits should not be seen as a foregone conclusion should a future DWS achieve more comprehensive coverage of England and Wales. Addressing the shortfalls of the previous DWS i.e. the gaps in geographic coverage and the smaller than desired sample size would only be expected to reduce the confidence limits if no substantial differences exist between the habitat utilisation by Cormorants in the areas that were covered and those areas not covered. In that case, the general statistical expectation of increased sample size leading to narrower confidence limits would apply. However, if coverage of those gaps were to bring with it more variation because Cormorants in those areas are utilising the habitat differently, of because habitat structure in those areas is different, then this would act in the opposite direction to broaden the confidence limits. Given the large swaths of England and Wales that were not covered by DWS, and broad differences in relative availability of different types of wetland habitat across the country, it is conceivable that such differences would be found.

5.   WeBS reporting schedule and delivery of the WeBS-Defra Cormorant Index

The delivery of the WeBS-Defra Cormorant Index to Fera follows the annual analysis of WeBS data. As a scheme primarily targeting the monitoring of over-wintering waterbirds, the WeBS count year is winter-centric running from the beginning of July in one year to the end of June in the following year. Increasingly, data are submitted to the central WeBS database on-line through the WeBS-on-

line interface. However, despite ongoing encouragement to all our volunteer counters to use this method of data submission, a substantial quantity of data, including those for a number of major wetland sites are still received on paper forms or as spreadsheets. Realistically, it will take six months from the end of the WeBS count year for all data to have been received and data from paper forms input and spreadsheet data loaded. Ongoing validation can be expected to continue for a further month after the last data have been received.

Historically (Figure 3), this has meant that it was late autumn before the WeBS data had been analysed and the report written and printed – some 15 months after the end of the corresponding WeBS count year, after which data, including the WeBS-Defra Index, could be disseminated.

During 2013 WeBS invested considerable time and effort into updating its database and analytical programs, and moving a major and much enhanced part of its reporting on-line. It was envisaged that this would cause a substantial delay in the reporting of data for winter 2011/12 but that this would pay substantial dividends in the long-term in terms of delivery cost, scope of reporting and reporting timetable. Consequently, the 2011/12 report was delayed until late January 2014 and this has had a knock-on effect of other WeBS outputs including the 2011/12 WeBS-Defra Index.

The WeBS-Defra Index revisions for 2009/10 and 2010/11, were delivered using the developmental work of Chamberlain *et al.* (2013) an approach that has proved to be unexpectedly labour intensive and therefore unsustainable. Consequently, there is a need to encapsulate this analysis into a custom analytical program that will be run as a routine part of the annual WeBS processing. It would not have been sensible to tackle development before the work on the new WeBS database was completed. At the time of writing, the new WeBS database is now fully implemented with regard to data storage and standard reporting, and work on custom analytical programs, including that to produce the WeBS-Defra Cormorant Index, is underway. The revision of the WeBS-Defra Cormorant Index for 2011/12 will be delivered as a product of this program development as soon as it becomes available.

Thereafter, revisions of the WeBS-Defra Cormorant Index will coincide with the release of the WeBS annual report. WeBS envisages the annual report for 2012/13 will be released during the summer, provisionally July 2014 (Figure 4), and thereafter to be released every March (Figure 5). This effectively brings the release of the report and associated provision of data forward six months as compared with the historic timetable.

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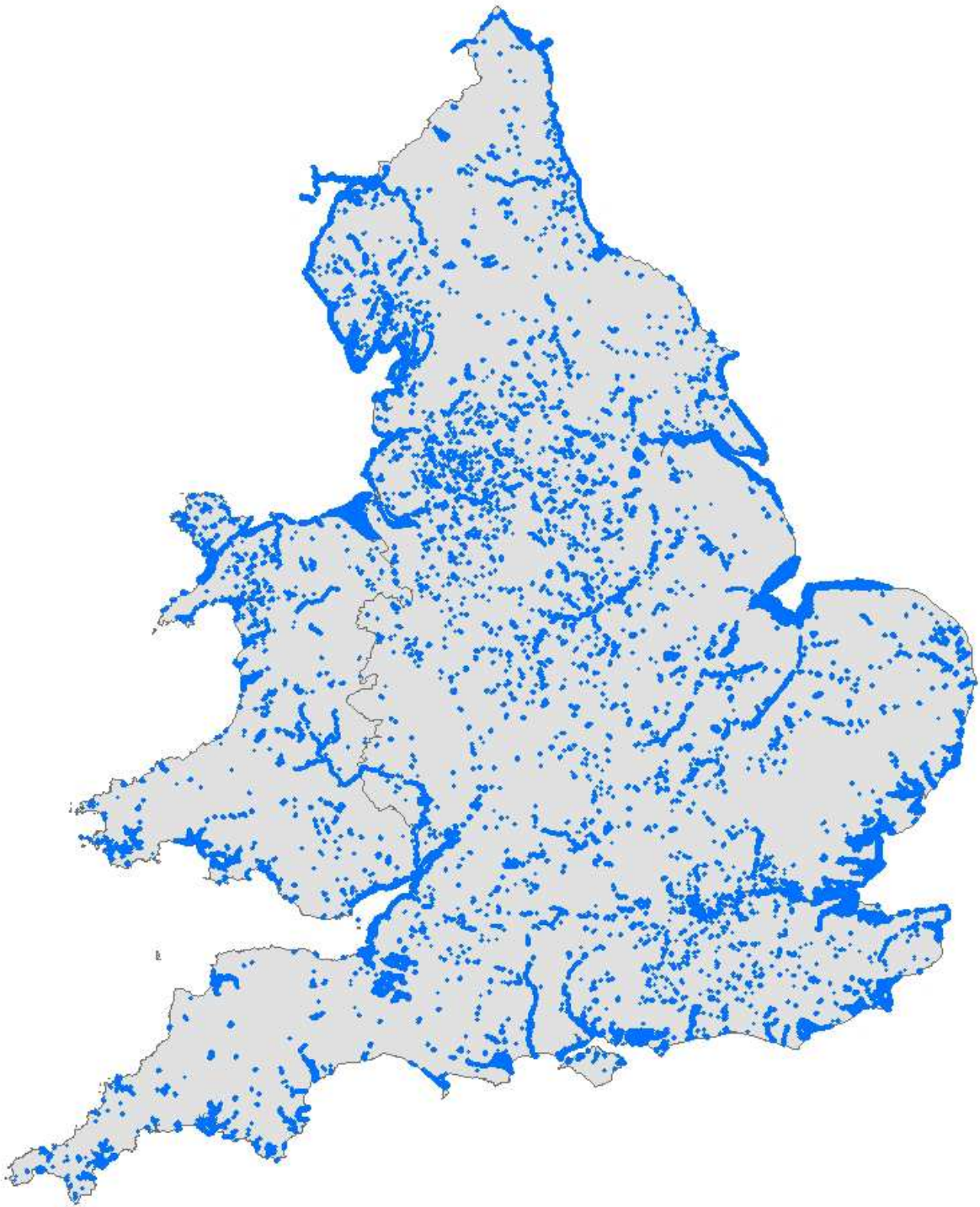
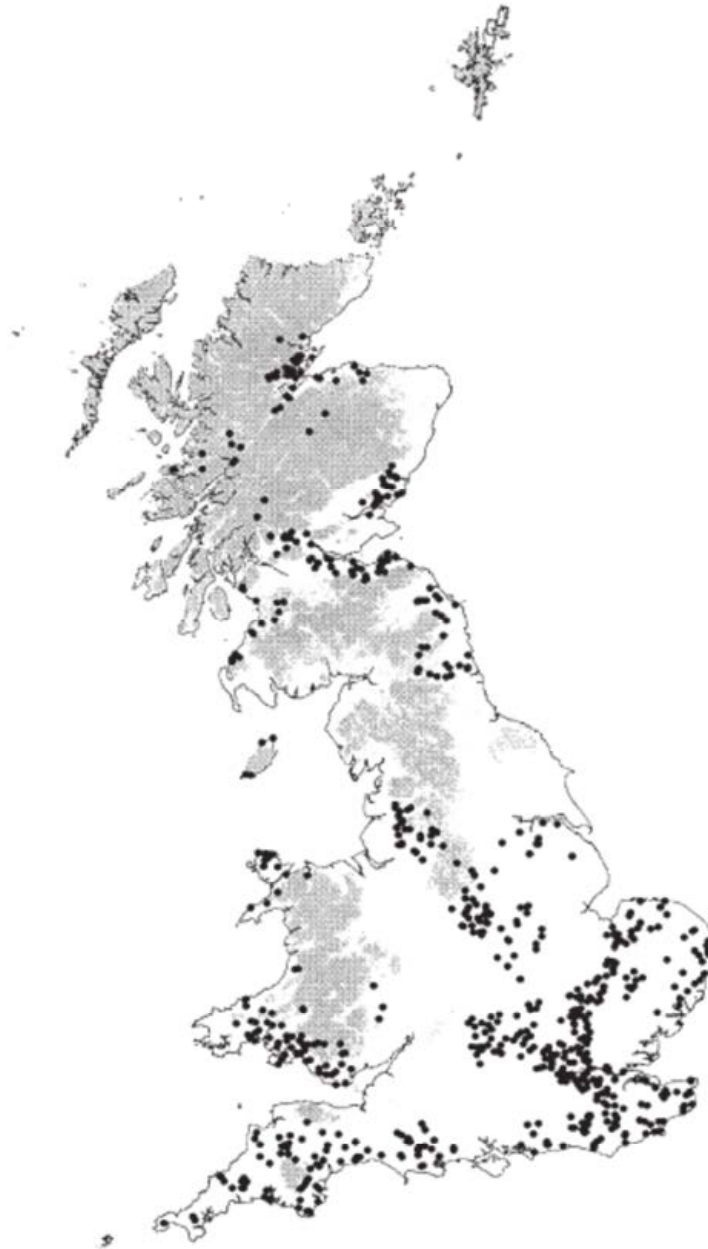**Figure 1**   Distribution of WeBS Core Count sites in England and Wales

Figure 2   Distribution of Dispersed Waterbird Survey (DWS) sampling units (from Jackson *et al*. 2006).

HISTORIC REPORTING CYCLE

WeBS Cycle	Winter 1												Winter 2												Winter 3											
Calandar Month	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC						
Calendar Year	e.g 2009						e.g. 2010												e.g. 2011																	
Data Collection	Winter 1												Winter 2												Winter 3											
Online data submission (70%)	Winter 1												Winter 2												Winter 3											
Paper Form data submission (30%)													Winter 1												Winter 2											
Data Validation													Winter 1												Winter 2											
Data Analysis																			Winter 1																	
Report Writing																							Winter 1													
Report proofing & printing																								Winter 1												
Official Release																									Winter 1											
Data available for analysis e.g. Cormorant index																										Winter 1										

Figure 3   Schematic of the historic WeBS reporting cycle

ENVISAGED REPORTING CYCLE Winter 12/13

WeBS Cycle	Winter 1												Winter 2												Winter 3						
Calendar Month	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Calendar Year	e.g 2012						e.g. 2013												e.g. 2014											
Data Collection	Winter 1												Winter 2												Winter 3						
Online data submission (70%)	Winter 1												Winter 2												Winter 3						
Paper Form data submission (30%)													Winter 1												Winter 2						
Data Validation													Winter 1												Winter 2						
Data Analysis																			Winter 1											
Report Writing																					Winter 1									
Report proofing & printing																							Winter 1							
Official Release																								Winter 1						
Data available for analysis e.g. Cormorant index																								Winter 1						

Figure 4   Schematic of the revised WeBS reporting cycle (Winter 2012/13)

ENVISAGED REPORTING CYCLE Winter from 13/14																																		
WeBS Cycle	Winter 1												Winter 2												Winter 3											
Calandar Month	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC						
Calendar Year	e.g 2012						e.g. 2013												e.g. 2014																	
Data Collection	Winter 1												Winter 2												Winter 3											
Online data submission (70%)	Winter 1												Winter 2												Winter 3											
Paper Form data submission (30%)													Winter 1																Winter 2							
Data Validation													Winter 1																Winter 2							
Data Analysis																			Winter 1																	
Report Writing																				Winter 1																
Report proofing & printing																					Winter 1															
Official Release																						Winter 1														
Data available for analysis e.g. Cormorant index																						Winter 1														

Figure 5   Schematic of the revised WeBS reporting cycle (from Winter 2013/14)