Written Representation
by the
Royal Society for the Protection of Birds

20 October 2014

Planning Act 2008 (as amended)

In the matter of:

Planning Application for the Proposed Navitus Bay Wind Park located approximately 14 km off the Dorset Coast

Planning Inspectorate Ref: EN010024

Registration Identification Ref: 10029429

rspb giving nature a home

CONTENTS

1. INTRODUCTION

1.1 The RSPB has been involved in pre-application discussions with the Applicant and has provided comments on draft ornithological information. Unfortunately, not all of our concerns had been addressed when the Application and its supporting documents were submitted to the Examining Authority. These concerns were highlighted in our Relevant Representation. We have continued to have discussions with the Applicant with a view to resolving the RSPB's outstanding concerns where possible and to ensure that robust evidence is submitted to the Examining Authority.

1.2 The RSPB is aware that the Applicant will submit further information of relevance to the RSPB's concerns. The RSPB will review and comment on this new information to the Examination at the next available opportunity and we therefore reserve the right to add to or amend its position.

1.3 This Written Representation focuses on three main issues of concern to the RSPB. First, the need to undertake an alternative approach for collision risk modelling for a suite of migrant seabirds and waterfowl, both alone and in combination. Second, the treatment of gannet and the possible effects on the Alderney West Coast and the Burhou Islands Ramsar site, due to collision risk and displacement from the Application alone and in combination. Third, the possible effects of the construction of the cable on internationally important heathlands due to direct habitat loss and indirect recreational displacement. We also raise fisheries issues but have elected to leave progression of these to other organisations with the requisite expertise.

1.4 At Annex A we append additional information on population viability analysis which is of relevance to our concerns relating to gannet. The RSPB's answers to the Examining Authority's First Written Questions are attached at Annex B.

2. THE RSPB

2.1 The RSPB was set up in 1889. It is a registered charity incorporated by Royal Charter and is Europe's largest wildlife conservation organisation, with a membership of over 1 million. The principal objective of the RSPB is the conservation of wild birds and their habitats. The RSPB therefore attaches great importance to all international, EU and national law, policy and guidance that assist in the attainment of this objective. The RSPB campaigns throughout the UK and in international fora for the development and effective delivery of such law and policy. In so doing, it also plays an active role in the domestic processes by which development plans and proposals are scrutinised and considered, offering ornithological and other wider environmental expertise.

The RSPB's interest in offshore wind development

2.2 The RSPB believes that climate change is the most pressing threat to the UK's wildlife and that wind energy has an important role to play in countering this threat. However, the RSPB will continue to oppose wind farms in inappropriate locations that risk significant impacts to protected species and their sites. At the same time, we will work with developers to find ways to minimise the risk of impacts.

2.3 The available evidence suggests that the main risks of offshore wind farms for birds are collision, disturbance/displacement, barriers to movement, habitat change and the in-combination effects of these across multiple wind farms (Langston & Pullan, 2003).

3. THE NATURE CONSERVATION INTEREST OF THE AREA

3.1 The Application is sited approximately 14 km from Durlston Head off the Dorset coast. The Dorset and Hampshire coasts and their hinterland contain a number of sites supporting aggregation and assemblages of birds in numbers of national, European and international importance. This includes the important sites of Poole Harbour, the Dorset Heaths, the New Forest and Avon Valley amongst many others.

3.2 The general coastal area is well known for its diverse ornithological interest, for breeding, passage and wintering birds. Also of relevance are the breeding seabird colonies of the Channel Islands. Recent research involving satellite tagged gannets has identified the use of the Application area by gannet from Alderney (Soanes et al 2013; Wakefield et al 2013).

4. THE RSPB'S CONCERNS ABOUT OFFSHORE ORNITHOLOGY

Treatment of offshore migrants

4.1 Upon reviewing draft ornithological reports provided to us we advised the Applicant that we considered the use of the APEM Migropath model was unsuitable for some migrants expected in the offshore Application area. This was due to the species' movements being characterised by movements generally parallel to the coast rather than perpendicular to it. The species of concern are:

- Dark-bellied Brent geese
- Bar-tailed godwit
- Great skua
- Arctic skua
- Common tern
- Sandwich tern

4.2 A commitment by the Applicant was made prior to submission to use a more appropriate apportionment methodology to feed into collision risk modelling. This commitment was confirmed in the Applicant's Environmental Statement (Volume B Offshore Environmental Statement Chapter 12 paragraphs 12.4.55 and 12.4.62) and we understand from recent discussions with the Applicant that this work has been completed and will be presented to the Examination, upon which we will review it and provide comments.

Treatment of gannet

4.3 Having reviewed the Application and its accompanying information, the RSPB considers that insufficient information is presented on the potential impacts on gannet.

Collision and displacement risk to gannet

4.4 We have identified apparent discrepancies within the Environmental Statement in terms of the presentation of collision risk estimates for gannet. We also are unclear as to how the baseline figures for the Applicant's population viability analysis (PVA) has been calculated (HRA Screening Report paragraph 10.1.20), as workings are not presented. This has made consideration of the likely impacts of the Application on gannet, alone and in combination with other projects, impossible. These discrepancies and omissions must be addressed by the Applicant in order to present robust evidence to the Examination.

4.5 On the basis of the information currently presented, it is not possible to rule out significant impacts from the Application on the gannet population of the Alderney West Coast and the Burhou Islands Ramsar site, due to collision risk and displacement, alone and in combination.

4.6 The Applicant is aware of our concerns on the methodology used to assess potential impacts on gannet, and we understand that a further technical report on gannet will be submitted to the Examination. The RSPB will consider this information and provide its comments to the Examining Authority.

Need for a revised population viability analysis

4.7 Having considered the position further since submission of our Relevant Representation, we consider that in line with developing approaches to offshore ornithological impact assessment the Applicant should prepare a revised PVA for gannet breeding at the Alderney West Coast and the Burhou Islands Ramsar site.

4.8 In our view, the most appropriate method to inform assessment of the effects of a proposed offshore development is to use PVA to compare expected bird population sizes with and without additional mortality, particularly that attributable to the project, at the end of the expected life of the project, either alone or in combination with other projects. We refer to this output of PVA modelling as the "Counterfactual of Population Size" (CPS). This metric can be calculated readily from a Leslie matrix (or similar) model with or without density dependence. This application of PVA is particularly suitable for appropriate assessment of breeding seabird features because:

1. It requires no assumptions to be made about future demographic rates, nor about the strength and form of density dependence (if the density-independent version is used).

2. Conservation objectives for Special Protection Area (SPA) bird features refer to population sizes, not population multiplication rates, and CPS identifies explicitly the impact upon seabird population size expected to result from the development.

3. It is a specific application of PVA population modelling, which is widely understood and robustly tested, including in the peer-reviewed, scientific literature, and therefore represents “the best scientific knowledge in the field”.

4.9 The demographic model requires initial numbers of animals in a starting year, estimates of age of first breeding (attaining adulthood), the probability that an individual will survive and remain within the population from one year to the next, and estimates of breeding productivity. The survival and breeding productivity rates are referred to as demographic rates. Demographic rates may vary between age classes, among individuals of a given age class, as well as in different years. The influence of external variables on demographic rates can be extremely hard to predict, notably where these influences are of anthropogenic origin, such as climate change and the influence of legislation, for example, on fisheries’ discard policy. However, for the purposes of Habitats Regulations Assessment (HRA), it may be reasonable to assume that these likely variations will apply to modelled populations equally in the presence and absence of the proposed development.

4.10 Projections from a well-conducted PVA population simulation could provide the type of quantitative information on future population trend required for an informed and qualitative appropriate assessment of the effects of an intervention. This is exactly what is needed to evaluate the impact of an intervention on the conservation status of an animal population at a designated site because the *counterfactual* – what would happen with and without the intervention - can be estimated, along with the relative scale of change.

The use of PVA to estimate impacts on gannets from the Alderney West Coast and the Burhou Islands Ramsar site

4.11 Whilst the Applicant has used PVA to examine the impact of wind farm related mortality on this gannet population, it is unclear exactly how the mortality threshold has been derived other than that the UK gannet PVA (WWT, 2012) was used to generate it. It seems likely that the derived threshold is simply a proportion of the total mortality threshold for the UK population (as presented in the report (WWT, 2012)) based on the size of the colony (now) relative to the UK population (then). It is unlikely that this threshold represents an accurate reflection of the level of acceptable mortality for this colony, as demographic rates for the UK population as a whole may not be representative for an individual colony, and there have been recent changes in the population size of both the UK population (the PVA being based on 1998-2000 data) and this particular colony. In addition, the most informative output - the counterfactual of population size as described above - requires a site specific PVA to be run with and without the additional mortality associated with the Application.

Requirements for site specific PVA and calculation of the counterfactual of population size for Alderney West Coast and the Burhou Islands Ramsar site

4.12 The following colony information and demographic data are required for PVA model of the breeding colony:

- Population estimate for gannet in starting year (including age distribution);
- Age of first breeding;
- Survival rates for various age classes; and
- Estimates of breeding productivity

Population estimates for Channel Island colonies

4.13 Colony size at the time of designation was 5,950 pairs based on 2000/2001 counts [HRA screening report, paragraph 10.1.13]. This consists of 2,500 pairs at Ortac and 3,450 pairs at Les Etacs (WWT, 2012).

In 2004/2005 JNCC carried out a count and found 7,409 pairs of gannet [HRA screening report, paragraph 10.1.13]. In 2011 Alderney Wildlife trust counted the birds and recorded 7,885 pairs [HRA Screening Report paragraph 10.1.13]. In other words, both colonies have been growing over the last 50+ years, and probably continue to grow, although the rate of growth may have slowed as space has become limited (Roland Gauvain, Alderney Wildlife Trust, pers. comm.).

4.14 The number of juveniles is estimated to be approximately one third of the total population i.e. 6,626 individuals [HRA Screening Report paragraph 10.1.19], giving a total population in the region of 22,396 individuals. However, this figure does not include non-breeding birds. HRA Screening Report Appendix C Table C1 Designation information reports 1,000 birds in this class at designation (6% of the population) equivalent to 1,344 birds in 2011. Therefore the 2011 population stands in the region of 23,740 birds.

Survival rates for various age classes

4.15 The HRA Screening Report (paragraph 10.1.19) reports that adult mortality for gannet is 8.1% per annum, whilst juvenile mortality is 70% within the first four years of life (Robinson, 2005). However, a more detailed assessment of survival rates can be found in the gannet PVA (WWT, 2012, section 3.6), from which it is clear that there is a degree of variability in gannet survival between both colonies and seasons.

Estimates of breeding productivity and age of first breeding

4.16 No figures for breeding productivity at the Alderney West Coast and the Burhou Islands Ramsar site are available in the information presented by the Applicant. Mean breeding success is reported to be 0.698 chicks raised per apparently occupied nest (WWT, 2012), but again there is a fair degree of variability between sites and from year to year. Age of first breeding is commonly accepted to be five years of age (WWT, 2012, section 3.7).

Conclusion

4.17 Sufficient data exists to carry out a site specific PVA for from the Alderney West Coast and the Burhou Islands Ramsar site, and therefore it is possible to calculate the *Counterfactual of Population Size* for this colony. There is sufficient data available on the size and age distribution of the gannet population at this specific colony. There may be some site specific data on productivity and survival rates available, but if such data do not exist there is a wealth of information from other sites that may be used instead. The RSPB would be happy to work with the Applicant and its ornithological advisers in developing such a PVA.

5. THE RSPB'S CONCERNS ONSHORE

Damage to internationally designated habitats

5.1 The Environmental Statement identifies that a section of the onshore cable will pass through the West Moors Ministry of Defence (MOD) site involving the scrub clearance and open trenching of approximately 2 ha of internationally designated habitats which form part of the Dorset Heathlands SPA and Ramsar site and Dorset Heaths Special Area of Conservation (SAC) (Volume C Onshore Environmental Statement Chapter 11 paragraph 11.5.10).

5.2 The RSPB is not satisfied that all possible less damaging alternatives have been explored in terms of constructing the cable within the West Moors MOD site. If the applicant persists with the current proposal, we would maintain that the proposal would trigger the need for an appropriate assessment by virtue of a likely significant effect on the Dorset Heathlands SPA and Ramsar site and the Dorset Heaths SAC .

5.3 The RSPB understands that there have been further discussions over the cable route and construction in this locality with Natural England, and that further information will be presented to the Examination. The RSPB will consider this information and provide its comments to the Examining Authority.

Displacement of recreational disturbance

5.4 The construction of a section of the cable through Hurn Forest and West Moors Plantation will result in the temporary closure of car parks serving the forest, and the temporary diversion/closure of footpaths (Volume C Onshore Environmental Statement Chapter 11 paragraph 11.5.14).

5.5 The RSPB is concerned that visitors will be minded to visit alternative sites to the Forest in the event of encountering a closed car park, and that will lead to increased recreational disturbance on internationally important designated sites within the Dorset Heathlands SPA and Ramsar site and Dorset Heaths SAC. Mitigation is proposed within the Environmental Statement including temporary wardening and an undertaking to ensure one car park is kept open at all times (Volume C Onshore Environmental Statement Chapter 11 paragraph 11.6.13).

5.6 The RSPB is not currently satisfied with this mitigation, given the limited information presented within the Environmental Statement on the pattern and intensity of use by visitors of Hurn Forest, and consequently the likely implications of the proposed works on those visitor patterns.

5.7 The RSPB considers further assessment is required of the possible displacement effects on visitors caused by the cable works within Hurn Forest and West Moors Plantation. The RSPB understands that there have been further discussions over the implications of the cable route in these localities with Natural England, and that further information will be presented to the Examination. The RSPB will consider this information and provide its comments to the Examining Authority.

6. OTHER CONCERNS

Atlantic salmon

6.1 In our Relevant Representation we stated our concern over the possible impacts of the proposal on Atlantic salmon. We had noted the concern of the Environment Agency and Natural England expressed in pre-submission meetings with the Applicant on the possible impacts of piling noise on migrating salmon. Atlantic salmon are an interest feature of the River Avon and River Itchen SACs.

6.2 The Environment Agency in its Relevant Representation highlighted the issue and uncertainty over possible barrier effects to migrating salmon.

6.3 We defer to the expertise of the Environment Agency, Natural England and other stakeholders on this matter, and understand discussions have taken place post submission with the Applicant. Further reports are to be submitted by the Applicant on the matter, which we understand detail proposed mitigation in terms of piling restrictions. The RSPB will consider this information and provide its comments to the Examining Authority.

Long snouted seahorses and black bream

6.4 The Environment Statement also identified possible impacts on long snouted seahorses and black bream by virtue of piling noise (Volume B Offshore Environmental Statement Chapter 10 paragraph 10.5.30). The RSPB understands that discussions have taken place post submission between the Applicant, Natural England and the Seahorse Trust regarding these species. Further reports are to be submitted by the Applicant on the matter, which we understand detail proposed mitigation in terms of piling restrictions. The RSPB will consider this information and provide its comments to the Examining Authority.

7. Conclusions

Treatment of offshore migrants

7.1 The RSPB does not support the use of Migropath modelling for dark-bellied brent geese, bar-tailed godwit, great skua, arctic skua, common tern and sandwich tern, and recommends an alternative apportionment methodology be adopted. The outputs of this modelling should then inform the collision risk modelling for these species.

Treatment of gannet

7.2 The RSPB considers that insufficient evidence has been presented by the Applicant to enable a robust assessment of potential impacts on the gannet population of the Alderney West Coast and the Burhou Islands Ramsar site. We advise the development of a revised population viability analysis in order to determine the potential impacts.

Damage to internationally designated habitats

7.3 The RSPB considers that insufficient consideration has been given to less damaging alternatives for the cable construction within the West Moors MOD site. The current cable route proposal leads to unacceptable damage to internationally designated habitats.

Displacement of recreational pressure

7.4 The RSPB considers that the implications of constructing the cable route within Hurn Forest has not been adequately examined, given the possible displacement of visitors to other internationally designated sites, increasing recreational disturbance to wildlife.

Other concerns

7.5 The RSPB has concerns over possible piling noise impacts on Atlantic salmon, long snouted seahorses and black bream. We have deferred representations on these species to the Environment Agency, Natural England and the Seahorse Trust who have the requisite expertise.

8. References

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ANNEX A

Extract from the Statement of Common Ground between RSPB and Forewind for the Dogger Bank Teesside A and B Offshore Wind Farm concerning Population Viability Analysis.

We would like to draw the Examining Authority's attention specifically to Section 4 of this document which addresses population viability analysis, as referred to in paragraphs 4.3 to 4.17 of our Written Representation.

RSPB Appendix to the draft Statement of Common Ground between Forewind and the RSPB

Contents

1. Introduction

Current offshore wind farm proposals for UK waters could affect seabird populations of coastal SPAs for the twenty-five year lifetime of their consents. In meeting the requirements of the Birds and Habitats Directives, and transposing regulations, it is critically important that appropriate assessments are carried out transparently and robustly. This means that the consenting bodies must be able to assure themselves beyond reasonable scientific doubt that breeding seabird populations of the potentially affected SPAs will not be adversely impacted by the projects. This will require judgements to be made that are informed by sound predictions of the effects of the project on the SPA populations.

This appendix gives further consideration to the “Matters Unresolved” in the draft Statement of Common Ground between Forewind and the RSPB. We present our case regarding collision risk modelling, in particular with respect to Option 3 of the Band Collision Risk Model (CRM) (Section 2). We present comments on the review undertaken by Forewind and SMartwind (Section 3). We present an overview of the use of Population Viability Analysis (PVA) and, in particular the PVA output of the Counterfactual of Population Size (CPS), as the RSPB’s recommended approach for environmental impact assessment of offshore wind farms (Section 4). We also present our reasons for considering inappropriate the use of Potential Biological Removal (PBR) for this purpose (Section 5).

2. Collision Risk Modelling: the RSPB's concerns

A method of quantifying the risk of bird collisions with the turbines of wind farms, known as the Band model, was first described in 2000 (SNH 2000), updated in 2007, (Band *et al.*, 2007) and has become the standard method. It combines a series of parameters describing the turbine design and operation with estimates of a bird's size and behaviour to generate a predicted number of birds that would collide with a turbine over a given time period. The model was refined to account for differences in survey methodology for offshore wind farms in 2012 (Band 2012), and this refinement also included an extended model, which took into account flight height distribution curves, (Cook *et al.*, 2012). This 2012 guidance recommended that the extended model be used, and presented alongside the basic model, if the data were suitably robust. SNH Avoidance Rate Guidance 2010 set out avoidance rates for use by wind farm developers when considering possible effects arising from their proposed wind farms (including advice for offshore proposals). This Guidance has been widely used, and, along with a review of flight heights and avoidance rates for offshore wind farm proposals in 2012, is still relevant guidance for use today, although a Marine Scotland Science commissioned review of avoidance rates is due to be completed in 2014.

2.1 Model Options

Currently the model has 4 different 'Options' two of which correspond to the basic model, and two to the extended model. They are as follows:

2.1.1 Basic model

Option 1 – the original "Band" model, assumes uniform distribution of bird flight heights between the lowest and highest blade sweep, and utilises data on bird movements collected on site, usually from boat-based surveys in which the observers usually assign flight height to below rotors, within rotor swept height or above the rotors. This model is only appropriate where the applicant has sufficiently robust data on densities to properly populate the model.

Option 2 – as for Option 1 but uses bird densities from site-specific data and calculates the proportions of birds at rotor swept height as determined by the generic flight height distribution. The generic data are from a British Trust for Ornithology (BTO) review of offshore wind studies for the Strategic Ornithological Support Services (SOSS), (Cook *et al.,* 2012, Johnston *et al.,* 2014), mainly from boat-based surveys, subsequently redrafted, peer-reviewed and published, with a further corrigendum added. This version of the model permits incorporation of changes in rotor swept height to determine how this may influence collision mortality, and also has the utility of allowing confidence limits to be placed on the mortality estimates, reflecting variability in flight altitude.

2.1.2 Extended model

Option 3 – an extended CRM which uses the generic flight height data, as described under Option 2, allocated to 1m bandwidths (see further below). This extended model takes account of how the distributions of flight height tend to be skewed toward the lower end of the potential collision window, and assume that there is a lower risk of collision further from the rotor hub. This therefore results in a lower predicted collision risk. Validation of the model with empirical data is essential to determine whether these assumptions are appropriate.

Option 4 – the extended model, as for Option 3, but using site-specific data allocated to 1m bandwidths. This is a further modification to the Band model that Band does not refer to in any detail, and is dependent on field data collected with a high degree of accuracy.

2.2 Lack of Validation and Uncertainty

There is a paucity of data to validate all these CRM Options for seabirds. This means that outputs from any CRM can provide only a relative estimate of collision risk. The single figure output from the CRM that is usually presented for each species, presents a misleading impression of accuracy when in fact the output is an approximation that may or may not be close to the actual value. Therefore, it is important that a measure of uncertainty around model outputs should be presented, as per the Band CRM, rather than a single figure, for each run of the model. A simple means of doing this is presented in the Band (2012) guidance as stage F, and the resulting range of values is more likely to alert the user to the rough approximation that the CRM output represents instead of taking the value to be absolute.

2.3 Potential inaccuracy in height estimation

The extended Band model relies on flight height distribution curves presented in Cook *et al.* (2012), and updated in Johnston *et al.* (2014). These papers used available survey data from pre-construction off shore wind farms to generate species specific distributions of the proportions of birds that would occupy 1m height bands above the water surface, along with confidence intervals around the distributions. While we are satisfied with the mathematical procedures used to generate these curves, we have concerns about the assumptions implicit in these models, which are largely acknowledged in the Band CRM report and the source papers, as well as increasingly within the industry. For example, in the recent pre-and post construction monitoring report for Robin Rigg offshore wind farm the following is described:

> *"Most flying birds were recorded below rotor height during the pre-construction phase and this was largely found to be the case during construction and operational monitoring. Gannet, kittiwake, herring gull and great black-backed gull were recorded at rotor height more often during the construction and operational phases than prior to construction. However, it is extremely difficult to judge the flight height of birds at sea with no landmarks and it is likely that these changes reflect an increase in accuracy of the observers due to the presence of landmarks (turbines) rather than changes in the behaviour of the birds. These species are commonly observed at rotor height (26 – 125 m) and if flight height genuinely changed as a result of the wind farm, it would be expected that birds should avoid rotor height rather than flying more often at the level of the rotor blades."*

In particular, the extended model assumes that birds have been correctly assigned to the appropriate height category in the surveys that generated source data for the flight height distributions. This assumption has not been validated, and the fact that there is likely to be some error associated with height estimation is acknowledged by the authors (Johnston *et al.* 2014).

Within the CRM guidance is the recommendation to utilise the 95% confidence intervals presented with the generic data, and this recommendation is also made in Cook *et al.,* (2012) and Johnston *et* *al.,* (2014). We welcome the fact that confidence limits around flight heights have been presented in collision predictions in Dogger Bank Teesside A&B Draft Environmental Statement Chapter 11 Appendix A, and Appendix 6, and in the RSPB Statement of Common Ground Appendix 4, although these limits are set at ±90% rather than the recommended 95%. We would, however, have preferred **that full reference was made to them in the main assessment**, rather than as appendices. Furthermore, we would have welcomed acknowledgement of the other sources of variability in collision estimates.

2.4 Avoidance Rates

Concerns over the extended Band CRM are shared by the RSPB and the Statutory Nature Conservation Bodies (SNCBs) and are the subject of considerable debate and ongoing work. Concerns are in part focused on a correction factor ("Avoidance Rate") to the output from the CRM, notably because of the paucity of empirical data to determine appropriate rates for seabirds. To date, the theoretical derivation of this correction factor has been based entirely on the original, basic version of the Band CRM (Options 1 and 2), and includes modeling error and uncertainty specific to that version.

Avoidance Rate is the inverse of the ratio of number of actual collisions to number of predicted collisions. For example, the Avoidance Rate would be 95% if 5 birds actually collide with turbines out of a predicted 100 collisions. As such "Avoidance Rate" is a misnomer; it is a catch all term for the inconsistency between predicted and actual mortalities, an inconsistency that can be derived from a variety of sources, including avoidance behaviour, survey error and model conservatism. Developing this argument further, because Avoidance Rate encompasses specific model error it is inappropriate to use the same Avoidance Rate for what are essentially different models, the basic and extended versions of the Band CRM. This requirement for different avoidance rates for use with the basic and extended models is explicitly acknowledged by the Band CRM guidance, (Band 2012), where the recommendation is also made that in the absence of model specific avoidance rates that a range of outputs, including an avoidance rate of 95%, be presented.

The current SNH guidance (SNH 2010) gives a default Avoidance Rate of 98% for all seabird species. However as this predates the extended Band CRM, this can only be considered applicable to the basic model. Subsequently, the Strategic Ornithological Support Services (SOSS) work program, commissioned a review of avoidance rates from Cook *et al.* (2012) as part of the work package: "*SOSS-02: A review of methods to estimate the risk of bird collisions with offshore wind farms*". This package included the development of the extended model, and the flight height distributions used in the Band CRM, Options 2 and 3. The Avoidance Rate review dealt implicitly with the basic Band model, and concluded "*there is not a robust enough evidence base to suggest existing guidance should be changed*". We note that both JNCC and Natural England support the use of the basic model with a 98% avoidance rate for all seabirds, at the present time.

A detailed review of seabird avoidance rates is currently being carried out under commission of Marine Scotland Science, part of the Scottish Government, and is due to report in September 2014. This is overseen by a steering group of stakeholders, and will provide a comprehensive review. In particular this review will take a qualitative approach to the available evidence, and its applicability to offshore developments. This will include whether the evidence is from terrestrial, coastal or offshore studies, and examine seasonality, temporal scale and proximity to breeding colonies. Until this report is published we do not accept that there is sufficient evidence to support a change from the use of 98% with the basic model.

Until there is better evidence for CRM in general, and, in particular, the extended Band model has been tested and peer-reviewed, we are unhappy with the application of the extended model alone, and view collision risk estimates generated by it with extreme caution. In particular, it generates substantially lower collision risk estimates than does Option 1, the version which has been in routine use previously, and empirical clarification is required as to whether or not this difference is a function of a methodological difference that does not reflect actual risk. As yet there has been insufficient validation of the extended model. R**eference to a range of model options *throughout the assessment* is therefore crucially important, while** the extended model, particularly it's associated source data and avoidance rates, is still in question and the subject of wide debate and on-going work across the SNCBs and offshore wind stakeholders. As such it should be considered a work in progress, and therefore not suitable for consideration in the consenting process. However, we do acknowledge that it can provide useful contextual information for that consideration.

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SNH 2010. *Avoidance Rate Information & Guidance Note on the Use of Avoidance Rates in the SNH Wind Farm Collision Risk Model*

3. RSPB comments on *Review of Avoidance Rates In Seabirds at Offshore Wind Farms and Applicability of Use in the Band Collision Model*

This review has been produced by SMartwind and Forewind in response to representations from SNCBs and RSPB in response to the EIA and HRA for Dogger Bank Creyke Beck and Hornsea Project One. These representations were critical of the use of Collision Risk Modelling in both applications, particularly with regard to the use of the extended Band model (Band 2012). The basis of the review is an argument to increase avoidance rate, and thereby reduce predicted collision mortalities. The two key issues in offshore avoidance rates are presented as being:

- macro avoidance (which overlaps with displacement) and the inconsistency with which it has been dealt with.
- the derivation of AR from onshore sites.

Avoidance Rate is the inverse of the ratio of number of actual collisions to number of predicted collisions. As such "Avoidance Rate" is a misnomer; it is a catch all term for the inconsistency between predicted and actual mortalities, an inconsistency that can be derived from a variety of sources, including avoidance behaviour, survey error and model conservatism.

This model error aspect of avoidance rate is acknowledged in the SMW/FWD review in para 6.7: "the avoidance rate needs to take account of both bird avoidance behaviour and a correction for model conservatism". This is essentially an agreement with what has been one of our key arguments, that avoidance rate is not just about avoidance *per se,* it is also a correction for inherent error in both the model and the inputs to it. Further to this argument, because Avoidance Rate encompasses model error it is inappropriate to use the same avoidance rate for what are essentially different models, the basic and extended versions of Band 2012.

This is also acknowledged in the review: "The significant influence that the choice of avoidance rate has on model predictions is recognised and the need to consider the appropriate avoidance rates to use with the extended model (Options 3 and 4) is not under question." (Para 2.13). This agreement that cross-option application of avoidance rates is not valid should be welcomed.

The current guidance (SNH 2010) gives a default Avoidance Rate of 98% for seabird species. However as this predates the extended model (Band, 2012), this can only be considered applicable to the basic model. Subsequently, the Strategic Ornithological Support Services (SOSS) work program, commissioned a review of avoidance rates from Cook *et al.* (2012) as part of the work package: "*SOSS-02: A review of methods to estimate the risk of bird collisions with offshore wind farms*". (This package included the development of the extended model, and the flight height distributions used in Options 2 and 3.) The Avoidance Rate review dealt implicitly with the basic model, and concluded "there is not a robust enough evidence base to suggest existing guidance should be changed".

The SMW/FWD review now argues that this Avoidance Rate should be changed. Essentially it is argued that the 98% AR was derived for terrestrial wind farms and so the reasoning for a change in avoidance rate is based on comparison with terrestrial ARs, using the basic model. This argument says the source of model error in the model comes largely from a decay in the detectability of birds over an observation distance that is not applicable offshore (because the observation sampling distance is considerably shorter). However, this is not the only source of error in the model; other sources include incorrect estimation of height, decreased detection of higher flying birds, natural variability in numbers detected, and many others. This means that until full validation of the model has been done, the assumption that the model needs no further correction is not valid.

The review also contains a critical evaluation of the evidence base for avoidance rates in seabirds. It asserts that “there has not been a comprehensive review of the evidence base for avoidance rates in seabirds” since the SNH 2010 guidance, despite the existence of the SOSS-2 report , “A review of flight heights and avoidance rates of birds in relation to offshore wind farms” (Cook *et al.* 2012). The conclusion of this report is quoted above and was overseen by a steering group comprising representatives of developers, regulators and advisory bodies. A detailed review of seabird avoidance rates is currently being carried out under commission of Marine Scotland Science, due to report in September. This is also overseen by a steering group of stakeholders, and will provide a more comprehensive and impartial review.

The positions stated in the review are supported by 4 appendices.

3.1 Appendix O.1. *Review of assumptions used in generating avoidance rates for onshore wind farms and applicability for conversion to avoidance rates for offshore wind farms.*

Key concerns:

- Assumes SNH (2010) guidance is only for terrestrial windfarms
- Assumes detectability is the only source of error in bird density data inputted into the model, whereas numerous other sources of error exist

There is an implication throughout this document that the SNH guidance of 2010 is only for onshore wind farms. This is misleading, as at no point in the guidance is this said and it includes guidance specific for marine wind farms.

Page 2 para 2 says “avoidance rates derived from actual observations of avoidance behaviour may be transferrable”. This does not take into account the component of AR that is model error, and therefore is inconsistent with the statement in 6.7 “avoidance rate needs to take account of both bird avoidance behaviour and a correction for model conservatism”.

On page 5, paragraph 8 it says “the flight behaviour and flight height distributions of seabirds may, therefore, most closely resemble those of the hen harrier.” This example of hen harrier is pertinent, as it shows how assumptions of flight behaviour and avoidance rate can be wrong. Hen harrier are generally thought of as being at low risk of collision, (Whitfield and Madders, 2006) because they forage close to the ground. As such avoidance rate has been recommended to be 99%. However, at a wind farm in Perth, Scotland, within 18 months of becoming operational 3 hen harriers were killed, presumably as the result of collisions. Subsequent studies of flight behaviour, where for the first time actual height was measured (rather than estimated), it was demonstrated that during the breeding season 55% of flights were at risk height, (Stanek 2013), far higher than predicted. This clearly demonstrates why high levels of precaution should be incorporated into the setting of avoidance rates.

On page 6 paragraph 5 it is argued that the 98% AR was derived for terrestrial wind farms and that the source of model error in the model comes largely from a decay in the detectability of birds over an observation distance that is not applicable offshore (because the observation sampling distance is considerably shorter). However, this is not the only source of error in the model; other sources include incorrect estimation of height, decreased detection of higher flying birds, natural variability in numbers detected, and changes in bird behaviour in the presence of the survey boat. This means that until full validation of the model has been done, the assumption that the model needs no further correction, via the use of avoidance rate, is not valid.

The subsequent calculations using merlin as an example of the influence of detectability on avoidance rate is spurious. It is one of the hardest raptor species to detect when not breeding (Hardey *et al.* 2012) due to its fleeting flight and small size. It is certainly not comparable with species such as golden eagle, as is implied in the concluding paragraph. For consistency, a similar exercise should perhaps be carried out for white-tailed eagles, a species with highest detectability but lowest avoidance rate (95%)

3.2 Appendix O.2. *Reverse calculation of Option 3 numbers to show the avoidance rates that would be required to produce an equivalent collision rate to those derived from Option 1*.

This reverse calculation is entirely unnecessary, as there has been no suggestion that avoidance rates should be adjusted to produce equivalent predicted collision mortalities. If such an adjustment was required, there would be no utility in having an extended model.

The discrepancy between basic and extended models' avoidance rates is largely due to the extended models exclusion from analysis of the proportion of flights that occur within the spandrels; that is the parts of the rotor height band, defined by upper and lower rotor tip heights, that lie outwith the actual rotor swept area. Flights that occur within these spandrels are included in the basic model and are accounted for in the use of a higher avoidance rate. The use of the same avoidance rate in the extended would double count the birds that do not collide but rather simply miss the rotor and therefore would predict a falsely depressed collision mortality.

Furthermore the comparison of Option 3 against Option 1 is not just a question of avoidance rates, but also relates to the data input on flights at risk height. For Option 3 these *turbine specific* data (as opposed to those relating to bird densities and height) are likely to be lower than those for Option 1, as the minimum rotor height is likely to be higher. (This is because the survey guidance was produced for older, smaller turbines than are generally proposed. Option 3 is sensitive to such changes, Option 1 is not) So fewer birds inputted as at risk height will of course result in fewer birds predicted to collide. Thus, equation (1) is not valid as a comparison of the extended versus basic model. It would be valid if 'Option 1' were replaced by 'Option 2' in the equation, since Option 2 (which is still the basic model) uses the same flight height distribution as Option 3 to calculate the proportion of birds at risk.

3.3 Appendix O.3. *Review of avoidance rate estimates for seabirds.*

Key concerns:

- There are no details provided as to how collision risks have been calculated. For avoidance rates to be applicable to other sites, they must be calculated using the same model (and model version).

- It does not take into account potential variability in actual bird behaviour at different distances from the rotor hub.
- There is large scale temporal variability in the studies reported, all of which are relatively short term.
- Does not include the potential for habituation and consequent decrease in macro-avoidance and increased risk of collision.
- The studies reporting avoidance by gannets are only applicable outwith the breeding season.
- Other studies do not report on the key species of concern: gannet and kittiwake.

This review examines the current guidance and literature on the use of avoidance rates in the Band (2012) collision risk model. Underpinning it is the standard guidance from SNH (2010), which recommended the use of a 98% avoidance rate for all seabirds. While this was based on data from terrestrial wind farms, it was not, as this review asserts, solely for the use in terrestrial wind farms, and contains guidance specific to marine developments. It also makes no reference to a subsequent review, Cook *et al.*, 2012 which recommended the continued use of 98% AR for seabirds in offshore wind farms. A further complete review is currently underway, commissioned by Marine Scotland Science, which is overseen by a project steering group, and will report at the end of September.

SNH guidance says: “Avoidance rates, as used by SNH, make allowance for both of these behavioural responses (*avoidance and displacement*), and avoidance rates are a numerical expression of these behaviours”. Displacement (macro-avoidance) is thought to act on a lower scale with larger turbine arrays. This has not been taken into account.

Within the critical evaluation there is an argument made that avoidance rates for seabirds should be higher than terrestrial species because of the high macro-avoidance of wind farms by seabirds. Macro-avoidance is an evasive flight response to a whole wind farm (as opposed to individual turbines). Another potential impact of wind farms is displacement which has been defined as “a reduced number of birds occurring within or immediately adjacent to offshore wind farms” (Furness *et al.* 2013), and as such the definitions overlap to a degree, since displacement may be a consequence of avoidance behaviour” (Furness *et al.* 2013). In the FWD/SWD review, macro-avoidance is argued to be different from displacement “if birds are willing to either swim into the area or to land there and remain in the water”, a distinction which can only apply to birds that spend large periods of time on the water and/or forage from the water surface. As such it is not applicable to species such as gannet and kittiwake, and so for these species the distinction between macro-avoidance and displacement is not clear. This is of relevance because while in the avoidance rate review document it is argued that for gannets there is consistently “particularly high macro-avoidance”, in a displacement review, by the same author, submitted as an appendix to the Dogger Bank Creyke Beck application, it is asserted that “gannets may be displaced, but responses seem to vary among sites ”. These two statements are not consistent, and suggest that the evidence presented is far from conclusive. This is supported by a conclusion of Cook *et al.,* “there is little consistency in the species-specific macro-avoidance rates available from different study sites, in part due to the different methodologies used”.

Furthermore no mention is made of attraction, despite attraction being recorded at some wind farms post construction, for example attraction was reported at Barrow Offshore Wind Farm in species including kittiwake, unidentified gulls and gannet. This would in fact decrease the overall avoidance rate, thereby increases collision risk. In fact macro-avoidance should more correctly be referred to as “macro-response”.

Crucially in dealing with “macro-avoidance” or “displacement”, for displaced birds there is the potential for habituation, where birds become accustomed to the presence of the turbines. They then would fly closer to the rotating blades, and be at risk of collision. This potential temporal increase in collision risk has not been considered anywhere in the documentation.

On page 3, para 4a the argument from appendix 0.2 is repeated that onshore avoidance rates reflect the decreased detectability of birds with distance. It also incorrectly states that onshore wind farm surveys potentially under-record activity because observers following the flights of focal birds, are unable to record other birds. Good practice dictates that such time spent tracking focal species should be subtracted from the total observation time. The guidance also recommends multiple observers used where there are likely to be large numbers of such focal species (SNH 2010). Bizarrely, there is a citation of Warren and Baines (2011) as evidence of decrease in detectability of birds by surveyors of proposed wind farms. This paper in fact deals with the surveying of game birds using pointing dogs as a method of detection, and is therefore inapplicable.

On page 5, the citation of Whitfield and Urquhart (2013) refers to an earlier Marine Scotland Science commissioned review which is unapproved by the commissioning body and not officially released into the public domain.

3.4 Section 4. Empirical Evidence Review:

Key concerns:

- None of the reported avoidance rates (onshore or offshore) were derived using the survey guidance methodology.
- No details are given on how collision risks were calculated and therefore whether comparable with avoidance rates used with any Band model.
- None report on breeding gannets (*SPA are designated on breeding population*).

Section by section comments:

4.1. The report favours un-reviewed direct observation rather than the peer reviewed study of carcass collection. The data may have underestimated gull movements within the surrounding area for two key reasons. Firstly, no corrections were applied to account for imperfect detection of birds and collision events. Secondly, by limiting observations to the period between 0800 and 1500 h, key movements of gulls to and from roost sites may have been missed during the summer and autumn. Finally observers may not detect collision events.

4.2 These Krijgsveld studies suffer from no preconstruction monitoring. Flux rates were estimated using x-band radar, with the considerable disadvantage that it cannot be used to estimate the flux rates of different species. As a consequence, using individual species collision rates to estimate an avoidance rate may have led to an inaccurate estimate of the true value. There are no details as to how collision risk figure was calculated; if not Band is not applicable to this work.

4.3 The gannet data is for birds in passage and therefore not applicable for breeding birds. Similarly the study was not in the proximity of breeding kittiwake.

4.4. As above.

4.5. As above.

4.6. No corrections were applied to account for the imperfect detection of birds during the survey. Consequently, the true level of bird activity within the study area was likely to have been underestimated. Additionally, it was not possible to search for carcasses, meaning that inferences about avoidance behaviour can only be drawn from the failure of observers to detect a collision from a total of 36 hours of monitoring. Given the low probability of a collision occurring, and the levels of flight activity recorded, this outcome is unsurprising. It is also important to note that the size of the OWF was very small (two turbines) and therefore caution must be applied when considering how applicable these avoidance rates are for much bigger arrays.

4.7. This is a terrestrial wind farm, despite the authors already being critical of using data from VPs at terrestrial wind farms. We have been unable to obtain the source data.

4.8. Avonmouth Docks is a small coastal wind farm comprising three turbines. Again the only documentation related to the post construction monitoring is in a report that we are unable to obtain, and so we are unable to verify how these data were obtained.

4.9. There are no details as to how predicted mortalities and subsequent avoidance rates were calculated, but may not have been using any Band model. In this situation the results will not be comparable

4.10. There are no details as to how the presented avoidance rates were calculated, but the reference predates the Band model. In this situation the results will not be comparable.

4.11. Beatrice Demonstrator is a small offshore wind farm comprising two turbines. We were unable to find any mention of the post construction monitoring in the cited document (RPS 2010) and are therefore unable to verify how these data were obtained.

4.12. Haverigg is a small terrestrial wind farm comprising 8 turbines in Cumbria. Post-construction monitoring was carried out to inform the environmental assessment for Galloper Offshore Wind Farm (RPS 2011). This included running the 2007 version of the model (Band *et al.,* 2007). These calculations predicted 3.8 collisions of lesser black backed gulls, and 0.08 collisions with a 98% avoidance rate. For large gulls combined the model predicted 7.9 collisions during the survey period with no avoidance, and 0.16 collisions with a 98% avoidance rate. Therefore it is unsurprising that no collisions were recorded.

4.13. Hellrigg is a small terrestrial wind farm comprising 4 turbines in Cumbria. Again the only documentation related to the post construction monitoring is in a report that we are unable to obtain, and so we are unable to verify how these data were obtained.

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4. The Use of PVA for the Appropriate Assessment of Offshore Wind Farm Developments

Of the range of methods potentially available, the RSPB does not consider Potential Biological Removal ("PBR") (see Section 5 of this document) to represent the "best available science" as a framework for assessing impacts on SPA qualifying features to the standard implicit in the regulations and EU caselaw and guidance. Instead, in our view, the most appropriate method to inform assessment of the effects of a proposed development is to use Population Viability Analysis (PVA) to compare expected bird population sizes with and without additional mortality, particularly that attributable to the project, at the end of the expected life of the project, either alone or in-combination with other projects. We refer to this output of PVA modelling as the "Counterfactual of Population Size" (CPS). This metric can be calculated readily from a Leslie matrix (or similar) model with or without density dependence. This application of PVA is particularly suitable for appropriate assessment of breeding seabird features because:

1. It requires no assumptions to be made about future demographic rates (if the density-independent version is used).
2. Conservation objectives for SPA bird features refer to population sizes, not population multiplication rates.
3. It is a specific application of PVA population modelling, which is widely understood and robustly tested, including in the peer-reviewed, scientific literature, and therefore represents "the best scientific knowledge in the field".

4.1 Population Modelling

Any assessment of impact should take account of the effect on population size of the additional mortality caused by a project for those species predicted to be potentially significantly affected. This requires baseline population forecasts to be made, in the absence of the proposed project.

PVA includes a range of population modelling and estimation methods. The method has been tested and validated in a number of cases (Brook *et al.,* 2000, 2002) and is one of the most widespread means of answering questions of impacts in a population context (Akçakaya *et al.*, 2004, Sutherland 2006, Turvey & Risley 2006), including impacts of wind farms on birds (Maclean *et al.* 2007, Carrete *et al.* 2009, Garcia-Ripolles & Lopez-Lopez 2011). In the context of Habitats Regulations Assessment (HRA) of species features, this will generally involve simulating the projected size of an animal population by means of a demographic model, under different scenarios.

The demographic model requires initial numbers of animals in a starting year, estimates of age of first breeding (attaining adulthood), the probability that an individual will survive and remain within the population from one year to the next, and estimates of breeding productivity. The survival and breeding productivity rates are referred to as demographic rates. Demographic rates may vary between age classes, among individuals of a given age class, as well as in different years. The influence of external variables on demographic rates can be extremely hard to predict, notably where these influences are of anthropogenic origin, such as climate change and the influence of legislation, for example, on fisheries' discard policy. However, for the purposes of HRA, it may be reasonable to assume that these likely variations will apply to modelled populations equally in the presence and absence of the proposed development.

Density dependence occurs when the population growth rate or demographic rates vary causally with population size or density (Hixon & Johnson 2009). Newton (1998) provides a comprehensive overview of population limitation in birds, including density-dependent responses. When population density is high, increased competition for resources – food, nest sites, mates etc, tends to slow or halt population growth, whilst at lower population density competition tends to be reduced, leading to increases in population growth rates. At very low population density, individuals may be less able to find mates; inverse density dependence. This is necessarily a simplified description of density dependence.

4.2 Relevance to assessment

PVA population simulations have the potential to be used to predict population trends at a specified future time, given estimates of starting population size and initial demographic rates, and how these will change in relation to intervention, such as predicted additional mortality attributable to collision. Projections from a well-conducted PVA population simulation could provide the type of quantitative information on future population trend required for an informed and qualitative Appropriate Assessment of the effects of an intervention. This is exactly what is needed to evaluate the impact of an intervention on the conservation status of an animal population at a designated site because the *counterfactual* – what would happen with and without the intervention - can be estimated, along with the relative scale of change.

For species that aggregate in large numbers, there is no merit in making comparisons of population multiplication rates, because to do so assumes that ecological conditions in the future are predictable and can be reliably assumed to permit rates of population change that result from the assumed input demographic rates. Such unsubstantiated assumptions are untestable and therefore not scientifically valid. Although PVA models generate predictions of population size, it is generally accepted that they are most useful for assessment purposes when focused on comparative results (Beissinger & Westphal 1998, Akçakaya & Sjögren-Gulve, 2000). This is also in alignment with the authors of the SOSS report on the use of PVA in offshore wind assessments, who state: “overall it is worth stressing that the predicted population sizes themselves are of lesser interest than the relative changes predicted” (WWT Consulting *et al.*, 2012).

4.3 PVA population simulation in practice

There might be difficulties in gathering all the information required to perform an accurate and realistic simulation of population size. The method requires estimates of starting values of population size, age distribution and demographic rates. If these are not available for the population involved from recent studies, it is possible to use estimates of some model parameters from other studies of the same or even similar species done elsewhere, although this approach will increase uncertainty. Values for the CPS output of PVAs based upon models that assume no density dependence remain very similar regardless (within limits) of the estimates of demographic rates used in the population models. In particular, there is little or no effect on the CPS from a density independent model of demographic rates being set so that the population is increasing, stable or declining. Furthermore, the counterfactual measure of change in population-size is robust even when different estimates of demographic rates are used. This is very important because future demographic rates are unknown.

Calculating the CPS using models that assume no density dependence gives outputs that are substantially more robust against failures of the assumptions than outputs of models that do assume density dependence. In particular, the values of parameters that determine the strength and form of the density dependence affect the calculated magnitude of the CPS.

There is generally a lack of empirical evidence for density dependence in seabird populations. Although it is thought likely that density dependence may apply at some, as yet unknown, level, it is difficult to measure. In the absence of measures of density dependence, the use of population models that do not incorporate density dependence is the appropriate precautionary approach to use because density dependent effects will tend to moderate any additive adverse effects of the project. An alternative approach would be to review the literature on density dependence in bird populations to identify a plausible range of parameter values for density dependence to test the sensitivity of model outputs to high, medium and low measures of density dependence. This set of projections also should include a scenario with no density dependence.

Some proposed alternative approaches, *e.g.* ABC or the risk based approach applied in the Greater Wash cases, to the assessment of population change, require estimation of a difference in probability of a selected population outcome with and without a development or intervention. Although this is a counterfactual approach, the RSPB considers the difficulty in estimating reliable probability distributions for future population scenarios to be unacceptably uncertain. A probabilistic approach is particularly difficult where population outcomes involve the modelling of collision mortality, for which formal estimates of uncertainty are usually absent or unreliable (see Section 2 of this document).

As with any tool to assess population-level effects on a species, the CPS derived from PVA modelling is not perfect. However it is the most robust method currently available to assess how a population may change over time as a result of an intervention and it ought to be used to inform consenting decisions where potential impacts to seabird populations have been identified. This method does not provide an impact threshold for the binary decision of whether a project is consented or not. It does however provide a sound scientific contextual basis for making what, ultimately, will be a qualitative judgement, based on the best (*i.e.* most robust) available science.

[This text has been authored by Professor Rhys Green, Dr Aly McCluskie, Richard Evans and Dr Rowena Langston]

5. Why it is incorrect to use the Potential Biological Removal method for assessment of bird population impacts of collision and displacement mortality at wind farms

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5.1 Principles of Potential Biological Removal

Potential Biological Removal (PBR) is a method for detecting overharvesting of exploited animal populations and unsustainable additional mortality of other kinds. In the simple implementation of PBR typically used in assessing effects of wind farm proposals on birds, PBR identifies levels of additional death in a population which, if exceeded, would be almost certain to cause it to decline to extinction. It does not identify sustainable levels of additional mortality. It also does not estimate how population size will change over a period of time as a result of an intervention such as wind farm construction. PBR can be valuable when applied to animal conservation. Thanks to an application of the Demographic Invariants Method by Lebreton (2005), it can be performed for bird populations using very few data. The required data are the minimum current population size, and estimates of two demographic rates: the mean age at first breeding and mean annual adult survival. Values for the demographic rates should be those observed under optimal environmental conditions when population size is increasing at the maximum possible rate (Niel & Lebreton 2005). PBR calculations use some observed values of mean age at first breeding and mean adult survival to calculate the maximum annual growth rate of the population λ_{max}. This is done by solving the equation

$$\lambda_{max} = \exp(1/(\alpha + (s/(\lambda_{max} - s))))$$

for λ_{max}, where α is mean age at first breeding in years and *s* is mean annual adult survival (Niel & Lebreton 2005). The maximum annual growth rate of the population λ_{max} is a number that exceeds 1 because the population is, by definition, increasing under optimal conditions. Populations usually do not achieve the maximum annual growth rate because they are usually not experiencing optimal conditions. Implicit in the use of PBR is that demographic rates are enhanced when population size is reduced by additional mortality. This reduction in population size allows the actual population growth rate to increase towards the maximum growth rate because of density-dependent enhancement of demographic rates, possibly because of reduced competition for resources at low population size. However, populations may not achieve the maximum growth rate even at very low population density because they are not experiencing optimal ecological conditions.

It can be seen that $\lambda_{max} - 1$ provides an upper limit to the maximum per capita rate at which an excess of young individuals over that required for population stability could recruit to the population. Hence, differences among species or populations in the largest per capita death rate that a population could sustain without declining to extinction, are likely to be proportional to λ_{max} – 1.

Adapting the population simulation study of marine mammals by Wade (1998), Niel and Lebreton (2005) proposed that overharvesting or unsustainable additional mortality of birds could be detected by comparing the number of birds killed per year by an additional source of mortality with the potential excess growth *P* where

$$P = N \beta (\lambda_{max} - 1),$$

N is the estimated population size and β is a factor. λ_{max} is first estimated from adult survival and mean age at first breeding, as described above. Expressing this as a per capita additional annual mortality rate gives

$$P/N = \beta (\lambda_{max} - 1).$$

If the actual level of additional mortality continues to exceed that defined by a high value of β, then the population is likely to decline to extinction. In practice, the maximum value of β considered likely to allow population persistence is $\beta = 0.5$ (Niel & Lebreton 2005). In most cases where the PBR method has been applied to additional mortality caused by renewable energy projects, an alternative expression has been used, based upon Dillingham & Fletcher (2008):

$$PBR = 0.5\, N_{min}\, f\, (\lambda_{max} - 1)$$

in which *PBR* (Potential Biological Removal) is equivalent to the potential excess growth, N_{min} is a value of estimated population size lower than the most probable value (usually the 20th percentile of its cumulative probability distribution) and *f* is the recovery factor. Note that this expression is the same as that for *P*, except for the use of N_{min} instead of *N* and the substitution of $f = 2\beta$. N_{min} is a lower confidence bound of the estimated population size, adopted for precautionary reasons when population size is not known precisely. The maximum value of *f* typically used is $f = 1$, which is equivalent to the maximum value of $\beta = 0.5$ proposed by Niel & Lebreton (2005).

5.2 The use of PBR is not appropriate to practical applications in wind farm assessments because it does not quantify the impact of additional mortality on population size

The PBR method can be used to identify levels of additional mortality that are almost certainly not sustainable by the population of interest. It is important to understand what the term 'sustainable' means in this context. The management goal set by the US Marine Mammal Protection Act, that underpins the original PBR calculations, is to prevent populations from 'depletion', in which a population is considered depleted if it falls below its maximum net productivity level (MNPL) (Wade 1998). Hence, a population incurring additional mortality caused by an intervention such as a wind energy project which is below the level defined by a PBR would still be likely to decline substantially below the population size that would have occurred in the absence of the project. PBR calculations do not themselves provide an estimate of how large this difference between the population with and without the intervention is expected to be. To estimate that difference requires a population simulation model and knowledge of the strength and form of density dependence. It cannot be done using only knowledge of adult survival rate and mean age at first breeding.

5.3 The use of PBR is not appropriate to practical applications in wind farm assessments because of inadequate knowledge about density dependence

A reliable measure of the level of additional mortality that a population can sustain without declining to extinction is not given by the simple PBR calculation described above, because it is affected by the strength and form of density dependence occurring in the population. Hence, it cannot be obtained using only knowledge of adult survival rate and mean age at first breeding. An important feature of density dependence is the form of the relationship between the demographic rate (or rates) affected by it and population size. A simple simulation model of a hypothetical kittiwake population, in which breeding success is subject to density dependence illustrates clearly that both the level of additional mortality at which the population declines to extinction and the reduction in population size in cases where extinction does not occur are strongly influenced by the form of density dependence (Figures 1 and 2). In this model, it is the shape parameter of a Weibull equation relating breeding success to adult population size that has the effect. In the simulation studies of Wade (1998) and Bellebaum *et al.* (2013) the shape parameter ϑ of the generalised logistic equation was also found to have a strong effect on PBR results. Details of the shape parameter and other aspects of density-dependent relationships are only rarely known for animal populations.

Hence, both the threshold of additional mortality for population extinction and the level to which a population will fall when exposed to a given level of mortality below this threshold cannot be determined reliably from a simple PBR calculation. That can only be done by realistic simulations of the population in which explicit assumptions are made about the form of density dependence. Because accurate information on density dependence is rarely available, this means that PBR usually cannot give reliable results.

5.4 The results of PBR calculations depend upon a choice of a recovery factor which is not supported by empirical evidence

PBR requires the use of a recovery factor f which is set based upon opinion rather than being determined by theoretical or empirical constraints. Whilst suggestions have been put forward for suitable recovery factors for populations of different status (Dillingham & Fletcher 2008), and a maximum default recovery rate of $f = 0.5$ has been recommended, these values are simply matters of opinion and appropriate recovery factors are really unknown. A higher value of the recovery factor increases the PBR. High values of recovery factor are claimed to be justified based on the premise that the capacity for increased recruitment to offset any additional mortality incurred is likely to be greater in populations that are increasing in size than in those where numbers are stable or declining. According to the marine mammal simulation study examples of Wade (1998), the recovery factor should not be higher than 0.1-0.2 if the aim is to maintain the population at 90-95% of the starting population size (*i.e.* a decline no greater than 5-10%), or in the case of a declining population, the recovery factor should be no higher than 0.1-0.3 if to avoid delaying the recovery time by more than 10-20%. The results from Wade’s simulations are dependent on features of the assumptions about the form and strength of density dependence which are unknown for the birds under consideration in virtually all PBR applications. It is necessary to understand that the PBR values are dependent upon a factor which is based simply upon opinion and on simulation results that are sensitive to untested assumptions.

Given this deficiency, it is important to realise that the PBR method has not been validated for birds or mammals. Proper validation would require that comparisons of reliably measured trends in population size with PBR calculations indicated that populations subject to additional mortality less than the PBR were not declining whereas those with additional mortality exceeding the PBR were declining. In practice, because any PBR calculation involves an unsubstantiated choice of the recovery factor (see above) such an analysis might indicate which values of the recovery factor produce the most robust results in defined circumstances. However, such a validation test has not been done. When used for setting marine mammal bycatch or hunting bag limits, PBR is predicated on a feedback loop to modify "harvesting" rates iteratively, if necessary. This offers opportunities to validate the initial PBR calculation by experiment and, if it fails the test, to modify the recovery factor as part of adaptive management. This opportunity is not present for wind energy developments. Once wind turbines are erected, there will be limited scope for modifying mortality rates if they are found not to be sustainable.

5.5 Other problems with oversimplistic use of PBR

The PBR approach evaluates whether the effects of all sources of additional mortality in combination exceed the levels that a defined population could sustain. The capacity of bird populations to compensate for additional mortality caused by wind energy developments is likely to be compromised if there are also other frequent sources of additional mortality, such as drowning in fishing gear. In applications of the PBR approach to the assessment of the impact of additional mortality, it has been emphasized that it is essential to have accurate estimates of all sources of additional mortality affecting the whole population under consideration if comparison of additional losses with PBR is to be performed (Zydelis *et al.* 2009). Whilst these other additional losses may be difficult to measure precisely, ignoring them obviously invalidates the use of PBR, even if the other objections described above were to be overcome.

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Figure 1. Density-dependent breeding success in a hypothetical population of kittiwakes. The relationship of the number of female young fledged per year per adult female to adult female population size is shown, assuming a Weibull relationship of breeding success to population size. Breeding success is expressed as a proportion of the maximum possible. Results are shown for seven values of the shape parameter *β* of the Weibull function. Numerals next to the curves refer to shape parameter values. In all cases, the scale parameter *α* of the Weibull function was adjusted so that the population stabilised at 1000 adult females.

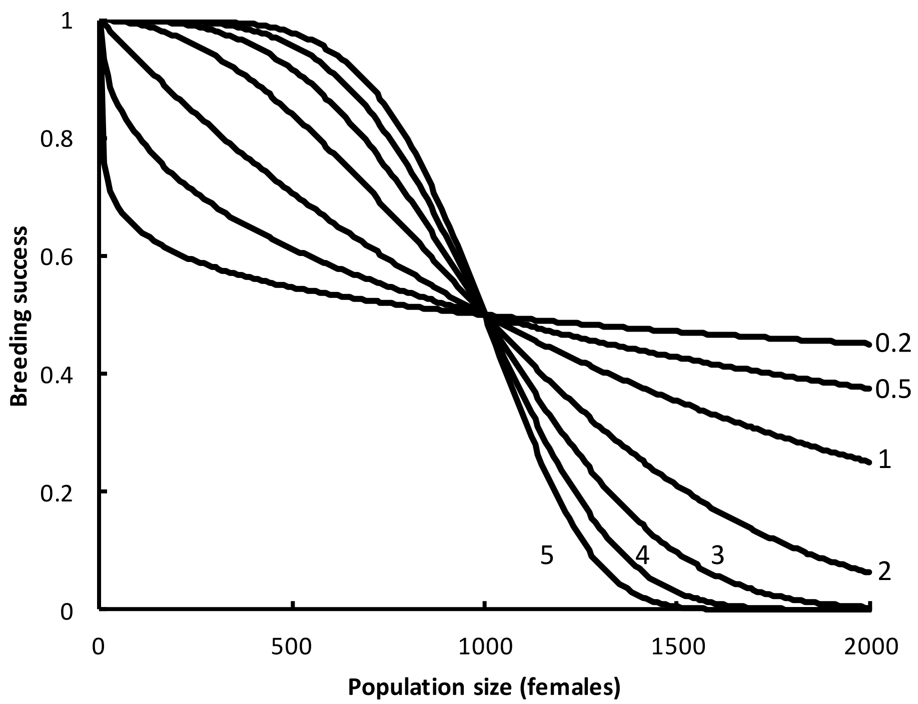
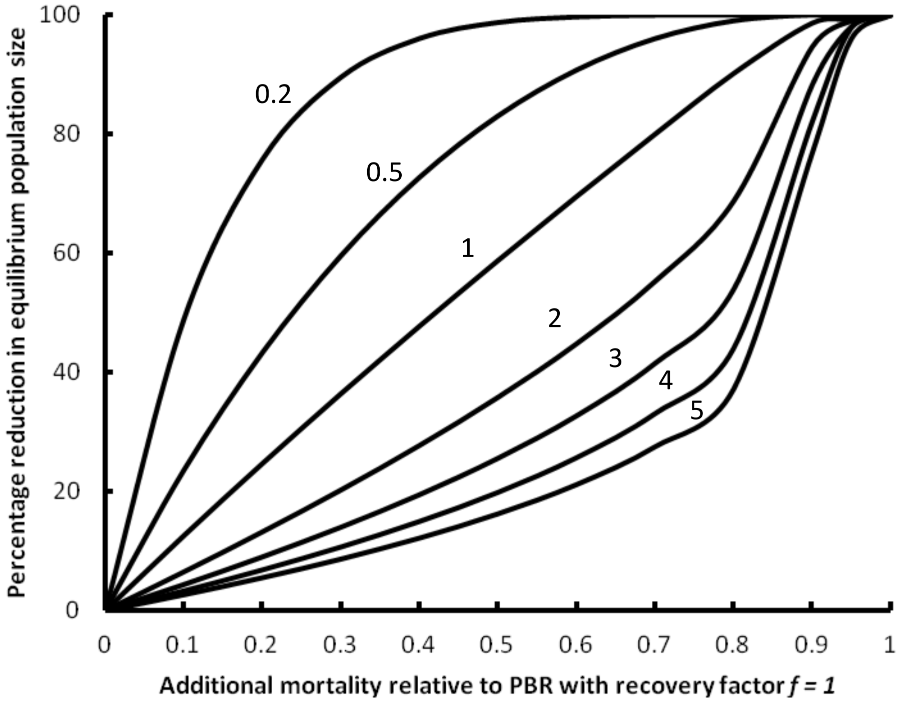


Figure 2. Percentage reduction in equilibrium population size in a hypothetical population of kittiwakes in relation to the magnitude of a constant per capita additional annual mortality rate imposed upon all full-grown individuals. Additional mortality is expressed relative to the level identified as being sustainable using the Potential Biological Removal method with recovery factor *f* = 1. Results are shown for seven values of the shape parameter *θ* of the Weibull density-dependence function. Numerals next to the curves refer to shape parameter values.



5.6 Annex: Model of a hypothetical population of kittiwakes

It was assumed that the equilibrium population size in the absence of additional mortality was 1,000 adult females. An age and time-structured matrix model was used with parameters based upon a simplification of results in Frederiksen *et al.* (2004). The estimate of adult (>= 4 years) annual survival was approximately that from the quadratic model of Frederiksen *et al.* (2004) relating survival to age (0.9). Breeding was assumed to commence at four years old for all individuals rather than some individuals breeding for the first time at 3, 4 and 5 years old, as has been observed. Survival between fledging and maturity was taken to be 0.3. All adults were assumed to breed. Maximum possible average breeding success F_{max} was taken to be 0.6667 female fledglings per adult female for all ages of adults. This was reduced by a factor dependent upon the number of adult females N_i in year i, according to the Weibull equation

$$F_i = F_{max} \exp(-\alpha N_i^{\beta}),$$

where α is the scale constant and β the shape constant of the Weibull equation. For a given value of β, the value of α was obtained that gave an equilibrium population size of 1,000 adult females. There was no stochastic variation in parameter values.

The model was run for 1,000 years with no additional mortality. A specified level of additional per capita mortality was then imposed on all age classes for 1,700 years and total population size calculated at the end of that period. The maximum growth rate according to the method of Niel & Lebreton (2005) was 1.1368, giving a per capita PBR with recovery factor f = 1 of 0.068. Additional mortality was imposed at various levels up to 0.068 and divided by 0.068 to give additional mortality relative to PBR with f = 1.

ANNEX B

Examining Authority's
First Written Questions

Response by the
Royal Society for the Protection of Birds

20 October 2014

Planning Act 2008 (as amended)

In the matter of:

Planning Application for the Proposed Navitus Bay Wind Park located approximately 14 km off the Dorset Coast

Planning Inspectorate Ref: EN010024

Registration Identification Ref: 10029429

rspb giving nature a home

Issued on 22 September 2014

Q2.1.22

Biodiversity, Biological Environment and Ecology

Can the RSPB provide further details of their concern over the methodological approach to the assessment of potential impacts on gannet and provide an update on their further work with the applicant to resolve these concerns?

We set out in paragraphs 4.3 to 4.17 of our Written Representation the current position with respect to the assessment of potential impacts on gannets and our recommended approach.

Q2.1.26

a) **Can the applicant provide further details on how construction and operational vessel routes will be determined once a port is chosen, to take into account the potential disturbance and displacement impacts on ornithological species?**
b) **Can routeing principles be secured?**

For the Applicant.

Q2.1.36

Can the interested parties and applicant confirm that the correct features have been identified in the HRA Screening Report for all relevant UK sites and that nobody is aware of any feature or European sites that have been omitted.

For Natural England.