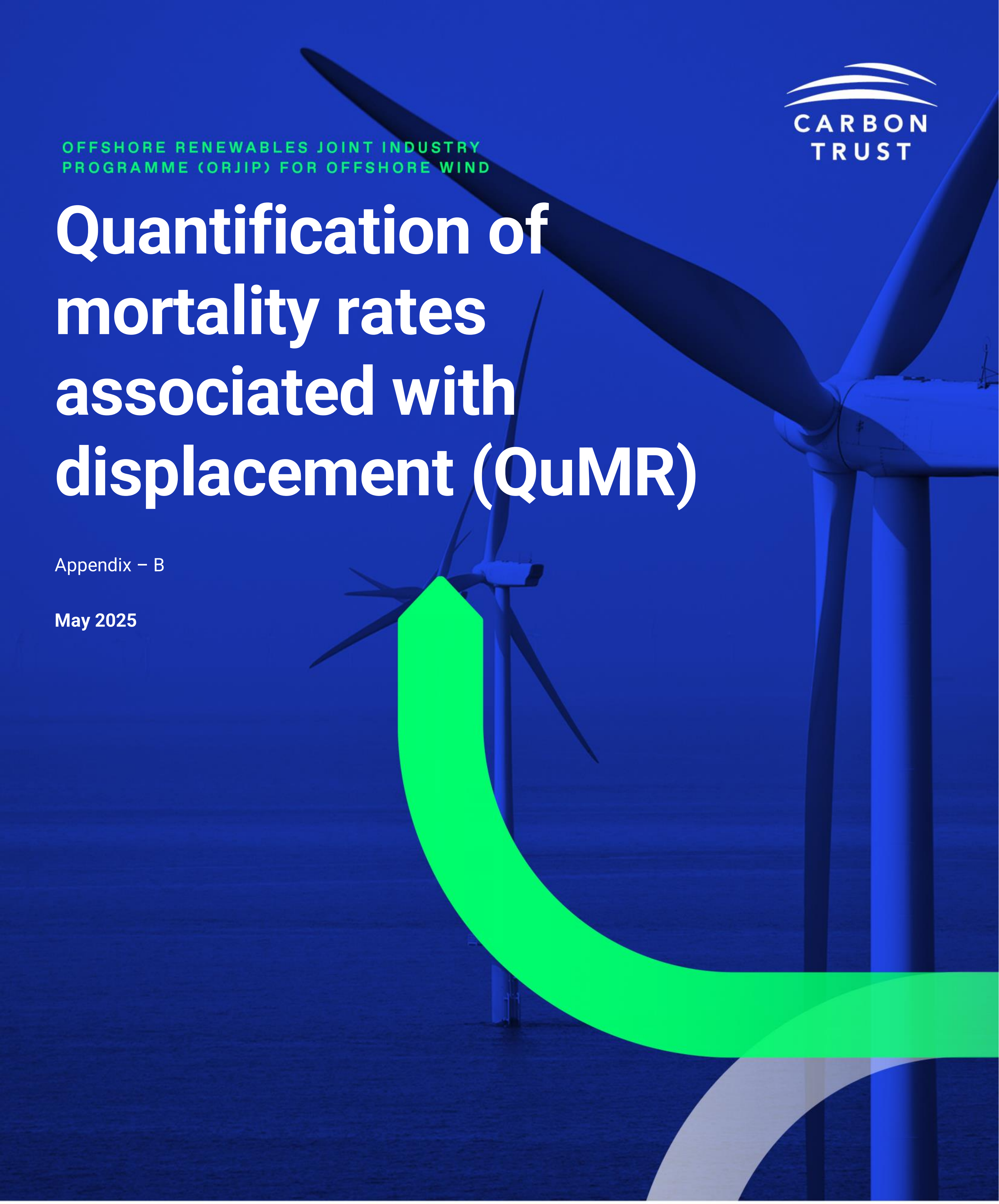

OFFSHORE RENEWABLES JOINT INDUSTRY PROGRAMME (ORJIP) FOR OFFSHORE WIND

Quantification of mortality rates associated with displacement (QuMR)

Appendix – B

May 2025

working to accelerate offshore consenting

ORJIP Offshore Wind

The Offshore Renewables Joint Industry Programme (ORJIP) for Offshore Wind is a collaborative initiative that aims to:

- Fund research to improve our understanding of the effects of offshore wind on the marine environment.
- Reduce the risk of not getting, or delaying consent for, offshore wind developments.
- Reduce the risk of getting consent with conditions that reduce viability of the project.

The programme pools resources from the private sector and public sector bodies to fund projects that provide empirical data to support consenting authorities in evaluating the environmental risk of offshore wind. Projects are prioritised and informed by the ORJIP Advisory Network which includes key stakeholders, including statutory nature conservation bodies, academics, non-governmental organisations and others.

The current stage is a collaboration between the Carbon Trust, EDF Energy Renewables Limited, Ocean Winds UK Limited, Equinor ASA, Ørsted Power (UK) Limited, RWE Offshore Wind GmbH, Shell Global Solutions International B.V., SSE Renewables Services (UK) Limited, TotalEnergies OneTech, Crown Estate Scotland, Scottish Government (acting through the Offshore Wind Directorate and the Marine Directorate) and The Crown Estate Commissioners.

For further information regarding the ORJIP Offshore Wind programme, please refer to the Carbon Trust website, or contact Ivan Savitsky (ivan.savitsky@carbontrust.com) and Žilvinas Valantiejus (zilvinas.valantiejus@carbontrust.com).

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- Joint Nature Conservation Committee (JNCC)
- Natural England
- Natural Resources Wales
- NatureScot
- Scottish Government's Marine Directorate

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Who we are

Our mission is to accelerate the move to a decarbonised future.

We have been climate pioneers for more than 20 years, partnering with leading businesses, governments and financial institutions globally. From strategic planning and target setting to activation and communication - we are your expert guide to turn your climate ambition into impact.

We are one global network of 400 experts with offices in the UK, the Netherlands, Germany, South Africa, Singapore and Mexico. To date, we have helped set 200+ science-based targets and guided 3,000+ organisations in 70 countries on their route to Net Zero.

Contents

ORJIP Offshore Wind 2

Acknowledgements 2

Who we are 2

Abbreviations 4

1. Recommendations..1

References..6

Abbreviations

Term	Description
EE	Expert Elicitation
ORJIP	Offshore Renewables Joint Industry Programme
WP	Work Package

1. Recommendations

Using expert elicitation results in the displacement matrix tool for assessments

In this section we provide recommendations on the usage of the expert elicitation results for the mortality rate of displaced birds (hereafter '*displacement mortality rate*') within the main tool that is currently used in assessing risk from displacement – the "Displacement Matrix", which requires this parameter as an input to the tool.

A very broad operational definition of the displacement mortality rate is that it is equal to the ratio of the absolute level of displacement mortality from a windfarm to the number of individuals experiencing displacement by a windfarm, so that the absolute level of displacement mortality from a windfarm is equal to the number of individuals experiencing displacement by a windfarm multiplied by the displacement mortality rate. The number of individuals experiencing displacement by a windfarm can itself, in general, be calculated to be equal to the baseline number of individuals using the windfarm footprint area prior to construction multiplied by the proportion of these individuals that would experience displacement if there were a windfarm (the "displacement rate"). The absolute level of mortality is therefore equal to:

*Absolute level of displacement mortality from a windfarm = Baseline number of individuals using windfarm * Displacement rate * Displacement mortality rate*

[Equation 1]

The current Displacement Matrix approach, which is extensively used in assessments, performs this calculation for a pre-specified set of values for the displacement rate and displacement mortality rate. A range of values for both of these parameters are used to provide a visual means of examining the consequences arising from the uncertainty associated with both rates. Within the current Displacement Matrix approach the baseline number of individuals using the windfarm is defined in a specific way -- as the maximum monthly estimated baseline abundance within the windfarm footprint within the season of interest, as estimated using at-sea survey data. The current approach focuses only on individuals that use the windfarm and so does not account for indirect effects on individuals that do not use the windfarm but may be impacted by it – e.g., in particular, it does not account for indirect effects on chicks driven by displacement impacts on breeding pairs.

There is currently no direct empirical evidence regarding the displacement mortality rate (see WP1 report), leading to considerable uncertainty in the appropriate parameter values to use within the Displacement Matrix tool. The expert elicitation (EE) within this project used expert judgement to assign values to the displacement mortality rate, for six species in breeding and non-breeding seasons. The displacement mortality rate is a key input to the Displacement Matrix approach, so the results of the EE have clear relevance to the way that the Displacement Matrix is used and should be considered in relation to updating SNCB guidance for this approach. However, there are a number of important issues that need to be taken into account when using the results of the EE within the Displacement Matrix approach:

(1) the way in which the EE accounts for uncertainty and variability
(2) the way in which baseline abundance is estimated within assessments, and how this relates to the biological interpretation of seabird space use of windfarm footprints developed by the experts and used to frame displacement mortality rate estimation within the EE
(3) the fact that the EE produced separate estimates for indirect displacement effects on chicks as well as for direct effects on adults

Issue 1: The approach that the EE uses to account for uncertainty and variability

The current displacement matrix approach uses pre-specified ranges of values (defined by the regulator and their advisors) for the displacement rate and displacement mortality rate. The EE results differ from this in two important ways:

1. They provide a probability distribution, rather than a discrete set of fixed values.

2. They provide a separate distribution for each expert, rather than providing a single overall distribution or range.

These differences have consequences for the potential use of elicited values for displacement mortality rates within the current UK assessment framework. It is generally recommended that the distributions for individuals experts are used, rather than pooling these distributions, to retain the uncertainty from the EE that arises from differences between individual experts. A simulation-based approach could be used to capture uncertainty both within and between experts: within each of a large number of simulations, a random expert is first selected, and a value of the displacement mortality rate is then simulated using the probability distribution for this expert. The simulated rates therefore capture both sources of uncertainty – uncertainty associated with the estimate provided by each expert, and uncertainty arising from variation in estimates across all experts involved in the EE.

The Marine Scotland CEF project has developed a simulation-based approach to propagate uncertainty between individual assessment tools and provides the functionality for a set of simulated displacement mortality rates to be provided. Each rate is then converted into absolute displacement mortality, using Equation 1, and this is propagated through the subsequent stages of modelling (e.g., Population Viability Analysis) using the simulation-based approach. This functionality could allow for the uncertainty captured in the EE to be used within the assessment process via the CEF (both in terms of differences between experts, and within the probability distribution resulting from each individual expert's judgements). This simulation-based approach for propagating uncertainty should, in principle, allow the current approach, of applying precaution at each modelling step within the assessment process, to be avoided: by propagating uncertainty through the whole process, the simulation-based approach should allow precaution to only be considered at the final step in the chain of models, because the uncertainty at this final step has incorporated individual components of uncertainty from each earlier step in the assessment process.

A practical challenge, however, is that the extent to which uncertainty is quantified currently varies considerably between tools and steps in the assessment process. In the context of the Displacement Matrix, a key challenge lies in how the probabilistic quantification of uncertainty in the Displacement Mortality Rate arising from the EE can be combined with the way that uncertainty is accounted for in the Displacement Rate. Because uncertainty in the Displacement Rate is currently dealt with in a non-probabilistic way, and it is difficult to combine uncertainties obtained using probabilistic and non-probabilistic approaches, this requires further research, such as a meta-analysis of existing studies estimating displacement rates, or expert elicitation to quantify the uncertainty associated with displacement rates.

Issue 2: Definition of baseline bird abundance for use in the Displacement Matrix

The current Displacement Matrix approach defines the baseline number of individuals using the windfarm to be the maximum monthly estimated baseline abundance within the windfarm footprint in the season of interest, estimated from at-sea survey data. This quantity can be calculated directly from data that are routinely collected, so is in operational terms, straightforward to use.

However, during the EE the experts considered whether it was possible to provide judgements on the displacement mortality rate in the context of the way in which baseline bird abundance is currently estimated in Displacement Matrix approach. The experts concluded that this was not possible because the definition of baseline abundance is broadly incompatible with a biological understanding of seabird space use patterns over time, including biological processes such as turnover, fidelity in space use, and behavioural patterns associated with breeding pairs and attendance of offspring.

The experts in the EE therefore defined the Displacement Mortality Rate using a biological, rather than operational, definition of the extent to which seabirds use the windfarm footprint, which then allowed them to meaningfully provide judgement on the values of the displacement mortality rate. The specific definition that was adopted related to any:

"Individual bird or their dependents and inter-dependents that would have used the area of influence of the offshore wind farm and associated infrastructure if there had been no offshore wind farm."

hence, the elicited mortality rates were specifically defined as:

"The excess mortality rates (as an absolute %) for an individual bird or their dependents and inter-dependents that would have used the area of influence of the offshore wind farm and associated infrastructure if there had been no offshore wind farm, but which is displaced away from the area during construction and/or operation."

This definition implicitly assumes that the displacement mortality rate applies to all individuals that experience displacement at any point during the season of interest. This, in turn, implies that the baseline abundance that is effectively being used in defining the displacement mortality rate is the **total number of individuals that utilise the windfarm footprint, during the baseline period, at any point during the season of interest**. The experts stated that this definition was likely to result in very different numbers of birds than the one used in the current assessment process based on at-sea surveys.

The level of baseline abundance used in the EE definition of the displacement mortality rate is, therefore, likely to be substantially different to that used in the current Displacement Matrix approach. The baseline abundance level used in the EE definition might be expected to be both systematically and potentially substantially larger than that used in the current displacement matrix approach. This systematic difference arises because the EE definition accounts for turnover in space use of birds at sea, whereas the current Displacement Matrix definition does not. The EE definition considers all individuals that *ever* use the windfarm footprint during a particular season, whereas the Displacement Matrix definition focuses only on the number of individuals using the footprint at a particular point in time (albeit that with high abundance, amongst the points at which surveys occurred).

Our belief is that it is not appropriate to use the displacement mortality rates arising from the EE within the Displacement Mortality in its current form, unless adjustments are made to account for this discrepancy. We consider a simple example to demonstrate the potential variation in mortality levels arising from this mismatch, in which the baseline abundance is 200 individuals based on the definition in the current Displacement Mortality approach (e.g., from at-sea surveys), versus a value of 800 individuals according to the definition used in the EE (e.g., all *individual birds or their dependents and inter-dependents that would have used the area of influence of the offshore wind farm and associated infrastructure if there had been no offshore wind farm*). If we assume the EE estimated a single displacement mortality rate of

1%, then when this EE displacement mortality rate is used in combination with the baseline abundance value from the current method for the input to the Displacement Matrix (at-sea surveys) the resulting mortality level will be just 25% (e.g., 100 * [200/800]) of the value arising from the application of the definition used in the EE process. To adjust for this discrepancy, the baseline abundance from the current Displacement Matrix could either be multiplied by the ratio of the baseline abundances (800/200 = 4) before combining it with the displacement mortality rate from the EE, or, equivalently, the displacement mortality rate from the EE could be multiplied by this ratio prior to combining it with the baseline abundance from the current Displacement Matrix approach. However, we currently lack an agreed methodology for how these conversions could be applied, and the precise way in which conversion values should be calculated.

This adjustment or conversion fundamentally relies on estimating **turnover** in space use of seabirds at sea:

"The ratio of the number of birds that ever use the windfarm footprint at any point during the season of interest to the number of birds estimated using the peak monthly at-sea survey."

Turnover is influenced by site fidelity (e.g., from individuals choosing to similar foraging locations over time), but is also affected by daily time budgets, particularly in breeding pairs in which attendance of chicks is critical to chick survival. This is because even if individuals always forage in the proposed windfarm location, they will still spend only a proportion of their time in the windfarm area (and therefore be available to be counted within at-sea surveys) because they must engage in other activities such as returning to the nest to attend their chicks and relieve their breeding partner. Turnover cannot be estimated using at-sea survey data because at-sea surveys do not track the extent to which the same individuals are observed in different surveys, so needs to be estimated using other data sources. GPS tracking data can provide a way of estimating turnover values, because it tracks specific individuals over time. There are, however, challenges in using GPS tracking data for this purpose, such as datasets tending to focus on a subset of the population and typically tracking individuals for part of a season over relatively short time periods. Expert elicitation could provide another possible approach for estimating turnover rates in the absence of sufficient GPS tracking data for each species and location of interest, as turnover is likely to vary in both space and time depending on environmental characteristics and lifecycle phase.

A previous project funded by Marine Scotland considered processes relating to, and estimates of turnover for some seabird species in one region of the North Sea (Searle et al. 2015), providing recommendations for how turnover could be estimated, and the potential extent to which it could affect estimates of the number of individuals using a discrete area of space derived from at-sea survey data. Key inference from this project was as follows:

- The turnover values calculated could, in principle, provide a basis for scaling the abundance estimates of breeding individuals obtained during bird surveys of a particular area (such as a wind farm footprint) up to estimates of the number of breeding birds that are using that area during the entire breeding season. However, there were three key reasons why considerable caution needs to be taken in trying to do this:

    - The results were contingent upon particular scenarios regarding the level and spatial scale of site fidelity, which is currently unknown for most species of interest. The results therefore provide a guide to assess how the level of turnover changes with site fidelity behaviours and patterns, and with the spatial scale of wind farm footprints, but they cannot provide specific estimates of turnover until further data on both the level and spatial scale of site fidelity of these species become available.

    - The literature review in the project highlighted the considerable variability in seabird foraging ranges and foraging trip characteristics both within and between species, and within and between years – all of which will affect estimates of turnover. This variation may translate into among-population and inter-annual differences in turnover of individuals at sea that should be considered when assessing the potential impacts of offshore renewable energy developments on breeding seabirds.

- Current methods for surveying seabirds at-sea cannot achieve a complete census of all birds within an area the size of most windfarm footprints. At-sea surveys will, therefore, generally be a sample, rather than a complete census, and will typically take place over a longer time period rather than at an instantaneous snapshot. In order to scale actual survey data (e.g., at-sea surveys) up to the total number of birds in the area it is necessary to use statistical adjustments to account for factors other than turnover, such as non-detection. In addition, at sea survey estimates cannot distinguish between breeding and non-breeding individuals, nor assign birds to specific colonies. An additional step is required to adjust the at sea estimate by the proportion of non-breeding birds and to assign remaining birds to the appropriate colony or population of interest.

Issue 3: Impacts on chicks

Implementing the EE estimates for impacts of displacement on breeding success of affected adults is in principle straightforward, as it produces a change in breeding success for affected birds which may be used within a PVA in the same way that any change in adult mortality is implemented. However, such an implementation encounters the same challenge described above, namely the discrepancy between how inputs for the Displacement Matrix are currently calculated and the definition assumed within the EE of impacts on adults and chicks – how to reliably estimate the number of adult birds that would have used the area of influence of the offshore wind farm and its associated infrastructure at any time during the season of interest. Consideration would also have to be given to the breeding state of individuals observed in at-sea surveys when making this adjustment for impacts in the breeding season. For many species it is not possibly to separate breeders from non-breeders (e.g., adults from immatures, or to identify adults that are not breeding but still in using the area around a breeding colony) in aerial survey data. As with the previous recommendation, both GPS tracking data and expert elicitation could be used to estimate the adjustment needed to convert estimates of all birds observed within at-sea surveys to estimate the number of breeding birds likely to be using the area of sea at any point during the breeding season. This will require further research to develop a standardised and reliable method.

Research recommended to facilitate use of the EE outputs within the Displacement Matrix, and to improve estimates of displacement mortality rates:

- Interrogation of GPS tracking data to estimate rates of fidelity in seabird species, including influence of environmental variation and seasonal variation.

- Examination of seabird time-activity budgets to understand influence of division of behaviour between at-sea and colony behaviours and how this might be used to adjust at-sea survey data.

- Tracking of individual birds to link observed interactions with operational offshore windfarms (barrier effects and displacement) with subsequent demographic rates (breeding success and survival).

These recommendations relate to research that is needed to provide underpinning evidence upon which a decision to use the elicited displacement mortality rates within the Displacement Matrix approach should be based (via a conversion for the number of birds likely to be using the area of interest over the course of each month and/or season). At present, we believe we do not have the required research evidence to estimate robust turnover values that could be used to convert abundance estimates and thus enable the direct application of the mortality rates generated by the EE process within the Displacement Matrix. Whilst these research outputs would enable this conversion of at-sea survey counts to allow for the use of the elicited rates in the Displacement Matrix, it is likely that uncertainty around the form and magnitude of this conversion will persist. Therefore, it will ultimately be up to regulators to determine guidance on how to implement the new research findings to enable the use of the elicited values within the Displacement Matrix approach.

References

Searle KR, A Butler, D Mobbs, M Bogdanova, S Wanless, M Bolton and F Daunt. 2015. At-Sea Turnover of Breeding Seabirds. Scottish Marine and Freshwater Science Volume 6 Number 10. DOI: 10.7489/1622-1

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