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OcCAM offshore wind seabird mortality tool: user guide

OCcAM offshore wind farm seabird mortality tool

User Guide

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Document history

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1. Introduction

Alongside its environmental benefits, offshore wind energy generation also has the potential to negatively impact upon the environment, including seabird populations. Environmental Impact Assessment (EIA) is carried out to understand this risk, with industry standard EIA and Habitats Regulations Assessment (HRA) processes for offshore wind projects across the UK requiring prediction of potential mortality of key seabird species as a result of collision with, or distributional responses arising from the proposed offshore wind farm development. These are then used to understand potential consequences at the regional or SPA (Special Protection Area) population level.

OCcAM has been designed as a simple, user-friendly and transparent tool to assess the impacts of offshore renewable energy developments on seabirds and provides a rapid method of simultaneously estimating mortalities associated with collision and distributional responses for a number of species, based on existing models currently applied for that purpose within for EIA and HRA in the UK. These estimates may also be put into the context as a percentage of a reference population of interest.

OCcAM was originally designed to generate order-of-magnitude cumulative predictions to provide an indication of potential compensation requirements for offshore wind farms in the UK (OCcAM is an acronym for the Ornithological Cumulative Assessment Model which derives from this first usage). As such it was envisaged to be used with densities derived from broad-scale generic datasets such as the publicly available MERP seabird density surfaces (Waggit *et al.*, 2020). However, the tool is equally applicable for use with more specific datasets at the project level.

The tool includes “default” input parameters, such as bird biometric parameters and flight height distributions, which represent suggested values for those parameters that may be less likely to be updated regularly or that may be unknown or difficult to access when conducting first pass analyses. However, all default values can be readily over-written as required by the user (see section 2.3.6). Parameters considered likely to change from run to run, or to be of interest when comparing runs, such as numbers of turbines and bird densities, are included as user-defined parameters and must be entered by the user (see sections 2.3.3, 2.3.4 and 2.3.5).

The tool is expected to be of particular value at the scoping and early consultation phases of project development, when it can be used to give first indications of risk for the seabird species covered, based on the best available data at the time, which is likely to be generic densities and indicative wind farm and turbine parameters. This approach could form the basis of a transparent, data-driven and systematic approach to identifying what key issues are likely to be at this early stage. In addition, parameters may be updated and new predictions generated as more detailed data become available. The tool can also aid optioneering and wind farm design, providing a rapid indication of relative risk and an understanding of how individual parameters impact upon seabird mortality estimates.

This user guide details the scope and methods employed within the tool and then provides a detailed explanation of the structure of the tool and how it is used.

2. Tool specification

2.1. Scope of the tool

OCcAM (version 3.0 onwards) generates predictions of mortalities for nine key seabird species, selected based on their potential sensitivity to offshore wind farms in UK waters. These are:

- Black-legged kittiwake (*Rissa tridactyla*) – hereafter ‘kittiwake’
- Common guillemot (*Uria aalge*) – hereafter ‘guillemot’
- Razorbill (*Alca torda*)

- Atlantic puffin (*Fratercula arctica*) – hereafter 'puffin'
- Northern gannet (*Morus bassanus*) – hereafter 'gannet'
- Great black-backed gull (*Larus marinus*)
- Lesser black-backed gull (*Larus fuscus*)
- Herring gull (*Larus argentatus*)
- Manx shearwater (*Puffinus puffinus*)

Mortalities are calculated based on two industry standard protocols currently used in the UK to inform EIA and HRA: the Band collision risk model (CRM; Band, 2012), used to predict mortalities associated with collision of birds with offshore wind turbine blades, and the matrix-based displacement approach (SNCBs, 2022), used to predict mortalities associated with displacement of seabirds from wind farm footprints.

Guillemot, razorbill and puffin generally fly below the height that will be rotor-swept by the blades of offshore wind turbines and are therefore generally considered to be at low risk of collision with wind turbines (Bradbury *et al.*, 2014; SNCBs, 2024). OCcAM therefore does not run collision risk modelling for these species, instead producing mortality estimates that are based solely on the displacement matrix model. Generic species-specific flight height data used in collision risk modelling indicates that, similarly, Manx shearwater do not regularly fly at collision height. However, the ongoing ProcBe project, which seeks to better understand Procellariiform behaviour at sea, is expected to provide an updated understanding of how this species flies, particularly in adverse weather conditions, which may alter this understanding (JNCC, 2025). As a result, the OCcAM tool has been 'future-proofed' to allow enable the prediction of collision mortality for Manx shearwater if required. For kittiwake, the user may choose between running both the collision model and the displacement model, in which mortalities from both impacts will be estimated and summed (see section 2.3.4.6) or only running the collision model, since kittiwake may be considered to be at low risk from displacement (SNCBs, 2022). For great black-backed, lesser black-backed and herring gull, only collision impacts are run based on their low to very low risk of displacement effects (Bradbury *et al.,* 2014; SNCBs, 2022). The model runs both collision and displacement models for gannet since this species is considered to be sensitive to both impacts. However, predicted mortalities from each type of impact are provided both individually and summed in the results tab (see section 2.3.7).

OCcAM allows application of up to three different parameter sets which can be used either to investigate three different realisations of the same scenario e.g. three different sets of wind farm/turbine specifications, or to generate a single mortality estimate based on sub-strata, for example, to predict the combined mortality associated with three different wind farm projects requiring different input parameters. The tool is not intended to make very specific predictions, but rather, to provide approximate figures which can be used comparatively, for example during project optioneering, or to generate indicative values for example, to indicate likely species risk during scoping. It is not intended to replace tools such as the stochastic collision risk model tool (sCRM – Caneco *et al.,* 2022 – see Section 2.2.1) for final assessment, but instead, seeks to provide a simple, accessible and transparent tool to instantly generate reasonable approximations of the risk of seabird mortality.

2.2. Methods employed by the tool

2.2.1. Collision mortality - The Band collision risk model

The Band (2012) collision model predicts collision rates for a proposed development as a function of number of turbines, wind turbine specifications, expected operational patterns of the turbines, density of seabirds at the site, their flight heights and species-specific biometric and behavioural data. The overall collision risk in the absence of any avoidance behaviour by the birds is calculated as the product of two components: the predicted number of rotor transits per month per species, based on bird densities, flight speeds and flight heights, and the individual probability of a bird colliding with a turbine blade given that it flies through rotor-swept space, based on the characteristics of the bird species and of the turbines. The resulting value is then scaled using avoidance rates that represent the avoidance action expected to be taken by the birds to give a final predicted number of individuals per species expected to collide with the turbine rotors per month.

The most recent implementation of the Band model in the UK is the sCRM model (Caneco *et al*., 2022). This builds on the original model by allowing the incorporation of uncertainty in the input parameters to randomly sample from distributions of input parameters over iterative models runs to derive output distributions which can be summarised to give a point estimate and associated confidence intervals. However, this type of functionality is not straightforward to integrate into a simple Excel framework. Therefore, with simplicity and transparency in mind, the OCcAM tool uses the original Band model as implemented in the publicly available Excel file that accompanied the model (available in SOSS, 2012).

Some information on the process underlying the Band model is provided in the tool description below, and more detailed information including assumptions and caveats can be found in Band (2012).

2.2.2. Distributional responses - The displacement matrix approach

The matrix approach is an industry standard method to predict mortalities associated with distributional responses of seabirds to offshore wind farms (SNCBs, 2022). The method uses mean seasonal-peak abundances of birds predicted to be either using wind farm sites or passing through them to derive a number of birds with the potential to experience displacement effects. Predicted mortalities are then calculated based on species-specific rates representing susceptibility to displacement and mortality resulting from displacement. It is known as the matrix approach because results are generally provided within a matrix representing a range of possible displacement rates along one axis and a range or possible mortality rates on the other, reflecting high levels of uncertainty in what these parameters should be.

OCcAM applies a single displacement rate per species, and associated season-specific displacement mortality rates. These are user-definable and can therefore readily be updated if new information to inform these parameters comes to light, or to investigate the magnitude of changes to overall predictions associated with updating these parameters e.g. to explore outputs across a range of potential displacement and mortality rates.

2.2.3. Apportionment to a population of interest

The OCcAM tool has basic functionality to allow predicted mortalities to be put into the context of a reference population of interest. In some cases, all of the mortality predicted by the tool may be expected to be attributable to the population of interest (i.e. all of the birds expected to encounter and be impacted by the wind farm, or wind farms, are expected to come from the reference population). However, more frequently, the reference population will include only a subset of the total birds expected to be impacted and may be related to geographic space e.g. birds breeding at a specific Special Protection Area (SPA) and/or to the demographic makeup, e.g. breeding adults (see section 2.3.5). In these cases, mortalities must be apportioned in order to understand the relative impacts upon the particular reference population of interest.

OCcAM includes three optional correction factors which can be accounted for in order to obtain appropriate final predicted mortalities for a reference population. These are:

- The proportion of birds exposed to impacts from the wind farm, or wind farms, that are expected to originate from the reference population.
- The proportion of birds exposed to impacts from the wind farm, or wind farms, that are expected to be adults
- The proportion of adult birds expected to be sabbaticals (i.e. the proportion of adult birds not breeding in any given year).

The proportion of birds exposed to impacts from the wind farm, or wind farms, that are expected to originate from the reference population is required because seabirds are far ranging and, particularly in the non-breeding periods, may originate from what may be considered as several different populations during offshore wind farm impact assessment. These corrections are user-inputs as they will vary depending on the combination of populations and wind farms under consideration. These corrections will vary by season due to changes in seabird behaviour across the annual cycle (e.g. acting as central place foragers during the breeding season versus travelling more broadly during migration and non-breeding seasons) and are input separately for the full suite of species-specific seabird seasons defined within Furness (2015). Incorporation of this parameter within the tool is discussed within Section 2.3.5.2.

The proportion of birds exposed to impacts from the wind farm, or wind farms, that are expected to be adults can be applied where the reference population size relates only to adults. This is commonly the case since it is generally feasible to count adult birds in attendance at breeding colonies during the breeding season, whilst it is usually difficult to obtain accurate counts of non-adult age classes and therefore to describe population sizes in terms of all individuals within a population. These corrections are included as default parameters within the tool and their derivation is described in the section 2.3.6.4 below. However, there is also the option to input user-defined values for these parameters which provides flexibility to base this input on other available data or to incorporate different scales for different seasons. Incorporation of this parameter within the tool is discussed within Section 2.3.5.3.

As above, the proportion of adult birds expected to be sabbatical can be user-defined. However, the tool also includes the option to use default parameters, and these are based on parameters that have been used in recent offshore wind farm assessments e.g. Ossian (2024). Incorporation of this parameter within the tool is discussed within Section 2.3.5.4.

2.2.4. Calculation of outputs

OCcAM calculates collision and distributional response mortality rates by season according to the methods described in sections 2.2.1 and 2.2.2 above, apportions them to a reference population of interest based on the correction factors described in section 2.2.3 above if applicable, and then calculates the sum of the total seasonal predicted collision and distributional response mortality estimates and the sum of the apportioned seasonal collision and distributional response mortality estimates (i.e. those relevant to the reference population) to provide annual estimates for each. Annual apportioned mortality estimates are then expressed as a proportion of the user-defined input reference population sizes to indicate the proportional impact of the predicted mortality upon that population.

2.3. Structure of the tool

2.3.1. Overview

The OCcAM tool includes twelve tabs listed below.

1. Introduction
2. User inputs – run and wind farm
3. User inputs – bird impacts
4. User inputs - bird populations
5. Default parameters
6. Results
7. Run log and assumptions
8. Overall collision risk
9. Single transit collision risk
10. Hours of daylight
11. Proportion at collision height

Each of these tabs is described in more detail in its own separate section below, hyperlinked in the list above.

Throughout the tool, Excel's data validation functionality has been used to annotate certain key cells. These instances are marked with a ⓘ. This functionality has also been used to limit the format and range of some user-input cells to avoid invalid values being input, for example, text in a field that would be expected to be a number. Where this happens, Excel will generate a pop-up indicating that the value doesn't match the data validation restrictions. It is noted that these checks can be over-ridden when pasting in blocks of values, so users should take care to ensure validity of any data being pasted into the tool.

Excel's conditional formatting functionality has been used to grey out cells that are not relevant to a given analysis, for example if only one parameter set is to be investigated then the tool will grey out options for parameter sets 2 and 3. "If" statements are used in formulae within cells to ensure that any inputs in greyed out cells are not incorporated into final calculations. However, inputs that have been entered into these cells remain there even if when they are greyed out and will reappear if the condition that has resulted in them being greyed out is no longer fulfilled.

All tabs are protected such that only cells used for entering user-definable parameters can be edited. This has been done to avoid accidental edits to the formulae underlying the tool. However, tabs can be unlocked by clicking 'Unprotect sheet' in Excel's Review ribbon, for example, to allow default values to be overridden if required. No macros have been used within the tool so all calculations and formatting used is readily accessible and editable to a user with a moderate knowledge of Excel.

2.3.2. Introduction

The introduction tab provides a brief overview of the aim of the tool, its functionality and usage. Data validation messages (indicated with an ⓘ) provide key references used during the construction of the tool.

2.3.3. User inputs – run and wind farm

Within this tab, the user must enter parameters associated with up to three wind farm areas and wind turbines of interest. The structure of this tab is shown in Figure 2.1. The parameters are divided into General run parameters, which will be used across the whole run, Collision inputs, which will feed into collision risk modelling, and Distributional response inputs, which will feed into modelling of distributional responses. More information about each input can be found by clicking on the cell with the description of the parameter (indicated with a ⓘ). Those inputs required for the modelling but not displayed in this tab, e.g. turbine downtime, are taken from the Default parameters tab.

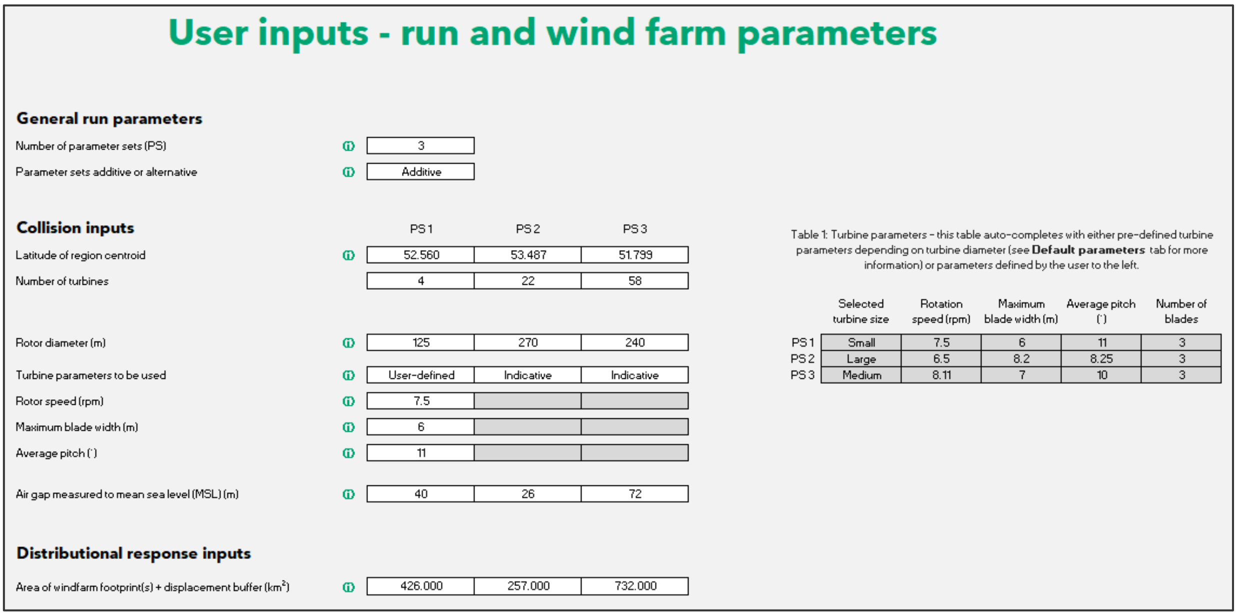


Figure 2.1: The "User inputs - wind farm" tab in OCcAM.

General run parameters

2.3.3.1. Number of parameter sets

As mentioned, OCcAM allows the inclusion of up to three separate parameter sets (combinations of wind farm and bird input parameters). The "number of parameter sets" input is a dropdown menu, allowing the user to select between running models for 1, 2 or 3 parameter sets. Cells relating to parameter sets 2 and 3 will be greyed out or otherwise dependent on the value that is selected here. In this case, the corresponding results cells for the parameter set(s) will also be set to 0 in the Results tab to ensure that any data in greyed out cells are not pulled through to the final results. If no value is selected here then the tool will act in the same way as if a single parameter set had been specified.

2.3.3.2. Parameter sets additive or alternative

Here, the user can select between an "additive" run, in which mortalities predicted for each parameter set are summed in the Results tab, and an "alternative" run, in which mortalities predicted for each parameter set are not summed in the Results tab. If no value is selected, the tool will act in the same way as if the "alternative" run had been selected. If OCcAM is set up for a single parameter set only, the value displayed in this cell will not make a difference to the final results.

The additive option could be used for projects with multiple development zones, or potentially if running a multi-windfarm analysis in which different wind farms of interest might be expected to have different design or bird density parameters, using averaged input parameters where necessary. The latter case would be expected to provide indicative order of magnitude predictions rather than specific predictions for e.g. EIA purposes.

The alternative option can be used if investigating the impact of altering one or more input parameters on the predicted number of mortalities. This could be used, for example, to investigate the impact of varying wind farm parameters such as airgap, or to compare impacts of a wind farm among locations where bird densities vary.

Collision inputs

2.3.3.3. Latitude of region centroid

This input should be the latitude of the centroid of the area of interest in degrees. If multiple wind farms are modelled using a single parameter set then a centroid of the polygons representing all of the developments would be appropriate here, with the understanding that the further apart wind farms are on a north-south axis, the less representative this value will become. Seabird flight activity differs between light and dark periods of the day, and collision risk modelling accounts for this by using a value representing the ratio of bird activity during the night to levels of activity during daylight hours to extrapolate collision estimates representative of a full 24-hour period (see section 2.3.4.5). This parameter is used in that process, to determine the number of daylight and nocturnal hours within each month.

This input is applied in the Hours of daylight tab. Inputs to these cells are restricted to a value between 45 and 65 since the function used to calculate daylength within the Band (2012) collision risk model spreadsheet upon which this tool is based, does not operate correctly outside of these limits.

2.3.3.4. Number of turbines

This input should be the total number of turbines in the scenario under consideration. If this relates to a single windfarm then it will be the proposed number of turbines for that wind farm, but if multiple wind farms are being considered in a single parameter set then this will be the total number of turbines across all wind farms. Note that where multiple wind farms are being included in a single parameter set run, the associated turbine parameters (see below) should be a mean value across all of the turbines.

This input is used for collision risk modelling in the Overall collision risk tab. Inputs to these cells are restricted to being a whole, positive number.

2.3.3.5. Rotor diameter

This input should represent the mean rotor diameter across the turbines included in the parameter set, in metres. This input is used for collision risk modelling in the Overall collision risk, the Single transit collision risk and the Proportion at collision height tabs. Inputs to these cells are restricted to being a positive number.

2.3.3.6. Turbine parameters to be used

This input allows the user to select between use of in-built parameters or user-defined values. Other turbine parameters required for collision risk modelling include average rotation speed, maximum blade width, average blade pitch and number of blades. Apart from the latter which tends to remain as 3, these parameters can be quite difficult to obtain, particularly in relation to possible future wind farms. In order to aid the user, default parameters for small (<220 m diameter), medium (220 – 250 m diameter) and large (>250 m+ diameter) turbines have been included within the tool and can be applied based on the value provided for the rotor diameter. These are applied by selecting the “Indicative” option here. Selecting the “User-defined” option allows rotation speed, maximum blade width and average blade pitch to be entered by the user.

A table displaying the values that will be used in the analysis based on this selection, is provided to the right of the rotor diameter input cells (see Figure 2.1). If “Indicative” is selected, this will update depending on the rotor diameter input, with values being referenced from the Default parameters tab. More information on the derivation of the indicative values can be found in the wind turbine specifications section below. If “User-defined” is selected, then the table will duplicate the values entered by the user.

2.3.3.7. Rotor speed

Rotor speed represents the average number of rotations per minute made by the turbine rotor, in rpm. It can also be referred to as the rotation speed.

This input is used for collision risk modelling in the Single transit collision risk tab. Inputs to these cells are restricted to being a positive number.

2.3.3.8. Maximum blade width

This input represents the blade width at the widest part of the blade, in metres. It is sometimes also referred to as the chord width.

This input is used for collision risk modelling in the Single transit collision risk tab. Inputs to these cells are restricted to being a positive number.

2.3.3.9. Average pitch

This input represents the average pitch along the blade length, relative to the plane of the turbine, in degrees.

This input is used for collision risk modelling in the Single transit collision risk tab. Inputs to these cells are restricted to being a positive number.

2.3.3.10. Air gap

This input should represent the mean air gap across all the turbines included in the parameter set, in metres. This should represent the distance between sea level and the lowest rotor-swept height measured to Mean Sea Level (MSL). Particularly for fixed bottom turbines, engineering parameters are often reported using an alternative datum such as lowest astronomical tide (LAT) or highest astronomical tide (HAT). The SOSS spreadsheet includes a tidal offset parameter to account for the discrepancy among the turbine measurements and the bird flight heights (assumed to be relative to mean sea level. Direct use of measurements to MSL within OCcAM removes the need for this additional parameter in the model.

This parameter is used alongside the rotor diameter to determine the proportion of birds at rotor height for collision risk modelling in the Proportion at collision height tab. Inputs to these cells are restricted to being a positive number.

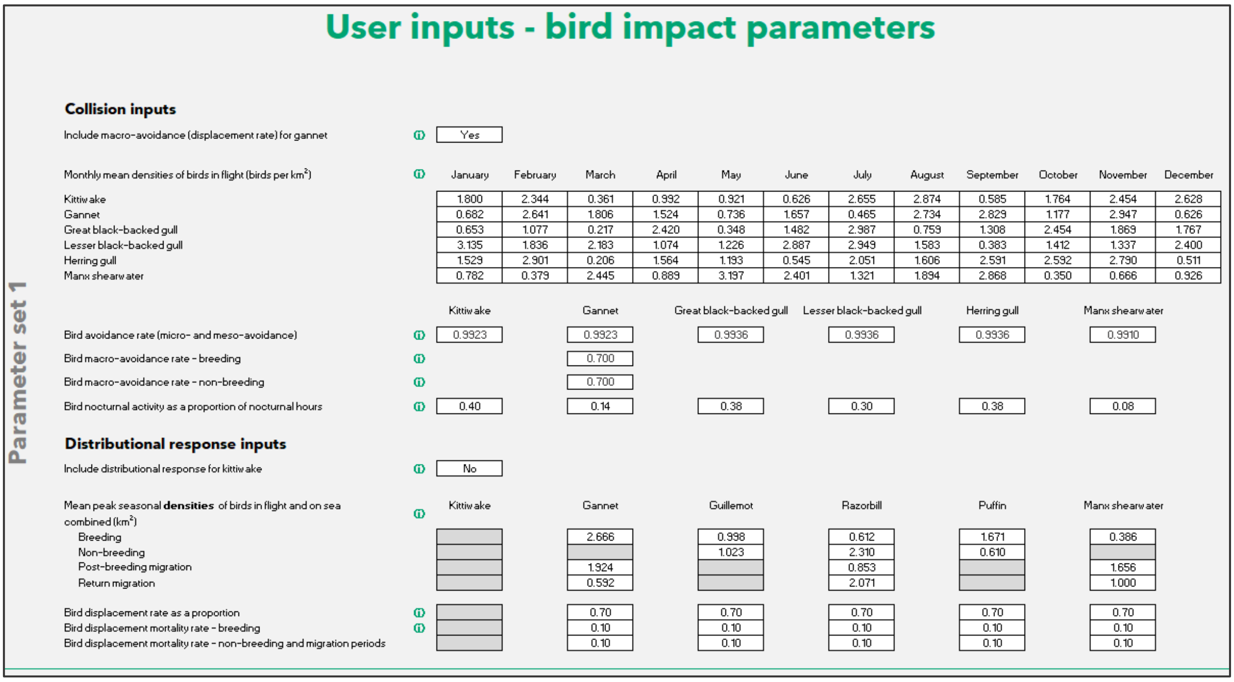
Distributional response inputs

2.3.3.11. Area of windfarm footprint(s) plus displacement buffer

This parameter is used to predict mortality arising from distributional responses and represents the area from which birds are expected to be displaced. For individual wind farms, this is usually estimated as the array area plus a buffer zone corresponding to species-specific displacement distances. For the species included in the model, this is currently generally taken as 2 km (SNCBs, 2022). This parameter should represent the sum of the displacement zones of all wind farms included within the parameter set and should be reported in km^2. Values in these cells are restricted to being a positive number.

2.3.4. User inputs – bird impacts

Within this tab, the user must enter bird parameters required for mortality predictions. Bird data to be used for predicting impacts must be inputted separately for each parameter set being investigated and input cells will be greyed out depending on how many parameter sets have been specified in the User inputs – run and wind farm tab. The structure of this tab is shown in Figure 2.2. The parameters are divided into Collision inputs, which will feed into collision risk modelling, and Distributional response inputs, which will feed into modelling of distributional responses. More information about each input can be found by clicking on the cell with the description of the parameter (indicated with a ⓘ).



User inputs - bird impact parameters

Parameter set 1

Collision inputs

Include macro-avoidance (displacement rate) for gannet: Yes

Monthly mean densities of birds in flight (birds per km^2)	January	February	March	April	May	June	July	August	September	October	November	December
Kittiwake	1.800	2.344	0.361	0.992	0.921	0.626	2.655	2.874	0.585	1.764	2.454	2.628
Gannet	0.682	2.641	1.806	1.524	0.736	1.657	0.465	2.734	2.829	1.177	2.947	0.626
Great black-backed gull	0.653	1.077	0.217	2.420	0.348	1.482	2.987	0.759	1.308	2.454	1.869	1.767
Lesser black-backed gull	3.135	1.836	2.183	1.074	1.226	2.887	2.949	1.583	0.383	1.412	1.337	2.400
Herring gull	1.529	2.901	0.206	1.564	1.193	0.545	2.051	1.606	2.591	2.592	2.790	0.511
Manx shearwater	0.782	0.379	2.445	0.889	3.197	2.401	1.321	1.894	2.868	0.350	0.666	0.926

	Kittiwake	Gannet	Great black-backed gull	Lesser black-backed gull	Herring gull	Manx shearwater
Bird avoidance rate (micro- and meso-avoidance)	0.9923	0.9923	0.9936	0.9936	0.9936	0.9910
Bird macro-avoidance rate - breeding		0.700				
Bird macro-avoidance rate - non-breeding		0.700				
Bird nocturnal activity as a proportion of nocturnal hours	0.40	0.14	0.38	0.30	0.38	0.08

Distributional response inputs

Include distributional response for kittiwake: No

Mean peak seasonal **densities** of birds in flight and on sea combined (km^2)	Kittiwake	Gannet	Guillemot	Razorbill	Puffin	Manx shearwater
Breeding		2.666	0.998	0.612	1.671	0.386
Non-breeding			1.023	2.310	0.610	
Post-breeding migration		1.924		0.853		1.656
Return migration		0.592		2.071		1.000
Bird displacement rate as a proportion		0.70	0.70	0.70	0.70	0.70
Bird displacement mortality rate - breeding		0.10	0.10	0.10	0.10	0.10
Bird displacement mortality rate - non-breeding and migration periods		0.10	0.10	0.10	0.10	0.10

Figure 2.2: The “User inputs – bird impacts” tab in OCcAM

Collision inputs

2.3.4.1. Include macro-avoidance (displacement rate) for gannet

Collision predictions account for the fact that birds will show behavioural responses to avoid colliding with turbines. These may be in the form of micro-avoidance (avoiding the turbine blade as it rotates), meso-avoidance (avoiding the rotor-swept volume within the array area) and macro-avoidance (avoiding the array area altogether). Avoidance rates generally applied during collision risk modelling do not account for macro-avoidance (Ozsanlav-Harris *et al.*, 2023). However, there is evidence that gannet show a strong avoidance response to wind farms as a whole (SNCBs, 2024), and therefore the option to account for macro-avoidance by gannets only has been incorporated. It is recommended that macro-avoidance be incorporated into collision risk modelling by updating input densities prior to modelling (SNCBs, 2024; NatureScot, 2025). However, this is not possible within OCcAM since months specified as two seasons (e.g. breeding/post-breeding) would then have to have two separate input densities. Instead, the macro-avoidance rate is applied to the output of the collision risk model in the Results tab. This difference in methodology does not change the numerical output.

If this parameter is set to “Yes” then the user is able to specify macro-avoidance rates for the breeding and non-breeding seasons. If “No” is selected or if no response is selected then the tool will not include macro-avoidance for gannet.

2.3.4.2. Monthly mean densities of birds in flight

These numbers represent the mean predicted density of each species in flight within the wind farm array area(s) (no buffer is applied when calculating densities for collision) in each month of the year. These should represent an expected average across the wind farm(s) included in the parameter set.

These numbers are used to calculate bird flux through the wind farms during collision risk modelling and are applied in the Overall collision risk tab. The inputs are restricted to being numerical and positive.

2.3.4.3. Bird avoidance rate (micro- and meso-avoidance)

This number represents the probability that a bird that would have passed through a rotor-swept area will avoid collision either by avoiding the blade as it rotates (micro-avoidance) or by avoiding the turbine itself within the wind farm area (meso-avoidance).

This parameter is used in the Overall collision risk tab to correct the number of mortalities predicted in the absence of avoidance behaviour.

2.3.4.4. Bird macro-avoidance rate – breeding and non-breeding

If the include macro-avoidance for gannet option is set to “No” then these cells will be greyed out, but if it is set to “Yes” then the user can define a macro-avoidance rate to be applied to the breeding season collision estimates, and one to be applied to the non-breeding (post-breeding migration and return migration) season collision estimates.

These parameters are used in the Results tab to correct the number of gannet mortalities predicted in the absence of macro-avoidance behaviour.

2.3.4.5. Bird nocturnal activity

This parameter represents the ratio of bird activity during the night to levels of activity during daylight hours (see Section 2.3.3.3).

This parameter is used to extrapolate collision estimates to represent the full period during which birds are assumed to be active in the Overall collision risk tab.

Distributional response inputs

2.3.4.6. Include distributional response for kittiwake

Due to the apparent low sensitivity of kittiwake to anthropogenic disturbances (SNCBs, 2022) it may be assumed that kittiwake are not susceptible to mortality resulting from distributional responses to wind farms. If this is the case then this parameter can be set to “No” in which case, mortalities arising from collision only will be calculated. If this parameter is set to “Yes” (or left blank) then kittiwake mortalities from both collision and distributional responses will be predicted, as is currently required for project-level assessments in Scotland (NatureScot, 2023). Note that these are provided both as impact-specific and combined estimates in the Results tab.

2.3.4.7. Mean peak seasonal densities of birds in flight and on the sea

These numbers represent the mean peak density of each species for any behaviour (i.e. both flying through the site and actively using the site, including birds on the sea) for each relevant bio-season. Note that the tool uses density as opposed to abundance for estimation of distributional responses, even though abundance is more commonly used for project-level assessments. The reason for this is that the tool was originally designed for use with generic density surface data. However, input densities for OCcAM can readily be calculated from abundance data by dividing abundance by area.

Bio-seasons included are based on those indicated in Furness (2015). Mean seasonal peak refers to the mean of the densities of the month of the season which had/has the highest predicted density for each year for which estimates are available, for example, if the breeding season spanned April to August And estimated seabird densities were highest in May in a first year of surveys and June in a second, then the value taken forward would be the mean of these two densities. These should represent an expected average across the wind farm(s) included in the parameter set.

These numbers are used to calculate the number of birds exposed to the wind farm(s) and therefore potentially susceptible to mortality as a result of distributional responses. They are applied in the Results tab.

2.3.4.8. Bird displacement rate

This value represents the probability that a bird that would use the windfarm footprint(s) and surrounding buffer areas in the absence of the wind farm will be displaced from those areas when a wind farm is present. These values are those that would be represented by the displacement axis of the displacement matrix. Values entered within these cells are constrained to be decimal values between 0 and 1 i.e. if 60% of guillemot were expected to be displaced from the windfarm footprint then this value would be 0.6. They are applied in the Results tab.

2.3.4.9. Bird displacement mortality rate - breeding

This value represents the probability that a bird being displaced from the windfarm footprint(s) and surrounding buffer areas during the breeding season will not survive. These values are those that would be represented by the mortality axis of the displacement matrix. Values entered within these cells are constrained to be decimal values between 0 and 1 i.e. if in 5% of the time, displacement of a bird was expected to lead to a mortality even then this value would be 0.05. They are applied in the Results tab.

2.3.4.10. Bird displacement mortality rate – non-breeding and migration

This value represents the probability that a bird being displaced from the windfarm footprint(s) and surrounding buffer areas during the non-breeding and migration periods will not survive. As above, these values are those that would be represented by the mortality axis of the displacement matrix. Values entered within these cells are constrained to be decimal values between 0 and 1 as above. They are applied in the Results tab.

2.3.5. User inputs - bird populations

Within this tab, the user can enter parameters which allow total mortality estimates to be quantified in relation to specific bird populations. Bird data used to link estimated mortalities to populations of interest must be inputted separately for each parameter set being investigated and redundant input cells will be greyed out depending on how many parameter sets have been specified in the User inputs – run and wind farm tab. The structure of this tab is shown in Figure 2.3. More information about each input can be found by clicking on the cell with the description of the parameter (indicated with a ⓘ).

In this tab, reference population sizes are entered alongside a series of correction factors which are used to adjust the total mortalities predicted so that they relate to a reference population of interest. All corrections are user-definable but some also have defaults available within the tool. The grey correction factor cells display the final correction taken through to the Results tab.

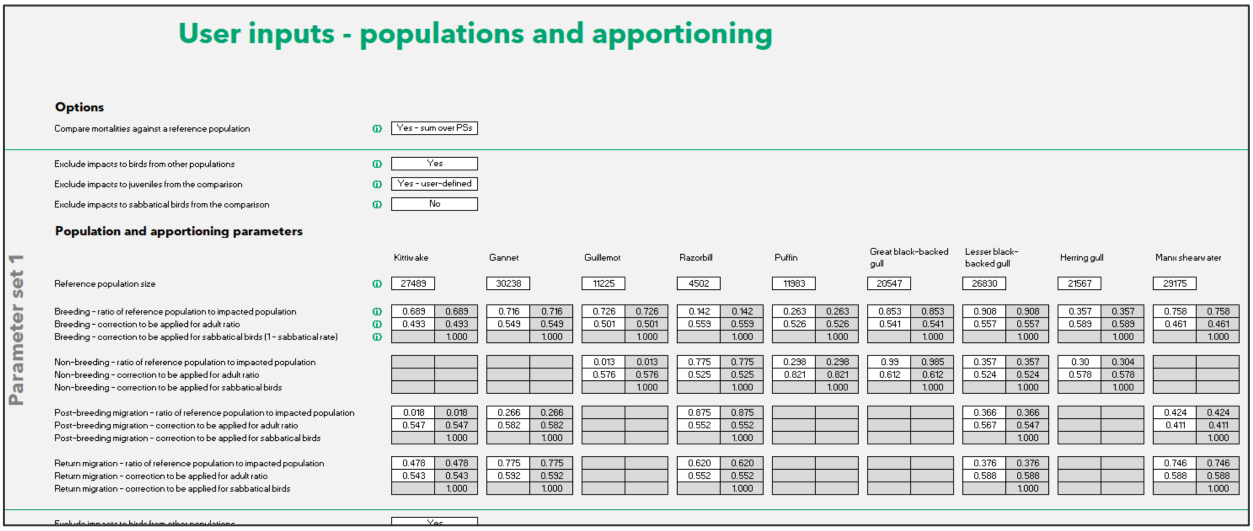


Figure 2.3: The "User inputs - bird populations" tab in OCcAM

2.3.5.1. Compare mortalities against a reference population

This option allows the user to specify whether impacts should be related back to a reference population. If "No" is selected here, all other options within the tab are greyed out and all cells containing correction factors used by the Results tab are set to 1. In addition, cells where apportioned outputs would be provided are also greyed out in the Results tab.

2.3.5.2. Exclude mortalities to birds from other populations

This option allows the user to specify whether a correction factor should be used to apportion those mortalities that are expected to relate to the reference population versus other populations. This option should be used if the birds at risk of impacts from the windfarm are expected to also come from populations other than the reference population. If "No" is selected, the ratio of the reference population to the total population (i.e. reference plus other populations) inputs will be set to 1 and the associated user inputs will be greyed out. If "Yes" is selected, the user must also complete the ratio of reference population to impacted population cells.

2.3.5.3. Exclude impacts to juveniles

This option allows the user to specify whether a correction factor should be used to apportion those mortalities that are expected to relate to adults versus other age classes. This option can be used if the reference population relates to adults only. If the "Yes – user-defined" option is used, then the user must also fill in the desired correction factors in the correction to be applied for adult ratio cells. If the "Yes – tool default" option is used, then the proportion of the population that is adult values from the Default parameters tab will be used and the user input cells associated with this correction will be greyed out. If "No" is selected, the correction to be applied for adult ratio will be set to 1 and the associated user-inputs will be greyed out.

2.3.5.4. Exclude impacts to sabbatical birds

This option allows the user to specify whether a correction factor should be used to apportion those mortalities that are expected to relate to adults breeding within any given year versus sabbatical birds. This option can be used if the reference population relates to breeding individuals only and is only available if the exclude impacts to juveniles is set to either "Yes – tool default" or "Yes – user-defined". As above, if the "Yes – user-defined" option is used, then the user must also fill in the desired correction factors in the correction to be applied for sabbatical birds cells. If the "Yes – tool default" option is used, then the sabbatical rate values from the Default parameters tab will be used and the user input cells associated with this correction will be greyed out. If "No" is selected then the correction to be applied for sabbatical birds inputs will be set to 1 and the associated user inputs will be greyed out.

2.3.5.5. Reference population size

Here the user can enter the reference population size for which a mortality rate will be calculated. This is expected to be in individuals, but may either relate to the population to which all mortalities will be attributable (in which case the exclude mortalities to birds from other populations, exclude impacts to juveniles and exclude impacts to sabbatical birds will all be set to "No") or a subset (in which case the different options within this tab can be applied).

2.3.5.6. Ratio of reference population to impacted population

Here, the user can enter species- and season-specific correction factors to account for the fact that a proportion of birds using the site may not originate from the reference population of interest. This option will only be available if the exclude mortalities to birds from other populations option is set to "Yes". The grey cells display the value which is taken forward to the Results tab, which will either be the user-defined ratio, or 1 if no ratio is to be applied. In the example of the screenshot above, user-inputs have been selected for all options therefore the grey cells reflect the values input into the white cells by the user.

2.3.5.7. Correction to be applied for adult ratio

If the exclude impacts to juveniles option has been set to "Yes – user-defined", then cells will be available here to enter species and season-specific correction factors which represent the proportion of the population expected to be adults. If the exclude impacts to juveniles option has been set to "Yes - tool default", then the cells will be greyed out but the adjacent grey cells will show the proportion of the population adult parameters from the Default parameters tab. The values in the same adjacent cells will be 1 if no ratio is to be applied, such that these cells always display the value which is taken forward to the Results tab.

2.3.5.8. Correction to be applied for sabbatical birds

If the exclude impacts to sabbatical birds option has been set to "Yes – user-defined", then cells will be available here to enter species and season-specific correction factors which represent the proportion of the adults within the population expected to be sabbatical birds (i.e. the proportion not breeding in any given year). If the exclude impacts to sabbatical birds option has been set to "Yes - tool default", then the cells will be greyed out but the adjacent grey cells will show the sabbatical rate parameters from the Default parameters tab. The value in the adjacent cells will be 1 if no ratio is to be applied, such that the grey cells always display the value which is taken forward to the Results tab.

2.3.6. Default parameters

The default parameters used in the modelling can be found within this tab. Inputs have been divided into bird related parameters and wind farm related parameters. Within the tool, information about how the parameters have been derived can be found by clicking on the cell with the description of the parameter (indicated with a ⓘ).

2.3.6.1. Bird biometric parameters

Several bird biometric parameters are required for collision risk modelling. These include the average length, wingspan and flight speed of the bird species of interest, whether their flight patterns are characterised by flapping or gliding motion and the proportion of birds which are expected to be flying upwind versus downwind. Since collision risk modelling is only available for gannet, kittiwake, greater black-backed gull, lesser black-backed gull, herring gull and Manx shearwater within the tool, these are the only species for which default parameters have been provided.

For all species except Manx shearwater, the parameters included in the tool are those recommended by the UK SNCBs for use with collision risk modelling for offshore wind farm applications (SNCBs, 2024; Table 2.2). Since Manx shearwater is not covered in the current guidance (SNCBs, 2024), parameters for this species were based on those used in the EIA for the recently consented Morecambe Offshore Wind Project (RoyalHaskoning, 2024). Body length and wingspan were taken from Snow and Perrins (1998), while flight speed is taken as the mean ground speed reported by Spivey et al. (2014). For flight type, shearwaters are known to exhibit both flapping and gliding flight (Gibb *et al.*, 2017). However, assuming flapping flight produces a more precautionary (i.e. higher) mortality estimate and given that any birds flying at collision height will be most likely to be using flapping flight, the default flight type for this species has been set to 'flapping'.

These parameters are used in both the Overall collision risk (bird flight speed only) and the Single transit collision risk tabs (all parameters).

Table 2.1: Default bird biometric parameters used by the OCcAM tool

Biometric parameters	Kittiwake	Gannet	Great black-backed gull	Lesser black-backed gull	Herring gull	Manx shearwater
Average length (m)	0.39	0.94	0.71	0.58	0.60	0.34
Average wingspan (m)	1.08	1.72	1.58	1.42	1.44	0.82
Average flight speed (m/s)	13.1	14.9	13.70	13.10	12.80	14.1
Flight type	Flapping	Flapping	Flapping	Flapping	Flapping	Flapping
Proportion of flights upwind	0.5	0.5	0.5	0.5	0.5	0.5

Source: SNCBs, 2024. For Manx shearwater parameters, please refer to section 2.3.6.1.

2.3.6.2. Bird flight height distributions

OCcAM uses generic flight height distributions to determine the proportion of total bird flights expected to be at risk height. The tool includes default flight height distributions for kittiwake, gannet, great black-backed gull, lesser black-backed gull, herring gull and Manx shearwater, which are those derived by Johnston *et al.* (2014).

2.3.6.3. Seasonal definitions

The Band offshore collision risk model calculates mortalities on a monthly basis. However, assessments generally focus on mortality rates at a seasonal or annual scale. Seasonal definitions provided within the default parameters tab are used to sum monthly collision estimates across those months contributing to each season to give seasonal predictions. Note that for distributional response estimates, no specific seasonal definitions are assumed. Seasonal definitions used to derive the mean peak seasonal densities of birds in flight and on the sea entered into the User inputs – bird impacts tab should be consistent with these definitions. The definitions are only provided for kittiwake, gannet, great black-backed gull, lesser black-backed gull, herring gull and Manx shearwater since these are the species for which the input is explicitly required within the tool.

The default seasonal definitions used within the tool are based on the BDMPS (Biologically Defined Minimum Population Scales) periods defined within Furness (2015) (Table 2.3). Where seasonal definitions include overlapping months, the month of overlap has been preferentially included within the breeding season, following the assessment for the consented Morecambe Offshore Wind Farm (Royal Haskoning, 2024). For great black-backed gull, the breeding season is defined as late March until August, and March is also included in the non-breeding season definition. For OCcAM, March has been included in the breeding season, following the Morecambe assessment (Royal Haskoning, 2024). Similarly for Manx shearwater, the post-breeding migration season is defined as ending in early October and the return migration season as beginning in late March. However, since Manx shearwater are not expected to be present in UK waters over the winter period (Furness, 2015), the entire months of March and October have been included in the respective migration seasons. The non-breeding season for Manx shearwater has not been included within the tool for the same reason. Note that for months which can be considered as contributing to two seasons (e.g. the month of March can be considered as a breeding or non-breeding season month in the case of great black-backed gull), OCcAM has functionality to split the predicted mortalities for the month of interest across seasons.

The default seasonal definitions can be updated by unprotecting the default parameters sheet and selecting new season names from the drop-down menu provided in the seasonal definitions table. Where two seasons are separated by a forward slash, half of the impacts from that month will be assigned to each of the seasons e.g. if March was specified as "non-breeding/breeding" then half of the predicted mortalities from March would be assigned to the non-breeding and breeding seasons respectively.

Table 2.2: Seasonal definitions used as defaults within the OCcAM tool. These are defined in Furness (2015) and follow the approach taken in Royal Haskoning (2024) for great black-backed gull and Manx shearwater.

Season	Kittiwake	Gannet	Great black-backed gull	Lesser black-backed gull	Herring gull	Manx shearwater
Breeding	May to July	April to August	March to August	April to August	March to August	April to August
Non-breeding	-	-	September to February	November to February	September to February	-
Post-breeding migration	August to December	September to November	-	September to October	-	September to October
Return migration	January to April	December to March	-	March	-	March

Source: Furness (2015)

2.3.6.4. Proportion of the population that is adult

In many cases, reference populations of interest during assessment of the impacts of offshore wind farms on seabirds refer to breeding adults rather than the whole population. Since not all individuals that may encounter a wind farm site are likely to be breeding adults, it may be necessary to adjust predicted impacts so that they represent adult mortality only. OCcAM includes default parameters representing predicted adult to non-adult ratios for each species which can be applied to do this. These values were estimated using stable age structures determined from Leslie matrices (often used to project populations forward for population viability analysis, for example, within the NEPVA tool (Searle et al., 2019)). Species-specific matrices were constructed using national parameter values provided in Horswill and Robinson, 2015 (Table 2.4). The right eigenvector associated with the largest eigenvalue of each matrix was assumed to represent the age structure of individuals and the proportion of individuals in the reproductive age group was assumed to be the proportion of adults within the population. These values are presented in Table 2.4. Since survival rates for immature Manx shearwater are not reported in Horswill and Robinson

(2015), gannet immature survival rates have been used for the 0 – 1 and 1 – 2 age classes following PVA analysis carried out for the consented Morlais Project (Royal HaskoningDHV, 2020). Similarly, survival rates for immature great black-backed gull are not known (Horswill and Robinson, 2015) so rates used were those of herring gull, following the approach taken by the submitted Caledonia Offshore Wind Farm (Caledonia Offshore Wind Farm, 2024a).

Table 2.3: Demographic rates used to calculate the default adult ratios included in the OCcAM tool, and the proportion of the population that is adult derived from these.

Age class (years)	Kittiwake	Gannet	Guillemot	Puffin	Razorbill	Great black-backed gull	Lesser black-backed gull	Herring gull	Manx shearwater
0 - 1	0.790	0.424	0.560	0.709	0.630	0.798*	0.820	0.798	0.424*
1 - 2	0.854	0.829	0.792	0.709	0.630	0.834*	0.885	0.834	0.829*
2 - 3	0.854	0.891	0.917	0.709	0.895	0.834*	0.885	0.834	0.870
3 - 4	0.854	0.895	0.939	0.760	0.895	0.834*	0.885	0.834	0.870
4 - 5	0.854	0.919	0.939	0.805	0.895	0.834*	0.885	0.834	0.870
5 - 6	-	0.919	0.939	0.906	0.895	0.930	0.885	0.834	0.870
6 - 7	-	-	0.939	-	-	-	-	-	-
Productivity**	0.690	0.700	0.672	0.617	0.570	1.139	0.530	0.920	0.697
Proportion of the population adult	0.493	0.549	0.501	0.559	0.526	0.365	0.506	0.387	0.538

*Source: Horswill and Robinson (2015). *Values for great black-backed gull and Manx shearwater – see section 2.3.6.4. **National-average productivity from Horswill and Robinson, 2015.*

Use of these values assume that the model itself provides a reasonable representation of the realised dynamics of the population and that the structure of the "population" of birds that will encounter the offshore wind farms is the same as in the population as a whole. Since national values were used, this does not account for regional differences in demographic parameters.

2.3.6.5. Sabbatical rate

Since counts of seabirds are generally carried out at breeding sites during the breeding season, counts may only represent adults that are breeding in a given year, with a proportion of non-breeding sabbatical adults not being counted. If these birds are using the wind farm site(s) but are not included in the count then impacts to the population could be overestimated if these sabbatical birds were not accounted for.

The OCcAM tool provides default parameters for sabbatical rates which are based on those currently being used in ScotWind offshore wind farm assessments (e.g. Ossian, 2024; Caledonia Offshore Wind Farm, 2024b). Since there is very little data available on Manx shearwater sabbatical rates, the proposed default sabbatical rate is 0. This will result in a precautionary estimate of mortalities.

Sabbatical rates are presented in Table 2.5. The sabbatical rate parameters are used in the Results tab.

Table 2.4: Default sabbatical rates provided within the OCcAM tool

	Kittiwake	Gannet	Guillemot	Puffin	Razorbill	Great black-backed gull	Lesser black-backed gull	Herring gull	Manx shearwater
Sabbatical rate	0.10	0.10	0.07	0.07	0.07	0.35	0.35	0.35	0

2.3.6.6. Wind turbine specifications

Average rotation speed, maximum blade width, average blade pitch and number of blades are used in collision risk modelling to determine the probability of a bird colliding with a blade given that it passes through the rotor-swept volume. Number of blades is currently always 3, however, the other parameters can be difficult to obtain due to commercial sensitivity and/or the complexity of modelling required to derive them. OCcAM therefore offers indicative default parameters for small (defined as turbines with a rotor diameter of less than 220 m), medium (defined as turbines with a rotor diameter between 220 m and 250 m) and large turbines (defined as turbines with a rotor diameter of greater than 250 m). These parameters have been derived from a (non-exhaustive) desk study of parameters used in collision risk modelling presented in existing assessments, and represent the median value within each size class (data provided in Appendix A).

If the "Indicative" option is selected in the turbine parameters to be used cells in the User inputs – run and wind farm tab, these parameters will be used to auto-complete a table of inputs in the User inputs – run and wind farm tab, which are then used to calculate the probability of a bird passing through the rotor-swept volume colliding with a blade in the Single transit collision risk tab. Otherwise, this table will be populated with the values defined by the user in the corresponding cells in the User inputs – run and wind farm.

2.3.6.7. Proportion operational - wind availability

This parameter represents the proportion of time that the wind turbines are expected to be operational based on appropriate wind conditions (i.e. between cut-in and cut-out wind speeds). This is also a parameter set which can be difficult to obtain and for which, in the context of the main aims of the tool to carry out indicative rather than specific models, it seems appropriate to include indicative default parameters. The default parameters used have been taken from the latest version of the stochastic CRM tool (Caneco *et al.*, 2022).

These parameters are used in the Overall collision risk tab alongside the proportion downtime - maintenance values to calculate the total proportion of time the wind turbines are expected to be operational and therefore representing collision risk to birds (i.e. assuming that birds will not collide with stationary turbine blades).

2.3.6.8. Proportion downtime - maintenance

This parameter represents the proportion of time that the wind turbines are expected not to be operational as a result of maintenance or repair. As above, the default parameters are intended to represent average values across wind farms and have been taken from the latest version of the stochastic CRM tool (Caneco *et al.*, 2022).

These parameters are used in the Overall collision risk tab alongside the proportion operational - wind availability values to calculate the total proportion of time the wind turbines are expected to be operational and therefore representing collision risk to birds.

2.3.7. Results

The Results tab displays the outputs of the tool. The structure of the results tab is presented in Figure 2.4. The overall outputs and main results are presented at the top of the page, and the predicted mortalities are broken down into their constituent parts in separate distributional responses, and collision sections underneath.

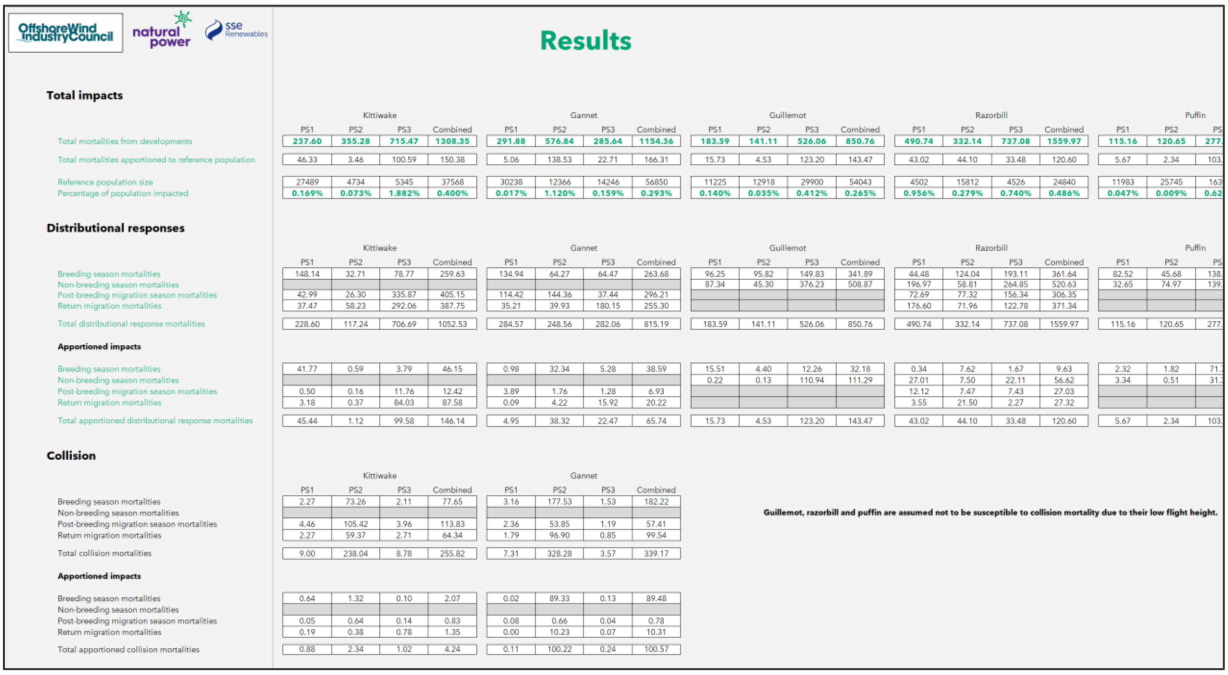


Figure 2.4: The "Results" tab in OCcAM

2.3.7.1. Total mortalities from developments

The "total mortalities from developments" row shows the total summed predicted mortalities from distributional responses and collision, where relevant. These are calculated as a sum of the total impacts calculated in the total distributional response mortality and the total collision mortality rows further down the sheet. If the "Alternative" option is selected in the parameter sets additive or alternative cell in the User inputs – run and wind farm tab then the "combined" column, which sums the impacts over each parameter set, will be greyed out.

2.3.7.2. Total mortalities apportioned to the reference population

The total mortalities apportioned to the reference population row shows the total summed predicted mortalities expected to be attributable to the reference population based on the apportioning correction factor inputs, from both distributional responses and collision, where relevant. These are calculated as a sum of the total impacts calculated in the total apportioned distributional response mortality and the total apportioned collision mortality rows further down the sheet.

2.3.7.3. Reference population size

This row duplicates the size of the reference population of interest data provided in the User inputs - bird populations tab and is for reference only.

2.3.7.4. Percentage of population impacted

This row calculates the apportioned mortality due to the impacts of the wind farms as a percentage of the total reference population. It is calculated from the total mortalities apportioned to the reference population divided by the reference population size rows.

2.3.7.5. Seasonal mortality distributional response rows

There are breeding, non-breeding, post-breeding migration and return migration season mortality rows within the distributional responses section of this tab. Cells relating to seasons which are not relevant for each species are greyed out. These rows predict seasonal mortalities associated with distributional responses by multiplying the area of windfarm footprint(s) from the User inputs – wind farm tab by the mean peak seasonal densities of birds in flight and on the sea, the bird displacement rate and the relevant bird displacement mortality rate from the User inputs – bird impacts tab. No distributional response impacts are predicted for great black-backed gull, lesser black-backed gull or herring gull, since these species are considered not to be susceptible to disturbance from offshore wind farm developments (see section 2.1).

2.3.7.6. Seasonal mortality collision rows

There are also breeding, non-breeding, post-breeding migration and return migration season mortality rows within the collision section in this tab. As above, cells relating to seasons which are not relevant for each species are greyed out and additionally, there are no collision impacts predicted for guillemot, razorbill or puffin, since these species are considered not to be susceptible to mortality from collision with offshore wind farms (see section 2.1). These rows take the seasonal predicted collision impacts from the Overall collision risk tab.

2.3.7.7. Total distributional response and collision mortalities rows

There is a total mortalities row in both the distributional responses and the collision sections of the sheet. These are calculated as the sum of the seasonal mortality distributional response rows and the seasonal mortality collision rows respectively.

2.3.7.8. Seasonal apportioned distributional response and collision mortality rows

There are breeding, non-breeding, post-breeding migration and return migration season apportioned mortality rows for both the distributional responses and the collision section within this tab. Apportioned mortalities are calculated by multiplying the seasonal mortality distributional response rows and the seasonal mortality collision rows respectively by the ratio of reference population to impacted population, the correction to be applied for adult ratio and the correction to be applied for sabbatical birds from the User inputs - bird populations tab.

2.3.7.9. Total apportioned distributional response and collision mortalities rows

There is a total apportioned mortality row in both the distributional responses and the collision sections of the sheet. These are calculated as the sum of the seasonal apportioned distributional response and collision mortality rows generated above.

2.3.8. Run log and assumptions

The run log and assumptions tab keeps a record of all of the user inputs that have been set within the tool, as well as the results, in a long format. In addition, there are free fields for each parameter-parameter set combination, allowing the user to note down rationale and assumptions behind the parameters that have been used. The data in this tab can be copied out into a separate spreadsheet allowing inputs and outputs from runs carried out for more than three parameter sets (i.e. using more than one OCcAM spreadsheet) to be recorded and compared. The structure of the run log and assumptions tab is presented in Figure 2.5.

Value	PS1	PS2	PS3	PS1 rationale	PS2 rationale	PS3 rationale
Tool version	OCcAM v3.0	OCcAM v3.0	OCcAM v3.0			
INPUT PARAMETERS						
Latitude of region centroid	52.56	53.487	51.799			
Number of turbines	4	22	58			
Rotor diameter (m)	125	270	240			
Turbine parameters to be used	User-defined	Indicative	Indicative			
Rotor speed (rpm)	7.5	6.5	8.11			
Maximum blade width (m)	6	8.2	7			
Average pitch (°)	11	8.25	10			
Air gap (m)	40	26	72			
Total area of wind farm footprint	426	257	732			
Include macro-avoidance for gannet	Yes	No	Yes			
Kittiwake collision risk densities - Jan	1.800	0.349	1.960			
Kittiwake collision risk densities - Feb	2.344	1.245	2.288			
Kittiwake collision risk densities - Mar	0.361	2.245	1.643			
Kittiwake collision risk densities - Apr	0.992	0.298	2.026			
Kittiwake collision risk densities - May	0.921	1.037	1.442			
Kittiwake collision risk densities - Jun	0.626	1.420	2.108			
Kittiwake collision risk densities - Jul	2.655	1.803	1.915			
Kittiwake collision risk densities - Aug	2.874	1.385	2.046			
Kittiwake collision risk densities - Sep	0.585	1.040	2.274			
Kittiwake collision risk densities - Oct	1.764	1.306	2.119			
Kittiwake collision risk densities - Nov	2.454	2.682	2.143			
Kittiwake collision risk densities - Dec	2.628	1.010	2.791			
Gannet collision risk densities - Jan	0.682	2.987	1.238			
Gannet collision risk densities - Feb	2.641	2.022	1.209			
Gannet collision risk densities - Mar	1.806	1.840	1.724			
Gannet collision risk densities - Apr	1.524	2.899	0.962			
Gannet collision risk densities - May	0.736	2.695	1.683			
Gannet collision risk densities - Jun	1.657	1.253	2.201			
Gannet collision risk densities - Jul	0.465	2.192	2.245			
Gannet collision risk densities - Aug	2.734	3.091	0.857			
Gannet collision risk densities - Sep	2.829	1.345	2.707			
Gannet collision risk densities - Oct	1.177	1.107	2.838			
Gannet collision risk densities - Nov	2.947	1.992	2.514			
Gannet collision risk densities - Dec	0.626	1.958	2.363			
Great black-backed gull collision risk densities - Jan	0.653	1.514	1.798			
Great black-backed gull collision risk densities - Feb	1.077	2.932	1.727			

Figure 2.5: The "Run log and assumptions" tab in OCcAM

2.3.9. Overall collision risk

This tab contains what is essentially eighteen copies of the overall collision risk tab from the Band, 2012 spreadsheet, one for each combination of kittiwake, gannet, great black-backed gull, lesser black-backed gull, herring gull and Manx shearwater, and parameter sets one, two and three (see Figure 2.6). The original spreadsheet is available to download from SOSS (2012) and an explanation of its functionality is provided in Band, 2012.

Minor edits which have been made to this spreadsheet are:

- An update which allows it to work directly with a percentage of nocturnal activity (e.g. cell C9 of the Overall collision risk tab in OCcAM) rather than the nocturnal activity factors between 1 and 5 that were applied in the original version of the Band model (which were then converted into a percentage by the spreadsheet itself).
- The addition of a 'seasons' row which allows automatic calculation of collisions by season from the monthly estimates
- The rows associated with different options for the method of incorporating bird flight height data/proportion at collision risk height have been removed with proportion at rotor height being based on a sum of densities at rotor-swept height upon which the potential bird transits through rotors calculation is based.
- The collisions assuming avoidance rows were simplified to a single row since a single avoidance rate will be considered within each individual collision risk model
- Additional rows were added to calculate seasonal collision mortalities based on the seasonal definitions included in the tool (including the option for 'split' seasons; see section 2.3.6.3).

The seasonal collision mortality rates derived within this tab pull through to the Results tab.

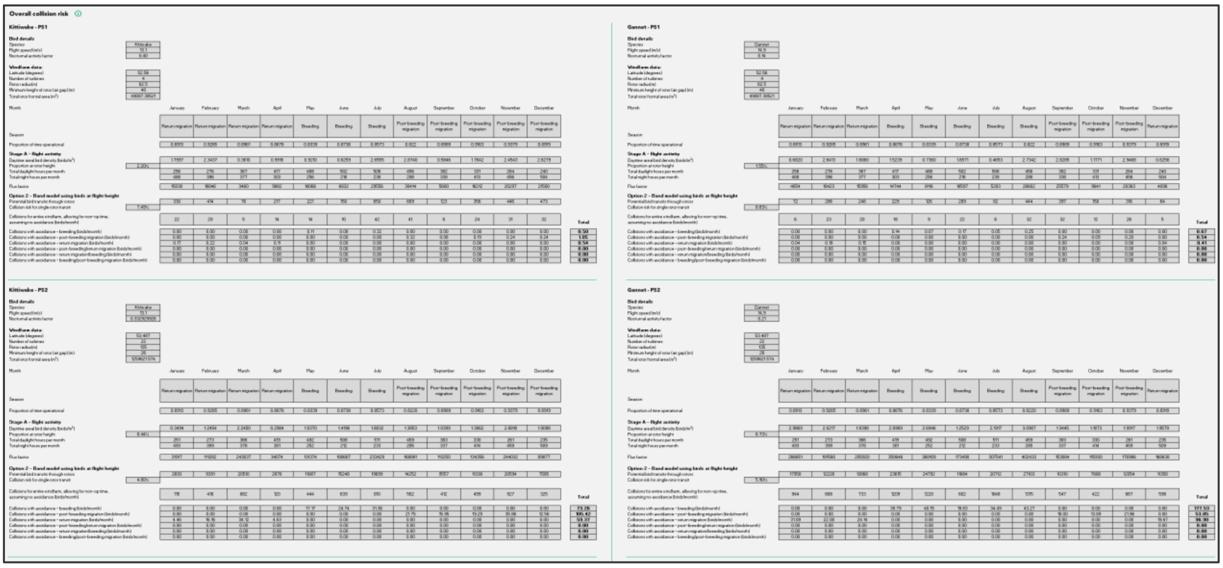


Figure 2.6: The “Overall collisions” tab in OCcAM

2.3.10. Single transit collision risk

This tab is used to calculate the probability that a bird collides with a rotor blade given that it flies through the rotor-swept volume. The tab contains eighteen copies of the single transit collision risk tab from the Band 2012 spreadsheet (SOSS, 2012), one for each combination of kittiwake, gannet, great black-backed gull, lesser black-backed gull, herring gull and Manx shearwater, and parameter sets one, two and three (see Figure 2.7). An explanation of the single transit collision probability calculations can be found in Band, 2012.

The calculations in these cells have not been altered at all from the original spreadsheet and the only difference is that data present but invisible within the SOSS, 2012 spreadsheet have been made visible within OCcAM (e.g. OCcAM cells D10 and D15). The predicted average single transit collision risks from this tab (e.g. cell J37) are used in the Overall collision risk tab.

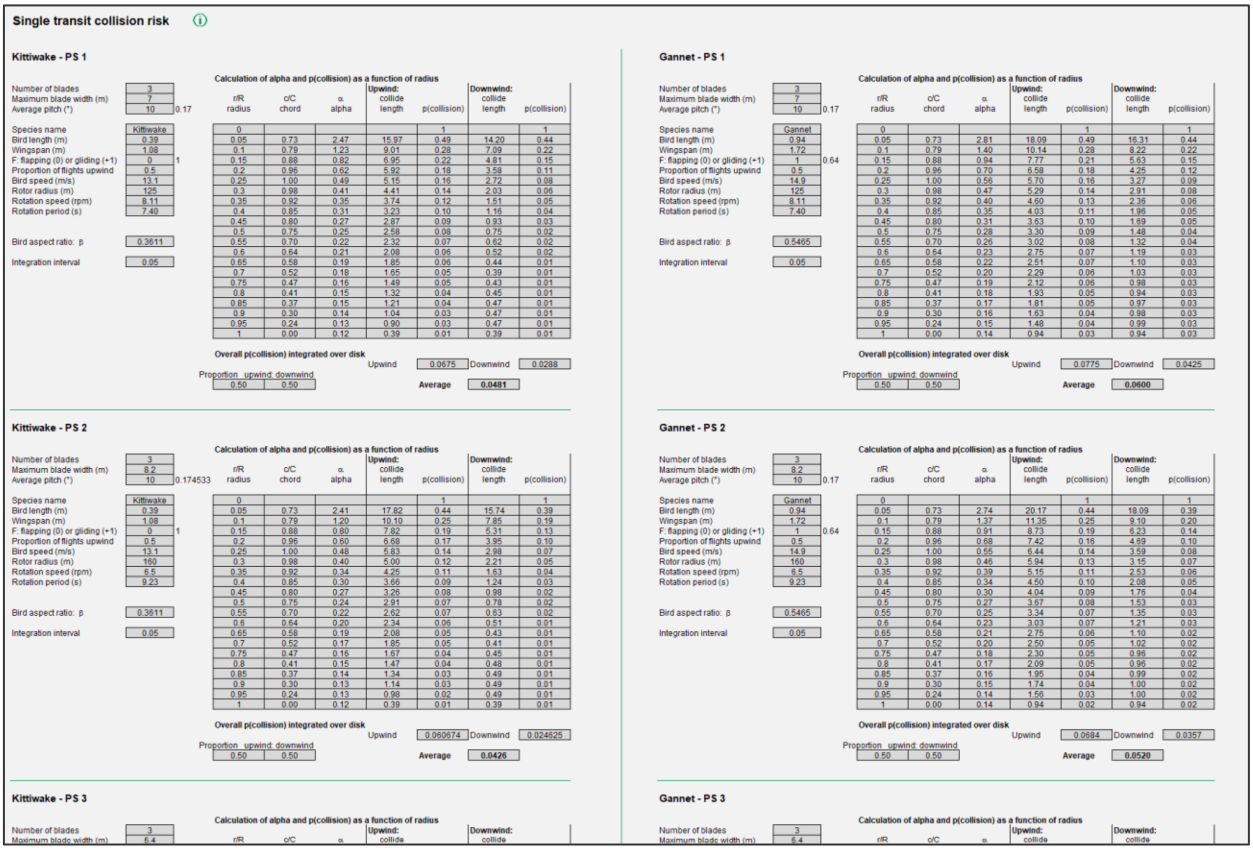


Figure 2.7: The "Single transit collision risk" tab in OCcAM

2.3.11. Hours of daylight

The hours of daylight tab calculates the hours of daylight and night-time for each parameter set using the user-defined latitude, based on an algorithm described in Forsyth *et al.* (1995). The structure of the sheet itself is based on the daylight and night hours tab in the Band (2012) spreadsheet. This spreadsheet is available at:

https://view.officeapps.live.com/op/view.aspx?src=https%3A%2F%2Fwww.bto.org%2Fsites%2Fdefault%2Ffiles%2Fu28%2Fdownloads%2FProjects%2FFinal_Report_SOSS02_Band2Tool.xlsm&wdOrigin=BROWSELINK

and is presented in Figure 2.8. The "monthly available daylight hours" and "monthly available nocturnal hours" calculated within this tab are used in the Overall collision risk tab to extrapolate the number of expected bird passages through turbine swept space across the year. The "monthly available total hours" are not used but provides a sense check to confirm that all hours are accounted for as either daytime or night-time.

Hours of daylight

Latitude PS1	60.0
Latitude PS2	48.0
Latitude PS3	65.0

Date	Day number	P	Daylength PS1	PS2	PS3
01-Jan	1	-0.40	6.01	8.44	3.84
02-Jan	2	-0.40	6.04	8.45	3.90
03-Jan	3	-0.40	6.07	8.47	3.96
04-Jan	4	-0.40	6.11	8.49	4.02
05-Jan	5	-0.40	6.15	8.51	4.09
06-Jan	6	-0.39	6.19	8.53	4.16
07-Jan	7	-0.39	6.23	8.55	4.24
08-Jan	8	-0.39	6.28	8.58	4.32
09-Jan	9	-0.39	6.33	8.60	4.40
10-Jan	10	-0.39	6.38	8.63	4.48
11-Jan	11	-0.38	6.43	8.66	4.57
12-Jan	12	-0.38	6.49	8.69	4.66
13-Jan	13	-0.38	6.54	8.72	4.75
14-Jan	14	-0.37	6.60	8.75	4.85
15-Jan	15	-0.37	6.66	8.78	4.94
16-Jan	16	-0.37	6.73	8.81	5.04
17-Jan	17	-0.36	6.79	8.85	5.14
18-Jan	18	-0.36	6.86	8.88	5.24
19-Jan	19	-0.36	6.92	8.92	5.34
20-Jan	20	-0.35	6.99	8.96	5.45
21-Jan	21	-0.35	7.06	9.00	5.55
22-Jan	22	-0.35	7.13	9.04	5.66
23-Jan	23	-0.34	7.21	9.08	5.77
24-Jan	24	-0.34	7.28	9.12	5.87
25-Jan	25	-0.33	7.36	9.16	5.98
26-Jan	26	-0.33	7.43	9.21	6.09
27-Jan	27	-0.33	7.51	9.25	6.20
28-Jan	28	-0.32	7.59	9.30	6.31
29-Jan	29	-0.32	7.67	9.34	6.43
30-Jan	30	-0.31	7.75	9.39	6.54
31-Jan	31	-0.31	7.83	9.43	6.65
01-Feb	32	-0.30	7.91	9.48	6.76
02-Feb	33	-0.30	7.99	9.53	6.88
03-Feb	34	-0.29	8.08	9.58	6.99
04-Feb	35	-0.29	8.16	9.63	7.10
05-Feb	36	-0.28	8.25	9.68	7.22
06-Feb	37	-0.28	8.33	9.73	7.33
07-Feb	38	-0.27	8.42	9.78	7.45
08-Feb	39	-0.27	8.50	9.83	7.56
09-Feb	40	-0.26	8.59	9.88	7.68
10-Feb	41	-0.25	8.68	9.94	7.79
11-Feb	42	-0.25	8.76	9.99	7.91

Monthly available daylight hours

	Jan	Feb	March	April	May	June	July	August	Sept	Oct	Nov	Dec
PS1	211	254	364	436	531	561	558	485	389	317	229	187
PS2	275	285	368	409	469	479	484	444	379	338	280	262
PS3	158	233	362	454	580	648	626	516	395	303	190	121

Monthly available nocturnal hours

PS1	533	418	380	284	213	159	186	259	331	427	491	557
PS2	469	387	376	311	275	241	260	300	341	406	440	482
PS3	586	439	382	266	164	72	118	228	325	441	530	623

Monthly available total hours

744	672	744	720	744	720	744	744	720	744	720	744

Calculations based on Forsythe et al., 1995), as implemented in Band et al., 2012.

Figure 2.8: The "Hours of daylight" tab in OCcAM

2.3.12. Proportion at collision height

The proportion at collision height tab uses the bird flight height distributions from the Default parameters tab alongside the user-defined air gap and rotor diameter to calculate the proportion of birds at rotor height for each CRM species and parameter set. The structure of the tab is presented in Figure 2.9. This is used in the Overall collision risk tab so that only birds flying at collision height are considered to be at collision risk.

Proportion of birds at collision height

Kittiwake

	PS1	PS2	PS3
Minimum rotor-swept height (m)	40.0	32.0	32.0
Maximum rotor-swept height (m)	290.0	352.0	192.0
Total proportion of birds at risk	**0.0122**	**0.0308**	**0.0308**

Lower bound of height band (m)	Proportion of birds in band	PS1		PS2		PS3	
		Included?	Proportion at risk	Included?	Proportion at risk	Included?	Proportion at risk
0	0.0857	0	0.0000	0	0.0000	0	0.0000
1	0.0785	0	0.0000	0	0.0000	0	0.0000
2	0.0718	0	0.0000	0	0.0000	0	0.0000
3	0.0653	0	0.0000	0	0.0000	0	0.0000
4	0.0599	0	0.0000	0	0.0000	0	0.0000
5	0.0550	0	0.0000	0	0.0000	0	0.0000
6	0.0510	0	0.0000	0	0.0000	0	0.0000
7	0.0468	0	0.0000	0	0.0000	0	0.0000
8	0.0426	0	0.0000	0	0.0000	0	0.0000
9	0.0391	0	0.0000	0	0.0000	0	0.0000
10	0.0359	0	0.0000	0	0.0000	0	0.0000
11	0.0329	0	0.0000	0	0.0000	0	0.0000
12	0.0300	0	0.0000	0	0.0000	0	0.0000
13	0.0275	0	0.0000	0	0.0000	0	0.0000
14	0.0251	0	0.0000	0	0.0000	0	0.0000
15	0.0231	0	0.0000	0	0.0000	0	0.0000
16	0.0212	0	0.0000	0	0.0000	0	0.0000
17	0.0193	0	0.0000	0	0.0000	0	0.0000
18	0.0177	0	0.0000	0	0.0000	0	0.0000
19	0.0159	0	0.0000	0	0.0000	0	0.0000
20	0.0140	0	0.0000	0	0.0000	0	0.0000
21	0.0125	0	0.0000	0	0.0000	0	0.0000
22	0.0112	0	0.0000	0	0.0000	0	0.0000
23	0.0100	0	0.0000	0	0.0000	0	0.0000
24	0.0090	0	0.0000	0	0.0000	0	0.0000
25	0.0080	0	0.0000	0	0.0000	0	0.0000
26	0.0071	0	0.0000	0	0.0000	0	0.0000
27	0.0063	0	0.0000	0	0.0000	0	0.0000
28	0.0057	0	0.0000	0	0.0000	0	0.0000
29	0.0050	0	0.0000	0	0.0000	0	0.0000
30	0.0044	0	0.0000	0	0.0000	0	0.0000
31	0.0039	0	0.0000	0	0.0000	0	0.0000
32	0.0035	0	0.0000	1	0.0035	1	0.0035
33	0.0031	0	0.0000	1	0.0031	1	0.0031
34	0.0027	0	0.0000	1	0.0027	1	0.0027
35	0.0024	0	0.0000	1	0.0024	1	0.0024
36	0.0021	0	0.0000	1	0.0021	1	0.0021
37	0.0019	0	0.0000	1	0.0019	1	0.0019

Gannet

	PS1	PS2	PS3
Minimum rotor-swept height (m)	40.0	32.0	32.0
Maximum rotor-swept height (m)	290.0	352.0	192.0
Total proportion of birds at risk	**0.0062**	**0.0192**	**0.0192**

Lower bound of height band (m)	Proportion of birds in band	PS1		PS2		PS3	
		Included?	Proportion at risk	Included?	Proportion at risk	Included?	Proportion at risk
0	0.2332	0	0.0000	0	0.0000	0	0.0000
1	0.1546	0	0.0000	0	0.0000	0	0.0000
2	0.1051	0	0.0000	0	0.0000	0	0.0000
3	0.0734	0	0.0000	0	0.0000	0	0.0000
4	0.0536	0	0.0000	0	0.0000	0	0.0000
5	0.0394	0	0.0000	0	0.0000	0	0.0000
6	0.0289	0	0.0000	0	0.0000	0	0.0000
7	0.0217	0	0.0000	0	0.0000	0	0.0000
8	0.0167	0	0.0000	0	0.0000	0	0.0000
9	0.0132	0	0.0000	0	0.0000	0	0.0000
10	0.0108	0	0.0000	0	0.0000	0	0.0000
11	0.0094	0	0.0000	0	0.0000	0	0.0000
12	0.0087	0	0.0000	0	0.0000	0	0.0000
13	0.0085	0	0.0000	0	0.0000	0	0.0000
14	0.0088	0	0.0000	0	0.0000	0	0.0000
15	0.0094	0	0.0000	0	0.0000	0	0.0000
16	0.0101	0	0.0000	0	0.0000	0	0.0000
17	0.0109	0	0.0000	0	0.0000	0	0.0000
18	0.0115	0	0.0000	0	0.0000	0	0.0000
19	0.0118	0	0.0000	0	0.0000	0	0.0000
20	0.0117	0	0.0000	0	0.0000	0	0.0000
21	0.0114	0	0.0000	0	0.0000	0	0.0000
22	0.0108	0	0.0000	0	0.0000	0	0.0000
23	0.0101	0	0.0000	0	0.0000	0	0.0000
24	0.0092	0	0.0000	0	0.0000	0	0.0000
25	0.0084	0	0.0000	0	0.0000	0	0.0000
26	0.0076	0	0.0000	0	0.0000	0	0.0000
27	0.0066	0	0.0000	0	0.0000	0	0.0000
28	0.0058	0	0.0000	0	0.0000	0	0.0000
29	0.0050	0	0.0000	0	0.0000	0	0.0000
30	0.0043	0	0.0000	0	0.0000	0	0.0000
31	0.0035	0	0.0000	0	0.0000	0	0.0000
32	0.0030	0	0.0000	1	0.0030	1	0.0030
33	0.0024	0	0.0000	1	0.0024	1	0.0024
34	0.0020	0	0.0000	1	0.0020	1	0.0020
35	0.0017	0	0.0000	1	0.0017	1	0.0017
36	0.0014	0	0.0000	1	0.0014	1	0.0014
37	0.0011	0	0.0000	1	0.0011	1	0.0011

Figure 2.9: The "Proportion at collision height" tab in OCcAM

3. Reporting of issues and requesting additional functionality

OCcAM has been developed as a quick, simple and user-friendly method to generate indicative estimates of mortalities associated with different offshore wind farm build out scenarios. It has been built using basic Excel functionality in order to maximise transparency and has been designed with the aim of balancing default and user-defined parameters to maximise ease of use, whilst simultaneously providing the flexibility required to apply it in a range of scenarios. However, it is acknowledged that there may be some limitations to the tool usage as it stands and that these will likely become apparent as users seek to apply the tool in different situations. It would be possible to update the tool to, for example, cover additional species, add new parameters, or convert some parameters from defaults to user-definable, update the way that the parameters for the modelling are defined within the tool, and incorporate additional optional defaults as are currently available in the User inputs - bird populations tab.

OCcAM is hosted by the Offshore Wind Industry Council (OWIC) and is available in the resources and publications area of the website. Any technical issues or requests for additional functionality should be reported to OWIC by emailing info@RenewableUK.com with the subject line "OWIC OCcAM Tool Functionality".

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A. Data used to derive default turbine parameters

Table 4.1: Data used to derive default turbine parameters used in OCcAM

Site	Turbine diameter (m)	Size	Rotation speed (rpm)	Maximum blade width (m)	Average pitch (°)	Document link
Berwick Bank	222	Medium	7.81	7	10	https://berwickbank-eia.com/offshore-eia/vol3-ap1103-crm/part-1.html#3.4.-Parameterising-the-collision-risk-models
Berwick Bank	236	Medium	8.4	5.2	10	https://berwickbank-eia.com/offshore-eia/vol3-ap1103-crm/part-1.html#3.4.-Parameterising-the-collision-risk-models
Berwick Bank	265	Large	6.49	8.4	10	https://berwickbank-eia.com/offshore-eia/vol3-ap1103-crm/part-1.html#3.4.-Parameterising-the-collision-risk-models
Berwick Bank	265	Large	7.9	6.1		https://berwickbank-eia.com/offshore-eia/vol3-ap1103-crm/part-1.html#3.4.-Parameterising-the-collision-risk-models
Berwick Bank	290	Large	5.93	9.1	10	https://berwickbank-eia.com/offshore-eia/vol3-ap1103-crm/part-1.html#3.4.-Parameterising-the-collision-risk-models
Berwick Bank	290	Large	7.51	6.7		https://berwickbank-eia.com/offshore-eia/vol3-ap1103-crm/part-1.html#3.4.-Parameterising-the-collision-risk-models
Berwick Bank	310	Large	5.55	7.2	10	https://berwickbank-eia.com/offshore-eia/vol3-ap1103-crm/part-1.html#3.4.-Parameterising-the-collision-risk-models
Berwick Bank	310	Large	7.39	5.55		https://berwickbank-eia.com/offshore-eia/vol3-ap1103-crm/part-1.html#3.4.-Parameterising-the-collision-risk-models
Seagreen	167	Small	14	5.4	10	https://marine.gov.scot/sites/default/files/appendix_c_-_seagreen_collision_risk_modelling_apr_2022_0.pdf

Site	Turbine diameter (m)	Size	Rotation speed (rpm)	Maximum blade width (m)	Average pitch (°)	Document link
Seagreen	164	Small	8.8	5.4	10	https://marine.gov.scot/sites/default/files/appendix_c_-_seagreen_collision_risk_modelling_apr_2022_0.pdf
Seagreen	242	Medium	14	7.6	10	https://marine.gov.scot/sites/default/files/appendix_c_-_seagreen_collision_risk_modelling_apr_2022_0.pdf
Inch Cape	236	Medium	7.19	5.1	4.38	https://www.inchcapewind.com/wp-content/uploads/2022/11/Appendix-C-Collision-Risk-Estimates-for-Key-Seabird-Species-at-Inch-Cape-Offshore-Wind-Farm.pdf
Inch Cape	167	Small	8.72	6	10	https://www.inchcapewind.com/wp-content/uploads/2022/11/Appendix-C-Collision-Risk-Estimates-for-Key-Seabird-Species-at-Inch-Cape-Offshore-Wind-Farm.pdf
Inch Cape	250	Large	5.72	7.8	10	https://www.inchcapewind.com/wp-content/uploads/2022/11/Appendix-C-Collision-Risk-Estimates-for-Key-Seabird-Species-at-Inch-Cape-Offshore-Wind-Farm.pdf
Sofia	167	Small	8.84	5.5	10	https://assets.publishing.service.gov.uk/media/5cc8095ced915d5dbf628c37/SOWF_DCO-2013-00011-dML_Variation_June_2018_-_Appendix_-_Ornithology_technical_note_in_support_of_NMC.pdf
Sofia	220	Medium	8.7	7.2	10	https://assets.publishing.service.gov.uk/media/5cc8095ced915d5dbf628c37/SOWF_DCO-2013-00011-dML_Variation_June_2018_-_Appendix_-_Ornithology_technical_note_in_support_of_NMC.pdf
Sofia	250	Large	7.6	8.2	10	https://assets.publishing.service.gov.uk/media/5cc8095ced915d5dbf628c37/SOWF_DCO-2013-00011-dML_Variation_June_2018_-_Appendix_-_Ornithology_technical_note_in_support_of_NMC.pdf
Sofia	288	Large	6.6	9.5	10	https://assets.publishing.service.gov.uk/media/5cc8095ced915d5dbf628c37/SOWF_DCO-2013-00011-dML_Variation_June_2018_-_Appendix_-_Ornithology_technical_note_in_support_of_NMC.pdf

Site	Turbine diameter (m)	Size	Rotation speed (rpm)	Maximum blade width (m)	Average pitch (°)	Document link
NnG	167	Small	8.2	5	1.19	https://nngoffshorewind.com/files/EIA/Vol4/Appendix-9.3-CRM-methods,-inputs-and-results.pdf
Ossian	236	Medium	8.4	6.7	10	https://ossian-eia.com/offshore-eia/vol3/ap11-2-ornithology-collision-risk-model-crm-technical-report/
GreenVolt	242	Medium	8	8	6	https://greenvoltoffshorewind.com/wp-content/uploads/2023/02/Appendix-12.3-Offshore-Ornithology-Collision-Risk.pdf
Outer Dowsing	236	Medium	8.11	6	6.5	https://infrastructure.planninginspectorate.gov.uk/wp-content/ipc/uploads/projects/EN010130/EN010130-000445-6.3.12.2%20Chapter%2012%20Appendix%202%20Collision%20Risk%20Modelling.pdf
Salamander	250	Large	6.3	6.5	2.7	https://marine.gov.scot/sites/default/files/3.12_-_offshore_and_intertidal_ornithology.pdf
West of Orkney	236	Medium	8.11	8	6.5	https://marine.gov.scot/sites/default/files/supporting_study_12_-_offshore_ornithology_technical_supporting_study.pdf
West of Orkney	250	Large	7.66	8.5	6.5	https://marine.gov.scot/sites/default/files/supporting_study_12_-_offshore_ornithology_technical_supporting_study.pdf
West of Orkney	265	Large	7.23	8.5	6.5	https://marine.gov.scot/sites/default/files/supporting_study_12_-_offshore_ornithology_technical_supporting_study.pdf
West of Orkney	300	Large	6.38	8.5	6.5	https://marine.gov.scot/sites/default/files/supporting_study_12_-_offshore_ornithology_technical_supporting_study.pdf
West of Orkney	330	Large	5.8	9	6.5	https://marine.gov.scot/sites/default/files/supporting_study_12_-_offshore_ornithology_technical_supporting_study.pdf

Site	Turbine diameter (m)	Size	Rotation speed (rpm)	Maximum blade width (m)	Average pitch (°)	Document link
Hornsea 3	195	Small	8.1	6	4.3	https://infrastructure.planninginspectorate.gov.uk/wp-content/ipc/uploads/projects/EN010080/EN010080-001985-%C3%98rsted%20Hornsea%20Project%20Three%20(UK)%20Ltd%20-Appendix%2019%20-%20Response%20to%20Examining%20Authority%27s%20FQ3.1%20Rule%2017%20%E2%80%93%20Collision%20Risk%20Modelling.pdf
Hornsea 4	305	Large	6.5	6	4.6	https://infrastructure.planninginspectorate.gov.uk/wp-content/ipc/uploads/projects/EN010098/EN010098-000643-A5.5.3%20ES%20Volume%20A5%20Annex%205.3%20Offshore%20Ornithology%20Collision%20Risk%20Modelling.pdf
Dudgeon	126	Small	10.59	5.45	15	https://sheringhamshoal.co.uk/extensionproject/docs/PEIR%20Volume%203/Appendix%2013.2%20Supplementary%20CIA.pdf
Race Bank	90	Small	15.9	3.4	10	https://sheringhamshoal.co.uk/extensionproject/docs/PEIR%20Volume%203/Appendix%2013.2%20Supplementary%20CIA.pdf
Sheringham Shoal	104	Small	12.7	3.9	10	https://sheringhamshoal.co.uk/extensionproject/docs/PEIR%20Volume%203/Appendix%2013.2%20Supplementary%20CIA.pdf
Triton Knoll	125	Small	9.47	4.2	6	https://sheringhamshoal.co.uk/extensionproject/docs/PEIR%20Volume%203/Appendix%2013.2%20Supplementary%20CIA.pdf

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