Seagreen S36C Application
Environmental Appraisal Report

Appendix C – Updated Collision Risk Modelling

Collision Risk Model for Seagreen Wind Energy Wind farm

Comparison of different turbine parameters on estimated seabird mortality

7th April 2022

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Signature Page

7th April 2022

Collision Risk Model for Seagreen Wind Energy Wind farm

Comparison of different turbine parameters on estimated seabird mortality

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Acronyms and Abbreviations

BTO	British Trust for Ornithology
CRM	Collision Risk Model
Gannet	Northern gannet (*Morus bassanus*)
Herring gull	European herring gull (*Larus argentatus*)
JNCC	Joint Nature Conservation Committee
Kittiwake	Black-legged kittiwake (*Rissa tridactyla*)
MS-LOT	Marine Scotland - Licensing Operations Team
NatureScot	Scotland's Nature Agency
RPM	Revolutions per minute
RSPB	Royal Society for the Protection of Birds
sCRM	Stochastic Collision Risk Model
WTG	Wind Turbine Generator

1. INTRODUCTION

A Collision Risk Model (CRM) was used to estimate and compare the annual mortality of three species of seabird between different designs of Wind Turbine Generator (WTG) within a proposed Seagreen Wind Farm Array.

The three species of seabird compared were northern gannet (*Morus bassanus*), black-legged kittiwake (*Rissa tridactyla*), and European herring gull (*Larus argentatus*). These species were chosen to keep in line with previously conducted CRMs and were identified through a Marine Scotland Scoping Opinion in 2017.

The estimates have been calculated using the Band (2012) Collision Risk Model (Excel file accessed through the British Trust for Ornithology Strategic Ornithological Support Services website) and also using the McGregor (2018) Stochastic Collision Risk Model (sCRM) (rShiny App accessed through the Scottish Government website).

Three sets of WTGs were compared for this assessment they are categorised as:

- Originally consented WTGs
- Currently constructed WTGs
- Newly proposed WTGs

Two layouts of these WTGs were compared:

- 36 WTGs originally consented vs 36 WTGs newly proposed
- 150 WTGs originally consented vs 114 WTGs currently constructed + 36 WTGs newly proposed

Only turbine parameters were changed within the CRMs to allow for comparison, all other input parameters to the model were kept consistent within each model. Seabird density and biometric data was kept consistent between both CRMs. Site specific flight height distribution was not available from survey data and as such was taken from the Cook *et al* (2011) found within the Band CRM excel and from Johnston *et al* (2014) as is available within the sCRM webapp.

2. METHOD

Estimated mortality rates through collision with turbine blades are calculated using Option 2 of the Band deterministic CRM and Option 2 and Option 3 of the McGregor stochastic CRM. Whilst Option 1 would be preferable there was not enough site specific survey data that could be used. It is also in keeping as close as possible to the methods and parameters of the original consent application CRM in which Option 2 was chosen.

- Option 2 assumes uniform distribution, based on the proportion of sea birds at collision risk height (between lowest and highest height of the turbine blades) taken from species specific aggregated and modelled flight data.
    - Within the Band CRM this proportion at collision risk height data comes from the Cook *et al* (2011) aggregate dataset. Gannet and kittiwake flight height proportions are present from 0-150m within the Excel CRM. Flight height proportions between 0-150m herring gull were not available. As neither site survey data nor aggregate data of flight heights was available, and the known proportion of birds between 20-150m was 28.4% (Cook *et al* 2011) this proportion was used for herring gull for all WTGs in the Band CRM.
    - Within the McGregor sCRM the proportion at collision risk height comes from the Johnston *et al* (2014) modelled flight data. For all three species of seabird, flight height proportions were available within the sCRM rShiny app from 0-300m.

- Option 3 is an extension of Option 2, with the full range of flight distributions between minimum and maximum heights of the turbine blades is incorporated with a calculation of varying risk of collision across the swept area.
  - Within the Band CRM Option 3 was not considered as there was not a full enough range of flight height data from the Cook *et al* (2011) dataset as all turbines had a maximum height above 150m for gannet and kittiwake.
  - Within the McGregor sCRM this extended modelling is presented as per Nature Scot guidance for only the kittiwake and herring gull.

The parameters used within each model to obtain the collision estimates are presented below (see table(s) 1, 2, 3, and 4).

In both the Band CRM and McGregor sCRM sets of results were obtained for estimated mortality for each of the 3 seabird species, the number of WTGs in each set were:

- 36 WTGs with originally consented parameters,
- 150 WTGs with originally consented parameters,
- 36 WTGs newly proposed parameters, and
- 114 WTGs currently constructed parameters.

Parameters used whilst running the Band CRM were the same as or as close as possible to the parameters and methods used in the original Seagreen consent.

The Seagreen site has a latitude of 56.37 degrees and this was kept consistent in all models to inform number of daylight hours.

The maximum width of the windfarm was assessed to be 10km when comparing 36 WTGs and 30km when comparing the full array of 150 WTGs.

Tidal offset within the Band CRM was 0m and within the McGregor sCRM it was 2.3 meters, to provide correction for flight heights measured from mean sea level and turbine parameters measured from highest astronomical tide (tidal data from the National Tidal and Sea Level Facility at Aberdeen port shows mean sea level 2.55m and highest astronomical tide 4.85m).

Each WTG design has 3 blades. Monthly proportion of time operational was set at 88% for the WTGs originally consented and 90% for WTGs currently constructed and WTGs newly proposed. Rotation speed of 14rpm was used as a worst case scenario for the WTGs originally consented, and WTGs newly proposed. Rotation speed of 8.8rpm was used for the WTGs currently constructed. In the Band CRM to keep in line with a previously conducted CRM in 2012, a second model run was done for WTGs originally consented with a likely monthly average rpm, giving an annual average of 10.6rpm (see table 2). Rotor pitch was 10degrees consistently in each model. Maximum rotor width was set at 5.4m for the WTGs originally consented, and WTGs currently constructed, and at 7.6m for the WTGs newly proposed. Rotor radius was 83.5m for the WTGs originally consented, 82m for the WTGs currently constructed, and 121m for the WTGs newly proposed.

Maximum height above mean sea level was 194.3m for the WTGs originally consented, 198.5m for the WTGs currently constructed, and 273.5m for the WTGs newly proposed. Hub height above mean sea level was 110.8m for the WTGs originally consented, 116.5m for the WTGs currently constructed, and 152.5m for the WTGs newly proposed. The airgap between the lowest sweep of the rotor and mean sea level was 27.3m for the WTGs originally consented, 34.5m for the WTGs currently constructed, and 31.5m for the WTGs newly proposed.

Seabird morphological and behavioural parameters were kept the same in all models (see table 4). Bird length and wingspan from BWPi 2004 data, flight speed from Alerstam *et al* 2007, flight type set to flapping for all species, and nocturnal activity proportions from were taken from data previously agreed within a scoping opinion from MS-LOT and found within Seagreen (2018) EIAR Appendix 8B.

Seabird monthly flight density is derived from site survey data as used in the Seagreen (2018) EIAR Appendix 8B (see table 3).

Avoidance rates used within the Band CRM for Option 2 are the same as in Seagreen (2018) EIAR Appendix 8B and these are:

- Gannet – 98.9% (±0.2%)
- Kittiwake – 98.9% (±0.2%)
- Herring gull – 99.5% (±0.1%)

Avoidance rates used within the McGregor sCRM are taken from Bowgen & Cook (2018) as recommended in Nature Scot guidance. The avoidance rates are:

- Gannet:
  - Option 2 – 99.7% (±0.2%)
  - Option 3 – N/A (Option 3 not considered for gannet)
- Kittiwake:
  - Option 2 – 99.2% (±0.2%)
  - Option 3 – 96.7% (±2.7%)
- Herring gull:
  - Option 2 – 99.7% (±0.2%)
  - Option 3 – 99.2% (±0.2%)

Table 1: WTG Parameters and data

Parameter	Consented WTG	Constructed WTG	Newly Proposed WTG
Array latitude (degrees)	56.37	56.37	56.37
Number of WTGs in Array	150 (36*)	114	36
Width of Array (km)	30 (10*)	30	10
Number of blades	3	3	3
Rotation speed (rpm)	14 (10.6**)	8.8	14
Rotor radius (m)	83.5	82	121
Maximum blade width (m)	5.4	5.4	7.6
Rotor blade pitch (degrees)	10	10	10
Airgap above mean sea level (m)	27.3	34.5	31.5
Total height of WTG above mean sea level (m)	194.3	198.5	273.5
Hub height above mean sea level (m)	110.8	116.5	152.5
Monthly proportion of time operational (%)	88	90	90

**For comparison against 36 Newly proposed WTG*

***Consented worst case 14rpm but expected 10.6rpm annually (see Table 2)*

Table 2: Monthly Predicted RPM of Consented Turbines from Seagreen Vortex Hindcast modelling (Used in Band deterministic CRM)*

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Avg
11.2	10.9	10.8	10.5	10.2	10.3	10.1	10.0	10.7	11.0	11.1	10.9	10.6

**As used in Addendum to the Seagreen (2018) EIAR – Appendix 8B*

Table 3: Mean Monthly Densities (km^{-2}) of flying birds, with standard deviations. Breeding season in grey, precautionary breeding season in blue.

Species	Value	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Gannet	Mean	0.309	0.613	1.900	1.154	4.986	7.612	2.116	3.403	2.197	1.333	0.532	0.083
	SD	0.126	-	0.752	0.704	0.932	2.809	1.454	2.653	1.078	1.372	0.485	0.118
Kittiwake	Mean	1.911	1.355	2.629	1.804	2.947	2.409	3.414	1.167	2.017	1.999	8.610	0.666
	SD	0.072	-	2.618	0.121	1.604	1.563	3.053	1.225	2.737	1.201	11.332	0.748
Herring gull	Mean	0.120	0.108	0.190	0.028	0.078	0.128	0.019	0.000	0.028	0.072	0.027	0.235
	SD	0.130	-	0.229	0.001	0.053	0.171	0.033	0.000	0.040	0.022	0.038	0.255

Table 4: Seabird morphological and behaviour parameters

Bird	Length (m)	Wingspan (m)	Flight speed ($m\ sec^{-1}$)	Nocturnal Activity	Flight Type
Gannet	0.94	1.72	14.9	1 (0%)*	Flapping
Kittiwake	0.39	1.08	13.1	2 (50%)*	Flapping
Herring gull	0.61	1.44	12.8	2 (50%)*	Flapping

**Integer for use in Band CRM, percentage for use in McGregor sCRM*

3. RESULTS

The results are presented as annual collision estimates for each species and each Seagreen WTG option, with relevant avoidance rates detailed in the methods applied. The results are based on all flying seabirds regardless of age or breeding status. Due to the model expressing estimated mortality as a non-whole numbers and excel rounding to the nearest whole number some additions may not sum as displayed.

Table 5 shows estimated annual mortality using the Band CRM option 2. In the 36 WTGs comparison there is a decrease in mortality for gannet from consented WTGs to newly proposed. In kittiwake there is a slight decrease from worst case 14rpm, but a slight increase from expected 10.6rpm to the newly proposed WTGs. European herring gull sees an increase from consented WTG to newly proposed. It is probable, as airgap is not factored into the herring gull modelling due to data limitations, that this reflects the larger swept area of the newly proposed WTG. For the 150 WTGs comparison there is a decrease in estimated mortality for gannet and kittiwake from the consented WTGs to the combination of newly proposed and constructed WTGs. This is possibly due to the slightly smaller swept area of the 114 constructed WTGs and the larger airgap in both the constructed and newly proposed WTGs. Herring gull sees a slight increase in estimated mortality in the 150 WTGs comparison, possibly as a result of the data limitations reflecting the larger swept area and not the increased airgap.

McGregor sCRM annual estimated mortality as seen in Tables 6 and 7 shows a slight increase in Option 2 for 36 WTGs comparison for all species from the consented to the newly proposed WTGs. In the 150 WTGs comparison there is a large decrease in mortality for all species from the 150 consented to the combination of constructed and newly proposed. Using Option 3 for kittiwake and herring gull there is a decrease in both comparisons from consented to newly proposed (and constructed) WTGs.

Table 5: Band 2012 deterministic CRM Estimated Annual Mortality - Option 2

Species	36 WTGs Consented 10.6rpm	36 WTGs Consented 14rpm	36 WTGs Newly proposed	150 WTGs Consented 10.6rpm	150 WTGs Consented 14rpm	114 WTGs Constructed	114 WTGs Constructed + 36 WTGs Newly proposed
Northern gannet	89	104	83	372	431	83	166
Black-legged kittiwake	91	102	101	381	424	120	222
European herring gull*	8*	9*	15*	34*	39*	25*	40*

**Flight height data was not available for herring gull and as such 28.4% proportion at collision risk height was used for all WTG options.*

Table 6: McGregor 2018 stochastic CRM Estimated Annual Mortality - Option 2

Species	36 WTGs Consented	36 WTGs Newly proposed	150 WTGs Consented	114 WTGs Constructed	114 WTGs Constructed + 36 WTGs Newly proposed
Northern gannet	40	46	173	56	101
Black-legged kittiwake	142	162	587	188	350
European herring gull	6	8	26	11	19

Table 7: McGregor 2018 stochastic CRM Estimated Annual Mortality - Option 3

Species	36 WTGs Consented	36 WTGs Newly proposed	150 WTGs Consented	114 WTGs Constructed	114 WTGs Constructed + 36 WTGs Newly proposed
Black-legged kittiwake	145	112	636	189	301
European herring gull	8	7	32	12	19

4. RESPONSE TO STAKEHOLDER COMMENTS

This report was presented to the RSPB and NatureScot for review, and meetings were conducted on the 3rd February 2022 with the RSPB and on the 4th March 2022 with NatureScot.

Following feedback from both stakeholders the Band 2012 deterministic CRM was re-run using Johnston et al (2014) flight height data. This dataset has a flight height range from 0-300m and includes all three species of interest, as opposed to originally used Cook et al (2011) data with a flight height range from 0-150m and only a full set of data for Kittiwake and Gannet. Following feedback from NatureScot flight type for Gannet was changed to gliding, this slightly reduces expected mortality when compared to flapping flight type. It is noted that the RSPB has recommended the use of different avoidance rates, and that there is a pending publication of JNCC commissioned avoidance rates review. For the purposes of this modelling to compare turbine designs avoidance rates were kept as Bowgen and Cook (2018), however different avoidance rates can be applied to the results in the future. The originally consented turbine design is presented using 14rpm, all other parameters are kept the same and as outlined in section 2. Results of the updated model are presented below in Table 8.

Table 8 shows estimated annual mortality using the Band deterministic CRM option 2. In the 36 WTGs comparison there is an increase in mortality for all three species from the consented WTGs to newly proposed. It is probable that this increase is mostly due to the larger swept area of the newly proposed WTG. For the 150 WTGs comparison there is a decrease in estimated mortality for all species from the consented WTGs to the combination of newly proposed and constructed WTGs. This is possibly due to the slightly smaller swept area of the 114 constructed WTGs and the larger airgap in both the constructed and newly proposed WTGs.

Table 8: Band 2012 deterministic CRM Estimated Annual Mortality - Option 2 – Johnston et al (2014) flight heights

Species	36 WTGs Consented	36 WTGs Newly proposed	150 WTGs Consented	114 WTGs Constructed	114 WTGs Constructed + 36 WTGs Newly proposed
Northern gannet	143	145	596	172	317
Black-legged kittiwake	141	152	586	195	347
European herring gull	7	8	28	14	22

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APPENDIX – A – FEEDBACK AND COMMENTS

RSPB CRM feedback following meeting on 3rd February 2022:

Comment	Action
For ease of reference, please could the different CRM be referred to as the stochastic and deterministic for consistency	Accepted and added to headers and text to aid reference
We recommend use of the Johnson et al (2014) with corrigendum avoidance rates	Accepted and included within Section 4 table 8, for the purposes of this model, which is to enable a comparison between as consented and as constructed plus proposed scenarios, avoidance rates have not been changed
Bowgen and Cook (2018) avoidance rates are based on data from one site and we do not recommend their use here (A JNCC commissioned review on avoidance rates is taking place, however the timescales for publication is currently unknown)	As JNCC commissioned avoidance rates are currently unavailable modelled avoidance rates have not been changed.
Presentation of the 2018 optimised design results alongside the original (2012) 150 turbine and this proposed change (114 as built and 36 as proposed) would be useful	Results from the 2018 optimised design application are not directly comparable as different model parameters and inputs were used (e.g. RPMs) which could lead to misinterpretation of results. For this reason, they have not been included within this report, but are available for reference here.
We note the monitoring programme is not proposed to change	N/A to this CRM report
The CRM for the 2012 application changed several times – different parameters were used in the original submission, later update and AA produced by Marine Scotland. This makes comparing the existing consent, original consent and the proposed development more challenging. We would welcome a summary data table (similar to Table B in the Marine Scotland AA in 2014) being provided. For clarity, we suggest this table should take into consideration the other permitted development in the Forth and Tay area (and further afield if relevant) with a commentary as to which Forth and Tay windfarm impact (e.g. whether the original or revised design of various windfarms) was used in their assessments.	For the purposes of this report, CRM modelling has been undertaken to compare collision risk impacts between the consented project and the project as being constructed plus the Variation. To enable this, model parameters were kept consistent between the two scenarios allowing for an accurate comparison. Previous CRM model outputs have not been presented due to inconsistent model inputs leading to potential misinterpretations of outputs. Based on the assessment within this report showing the Variation will not cause any further significant effects compared to the consented Project, an update to cumulative effects would not be necessary as it will not change cumulative effects assessments undertaken by more recent developments.

NatureScot CRM feedback following meeting on 4th March 2022:

Comment	Action
We are content with the CRM approach outlined in the Screening Report and Annex 1, but advise that 'flapping' flight should only be used for kittiwake and herring gull, with 'gliding' used for gannet instead.	Accepted and included within Section 4 table 8
We also welcome the updated Band CRM using flight heights from Johnston et al. (2014), which we understand from our meeting with Seagreen will be presented alongside the variation application.	Accepted and included within Section 4 table 8

We agree with the conclusions of the Screening Report that the variation will not cause any material increases to impacts from the Seagreen Project as assessed under the 2014 consent.	N/A to this CRM report

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