FIVE ESTUARIES OFFSHORE WIND FARM

ENVIRONMENTAL STATEMENT

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Five Estuaries Offshore Windfarm

Ornithology Technical Annex 4.10 Collision Risk Modelling: comparison of model results

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1 INTRODUCTION

The Five Estuaries Offshore Windfarm (VE) PEIR presented collision risks calculated using the deterministic Band (2012) collision risk model (CRM) implemented within the stochLAB R package (https://github.com/HiDef-Aerial-Surveying/stochLAB).

Natural England, in their review of the PEIR Volume 2, Chapter 4: Offshore Ornithology, provided the following summary comments on this approach to CRM (Table 1).

Table 1. Natural England comments on the collision risk modelling presented in the Five Estuaries PEIR.

Summary concern	NE comment	VE Response
The Collision Risk Modelling (CRM) was undertaken using the stochLAB package. This tool has not yet been tested or reviewed by Natural England and therefore we do not currently advocate its use. Furthermore, no exhaustive testing is available for review to the best of our knowledge.	Undertake the CRM following NE best practice guidance and/or present evidence in support of the stochLAB package. This could be achieved by running test scenarios through both the stochLAB tool and the Shiny app or Band spreadsheet to demonstrate any discrepancies (or not) between outputs.	This report provides a comparison of collision risk model outputs as obtained from the following versions of the Band CRM: • Deterministic Band (implemented in R using stochLAB); • Stochastic Band (implemented in R using stochLAB); and • Stochastic Band implemented using the online shiny app tool. The comparison demonstrates that the different implementations of the Band CRM generate mean values that are very similar (differences < 1-2%), with variation due simply to chance. The deterministic collision estimates, and stochastic collision estimates using the stochLAB R Package are therefore used in the assessment within Volume 6, Part 2, Chapter 4: Offshore Ornithology for appropriate species (see Volume 6, Part 5, Annex 4.8).
CRM has been undertaken using the deterministic Band model. Uncertainty in flight density has been incorporated by estimating collisions using mean, Upper Confidence Interval (UCI) & Lower Confidence Interval (LCI) density estimates. However, other model parameters have not been varied.	Natural England note that the deterministic Band model has been used. Our best practice guidance recommends the use of the stochastic model to fully incorporate uncertainty and variability in input parameters. If the deterministic model is to be used (as in this case) we advise that for the key input parameters below, uncertainty around the parameter estimates should be considered on an individual parameter basis: • Monthly bird density; • Flight height; • Avoidance rate; and • Nocturnal activity factor.	As noted above, the stochastic CRM using stochLAB has been considered appropriate to use for the assessment of species where sufficient data are available (see Volume 6, Part 5, Annex 4.8). This report demonstrates that variation in density accounts for the majority of variation in the stochastic outputs, since the upper 95% confidence interval collision estimates derived using just the seabird densities (deterministic) were approximately half the size of those obtained with variation in the other six (avoidance rate, flight

Summary concern	NE comment	VE Response
	This can be done using the Band (2012) spreadsheet or by running the sCRM model developed by McGregor et al. (2018) by having no variability (i.e., standard deviations) set for any input parameter, and then undertaking multiple runs of the model to account for individual variation in each relevant input parameter. This gives an indication of which parameters might have the most influence on the prediction of collision risk, recognising that individually these will not reflect the effect of uncertainty across all parameters. Natural England agree that variation in density is likely to be the most influential and welcome its consideration here. However, we advise that the other sources of variability/uncertainty should also be fully considered. If other parameters (beside bird density) are not varied, Natural England advise that a worst case should be identified and used for all parameters. It is not clear if this has been the case or not, e.g. for flight height. More detail in the form of logfiles for models run would aid a more detailed review.	height, flight speed, body length, wingspan, nocturnal activity).

2 METHODS

To address Natural England's comments this report provides a comparison of collision risk model outputs as obtained from the following versions of the Band CRM:

- Deterministic Band (implemented in R using stochLAB);
- Stochastic Band (implemented in R using stochLAB); and
- Stochastic Band (implemented using the online tool available at https://dmpstats.shinyapps.io/avian_stochcrm/).

Two species were selected for this comparison, gannet and lesser black-backed gull, on the basis that between them these species spanned a wide range of predicted collisions (an order of magnitude) and bracketed the values for most other species.

Since the purpose of this assessment was to provide a comparison of the outputs from each of the versions of the model, for simplicity only the collisions for VE Northern Array, calculated using Turbine parameter set 1 are presented here. The input parameters are provided in Tables 2 to 4.

Table 2. Monthly densities of gannet and lesser black-backed gull recorded in flight, S.D. and 95% confidence intervals, in the Northern Array Area only.

Month	Gannet		Lesser black-backed gull	
	Estimate (S.D.)	**95% c.i.**	**Estimate (S.D.)**	**95% c.i.**
Jan	0 (0)	0-0	0.05 (0.04)	0-0.15
Feb	0 (0)	0-0	0 (0)	0-0
Mar	0.05 (0.04)	0-0.16	0 (0)	0-0
Apr	0.05 (0.04)	0-0.16	0 (0)	0-0
May	0 (0)	0-0	0 (0)	0-0
Jun	0.16 (0.08)	0-0.32	0.36 (0.23)	0-0.88
Jul	0.15 (0.07)	0-0.3	1.89 (1.42)	0-4.93
Aug	0.1 (0.08)	0-0.26	0 (0)	0-0
Sep	0 (0)	0-0	0.05 (0.04)	0-0.15
Oct	0.26 (0.19)	0-0.68	0 (0)	0-0
Nov	1.09 (0.55)	0.11-2.22	0 (0)	0-0
Dec	0.05 (0.04)	0-0.15	0 (0)	0-0

Table 3. VE Northern Array Area and turbine data used in the comparison of CRM results.

Parameter	Turbine parameters
No. turbines	31
Rotor radius (m)	129.6
Hub height (m; HAT)	157.6
Tidal offset (m; MSL to HAT)	1.2
Max. blade width (m)	9.4
Mean RPM	7.3
Mean blade angle (°)	15
Array Area width (km)	14.5
Array Area latitude (centre; °)	51.97
Percentage operational	95

Table 4: Biometrics of gannet and lesser black-backed gull used in the CRM comparison. Note that the gannet avoidance rates incorporate standard avoidance (0.992 deterministic and 0.993 stochastic) and macro avoidance of 70% as per Natural England advice.

Species	Body length (m)	Wingspan (m)	Flight speed (ms-1)	Nocturnal activity factor (%)	Flight type	Avoidance rate (%) deterministic	Avoidance rate (%) stochastic
Gannet	0.94 (sd 0.0325)	1.72 (sd 0.0375)	14.9 (sd 0)	8% (sd 10%)	Flapping	0.9976	0.9979 (sd 0.0004)
Lesser black-backed gull	0.58 (sd 0.03)	1.42 (sd 0.0375)	13.1 (sd 1.9)	37.5% (sd 6.37%)	Flapping	0.994	0.994 (sd 0.0004

To generate random monthly density values from the mean and standard deviation values (Table 2), both stochLAB and the online sCRM use the truncated normal distribution, with the lower limit set to zero (and an upper limit of infinity). However, using this approach for values close to zero has the effect of shifting the range of monthly density values up. For example, the lesser black-backed gull mean density in July was 1.89 birds/km^2, but inputting this mean and the SD of 1.42 to the truncated normal function in R (*truncnorm::rtruncnorm*) the mean of 10,000 draws was 2.14, 15% higher than the inputted mean value. This effect was highlighted in Trinder (2017) as an issue when estimating random density estimates for use in CRM.

To prevent this effect biasing the CRM results both stochLAB and sCRM provide an option to use density estimates generated as bootstrap resamples from the original seabird survey data, thereby preserving the original distribution of densities rather than redefining them using summary values (e.g. mean and SD) which may not robustly represent the survey observations. This option, to use bootstrap resamples, was used in the stochastic CRM presented here. The bootstrap sample datasets for each species contained 2,000 density estimates in each calendar month, half of which were drawn from the resampled data for each of the surveyed months (i.e. 1,000 from January in year 1 and 1,000 from January in year 2; these data can be provided to Natural England on request). Each iteration of the stochastic CRM uses values drawn randomly from within these datasets. The same bootstrap dataset was used for both stochastic models.

The stochastic models (stochLAB and sCRM) were run for 5,000 simulations and the summary values are reported here. All outputs presented below are for option 2 (generic flight height distributions). The deterministic results were obtained from three runs of the model, using in turn the mean, lower and upper 95% confidence intervals for density combined with the mean values for all other parameters.

3 RESULTS

The collision predictions obtained using the three versions of the CRM are provided for gannet (Table 5) and lesser black-backed gull (Table 6).

3.1 Gannet

The annual mean gannet collisions for all three models were in a range from 1.784 (sCRM) to 1.823 (stochLAB), a difference of 0.04 collisions. The confidence interval range was also very similar for the two stochastic models, 0 – 7.37 (sCRM) and 0 -7.41 (stochLAB), while this range was much smaller for the deterministic model (0.08 – 4.04) due to the more restricted degree of parameter variation (i..e only the seabird densities varied on each simulation).

Table 5. Gannet monthly mean collision estimates and 95% confidence intervals obtained using the deterministic stochLAB, stochastic stochLAB and sCRM (online).

Month	Deterministic (stochLAB)			Stochastic (stochLAB)			Stochastic (sCRM)		
	Lwr 95% c.i.	Mean	Upr 95% c.i.	Lwr 95% c.i.	Mean	Upr 95% c.i.	Lwr 95% c.i.	Mean	Upr 95% c.i.
Jan	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Feb	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Mar	0.000	0.055	0.164	0.000	0.056	0.336	0.000	0.055	0.341
Apr	0.000	0.061	0.181	0.000	0.065	0.383	0.000	0.060	0.380
May	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Jun	0.000	0.216	0.432	0.000	0.227	1.061	0.000	0.215	1.078
Jul	0.000	0.207	0.414	0.000	0.198	0.978	0.000	0.201	0.992
Aug	0.000	0.129	0.326	0.000	0.126	0.445	0.000	0.125	0.447
Sep	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Oct	0.000	0.249	0.647	0.000	0.247	1.104	0.000	0.248	1.133
Nov	0.084	0.864	1.764	0.000	0.870	2.872	0.000	0.843	2.772
Dec	0.000	0.037	0.112	0.000	0.035	0.227	0.000	0.037	0.227
Annual	**0.084**	**1.818**	**4.041**	**0.000**	**1.823**	**7.407**	**0.000**	**1.784**	**7.370**

3.2 Lesser black-backed gull

The annual mean lesser black-backed gull collisions for all three models were in a range from 24.536 (stochLAB) to 25.439 (deterministic), a difference of 0.9 collisions. The confidence interval range was very similar for the two stochastic models, 0 – 121.48 (sCRM) and 0 -121.25 (stochLAB), while this range was much smaller for the deterministic model (0 – 66.10) due to the more restricted degree of parameter variation.

Table 6. Lesser black-backed gull monthly mean collision estimates and 95% confidence intervals obtained using the deterministic stochLAB, stochastic stochLAB and sCRM (online).

Month	Deterministic (stochLAB)			Stochastic (stochLAB)			Stochastic (sCRM)		
	Lwr 95% c.i.	Mean	Upr 95% c.i.	Lwr 95% c.i.	Mean	Upr 95% c.i.	Lwr 95% c.i.	Mean	Upr 95% c.i.
Jan	0.000	0.444	1.331	0.000	0.411	2.293	0.000	0.415	2.314
Feb	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Mar	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Apr	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
May	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Jun	0.000	3.863	9.401	0.000	3.816	10.595	0.000	3.835	10.985
Jul	0.000	20.647	53.913	0.000	19.856	105.808	0.000	20.168	105.603
Aug	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Sep	0.000	0.486	1.457	0.000	0.453	2.551	0.000	0.457	2.579
Oct	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Nov	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Dec	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Annual	**0.000**	**25.439**	**66.102**	**0.000**	**24.536**	**121.246**	**0.000**	**24.875**	**121.481**

4 CONCLUSION

This CRM comparison has demonstrated that the different implementations of the Band CRM generate central point (i.e. mean) values that are very similar (differences < 1-2%), with variation due simply to chance. The range of variation around the mean values is also very similar using either of the stochastic versions (sCRM and stochLAB) while those for the deterministic outputs, where the only source of variation is the upper and lower 95% confidence intervals for density, are around half that for the fully stochastic outputs, which is to be expected since the only source of variation between simulations was the seabird densities. However, it is also notable that variation in density clearly accounts for the majority of variation in the stochastic outputs, since the upper 95% confidence interval collision estimates derived using just the seabird densities ('deterministic') were approximately half the size of those obtained with variation in the other six (avoidance rate, flight height, flight speed, body length, wing span, nocturnal activity). For example for lesser black-backed gull the two values were 66.1 and 121.5 for the deterministic and stochastic model runs respectively.

5 REFERENCES

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