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Erebus: Offshore Ornithology 11.5 Technical Appendix - Population Modelling

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1 Introduction

1 At Erebus (hereafter 'the Project') the estimates of collision risk mortality and displacement mortality to each species are readily seen to be not significant against reference populations with the exception of gannet (*Morus bassanus*) at Grassholm SPA and guillemot (*Uria aalge*) at Skomer, Skokholm and Seas off Pembrokeshire Special Protection Areas (SPAs).

2 For gannet, there are 94 collision risk mortalities and five displacement mortalities predicted as a 'worst case' against the population at Grassholm SPA. For guillemot, there is one collision risk mortality and 99 displacement mortalities predicted as a 'worst case' against the population at Skomer, Skokholm and Seas off Pembrokeshire SPA. The SPA population estimates are given in Table 10 of Technical Appendix 11.2, Apportioning, and converted to breeding individuals for consideration in population modelling (Table 1).

3 For assessment it is assumed that all predicted mortalities relate to breeding adults as a qualifying interest of each SPA.

4 For these two species, the implications of mortality on the protected SPA populations were explored using a population viability analysis (PVA). PVA provides a framework that uses estimated demographic rates for a population (typically survival and productivity information) in a mathematical model to forecast future levels of a population, either under currently prevailing circumstances or as a consequence of some impact applied to the population.

5 PVA models can be used to forecast future population levels under different scenarios and can be used to compare baseline 'no impact' conditions with 'impact' scenarios based on actual or predicted impacts from a proposed development (such as an offshore wind farm) that may affect bird numbers via changes to the survival or productivity of individual birds. Population metrics that are derived from comparisons of 'baseline' and 'impacted' predictions generated by PVAs can then be used to assess the significance of the anticipated additional mortality associated with planned developments.

Table 1. Species and SPAs considered in PVA and their respective population sizes.

Species	SPA	Initial population size (breeding individuals)	Year of census	Source
Gannet	Grassholm	72,022	2015	Seabird Count
Guillemot	Skomer, Skokholm and Seas off Pembrokeshire	29,744	2017-2019	Seabird Count

2 Methods

2.1 Assessment method

6 Natural England commissioned the Centre for Hydrology and Ecology (CEH) to devise a standard, easy to use PVA tool for undertaking assessments of population-level consequences of development impacts on seabird species (Searle *et al.* 2019). The tool constructs a stochastic Leslie matrix and runs through a web-based 'R-Shiny' package in the R computer programming language.

2.1.1 Demographic parameters

7 For both species, input demographic parameters were primarily taken from Horswill & Robinson (2015), see Table 2. This provides a comprehensive assessment of the current literature.

8 For guillemot, the applicant commissioned a study of survival rates at Skomer, Skokholm and Seas off Pembrokeshire SPA (Birkhead 2021). This gave SPA-specific cohort survival probabilities, however, using these estimates for juvenile (0-3 years) and immature (4-6 years) survival produced unrealistic estimates of population growth; the population growth rate was estimated as 0.977 or a decline of approximately 2.3% per year. In contrast, the SPA population is currently estimated to be growing at *ca.* 5% per year (Birkhead, 2021).

9 Exploratory analysis suggests that this is due to difficulties translating cohort survival into annual estimates of survival for use in the PVA tool (Searle *et al.* 2019). Therefore, estimates of annual survival from Horswill & Robinson (2015) are used for juveniles and immatures, with the adult survival amended to the estimate provided by Birkhead (2021) (Table 2).

2.1.2 Age classes

10 The demographic data were used to parameterise a stochastic Leslie matrix (Caswell, 2000) built into the PVA tool (Searle *et al.* 2019). In the case of gannets this matrix had six age classes (five juvenile/ immature and one adult class) and in the case of common guillemot seven classes (six juvenile/ immature and one adult). For details of age specific survival rates see Table 2. In most cases year to year survival increases steadily with age however, it should be noted that common guillemot adult survival is slightly lower due to the use of the SPA population-specific estimate (Birkhead, 2021). Models included environmental and demographic stochasticity, but not density dependence.

2.1.3 Model duration

11 PVA models were run from the year of the population census and impacts were assumed to commence in 2027, based on an assumed commissioning date of October 2027, and last for 25 years (assumed lifetime of the windfarm). Each simulation was run 1000 times to obtain a projected population trajectory and associated uncertainty due to environmental and demographic stochasticity.

12 Density dependence was not modelled due to a lack of available data for each species on this parameter. It is still possible to investigate and interpret the significance of modelled impacts using a density independent model.

Table 2. Summary of demographic rates for PVA species. Source is Horswill & Robinson (2015) unless otherwise specified.

	Gannet		Guillemot	
	Mean	SD	Mean	SD
Adult survival	0.919	0.042	0.889[1]	0.024
Productivity (per pair)	0.710[2]	0.105	0.823[2a]	0.056
Age of recruitment	5		6	
Brood size (per pair)	1		1	
Survival 0 → 1	0.424	0.045	0.56	0.058
Survival 1 → 2	0.829	0.026	0.792	0.152
Survival 2 → 3	0.891	0.019	0.917	0.098
Survival 3 → 4	0.895	0.019	0.938	0.107
Survival 4 → 5	0.919	0.042	0.93	0.043
Survival 5 → 6	NA	NA	0.93	0.043

1. Mean adult survival between 2010 and 2017 taken from Birkhead (2021).
2. Horswill & Robinson (2015) provide productivity estimates broken down to different regions: the "west population" has been chosen as being the most relevant. (a) This is very close to the productivity reported by Meade *et al.* 2013 in a Skomer-specific study.

2.1.4 Modelled mortality

13 Each simulation was also paired with an impact scenario that included additional population-level mortality due to turbine collision or habitat displacement effects. This additional mortality was calculated as a proportion of the starting population and applied to the adult age class only. This way, the number of additional deaths scaled proportionately with changes to the simulated number of breeding adults in the population. For gannet, the estimated additional mortality was 99 individuals (0.14% of the population). For guillemot, the estimated additional mortality was 100 individuals (0.34% of the population) until the end of the development period.

2.1.5 Population metrics

14 The key outputs from the PVA tool are the counterfactuals of population growth rate and of population size (Searle *et al.* 2019). These are the ratios of the impacted to unimpacted scenarios and allow meaningful interpretation of the predicted effects against the

populations in question (Cook and Robinson, 2016). Developing guidance from the Statutory Nature Conservation Bodies, including Natural Resources Wales, indicates that these are the metrics that will be used in making judgements on the viability of protected seabird populations.

3 Results

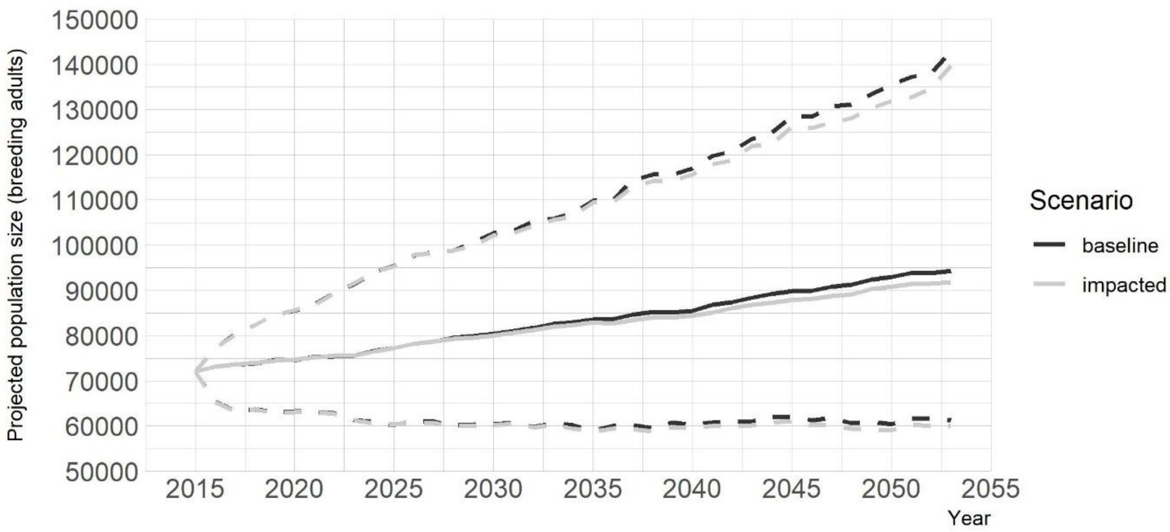
3.1 Gannet

Both baseline and impacted populations increased steadily between the census year (2015) and the commencement of impacts (2027). After this point, the baseline population increased slightly more than the impacted population (Figure 1). At the end of the 25 years of impact (2052), the difference in median population size between the two scenarios was 2.7% and the median counterfactual was 0.973 (Table 3).

Table 3. Metrics and counterfactuals for 1000 simulations of the gannet PVA.

	Additional Mortality	Median Growth Rate	Median population size at development end (individuals)	Median counterfactual of growth rate	Median counterfactual of population size
Baseline	0	1.007	94326		
Impacted	99	1.006	91823	0.999	0.973

Figure 1. Median population trajectory and 95% confidence intervals (broken lines) estimated from 1000 simulations of the PVA for baseline and impacted populations.



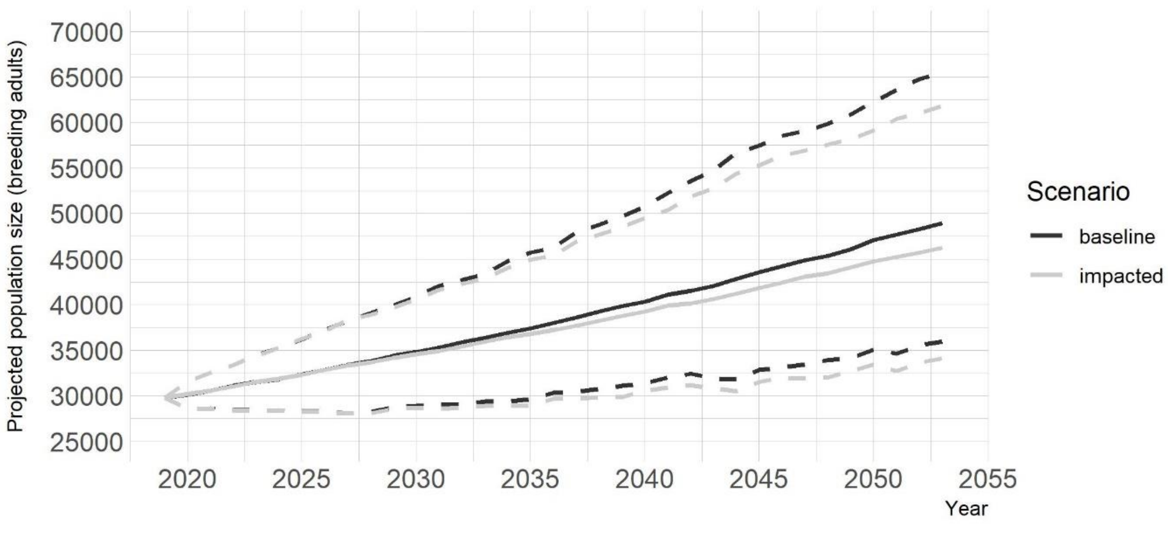
3.2 Guillemot

Both baseline and impacted populations increased steadily between the census year (2019) and the commencement of impacts (2027). After this point, the baseline population increased slightly more than the impacted population (Figure 1). At the end of the 25 years of impact (2052), the difference in median population size between the two scenarios was 5.8% and the median counterfactual was 0.946 (Table 4).

Table 4. Metrics and counterfactuals for 1000 simulations of the guillemot PVA.

	Additional Mortality	Median Growth Rate	Median population size at development end (individuals)	Median counterfactual of growth rate	Median counterfactual of population size
Baseline	0	1.015	48952		
Impacted	100	1.013	46265	0.998	0.946

Figure 2. Median population trajectory and 95% confidence intervals estimated from 1000 simulations of the PVA for both baseline and impacted populations.



4 Discussion and Conclusions

15 The baseline scenarios for each population show a stable growth rate and an increasing population size, this reflects what is known about each population in reality.

16 The counterfactuals (ratio) of population growth rate and population size, suggest that the estimates of mortality due to the operational phase of the Project (collision risk and displacement) would not have a large effect on the viability of either SPA population.

17 For both species, median growth rates are reduced in the impacted scenario which consequently reduces the median population size over the projected 25-year period. Final median population sizes are 0.973 and 0.946 of a non-impacted baseline for gannet and guillemot, respectively.

18 The trends in the lower confidence intervals for each simulation are also informative; for gannet there is a slight reduction which then stabilises for both the impacted and non-impacted predictions, and for guillemot there is ongoing growth after an initial small decline.

19 The population modelling gives confidence that the Project will not lead to adverse impacts on the viability of the breeding gannet population at Grassholm SPA, nor on the viability of the breeding guillemot population at Skomer, Skokholm and Seas off Pembrokeshire SPA.

20 Assessment of impacts to the SPAs are addressed in Volume 3, Technical Appendix 8.3: Report to Inform Appropriate Assessment and the outputs from this modelling are used to inform that assessment.

5 References

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