FIVE ESTUARIES OFFSHORE WIND FARM

ENVIRONMENTAL STATEMENT

VOLUME 6, PART 5, ANNEX 4.16: POPULATION VIABILITY ANALYSIS (CLEAN)

Application Reference	EN010115
Application Document Number	6.5.4.16
Revision	C
Pursuant to	Deadline 7
Ecodoc Number	005112775-05
Date	March 2025

Revision	Date	Status/Reason for Issue	Originator	Checked	Approved
C	Mar -25	Deadline 7	GoBe	GoBe	VE OWFL

CONTENTS

TABLES

DEFINITION OF ACRONYMS

Term	Definition
AOE	Alde-Ore Estuary
CGR	Counterfactual of Population Growth
CPS	Counterfactual of Population Size
EIA	Environmental Impact Assessment
FFC	Flamborough and Filey Coast
HRA	Habitats Regulations Assessment
OWF	Offshore Wind Farm
PVA	Population Viability Analysis
RIAA	Report to Inform Appropriate Assessment
SPA	Special Protection Area
VE	Five Estuaries Offshore Wind Farm
WTG	Wind Turbine Generators

GLOSSARY OF TERMS

Term	Definition
The Project	Refers to the Five Estuaries Offshore Wind Project
Array area	The area offshore within the order limits within which the generating stations will be situated (including wind turbine generators (WTG), offshore platforms and Inter-array cables).
Impact	An impact to the receiving environment is defined as any change to its baseline condition, either adverse or beneficial.
Wind turbine generator (WTG)	All the components of a wind turbine, including the tower, nacelle, and rotor.

1 INTRODUCTION

1.1 PROJECT BACKGROUND

1.1.0 Five Estuaries Offshore Wind Farm (VE) is a proposed extension to the operational Galloper Offshore Wind Farm. VE covers an area of 128km^2, split between north and south areas which extend eastwards from the operational Galloper offshore wind farm. At the closest point the array areas are located approximately 37km offshore

1.1.1 GoBe Consultants Ltd (hereafter "GoBe") was commissioned by the Applicant to undertake a modelling exercise to assess the potential for impacts from VE alone and in-combination with other projects for specific seabirds at designated sites through the use of Population Viability Analysis (PVA). This annex presents the approach to PVA modelling and results of the analysis and was produced to support the Report to Inform Appropriate Assessment (RIAA).

1.2 POPULATION VIABILITY ANALYSIS

1.2.1 Renewable energy projects in the marine environment, such as Offshore Wind Farms (OWFs), have the potential to impact on seabirds through a number of processes such as collision with turbine blades resulting in mortality, or displacement from an area due to the presence of Wind Turbine Generators (WTGs). These processes affect individuals, but the cumulative effects (when the project alone effects are considered alongside any effects from other projects on the same receptor) have the potential to affect the productivity or elevate the baseline mortality of a population. The Environmental Impact Assessment (EIA) and Habitats Regulations Assessment (HRA) processes provides the assessment of such potential effects as a consequence of OWFs at varying population scales, from a single Special Protection Area (SPA) colony to the wider biogeographic population.

1.2.2 One method to estimate the effect that developments alone or cumulatively may have on a population is through PVA. PVA provides a robust framework using demographic parameters to predict changes in the population, using statistical population models to forecast future changes over a set period. Comparisons are made between 'baseline' conditions whereby conditions remain unimpacted and under 'scenario' conditions where an impact is applied to a population by the alteration of demographic parameters.

1.2.3 This report provides PVA to assess the potential population level effects arising from VE both alone and in-combination for five identified species across two SPAs:

- Lesser black-backed gull (Alde-Ore Estuary SPA (AOE));
- Kittiwake (Flamborough and Filey Coast SPA (FFC));
- Gannet (FFC SPA);
- Guillemot (FFC SPA); and
- Razorbill (FFC SPA).

1.2.4 These species were selected to further assess the predicted cumulative impacts only, due to the predicted impacts at a cumulative scale exceeding a 1% increase relative to baseline mortality relative to the SPA population (based on both citation and recent counts), with a 1% increase being the level which is regarded as the threshold for undertaking further assessments such as PVA (Parker et al., 2022).

1.2.5 PVA was undertaken using the Seabird PVA Tool developed by Natural England (Searle et al. 2019). The Seabird PVA Tool was accessed via the ‘Shiny App’ interface, which is a user-friendly graphical user interface accessible via a standard web-browser that uses the nepva R package to perform the modelling and analysis. The advantages of using an online platform for modelling and analysis purposes are that users are not required to use any R code, users are not required to install or maintain R, and updates to the model are made directly to the server. The tool is capable of assessing any type of impact in terms of change to demographic parameters, or as a cull or harvest of a fixed size per year (Searle et al. 2019).

2 METHODS

2.1 GUIDANCE AND MODELS

OVERVIEW

2.1.1 The user guide for the Seabird PVA Tool provided by Natural England (Mobbs et al. 2020) has been followed for modelling and assessment of potential impacts. The demographic parameters used for the PVA are presented in Section 2.4, whilst the input log and outputs from the Shiny App are included in Appendix A of this report.

2.2 PVA MODELLING APPROACH

2.2.1 PVA models for all species were run using the ‘Simulation’ run type, which simulates population trajectories based on the specified demographic parameters, initial population sizes and scenarios the user inputs into the model.

2.2.2 The Seabird PVA Tool uses a Leslie matrix to construct a PVA model (Caswell 2000) based on the parameters provided by the user. Two broad types of population models are available: (a) deterministic Leslie matrix models, and (b) stochastic Leslie matrix models. Users are able to specify whether the model is run using environmental stochasticity (as opposed to a deterministic model), demographic stochasticity, and whether it incorporates density dependance.

2.2.3 PVA for VE was run using stochasticity, as this option incorporates uncertainty into inputs and outputs, and therefore provides more ecologically realistic values compared to deterministic models.

2.2.4 A stochastic model produces probabilistic outputs to account for the impact of environmental and demographic stochasticity. Environmental stochasticity describes the effects random variation in factors such as weather can have on a population and is modelled by the incorporation of randomly generated values for the probability of survival from one-time step to the next. Demographic stochasticity refers to the effect of random variation in population structure on demographic rates and is modelled by generating random numbers of surviving individuals for any given survival probability. Demographic stochasticity can usually be ignored for populations greater than 100 individuals, however including demographic stochasticity will not cause any penalty when simulating larger populations (WWT Consulting 2012). PVA modelling was therefore included in PVA models.

2.2.5 All PVA modelling in this report was undertaken with the Beta/Gamma model for environmental stochasticity, and was run with no density dependance. Demographic stochasticity was also incorporated into the model. To ensure robust results, all simulations were set to run 5,000 times. All models were run for a 40-year time span (2030 to 2070), representing the likely lifespan of VE. Modelling was run excluding burn in for all species and sites.

2.2.6 Demographic processes, such as growth, survival, productivity and recruitment, change relative to the number of individuals in a population, and are therefore density dependent. Density dependence can be described as being either compensatory or depensatory (Begon, Townsend & Harper 2005). Compensation is characterised by demographic changes that cause a stabilising effect on a populations long-term average. Depensation acts to further decrease the rate of population growth in declining populations and can delay the rate of recovery. Depensation is typically exhibited in populations that have been significantly depleted in size and is caused by a reduction in the benefits associated with conspecific presence.

2.2.7 Density dependence is self-evident in the natural environment, as without density dependence, populations would grow exponentially. However, the mechanisms as to how this operates in seabird populations are largely uncertain. If density dependence is mis-specified in an assessment, the modelled predictions will be unreliable. Therefore, it is more typical to use density independent models for seabird assessments, despite the lack of biologically necessary density dependence. As such, density independent models lack any means by which a population can recover once it has been reduced beyond a certain point, they are therefore appropriate for impact assessment purposes as it represents a precautionary approach (Ridge et al. 2019).

2.3 IMPACTS ASSESSED

COLLISION RISK

2.3.1 During the operation and maintenance phase of VE there is potential risk to some bird species of collision impacts (collision with WTGs and associated infrastructure) if/when birds fly through the site while foraging for food, commuting between breeding sites and foraging areas, or during migration. This potential impact has been assessed for relevant species, with project alone impacts presented in Volume 6, Part 5, Annex 4.8 Offshore Ornithology Collision Risk Modelling, and in-combination impacts presented in Volume 5, Report 4: Report to Inform Appropriate Assessment.

2.3.2 Following the Collision Risk assessment, three species at two SPAs were identified as requiring further analysis through the use of PVA:

- Lesser black-backed gull (AOE SPA);
- Kittiwake (FFC SPA); and
- Gannet (FFC SPA).

DISPLACEMENT

2.3.3 During all phases of VE, the presence of vessels (in the construction and decommissioning phases) and WTGs (in the operation and maintenance phase) have the potential to directly disturb and displace some seabird species that would normally reside within and around the area where VE will be located. This potential cumulative impact has been assessed for relevant species, with project alone impacts calculated from Volume 6, Part 5, Annex 4.6: Seabird Peak Seasonal Abundances, and presented in Volume 5, Report 4: Report to Inform Appropriate Assessment. In-combination impacts have also been presented in the RIAA.

2.3.4 Following the Collision Risk assessment, three species at two SPAs were identified as requiring further analysis through the use of PVA:

- Gannet (FFC SPA);
- Guillemot (FFC SPA); and
- Razorbill (FFC SPA).

COMBINED COLLISION AND DISPLACEMENT

2.3.5 As gannet is assessed for both collision and displacement impacts, the PVA analysis for this species considers the combined impacts (i.e., collision impacts plus displacement impacts).

2.4 SPECIES-SPECIFIC INPUT PARAMETERS

SPECIES DEMOGRAPHIC

2.4.1 The Shiny App offers the users the choice of using pre-set demographic parameters or the ability to enter custom values. The pre-set demographic values are available for a total of 15 different species. The values are derived from previously reported national or colony specific demographic parameters sourced from the British Trust for Ornithology (BTO) Seabird Monitoring Program (BTO, 2023), divided into eight regional classifications (further information on the eight regional classifications can be found in Mobbs et al. (2020)) for breeding success data or Horswill and Robinson (2015) for survival rate.

POPULATION SIZE

2.4.2 The initial population size used in PVA was the most recent population count available from the SMP database, with populations provided in Table 2.1 below.

Table 2.1: Initial population sizes used in PVA population models.

Species	Population size (individuals)	Year of population count	Source of population count
Lesser black-backed gull	3,498	2023	BTO 2023 /Galloper 2023 / MacArthur Green at al, 2020 / Rock (2021)
Kittiwake	89,148	2022	Clarkson et al., 2022
Gannet	30,466	2023	Butcher *et al*., 2023
Guillemot	149,980	2022	Clarkson et al., 2022
Razorbill	61,346	2022	Clarkson et al., 2022

BREEDING SUCCESS DATA

2.4.3 The input value used for mean productivity and SD was selected as the default values in the NE PVA tool for the relevant site for each species (the Flamborough and Filey Coast SPA for kittiwake, gannet and guillemot, and the Havergate Island values for lesser black-backed gull). Rates used are presented in Table 2.2 below:

Table 2.2 Breeding success parameters used in PVA population models.

Species	Productivity Rate ± SD
Lesser black-backed gull	0.46 (± 0.48)
Kittiwake	0.87 (± 0.33)
Gannet	0.80 (± 0.07)
Guillemot	0.72 (± 0.12)
Razorbill	0.62 (± 0.07)

SURVIVAL RATE

2.4.4 Survival rates used were based on the "National" values in the PVA tool, which are based on Horswill and Robinson (2015).

Table 2.3: Species survival rates used in PVA population models.

Species	Survival rate (± SD)						
	Adult	Immature 0 to 1	Immature 1 to 2	Immature 2 to 3	Immature 3 to 4	Immature 4 to 5	Immature 5 to 6
Lesser black-backed gull	0.89 (± 0.06)	0.82 (± 0.06)	0.89 (± 0.06)	0.89 (± 0.06)	0.89 (± 0.06)	0.89 (± 0.06)	-
Kittiwake	0.85 (± 0.08)	0.79 (± 0.08)	0.85 (± 0.08)	0.85 (± 0.08)	0.85 (± 0.08)	0.85 (± 0.08)	-
Gannet	0.92 (± 0.04)	0.42 (± 0.05)	0.83 (± 0.03)	0.89 (± 0.02)	0.90 (± 0.02)	0.92 (± 0.04)	-
Guillemot	0.94 (± 0.03)	0.56 (± 0.06)	0.79 (± 0.15)	0.92 (± 0.10)	0.94 (± 0.11)	0.94 (± 0.03)	0.94 (± 0.03)
Razorbill	0.90 (± 0.07)	0.63 (± 0.07)	0.63 (± 0.07)	0.90 (± 0.07)	0.90 (± 0.07)	0.90 (± 0.07)	

3 PVA SCENARIOS ASSESSED

3.1 INTRODUCTION

3.1.1 This section outlines the different PVA scenarios assessed for each species and designated sites. Key scenarios include assessment of impacts from VE alone, and VE in-combination with other projects, though further scenarios (e.g., different displacement rates) are described on a species-by-species basis below.

3.2 LESSER BLACK-BACKED GULL

3.2.1 For lesser black-backed gull, VE and NE have different approaches on the appropriate assessment, with VE proposing the use of adult proportion data from Furness (2015) and discounting breeding sabbaticals, while NE propose the use of site-specific adult proportions and including sabbatical birds. The Project believes that VE approach is the most appropriate results as the approach is evidence driven, which provides a balanced and appropriately conservative assessment of the impacts. Uncertainties in parameters have been included in collision risk modelling and results have been presented with associated confidence intervals. The sabbatical rates used also align with those recommended by Marine Scotland for the Seagreen Phase 1 Offshore Project (Marine Scotland, 2017).

3.2.2 Therefore, four scenarios are assessed for lesser black-backed gull:

- Project alone (VE approach);
- Project alone (NE approach);
- Project in-combination (VE approach); and
- Project in-combination (NE approach).

Table 3.1: PVA scenarios assessed for lesser black-backed gull at the Alde-Ore Estuary SPA.

Scenario	Breeding Adult mortality (individuals per annum)	Impact on adult survival rate
VE alone (VE approach)	5.70	0.002
VE alone (NE approach)	11.31	0.003
VE in-combination (VE approach)	62.10	0.018
VE in-combination (NE approach)	67.70	0.019

3.3 KITTIWAKE

3.3.1 For kittiwake, two main scenarios are assessed (VE alone and VE in-combination).

Table 3.2: PVA scenarios assessed for kitiwake at the Flamborough and Filey Coast SPA.

Scenario	Breeding Adult mortality (individuals per annum)	Impact on adult survival rate
VE alone	0.82	<0.001
VE in-combination (including compensated impacts).	548.8	0.006

3.4 GANNET

3.4.1 For gannet, the PVA assessment considers the combined impacts of collision and displacement. Within this, there are therefore two scenarios based on the project alone impacts and in-combination impacts.

3.4.2 There are therefore two scenarios assessed for PVA:

- Project alone with 70% displacement, 1% mortality; &
- Project in-combination with 70% displacement, 1% mortality

Table 3.3: PVA scenarios assessed for gannet at the Flamborough and Filey Coast SPA.

Scenario	Breeding Adult mortality (individuals per annum)	Impact on adult survival rate	Impact on productivity rate per pair
VE alone			
70% displacement, 1% mortality	1.9	<0.001	N/A
VE in-combination			
70% displacement, 1% mortality	144.2	0.005	N/A

3.5 GUILLEMOT

3.5.1 Guillemot scenarios assessed incorporate a range of different displacement and mortality results as resented in the RIAA, ranging from 50% displacement and 1% mortality to 70% displacement and 2% mortality. These are presented for both VE alone and in-combination.

3.5.2 There are therefore four scenarios assessed for PVA:

- Project alone (50% displacement, 1% mortality);

- Project alone (70% displacement, 2% mortality);
- Project in-combination (50% displacement, 1% mortality); and
- Project in-combination (70% displacement, 2% mortality);

Table 3.4: PVA scenarios assessed for guillemot at the Flamborough and Filey Coast SPA.

Scenario	Breeding Adult mortality (individuals per annum)	Impact on adult survival rate	Impact on productivity rate per pair
VE alone			
50% displacement, 1% mortality	0.82	<0.001	N/A
70% displacement, 2% mortality	2.28	<0.001	N/A
VE in-combination			
50% displacement, 1% mortality	564.2	0.004	N/A
70% displacement, 2% mortality	1579.9	0.010	N/A

3.6 RAZORBILL

3.6.1 Razorbill scenarios assessed incorporate a range of different displacement and mortality results as resented in the RIAA, ranging from 50% displacement and 1% mortality to 70% displacement and 2% mortality. These are presented for both VE alone and in-combination.

3.6.2 There are therefore four scenarios assessed for PVA:

- Project alone (50% displacement, 1% mortality);
- Project alone (70% displacement, 2% mortality);
- Project in-combination (50% displacement, 1% mortality); and
- Project in-combination (70% displacement, 2% mortality);

Table 3.5: PVA scenarios assessed for razorbill at the Flamborough and Filey Coast SPA.

Scenario	Breeding Adult mortality (individuals per annum)	Impact on adult survival rate	Impact on productivity rate per pair
VE alone			
50% displacement, 1% mortality	0.22	<0.001	N/A
70% displacement, 2% mortality	0.63	<0.001	N/A
VE in-combination			
50% displacement, 1% mortality	128.8	0.002	N/A
70% displacement, 2% mortality	360.6	0.006	N/A

4 PVA RESULTS

4.1 LESSER BLACK-BACKED GULL

4.1.1 For each scenario (Table 3.1), Counterfactual of population growth (CGR) and counterfactual population size (CPS) have been presented from the model outputs, measuring the changes in annual growth rate and population size respectively at the end of the impacted period of 40 years relative to a baseline scenario. The impact on adult survival is also presented, calculated as the number of mortalities divided by the relevant population size used in the PVA analysis (in this case, the 2022/23 Alde-Ore Estuary SPA count) (Table 4.1).

Table 4.1 PVA outputs for breeding adult lesser black-backed gulls at the Alde Ore Estuary SPA from collision impacts

Scenario	Breeding Adult mortality (individuals per annum)	CGR	CPS
VE alone (VE approach)	5.70	0.998	0.925
VE alone (NE approach)	11.31	0.996	0.859
VE in-combination (VE approach)	62.10	0.996	0.859
VE in-combination (NE approach)	67.70	0.978	0.401

4.2 KITTIWAKE

4.2.1 For each scenario (Table 3.2), CGR and CPS have been presented from the model outputs, measuring the changes in annual growth rate and population size respectively at the end of the impacted period of 40 years relative to a baseline scenario. The impact on adult survival is also presented, calculated as the number of mortalities divided by the relevant population size used in the PVA analysis (in this case, the 2023 FFC count) (Table 4.2).

Table 4.2 PVA outputs for breeding adult kittiwakes at the Flamborough and Filey Coast SPA incorporating combined collision and displacement impacts.

Scenario	Breeding Adult mortality (individuals per annum)	CGR	CPS
Project alone	0.8	1.000	1.000
Project in-combination	548.8	0.993	0.740

4.3 GANNET

4.3.1 For each scenario (Table 3.3), CGR and CPS have been presented from the model outputs, measuring the changes in annual growth rate and population size respectively at the end of the impacted period of 40 years relative to a baseline scenario. The impact on adult survival is also presented, calculated as the number of mortalities divided by the relevant population size used in the PVA analysis (in this case, the 2023 FFC count) (Table 4.3).

Table 4.3 PVA outputs for breeding adult gannets at the Flamborough and Filey Coast SPA incorporating combined collision and displacement impacts.

Scenario	Breeding Adult mortality (individuals per annum)	CGR	CPS
Project alone			
70% displacement, 1% mortality	1.9	1.000	0.997
In-combination			
70% displacement, 1% mortality	144.2	0.997	0.892

4.4 GUILLEMOT

4.4.1 For each scenario (Table 3.4), counterfactual of population growth (CGR) and counterfactual of population size (CPS) have been presented from the model outputs, measuring the changes in annual growth rate and population size respectively at the end of the impacted period of 40 years relative to a baseline scenario. The impact on adult survival is also presented, calculated as the number of mortalities divided by the relevant population size used in the PVA analysis (in this case, the 2022 FFC count) (Table 4.4).

Table 4.4 PVA outputs for breeding adult guillemot at the Flamborough and Filey Coast SPA resulting from displacement impacts

Scenario	Breeding Adult mortality (individuals per annum)	CGR	CPS
Project alone			
50% displacement, 1% mortality	0.82	1.000	1.000
70% displacement, 2% mortality	2.28	1.000	0.999

Scenario	Breeding Adult mortality (individuals per annum)	CGR	CPS
In-combination			
50% displacement, 1% mortality	564.2	0.996	0.841
70% displacement, 2% mortality	1579.9	0.988	0.614

4.5 RAZORBILL

4.5.1 For each scenario (Table 3.5), counterfactual of population growth (CGR) and counterfactual of population size (CPS) have been presented from the model outputs, measuring the changes in annual growth rate and population size respectively at the end of the impacted period of 40 years relative to a baseline scenario. The impact on adult survival is also presented, calculated as the number of mortalities divided by the relevant population size used in the PVA analysis (in this case, the 2022 FFC count) Table 4.5).

Table 4.5 PVA outputs for breeding adult razorbills at the Flamborough and Filey Coast SPA resulting from displacement impacts

Scenario	Breeding Adult mortality (individuals per annum)	CGR	CPS
Project alone			
50% displacement, 1% mortality	0.22	1.000	1.000
70% displacement, 2% mortality	0.63	1.000	0.999
In-combination			
50% displacement, 1% mortality	128.8	0.997	0.906
70% displacement, 2% mortality	360.6	0.993	0.759

5 REFERENCES

Begon, M., Townsend, C. R. and Harper John L. (2005), 'Ecology: From Individuals to Ecosystems', 4th Edition, Hoboken, New Jersey, USA: Wiley-Blackwell.

Butcher, J., Aitken, D., O'Hara, D. (2023), 'Flamborough and Filey Coast SPA Seabird Monitoring Programme 2023 Report'.

Caswell, H. (2000), 'Matrix Population Models', Sinauer Associates Inc., Sunderland

Clarkson, K., Aitken, D., Cope, R. and O'Harra, D. (2022), 'Flamborough and Filey Coast SPA: 2022 seabird colony count and population trends', RSPB.

Horswill, C. & Robinson R. A. (2015), 'Review of seabird demographic rates and density dependence', JNCC Report No. 552. Joint Nature Conservation Committee, Peterborough.

Mobbs, D., Searle, K., Daunt, F. & Butler, A. (2020), 'A Population Viability Analysis Modelling Tool for Seabird Species: Guide for using the PVA tool (v2.0) user interface', Available at: https://github.com/naturalengland/Seabird_PVA_Tool/blob/master/Documentation/PVA_Tool_UI_Guidance.pdf (Accessed: December 2023).

Parker, J., Fawcett, A., Banks, A., Rowson, T., Allen, S., Rowell, H., Harwood, A., Ludgate, C., Humphrey, O., Axelsson, M., Baker, A. & Copley, V. (2022c), 'Offshore Wind Marine Environmental Assessments: Best Practice Advice for Evidence and Data Standards. Phase III: Expectations for data analysis and presentation at examination for offshore wind applications', Natural England. Version 1.2. 140 pp.

Ridge, K., Jones, C., Jones, G. & Kean, G. (2019), 'Norfolk Vanguard Offshore Wind Farm Examining Authority's Report of Findings and Conclusions and Recommendations to the Secretary of State for Business, Energy and Industrial Strategy'.

Searle, K., Mobbs, D., Daunt, F. & Butler, A. (2019), 'A Population Viability Analysis Modelling Tool for Seabird Species', Natural England Commissioned Reports, Number 274.

WWT Consulting. (2012), 'SOSS-04 Gannet Population Viability Analysis: Developing guidelines on the se of Population Viability Analysis for investigating bird impacts due to offshore wind farms', Report to The Crown Estate.

6 APPENDIX A: SEABIRD PVA TOOL INPUT LOG

Five Estuaries lesser black-backed gull AOE SPA BDMPS

Set up

The log file was created on: 2024-09-25 17:59:12.202705 using Tool version 2, with R version 4.4.1, PVA package version: 4.18 (with UI version 1.7)

```
##                  Package         Version
## popbio           "popbio"        "2.8"
## shiny            "shiny"         "1.9.1"
## shinyjs          "shinyjs"       "2.1.0"
## shinydashboard "shinydashboard" "0.7.2"
## shinyWidgets     "shinyWidgets"  "0.8.6"
## DT               "DT"            "0.33"
## plotly           "plotly"        "4.10.4"
## rmarkdown        "rmarkdown"     "2.28"
## dplyr            "dplyr"         "1.1.4"
## tidyr            "tidyr"         "1.3.1"
```

Basic information

This run had reference name “LBBG AOE”.
PVA model run type: simplescenarios.
Model to use for environmental stochasticity: betagamma.
Model for density dependence: nodd.
Include demographic stochasticity in model?: Yes.
Number of simulations: 5000.
Random seed: 16.
Years for burn-in: 0.
Case study selected: None.

Baseline demographic rates

Species chosen to set initial values: Lesser Black-Backed Gull.
Region type to use for breeding success data: Site.
Available colony-specific survival rate: National. Sector to use within breeding success region: Havergate Island;Havergate Island.
Age at first breeding: 5.
Is there an upper constraint on productivity in the model?: Yes, constrained to 3 per pair.
Number of subpopulations: 1.
Are demographic rates applied separately to each subpopulation?: No.
Units for initial population size: breeding.adults
Are baseline demographic rates specified separately for immatures?: Yes.

Population 1

Initial population values: Initial population 3498 in 2023
Productivity rate per pair: mean: 0.46 , sd: 0.4772839826
Adult survival rate: mean: 0.885 , sd: 0.056
Immatures survival rates:
Age class 0 to 1 - mean: 0.82 , sd: 0.056 , DD: NA
Age class 1 to 2 - mean: 0.885 , sd: 0.056 , DD: NA
Age class 2 to 3 - mean: 0.885 , sd: 0.056 , DD: NA
Age class 3 to 4 - mean: 0.885 , sd: 0.056 , DD: NA
Age class 4 to 5 - mean: 0.885 , sd: 0.056 , DD: NA

Impacts

Number of impact scenarios: 4.
Are impacts applied separately to each subpopulation?: No
Are impacts of scenarios specified separately for immatures?: No
Are standard errors of impacts available?: No
Should random seeds be matched for impact scenarios?: Yes
Are impacts specified as a relative value or absolute harvest?: relative
Years in which impacts are assumed to begin and end: 2030 to 2070

Impact on Demographic Rates

Scenario A - Name: Alone - Project

All subpopulations

Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.00163 , se: NA

Scenario B - Name: In-combo - Project

All subpopulations

Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.017753 , se: NA

Scenario C - Name: Alone - NE

All subpopulations

Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.003233 , se: NA

Scenario D - Name: In-combo - NE

All subpopulations

Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.019354 , se: NA

Output:

First year to include in outputs: 2028
Final year to include in outputs: 2070
How should outputs be produced, in terms of ages?: breeding.adults
Target population size to use in calculating impact metrics: NA
Quasi-extinction threshold to use in calculating impact metrics: NA

Five Estuaries kittiwake FFC SPA BDMPS

Set up

The log file was created on: 2024-09-25 17:09:44.054394 using Tool version 2, with R version 4.4.1, PVA package version: 4.18 (with UI version 1.7)

```
##                Package         Version
## popbio         "popbio"        "2.8"
## shiny          "shiny"         "1.9.1"
## shinyjs        "shinyjs"       "2.1.0"
## shinydashboard "shinydashboard" "0.7.2"
## shinyWidgets   "shinyWidgets"  "0.8.6"
## DT             "DT"            "0.33"
## plotly         "plotly"        "4.10.4"
## rmarkdown      "rmarkdown"     "2.28"
```

```
## dplyr          "dplyr"          "1.1.4"
## tidyr          "tidyr"          "1.3.1"
```

Basic information

This run had reference name "KI FFC SPA".
PVA model run type: simplescenarios.
Model to use for environmental stochasticity: betagamma.
Model for density dependence: nodd.
Include demographic stochasticity in model?: Yes.
Number of simulations: 5000.
Random seed: 14.
Years for burn-in: 5.
Case study selected: None.

Baseline demographic rates

Species chosen to set initial values: Black-Legged Kittiwake.
Region type to use for breeding success data: Site.
Available colony-specific survival rate: National. Sector to use within breeding success region: Flamborough Head and Bempton Cliffs SPA;Flamborough Head and Bempton Cliffs.
Age at first breeding: 4.
Is there an upper constraint on productivity in the model?: Yes, constrained to 2 per pair.
Number of subpopulations: 1.
Are demographic rates applied separately to each subpopulation?: No.
Units for initial population size: breeding.adults
Are baseline demographic rates specified separately for immatures?: Yes.

Population 1

Initial population values: Initial population 89148 in 2022
Productivity rate per pair: mean: 0.8732258065 , sd: 0.3323290247
Adult survival rate: mean: 0.854 , sd: 0.077
Immatures survival rates:
Age class 0 to 1 - mean: 0.79 , sd: 0.077 , DD: NA
Age class 1 to 2 - mean: 0.854 , sd: 0.077 , DD: NA
Age class 2 to 3 - mean: 0.854 , sd: 0.077 , DD: NA
Age class 3 to 4 - mean: 0.854 , sd: 0.077 , DD: NA

Impacts

Number of impact scenarios: 2.
Are impacts applied separately to each subpopulation?: No
Are impacts of scenarios specified separately for immatures?: No
Are standard errors of impacts available?: No
Should random seeds be matched for impact scenarios?: Yes
Are impacts specified as a relative value or absolute harvest?: relative
Years in which impacts are assumed to begin and end: 2030 to 2070

Impact on Demographic Rates

Scenario A - Name: Alone

All subpopulations

Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 9e-06 , se: NA

Scenario B - Name: In-combo

All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.006156 , se: NA

Output:

First year to include in outputs: 2028
Final year to include in outputs: 2070
How should outputs be produced, in terms of ages?: breeding.pairs
Target population size to use in calculating impact metrics: NA
Quasi-extinction threshold to use in calculating impact metrics: NA

Five Estuaries gannet FFC SPA approach BDMPS

Set up

The log file was created on: 2024-09-25 18:23:45.237902 using Tool version 2, with R version 4.4.1, PVA package version: 4.18 (with UI version 1.7)

```
##                Package        Version
## popbio         "popbio"       "2.8"
## shiny          "shiny"        "1.9.1"
## shinyjs        "shinyjs"      "2.1.0"
## shinydashboard "shinydashboard" "0.7.2"
## shinyWidgets   "shinyWidgets" "0.8.6"
## DT             "DT"           "0.33"
## plotly         "plotly"       "4.10.4"
## rmarkdown      "rmarkdown"    "2.28"
## dplyr          "dplyr"        "1.1.4"
## tidyr          "tidyr"        "1.3.1"
```

Basic information

This run had reference name "Gannet FFC".
PVA model run type: simplescenarios.
Model to use for environmental stochasticity: betagamma.
Model for density dependence: nodd.
Include demographic stochasticity in model?: Yes.
Number of simulations: 5000.
Random seed: 1.
Years for burn-in: 5.
Case study selected: None.

Baseline demographic rates

Species chosen to set initial values: Northern Gannet.
Region type to use for breeding success data: Site.
Available colony-specific survival rate: National. Sector to use within breeding success region: Flamborough Head and Bempton Cliffs SPA;Flamborough Head and Bempton Cliffs.
Age at first breeding: 5.
Is there an upper constraint on productivity in the model?: Yes, constrained to 1 per pair.
Number of subpopulations: 1.
Are demographic rates applied separately to each subpopulation?: No.
Units for initial population size: breeding.adults
Are baseline demographic rates specified separately for immatures?: Yes.

Population 1

Initial population values: Initial population 30466 in 2023
Productivity rate per pair: mean: 0.7975 , sd: 0.06632257693
Adult survival rate: mean: 0.919 , sd: 0.042
Immatures survival rates:
Age class 0 to 1 - mean: 0.424 , sd: 0.045 , DD: NA
Age class 1 to 2 - mean: 0.829 , sd: 0.026 , DD: NA
Age class 2 to 3 - mean: 0.891 , sd: 0.019 , DD: NA
Age class 3 to 4 - mean: 0.895 , sd: 0.019 , DD: NA
Age class 4 to 5 - mean: 0.919 , sd: 0.042 , DD: NA

Impacts

Number of impact scenarios: 2.
Are impacts applied separately to each subpopulation?: No
Are impacts of scenarios specified separately for immatures?: No
Are standard errors of impacts available?: No
Should random seeds be matched for impact scenarios?: Yes
Are impacts specified as a relative value or absolute harvest?: relative
Years in which impacts are assumed to begin and end: 2030 to 2070

Impact on Demographic Rates

Scenario A - Name: Alone

All subpopulations

Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 4.2e-05 , se: NA

Scenario B - Name: In-combo

All subpopulations

Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.002357 , se: NA

Output:

First year to include in outputs: 2028
Final year to include in outputs: 2070
How should outputs be produced, in terms of ages?: breeding.adults
Target population size to use in calculating impact metrics: NA
Quasi-extinction threshold to use in calculating impact metrics: NA

Five Estuaries guillemot FFC SPA BDMPS

Set up

The log file was created on: 2025-02-20 16:20:53 using Tool version 2, with R version 3.5.1, PVA package version: 4.18 (with UI version 1.7)

```
##                  Package          Version[Text Wrapping Break]##
popbio          "popbio"         "2.4.4"[Text Wrapping Break]##
shiny           "shiny"          "1.1.0"[Text Wrapping Break]##
shinyjs         "shinyjs"        "1.0"  [Text Wrapping Break]## shinydashboard
"shinydashboard" "0.7.1"[Text Wrapping Break]##
shinyWidgets    "shinyWidgets"   "0.4.5"[Text Wrapping Break]##
DT              "DT"             "0.5"  [Text Wrapping Break]##
plotly          "plotly"         "4.8.0"[Text Wrapping Break]##
```

```
rmarkdown       "rmarkdown"       "1.10" [Text Wrapping Break]##
dplyr           "dplyr"           "0.7.6"[Text Wrapping Break]##
tidyr           "tidyr"           "0.8.1"
```

Basic information

This run had reference name “”.[Text Wrapping Break]PVA model run type: simplescenarios.[Text Wrapping Break]Model to use for environmental stochasticity: betagamma.[Text Wrapping Break]Model for density dependence: nodd.[Text Wrapping Break]Include demographic stochasticity in model?: Yes.[Text Wrapping Break]Number of simulations: 5000.[Text Wrapping Break]Random seed: 0.[Text Wrapping Break]Years for burn-in: 5.[Text Wrapping Break]Case study selected: None.

Baseline demographic rates

Species chosen to set initial values: Common Guillemot.[Text Wrapping Break]Region type to use for breeding success data: Site.[Text Wrapping Break]Available colony-specific survival rate: National. Sector to use within breeding success region: Flamborough Head and Bempton Cliffs SPA;Flamborough Head and Bempton Cliffs.[Text Wrapping Break]Age at first breeding: 6.[Text Wrapping Break]Is there an upper constraint on productivity in the model?: Yes, constrained to 1 per pair.[Text Wrapping Break]Number of subpopulations: 1.[Text Wrapping Break]Are demographic rates applied separately to each subpopulation?: No.[Text Wrapping Break]Units for initial population size: breeding.adults[Text Wrapping Break]Are baseline demographic rates specified separately for immatures?: Yes.

Population 1

Initial population values: Initial population 149980 in 2023
Productivity rate per pair: mean: 0.7241176 , sd: 0.1180603
Adult survival rate: mean: 0.94 , sd: 0.025
Immatures survival rates:
Age class 0 to 1 - mean: 0.56 , sd: 0.058 , DD: NA
Age class 1 to 2 - mean: 0.792 , sd: 0.152 , DD: NA
Age class 2 to 3 - mean: 0.917 , sd: 0.098 , DD: NA
Age class 3 to 4 - mean: 0.938 , sd: 0.107 , DD: NA
Age class 4 to 5 - mean: 0.94 , sd: 0.025 , DD: NA
Age class 5 to 6 - mean: 0.94 , sd: 0.025 , DD: NA

Impacts

Number of impact scenarios: 4.
Are impacts applied separately to each subpopulation?: No
Are impacts of scenarios specified separately for immatures?: No
Are standard errors of impacts available?: No
Should random seeds be matched for impact scenarios?: No
Are impacts specified as a relative value or absolute harvest?: relative
Years in which impacts are assumed to begin and end: 2030 to 2070

Impact on Demographic Rates

Scenario A - Name: 50,1 alone

All subpopulations

Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 5e-06 , se: NA

Scenario B - Name: 70,2 alone

All subpopulations

Impact on productivity rate mean: 0 , se: NA

Impact on adult survival rate mean: 1.5e-05 , se: NA

Scenario C - Name: 50,1 in-combo

All subpopulations

Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.003762 , se: NA

Scenario D - Name: 70,2 in-combo

All subpopulations

Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.010534 , se: NA

Output:

First year to include in outputs: 2028[Text Wrapping Break]Final year to include in outputs: 2070[Text Wrapping Break]How should outputs be produced, in terms of ages?: breeding.adults[Text Wrapping Break]Target population size to use in calculating impact metrics: NA[Text Wrapping Break]Quasi-extinction threshold to use in calculating impact metrics: NA

Five Estuaries razorbill FFC SPA BDMPS

Set up

The log file was created on: 2025-02-20 16:48:26 using Tool version 2, with R version 3.5.1, PVA package version: 4.18 (with UI version 1.7)

```
##                  Package          Version[Text Wrapping Break]##
popbio          "popbio"         "2.4.4"[Text Wrapping Break]##
shiny           "shiny"          "1.1.0"[Text Wrapping Break]##
shinyjs         "shinyjs"        "1.0"  [Text Wrapping Break]## shinydashboard
"shinydashboard" "0.7.1"[Text Wrapping Break]##
shinyWidgets    "shinyWidgets"   "0.4.5"[Text Wrapping Break]##
DT              "DT"             "0.5"  [Text Wrapping Break]##
plotly          "plotly"         "4.8.0"[Text Wrapping Break]##
rmarkdown       "rmarkdown"      "1.10" [Text Wrapping Break]##
dplyr           "dplyr"          "0.7.6"[Text Wrapping Break]##
tidyr           "tidyr"          "0.8.1"
```

Basic information

This run had reference name “Razorbill FFC”.[Text Wrapping Break]PVA model run type: simplescenarios.[Text Wrapping Break]Model to use for environmental stochasticity: betagamma.[Text Wrapping Break]Model for density dependence: nodd.[Text Wrapping Break]Include demographic stochasticity in model?: Yes.[Text Wrapping Break]Number of simulations: 5000.[Text Wrapping Break]Random seed: 0.[Text Wrapping Break]Years for burn-in: 5.[Text Wrapping Break]Case study selected: None.

Baseline demographic rates

Species chosen to set initial values: Razorbill.[Text Wrapping Break]Region type to use for breeding success data: Site.[Text Wrapping Break]Available colony-specific survival rate: National. Sector to use within breeding success region: Flamborough Head and Bempton Cliffs SPA;Flamborough Head and Bempton Cliffs.[Text Wrapping Break]Age at first breeding: 5.[Text Wrapping Break]Is there an upper constraint on productivity in the model?: Yes, constrained to 1 per pair.[Text Wrapping Break]Number of subpopulations: 1.[Text Wrapping Break]Are demographic rates applied separately to each subpopulation?: No.[Text Wrapping Break]Units for initial population size:

breeding.adults[Text Wrapping Break]Are baseline demographic rates specified separately for immatures?: Yes.

Population 1

Initial population values: Initial population 61346 in 2022
Productivity rate per pair: mean: 0.6188889 , sd: 0.07490735
Adult survival rate: mean: 0.895 , sd: 0.067
Immatures survival rates:
Age class 0 to 1 - mean: 0.794 , sd: 0.067 , DD: NA
Age class 1 to 2 - mean: 0.794 , sd: 0.067 , DD: NA
Age class 2 to 3 - mean: 0.895 , sd: 0.067 , DD: NA
Age class 3 to 4 - mean: 0.895 , sd: 0.067 , DD: NA
Age class 4 to 5 - mean: 0.895 , sd: 0.067 , DD: NA

Impacts

Number of impact scenarios: 4.
Are impacts applied separately to each subpopulation?: No
Are impacts of scenarios specified separately for immatures?: No
Are standard errors of impacts available?: No
Should random seeds be matched for impact scenarios?: No
Are impacts specified as a relative value or absolute harvest?: relative
Years in which impacts are assumed to begin and end: 2030 to 2070

Impact on Demographic Rates

Scenario A - Name: 50,1 alone

All subpopulations

Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 4e-06 , se: NA

Scenario B - Name: 70,2 alone

All subpopulations

Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 1e-05 , se: NA

Scenario C - Name: 50,1 in-combo

All subpopulations

Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.0021 , se: NA

Scenario D - Name: 70,2 in-combo

All subpopulations

Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.005878 , se: NA

Output:

First year to include in outputs: 2028[Text Wrapping Break]Final year to include in outputs: 2070[Text Wrapping Break]How should outputs be produced, in terms of ages?: breeding.adults[Text Wrapping Break]Target population size to use in calculating impact metrics: NA[Text Wrapping Break]Quasi-extinction threshold to use in calculating impact metrics: NA

PHONE 0333 880 5306
EMAIL fiveestuaries@rwe.com
WEBSITE www.fiveestuaries.co.uk
ADDRESS Five Estuaries Offshore Wind Farm Ltd
Windmill Hill Business Park
Whitehill Way, Swindon, SN5 6PB
COMPANY NO Registered in England and Wales
company number 12292474