Outer Dowsing Offshore Wind

Report to Inform Appropriate Assessment

Annex 2: Ornithology Population Viability Analysis (Habitats Regulations Assessment)

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Acronyms & Terminology

Abbreviations: Acronyms

Abbreviation: Acronym	Description
GT R4 ltd	The Applicant. The special project vehicle created in partnership between Corio Generation (a wholly owned Green Investment Group portfolio company), Gulf Energy Development and TotalEnergies.
PVA	Population Viability Analysis
SPA	Special Protection Area
CPS	Counterfactual of Population Size
CPGR	Counterfactual of Population Growth Rate
ORBA	Offshore Restricted Build Area

Terminology

Term	Definition
The Applicant	GT R4 Ltd. The Applicant making the application for a DCO. The Applicant is GT R4 Limited (a joint venture between Corio Generation, Total Energies and Gulf Energy Development (GULF)), trading as Outer Dowsing Offshore Wind. The Project is being developed by Corio Generation (a wholly owned Green Investment Group portfolio company), TotalEnergies and GULF.
The Project	Outer Dowsing Offshore Wind, an offshore wind generating station together with associated onshore and offshore infrastructure.
Offshore Restricted Build Area (ORBA)	The area within the array area, where no wind turbine generator, offshore transformer substation or offshore accommodation platform shall be erected

Reference Documentation

Document Number	Title
6.1.3	Project Description
7.1	Report to Inform Appropriate Assessment

1 Introduction

1.1 Project background

1. GT R4 Limited (trading as Outer Dowsing Offshore Wind) hereafter referred to as the 'Applicant', is proposing to develop the Project. The Project will be located approximately 54km from the Lincolnshire coastline in the southern North Sea. The Project will include both offshore and onshore infrastructure including an offshore generating station (windfarm), export cables to landfall, Offshore Reactive Compensation Platforms (ORCPs), onshore cables, connection to the electricity transmission network, ancillary and associated development and areas for the delivery of up to two Artificial Nesting Structures (ANS) and the creation of a biogenic reef (if these compensation measures are deemed to be required by the Secretary of State) (see Volume 1, Chapter 3: Project Description (document reference 6.1.3) for full details).
2. This technical appendix provides the methodology and results for any population viability analysis carried out to inform the conclusions of the Offshore and Intertidal Ornithology assessments presented Chapter 7.1 Report to Inform Appropriate Assessment (Document reference: 7.1). This document has been updated following a request from Natural England and as agreed by the Applicant with the Examining Authority (ExA) to update the Habitats Regulations Assessment (HRA) related documentation for Deadline 4 to reflect changes made by the Applicant to the Project during the Examination phase. The Applicant has previously provided environmental reports for these updates throughout the Examination (through the submission of the Habitats Regulations Assessment for the Offshore Restricted Build Area and Revision to the Offshore Export Cable Corridor (PD1-091), confirming that no changes made altered the previously drawn conclusions within the Report to Inform an Appropriate Assessment (RIAA).
3. This current version of this report updates the values submitted within the Application arising from the following project changes:
   - The introduction of an Offshore Restricted Build Area (ORBA) over the northern section of the Project array area; and
   - The removal of the northern section of the offshore Export Cable Corridor (ECC).
4. Further updates contained herein include:
   - Additional information on stable age structure and burn in;
   - Inclusion of demographic rates for puffin at the Farne Island SPA.
   - Updates to in-combination numbers from other relevant projects
5. The Applicant confirms that none of the updates as set out above have changed the conclusions previously drawn at the point of Application.

1.2 Population Viability Analysis (PVA)

~~2.~~6. For species that have predicted high number of mortalities due to displacement or collision with turbine blades, it is important to assess the implications of these moralities on SPA populations. To estimate the effect that a development, alone or in-combination, may have on a designated feature, Population Viability Analysis (PVA) can be used. PVA models use demographic parameters to forecast future population levels under different scenarios over a set period, comparing 'impacted' scenarios to a 'baseline' by alteration of demographic parameters (survival and productivity). The baseline conditions consider there to be no impact from the development and therefore the population will follow unaltered growth rates. Whereas the impact scenarios model an impacted population over a defined period.

~~3.~~7. This report provides the modelling methodology and results using SPA populations (as presented in the technical baseline). The species selected for PVA modelling were (see Table 1.1):

- Common guillemot (*Uria aalge*);
- Gannet (*Morus bassanus*);
- Kittiwake (*Rissa tridactyla*);
- Puffin (*Fratercula arctica*); and
- Razorbill (*Alca torda*).

Table 1.1. Initial SPA population sizes defined from recent Seabird Monitoring Programme (SMP) counts.

Species	Coquet Island SPA	Farne Islands SPA	Flamborough and Filey Coast SPA
Common guillemot	NA	46,332	149,980
Gannet	NA	NA	30,466
Kittiwake	NA	NA	89,148
Puffin	50,058	87,504~~NA~~	3,080~~NA~~
Razorbill	NA	NA	61,346

~~4.~~8. 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 can assess 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 Methodology

2.1 Guidance and models

~~5.~~9. The user guide for the Seabird PVA Tool provided by Natural England (Searle *et al.,* 2019) has been followed for modelling and assessment of potential impacts. The demographic parameters used for the PVA are presented in section 2.2.

2.2 PVA modelling approach and demographic parameters

2.2.1 Simulation type

~~6.~~10. All PVA models were undertaken using the 'Simulation' run type, which is used to simulate population trajectories based on the specified demographic parameters, initial population sizes and scenarios the user inputs into the model.

~~7.~~11. The Seabird PVA Tool uses a Leslie matrix to construct a PVA model (Caswell, 2000) based on the parameters provided by the user. Users can specify whether they wish the model to include demographic stochasticity, environmental stochasticity, density dependence, density independence or whether they want the model to run deterministically.

~~8.~~12. A deterministic model translates the demographic parameters provided into actual numbers and provides a simplistic model, which can be used to generate average trends. Due to the lack of stochasticity, a deterministic model will produce the same result every time the simulation is run. In situations where little is known about how the population size has varied, or how the scale of impact may vary, running a deterministic model might provide a more candid assessment of the population and how it may be impacted.

~~9.~~13. 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 that random variation has on population structure and demographic rates. It is modelled by generating random numbers of surviving individuals for any given survival probability distribution. 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).

14. All PVA modelling in this report was undertaken with environmental and deterministic stochasticity. To ensure robust results, all simulations were set to run 5,000 times. All models were run for a 35-year time span, representing the approximate likely lifespan of the Project, and providing a representative outcome regarding long-term impacts. Demographic processes such as growth, survival, productivity, and recruitment are density-dependent, as their rates change in relation to the number of individuals in a population. Density dependence can be described as 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. This 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.

~~10.~~15. The stable age structure represents the long-term age distribution of a population but may not match the initial age structure in finite simulations due to the time needed to reach stability. For stochastic PVA, a "burn-in" period is introduced to minimise bias, allowing the age structure to stabilise before the main simulations. During the burn-in, baseline simulations are run for a specified number of years, and the resulting age structure is then used as the starting point for the main PVA simulations. Burn-in was set to five years for all species and sites, except for Coquet Island SPA and Flamborough and Filey Coast SPA for Puffin, where the burn-in was set to zero due to the model failing with a five-year burn-in value.

~~11.~~16. Density dependence is self-evident in the natural environment, as without density dependence, populations would grow exponentially. For seabird populations, the mechanisms as to how this operates are largely uncertain. If density dependence is mis-specified in an assessment, the modelled predictions may 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 on the grounds of precaution (i.e. another source of precaution in the assessment process) (Ridge *et al.,* 2019).

~~12.~~17. Although both the counterfactual of population size (CPS) and counterfactual of population growth rate (CGR) are presented within this report, the Applicant considers that only the counterfactual of population growth rate should be used for interpreting the predicted impacts. This is because the counterfactual of population growth rate can be compared against known population trends for a feature~~-~~: receptor and is relatively insensitive to the baseline rate of growth and direction (positive or negative). Whereas the counterfactual of population size will predict very large differences in comparison to the baseline population size, especially when density dependent factors allowing for population recovery or preventing exponential growth are not considered within the PVA, as is the case with these assessments.

2.2.2 Demographic parameters

~~13.~~18. The input demographic parameters were primarily taken from Horswill and Robinson (2015), with some parameters provided within the tool. Where the parameters differ from this it has been highlighted in Table 2.1.

Table 2.1 Summary of SPA demographic rates for PVA species.

Demographic Parameter	Common Guillemot (Flamborough and Filey Coast SPA)	Common Guillemot (Farne Islands SPA)	Gannet (Flamborough and Filey Coast SPA)	Kittiwake (Flamborough and Filey Coast SPA)	Puffin (Coquet Island SPA; Flamborough and Filey Coast SPA)	Puffin (Farne Islands SPA)	Razorbill (Flamborough and Filey Coast SPA)
Adult Survival	0.940 (0.025)	0.940 (0.025)	0.919 (0.042)	0.854 (0.077)	0.907 (0.083)	0.907 (0.083)	0.895 (0.067)
Productivity (SD) (per pair)	0.724 (0.118)	0.787 (0.140)	0.798 (0.066)	0.873 (0.332)	0.576 (0.331)	0.769 (0.175)	0.619 (0.075)
Age of recruitment	6	6	5	4	5	5	5
Brood size (per pair)	1	1	1	2	1	1	1
Survival 0-1	0.560 (0.058)	0.560 (0.058)	0.424 (0.045)	0.790 (0.077)	0.709 (0.108)	0.709 (0.108)	0.630 (0.067)
Survival 1-2	0.792 (0.152)	0.792 (0.152)	0.829 (0.026)	0.854 (0.077)	0.709 (0.108)	0.709 (0.108)	0.630 (0.067)
Survival 2-3	0.917 (0.098)	0.917 (0.098)	0.891 (0.019)	0.854 (0.077)	0.709 (0.108)	0.709 (0.108)	0.895 (0.067)
Survival 3-4	0.938 (0.107)	0.938 (0.107)	0.895 (0.019)	0.854 (0.077)	0.760 (0.093)	0.760 (0.093)	0.895 (0.067)
Survival 4-5	0.940 (0.025)	0.940 (0.025)	0.919 (0.042)	-	0.805 (0.083)	0.805 (0.083)	0.895 (0.067)
Survival 5-6	0.940 (0.025)	0.940 (0.025)	-	-	-	-	-

2.2.3 PVA species-specific outputs

~~14.~~19. The outputs from the PVA tool are the CGR and CPS (Searle *et al.,* 2019). These provide the ratio of impacted to unimpacted scenarios and allows for interpretation of the predicted impact upon the population (Cook and Robinson, 2016). CPS is the median of the ratio of end-point population size of the impacted to un-impacted (baseline) scenarios. CGR is the median of the ratio of the annual growth rate of the impacted to un-impacted population. Both are expressed as a proportion.

3 Impact scenarios

3.1 Magnitude of impact

~~15.~~20. Each impact scenario has an additional population-level mortality due to the presence of turbines, and therefore imposed risk of collision and of displacement effects. This additional mortality impacts the survival rate and therefore predicts the magnitude of impact on an SPA population for different scenarios. The model used relative harvest (i.e. impact on adult survival rate) which was calculated using the predicted mortalities apportioned to the site divided by the initial population size (Table 1.1). Table 3.1 to Table 3.5 present the scenarios carried out, the estimated mortality for that scenario and the impact that mortality has on the survival rate for the relevant species. It is this reduction in survival rate which is input into the PVA model. For in-combination scenarios, those defined as 'low' reflect Applicant approach in-combination numbers and those defined as 'high' reflect in-combination numbers under Natural England's preferred approach.

Table 3.1 Common guillemot displacement magnitude of impact.

SPA	Impact scenario	Displacement : Mortality rate (%)	Mortalities	Impact on adult survival rate
Farne Islands SPA	Project alone (Applicant Approach)	50 : 1~~30 : 1~~	1.7~~1.3~~	0.00004~~0.000~~
		70 : 2~~50 : 1~~	4.7~~2.1~~	0.00010~~0.000~~
	In-combination (Low)	50 : 1~~30 : 1~~	77.1~~44.1~~	0.00166~~0.001~~
		70 : 2~~50 : 1~~	215.9~~73.5~~	0.00466~~0.002~~
	Project alone (Natural England Approach)	50 : 1	0.8	0.00002
		70 : 2	2.2	0.00005
	In-combination (High)	50 : 1	76.2	0.00164
		70 : 2	213.4	0.00460
Flamborough and Filey Coast SPA	Project alone (Applicant Approach)~~Project alone~~	50 : 1~~30 : 1~~	18.2~~15.5~~	0.00012~~0.000~~
		70 : 2~~50 : 1~~	50.9~~25.9~~	0.00034~~0.000~~
	In-combination (Low)~~In-combination~~	50 : 1~~30 : 1~~	270.3~~254.5~~	0.00180~~0.002~~
		70 : 2~~50 : 1~~	756.9~~424.1~~	0.00505~~0.003~~
	Project alone (Natural England Approach)~~NE method Project alone~~	50 : 1~~30 : 1~~	88.8~~50.8~~	0.00059~~0.000~~
		70 : 2~~50 : 1~~	248.7~~84.7~~	0.00166~~0.001~~
	In-combination (High)~~NE method In-combination~~	50 : 1~~30 : 1~~	481.0~~289.7~~	0.00321~~0.002~~
		70 : 2~~50 : 1~~	1346.9~~482.9~~	0.00898~~0.003~~

Table 3.2 Gannet combined collision and displacement magnitude of impact.

Scenario	Impact scenario	Displacement : Mortality rate (%)	Mortalities	Impact on adult survival rate
Flamborough and Filey Coast SPA (combined)	Project alone	70 : 160 : 1	4.84.700	0.0001600.000
	70/1 in-combination (Low)	70 : 170 : 1	154.65.400	0.0050700.000
	70/1 in-combination (High)	70 : 180 : 1	162.15.900	0.0050700.000
	In-combination	60 : 1	135.457	0.004

Table 3.3 Kittiwake collisions magnitude of impact

Scenario	Impact scenario	Mortalities	Impact on adult survival rate
Flamborough and Filey Coast SPA	Project alone	15.514.500	0.0001700.000
	In-combination (without compensated projects)In-combination (without compensated projects)	434.3383.000	0.0048700.004
	In-combination (with compensated projects)In-combination (with compensated projects)	618.9531.900	0.0069400.006

Table 3.4 Puffin displacement magnitude of impact

Scenario	Impact scenario	Displacement : Mortality rate (%)	Mortalities	Impact on adult survival rate
Coquet Island SPA	Project alone (Applicant Approach)	50 : 1	1.7	0.00003
		70 : 2	4.7	0.00009
	In-combination (Low)	50 : 1	16.4	0.00006
		70 : 2	46.0	0.00016
	Project alone (Natural England Approach)	50 : 1	2.8	0.00033
		70 : 2	8.0	0.00092
	In-combination (High)	50 : 1	17.7	0.00035
		70 : 2	49.6	0.00099
Flamborough and Filey Coast SPA	Project alone (Applicant Approach)	50 : 1	0.4	0.00013
		70 : 2	1.1	0.00037
	In-combination (Low)	50 : 1	6.6	0.00213
		70 : 2	18.4	0.00596

Scenario	Impact scenario	Displacement : Mortality rate (%)	Mortalities	Impact on adult survival rate
	Project alone (Natural England Approach)	50 : 1	0.7	0.00023
		70 : 2	2.0	0.00066
	In-combination (High)	50 : 1	7.0	0.00226
		70 : 2	19.5	0.00633
Farne Islands SPA	Project alone (Applicant Approach)	50 : 1	0.7	0.00001
		70 : 2	2.0	0.00002
	In-combination (Low)	50 : 1	48.2	0.00055
		70 : 2	134.8	0.00154
	In-combination (High)	50 : 1	48.3	0.00055
		70 : 2	135.3	0.00155

Table 3.5 Razorbill displacement magnitude of impact

Scenario	Impact scenario	Displacement : Mortality rate (%)	Mortalities	Impact on adult survival rate
Flamborough and Filey Coast SPA~~Flamborough and Filey Coast SPA~~	Project alone (Applicant Approach)~~Project alone~~	50 : 1~~30 : 1~~	10.5~~6.149~~	0.00017~~0.000~~
		70 : 2~~50 : 1~~	29.4~~10.249~~	0.00048~~0.000~~
	In-combination (Low)~~In-combination~~	50 : 1~~30 : 1~~	61.2~~49.724~~	0.00100~~0.001~~
		70 : 2~~50 : 1~~	171.3~~82.874~~	0.00279~~0.001~~
	Project alone (Natural England Approach)~~NE Method Project alone~~	50 : 1~~30 : 1~~	24.6~~10.789~~	0.00040~~0.000~~
		70 : 2~~50 : 1~~	68.9~~17.981~~	0.00112~~0.000~~
	In-combination (High)~~NE Method In-combination~~	50 : 1~~30 : 1~~	95.1~~54.364~~	0.00155~~0.001~~
		70 : 2~~50 : 1~~	266.2~~90.606~~	0.00434~~0.001~~

4 PVA results

4.1 Introduction

~~16.~~21. The outputs of the Seabird PVA Tool are set out in Table 4.1 to Table 4.8 below for all five species. The metrics used to summarise the PVA results are based on the CGR and CPS expressed as a percentage decrease. The parameter logs for all sites and species are presented in Annex 1.

4.2 Common Guillemot

4.2.1 Farne Islands SPA

Table 4.1 Metrics and counterfactuals for 5000 simulations, over 35 years, of guillemot PVA at Farne Islands SPA.

Scenario	Displacement : Mortality rate (%)	CGR	CPS	Difference in GR (%)	Difference in PS (%)
Project alone (Applicant Approach)~~Project alone~~	50 : 1~~30 : 1~~	1.000~~1.000~~	0.999~~0.999~~	0.004~~0.003~~	0.145~~0.095~~
	70 : 2~~50 : 1~~	1.000~~1.000~~	0.996~~0.998~~	0.012~~0.005~~	0.398~~0.177~~
In-combination (Low)~~In-combination~~	50 : 1~~30 : 1~~	0.998~~0.999~~	0.935~~0.962~~	0.187~~0.107~~	6.505~~3.760~~
	70 : 2~~50 : 1~~	0.995~~0.998~~	0.828~~0.938~~	0.523~~0.178~~	17.191~~6.211~~
Project alone (Natural England Approach)	50 : 1	1.000	0.999	0.002	0.069
	70 : 2	1.000	0.998	0.005	0.197
In-combination (High)	50 : 1	0.998	0.936	0.185	6.447
	70 : 2	0.995	0.830	0.517	17.022

4.2.2 Flamborough and Filey Coast SPA

Table 4.2 Metrics and counterfactuals for 5000 simulations, over 35 years, of guillemot PVA at Flamborough and Filey Coast SPA.

Scenario	Displacement : Mortality rate (%)	CGR	CPS	Difference in GR (%)	Difference in PS (%)
Project alone (Applicant Approach)~~Project alone~~	50 : 1~~30 : 1~~	1.000~~1.000~~	0.995~~0.996~~	0.014~~0.011~~	0.497~~0.413~~
	70 : 2~~50 : 1~~	1.000~~1.000~~	0.986~~0.993~~	0.038~~0.019~~	1.362~~0.698~~
In-combination (Low)	50 : 1~~30 : 1~~	0.998~~1.000~~	0.930~~0.986~~	0.202~~0.038~~	7.019~~1.355~~
	70 : 2~~50 : 1~~	0.994~~0.999~~	0.815~~0.977~~	0.565~~0.063~~	18.459~~2.258~~
	50 : 1~~70 : 2~~	0.999~~0.998~~	0.976~~0.938~~	0.066~~0.177~~	2.361~~6.180~~

Scenario	Displacement : Mortality rate (%)	CGR	CPS	Difference in GR (%)	Difference in PS (%)
Project alone (Natural England Approach)	70 : 270 : 10	0.9980.991	0.9350.726	0.1860.885	6.47827.396
In-combination (High)In-combination	50 : 130 : 1	0.9960.998	0.8780.934	0.3590.190	12.1536.622
	70 : 250 : 1	0.9900.997	0.6950.892	1.0060.317	30.49810.796
	70 : 2	0.991	0.726	0.886	27.427
	70 : 10	0.956	0.195	4.433	80.455
	30 : 1	0.998	0.925	0.216	7.493
	50 : 1	0.996	0.878	0.360	12.195
	70 : 2	0.990	0.694	1.009	30.596
	70 : 10	0.950	0.155	5.048	84.504

4.3 Gannet

4.3.1 Flamborough and Filey Coast SPA

Table 4.3 Metrics and counterfactuals for 5000 simulations, over 35 years, of gannet PVA at Flamborough and Filey Coast SPA.

Scenario	Displacement : Mortality rate (%)	CGR	CPS	Difference in GR (%)	Difference in PS (%)
Project alone Project alone	70 : 160 : 1	1.0001.000	0.9930.993	0.0190.019	0.6850.672
70/1 in-combination (Low)	70 : 170 : 1	0.9941.000	0.8060.993	0.5980.021	19.4480.744
70/1 in-combination (High)	70 : 180 : 1	0.9941.000	0.8060.992	0.5990.023	19.4400.798

4.4 Kittiwake

4.4.1 Flamborough and Filey Coast SPA

Table 4.4 Metrics and counterfactuals for 5000 simulations, over 35 years, of kittiwake PVA at Flamborough and Filey Coast SPA.

Scenario	CGR	CPS	Difference in GR (%)	Difference in PS (%)
Project alone Project alone	1.0001.000	0.9930.993	0.0200.001	0.7210.700

Scenario	CGR	CPS	Difference in GR (%)	Difference in PS (%)
In-combination (without compensated projects)~~In-combination~~	0.994~~0.995~~	0.812~~0.832~~	0.577~~0.512~~	18.807~~16.800~~
In-combination (with compensated projects)	0.992~~0.993~~	0.743~~0.775~~	0.822~~0.700~~	25.709~~22.500~~

4.5 Puffin

4.5.1 Coquet Island SPA

Table 4.5 Metrics and counterfactuals for 5000 simulations, over 35 years, of puffin PVA at Coquet Island SPA.

Scenario	Displacement : Mortality rate (%)	CGR	CPS	Difference in GR (%)	Difference in PS (%)
Project alone (Applicant Approach)~~Project alone~~	50 : 1~~30 : 1~~	1.000~~1.000~~	0.999~~0.999~~	0.004~~0.003~~	0.147~~0.119~~
	70 : 2~~50 : 1~~	1.000~~1.000~~	0.997~~0.999~~	0.010~~0.003~~	0.345~~0.141~~
In-combination (Low)	50 : 1~~70 : 2~~	1.000~~1.000~~	0.987~~0.996~~	0.037~~0.013~~	1.319~~0.425~~
	70 : 2~~70 : 10~~	0.999~~0.999~~	0.963~~0.979~~	0.104~~0.060~~	3.678~~2.097~~
Project alone (Natural England Approach)~~In-combination~~	50 : 1~~30 : 1~~	1.000~~1.000~~	0.998~~0.992~~	0.007~~0.021~~	0.226~~0.787~~
	70 : 2~~50 : 1~~	1.000~~1.000~~	0.994~~0.988~~	0.018~~0.035~~	0.642~~1.249~~
In-combination (High)	50 : 1~~70 : 2~~	1.000~~0.999~~	0.986~~0.964~~	0.040~~0.101~~	1.423~~3.582~~
	70 : 2~~70 : 10~~	0.999~~0.995~~	0.960~~0.834~~	0.112~~0.503~~	3.998~~16.617~~

4.5.2 Flamborough and Filey Coast SPA

Table 4.6 Metrics and counterfactuals for 5000 simulations, over 35 years, of puffin PVA at Coquet Island SPA.

Scenario	Displacement : Mortality rate (%)	CGR	CPS	Difference in GR (%)	Difference in PS (%)
Project alone (Applicant Approach)	50 : 1	1.000	0.994	0.017	0.638
	70 : 2	1.000	0.984	0.046	1.608
In-combination (Low)	50 : 1	0.998	0.916	0.246	8.418
	70 : 2	0.993	0.783	0.679	21.733
Project alone (Natural England Approach)	50 : 1	1.000	0.990	0.029	1.018
	70 : 2	0.999	0.972	0.077	2.771
In-combination (High)	50 : 1	0.997	0.911	0.260	8.863
	70 : 2	0.993	0.771	0.722	22.915

4.5.3 Farne Islands SPA

Table 4.7 Metrics and counterfactuals for 5000 simulations, over 35 years, of puffin PVA at Coquet Island SPA.

Scenario	Displacement : Mortality rate (%)	CGR	CPS	Difference in GR (%)	Difference in PS (%)
Project alone (Applicant Approach)	50 : 1	1.000	1.000	0.001	0.027
	70 : 2	1.000	0.999	0.003	0.089
In-combination (Low)	50 : 1	0.999	0.978	0.063	2.238
	70 : 2	0.998	0.939	0.176	6.138
In-combination (High)	50 : 1	0.999	0.978	0.063	2.245
	70 : 2	0.998	0.939	0.176	6.149

4.6 Razorbill

4.6.1 Flamborough and Filey Coast SPA

Table 4.8 Metrics and counterfactuals for 5000 simulations, over 35 years, of razorbill PVA at Flamborough and Filey Coast SPA.

Scenario	Displacement : Mortality rate (%)	CGR	CPS	Difference in GR (%)	Difference in PS (%)
Project alone (Applicant Approach)~~Project alone~~	50 : 1~~30 : 1~~	1.000~~1.000~~	0.993~~0.996~~	0.019~~0.012~~	0.708~~0.430~~
	70 : 2~~50 : 1~~	0.999~~1.000~~	0.980~~0.993~~	0.057~~0.019~~	2.036~~0.690~~
In-combination (Low)	50 : 1~~70 : 2~~	0.999~~0.999~~	0.958~~0.980~~	0.118~~0.056~~	4.162~~1.956~~
	70 : 2~~70 : 10~~	0.997~~0.997~~	0.888~~0.905~~	0.329~~0.276~~	11.175~~9.450~~
Project alone (Natural England Approach)	50 : 1~~30 : 1~~	1.000~~1.000~~	0.983~~0.986~~	0.048~~0.038~~	1.695~~1.355~~
	70 : 2~~50 : 1~~	0.999~~0.999~~	0.953~~0.977~~	0.132~~0.063~~	4.651~~2.258~~
In-combination (High)	50 : 1~~70 : 2~~	0.998~~0.998~~	0.937~~0.938~~	0.182~~0.177~~	6.339~~6.180~~
	70 : 2~~70 : 10~~	0.995~~0.991~~	0.831~~0.726~~	0.511~~0.885~~	16.860~~27.396~~
~~In-combination~~	~~30 : 1~~	~~0.999~~	~~0.966~~	~~0.096~~	~~3.401~~
	~~50 : 1~~	~~0.998~~	~~0.944~~	~~0.160~~	~~5.595~~
	~~70 : 2~~	~~0.996~~	~~0.851~~	~~0.446~~	~~14.862~~
	~~70 : 10~~	~~0.978~~	~~0.444~~	~~2.230~~	~~55.609~~
	~~30 : 1~~	~~0.998~~	~~0.925~~	~~0.216~~	~~7.493~~
	~~50 : 1~~	~~0.996~~	~~0.878~~	~~0.360~~	~~12.195~~
	~~70 : 2~~	~~0.990~~	~~0.694~~	~~1.009~~	~~30.596~~
	~~70 : 10~~	~~0.950~~	~~0.155~~	~~5.048~~	~~84.504~~

5 References

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

Ridge, K., Jones, C., Jones, G. & Kean, G. (2019). Norfolk Vanguard Offshore Wind Farm Examing 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. and 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 use of Population Viability Analysis for investigating bird impacts due to offshore wind farms. Report to The Crown Estate.

Annex 1 - PVA parameter logs

5.1 Guillemot FFC SPA

Set up

The log file was created on: 2025-01-09 20:41:35.533421 using Tool version 2, with R version 4.3.0, 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"    "0.8.7"
## DT             "DT"              "0.33"
## plotly         "plotly"          "4.10.4"
## rmarkdown      "rmarkdown"       "2.29"
## dplyr          "dplyr"           "1.1.4"
## tidyr          "tidyr"           "1.3.1"
```

Basic information

This run had reference name “GU 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: 3.

Years for burn-in: 5.

Case study selected: None.

Baseline demographic rates

Species chosen to set initial values: Common Guillemot.

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: 6.

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 149980 in 2022

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: 8.

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 2065

Impact on Demographic Rates

Scenario A - Name: 50/1 project alone (Project)

All subpopulations

Impact on productivity rate mean: 0 , se: NA

Impact on adult survival rate mean: 0.000121 , se: NA

Scenario B - Name: 70/2 project alone (Project)

All subpopulations

Impact on productivity rate mean: 0 , se: NA

Impact on adult survival rate mean: 0.00034 , se: NA

Scenario C - Name: 50/1 in-combination (Low)

All subpopulations

Impact on productivity rate mean: 0 , se: NA

Impact on adult survival rate mean: 0.001802 , se: NA

Scenario D - Name: 70/2 in-combination (Low)

All subpopulations

Impact on productivity rate mean: 0 , se: NA

Impact on adult survival rate mean: 0.005046 , se: NA

Scenario E - Name: 50/1 project alone (NE)

All subpopulations

Impact on productivity rate mean: 0 , se: NA

Impact on adult survival rate mean: 0.000592 , se: NA

Scenario F - Name: 70/2 project alone (NE)

All subpopulations

Impact on productivity rate mean: 0 , se: NA

Impact on adult survival rate mean: 0.001658 , se: NA

Scenario G - Name: 50/1 in-combination (High)

All subpopulations

Impact on productivity rate mean: 0 , se: NA

Impact on adult survival rate mean: 0.003207 , se: NA

Scenario H - Name: 70/2 in-combination (High)

All subpopulations

Impact on productivity rate mean: 0 , se: NA

Impact on adult survival rate mean: 0.00898 , se: NA

Output:

First year to include in outputs: 2030

Final year to include in outputs: 2065

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

5.2 Guillemot Farne Islands SPA

Set up

The log file was created on: 2025-01-17 15:16:29.389618 using Tool version 2, with R version 4.3.0, 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"    "0.8.7"
## DT             "DT"              "0.33"
## plotly         "plotly"          "4.10.4"
## rmarkdown      "rmarkdown"       "2.29"
## dplyr          "dplyr"           "1.1.4"
## tidyr          "tidyr"           "1.3.1"
```

Basic information

This run had reference name “GU Farne”.

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: 5.

Years for burn-in: 5.

Case study selected: None.

Baseline demographic rates

Species chosen to set initial values: Common Guillemot.

Region type to use for breeding success data: Site.

Available colony-specific survival rate: National. Sector to use within breeding success region: Farne Islands SPA;Farne Islands.

Age at first breeding: 6.

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 46332 in 2023

Productivity rate per pair: mean: 0.7877778 , sd: 0.1401586

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?: Yes

Are impacts specified as a relative value or absolute harvest?: relative

Years in which impacts are assumed to begin and end: 2030 to 2065

Impact on Demographic Rates

Scenario A - Name: 50/1 in-combination (Low)

All subpopulations

Impact on productivity rate mean: 0 , se: NA

Impact on adult survival rate mean: 0.001664 , se: NA

Scenario B - Name: 70/2 in-combination (Low)

All subpopulations

Impact on productivity rate mean: 0 , se: NA

Impact on adult survival rate mean: 0.004659 , se: NA

Scenario C - Name: 50/1 in-combination (High)

All subpopulations

Impact on productivity rate mean: 0 , se: NA

Impact on adult survival rate mean: 0.001645 , se: NA

Scenario D - Name: 70/2 in-combination (High)

All subpopulations

Impact on productivity rate mean: 0 , se: NA

Impact on adult survival rate mean: 0.004605 , se: NA

Output:

First year to include in outputs: 2030

Final year to include in outputs: 2065

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

5.3 Gannet FFC SPA

Set up

The log file was created on: 2025-01-10 11:32:27.726593 using Tool version 2, with R version 4.3.0, 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"    "0.8.7"
## DT             "DT"              "0.33"
## plotly         "plotly"          "4.10.4"
## rmarkdown      "rmarkdown"       "2.29"
## dplyr          "dplyr"           "1.1.4"
## tidyr          "tidyr"           "1.3.1"
```

Basic information

This run had reference name “GX 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: 2.

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: 0.06632258

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: 3.

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 2065

Impact on Demographic Rates

Scenario A - Name: 70/1 project alone

All subpopulations

Impact on productivity rate mean: 0 , se: NA

Impact on adult survival rate mean: 0.000156 , se: NA

Scenario B - Name: 70/1 in-combination (Low)

All subpopulations

Impact on productivity rate mean: 0 , se: NA

Impact on adult survival rate mean: 0.005074 , se: NA

Scenario C - Name: 70/1 in-combination (High)

All subpopulations

Impact on productivity rate mean: 0 , se: NA

Impact on adult survival rate mean: 0.005074 , se: NA

Output:

First year to include in outputs: 2030

Final year to include in outputs: 2065

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

5.4 Kittiwake FFC SPA

Set up

The log file was created on: 2025-01-10 11:20:21.982782 using Tool version 2, with R version 4.3.0, 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"    "0.8.7"
## DT             "DT"              "0.33"
## plotly         "plotly"          "4.10.4"
## rmarkdown      "rmarkdown"       "2.29"
## 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: 1.

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: 0.8732258 , sd: 0.332329

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: 3.

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 2065

Impact on Demographic Rates

Scenario A - Name: Project alone

All subpopulations

Impact on productivity rate mean: 0 , se: NA

Impact on adult survival rate mean: 0.000174 , se: NA

Scenario B - Name: In-combination (without compensated projects)

All subpopulations

Impact on productivity rate mean: 0 , se: NA

Impact on adult survival rate mean: 0.004872 , se: NA

Scenario C - Name: In-combination (with compensated projects)

All subpopulations

Impact on productivity rate mean: 0 , se: NA

Impact on adult survival rate mean: 0.006943 , se: NA

Output:

First year to include in outputs: 2030

Final year to include in outputs: 2065

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

5.5 Puffin Coquet Island SPA

Set up

The log file was created on: 2025-01-20 16:47:33.759702 using Tool version 2, with R version 4.3.0, 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"    "0.8.7"
## DT             "DT"              "0.33"
## plotly         "plotly"          "4.10.4"
```

```
## rmarkdown       "rmarkdown"       "2.29"
## dplyr           "dplyr"           "1.1.4"
## tidyr           "tidyr"           "1.3.1"
```

Basic information

This run had reference name “Pu Coquet”.

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: 6.

Years for burn-in: 0.

Case study selected: None.

Baseline demographic rates

Species chosen to set initial values: Atlantic Puffin.

Region type to use for breeding success data: MSFD.

Available colony-specific survival rate: National. Sector to use within breeding success region: Greater North Sea.

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 50058 in 2019

Productivity rate per pair: mean: 0.5760227 , sd: 0.3308661

Adult survival rate: mean: 0.907 , sd: 0.083

Immatures survival rates:

Age class 0 to 1 - mean: 0.892 , sd: 0.083 , DD: NA

Age class 1 to 2 - mean: 0.892 , sd: 0.083 , DD: NA

Age class 2 to 3 - mean: 0.892 , sd: 0.083 , DD: NA

Age class 3 to 4 - mean: 0.76 , sd: 0.093 , DD: NA

Age class 4 to 5 - mean: 0.805 , sd: 0.093 , DD: NA

Impacts

Number of impact scenarios: 8.

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 2065

Impact on Demographic Rates

Scenario A - Name: 50/1 project alone (Project)

All subpopulations

Impact on productivity rate mean: 0 , se: NA

Impact on adult survival rate mean: 3.3e-05 , se: NA

Scenario B - Name: 70/2 project alone (Project)

All subpopulations

Impact on productivity rate mean: 0 , se: NA

Impact on adult survival rate mean: 9.3e-05 , se: NA

Scenario C - Name: 50/1 in-combination (Low)

All subpopulations

Impact on productivity rate mean: 0 , se: NA

Impact on adult survival rate mean: 0.000328 , se: NA

Scenario D - Name: 70/2 in-combination (Low)

All subpopulations

Impact on productivity rate mean: 0 , se: NA

Impact on adult survival rate mean: 0.000919 , se: NA

Scenario E - Name: 50/1 project alone (NE)

All subpopulations

Impact on productivity rate mean: 0 , se: NA

Impact on adult survival rate mean: 5.7e-05 , se: NA

Scenario F - Name: 70/2 project alone (NE)

All subpopulations

Impact on productivity rate mean: 0 , se: NA

Impact on adult survival rate mean: 0.000159 , se: NA

Scenario G - Name: 50/1 in-combination (High)

All subpopulations

Impact on productivity rate mean: 0 , se: NA

Impact on adult survival rate mean: 0.000354 , se: NA

Scenario H - Name: 70/2 in-combination (High)

All subpopulations

Impact on productivity rate mean: 0 , se: NA

Impact on adult survival rate mean: 0.00099 , se: NA

Output:

First year to include in outputs: 2030

Final year to include in outputs: 2065

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

5.6 Puffin FFC SPA

Set up

The log file was created on: 2025-01-21 14:25:00.258492 using Tool version 2, with R version 4.3.0, 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"    "0.8.7"
## DT             "DT"              "0.33"
## plotly         "plotly"          "4.10.4"
## rmarkdown      "rmarkdown"       "2.29"
## dplyr          "dplyr"           "1.1.4"
## tidyr          "tidyr"           "1.3.1"
```

Basic information

This run had reference name “Pu 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: 7.

Years for burn-in: 0.

Case study selected: None.

Baseline demographic rates

Species chosen to set initial values: Atlantic Puffin.

Region type to use for breeding success data: MSFD.

Available colony-specific survival rate: National. Sector to use within breeding success region: Greater North Sea.

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 3080 in 2022

Productivity rate per pair: mean: 0.5760227 , sd: 0.3308661

Adult survival rate: mean: 0.907 , sd: 0.083

Immatures survival rates:

Age class 0 to 1 - mean: 0.892 , sd: 0.083 , DD: NA

Age class 1 to 2 - mean: 0.892 , sd: 0.083 , DD: NA

Age class 2 to 3 - mean: 0.892 , sd: 0.083 , DD: NA

Age class 3 to 4 - mean: 0.76 , sd: 0.093 , DD: NA

Age class 4 to 5 - mean: 0.805 , sd: 0.093 , DD: NA

Impacts

Number of impact scenarios: 8.

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 2065

Impact on Demographic Rates

Scenario A - Name: 50/1 project alone (Project)

All subpopulations

Impact on productivity rate mean: 0 , se: NA

Impact on adult survival rate mean: 0.000132 , se: NA

Scenario B - Name: 70/2 project alone (Project)

All subpopulations

Impact on productivity rate mean: 0 , se: NA

Impact on adult survival rate mean: 0.000369 , se: NA

Scenario C - Name: 50/1 in-combination (Low)

All subpopulations

Impact on productivity rate mean: 0 , se: NA

Impact on adult survival rate mean: 0.002128 , se: NA

Scenario D - Name: 70/2 in-combination (Low)

All subpopulations

Impact on productivity rate mean: 0 , se: NA

Impact on adult survival rate mean: 0.005959 , se: NA

Scenario E - Name: 50/1 project alone (NE)

All subpopulations

Impact on productivity rate mean: 0 , se: NA

Impact on adult survival rate mean: 0.000235 , se: NA

Scenario F - Name: 70/2 project alone (NE)

All subpopulations

Impact on productivity rate mean: 0 , se: NA

Impact on adult survival rate mean: 0.000657 , se: NA

Scenario G - Name: 50/1 in-combination (High)

All subpopulations

Impact on productivity rate mean: 0 , se: NA

Impact on adult survival rate mean: 0.00226 , se: NA

Scenario H - Name: 70/2 in-combination (High)

All subpopulations

Impact on productivity rate mean: 0 , se: NA

Impact on adult survival rate mean: 0.006328 , se: NA

Output:

First year to include in outputs: 2030

Final year to include in outputs: 2065

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

5.7 Puffin Farne Islands SPA

Set up

The log file was created on: 2025-01-21 14:44:39.255518 using Tool version 2, with R version 4.3.0, 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"    "0.8.7"
## DT             "DT"              "0.33"
## plotly         "plotly"          "4.10.4"
## rmarkdown      "rmarkdown"       "2.29"
## dplyr          "dplyr"           "1.1.4"
## tidyr          "tidyr"           "1.3.1"
```

Basic information

This run had reference name “Pu Farne 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: 8.

Years for burn-in: 5.

Case study selected: None.

Baseline demographic rates

Species chosen to set initial values: Atlantic Puffin.

Region type to use for breeding success data: Site.

Available colony-specific survival rate: National. Sector to use within breeding success region: Farne Islands SPA;Farne Islands.

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 87504 in 2019

Productivity rate per pair: mean: 0.7690909 , sd: 0.1753611

Adult survival rate: mean: 0.907 , sd: 0.083

Immatures survival rates:

Age class 0 to 1 - mean: 0.892 , sd: 0.083 , DD: NA

Age class 1 to 2 - mean: 0.892 , sd: 0.083 , DD: NA

Age class 2 to 3 - mean: 0.892 , sd: 0.083 , DD: NA

Age class 3 to 4 - mean: 0.76 , sd: 0.093 , DD: NA

Age class 4 to 5 - mean: 0.805 , sd: 0.093 , DD: NA

Impacts

Number of impact scenarios: 6.

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 2065

Impact on Demographic Rates

Scenario A - Name: 50/1 project alone (Project)

All subpopulations

Impact on productivity rate mean: 0 , se: NA

Impact on adult survival rate mean: 8e-06 , se: NA

Scenario B - Name: 70/2 project alone (Project)

All subpopulations

Impact on productivity rate mean: 0 , se: NA

Impact on adult survival rate mean: 2.3e-05 , se: NA

Scenario C - Name: 50/1 in-combination (Low)

All subpopulations

Impact on productivity rate mean: 0 , se: NA

Impact on adult survival rate mean: 0.00055 , se: NA

Scenario D - Name: 70/2 in-combination (Low)

All subpopulations

Impact on productivity rate mean: 0 , se: NA

Impact on adult survival rate mean: 0.001541 , se: NA

Scenario E - Name: 50/1 in-combination (High)

All subpopulations

Impact on productivity rate mean: 0 , se: NA

Impact on adult survival rate mean: 0.000552 , se: NA

Scenario F - Name: 70/2 in-combination (High)

All subpopulations

Impact on productivity rate mean: 0 , se: NA

Impact on adult survival rate mean: 0.001546 , se: NA

Output:

First year to include in outputs: 2030

Final year to include in outputs: 2065

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

~~5.1~~5.8Razorbill FFC SPA

Set up

The log file was created on: 2025-01-09 21:18:16.711488 using Tool version 2, with R version 4.3.0, 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"    "0.8.7"
## DT             "DT"              "0.33"
## plotly         "plotly"          "4.10.4"
## rmarkdown      "rmarkdown"       "2.29"
## dplyr          "dplyr"           "1.1.4"
## tidyr          "tidyr"           "1.3.1"
```

Basic information

This run had reference name “RA 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: 4.

Years for burn-in: 5.

Case study selected: None.

Baseline demographic rates

Species chosen to set initial values: Razorbill.

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 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: 0.63 , sd: 0.067 , DD: NA

Age class 1 to 2 - mean: 0.63 , 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: 8.

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 2065

Impact on Demographic Rates

Scenario A - Name: 50/1 project alone (Project)

All subpopulations

Impact on productivity rate mean: 0 , se: NA

Impact on adult survival rate mean: 0.000171 , se: NA

Scenario B - Name: 70/2 project alone (Project)

All subpopulations

Impact on productivity rate mean: 0 , se: NA

Impact on adult survival rate mean: 0.000479 , se: NA

Scenario C - Name: 50/1 in-combination (Low)

All subpopulations

Impact on productivity rate mean: 0 , se: NA

Impact on adult survival rate mean: 0.000997 , se: NA

Scenario D - Name: 70/2 in-combination (Low)

All subpopulations

Impact on productivity rate mean: 0 , se: NA

Impact on adult survival rate mean: 0.002792 , se: NA

Scenario E - Name: 50/1 project alone (NE)

All subpopulations

Impact on productivity rate mean: 0 , se: NA

Impact on adult survival rate mean: 0.000401 , se: NA

Scenario F - Name: 70/2 project alone (NE)

All subpopulations

Impact on productivity rate mean: 0 , se: NA

Impact on adult survival rate mean: 0.001124 , se: NA

Scenario G - Name: 50/1 in-combination (High)

All subpopulations

Impact on productivity rate mean: 0 , se: NA

Impact on adult survival rate mean: 0.00155 , se: NA

Scenario H - Name: 70/2 in-combination (High)

All subpopulations

Impact on productivity rate mean: 0 , se: NA

Impact on adult survival rate mean: 0.004339 , se: NA

Output:

First year to include in outputs: 2030

Final year to include in outputs: 2065

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