Environmental Impact Assessment Report
Volume 3, Appendix 12.4: Offshore Ornithology EIA
Population Viability Analysis Report

MarramWind Offshore Wind Farm

December 2025

MarramWind

Document code:	MAR-GEN-ENV-REP-WSP-000143
Contractor document number:	852346-WEIS-IA-O1-RP-O6-373987
Version:	Final for Submission
Date:	08/12/2025
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1. Introduction

1.1 Background

1.1.1.1 The following Appendix has been created to provide background information, display the methodology used for, and present the results of population viability analysis (PVA) for the proposed MarramWind Offshore Wind Farm (hereafter, referred to as 'the Project'). This Appendix should be read in conjunction with **Volume 1, Chapter 12: Offshore and Intertidal Ornithology**.

1.2 Population viability analysis

1.2.1.1 Marine renewable energy developments, including offshore wind farms, have the potential to affect seabirds through pathways such as distributional responses and collision risk with turbine blades. These impacts occur at the individual level but may also influence population-level dynamics by reducing productivity or increasing baseline mortality. As part of the Environmental Impact Assessment (EIA) process, these potential effects are evaluated across various population scales. Additionally, the Habitat Regulations Appraisal (HRA) considers these impacts in relation to individual Special Protection Area (SPA) colonies and the wider population context.

1.2.1.2 For species predicted to experience elevated mortality due to distributional changes and/or collision risk, it is necessary to assess the potential population-level consequences. PVA is used to estimate these effects, either in isolation or cumulatively with other developments. PVA provides a robust and accessible framework for projecting future population trends using demographic parameters. The approach involves comparing a baseline scenario, representing natural population growth under assumed conditions, with one or more impact scenarios, where demographic parameters such as survival or productivity are adjusted to reflect predicted offshore wind farm related effects.

1.2.1.3 PVA was carried out for both EIA and HRA, assessing the predicted mortalities on a regional scale and at impacted SPAs. The EIA PVA results are presented in **Section 3** and SPA specific assessments are presented in the **Report to Inform Appropriate Assessment**.

2. Method

2.1 Overview

2.1.1.1 PVA was carried out in accordance with NatureScot Guidance Note 11 (2023). The guidance threshold recommended for use of PVA is a predicted change of 0.02% in the adult survival rate of each species scoped in for assessment. Following this guidance, the analysis was conducted using the Seabird PVA Tool developed by the UK Centre for Ecology and Hydrology and Biomathematics and Statistics Scotland, under contract to Natural England and Joint Nature Conservation Committee (JNCC) (Searle *et al.*, 2019). The code required to run the tool was obtained from the Natural England GitHub repository, which is publicly accessible to download (Natural England, 2025). The tool was run via the 'Shiny App' interface, which provides a user-friendly graphical interface for the underlying functions of the nepva R package (tool v2.0, code v4.18, interface v1.7).

2.2 Modelling approach

2.2.1.1 All PVA models were conducted using the 'Simulation' run type. This approach simulates population trajectories based on defined demographic parameters, initial population sizes, and scenario-specific conditions.

2.2.1.2 Stochastic modelling was employed to incorporate probabilistic variation arising from environmental and demographic stochasticity. Environmental stochasticity reflects random fluctuations in external factors such as weather and is represented in the model by generating random survival values from a probability distribution across time steps. Demographic stochasticity accounts for random variation in individual survival and reproduction outcomes, even when average rates remain constant. In the NEPVA model, this is implemented using a binomial process. For example, if individuals have a 90% survival probability, the actual number surviving will vary between simulations due to chance. While demographic stochasticity has minimal influence on populations exceeding 100 individuals, it does not affect model outputs for larger populations (Wildfowl and Wetlands Trust Consulting, 2012).

2.2.1.3 All PVA simulations in this report incorporated both environmental and demographic stochasticity. Each model was run for 5,000 iterations, focussing on the anticipated 35-year operational lifespan of the Project. In line with NatureScot guidance, results for 50-year timeframes are also presented.

2.2.1.4 A ten-year "burn-in" period was included in each model, where applicable, to allow the population structure to stabilise prior to the application of development-related impacts. This stabilisation reflects internal model parameterisation, ensuring a balanced age structure (e.g., immature to adult ratios). For species with small population sizes, no burn-in was applied in that specific PVA run.

2.2.1.5 The demographic parameters used in the PVA are detailed in **Table 2.1**. Input log files and other outputs generated via the Shiny App interface were stored and are presented in **Appendix A**.

2.2.1.6 Demographic processes such as survival, productivity, recruitment, and growth are influenced by population density. These density-dependent effects can be either compensatory or depensatory (Begon *et al.*, 2005). Compensatory mechanisms tend to stabilise population size over time, while depensatory effects reduce population growth rates in already declining populations, often delaying recovery. Depensation typically occurs in small or depleted populations due to reduced benefits from conspecific interactions.

2.2.1.7 Density dependence is a fundamental ecological principle, preventing unchecked population growth. Although evidence suggests that seabird populations are subject to density-dependent regulation, the specific mechanisms remain poorly understood (Horswill *et al*., 2016). Mis-specification of density dependence in PVA models can lead to unreliable predictions. Consequently, density-independent models are commonly used in seabird impact assessments to maintain a precautionary approach. These models do not allow for population recovery once a decline has occurred, making them suitable for assessing potential impacts. However, they may also produce projections of exponential growth in the absence of a defined carrying capacity (Ridge *et al*., 2019).

2.2.1.8 The species included in the PVA analysis are:

- black-legged kittiwake (*Rissa tridactyla*), hereafter 'kittiwake';
- northern gannet (*Morus bassanus*), hereafter 'gannet';
- great black-backed gull (*Larus marinus*);
- herring gull (*Larus argentatus*);
- common guillemot (*Uria aalge*), hereafter 'guillemot';
- razorbill (*Alca torda*); and
- Atlantic puffin (*Fratercula arctica*), hereafter 'puffin'.

2.2.1.9 The above species were selected for PVA due to impact predictions from the Project alone or cumulatively exceeding a 0.02% change in survival rate, which is the threshold recommended within NatureScot's Guidance Note 11 (NatureScot, 2023) for requiring PVA.

2.3 Population viability analysis demographic parameters

2.3.1.1 Species-specific survival and productivity rates were sourced from Horswill and Robinson (2015) and are summarised in **Table 2.1**, with further detail provided in the following subsections. For great black-backed gull, juvenile and adult survival rates from age classes 1 to 2 to 4 to 5 were adopted from herring gull data, as recommended by the authors, due to limited species-specific data availability.

2.3.1.2 Survival rates differ across age classes. Age class 0 to 1 represents birds less than one year old, 1 to 2 includes birds under two years, and 2 to 3 includes birds aged two, and so on. Adult birds are grouped together, as survival rates tend to stabilise once maturity is reached. Age at first breeding and maximum brood size per pair were selected from the predefined values available within the PVA Tool (Searle *et al*., 2019).

2.3.1.3 The largest annual Biologically Defined Maximum Population Size (BDMPS) was selected for use within the PVA as an initial population size for most species (Furness, 2015). However, for herring gull, guillemot and puffin specific regional populations were selected based on guidance from NatureScot. The methodology used to calculate specific annual regional population sizes can be found in **Volume 1, Chapter 12: Offshore and Intertidal Ornithology**.

2.3.1.4 Initial population sizes used to assess impacts on adult annual survival under each scenario are presented in **Table 2.2**.

Table 2.1 Summary of demographic rates for PVA species. (Horswill and Robinson (2015), unless described in text as separate calculation

Species	Adult survival rate (standard deviation (SD))	Productivity (SD) (per pair)	Age of recruitment	Brood size (per pair)	Survival 0 to 1 (SD)	Survival 1 to 2 (SD)	Survival 2 to 3 (SD)	Survival 3 to 4 (SD)	Survival 4 to5 (SD)	Survival 5 to 6 (SD)
Kittiwake	0.854 (0.051)	0.690 (0.296)	4	2	0.790 (0.0001)	0.854 (0.051)	0.854 (0.051)	0.854 (0.051)	-	-
Gannet	0.919 (0.042)	0.700 (0.082)	5	1	0.424 (0.007)	0.829 (0.004)	0.891 (0.003)	0.895 (0.003)	0.919 (0.042)	-
Great black-backed gull	0.930 (0.0001)	1.139 (0.533)	5	3	0.798 (0.092)	0.834 (0.034)	0.834 (0.034)	0.834 (0.034)	0.834 (0.034)	-
Herring gull	0.834 (0.034)	0.920 (0.477)	5	3	0.798 (0.092)	0.834 (0.034)	0.834 (0.034)	0.834 (0.034)	0.834 (0.034)	-
Guillemot	0.939 (0.015)	0.672 (0.147)	6	1	0.560 (0.001)	0.792 (0.001)	0.917 (0.001)	0.939 (0.015)	0.939 (0.015)	0.939 (0.015)
Puffin	0.906 (0.083)	0.617 (0.151)	5	1	0.709 (0.001)	0.790 (0.001)	0.790 (0.001)	0.760 (0.001)	0.805 (0.001)	-
Razorbill	0.895 (0.067)	0.570 (0.247)	5	1	0.630 (0.209)	0.630 (0.209)	0.895 (0.067)	0.895 (0.067)	0.895 (0.067)	-

Table 2.2 Season specific population estimates used in PVA

Species	Season	BDMPS region	Population estimates
Kittiwake	Annual (BDMPS)	UK North Sea	829,937
Gannet	Annual (BDMPS)	UK North Sea and Channel	456,298
Great black-backed gull	Annual (BDMPS)	UK North Sea	91,399
Herring gull	Annual (regional)	-	307,422
Guillemot	Annual (regional)	-	189,381
Puffin	Annual (regional)	-	248,313
Razorbill	Annual (BDMPS)	UK North Sea and Channel	591,874

2.4 Population viability analysis outputs

2.4.1.1 The PVA Tool outputs focus on two key metrics: the counterfactual of population growth rate (CGR) and the counterfactual of population size (CPS) (Searle *et al*., 2019). These metrics compare projected outcomes under impact scenarios with those under baseline (unimpacted) conditions, allowing interpretation of potential population-level effects (Cook and Robinson, 2016). CPS represents the median ratio of the final population size under the impact scenario relative to the baseline scenario. CGR reflects the median ratio of the annual population growth rate under the impact scenario compared to the baseline. Both metrics are expressed as proportions.

2.4.1.2 For assessments using density-independent models, CGR is considered the more appropriate metric. This is because CPS can produce unrealistic projections in the absence of density-dependent regulation. Accordingly, greater emphasis has been placed on CGR within the assessment conclusions, while also considering both short- and long-term population trends.

3. Results

3.1 Overview

3.1.1.1 PVA results for each species are presented below, using the median values for both the CGR and CPS, as shown in **Table 3.1** to **Table 3.13**. Outputs are provided for 35-year and 50-year timeframes. Detailed log files for each species are available in **Appendix A**.

3.2 Kittiwake

3.2.1 Cumulative

Table 3.1 Kittiwake PVA results cumulative

			35 Years		50 Years	
Scenario	**Estimated mortalities**	**Impact on adult survival**	**Median CGR**	**Median CPS**	**Median CGR**	**Median CPS**
Displacement low (30,1)	302.72	0.000365	1.000	0.985	1.000	0.978
Displacement high (30,3)	908.16	0.001094	0.999	0.954	0.999	0.936
Collision	4,010.63	0.004832	0.994	0.814	0.994	0.746
Combined low (30,1)	4,313.35	0.005197	0.994	0.801	0.994	0.730
Combined high (30,3)	4,918.79	0.005927	0.993	0.776	0.993	0.699

3.3 Gannet

3.3.1 Cumulative

Table 3.2 Gannet PVA results cumulative (Guidance approach)

			35 Years		50 Years	
Scenario	**Estimated mortalities**	**Impact on adult survival**	**Median CGR**	**Median CPS**	**Median CGR**	**Median CPS**
Displacement low (70,1)	511.89	0.001122	0.999	0.953	0.999	0.934
Displacement high (70,3)	1,535.67	0.003365	0.996	0.866	0.996	0.816
Collision	1,071.15	0.002347	0.997	0.905	0.997	0.868
Combined low (70,1)	1,583.04	0.003469	0.996	0.862	0.996	0.811
Combined high (70,3)	2,606.82	0.005713	0.993	0.783	0.993	0.708

Table 3.3 Gannet PVA results cumulative (Developer approach)

			35 Years		50 Years	
Scenario	**Estimated mortalities**	**Impact on adult survival**	**Median CGR**	**Median CPS**	**Median CGR**	**Median CPS**
Displacement low (60,1)	438.76	0.000962	0.999	0.960	0.999	0.944
Displacement high (80,1)	585.02	0.001282	0.998	0.947	0.998	0.925
Collision	1,071.15	0.002347	0.997	0.905	0.997	0.868
Combined low (60,1)	1,509.92	0.003309	0.996	0.868	0.996	0.819
Combined high (80,1)	1,656.17	0.003630	0.996	0.856	0.996	0.803

3.4 Great black-backed gull

3.4.1 Alone

Table 3.4 Great black-backed gull PVA results alone

			35 Years		50 Years	
Scenario	**Estimated mortalities**	**Impact on adult survival**	**Median CGR**	**Median CPS**	**Median CGR**	**Median CPS**
Collision	19.50	0.000213	1.000	0.991	1.000	0.988

3.4.2 Cumulative

Table 3.5 Great black-backed gull PVA results cumulative

			35 Years		50 Years	
Scenario	**Estimated mortalities**	**Impact on adult survival**	**Median CGR**	**Median CPS**	**Median CGR**	**Median CPS**
Collision	1,250.54	0.013682	0.984	0.569	0.984	0.450

3.5 Herring gull

3.5.1 Cumulative

Table 3.6 Herring gull PVA results cumulative

			35 Years		50 Years	
Scenario	**Estimated mortalities**	**Impact on adult survival**	**Median CGR**	**Median CPS**	**Median CGR**	**Median CPS**
Collision	28.29	0.000092	1.000	0.996	1.000	0.995

3.6 Guillemot

3.6.1 Alone

Table 3.7 Guillemot PVA results alone (Guidance approach)

			35 Years		50 Years	
Scenario	**Estimated mortalities**	**Impact on adult survival**	**Median CGR**	**Median CPS**	**Median CGR**	**Median CPS**
Displacement low (breeding (B): 60,3 and non-breeding (NB): 60,1)	337.22	0.001781	0.998	0.930	0.998	0.903
Displacement high (B: 60,5 and NB: 60,3)	603.94	0.003189	0.996	0.879	0.996	0.832

Table 3.8 Guillemot PVA results alone (Developer approach)

			35 Years		50 Years	
Scenario	**Estimated mortalities**	**Impact on adult survival**	**Median CGR**	**Median CPS**	**Median CGR**	**Median CPS**
Displacement high (50,1)	111.13	0.000587	0.999	0.976	0.999	0.967

3.6.2 Cumulative

Table 3.9 Guillemot PVA results cumulative (Guidance approach)

			35 Years		50 Years	
Scenario	**Estimated Mortalities**	**Impact on Adult Survival**	**Median CGR**	**Median CPS**	**Median CGR**	**Median CPS**
Displacement low (B: 60,3 and NB: 60,1)	1,494.31	0.007891	0.991	0.726	0.991	0.635
Displacement high (B: 60,5 and NB: 60,3)	2,984.62	0.015760	0.982	0.525	0.982	0.402

Table 3.10 Guillemot PVA results cumulative (Developer approach)

			35 Years		50 Years	
Scenario	**Estimated mortalities**	**Impact on adult survival**	**Median CGR**	**Median CPS**	**Median CGR**	**Median CPS**
Displacement high (50,1)	620.96	0.003279	0.996	0.875	0.996	0.828

3.7 Puffin

3.7.1 Cumulative

Table 3.11 Puffin PVA results cumulative (Guidance approach)

			35 Years		50 Years	
Scenario	**Estimated mortalities**	**Impact on adult survival**	**Median CGR**	**Median CPS**	**Median CGR**	**Median CPS**
Displacement low (B: 60,3 and NB: 60,1)	1,020.83	0.004111	0.995	0.839	0.998	0.897
Displacement high (B: 60,5 and NB: 60,3)	2,040.83	0.008219	0.990	0.704	0.995	0.780

Table 3.12 Puffin PVA Results Cumulative (Developer approach)

			35 Years		50 Years	
Scenario	**Estimated Mortalities**	**Impact on Adult Survival**	**Median CGR**	**Median CPS**	**Median CGR**	**Median CPS**
Displacement High (50,1)	447.07	0.001800	0.998	0.926	0.990	0.608

3.8 Razorbill

3.8.1 Cumulative

Table 3.13 Razorbill PVA results cumulative (Guidance approach)

			35 Years		50 Years	
Scenario	**Estimated mortalities**	**Impact on adult survival**	**Median CGR**	**Median CPS**	**Median CGR**	**Median CPS**
Displacement low (B: 60,3 and NB: 60,1)	1,269.57	0.002145	0.997	0.912	0.997	0.879
Displacement high (B: 60,5 and NB: 60,3)	3,552.94	0.006003	0.993	0.774	0.993	0.696

Table 3.14 Razorbill PVA results cumulative (Developer approach)

			35 Years		50 Years	
Scenario	**Estimated mortalities**	**Impact on adult survival**	**Median CGR**	**Median CPS**	**Median CGR**	**Median CPS**
Displacement high (50,1)	1,160.21	0.001960	0.998	0.920	0.998	0.888

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5. Glossary of Terms and Abbreviations

5.1 Abbreviations

Acronym	Definition
B	Breeding
BDMPS	Biologically Defined Maximum Population Scale
CGR	Counterfactual of Population Growth
CPS	Counterfactual of Population Size
EIA	Environmental Impact Assessment
HRA	Habitats Regulations Appraisal
JNCC	Joint Nature Conservation Committee
NB	Non-Breeding
PVA	Population Viability Analysis
SD	Standard Deviation
SPA	Special Protection Area

5.2 Glossary of terms

Term	Definition
All Individuals	The whole population including all adults and juveniles
Cumulative effects	The combined effect of the project together with the effects from a number of different projects, on the same single receptor/resource. Cumulative impacts are those that result from changes caused by other past, present or reasonably foreseeable actions together with the Project.
Demographic Parameter	A factor that determines the population size.
Density Dependence	The influence of population size or density on one or more demographic parameters.
Population Viability Analysis	The process of determining the probability that a population will persist over a specified time period.
Probabilistic	Based on a theory of probability involving chance variation.
Productivity	The annual population estimate of number of chicks fledged per pair.

Term	Definition
Shiny App	User-friendly graphical user interface accessible via a standard web-browser that uses underlying R code.
Stochasticity	The lack of any predictable order or plan.
Survival Rate	The probability of an individual to survive from one breeding season to the next.

Appendix A
Log Files

Kittiwake Cumulative

Set up

The log file was created on: 2025-10-08 11:17:14.492977 using Tool version 2, with R version 4.5.1, PVA package version: 4.18 (with UI version 1.7) .

```
##               Package          Version
## popbio         "popbio"         "2.8"
## shiny          "shiny"          "1.11.1"
## shinyjs        "shinyjs"        "2.1.0"
## shinydashboard "shinydashboard" "0.7.3"
## shinyWidgets   "shinyWidgets"   "0.9.0"
## DT             "DT"             "0.34.0"
## plotly         "plotly"         "4.11.0"
## rmarkdown      "rmarkdown"      "2.30"
## dplyr          "dplyr"          "1.1.4"
## tidyr          "tidyr"          "1.3.1"
```

Basic information

This run had reference name “Kittiwake_Cumulative_EIA”.
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: 6018.
Years for burn-in: 0.
Case study selected: None.

Baseline demographic rates

Species chosen to set initial values: Black-Legged Kittiwake.
Region type to use for breeding success data: Global.
Available colony-specific survival rate: National. Sector to use within breeding success region: Global.
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: all.individuals
Are baseline demographic rates specified separately for immatures?: Yes.

Population 1

Initial population values: Initial population 829937 in 2025
Productivity rate per pair: mean: 0.69 , sd: 0.296
Adult survival rate: mean: 0.854 , sd: 0.051
Immatures survival rates:
Age class 0 to 1 - mean: 0.79 , sd: 1e-07 , DD: NA

Age class 1 to 2 - mean: 0.854 , sd: 0.051 , DD: NA
Age class 2 to 3 - mean: 0.854 , sd: 0.051 , DD: NA
Age class 3 to 4 - mean: 0.854 , sd: 0.051 , DD: NA

Impacts

Number of impact scenarios: 5.
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: 2035 to 2085

Impact on Demographic Rates

Scenario A - Name: Cumulative_Disp_Annual_Low

All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.000365 , se: NA

Scenario B - Name: Cumulative_Disp_Annual_High

All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.001094 , se: NA

Scenario C - Name: Cumulative_CRM_Annual

All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.004832 , se: NA

Scenario D - Name: Cumulative_Combined_Annual_Low

All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.005197 , se: NA

Scenario E - Name: Cumulative_Combined_Annual_High

All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.005927 , se: NA

Output:

First year to include in outputs: 2035
Final year to include in outputs: 2085
How should outputs be produced, in terms of ages?: whole.population
Target population size to use in calculating impact metrics: NA
Quasi-extinction threshold to use in calculating impact metrics: NA

Gannet Cumulative (Guidance Approach)

Set up

The log file was created on: 2025-10-07 17:04:24.354961 using Tool version 2, with R version 4.5.1, PVA package version: 4.18 (with UI version 1.7)

```
##               Package         Version
## popbio         "popbio"         "2.8"
## shiny           "shiny"         "1.11.1"
## shinyjs         "shinyjs"        "2.1.0"
## shinydashboard "shinydashboard" "0.7.3"
## shinyWidgets   "shinyWidgets"   "0.9.0"
## DT              "DT"            "0.33"
## plotly          "plotly"        "4.11.0"
## rmarkdown       "rmarkdown"     "2.29"
## dplyr           "dplyr"         "1.1.4"
## tidyr           "tidyr"         "1.3.1"
```

Basic information

This run had reference name “Gannet_Guidance_Cumulative_EIA”.
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: 1275.
Years for burn-in: 0.
Case study selected: None.

Baseline demographic rates

Species chosen to set initial values: Northern Gannet.
Region type to use for breeding success data: Global.
Available colony-specific survival rate: National. Sector to use within breeding success region: Global.
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: all.individuals
Are baseline demographic rates specified separately for immatures?: Yes.

Population 1

Initial population values: Initial population 456298 in 2025
Productivity rate per pair: mean: 0.7 , sd: 0.082
Adult survival rate: mean: 0.919 , sd: 0.042

Immatures survival rates:
Age class 0 to 1 - mean: 0.424 , sd: 1e-07 , DD: NA
Age class 1 to 2 - mean: 0.829 , sd: 1e-07 , DD: NA
Age class 2 to 3 - mean: 0.891 , sd: 1e-07 , DD: NA
Age class 3 to 4 - mean: 0.895 , sd: 1e-07 , DD: NA
Age class 4 to 5 - mean: 0.919 , sd: 0.042 , 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: 2035 to 2085

Impact on Demographic Rates

Scenario A - Name: Guidance_Cumulative_Disp_Annual_Low

All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.001122 , se: NA

Scenario B - Name: Guidance_Cumulative_Disp_Annual_High

All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.003365 , se: NA

Scenario C - Name: Guidance_Cumulative_Combined_Annual_Low

All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.003469 , se: NA

Scenario D - Name: Guidance_Cumulative_Combined_Annual_High

All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.005713 , se: NA

Output:

First year to include in outputs: 2035
Final year to include in outputs: 2085
How should outputs be produced, in terms of ages?: whole.population
Target population size to use in calculating impact metrics: NA
Quasi-extinction threshold to use in calculating impact metrics: NA

Gannet Cumulative (Developer Approach)

Set up

The log file was created on: 2025-10-07 16:41:36.209071 using Tool version 2, with R version 4.5.1, PVA package version: 4.18 (with UI version 1.7)

```
##               Package         Version
## popbio         "popbio"         "2.8"
## shiny           "shiny"         "1.11.1"
## shinyjs         "shinyjs"       "2.1.0"
## shinydashboard "shinydashboard" "0.7.3"
## shinyWidgets   "shinyWidgets"   "0.9.0"
## DT              "DT"            "0.33"
## plotly          "plotly"        "4.11.0"
## rmarkdown       "rmarkdown"     "2.29"
## dplyr           "dplyr"         "1.1.4"
## tidyr           "tidyr"         "1.3.1"
```

Basic information

This run had reference name “Gannet_Developer_Cumulative_EIA”.
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: 7617.
Years for burn-in: 0.
Case study selected: None.

Baseline demographic rates

Species chosen to set initial values: Northern Gannet.
Region type to use for breeding success data: Global.
Available colony-specific survival rate: National. Sector to use within breeding success region: Global.
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: all.individuals
Are baseline demographic rates specified separately for immatures?: Yes.

Population 1

Initial population values: Initial population 456298 in 2025
Productivity rate per pair: mean: 0.7 , sd: 0.082
Adult survival rate: mean: 0.919 , sd: 0.042
Immatures survival rates:
Age class 0 to 1 - mean: 0.424 , sd: 1e-07 , DD: NA
Age class 1 to 2 - mean: 0.829 , sd: 1e-07 , DD: NA

Age class 2 to 3 - mean: 0.891 , sd: 1e-07 , DD: NA
Age class 3 to 4 - mean: 0.895 , sd: 1e-07 , DD: NA
Age class 4 to 5 - mean: 0.919 , sd: 0.042 , DD: NA

Impacts

Number of impact scenarios: 5.
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: 2035 to 2085

Impact on Demographic Rates

Scenario A - Name: Developers_Cumulative_Disp_Annual_Low

All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.000962 , se: NA

Scenario B - Name: Developers_Cumulative_Disp_Annual_High

All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.001282 , se: NA

Scenario C - Name: Cumulative_CRM_Annual

All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.002347 , se: NA

Scenario D - Name: Developers_Cumulative_Combined_Annual_Low

All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.003309 , se: NA

Scenario E - Name: Developers_Cumulative_Combined_Annual_High

All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.00363 , se: NA

Output:

First year to include in outputs: 2035
Final year to include in outputs: 2085
How should outputs be produced, in terms of ages?: whole.population
Target population size to use in calculating impact metrics: NA
Quasi-extinction threshold to use in calculating impact metrics: NA

Great black-backed gull

Set up

The log file was created on: 2025-10-08 14:57:32.253708 using Tool version 2, with R version 4.5.1, PVA package version: 4.18 (with UI version 1.7)

```
##               Package         Version
## popbio         "popbio"         "2.8"
## shiny           "shiny"         "1.11.1"
## shinyjs         "shinyjs"       "2.1.0"
## shinydashboard "shinydashboard" "0.7.3"
## shinyWidgets   "shinyWidgets"   "0.9.0"
## DT              "DT"            "0.34.0"
## plotly          "plotly"        "4.11.0"
## rmarkdown       "rmarkdown"     "2.30"
## dplyr           "dplyr"         "1.1.4"
## tidyr           "tidyr"         "1.3.1"
```

Basic information

This run had reference name “GBBG_CRM_EIA”.
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: 4906.
Years for burn-in: 0.
Case study selected: None.

Baseline demographic rates

Species chosen to set initial values: Great Black-Backed Gull.
Region type to use for breeding success data: Global.
Available colony-specific survival rate: National. Sector to use within breeding success region: Global.
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: all.individuals
Are baseline demographic rates specified separately for immatures?: Yes.

Population 1

Initial population values: Initial population 91399 in 2025
Productivity rate per pair: mean: 1.139 , sd: 0.533
Adult survival rate: mean: 0.93 , sd: 1e-07
Immatures survival rates:
Age class 0 to 1 - mean: 0.798 , sd: 0.092 , DD: NA

Age class 1 to 2 - mean: 0.834 , sd: 0.034 , DD: NA
Age class 2 to 3 - mean: 0.834 , sd: 0.034 , DD: NA
Age class 3 to 4 - mean: 0.834 , sd: 0.034 , DD: NA
Age class 4 to 5 - mean: 0.834 , sd: 0.034 , 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?: No
Are impacts specified as a relative value or absolute harvest?: relative
Years in which impacts are assumed to begin and end: 2035 to 2085

Impact on Demographic Rates

Scenario A - Name: Cumulative_CRM_Annual

All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.013682 , se: NA

Scenario B - Name: Alone_CRM_Annual

All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.000213 , se: NA

Output:

First year to include in outputs: 2035
Final year to include in outputs: 2085
How should outputs be produced, in terms of ages?: whole.population
Target population size to use in calculating impact metrics: NA
Quasi-extinction threshold to use in calculating impact metrics: NA

Herring gull

Set up

The log file was created on: 2025-10-10 11:40:18.316269 using Tool version 2, with R version 4.5.1, PVA package version: 4.18 (with UI version 1.7)

```
##                Package          Version
## popbio          "popbio"          "2.8"
## shiny           "shiny"          "1.11.1"
## shinyjs         "shinyjs"         "2.1.0"
## shinydashboard "shinydashboard" "0.7.3"
## shinyWidgets    "shinyWidgets"    "0.9.0"
## DT              "DT"              "0.34.0"
## plotly          "plotly"          "4.11.0"
## rmarkdown       "rmarkdown"       "2.30"
## dplyr           "dplyr"           "1.1.4"
## tidyr           "tidyr"           "1.3.1"
```

Basic information

This run had reference name “Herring_Gull_CRM_EIA”.
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: 3354.
Years for burn-in: 0.
Case study selected: None.

Baseline demographic rates

Species chosen to set initial values: Herring Gull.
Region type to use for breeding success data: Global.
Available colony-specific survival rate: National. Sector to use within breeding success region: Global.
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: all.individuals
Are baseline demographic rates specified separately for immatures?: Yes.

Population 1

Initial population values: Initial population 307422 in 2025
Productivity rate per pair: mean: 0.92 , sd: 0.477
Adult survival rate: mean: 0.834 , sd: 0.034
Immatures survival rates:

Age class 0 to 1 - mean: 0.794 , sd: 0.092 , DD: NA
Age class 1 to 2 - mean: 0.834 , sd: 0.034 , DD: NA
Age class 2 to 3 - mean: 0.834 , sd: 0.034 , DD: NA
Age class 3 to 4 - mean: 0.834 , sd: 0.034 , DD: NA
Age class 4 to 5 - mean: 0.834 , sd: 0.034 , 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?: No
Are impacts specified as a relative value or absolute harvest?: relative
Years in which impacts are assumed to begin and end: 2035 to 2085

Impact on Demographic Rates

Scenario A - Name: Cumulative_CRM_Annual

All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 9.2e-05 , se: NA

Scenario B - Name: Alone_CRM_Annual

All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 2.4e-05 , se: NA

Output:

First year to include in outputs: 2035
Final year to include in outputs: 2085
How should outputs be produced, in terms of ages?: whole.population
Target population size to use in calculating impact metrics: NA
Quasi-extinction threshold to use in calculating impact metrics: NA

Guillemot Alone

Set up

The log file was created on: 2025-10-08 12:28:20.580218 using Tool version 2, with R version 4.5.1, PVA package version: 4.18 (with UI version 1.7)

```
##               Package         Version
## popbio         "popbio"         "2.8"
## shiny           "shiny"         "1.11.1"
## shinyjs         "shinyjs"       "2.1.0"
## shinydashboard "shinydashboard" "0.7.3"
## shinyWidgets   "shinyWidgets"   "0.9.0"
## DT              "DT"            "0.34.0"
## plotly          "plotly"        "4.11.0"
## rmarkdown       "rmarkdown"     "2.30"
## dplyr           "dplyr"         "1.1.4"
## tidyr           "tidyr"         "1.3.1"
```

Basic information

This run had reference name “Guillemot_Alone_EIA”.
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: 362.
Years for burn-in: 0.
Case study selected: None.

Baseline demographic rates

Species chosen to set initial values: Common Guillemot.
Region type to use for breeding success data: Global.
Available colony-specific survival rate: National. Sector to use within breeding success region: Global.
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: all.individuals
Are baseline demographic rates specified separately for immatures?: Yes.

Population 1

Initial population values: Initial population 189381 in 2025
Productivity rate per pair: mean: 0.672 , sd: 0.147
Adult survival rate: mean: 0.939 , sd: 0.015
Immatures survival rates:

Age class 0 to 1 - mean: 0.56 , sd: 1e-07 , DD: NA
Age class 1 to 2 - mean: 0.792 , sd: 1e-07 , DD: NA
Age class 2 to 3 - mean: 0.917 , sd: 1e-07 , DD: NA
Age class 3 to 4 - mean: 0.939 , sd: 0.015 , DD: NA
Age class 4 to 5 - mean: 0.939 , sd: 0.015 , DD: NA
Age class 5 to 6 - mean: 0.939 , sd: 0.015 , 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?: No
Are impacts specified as a relative value or absolute harvest?: relative
Years in which impacts are assumed to begin and end: 2035 to 2085

Impact on Demographic Rates

Scenario A - Name: Developers_Alone_Disp_Annual_High

All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.000587 , se: NA

Scenario B - Name: Guidance_Alone_Disp_Annual_Low

All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.001781 , se: NA

Scenario C - Name: Guidance_Alone_Disp_Annual_High

All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.003189 , se: NA

Output:

First year to include in outputs: 2035
Final year to include in outputs: 2085
How should outputs be produced, in terms of ages?: whole.population
Target population size to use in calculating impact metrics: NA
Quasi-extinction threshold to use in calculating impact metrics: NA

Guillemot Cumulative

Set up

The log file was created on: 2025-10-08 12:05:43.129852 using Tool version 2, with R version 4.5.1, PVA package version: 4.18 (with UI version 1.7)

```
##               Package         Version
## popbio         "popbio"         "2.8"
## shiny           "shiny"         "1.11.1"
## shinyjs         "shinyjs"       "2.1.0"
## shinydashboard "shinydashboard" "0.7.3"
## shinyWidgets   "shinyWidgets"   "0.9.0"
## DT              "DT"            "0.34.0"
## plotly          "plotly"        "4.11.0"
## rmarkdown       "rmarkdown"     "2.30"
## dplyr           "dplyr"         "1.1.4"
## tidyr           "tidyr"         "1.3.1"
```

Basic information

This run had reference name “Guillemot_Cumulative_EIA”.
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: 362.
Years for burn-in: 0.
Case study selected: None.

Baseline demographic rates

Species chosen to set initial values: Common Guillemot.
Region type to use for breeding success data: Global.
Available colony-specific survival rate: National. Sector to use within breeding success region: Global.
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: all.individuals
Are baseline demographic rates specified separately for immatures?: Yes.

Population 1

Initial population values: Initial population 189381 in 2025
Productivity rate per pair: mean: 0.672 , sd: 0.147
Adult survival rate: mean: 0.939 , sd: 0.015
Immatures survival rates:

Age class 0 to 1 - mean: 0.56 , sd: 1e-07 , DD: NA
Age class 1 to 2 - mean: 0.792 , sd: 1e-07 , DD: NA
Age class 2 to 3 - mean: 0.917 , sd: 1e-07 , DD: NA
Age class 3 to 4 - mean: 0.939 , sd: 0.015 , DD: NA
Age class 4 to 5 - mean: 0.939 , sd: 0.015 , DD: NA
Age class 5 to 6 - mean: 0.939 , sd: 0.015 , 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?: No
Are impacts specified as a relative value or absolute harvest?: relative
Years in which impacts are assumed to begin and end: 2035 to 2085

Impact on Demographic Rates

Scenario A - Name: Developers_Cumulative_Disp_Annual_High

All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.003279 , se: NA

Scenario B - Name: Guidance_Cumulative_Disp_Annual_Low

All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.007891 , se: NA

Scenario C - Name: Guidance_Cumulative_Disp_Annual_High

All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.01576 , se: NA

Output:

First year to include in outputs: 2035
Final year to include in outputs: 2085
How should outputs be produced, in terms of ages?: whole.population
Target population size to use in calculating impact metrics: NA
Quasi-extinction threshold to use in calculating impact metrics: NA

Puffin Cumulative

Set up

The log file was created on: 2025-10-08 14:11:41.568344 using Tool version 2, with R version 4.5.1, PVA package version: 4.18 (with UI version 1.7)

```
##               Package         Version
## popbio         "popbio"         "2.8"
## shiny           "shiny"         "1.11.1"
## shinyjs         "shinyjs"       "2.1.0"
## shinydashboard "shinydashboard" "0.7.3"
## shinyWidgets   "shinyWidgets"   "0.9.0"
## DT              "DT"            "0.34.0"
## plotly          "plotly"        "4.11.0"
## rmarkdown       "rmarkdown"     "2.30"
## dplyr           "dplyr"         "1.1.4"
## tidyr           "tidyr"         "1.3.1"
```

Basic information

This run had reference name “Puffin_Cumulative_EIA”.
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: 7846.
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: Global.
Available colony-specific survival rate: National. Sector to use within breeding success region: Global.
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: all.individuals
Are baseline demographic rates specified separately for immatures?: Yes.

Population 1

Initial population values: Initial population 248313 in 2025
Productivity rate per pair: mean: 0.617 , sd: 0.151
Adult survival rate: mean: 0.906 , sd: 0.083
Immatures survival rates:

Age class 0 to 1 - mean: 0.709 , sd: 1e-07 , DD: NA
Age class 1 to 2 - mean: 0.709 , sd: 1e-07 , DD: NA
Age class 2 to 3 - mean: 0.709 , sd: 1e-07 , DD: NA
Age class 3 to 4 - mean: 0.76 , sd: 1e-07 , DD: NA
Age class 4 to 5 - mean: 0.805 , sd: 1e-07 , 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?: No
Are impacts specified as a relative value or absolute harvest?: relative
Years in which impacts are assumed to begin and end: 2035 to 2085

Impact on Demographic Rates

Scenario A - Name: Developers_Cumulative_Disp_Annual_High

All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.0018 , se: NA

Scenario B - Name: Guidance_Cumulative_Disp_Annual_Low

All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.004111 , se: NA

Scenario C - Name: Guidance_Cumulative_Disp_Annual_High

All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.008219 , se: NA

Output:

First year to include in outputs: 2035
Final year to include in outputs: 2085
How should outputs be produced, in terms of ages?: whole.population
Target population size to use in calculating impact metrics: NA
Quasi-extinction threshold to use in calculating impact metrics: NA

Razorbill Cumulative

Set up

The log file was created on: 2025-10-08 12:45:09.470673 using Tool version 2, with R version 4.5.1, PVA package version: 4.18 (with UI version 1.7)

```
##               Package         Version
## popbio         "popbio"         "2.8"
## shiny           "shiny"         "1.11.1"
## shinyjs         "shinyjs"       "2.1.0"
## shinydashboard "shinydashboard" "0.7.3"
## shinyWidgets   "shinyWidgets"   "0.9.0"
## DT              "DT"            "0.34.0"
## plotly          "plotly"        "4.11.0"
## rmarkdown       "rmarkdown"     "2.30"
## dplyr           "dplyr"         "1.1.4"
## tidyr           "tidyr"         "1.3.1"
```

Basic information

This run had reference name “Razorbill_Cumulative_EIA”.
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: 362.
Years for burn-in: 0.
Case study selected: None.

Baseline demographic rates

Species chosen to set initial values: Razorbill.
Region type to use for breeding success data: Global.
Available colony-specific survival rate: National. Sector to use within breeding success region: Global.
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: all.individuals
Are baseline demographic rates specified separately for immatures?: Yes.

Population 1

Initial population values: Initial population 591874 in 2025
Productivity rate per pair: mean: 0.57 , sd: 0.247
Adult survival rate: mean: 0.895 , sd: 0.067
Immatures survival rates:

Age class 0 to 1 - mean: 0.63 , sd: 0.209 , DD: NA
Age class 1 to 2 - mean: 0.63 , sd: 0.209 , 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: 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?: No
Are impacts specified as a relative value or absolute harvest?: relative
Years in which impacts are assumed to begin and end: 2035 to 2085

Impact on Demographic Rates

Scenario A - Name: Developer_Cumulative_Disp_Annual_High

All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.00196 , se: NA

Scenario B - Name: Guidance_Cumulative_Disp_Annual_Low

All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.002145 , se: NA

Scenario C - Name: Guidance_Cumulative_Disp_Annual_High

All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.006003 , se: NA

Output:

First year to include in outputs: 2035
Final year to include in outputs: 2085
How should outputs be produced, in terms of ages?: whole.population
Target population size to use in calculating impact metrics: NA
Quasi-extinction threshold to use in calculating impact metrics: NA

MarramWind