Hornsea Project Four: Reports

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B2.2 Report to Inform Appropriate Assessment Part 11: Appendix H: Offshore Ornithology FFC SPA Population Viability Analysis

Prepared APEM Ltd., September 2021
Checked GoBe Consultants Ltd, September 2021
Accepted Sarah Randall, Orsted. September 2021
Approved Julian Carolan, Orsted. September 2021

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Glossary

Term	Definition
All Individuals	The whole population including all adults and juveniles
Bio-Season	Bird behaviour and abundance is recognised to differ across a calendar year, with particular months recognised as being part of different seasons. The biologically defined minimum population scales (BDMPS) bio-seasons used in this report are based on those in Furness (2015), hereafter referred to as bio-seasons. Separate bio-seasons are recognised in this technical report in order to establish the level of importance any seabird species has within the study area during any particular period of time.
Breeding Adults	Adults at breeding age proportion of a population.
Demographic Parameter	A factor that determines the population size.
Density Dependence	The influence of population size or density on one or more demographic parameters.
Development Consent Order (DCO)	An order made under the Planning Act 2008 granting development consent for one or more Nationally Significant Infrastructure Projects (NSIPs).
Hornsea Project Four Offshore Wind Farm	The term covers all elements of the project (i.e. both the offshore and onshore). Hornsea Four infrastructure will include offshore generating stations (wind turbines), electrical export cables to landfall, and connection to the electricity transmission network. Hereafter referred to as Hornsea Four.
In-Combination Effect	The combined action of different environmental topic-specific impacts on the same resource/receptor.
Orsted Hornsea Project Four Ltd	The Applicant for the proposed Hornsea Project Four Offshore Wind Farm Development Consent Order (DCO).
Population Viability Analysis (PVA)	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.
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.

Acronyms

Acronym	Definition
AfL	Agreement for Lease
AON	Apparently Occupied Nest
BDMPS	Biologically Defined Minimum Population Scale
CEA	Cumulative Effects Assessment
CRM	Collision Risk Modelling
DCO	Development Consent Order
EIA	Environmental Impact Assessment
EP	Evidence Plan
ES	Environmental Statement
FFC	Flamborough and Filey Coast
JNCC	Joint Nature Conservation Committee
NMC	Non Material Change
OWF	Offshore Wind Farm
PEIR	Preliminary Environmental Information Report
PVA	Population Viability Analysis
RIAA	Report to Inform Appropriate Assessment
RSPB	Royal Society for the Protection of Birds
SD	Standard Deviation
SMP	Seabird Monitoring Programme
SPA	Special Protection Area
WTG	Wind Turbine Generator

Units

Unit	Definition
km	Kilometre
km^2	Kilometre squared
%	Percentage (proportion)

1 Introduction

1.1 Project Background

1.1.1.1 Orsted Hornsea Project Four Ltd. (hereafter the 'Applicant') is proposing to develop the Hornsea Project Four Offshore Wind Farm (hereafter 'Hornsea Four'). Hornsea Four will be located approximately 69 km offshore from coastline of the East Riding of Yorkshire in the Southern North Sea, with the array area covering an area of approximately 468 km^2 and will be the fourth project to be developed in the former Hornsea Zone. Hornsea Four will include both offshore and onshore infrastructure including an offshore generating station (wind farm), export cables to landfall, and connection to the electricity transmission network (please see **Volume A1, Chapter 4: Project Description** for full details on the Project Design).

1.1.1.2 The Hornsea Four Agreement for Lease (AfL) area was 846 km^2 at the Scoping phase of project development. In the spirit of keeping with Hornsea Four's approach to Proportionate Environmental Impact Assessment (EIA), the project gave due consideration to the size and location (within the existing AfL area of the final project that is being taken forward to Development Consent Order (DCO) application). This consideration is captured internally as the "Developable Area Process", which includes Physical, Biological and Human constraints in refining the developable area, balancing consenting and commercial considerations with technical feasibility for construction.

1.1.1.3 The combination of Hornsea Four's Proportionality in EIA and Developable Area process have resulted in a marked reduction in the array area taken forward at the point of DCO application. Hornsea Four adopted a major site reduction from the array area presented at Scoping (846 km^2) to the Preliminary Environmental Information Report (PEIR) boundary (600 km^2), with a further reduction adopted for the Environmental Statement (ES) and DCO application (468 km^2) due to the results of the PEIR, technical considerations and stakeholder feedback. The evolution of the Hornsea Four Order Limits is detailed in **Volume A1, Chapter 3: Site Selection and Consideration of Alternatives** and **Volume A4, Annex 3.2: Selection and Refinement of the Offshore Infrastructure**.

1.1.1.4 APEM Ltd (hereafter APEM) was commissioned by the Applicant to undertake a modelling exercise to assess the potential for impacts from Hornsea Four alone and in-combination with other projects for specific seabirds from the Flamborough and Filey Coast Special Protection Area (FFC SPA) colony through the use of Population Viability Analysis (PVA). This technical appendix contains the methodology and results of the PVAs run for the selected seabirds and was produced to support **Volume B2.2, Report to Inform Appropriate Assessment**.

1.1.1.5 The consideration of offshore and intertidal ornithology for Hornsea Four has been discussed with consultees through the Hornsea Four Evidence Plan (EP) process; specifically with the Offshore and Intertidal Ornithology Evidence Plan Technical Panel (hereafter EP Technical Panel) of which Natural England and the Royal Society for the Protection of Birds (RSPB) are members. Agreements made with consultees within the EP process are set out in the topic specific EP Logs, which are appendices to the Hornsea Four Evidence Plan (**B1.1.1: Evidence Plan**), an annex of the Hornsea Four Consultation Report (**Volume B1, Chapter 1: Consultation Report**). All agreements with Natural England and the RSPB within the EP Logs have unique identifier codes, which have been used throughout this document to signpost to the specific agreements made (e.g. OFF-ORN-2.1).

1.2 Population Viability Analysis

1.2.1.1 Renewable energy projects in the marine environment, such as Offshore Wind Farms (OWFs), have the potential to impact on seabirds through a number of processes such as collision with turbine blades resulting in mortality, or displacement from an area due to the presence of Wind Turbine Generators (WTGs). These processes affect individuals, but the in-combination effects (when the project alone effects are considered alongside any effects from other projects on the same receptor) have the potential to effect species at the colony level through altering the productivity of a species from a specific colony or designated population or elevating the baseline mortality of a colony or designated population.

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

1.2.1.3 For Hornsea Four, PVA has been carried out to assess the potential population level effects that may arise from the project alone and in-combination for five seabird species identified as being susceptible to change. Four of these species are qualifying features of the FFC SPA, whilst puffin is a named feature of the seabird assemblage, for which this report provides PVAs modelled at the FFC SPA population scale as agreed with the EP Technical Panel (OFF-ORN-2.27). The five species selected for modelling were:

- Gannet, *Morus bassanus*;
- Kittiwake, *Rissa tridactyla*;
- Guillemot, *Uria aalge*;
- Razorbill, *Alca torda*; and
- Puffin, Fratacula artica.

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

2 Methodology

2.1 Guidance and Models

2.1.1.1 The user guide for the Seabird PVA Tool provided by Natural England (Mobbs et al. 2020) has been followed for modelling and assessment of potential impacts.

2.1.1.2 The demographic parameters used for the PVA are presented in **Section 2.2**, whilst the input log and outputs from the Shiny App are included in **Appendix C** of this report.

2.2 PVA Demographic Parameters

2.2.1 Modelling Approach

Simulation Type

2.2.1.1 All PVA modelling 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.

2.2.1.2 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 an entirely deterministic model.

2.2.1.3 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.

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

2.2.1.5 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, as requested by Natural England (OFF-ORN-2.46). All models were run for a 35-year time span, representing the likely lifespan of Hornsea Four.

2.2.1.6 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 being either compensatory or depensatory (Begon, Townsend & Harper 2005). Compensation is characterised by demographic changes that cause a stabilising effect on a populations long-term average. Depensation acts to further decrease the rate of population growth in declining populations and can delay the rate of recovery. 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.

2.2.1.7 Density dependence is self-evident in the natural environment, as without density dependence, populations would grow exponentially or be unable to recover from significant population declines. For seabird populations the mechanisms by which density dependence can be incorporated into PVA remains 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. Although precaution should be taken when interpreting the outputs due to density independent models lacking any means by which a population can recover once it has been reduced beyond a certain point (i.e. another source of precaution in the assessment process) (Ridge et al. 2019).

2.2.1.8 Although both the counterfactual of population size and population growth rate are presented as outputs from the Natural England PVA Tool, 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 PVA models for assessments of effects from Hornsea Four alone and in-combination.

2.2.2 Species-specific values

2.2.2.1 The Shiny App offers the users the choice of using pre-set demographic parameters or the ability to enter custom values. The pre-set demographic values are available for a total of 15 different species. The values are derived from previously reported national or colony specific demographic parameters sourced from the Joint Nature Conservation Committee (JNCC) Seabird Monitoring Programme (SMP 2020), divided into eight regional classifications (further information on the eight regional classifications can be found in Mobbs et al. 2020) for breeding success data or Horswill and Robinson (2015) for survival rate. The species-specific values selected for the five seabird species within this report, for which PVAs were simulated at the FFC SPA population scales, are summarised in **Table 1**.

Demographic Parameters of five key species from FFC SPA

2.2.2.2 Average productivity rates and Standard Deviation (SD) for the five species from FFC SPA are presented in **Table 1**, which were calculated using the data provided in the FFC SPA Seabird Monitoring Programme reports from 2009 – 2019 (Aitken et al. 2017; Babcock et al. 2014, 2015, 2016, 2018 & Lloyd et al. 2020) for four species: gannet, kittiwake, guillemot and razorbill as agreed through the EP Technical Panel (OFF-ORN-2.31). A range of values were selected due to the year-on-year variation of productivity and to be able to run the PVA stochastically inter-annual variability in the form of SDs are required. **Appendix A** provides a full breakdown of all the plot count data which fed into calculating the average productivity values for gannet, kittiwake, guillemot and razorbill for the FFC SPA. As presented in **Appendix A**, the 2009 productivity data has been excluded for razorbill as recommended by Natural England (OFF-ORN-6.17) due to only five out of the eight study plots being monitored in 2009. The annual productivity was calculated as the mean of each study plot for gannet, guillemot and razorbill (OFF-ORN-6.19), as these are representative of the whole colony for each of these species. The annual productivity value for kittiwake was calculated using a weighted mean approach to ensure that data were not biased towards the much smaller proportion of the population within monitored plots at Filey and to reflect the larger proportion of the overall population being at Flamborough Head and

Bempton Cliffs and agreed with Natural England as being the most appropriate method (OFF-ORN-6.21).

2.2.2.3 Due to the absence of site-specific productivity values for puffin, the national productivity rates presented in Horswill and Robinson (2015) were deemed the most appropriate for assessment of puffin at the FFC SPA scale (OFF-ORN-6.19).

2.2.2.4 Initial population size and corresponding units are presented in **Table 1**. Population estimates for gannet, kittiwake, guillemot and razorbill are derived from the FFC pSPA Seabird Monitoring Programme 2017 report (Aitken et al. 2017), which provides full colony count data for the four species as agreed with the EP Technical Panel (OFF-ORN-2.30). The 2017 colony counts were deemed the most appropriate population estimates as the timing coincides with the Hornsea Four baseline surveys. Puffin initial population size is calculated from the mean of the 2017 and 2018 colony counts, this is due to uncertainty regarding which of the two counts had the greatest accuracy and follows the guidance provided by Natural England (OFF-ORN-2.30).

2.2.2.5 For the FFC SPA, there is currently no available data on colony specific survival rates. In the absence of colony specific survival rates, the default national survival rates derived from the Horswill and Robinson (2015) data were deemed the most appropriate.

Table 1: FFC SPA demographic parameters selected for all five species.

Species	Productivity Rate ± SD	Available Colony-Specific Survival Rate	Initial Population Size (breeding adults)
Gannet	0.823 ± 0.038	National	26,784
Kittiwake	0.722 ± 0.210	National	103,070
Guillemot	0.716 ± 0.076	National	121,754
Razorbill	0.641 ± 0.068	National	40,506
Puffin	0.617 ± 0.151	National	3,579

3 Impacts Assessed

3.1 Collision Risk

3.1.1.1 There is potential of collision risk to birds as a result of operational activities associated with Hornsea Four and other projects. The risk to birds is through potential collision with WTGs and associated infrastructure from OWFs, resulting in injury or fatality. This may occur when birds fly through the OWFs whilst foraging for food, commuting between breeding sites and foraging areas, or during migration.

3.1.1.2 Following the results of the collision risk modelling described in **Volume A5, Annex 5.3: Offshore Ornithology Collision Risk Modelling**, two species (gannet and kittiwake) were deemed to require further consideration of potential population level effects for the FFC SPA through the use of PVA.

3.1.1.3 The collision risk values for Hornsea Four alone are based off the multiple assessments presented in **Volume A5, Annex 5.3: Offshore Ornithology Collision Risk Modelling**. The in-combination values for Hornsea Four in **Table 7** and **Table 9** below are based on the Band Option 2, Cook et al. (2014) avoidance rates and mean density estimates for gannet and kittiwake as calculated in **Volume A5, Annex 5.3: Offshore Ornithology Collision Risk Modelling**.

3.2 Displacement

3.2.1.1 The presence of WTGs has the potential to directly disturb and displace seabirds that would normally reside within and around the area of sea where OWFs are located. This in effect represents indirect habitat loss, which would potentially reduce the area available to those seabirds to forage, loaf and / or moult that currently occur within and around OWFs and may be susceptible to displacement from such developments. Displacement may contribute to individual birds experiencing fitness consequences, which at an extreme level could lead to the mortality of individuals. Cumulative displacement therefore has the potential to lead to effects on a wider scale.

3.2.1.2 Following the results of the displacement analysis described in **Volume A5, Annex 5.2: Offshore Ornithology Displacement Analysis**, four species (gannet, guillemot, razorbill and puffin) were deemed to require further consideration of potential population level effects through the use of PVA. The displacement impacts assessed for both Hornsea Four alone and in-combination with other OWF projects follows a range-based approach as advised by Natural England (OFF-ORN-4.8), considering a displacement value of 60 to 80% displacement and 1% mortality for gannet, and 30 to 70% displacement and 1 to 10% mortality for the auk species, with the Applicant's position on auk displacement being 50% displacement and 1% mortality based on an Evidence-led approach (rationale for auk displacement Evidence-led approach provided in **Volume A2, Chapter 5: Offshore and Intertidal Ornithology**). The extent of displacement assessed for all four species is the Hornsea Four array area and a 2 km buffer.

4 Apportionment of Impacts from Hornsea Four alone to the FFC SPA

4.1.1.1 To determine how potential impacts predicted for displacement and collision risk may affect seabird features of the FFC SPA and whether an adverse effect on site integrity (AEoI) may occur, the predicted impacts were apportioned to this designated site using two methods (Evidence-led apportionment and Natural England's Worst Case Scenario (WCS)). Full details of these two methods, including equations and input values, can be found in **Appendix B**. The following sections provide a summary of these methods, along with apportioned impacts.

4.2 Evidence-led Apportionment

4.2.1 Breeding season

4.2.1.1 The Evidence-led apportionment method acknowledges that the total abundance for each species during the breeding season consists of a mixture of adults, sub-adults and juveniles. The proportion of adult birds within Hornsea Four is derived from tables within Appendix A of Furness (2015) for the FFC SPA. These data are presented in Furness (2015) and are considered to provide a more accurate representation of population age structure than site-based data, since only a small proportion of individuals for each species could be positively aged within the latter. Furness (2015) draws upon a wide number of data sources gathered across multiple years in order to model population age structure, thus reducing the potential for any bias associated with the snapshot nature of site-based surveys.

4.2.1.2 Not all adult birds present within the Hornsea Four array area or 2 km buffer will be breeding birds. This is evidenced from adult sabbatical birds free roaming the North Sea whilst taking a break from breeding activities (Marine Scotland 2017). A sabbatical rate of 10% for gannet and kittiwake populations and 7% for auk species was recently agreed by Marine Scotland for inclusion in revised Forth and Tay OWF applications (Neart na Gaoithe OWF, Seagreen Alpha and Bravo OWF, and Inch Cape OWF) in relation to the Forth Islands SPA and Firth of Forth and St. Andrews Bay Complex SPA, designated for breeding gannets, kittiwakes, guillemot, razorbill and puffin (Marine Scotland 2017). With similarities in the seabird assemblage and distance to colonies between the OWFs within the Forth and Tay region and Hornsea Four in relation to the waters out from the FFC SPA these values have been applied for use in this assessment of designated features from FFC SPA during the breeding season.

4.2.1.3 During the breeding season, when birds are limited in the distance and number of days over which they can forage by the need to return regularly to the nest site, it can be expected that the area in and around Hornsea Four will contain a high proportion of adult birds from colonies and nest sites within the species mean max foraging ranges as defined by Woodward et al. (2019). In order to attribute the correct proportion of adult breeding birds to different colonies appropriately, the method used to determine any adult's bird origin followed the Scottish National Heritage (SNH) apportionment Tool (SNH 2018) methodology. The SNH apportionment Tool (SNH 2018) methodology is based on considering a species' foraging range in addition to three colony-specific weighting factors; colony size (in individuals); distance to colony from the development sites; and sea area (the real extent of the open sea within foraging range of the relevant species). Full details of the SNH apportionment process are presented in **Appendix B** with a summary of the findings presented in **Table 2**.

4.2.1.4 Despite the results of the SNH apportionment tool recommending an apportionment value of 64% (**Table B 1**) to the FFC SPA for gannet, evidence gained from tracking adult gannets during the breeding season across a series of colonies is that gannets show 'space partitioning', that is adjacent colonies do not have overlapping foraging areas in the breeding season (Wakefield et al. 2013). The consequence of this is that following consideration of non-breeding adults, 100% of the breeding adult birds in and around the Hornsea Four array area and those predicted to suffer from displacement and collision related mortality are attributable to the FFC SPA.

4.2.1.5 After consideration of the proportion of immature birds present, together with the sabbatical rate and colonies within foraging distance, the overall proportion of adult breeding birds for the five seabird species assessed from FFC SPA present within the Hornsea Four array area during the breeding season are presented in **Table 2** following this Evidence-led approach.

Table 2: Summary of the Hornsea Four Evidence-led breeding season apportionment rates for designated features of the FFC SPA assessed.

Species	Adult age ratio (Furness 2015) (%)	Sabbatical Rate (Marine Scotland 2017) (%)	SNH (2018) Apportionment results (%)	FFC SPA overall breeding season apportionment (%)
Gannet	68	10	100[1]	61
Kittiwake	69	10	94	58
Guillemot	60	7	100	56
Razorbill	60	7	100	56
Puffin	96	7	100	89

4.2.2 Non-breeding season

4.2.2.1 Outside of the breeding bio-season, when the population found within Hornsea Four contains a mix of birds from different UK breeding colonies and breeding colonies from further away (e.g. Furness 2015; Dunn et al. 2020), then a much lower percentage of birds can be attributed to any particular breeding colony SPA population. For gannet, kittiwake, razorbill and puffin, this apportionment is based on calculating the proportion of the breeding adults within the UK North Sea and English Channel BDMPS population that can be attributed to the FFC SPA as defined by Furness (2015), based on the data within that report. The proportion of birds within Hornsea Four which can be apportioned to the FFC SPA during the non-breeding season is summarised in **Table 6** as agreed for this project through the EP process (OFF-ORN-6.13).

4.2.2.2 Despite agreement on the non-breeding apportionment for guillemot at EP#11 equating to 4.41% using the method described above (OFF-ORN-6.13), at EP#14 Natural England requested that a bespoke method to apportionment in the non-breeding bio-season to incorporate a higher proportion of guillemots apportioned to the FFC SPA. This was to account for a higher proportion of birds during the post dispersal months of August and September that may be from FFC SPA (OFF-ORN-2.52).

4.2.2.3 In order to account for a potentially higher proportion of FFC SPA guillemots during the post dispersal months of the non-breeding bio-season a weighted approach to apportionment has been taken to accommodate Natural England's request. As it is not possible to determine exactly how many guillemots within the Hornsea Four array area and 2 km buffer during the post dispersal months are from the FFC SPA an Evidence-led approach was taken. Studies on guillemot dispersal indicate that guillemots can begin leaving the colony as early as the end of June (Camphuysen 2002) and from July to September have been recorded over 300 km from the nearest attributable colony (Camphuysen 2002; Harris et al. 2015; Dunn et al. 2020). This means that within the months of August and September guillemots from colonies in Scotland have dispersed as far south as the Hornsea Four array area. Based on these studies of guillemot dispersal, an Evidence-led expert judgement has been made considering 25% may be from other more northern colonies and an apportionment value of 75% of all guillemots being from the FFC SPA has been applied to account for this colony being the closest to the Hornsea Four array area. This expert judgement also acknowledges that guillemots from colonies further north migrate in

[1] Due to evidence gained from tracking studies suggesting that gannets from adjacent colonies show 'space partitioning', a precautionary approach has been taken and 100% of breeding adult gannets in and around Hornsea Four have been attributed to the FFC SPA, instead of 64.29% calculated using the SNH apportionment tool (SNH 2018).

substantial numbers into the Southern North Sea, including the waters within and surrounding the Hornsea Four array area, during the months of August and September (Dunn et al. 2020).

4.2.2.4 Not all guillemots within the post dispersal months attributed to the FFC SPA will be adult birds. Consideration has been given to the number of adults likely to be within the Hornsea Four array area, estimated to be 60% as derived from Appendix A: Table 62 of Furness for FFC SPA as detailed in **paragraph 4.2.2.1**. During the post dispersal months of August and September it is highly likely that this value will be lower than calculated in the breeding bio-season due to the influx of first year fledglings and likelihood that adult females will have begun migrating to their wintering foraging areas. To account for this likely greater proportion of juveniles than the rest of year, the proportion of adult birds was reduced to 50% of guillemots recorded.

4.2.2.5 Furthermore, not all adult guillemots present in the post dispersal months will be breeding adults. As detailed in **paragraph 4.2.1.2**, a sabbatical rate of 7% has been applied to account for guillemots free roaming the North Sea taking a break from breeding. When considering the proportion of individuals attributable to the FFC SPA, proportion of adults and proportion of sabbaticals, this equates to an overall apportionment in the post dispersal months to the FFC SPA of 35% with a weighting factor of two to account for the number of component months, as summarised in **Table 3**.

4.2.2.6 For the remaining five months the proportion of breeding adults was calculated as the standard 4.41% based on the proportion of the breeding adults within the UK North Sea and English Channel BDMPS population that can be attributed to the FFC SPA as defined by Furness (2015) with a weighting factor of five to account for the number of component months.

4.2.2.7 The overall apportionment to the FFC SPA in the non-breeding bio-season for the full seven months (August to February) was calculated as 13% using the weighted approach as summarised in **Table 3** and the equation below.

$$\boldsymbol{Entire\ non\ breeding\ apportionment\ (Aug\ to\ Feb)} = \frac{((\boldsymbol{PDr} \times \boldsymbol{t_{PD}}) + (\boldsymbol{NB} \times \boldsymbol{t_{NB}}))}{(\boldsymbol{t_{PD}} + \boldsymbol{t_{NB}})}$$

Where:
PD = Calculated apportionment in the post-dispersal months (35%)
NB = Calculated apportionment in the remaining non-breeding bio-season months (4.41%)
tPD = number of post-dispersal months (2)
tNB = number of remaining non-breeding bio-season months (5)

Table 3: Summary of the Evidence-led non-breeding season apportionment rate for guillemot feature of the FFC SPA.

Months	Adult age ratio (%)	Sabbatical Rate (Marine Scotland 2017) (%)	Predicted proportion of FFC SPA breeding adults (%)	overall apportionment (%)	Weighting Factor
Post dispersal months (Aug – Sep)	50.00	7.00	75.00	35.00	2
Remaining Non-breeding months (Oct – Feb)	N/A	N/A	4.41	4.41	5
Overall Weighted Apportionment for the entire non-breeding bio-season (Aug – Feb)					**13%**

4.3 Natural England WCS Apportionment

4.3.1.1 The Natural England WCS method is based on the Applicant's interpretation of Natural England's preferred parameters for apportionment based on consultation through the EP Process. During the breeding season uses the same age / juvenile proportion method as described in the Evidence-led apportionment method, but does not take into account sabbatical rates for adult birds (assumes all adults are breeding adults) and assumes all adult birds within Hornsea Four are from FFC SPA. A summary of the apportionment rates using the Natural England WCS method for the breeding season is summarised in **Table 4**. As the Natural England WCS apportionment does not take into account sabbatical rates of breeding birds and the potential for birds to be from other nearby colonies for kittiwake, the final values can be considered overly precautionary.

Table 4: Summary of the Natural England WCS breeding season apportionment rates for designated features of the FFC SPA assessed.

Species	Adult age ratio (Furness 2015)	Sabbatical Rate (Marine Scotland 2017)	SNH (2018) Apportionment results	FFC SPA overall breeding season apportionment (%)
Gannet	68	100	100	68
Kittiwake	69	100	100	69
Guillemot	60	100	100	60
Razorbill	60	100	100	60
Puffin	96	100	100	96

4.3.1.2 Outside of the breeding season both methods follow the same approach as summarised in **Table 6** for gannet, kittiwake, razorbill and puffin. For guillemot a weighted approach has been taken as described above for the Evidence-led apportionment method, but does not take into account sabbatical rates for adult birds (assumes all adults are breeding adults) and assumes all adult birds within Hornsea Four are from FFC SPA. A summary of the Natural England WCS apportionment rate for guillemot in the non-breeding bio-season is presented in **Table 5**.

Table 5: Summary of the Natural England WCS non-breeding season apportionment rate for guillemot feature of the FFC SPA.

Months	Adult age ratio (%)	Sabbatical Rate (Marine Scotland 2017) (%)	Predicted proportion of FFC SPA breeding adults (%)	overall apportionment (%)	Weighting Factor
Post dispersal months (Aug – Sep)	50.00	100.00	100.00	50.00	2
Remaining Non-breeding months (Oct – Feb)	N/A	N/A	4.41	4.41	5
Overall Weighted Apportionment for the entire non-breeding bio-season (Aug – Feb)					**17.44%**

Table 6: Summary of the Evidence-led non-breeding season apportionment rates for designated features of the FFC SPA assessed.

Species	BDMPS North Sea and English Channel Return Migration population (Furness 2015)	FFC SPA remaining in the North Sea and English Channel Return Migration population (Furness 2015)	Apportionment during the return migration to the FFC SPA (%)	BDMPS North Sea and English Channel post-breeding migration population (Furness 2015)	FFC SPA remaining in the North Sea and English Channel post-breeding migration population (Furness 2015)	Apportionment during the post-breeding migration to the FFC SPA (%)	BDMPS North Sea and English Channel migration-free winter population (Furness 2015)	FFC SPA remaining in the North Sea and English Channel migration-free winter population (Furness 2015)	Apportionment during the migration-free winter to the FFC SPA (%)	BDMPS North Sea and English Channel non-breeding population (Furness 2015)	FFC SPA remaining in the North Sea and English Channel non-breeding population (Furness 2015)	Apportionment during the non-breeding to the FFC SPA (%)
Gannet	248,385	22,122	**6.23**	456,928	15,485	**4.84**	N/A	N/A	N/A	N/A	N/A	N/A
Kittiwake	627,816	45,140	**7.19**	829,937	45,140	**5.44**	N/A	N/A	N/A	N/A	N/A	N/A
Razorbill	591,874	20,002	**3.38**	591,874	20,002	**3.38**	218,622	6,001	**2.74**	N/A	N/A	N/A
Puffin	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	231,957	958	**0.41**

4.3.1.3 Following both apportionment methods described above the resulting predicted impacts apportioned to the FFC SPA from Hornsea Four alone are included in the in-combination tables below for both the Evidence-led and Natural England WCS values.

5 Impacts Apportioned to the FFC SPA from Hornsea Four In-combination with other OWFs

5.1 In-combination disturbance and displacement

5.1.1.1 For displacement assessments, the projects identified for in-combination assessment are those defined as being within Tier 1 (sub-tiers 1a to 1d) and Tier 2, as described in Section 8.2.4 of **Volume B2.2 Report to Inform Appropriate Assessment**. The in-combination abundance figures (to which the range of displacement and mortality rates are applied) for gannet, guillemot and razorbill presented below are based on the values submitted at Deadline XI for EA1N / EA2 (SPR, 2021), which are the most up to date in-combination disturbance and displacement tables currently available. The following amendments were made to the values published at Deadline XI for EA1N / EA2 (SPR, 2021) for assessments included within this report:

- Updated displacement values for Hornsea Four attributed to the FFC SPA using the apportionment rates as described within this report;
- Removal of Beatrice Demonstrator as the project will be decommissioned by the time Hornsea Four is predicted to be operational; and
- Inclusion of both Hornsea Three Applicant's and Natural England's final values as presented in (Orsted, 2021).

5.1.1.2 The in-combination displacement abundance figures for puffin presented below are based on the values submitted at Deadline VIII for Norfolk Vanguard (MacArthur Green 2019), with the addition of Gun fleet sands, Kentish Flats (and subsequent extension) Methil, Rampion and Scroby Sands at the request of Natural England (OFF-ORN-4.7 and 6.7). For the remaining projects (Norfolk Boreas, Hornsea Three, EA1N, EA2, Sheringham Shoal Extension and Dudgeon Extension projects) the totals were derived from the latest relevant individual project submissions.

5.2 In-combination collision risk

5.2.1.1 For collision risk assessments, the projects identified for in-combination collision risk assessment are those defined as being within Tier 1 (sub-tiers 1a to 1d) and Tier 2, as described in Section 8.2.4 of **Volume B2.2 Report to Inform Appropriate Assessment**. The approach taken to assessing in-combination collision risk is a quantitative one, drawing upon the published information produced by the respective project developers. Such published, quantitative information on predicted collisions is not available at an early stage in the development of a project. The result is that the cumulative collision risk assessment addresses projects in Tiers 1 and 2 but not Tier 3 or below, as these are projects that are at the pre-scoping and scoping stage where no data are currently available with respect to impact assessments.

5.2.1.2 The in-combination collision risk figures for gannet and kittiwake for other OWFs included for assessment presented below are based on the values submitted at Deadline XI for EA1N / EA2 (SPR, 2021), which are the most up to date in-combination collision risk tables currently available. The following amendments were made to the values published at Deadline XI for EA1N / EA2 (SPR, 2021) for assessments included within this report:

- Updated collision risk values for Hornsea Four attributed to the FFC SPA using the apportionment rates as described within this report;
- Removal of Beatrice Demonstrator as the project will be decommissioned by the time Hornsea Four is predicted to be operational; and
- Inclusion of both Hornsea Three Applicant's and Natural England's final values as presented in (Orsted, 2021).

5.2.2 Gannet in-combination collision and displacement attributed to the FFC SPA

5.2.2.1 The bio-season and annual collision risk and displacement mortality estimates for gannet From Hornsea Four in-combination with other OWF projects are presented in **Table 7** and **Table 8**. These data represent the potential in-combination collision risk from Hornsea Four and displacement for gannet within the array area and a 2 km buffer for all OWFs identified for inclusion in these assessments.

Table 7: In-combination bio-season and annual collision mortality estimates for gannet for all projects including Hornsea Four apportioned to the FFC SPA.

Project	Breeding	Autumn	Spring	Annual
Projects in-combination up to Hornsea Three Applicant's final values (all current consented projects)	179.4	35.9	18.9	234.0
Projects in-combination up to Hornsea Three Natural England's final values (all current consented projects)	184.8	36.1	19.2	239.8
Norfolk Boreas	14.2	0.6	0.2	15.1
East Anglia ONE North	12.4	0.5	0.1	13.0
East Anglia TWO	12.5	1.1	0.2	13.8
Norfolk Vanguard	8.2	0.9	0.3	9.4
Dudgeon Extension Project	3.6	0.2	0.0	3.9
Sheringham Shoal Extension Project	0.3	0.1	0.0	0.4
Hornsea Four Applicant's approach[2]	8.2	0.2	0.1	8.5
All projects Applicant's approach	**238.8**	**39.6**	**19.9**	**298.1**
Hornsea Four Natural England's WCS approach[3]	13.0	0.2	0.1	13.3
All projects Natural England's WCS approach	**248.9**	**39.8**	**20.1**	**308.7**

[2] Applicant's approach is based on the CRM results presented within the main body of **Volume A5, Annex 5.3: Offshore Ornithology Collision Risk Modelling** and Evidence-led breeding season apportionment (**Table 2**) using the standard migration-free breeding bio-season (April to August for gannet and May to July for kittiwake).
[3] Natural England's approach is based on the CRM results presented within Appendix A of **Volume A5, Annex 5.3: Offshore Ornithology Collision Risk Modelling** and Natural England WCS breeding season apportionment (**Table 4**) using the full breeding bio-season (March to September for gannet and April to August for kittiwake).

Table 8: In-combination bio-season and annual displacement mortality estimates for gannet for all projects including Hornsea Four apportioned to the FFC SPA.

Projects	Season	Apportioned abundance to the FFC SPA	60% Disp, 1% Mort	80% Disp, 1% Mort
Projects in-combination up to Hornsea Three Applicant's final values (all current consented projects)	Breeding	4,346	26.1	34.8
	Autumn	720	4.3	5.8
	Spring	237	1.4	1.9
	Annual	5,303	31.8	42.4
Projects in-combination up to Hornsea Three Natural England's final values (all current consented projects)	Breeding	4,651	27.9	37.2
	Autumn	720	4.3	5.8
	Spring	237	1.4	1.9
	Annual	5,608	33.6	44.9
Norfolk Boreas	Breeding	1,229	7.4	9.8
	Autumn	83	0.5	0.7
	Spring	33	0.2	0.3
	Annual	1,344	8.1	10.8
EA1N	Breeding	149	0.9	1.2
	Autumn	23	0.1	0.2
	Spring	3	0.0	0.0
	Annual	174	1.0	1.4
EA2	Breeding	192	1.2	1.5
	Autumn	43	0.3	0.3
	Spring	12	0.1	0.1
	Annual	247	1.5	2.0
Norfolk Vanguard	Breeding	271	1.6	2.2
	Autumn	118	0.7	0.9
	Spring	27	0.2	0.2
	Annual	416	2.5	3.3
Dudgeon Extension Project	Breeding	361	2.2	2.9
	Autumn	16	0.1	0.1
	Spring	3	0.0	0.0
	Annual	380	2.3	3.0
Sheringham Shoal Extension Project	Breeding	40	0.2	0.3
	Autumn	14	0.1	0.1
	Spring	0	0.0	0.0
	Annual	54	0.3	0.4
Hornsea Four Applicant's approach[4]	Breeding	484	2.9	3.9
	Autumn	41	0.2	0.3
	Spring	15	0.1	0.1
	Annual	540	3.2	4.3
All projects Applicant's approach	**Breeding**	**7,072**	**42.4**	**56.6**
	Autumn	**1,057**	**6.3**	**8.5**
	Spring	**329**	**2.0**	**2.6**
	Annual	**8,458**	**50.7**	**67.7**

[4] Applicant's approach is based on the Evidence-led breeding season apportionment (Table 2) using the standard migration-free breeding bio-season (April to August).

Projects	Season	Apportioned abundance to the FFC SPA	60% Disp, 1% Mort	80% Disp, 1% Mort
Hornsea Four Natural England's WCS approach[5]	Breeding	538	3.2	4.3
	Autumn	41	0.2	0.3
	Spring	15	0.1	0.1
	Annual	594	3.6	4.8
All projects Natural England's WCS approach	**Breeding**	**7,431**	**44.6**	**59.4**
	Autumn	**1,057**	**6.3**	**8.5**
	Spring	**329**	**2.0**	**2.6**
	Annual	**8,817**	**52.9**	**70.5**

5.2.2.2 The annual total collision and displacement mortality rates for Hornsea Four in-combination with other projects apportioned to FFC SPA is estimated between 349 to 366 based on the Applicant's approach and between 362 to 379 based on Natural England's approach, as presented in Table 7 and Table 8. These totals have been modelled using the Seabird PVA Tool and the results are presented in Table 13 to estimate the potential population level effects of such potential in-combination collision and displacement mortality.

5.2.3 Kittiwake in-combination collision risk attributed to the FFC SPA

5.2.3.1 The bio-season and annual collision risk mortality estimates for kittiwake From Hornsea Four in-combination with other OWF projects are presented in Table 9.

Table 9: In-combination bio-season and annual collision mortality estimates for kittiwake for all projects including Hornsea Four apportioned to the FFC SPA.

Projects	Breeding	Autumn	Spring	Annual
All OWFs in-combination up to Hornsea Three (all current consented projects)				
Norfolk Boreas	11.4	1.7	0.9	14.0
East Anglia ONE North	0.0	0.4	0.3	0.7
East Anglia TWO	0.0	0.3	0.5	0.8
Norfolk Vanguard	18.7	0.9	1.4	21.0
Dudgeon Extension Project	17.2	0.5	0.2	17.9
Sheringham Shoal Extension Project	0.9	0.1	0.0	1.0
Hornsea Four Applicant's approach[2]	17.3	2.1	1.8	21.2
All projects Applicant's approach	**226.8**	**83.4**	**86.8**	**396.9**
Hornsea Four Natural England's WCS approach[3]	61.4	0.8	0.3	62.5
All projects Natural England's WCS approach	**270.9**	**82.1**	**85.3**	**438.1**

[5] Natural England's approach is based on the Natural England WCS breeding season apportionment (Table 4) using the full breeding bio-season (March to September).

5.2.3.2 The annual total collision mortality rates for Hornsea Four in-combination with other projects apportioned to FFC SPA is estimated at 397 using the Applicant's approach and 438 using Natural England's WCS approach, as presented in **Table 9**. These totals have been modelled using the Seabird PVA Tool and the results are presented in **Table 15** below to estimate the potential population level effects of such potential in-combination collision mortality.

5.2.4 Guillemot in-combination disturbance and displacement attributed to the FFC SPA

5.2.4.1 The bio-season and annual displacement mortality estimates for guillemot From Hornsea Four in-combination with other OWF projects are presented in **Table 10**. These data represent the potential in-combination displacement for guillemot within the array area and a 2 km buffer for all OWFs identified for inclusion in this assessment.

Table 10: In-combination bio-season and annual displacement estimates for guillemot from all projects including Hornsea Four apportioned to the FFC SPA.

Projects	Season	Apportioned abundance to the FFC SPA	30% Disp, 1% Mort	50% Disp, 1% Mort	70% Disp, 10% Mort
Projects in-combination up to Hornsea Three (all current consented projects)	Breeding Season	25,959	77.9	129.8	1,817.1
	Non-Breeding Season	6,546	19.6	32.7	458.2
	Annual	32,504	97.5	162.5	2,275.3
Norfolk Boreas	Breeding	0	0.0	0.0	0.0
	Non-breeding	606	1.8	3.0	42.4
	Annual	606	1.8	3.0	42.4
East Anglia ONE North	Breeding	0	0.0	0.0	0.0
	Non-breeding	83	0.2	0.4	5.8
	Annual	83	0.2	0.4	5.8
East Anglia TWO	Breeding	0	0.0	0.0	0.0
	Non-breeding	74	0.2	0.4	5.2
	Annual	74	0.2	0.4	5.2
Norfolk Vanguard	Breeding	0	0.0	0.0	0.0
	Non-breeding	210	0.6	1.1	14.7
	Annual	210	0.6	1.1	14.7
Dudgeon Extension Project	Breeding	0	0.0	0.0	0.0
	Non-breeding	355	1.1	1.8	24.9
	Annual	355	1.1	1.8	24.9
Sheringham Shoal Extension Project	Breeding	0	0.0	0.0	0.0
	Non-breeding	27	0.1	0.1	1.9
	Annual	27	0.1	0.1	1.9
Hornsea Four Applicant's approach[6]	Breeding Season	4,773	14.3	23.9	334.1
	Non-Breeding Season	2,238	6.7	11.2	156.6
	Annual	7,011	21.0	35.1	490.7
All projects Applicant's approach	**Breeding Season**	**30,731**	**92.2**	**153.7**	**2,151.2**
	Non-Breeding Season	**10,139**	**30.4**	**50.7**	**709.7**
	Annual	**40,870**	**122.6**	**204.3**	**2,860.9**

[6] Applicant's approach is based on the evidence-led apportionment approach as detailed in **Section 4.2**.

Projects	Season	Apportioned abundance to the FFC SPA	30% Disp, 1% Mort	50% Disp, 1% Mort	70% Disp, 10% Mort
Hornsea Four Natural England's WCS approach[7]	Breeding Season	5,132	15.4	25.7	359.2
	Non-Breeding Season	5,726	17.2	28.6	400.8
	Annual	10,858	32.6	54.3	760.1
All projects Natural England's WCS approach	**Breeding Season**	**31,091**	**93.3**	**155.5**	**2,176.3**
	Non-Breeding Season	**13,627**	**40.9**	**68.1**	**953.9**
	Annual	**44,717**	**134.2**	**223.6**	**3,130.2**

5.2.4.2 The in-combination total abundance of guillemots at risk of displacement from OWFs apportioned to adults from the FFC SPA for all projects is estimated at 40,870 based on the Applicant's approach and 44,717 based on Natural England's WCS approach, as presented in **Table 10**. These totals have been modelled using an Evidence-led displacement rate of 50% and a 1% mortality rate, and a displacement rate of between 30% to 70% and mortality rate of between 1% to 10% as requested by Natural England (OFF-ORN-2.43). These totals have been modelled using the Seabird PVA Tool and the results are presented in **Table 17** to estimate the potential population level effects of such potential in-combination displacement mortality.

5.2.5 Razorbill in-combination disturbance and displacement attributed to the FFC SPA

5.2.5.1 The bio-season and annual displacement mortality estimates for razorbill From Hornsea Four in-combination with other OWF projects are presented in **Table 11**. These data represent the potential in-combination displacement for razorbill within the array area and a 2 km buffer for all OWFs identified for inclusion in this assessment.

Table 11: In-combination bio-season and annual displacement estimates for razorbill from all projects including Hornsea Four apportioned to the FFC SPA.

Projects	Season	Apportioned abundance to the FFC SPA	30% Disp, 1% Mort	50% Disp, 1% Mort	70% Disp, 10% Mort
Projects in-combination up to Hornsea Three (all current consented projects)	Breeding	3,784	11.4	18.9	264.9
	Autumn	1,151	3.5	5.8	80.6
	Winter	595	1.8	3.0	41.6
	Spring	1,048	3.1	5.2	73.4
	Annual	6,579	19.7	32.9	460.5
Norfolk Boreas	Breeding	0	0.0	0.0	0.0
	Autumn	9	0.0	0.0	0.6
	Winter	29	0.1	0.1	2.0
	Spring	12	0.0	0.1	0.8
	Annual	49	0.1	0.2	3.4
EA1N	Breeding	0	0.0	0.0	0.0
	Autumn	3	0.0	0.0	0.2
	Winter	2	0.0	0.0	0.1
	Spring	7	0.0	0.0	0.5
	Annual	11	0.0	0.1	0.8
EA2	Breeding	0	0.0	0.0	0.0

[7] Natural England's approach is based on the Natural England WCS apportionment approach as detailed in **Section 4.3**.

Projects	Season	Apportioned abundance to the FFC SPA	30% Disp, 1% Mort	50% Disp, 1% Mort	70% Disp, 10% Mort
	Autumn	2	0.0	0.0	0.1
	Winter	4	0.0	0.0	0.3
	Spring	8	0.0	0.0	0.5
	Annual	13	0.0	0.1	0.9
Norfolk Vanguard	Breeding	0	0.0	0.0	0.0
	Autumn	30	0.1	0.1	2.1
	Winter	23	0.1	0.1	1.6
	Spring	31	0.1	0.2	2.2
	Annual	84	0.3	0.4	5.9
Dudgeon Extension Project	Breeding	0	0.0	0.0	0.0
	Autumn	124	0.4	0.6	8.7
	Winter	19	0.1	0.1	1.3
	Spring	9	0.0	0.0	0.6
	Annual	153	0.5	0.8	10.7
Sheringham Shoal Extension Project	Breeding	0	0.0	0.0	0.0
	Autumn	22	0.1	0.1	1.5
	Winter	16	0.0	0.1	1.1
	Spring	5	0.0	0.0	0.4
	Annual	43	0.1	0.2	3.0
Hornsea Four Applicant's approach[6]	Breeding	154	0.5	0.8	10.8
	Autumn	121	0.4	0.6	8.5
	Winter	13	0.0	0.1	0.9
	Spring	13	0.0	0.1	0.9
	Annual	301	0.9	1.5	21.1
All projects Applicant's approach	**Breeding**	**3,938**	**11.8**	**19.7**	**275.7**
	Autumn	**1,461**	**4.4**	**7.3**	**102.3**
	Winter	**700**	**2.1**	**3.5**	**49.0**
	Spring	**1,133**	**3.4**	**5.7**	**79.3**
	Annual	**7,232**	**21.7**	**36.2**	**506.3**
Hornsea Four Natural England's WCS approach[7]	Breeding	166	0.5	0.8	11.6
	Autumn	121	0.4	0.6	8.5
	Winter	13	0.0	0.1	0.9
	Spring	13	0.0	0.1	0.9
	Annual	313	0.9	1.6	21.9
All projects Natural England's WCS approach	**Breeding**	**3,950**	**11.9**	**19.8**	**276.5**
	Autumn	**1,461**	**4.4**	**7.3**	**102.3**
	Winter	**700**	**2.1**	**3.5**	**49.0**
	Spring	**1,133**	**3.4**	**5.7**	**79.3**
	Annual	**7,244**	**21.7**	**36.2**	**507.1**

5.2.5.2 The in-combination total abundance of razorbills at risk of displacement from OWFs apportioned to adults from the FFC SPA for all projects is estimated at 7,232 using the Applicant's approach and 7,244 using Natural England's WCS approach, as presented in Table 11. These totals have been modelled using an Evidence-led displacement rate of 50% and a 1% mortality rate, and a displacement rate of between 30% to 70% and mortality rate of between 1% to 10% as requested by Natural England (OFF-ORN-2.43). These increases in mortality have been modelled using the Seabird PVA Tool and the results are presented in **Table 19** to estimate the potential population level effects of such potential in-combination displacement mortality.

5.2.6 Puffin in-combination disturbance and displacement attributed to the FFC SPA

5.2.6.1 The bio-season and annual displacement mortality estimates for puffin From Hornsea Four in-combination with other OWF projects are presented in **Table 12**. These data represent the potential in-combination displacement for puffin within the array area and a 2 km buffer for all OWFs identified for inclusion in this assessment.

Table 12: In-combination bio-season and annual displacement estimates for puffin from all projects including Hornsea Four apportioned to the FFC SPA.

Projects	Season	Apportioned abundance to the FFC SPA	30% Disp, 1% Mort	40% Disp, 1% Mort	70% Disp, 10% Mort
Projects in-combination up to Hornsea Three Applicant's final values (all current consented projects)	Breeding Season	801	2.4	4.0	56.1
	Non-Breeding Season	95	0.3	0..5	6.7
	Annual	896	2.7	4.5	62.7
Projects in-combination up to Hornsea Three Natural England's final values (all current consented projects)	Breeding Season	908	2.7	4.5	63.5
	Non-Breeding Season	94	0.3	0.5	6.6
	Annual	1,002	3.0	5.0	70.1
Norfolk Boreas	Breeding Season	0	0.0	0.0	0.0
	Non-Breeding Season	1	0.0	0.0	0.1
	Annual	1	0.0	0.0	0.1
EA1N	Breeding Season	-	-	-	-
	Non-Breeding Season	-	-	-	-
	Annual	0	0.0	0.0	0.0
EA2	Breeding Season	0	0.0	0.0	0.0
	Non-Breeding Season	0	0.0	0.0	0.0
	Annual	0	0.0	0.0	0.0
Norfolk Vanguard	Breeding Season	0	0.0	0.0	0.0
	Non-Breeding Season	0	0.0	0.0	0.0
	Annual	0	0.0	0.0	0.0
Dudgeon Extension Project	Breeding Season	0	0.0	0.0	0.0
	Non-Breeding Season	0	0.0	0.0	0.0
	Annual	0	0.0	0.0	0.0
Sheringham Shoal Extension Project	Breeding Season	0	0.0	0.0	0.0
	Non-Breeding Season	0	0.0	0.0	0.0
	Annual	0	0.0	0.0	0.0
Hornsea Four Applicant's approach[6]	Breeding Season	137	0.4	0.7	9.6
	Non-Breeding Season	2	0.0	0.0	0.1
	Annual	139	0.4	0.7	9.7
	Breeding Season	**938**	**2.8**	**4.7**	**65.6**

Projects	Season	Apportioned abundance to the FFC SPA	30% Disp, 1% Mort	40% Disp, 1% Mort	70% Disp, 10% Mort
All projects Applicant's approach	**Non-Breeding Season**	**98**	**0.3**	**0.5**	**6.9**
	Annual	**1,036**	**3.1**	**5.2**	**72.5**
Hornsea Four Natural England's WCS approach[7]	Breeding Season	147	0.4	0.7	10.3
	Non-Breeding Season	2	0.0	0.0	0.1
	Annual	149	0.4	0.7	10.4
All projects Natural England's WCS approach	**Breeding Season**	**1,055**	**3.2**	**5.3**	**73.9**
	Non-Breeding Season	**97**	**0.3**	**0.5**	**6.8**
	Annual	**1,152**	**3.5**	**5.8**	**80.7**

5.2.6.2 The in-combination total abundance of puffins at risk of displacement from OWFs apportioned to adults from the FFC SPA for all projects is estimated at 1,036 using the Applicant's approach and 1,152 using Natural England's approach, as presented in **Table 12**. These totals have been modelled using an Evidence-led displacement rate of 50% and a 1% mortality rate, and a displacement rate of between 30% to 70% and mortality rate of between 1% to 10% as requested by Natural England (OFF-ORN-2.43). These increases in mortality have been modelled using the Seabird PVA Tool and the results are presented in **Table 21** to estimate the potential population level effects of such potential in-combination displacement mortality.

6 PVA Results

6.1 Introduction

6.1.1.1 The outputs of the Seabird PVA Tool are set out in **Table 13** to **Table 22** below for all five species. The metrics used to summarise the PVA results are based on the counterfactual of population growth calculated as the median of the ratio of the annual growth rate of the impacted to un-impacted population, expressed as a proportion.

6.2 Gannet

6.2.1 Hornsea Four alone

6.2.1.1 The results of the PVA runs for gannet at the FFC SPA scale for Hornsea Four alone are presented in **Table 13** below.

Table 13: Gannet FFC SPA population modelling results using the Seabird PVA Tool.

Apportionment approach	Scenario	Adult mortality (per annum)	Density-independent counterfactual of population growth rate (after 35 Years)	Reduction in growth rate (per annum)
Evidence Led	1. 60% displacement, 1% mortality estimate	3.2	1.000	0.01%
	2. 80% displacement, 1% mortality estimate	4.3	1.000	0.02%
	3. Collision mortality estimate (Option 2 Cook et al. 2014, mean density values[8])	8.5	1.000	0.04%

Apportionment approach	Scenario	Adult mortality (per annum)	Density-independent counterfactual of population growth rate (after 35 Years)	Reduction in growth rate (per annum)
	4. Collision mortality estimate (Option 2 Cook et al. 2014, max density estimate[8])	17.0	0.999	0.08%
	5. Collision mortality estimate (Option 2 Cook et al. 2014, min density estimate[8])	3.7	1.000	0.02%
	6. Combined collision and displacement mortality estimate (scenario 1+3)	11.8	0.999	0.05%
	7. Combined collision and displacement mortality estimate (scenario 2+3)	12.9	0.999	0.06%
Natural England WCS	8. 60% displacement, 1% mortality estimate	3.6	1.000	0.02%
	9. 80% displacement, 1% mortality estimate	4.8	1.000	0.02%
	10. Collision mortality estimate (Option 2 SNCB, mean density estimate[9])	13.3	0.999	0.06%
	11. Collision mortality estimate (Option 2 SNCB, max density estimate[9])	23.2	0.999	0.10%
	12. Collision mortality estimate (Option 2 SNCB, min density estimate[9])	5.1	1.000	0.02%
	13. Combined collision and displacement mortality estimate (scenario 8+10)	16.9	0.999	0.07%
	14. Combined collision and displacement mortality estimate (scenario 9+10)	18.1	0.999	0.08%

6.2.2 Hornsea Four in-combination

6.2.2.1 The results of the PVA runs for gannet at the FFC SPA scale for Hornsea Four in-combination with other OWFs suggest are presented in **Table 14** below.

Table 14: Gannet FFC SPA population modelling results using the Seabird PVA Tool.

Apportionment approach	Scenario	Adult mortality (per annum)	Density-independent counterfactual of population growth rate (after 35 Years)	Reduction in growth rate (per annum)
Evidence Led	1. In-combination 60% displacement, 1% mortality estimate (**Table 8**)	50.6	0.998	0.22%
	2. In-combination 80% displacement, 1% mortality estimate (**Table 8**)	67.7	0.997	0.30%

[8] Based on the annual collision result values presented in Table 11 of **Volume A5, Annex 5.3: Offshore Ornithology Collision Risk Modelling** and Evidence-led breeding season apportionment (**Table 2**) using the standard migration-free breeding bio-season (April to August for gannet.

[9] Based on the annual collision result values presented in Table A2 of **Volume A5, Annex 5.3: Offshore Ornithology Collision Risk Modelling** and Natural England WCS breeding season apportionment (**Table 4**) using the full breeding bio-season (March to September for gannet.

Apportionment approach	Scenario	Adult mortality (per annum)	Density-independent counterfactual of population growth rate (after 35 Years)	Reduction in growth rate (per annum)
	3. In-combination Collision mortality estimate (Table 7)	298.1	0.987	1.32%
	4. Combined collision and displacement mortality estimate (scenario 1+3)	348.8	0.985	1.54%
	5. Combined collision and displacement mortality estimate (scenario 2+3)	365.7	0.984	1.61%
Natural England WCS	6. In-combination 60% Displacement, 1% Mortality estimate (Table 8)	52.9	0.998	0.23%
	7. In-combination 80% Displacement, 1% Mortality estimate (Table 8)	70.5	0.997	0.31%
	8. In-combination Collision mortality estimate (Table 7)	308.7	0.986	1.36%
	9. Combined collision and displacement mortality estimate (scenario 6+8)	361.6	0.984	1.60%
	10. Combined collision and displacement mortality estimate (scenario 7+8)	379.3	0.983	1.67%

6.3 Kittiwake

6.3.1 Hornsea Four alone

6.3.1.1 The results of the PVA runs for kittiwake at the FFC SPA scale for Hornsea Four alone are presented in Table 15 below.

Table 15: Kittiwake FFC SPA population modelling results using the Seabird PVA Tool.

Apportionment approach	Scenario	Adult mortality (per annum)	Density-independent counterfactual of population growth rate (after 35 Years)	Reduction in growth rate (per annum)
Evidence Led	1. Collision mortality estimate (Option 2 Cook et al. 2014, mean density values[10])	21.2	1.000	0.03%
	2. Collision mortality estimate (Option 2 Cook et al. 2014, max density values[10])	41.7	0.999	0.05%
	3. Collision mortality estimate (Option 2 Cook et al. 2014, min density values[10])	9.0	1.000	0.01%
	4. Collision mortality estimate (Option 2 Bowgen & Cook 2018, mean density values[10])	19.3	1.000	0.02%

[10] Based on the annual collision result values presented in Table 12 of Volume A5, Annex 5.3: Offshore Ornithology Collision Risk Modelling and Evidence-led breeding season apportionment (Table 2) using the standard migration-free breeding bio-season (May to July) for kittiwake.

Apportionment approach	Scenario	Adult mortality (per annum)	Density-independent counterfactual of population growth rate (after 35 Years)	Reduction in growth rate (per annum)
	5. Collision mortality estimate (Option 3 Bowgen & Cook 2018, mean density values[10])	5.4	1.000	0.01%
Natural England WCS	6. Collision mortality estimate (Option 2 SNCB, mean density estimate[11])	62.5	0.999	0.08%
	7. Collision mortality estimate (Option 2 SNCB, max density estimate[11])	120.2	0.999	0.15%
	8. Collision mortality estimate (Option 2 SNCB, min density estimate[11])	17.3	1.000	0.02%

6.3.2 Hornsea Four in-combination

6.3.2.1 The results of the PVA runs for kittiwake at the FFC SPA scale for Hornsea Four in-combination with other OWFs alone are presented in **Table 16** below.

Table 16: Kittiwake FFC SPA population modelling results using the Seabird PVA Tool.

Apportionment approach	Scenario	Adult mortality (per annum)	Density-independent counterfactual of population growth rate (after 35 Years)	Reduction in growth rate (per annum)
Evidence Led	1. In-combination collision mortality estimate up to and Including Hornsea 2 (The point of no AEoI)	351.3	0.996	0.42%
	2. In-combination collision mortality estimate (**Table 9**)	396.9	0.995	0.48%
Natural England WCS	3. In-combination collision mortality estimate (**Table 9**)	438.1	0.995	0.53%

6.4 Guillemot

6.4.1 Hornsea Four alone

6.4.1.1 The results of the PVA runs for guillemot at the FFC SPA scale for Hornsea Four alone are presented in **Table 17** below.

[11] Based on the annual collision result values presented in Table A3 of **Volume A5, Annex 5.3: Offshore Ornithology Collision Risk Modelling** and Natural England WCS breeding season apportionment (**Table 4**) using the full breeding bio-season (April to August for kittiwake.

Table 17: Guillemot FFC SPA population modelling results using the Seabird PVA Tool.

Apportionment approach	Scenario	Adult mortality (per annum)	Density-independent counterfactual of population growth rate (after 35 Years)	Reduction in growth rate (per annum)
Evidence Led	1. 30% displacement, 1% mortality estimate	21.0	1.000	0.02%
	2. 50% displacement, 1% mortality estimate	35.1	1.000	0.03%
	3. 60% displacement, 1% mortality estimate (Forth of Tay Consented Values)	42.1	1.000	0.04%
	4. 70% displacement, 1% mortality estimate	49.1	1.000	0.05%
	5. 30% displacement, 2% mortality estimate	42.1	1.000	0.04%
	6. 50% displacement, 2% mortality estimate	70.1	0.999	0.06%
	7. 70% displacement, 2% mortality estimate	98.1	0.999	0.09%
	8. 30% displacement, 5% mortality estimate	105.2	0.999	0.10%
	9. 50% displacement, 5% mortality estimate	175.3	0.998	0.16%
	10. 70% displacement, 5% mortality estimate	245.4	0.998	0.23%
	11. 30% displacement, 10% mortality estimate	210.3	0.998	0.19%
	12. 50% displacement, 10% mortality estimate	350.5	0.997	0.32%
	13. 70% displacement, 10% mortality estimate	490.7	0.995	0.45%
Natural England WCS	14. 30% displacement, 1% mortality estimate	32.6	1.000	0.03%
	15. 50% displacement, 1% mortality estimate	54.3	1.000	0.05%
	16. 60% displacement, 1% mortality estimate (Forth of Tay Consented Values)	65.1	0.999	0.06%
	17. 70% displacement, 1% mortality estimate	76.0	0.999	0.07%
	18. 30% displacement, 2% mortality estimate	65.1	0.999	0.06%
	19. 50% displacement, 2% mortality estimate	108.6	0.999	0.10%
	20. 70% displacement, 2% mortality estimate	152.0	0.999	0.14%
	21. 30% displacement, 5% mortality estimate	162.9	0.999	0.15%
	22. 50% displacement, 5% mortality estimate	271.5	0.998	0.25%
	23. 70% displacement, 5% mortality estimate	380.0	0.997	0.35%
	24. 30% displacement, 10% mortality estimate	325.7	0.997	0.30%
	25. 50% displacement, 10% mortality estimate	542.9	0.995	0.50%
	26. 70% displacement, 10% mortality estimate	760.1	0.993	0.70%

6.4.2 Hornsea Four in-combination

6.4.2.1 The results of the PVA runs for guillemot at the FFC SPA scale for Hornsea Four in-combination with other OWFs are presented in **Table 18** below.

Table 18: Guillemot FFC SPA population modelling results using the Seabird PVA Tool.

Apportionment approach	Scenario	Adult mortality (per annum)	Density-independent counterfactual of population growth rate (after 35 Years)	Reduction in growth rate (per annum)
Evidence Led	1. In-combination 30% displacement, 1% mortality estimate	122.6	0.999	0.11%
	2. In-combination 50% displacement, 1% mortality estimate	204.4	0.998	0.19%
	3. In-combination 70% displacement, 1% mortality estimate	286.1	0.997	0.26%
	4. In-combination 30% displacement, 2% mortality estimate	245.2	0.998	0.23%
	5. In-combination 50% displacement, 2% mortality estimate	408.7	0.996	0.38%
	6. In-combination 70% displacement, 2% mortality estimate	572.2	0.995	0.53%
	7. In-combination 30% displacement, 5% mortality estimate	613.1	0.994	0.56%
	8. In-combination 50% displacement, 5% mortality estimate	1,021.8	0.991	0.94%
	9. In-combination 70% displacement, 5% mortality estimate	1,430.5	0.987	1.31%
	10. In-combination 30% displacement, 10% mortality estimate	1,226.1	0.989	1.13%
	11. In-combination 50% displacement, 10% mortality estimate	2,043.5	0.981	1.88%
	12. In-combination 70% displacement, 10% mortality estimate	2,860.9	0.974	2.63%
Natural England WCS	13. In-combination 30% displacement, 1% mortality estimate	134.2	0.999	0.12%
	14. In-combination 50% displacement, 1% mortality estimate	223.6	0.998	0.21%
	15. In-combination 70% displacement, 1% mortality estimate	313.0	0.997	0.29%
	16. In-combination 30% displacement, 2% mortality estimate	268.3	0.998	0.25%
	17. In-combination 50% displacement, 2% mortality estimate	447.2	0.996	0.41%
	18. In-combination 70% displacement, 2% mortality estimate	626.0	0.994	0.58%
	19. In-combination 30% displacement, 5% mortality estimate	670.8	0.994	0.62%
	20. In-combination 50% displacement, 5% mortality estimate	1,117.9	0.990	1.03%

Apportionment approach	Scenario	Adult mortality (per annum)	Density-independent counterfactual of population growth rate (after 35 Years)	Reduction in growth rate (per annum)
	21. In-combination 70% displacement, 5% mortality estimate	1,565.1	0.986	1.44%
	22. In-combination 30% displacement, 10% mortality estimate	1,341.5	0.988	1.23%
	23. In-combination 50% displacement, 10% mortality estimate	2,235.9	0.979	2.06%
	24. In-combination 70% displacement, 10% mortality estimate	3,130.2	0.971	2.88%

6.5 Razorbill

6.5.1 Hornsea Four alone

6.5.1.1 The results of the PVA runs for razorbill at the FFC SPA scale for Hornsea Four alone are presented in **Table 19** below.

Table 19: Razorbill FFC SPA population modelling results using the Seabird PVA Tool.

Apportionment approach	Scenario	Adult mortality (per annum)	Density-independent counterfactual of population growth rate (after 35 Years)	Reduction in growth rate (per annum)
Evidence Led	1. 30% displacement, 1% mortality estimate	0.9	1.000	0.00%
	2. 50% displacement, 1% mortality estimate	1.5	1.000	0.00%
	3. 60% displacement, 1% mortality estimate (Forth of Tay Consented Values)	1.8	1.000	0.00%
	4. 70% displacement, 1% mortality estimate	2.1	1.000	0.01%
	5. 30% displacement, 2% mortality estimate	1.8	1.000	0.01%
	6. 50% displacement, 2% mortality estimate	3.0	1.000	0.01%
	7. 70% displacement, 2% mortality estimate	4.2	1.000	0.01%
	8. 30% displacement, 5% mortality estimate	4.5	1.000	0.01%
	9. 50% displacement, 5% mortality estimate	7.5	1.000	0.02%
	10. 70% displacement, 5% mortality estimate	10.5	1.000	0.03%
	11. 30% displacement, 10% mortality estimate	9.0	1.000	0.03%
	12. 50% displacement, 10% mortality estimate	15.0	1.000	0.04%
	13. 70% displacement, 10% mortality estimate	21.1	0.999	0.06%
Natural England WCS	14. 30% displacement, 1% mortality estimate	0.9	1.000	0.00%
	15. 50% displacement, 1% mortality estimate	1.6	1.000	0.00%
	16. 60% displacement, 1% mortality estimate (Forth of Tay Consented Values)	1.9	1.000	0.01%
	17. 70% displacement, 1% mortality estimate	2.2	1.000	0.01%

Apportionment approach	Scenario	Adult mortality (per annum)	Density-independent counterfactual of population growth rate (after 35 Years)	Reduction in growth rate (per annum)
	18. 30% displacement, 2% mortality estimate	1.9	1.000	0.01%
	19. 50% displacement, 2% mortality estimate	3.1	1.000	0.01%
	20. 70% displacement, 2% mortality estimate	4.4	1.000	0.01%
	21. 30% displacement, 5% mortality estimate	4.7	1.000	0.01%
	22. 50% displacement, 5% mortality estimate	7.8	1.000	0.02%
	23. 70% displacement, 5% mortality estimate	10.9	1.000	0.03%
	24. 30% displacement, 10% mortality estimate	9.4	1.000	0.03%
	25. 50% displacement, 10% mortality estimate	15.6	1.000	0.05%
	26. 70% displacement, 10% mortality estimate	21.9	0.999	0.06%

6.5.2 Hornsea Four in-combination

6.5.2.1 The results of the PVA runs for razorbill at the FFC SPA scale for Hornsea Four in-combination with other OWFs are presented in **Table 20** below.

Table 20: Razorbill FFC SPA population modelling results using the Seabird PVA Tool.

Apportionment approach	Scenario	Adult mortality (per annum)	Density-independent counterfactual of population growth rate (after 35 Years)	Reduction in growth rate (per annum)
Evidence Led	1. In-combination 30% displacement, 1% mortality estimate	21.7	0.999	0.06%
	2. In-combination 50% displacement, 1% mortality estimate	36.2	0.999	0.11%
	3. In-combination 70% displacement, 1% mortality estimate	50.6	0.999	0.15%
	4. In-combination 30% displacement, 2% mortality estimate	43.4	0.999	0.13%
	5. In-combination 50% displacement, 2% mortality estimate	72.3	0.998	0.21%
	6. In-combination 70% displacement, 2% mortality estimate	101.3	0.997	0.30%
	7. In-combination 30% displacement, 5% mortality estimate	108.5	0.997	0.32%
	8. In-combination 50% displacement, 5% mortality estimate	180.8	0.995	0.53%
	9. In-combination 70% displacement, 5% mortality estimate	253.1	0.993	0.74%
	10. In-combination 30% displacement, 10% mortality estimate	217.0	0.994	0.63%

Apportionment approach	Scenario	Adult mortality (per annum)	Density-independent counterfactual of population growth rate (after 35 Years)	Reduction in growth rate (per annum)
	11. In-combination 50% displacement, 10% mortality estimate	361.6	0.989	1.05%
	12. In-combination 70% displacement, 10% mortality estimate	506.3	0.985	1.48%
Natural England WCS	13. In-combination 30% displacement, 1% mortality estimate	21.7	0.999	0.06%
	14. In-combination 50% displacement, 1% mortality estimate	36.2	0.999	0.11%
	15. In-combination 70% displacement, 1% mortality estimate	50.7	0.999	0.15%
	16. In-combination 30% displacement, 2% mortality estimate	43.5	0.999	0.13%
	17. In-combination 50% displacement, 2% mortality estimate	72.4	0.998	0.21%
	18. In-combination 70% displacement, 2% mortality estimate	101.4	0.997	0.30%
	19. In-combination 30% displacement, 5% mortality estimate	108.7	0.997	0.32%
	20. In-combination 50% displacement, 5% mortality estimate	181.1	0.995	0.53%
	21. In-combination 70% displacement, 5% mortality estimate	253.5	0.993	0.74%
	22. In-combination 30% displacement, 10% mortality estimate	217.3	0.994	0.63%
	23. In-combination 50% displacement, 10% mortality estimate	362.2	0.989	1.05%
	24. In-combination 70% displacement, 10% mortality estimate	507.1	0.985	1.48%

6.6 Puffin

6.6.1 Hornsea Four alone

6.6.1.1 The results of the PVA runs for puffin at the FFC SPA scale for Hornsea Four alone are presented in **Table 21** below.

Table 21: Puffin FFC SPA population modelling results using the Seabird PVA Tool.

Apportionment approach	Scenario	Adult mortality (per annum)	Density-independent counterfactual of population growth rate (after 35 Years)	Reduction in growth rate (per annum)
Evidence Led	1. 30% displacement, 1% mortality estimate	0.4	1.000	0.01%
	2. 50% displacement, 1% mortality estimate	0.7	1.000	0.02%
	3. 60% displacement, 1% mortality estimate (Forth of Tay Consented Values)	0.8	1.000	0.02%
	4. 70% displacement, 1% mortality estimate	1.0	1.000	0.03%
	5. 30% displacement, 2% mortality estimate	0.8	1.000	0.02%
	6. 50% displacement, 2% mortality estimate	1.4	1.000	0.04%
	7. 70% displacement, 2% mortality estimate	1.9	0.999	0.06%
	8. 30% displacement, 5% mortality estimate	2.1	0.999	0.06%
	9. 50% displacement, 5% mortality estimate	3.5	0.999	0.12%
	10. 70% displacement, 5% mortality estimate	4.8	0.998	0.16%
	11. 30% displacement, 10% mortality estimate	4.2	0.999	0.14%
	12. 50% displacement, 10% mortality estimate	6.9	0.998	0.23%
	13. 70% displacement, 10% mortality estimate	9.7	0.997	0.32%
Natural England WCS	14. 30% displacement, 1% mortality estimate	0.4	1.000	0.02%
	15. 50% displacement, 1% mortality estimate	0.7	1.000	0.03%
	16. 60% displacement, 1% mortality estimate (Forth of Tay Consented Values)	0.9	1.000	0.03%
	17. 70% displacement, 1% mortality estimate	1.0	1.000	0.04%
	18. 30% displacement, 2% mortality estimate	0.9	1.000	0.03%
	19. 50% displacement, 2% mortality estimate	1.5	0.999	0.05%
	20. 70% displacement, 2% mortality estimate	2.1	0.999	0.07%
	21. 30% displacement, 5% mortality estimate	2.2	0.999	0.08%
	22. 50% displacement, 5% mortality estimate	3.7	0.999	0.12%
	23. 70% displacement, 5% mortality estimate	5.2	0.998	0.17%
	24. 30% displacement, 10% mortality estimate	4.5	0.999	0.14%
	25. 50% displacement, 10% mortality estimate	7.4	0.998	0.24%
	26. 70% displacement, 10% mortality estimate	10.4	0.997	0.34%

6.6.2 Hornsea Four in-combination

6.6.2.1 The results of the PVA runs for puffin at the FFC SPA scale for Hornsea Four in-combination with other OWFs are presented in **Table 22** below.

Table 22: Puffin FFC SPA population modelling results using the Seabird PVA Tool.

Apportionment approach	Scenario	Adult mortality (per annum)	Density-independent counterfactual of population growth rate (after 35 Years)	Reduction in growth rate (per annum)
Evidence Led	1. In-combination 30% displacement, 1% mortality estimate	3.1	0.999	0.10%
	2. In-combination 50% displacement, 1% mortality estimate	5.2	0.998	0.17%
	3. In-combination 70% displacement, 1% mortality estimate	7.3	0.998	0.24%
	4. In-combination 30% displacement, 2% mortality estimate	6.2	0.998	0.21%
	5. In-combination 50% displacement, 2% mortality estimate	10.4	0.997	0.34%
	6. In-combination 70% displacement, 2% mortality estimate	14.5	0.995	0.48%
	7. In-combination 30% displacement, 5% mortality estimate	15.5	0.995	0.51%
	8. In-combination 50% displacement, 5% mortality estimate	25.9	0.991	0.85%
	9. In-combination 70% displacement, 5% mortality estimate	36.3	0.988	1.19%
	10. In-combination 30% displacement, 10% mortality estimate	31.1	0.990	1.02%
	11. In-combination 50% displacement, 10% mortality estimate	51.8	0.983	1.70%
	12. In-combination 70% displacement, 10% mortality estimate	72.5	0.976	2.38%
Natural England WCS	13. In-combination 30% displacement, 1% mortality estimate	3.5	0.999	0.11%
	14. In-combination 50% displacement, 1% mortality estimate	5.8	0.998	0.19%
	15. In-combination 70% displacement, 1% mortality estimate	8.1	0.997	0.26%
	16. In-combination 30% displacement, 2% mortality estimate	6.9	0.998	0.23%
	17. In-combination 50% displacement, 2% mortality estimate	11.5	0.996	0.38%
	18. In-combination 70% displacement, 2% mortality estimate	16.1	0.995	0.53%
	19. In-combination 30% displacement, 5% mortality estimate	17.3	0.994	0.57%
	20. In-combination 50% displacement, 5% mortality estimate	28.8	0.991	0.94%

Apportionment approach	Scenario	Adult mortality (per annum)	Density-independent counterfactual of population growth rate (after 35 Years)	Reduction in growth rate (per annum)
	21. In-combination 70% displacement, 5% mortality estimate	40.3	0.987	1.32%
	22. In-combination 30% displacement, 10% mortality estimate	34.6	0.989	1.14%
	23. In-combination 50% displacement, 10% mortality estimate	57.6	0.981	1.89%
	24. In-combination 70% displacement, 10% mortality estimate	80.7	0.974	2.65%

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Appendix A : Flamborough and Filey SPA Productivity results

Table A1: Gannet FFC SPA Productivity.

Monitoring Site		Jubilee Corner	Nettletrip	Staple Newk 1	Staple Newk 2	Staple Newk 3	Total
2009	Apparently Occupied Nests (AON)	52	49	50	50	50	251
	Fledged	43	45	43	43	41	215
	Productivity	0.827	0.918	0.860	0.860	0.820	0.857
2010	AON	50	50	50	50	50	250
	Fledged	41	41	41	44	39	206
	Productivity	0.820	0.820	0.820	0.880	0.780	0.824
2011	AON	49	49	49	49	50	246
	Fledged	40	44	40	39	43	206
	Productivity	0.816	0.898	0.816	0.796	0.860	0.837
2012	AON	51	52	50	50	52	255
	Fledged	46	46	45	41	40	218
	Productivity	0.902	0.885	0.900	0.820	0.769	0.855
2013	AON	51	51	50	50	52	254
	Fledged	42	40	46	42	42	212
	Productivity	0.824	0.784	0.920	0.840	0.808	0.835
2014	AON	52	55	50	52	50	259
	Fledged	41	36	42	39	43	201
	Productivity	0.788	0.655	0.840	0.750	0.860	0.779
2015	AON	53	57	48	52	50	260
	Fledged	38	50	42	47	45	222
	Productivity	0.717	0.877	0.875	0.904	0.900	0.855
2016	AON	53	52	53	55	52	265
	Fledged	45	46	45	46	46	228
	Productivity	0.849	0.885	0.849	0.836	0.885	0.861

Monitoring Site		Jubilee Corner	Nettletrip	Staple Newk 1	Staple Newk 2	Staple Newk 3	Total
2017	AON	53	57	52	53	58	273
	Fledged	44	48	44	45	39	220
	Productivity	0.830	0.842	0.846	0.849	0.672	0.808
2018	AON	52	53	53	53	51	262
	Fledged	41	42	45	42	39	209
	Productivity	0.788	0.792	0.849	0.792	0.765	0.797
2019	AON	54	52	52	52	54	264
	Fledged	45	43	35	37	36	196
	Productivity	0.833	0.827	0.673	0.712	0.667	0.742
Average productivity between 2009 - 2019							**0.823 ± 0.038**

Table A2: Kittiwake FFC SPA Productivity.

	Monitoring Site	Jubilee Far	Bartlett Nab Plots	Grandstand Plots	Old Dor	Newcombe Plots	Carter Lane Plots	Saddle Nook Plots	Breil Nook Plots	Swineshaw Hole	Lighthouse	Tagging Site	Filey Plots	Total[12]
2009	AON	50	50	100	50	50	0	100	100	0	50	0	0	950
	Fledged	54	50	102	55	36	0	103	93	0	38	0	0	915
	Productivity	1.080	1.000	1.020	1.100	0.720	0.000	1.030	0.930	0.000	0.760	0.000	0.000	0.965
2010	AON	50	106	261	50	100	100	100	201	50	50	74	0	2010
	Fledged	60	127	318	61	117	103	127	223	49	78	69	0	2347
	Productivity	1.200	1.193	1.209	1.220	1.170	1.030	1.270	1.110	0.980	1.560	0.932	0.000	1.168
2011	AON	50	100	250	50	100	50	100	201	50	50	0	0	1802
	Fledged	50	99	257	57	71	38	86	144	34	27	0	0	1558
	Productivity	1.000	0.990	1.028	1.140	0.710	0.760	0.860	0.717	0.680	0.540	0.000	0.000	0.862
2012	AON	50	97	252	50	103	0	98	147	53	48	0	252	2099
	Fledged	32	87	224	49	86	0	52	96	38	46	0	55	1365
	Productivity	0.640	0.896	0.889	0.980	0.835	0.000	0.534	0.659	0.717	0.958	0.000	0.216	0.732
2013	AON	50	100	201	50	99	0	101	201	44	49	0	223	2043
	Fledged	9	55	140	24	48	0	49	90	8	35	0	58	956
	Productivity	0.180	0.550	0.696	0.480	0.485	0.000	0.484	0.447	0.182	0.714	0.000	0.255	0.500
2014	AON	50	100	254	49	102	0	52	200	49	50	0	255	2124
	Fledged	44	86	228	26	85	0	33	118	33	56	0	114	1487
	Productivity	0.880	0.860	0.899	0.531	0.834	0.000	0.635	0.590	0.673	1.120	0.000	0.447	0.770
2015	AON	50	101	250	50	106	101	100	202	48	50	0	257	2432
	Fledged	37	83	206	29	57	57	85	144	33	43	0	119	1644
	Productivity	0.740	0.821	0.824	0.580	0.513	0.563	0.850	0.714	0.688	0.860	0.000	0.472	0.723
2016	AON	50	101	254	50	111	100	50	203	50	50	0	231	2300

[12] A weighted mean approach has been used to calculate the average productivity due to the different proportion of the population the productivity plots at FH&BC SPA (88% of the total FFC SPA population) present in comparison to Filey plots (12% of the overall population).

	Monitoring Site	Jubilee Far	Bartlett Nab Plots	Grandstand Plots	Old Dor	Newcombe Plots	Carter Lane Plots	Saddle Nook Plots	Breil Nook Plots	Swineshaw Hole	Lighthouse	Tagging Site	Filey Plots	Total[12]
	Fledged	25	51	126	28	36	48	43	140	22	27	0	55	1100
	Productivity	0.500	0.503	0.495	0.560	0.310	0.480	0.860	0.692	0.440	0.540	0.000	0.232	0.527
	AON	50	100	200	50	97	50	100	203	50	0	0	150	1950
	Fledged	26	64	115	31	42	25	68	118	38	0	0	59	1077
2017	Productivity	0.520	0.640	0.575	0.620	0.426	0.500	0.680	0.582	0.760	0.000	0.000	0.393	0.580
	AON	50	100	250	50	104	53	50	154	50	54	0	100	1826
	Fledged	27	49	126	35	45	36	31	91	28	36	0	54	990
2018	Productivity	0.540	0.490	0.504	0.700	0.423	0.679	0.620	0.595	0.560	0.667	0.000	0.540	0.550
	AON	50	104	200	50	105	52	50	97	49	51	0	153	1722
	Fledged	27	48	104	34	67	23	21	66	29	44	0	64	920
2019	Productivity	0.540	0.461	0.520	0.680	0.630	0.442	0.420	0.671	0.592	0.863	0.000	0.427	0.568
Average productivity between 2009 - 2019														**0.722 ± 0.210**

Table A3: Guillemot FFC SPA Productivity.

Monitoring Site		Nettletrip	Grandstand North	Grandstand South	Carter Lane 1	Carter Lane 2	Breil Nook	Total
2009	AON	51	48	45	47	45		236
	Fledged	36	39	36	39	34		184
	Productivity	0.706	0.813	0.800	0.830	0.756		0.781
2010	AON	50	50	49	48	54	50	301
	Fledged	31	36	36	39	38	46	226
	Productivity	0.620	0.720	0.735	0.813	0.704	0.920	0.752
2011	AON	50		48	50	50	50	248
	Fledged	37		32	46	41	46	202
	Productivity	0.740		0.667	0.920	0.820	0.920	0.813
2012	AON	58	55	48	48	54	65	328
	Fledged	33	35	33	40	44	57	242
	Productivity	0.569	0.636	0.688	0.833	0.815	0.877	0.736
2013	AON	52		45	49	51	52	249
	Fledged	30		36	42	38	48	194
	Productivity	0.577		0.800	0.857	0.745	0.923	0.780
2014	AON	47		50	49	51	54	251
	Fledged	30		41	41	37	49	198
	Productivity	0.638		0.820	0.837	0.725	0.907	0.786
2015	AON	50	42	54	49	45	53	293
	Fledged	25	28	40	41	32	45	211
	Productivity	0.500	0.667	0.741	0.837	0.711	0.849	0.717
2016	AON	50	58	50	56	55	53	322
	Fledged	28	33	32	35	41	37	206
	Productivity	0.560	0.569	0.640	0.625	0.745	0.698	0.640
2017	AON	47	44	55	47	56	55	304
	Fledged	29	7	42	30	40	37	185

Monitoring Site		Nettletrip	Grandstand North	Grandstand South	Carter Lane 1	Carter Lane 2	Breil Nook	Total
	Productivity	0.617	0.159	0.764	0.638	0.714	0.673	0.594
2018	AON	55	64	52	47	48	53	319
	Fledged	31	32	35	36	27	35	196
	Productivity	0.564	0.500	0.673	0.766	0.563	0.660	0.621
2019	AON	50	47	55	54	55	57	318
	Fledged	19	25	40	43	40	45	212
	Productivity	0.380	0.532	0.727	0.796	0.727	0.789	0.659
Average productivity between 2009 - 2019								**0.716 ± 0.076**

Table A4: Razorbill FFC SPA Productivity.

Monitoring Site[13]		Grandstand Gully	Grandstand North	Grandstand South	Newcombe	Back of Newcombe	Saddle Nook	Breil Nook	Swineshaw Hole	Total
2010	AON	14	34	17	61	18	35	40	34	253
	Fledged	6	26	11	43	13	21	26	16	162
	Productivity	0.429	0.765	0.647	0.705	0.722	0.600	0.650	0.471	0.624
2011	AON	11	28	18	66	36	50	49	48	306
	Fledged	4	14	12	52	28	41	41	35	227
	Productivity	0.364	0.500	0.667	0.788	0.778	0.820	0.837	0.729	0.685
2012	AON	13	29	18	47	42	50	49	53	301
	Fledged	5	14	15	40	29	36	38	39	216
	Productivity	0.385	0.483	0.833	0.851	0.690	0.720	0.776	0.736	0.684
2013	AON	12	45	16	52	42	52	52	50	321
	Fledged	7	30	6	27	32	42	39	32	215
	Productivity	0.583	0.667	0.375	0.519	0.762	0.808	0.750	0.640	0.638
2014	AON	16	49	16	53	45	48	53	53	333
	Fledged	7	37	11	39	37	26	44	42	243
	Productivity	0.438	0.755	0.688	0.736	0.822	0.542	0.830	0.792	0.700
2015	AON	16	25	19	66	53	43	62	66	350
	Fledged	8	17	9	45	40	34	51	39	243
	Productivity	0.500	0.680	0.474	0.682	0.755	0.791	0.823	0.591	0.662
2016	AON	17	55	28	68	53	56	55	51	383
	Fledged	4	25	7	41	34	27	36	35	209
	Productivity	0.235	0.455	0.250	0.603	0.642	0.482	0.655	0.686	0.501
2017	AON	13	46	22	80	49	53	56	58	377
	Fledged	2	17	7	67	29	37	46	39	244
	Productivity	0.154	0.370	0.318	0.838	0.592	0.698	0.821	0.672	0.558

[13] Due to only five out of the eight productivity plots monitored in 2009, the 2009 productivity data was not included in the average productivity calculation as requested by Natural England (**OFF-ORN-6.17**).

Monitoring Site[13]		Grandstand Gully	Grandstand North	Grandstand South	Newcombe	Back of Newcombe	Saddle Nook	Breil Nook	Swineshaw Hole	Total
2018	AON	17	42	26	84	48		61	63	341
	Fledged	12	27	20	64	37		45	43	248
	Productivity	0.706	0.643	0.769	0.762	0.771		0.738	0.683	0.724
2019	AON	35	56	53	56	46	45	50	50	391
	Fledged	25	29	24	37	28	33	32	37	245
	Productivity	0.714	0.518	0.453	0.661	0.609	0.733	0.640	0.740	0.633
Average productivity between 2010 - 2019										**0.641 ± 0.068**

Appendix B : SNH (2018) Seabird Colony Apportionment Methodology

The SNH (2018) apportionment approach is based on considering foraging ranges in addition to three colony-specific weighting factors:

- Colony size (in individuals);
- Distance of colony from the development site; and
- Sea area (the real extent of the open sea within the foraging range of the relevant species).

All colonies within mean-max foraging range are included and the three weighting factors noted above were calculated for each species / colony of interest.

Sea proportion is defined as:

Sea area / Theoretical Foraging Area

Where Theoretical Foraging Area is the area of a circle with radius equal to the mean-max foraging range. For a hypothetical colony on the edge of a continent with a perfectly straight coastline, the sea proportion would equal 0.5 (i.e. half the theoretical foraging area is sea; the other half is land).

A colony-specific weighting is calculated as follows:

*Colony Weight = (Colony Population / Sum of Populations) * (Sum of Distance2 / Colony Distance2) * (1/Colony Sea Proportion / Sum of 1/Sea Proportions).*

The proportion apportioned to each colony is calculated as:

Colony Weight / Sum of Colony Weights

The SNH (2018) apportionment input values and resulting apportionment to the FFC SPA is presented for all five species assessed in **Table B 1** to **Table B 5** below.

Table B 1: Gannet calculation values following the SNH Apportionment tool (SNH 2018).

Colony Name	Colony size (Breeding adults)	Distance to Project Site (km)	Distance2	Area of foraging range as sea (km2)	Proportion of Foraging Range as Sea	1/P(Sea)	Weight	Proportion (%)
Flamborough Head and Bempton Cliffs	26,798	87	7,523	159,527	0.511	1.957	1.192	64.29
St Abb's Head NNR	2	329	108,501	124,473	0.399	2.508	0.000	0.00
Bass Rock	150,518	297	88,043	137,813	0.442	2.265	0.662	35.71
Column Sums	177,318		204,067			6.729	1.854	100.00
FFC SPA Total								**64.29**[14]

Foraging range and foraging area	
Foraging range (mean-max) (km)	315
Maximum theoretical foraging area (km2)	312,120

Table B 2: Kittiwake calculation values following the SNH Apportionment tool (SNH 2018).

Colony Name	Colony size (Breeding adults)	Distance to Project Site (km)	Distance^2	Area of foraging range as sea (km^2)	Proportion of Foraging Range as Sea	1/P(Sea)	Weight	Proportion (%)
Filey 1	1,580	100	10,078	41,793	0.546	1.832	0.017	1.13
Filey 2	6,368	99	9,861	41,984	0.548	1.823	0.070	4.63
Filey 3	4,114	98	9,652	42,192	0.551	1.814	0.046	3.04
Flamborough Head and Bempton Cliffs	91,008	87	7,523	42,921	0.561	1.784	1.281	84.80

[14] Due to evidence gained from tracking studies suggesting that gannets from adjacent colonies show 'space partitioning', a precautionary approach has been taken and 100% of breeding adult gannets in and around Hornsea Four have been attributed to the FFC SPA, instead of 64.29% calculated using the SNH apportionment tool (SNH 2018).

Colony Name	Colony size (Breeding adults)	Distance to Project Site (km)	Distance[2]	Area of foraging range as sea (km^2)	Proportion of Foraging Range as Sea	1/P(Sea)	Weight	Proportion (%)
Flamborough 8	96	91	8,251	41,606	0.544	1.84	0.001	0.08
Castle Headland	3,089	107	11,479	40,908	0.534	1.871	0.030	1.98
Cayton Bay 1	0	103	10,597	41,248	0.539	1.856	0.000	0.00
Cloughton Wyke	0	110	12,129	40,973	0.535	1.868	0.000	0.00
Grand Hotel	487	107	11,361	40,881	0.534	1.873	0.005	0.32
Harbourside Houses	39	106	11,297	41,021	0.536	1.866	0.000	0.03
Hawsker Bottoms 1	212	122	14,936	40,516	0.529	1.889	0.002	0.11
Hundale	0	109	11,948	41,121	0.537	1.862	0.000	0.00
Huntress Row	77	107	11,407	40,845	0.534	1.874	0.001	0.05
Kettleness 1	172	134	17,940	38,777	0.507	1.974	0.001	0.07
Kettleness 2	1,366	134	17,849	38,826	0.507	1.972	0.009	0.59
Long Nab	90	109	11,883	41,039	0.536	1.865	0.001	0.06
Nelson Pub and Foreshore	136	107	11,348	40,904	0.534	1.872	0.001	0.09
Old Britannia Inn / Eastborough	19	106	11,310	41,017	0.536	1.866	0.000	0.01
Robin Hoods Bay Ness Point	0	119	14,151	40,392	0.528	1.895	0.000	0.00
Royal Hotel	43	107	11,374	40,881	0.534	1.873	0.000	0.03
Sandside	8	106	11,300	41,023	0.536	1.866	0.000	0.01
Sea Cadets	9	106	11,286	41,054	0.536	1.865	0.000	0.01
Spa Bridge	353	107	11,363	40,857	0.534	1.874	0.003	0.23
Sulmans	38	107	11,355	40,888	0.534	1.872	0.000	0.02
Scarborough Town Hall	113	107	11,368	40,893	0.534	1.872	0.001	0.07

Colony Name	Colony size (Breeding adults)	Distance to Project Site (km)	Distance^2	Area of foraging range as sea (km^2)	Proportion of Foraging Range as Sea	1/P(Sea)	Weight	Proportion (%)
Boulby Cliffs	2,520	147	21,614	36,214	0.473	2.114	0.015	0.97
Hartlepool Fish Quay 1	322	169	28,510	33,269	0.435	2.301	0.002	0.10
Phillips Jetty	754	166	27,432	32,292	0.422	2.371	0.004	0.26
Saltburn Cliffs	3,220	152	23,178	35,160	0.459	2.177	0.018	1.19
Bridlington Gypsey Race Beck Buildings	64	92	8,379	41,295	0.539	1.854	0.001	0.06
Bridlington Town	104	92	8,379	41,311	0.540	1.853	0.001	0.09
Column Sums	116,401	3,511	410,536			59.387	1.511	100.00
FFC SPA Total								**93.68**

Foraging range and foraging area	
Foraging range (mean-max) (km)	156
Maximum theoretical foraging area (km^2)	76,552

Table B 3: Guillemot calculation values following the SNH Apportionment tool (SNH 2018).

Colony Name	Colony size (Breeding adults)	Distance to Project Site (km)	Distance2	Area of foraging range as sea (km2)	Proportion of Foraging Range as Sea	1/P(Sea)	Weight	Proportion (%)
Filey 1	82	100	10,078	9,197	0.546	1.830	0.546	0.07
Filey 2	1,101	99	9,861	9,257	0.550	1.819	0.550	0.97
Filey 3	5,031	98	9,652	9,331	0.554	1.804	0.554	4.50

Colony Name	Colony size (Breeding adults)	Distance to Project Site (km)	Distance2	Area of foraging range as sea (km2)	Proportion of Foraging Range as Sea	1/P(Sea)	Weight	Proportion (%)
Flamborough Head and Bempton Cliffs	84,647	87	7,523	9,586	0.569	1.756	0.569	94.46
Column Sums	90,861	385	37,114			1.830	0.546	100.00
FFC SPA Total								**100.00**

Foraging range and foraging area	
Foraging range (mean-max) (km)	73
Maximum theoretical foraging area (km2)	16,833

Table B 4: Razorbill calculation values following the SNH Apportionment tool (SNH 2018).

Colony Name	Colony size (Breeding adults)	Distance to Project Site (km)	$Distance^2$	Area of foraging range as sea (km^2)	Proportion of Foraging Range as Sea	1/P(Sea)	Weight	Proportion (%)
Filey 1	365	100	10,078	13,632	0.552	1.813	0.011	0.95
Filey 2	550	99	9,861	13,715	0.555	1.802	0.017	1.45
Filey 3	1,346	98	9,652	13,814	0.559	1.789	0.043	3.61
Flamborough Head and Bempton Cliffs	27,967	87	7,523	14,147	0.572	1.747	1.115	93.98
Column Sums	30,228		37,114			7.152	1.186	100.00
FFC SPA Total								**100.00**

Foraging range and foraging area	
Foraging range (mean-max) (km)	88.7
Maximum theoretical foraging area (km^2)	24,717

Table B 5: Puffin calculation values following the SNH Apportionment tool (SNH 2018).

Colony Name	Colony size (Breeding adults)	Distance to Project Site (km)	$Distance^2$	Area of foraging range as sea (km^2)	Proportion of Foraging Range as Sea	1/P(Sea)	Weight	Proportion (%)
Filey 1	0	100	10,078	32199	0.545	1.834	0.000	0.00
Filey 2	2	99	9,861	32369	0.548	1.824	0.001	0.08
Filey 3	72	98	9,652	32558	0.551	1.814	0.035	2.94
Flamborough Head and Bempton Cliffs	1,916	87	7,523	33754	0.572	1.749	1.151	96.97
Column Sums	1,990		37,114			7.221	1.187	100.00
FFC SPA Total								**100.00**

Foraging range and foraging area	
Foraging range (mean-max) (km)	137
Maximum theoretical foraging area (km^2)	59,051

Appendix C : Seabird PVA Tool Input Log

Hornsea Four alone gannet FFC SPA PVA log

Set up

The log file was created on: 2021-05-18 07:43:10 using Tool version 2, with R version 3.5.1, PVA package version: 4.17 (with UI version 1.7)

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

Basic information

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: 963.
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: breeding.adults
Are baseline demographic rates specified separately for immatures?: Yes.

Population 1

Initial population values: Initial population 26784 in 2022
Productivity rate per pair: mean: 0.823 , sd: 0.038
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: 14.
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: 2023 to 2058

Impact on Demographic Rates

Scenario 1
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.000121 , se: NA

Scenario 2
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.000161 , se: NA

Scenario 3
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.000133 , se: NA

Scenario 4
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.000177 , se: NA

Scenario 5
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.000319 , se: NA

Scenario 6
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.000635 , se: NA

Scenario 7
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.000139 , se: NA

Scenario 8

All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.000497 , se: NA

Scenario 9
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.000865 , se: NA

Scenario 10
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.00019 , se: NA

Scenario 11
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.00044 , se: NA

Scenario 12
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.00048 , se: NA

Scenario 13
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.00063 , se: NA

Scenario 14
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.000675 , se: NA

Output:
First year to include in outputs: 2023
Final year to include in outputs: 2058
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

Hornsea Four in-combination gannet FFC SPA PVA log

Set up
The log file was created on: 2021-06-15 08:58:00 using Tool version 2, with R version 3.5.1, PVA package version: 4.17 (with UI version 1.7)
Package Version
popbio "popbio" "2.4.4"
shiny "shiny" "1.1.0"
shinyjs "shinyjs" "1.0"
shinydashboard "shinydashboard" "0.7.1"
shinyWidgets "shinyWidgets" "0.4.5"
DT "DT" "0.5"
plotly "plotly" "4.8.0"
rmarkdown "rmarkdown" "1.10"
dplyr "dplyr" "0.7.6"
tidyr "tidyr" "0.8.1"

Basic information

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: 5028.
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: breeding.adults
Are baseline demographic rates specified separately for immatures?: Yes.

Population 1

Initial population values: Initial population 26784 in 2022
Productivity rate per pair: mean: 0.823 , sd: 0.038
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: 10.
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: 2023 to 2058

Impact on Demographic Rates

Scenario 1
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.001895 , se: NA

Scenario 2
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.002526 , se: NA

Scenario 3
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.011128 , se: NA

Scenario 4
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.013023 , se: NA

Scenario 5
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.013655 , se: NA

Scenario 6
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.001975 , se: NA

Scenario 7
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.002633 , se: NA

Scenario 8
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.011526 , se: NA

Scenario 9
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.013501 , se: NA

Scenario 10
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.01416 , se: NA

Output:

First year to include in outputs: 2023
Final year to include in outputs: 2058
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

Hornsea Four alone kittiwake FFC SPA PVA log

Set up

The log file was created on: 2021-05-18 08:52:17 using Tool version 2, with R version 3.5.1, PVA package version: 4.17 (with UI version 1.7)

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

Basic information

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: 3792.
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: breeding.adults
Are baseline demographic rates specified separately for immatures?: Yes.

Population 1

Initial population values: Initial population 103070 in 2022
Productivity rate per pair: mean: 0.722 , sd: 0.21
Adult survival rate: mean: 0.854 , sd: 0.077
Immatures survival rates:
Age class 0 to 1 - mean: 0.79 , sd: 0 , 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: 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?: No
Are impacts specified as a relative value or absolute harvest?: relative
Years in which impacts are assumed to begin and end: 2023 to 2058

Impact on Demographic Rates

Scenario 1
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.000206 , se: NA

Scenario 2
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.000404 , se: NA

Scenario 3
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 8.8e-05 , se: NA

Scenario 4
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.000187 , se: NA

Scenario 5
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 5.2e-05 , se: NA

Scenario 6
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.000606 , se: NA

Scenario 7
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.001167 , se: NA

Scenario 8
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.000168 , se: NA

Output:

First year to include in outputs: 2023
Final year to include in outputs: 2058
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

Hornsea Four in-combination kittiwake FFC SPA PVA log

Set up

The log file was created on: 2021-06-15 09:06:43 using Tool version 2, with R version 3.5.1, PVA package version: 4.17 (with UI version 1.7)

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

Basic information

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: 5028.
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: breeding.adults
Are baseline demographic rates specified separately for immatures?: Yes.

Population 1

Initial population values: Initial population 103070 in 2022
Productivity rate per pair: mean: 0.722 , sd: 0.21
Adult survival rate: mean: 0.854 , sd: 0.077
Immatures survival rates:
Age class 0 to 1 - mean: 0.79 , sd: 0 , 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?: No
Are impacts specified as a relative value or absolute harvest?: relative
Years in which impacts are assumed to begin and end: 2023 to 2058

Impact on Demographic Rates

Scenario 1
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.003408 , se: NA

Scenario 2
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.00385 , se: NA

Scenario 3
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.004251 , se: NA

Output:

First year to include in outputs: 2023
Final year to include in outputs: 2058
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

Hornsea Four alone guillemot FFC SPA PVA log

Set up

The log file was created on: 2021-06-28 11:16:38 using Tool version 2, with R version 3.5.1, PVA package version: 4.17 (with UI version 1.7)

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

Basic information

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: 1211.
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: breeding.adults
Are baseline demographic rates specified separately for immatures?: Yes.

Population 1

Initial population values: Initial population 121754 in 2022
Productivity rate per pair: mean: 0.716 , sd: 0.076
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: 26.
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: 2023 to 2058

Impact on Demographic Rates

Scenario 1
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.000173 , se: NA

Scenario 2
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.000288 , se: NA

Scenario 3
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.000345 , se: NA

Scenario 4
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.000403 , se: NA

Scenario 5
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.000345 , se: NA

Scenario 6
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.000576 , se: NA

Scenario 7
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.000806 , se: NA

Scenario 8
All subpopulations

Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.000864 , se: NA

Scenario 9
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.001439 , se: NA

Scenario 10
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.002015 , se: NA

Scenario 11
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.001727 , se: NA

Scenario 12
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.002879 , se: NA

Scenario 13
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.004031 , se: NA

Scenario 14
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.000268 , se: NA

Scenario 15
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.000446 , se: NA

Scenario 16
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.000535 , se: NA

Scenario 17
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.000624 , se: NA

Scenario 18
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.000535 , se: NA

Scenario 19
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.000892 , se: NA

Scenario 20
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.001249 , se: NA

Scenario 21
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.001338 , se: NA

Scenario 22
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.002229 , se: NA

Scenario 23
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.003121 , se: NA

Scenario 24
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.002675 , se: NA

Scenario 25
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.004459 , se: NA

Scenario 26
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.006243 , se: NA

Output:

First year to include in outputs: 2023
Final year to include in outputs: 2058
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

Hornsea Four in-combination guillemot FFC SPA PVA log

Set up

The log file was created on: 2021-06-29 11:35:43 using Tool version 2, with R version 3.5.1, PVA package version: 4.17 (with UI version 1.7)

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

Basic information

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: 3925.
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: breeding.adults
Are baseline demographic rates specified separately for immatures?: Yes.

Population 1

Initial population values: Initial population 121754 in 2022
Productivity rate per pair: mean: 0.716 , sd: 0.076
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: 24.
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: 2023 to 2058

Impact on Demographic Rates

Scenario 1
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.001007 , se: NA

Scenario 2
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.001678 , se: NA

Scenario 3
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.00235 , se: NA

Scenario 4
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.002014 , se: NA

Scenario 5
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.003357 , se: NA

Scenario 6
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.004699 , se: NA

Scenario 7
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.005035 , se: NA

Scenario 8
All subpopulations

Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.008392 , se: NA

Scenario 9
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.011749 , se: NA

Scenario 10
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.01007 , se: NA

Scenario 11
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.016784 , se: NA

Scenario 12
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.023497 , se: NA

Scenario 13
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.001102 , se: NA

Scenario 14
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.001836 , se: NA

Scenario 15
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.002571 , se: NA

Scenario 16
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.002204 , se: NA

Scenario 17
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.003673 , se: NA

Scenario 18
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.005142 , se: NA

Scenario 19
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.005509 , se: NA

Scenario 20
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.009182 , se: NA

Scenario 21
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.012855 , se: NA

Scenario 22
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.011018 , se: NA

Scenario 23
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.018364 , se: NA

Scenario 24
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.025709 , se: NA

Output:

First year to include in outputs: 2023
Final year to include in outputs: 2058
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

Hornsea Four alone razorbill FFC SPA PVA log

Set up

The log file was created on: 2021-05-18 14:55:56 using Tool version 2, with R version 3.5.1, PVA package version: 4.17 (with UI version 1.7)

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

Basic information

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: 6699.
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: breeding.adults
Are baseline demographic rates specified separately for immatures?: Yes.

Population 1

Initial population values: Initial population 40506 in 2022
Productivity rate per pair: mean: 0.641 , sd: 0.068
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: 26
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: 2023 to 2058

Impact on Demographic Rates

Scenario 1
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 2.2e-05 , se: NA

Scenario 2
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 3.7e-05 , se: NA

Scenario 3
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 4.5e-05 , se: NA

Scenario 4
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 5.2e-05 , se: NA

Scenario 5
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 4.5e-05 , se: NA

Scenario 6
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 7.4e-05 , se: NA

Scenario 7
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.000104 , se: NA

Scenario 8
All subpopulations
Impact on productivity rate mean: 0 , se: NA

Impact on adult survival rate mean: 0.000111 , se: NA

Scenario 9
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.000186 , se: NA

Scenario 10
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.00026 , se: NA

Scenario 11
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.000223 , se: NA

Scenario 12
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.000372 , se: NA

Scenario 13
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.00052 , se: NA

Scenario 14
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 2.3e-05 , se: NA

Scenario 15
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 3.9e-05 , se: NA

Scenario 16
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 4.6e-05 , se: NA

Scenario 17
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 5.4e-05 , se: NA

Scenario 18
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 4.6e-05 , se: NA

Scenario 19
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 7.7e-05 , se: NA

Scenario 20
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.000108 , se: NA

Scenario 21
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.000116 , se: NA

Scenario 22
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.000193 , se: NA

Scenario 23
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.00027 , se: NA

Scenario 24
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.000231 , se: NA

Scenario 25
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.000386 , se: NA

Scenario 26
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.00054 , se: NA

Output:

First year to include in outputs: 2023
Final year to include in outputs: 2058
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

Hornsea Four in-combination razorbill FFC SPA PVA log

Set up

The log file was created on: 2021-06-15 10:29:21 using Tool version 2, with R version 3.5.1, PVA package version: 4.17 (with UI version 1.7)

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

Basic information

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: 5028.
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: breeding.adults
Are baseline demographic rates specified separately for immatures?: Yes.

Population 1

Initial population values: Initial population 40506 in 2022
Productivity rate per pair: mean: 0.641 , sd: 0.068
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: 24
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: 2023 to 2058

Impact on Demographic Rates

Scenario 1
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.000536 , se: NA

Scenario 2
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.000893 , se: NA

Scenario 3
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.00125 , se: NA

Scenario 4
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.001071 , se: NA

Scenario 5
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.001786 , se: NA

Scenario 6
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.0025 , se: NA

Scenario 7
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.002678 , se: NA

Scenario 8
All subpopulations
Impact on productivity rate mean: 0 , se: NA

Impact on adult survival rate mean: 0.004464 , se: NA

Scenario 9
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.006249 , se: NA

Scenario 10
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.005357 , se: NA

Scenario 11
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.008928 , se: NA

Scenario 12
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.012499 , se: NA

Scenario 13
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.000537 , se: NA

Scenario 14
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.000894 , se: NA

Scenario 15
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.001252 , se: NA

Scenario 16
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.001073 , se: NA

Scenario 17
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.001788 , se: NA

Scenario 18
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.002504 , se: NA

Scenario 19
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.002683 , se: NA

Scenario 20
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.004471 , se: NA

Scenario 21
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.006259 , se: NA

Scenario 22
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.005365 , se: NA

Scenario 23
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.008942 , se: NA

Scenario 24
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.012519 , se: NA

Output:

First year to include in outputs: 2023
Final year to include in outputs: 2058
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

Hornsea Four alone puffin FFC SPA PVA log

Set up

The log file was created on: 2021-05-19 08:04:12 using Tool version 2, with R version 3.5.1, PVA package version: 4.17 (with UI version 1.7)
Package Version
popbio "popbio" "2.4.4"
shiny "shiny" "1.1.0"
shinyjs "shinyjs" "1.0"
shinydashboard "shinydashboard" "0.7.1"
shinyWidgets "shinyWidgets" "0.4.5"
DT "DT" "0.5"
plotly "plotly" "4.8.0"
rmarkdown "rmarkdown" "1.10"
dplyr "dplyr" "0.7.6"
tidyr "tidyr" "0.8.1"

Basic information

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: 8787.
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: breeding.adults
Are baseline demographic rates specified separately for immatures?: Yes.

Population 1

Initial population values: Initial population 3579 in 2022
Productivity rate per pair: mean: 0.617 , sd: 0.151
Adult survival rate: mean: 0.907 , sd: 0.083
Immatures survival rates:
Age class 0 to 1 - mean: 0.709 , sd: 0.108 , DD: NA
Age class 1 to 2 - mean: 0.709 , sd: 0.108 , DD: NA
Age class 2 to 3 - mean: 0.709 , sd: 0.108 , DD: NA
Age class 3 to 4 - mean: 0.76 , sd: 0.093 , DD: NA
Age class 4 to 5 - mean: 0.805 , sd: 0.083 , DD: NA

Impacts

Number of impact scenarios: 26
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: 2023 to 2058

Impact on Demographic Rates

Scenario 1
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.000116 , se: NA

Scenario 2
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.000193 , se: NA

Scenario 3
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.000232 , se: NA

Scenario 4
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.000271 , se: NA

Scenario 5
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.000232 , se: NA

Scenario 6
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.000387 , se: NA

Scenario 7
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.000542 , se: NA

Scenario 8
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.00058 , se: NA

Scenario 9
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.000967 , se: NA

Scenario 10
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.001354 , se: NA

Scenario 11
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.001161 , se: NA

Scenario 12
All subpopulations

Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.001935 , se: NA

Scenario 13
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.002708 , se: NA

Scenario 14
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.000125 , se: NA

Scenario 15
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.000208 , se: NA

Scenario 16
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.000249 , se: NA

Scenario 17
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.000291 , se: NA

Scenario 18
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.000249 , se: NA

Scenario 19
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.000416 , se: NA

Scenario 20
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.000582 , se: NA

Scenario 21
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.000624 , se: NA

Scenario 22
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.001039 , se: NA

Scenario 23
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.001455 , se: NA

Scenario 24
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.001247 , se: NA

Scenario 25
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.002079 , se: NA

Scenario 26
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.00291 , se: NA

Output:
First year to include in outputs: 2023
Final year to include in outputs: 2058
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

Hornsea Four in-combination puffin FFC SPA PVA log

Set up

The log file was created on: 2021-06-15 11:53:24 using Tool version 2, with R version 3.5.1, PVA package version: 4.17 (with UI version 1.7)
Package Version
popbio "popbio" "2.4.4"
shiny "shiny" "1.1.0"
shinyjs "shinyjs" "1.0"
shinydashboard "shinydashboard" "0.7.1"
shinyWidgets "shinyWidgets" "0.4.5"
DT "DT" "0.5"
plotly "plotly" "4.8.0"
rmarkdown "rmarkdown" "1.10"
dplyr "dplyr" "0.7.6"
tidyr "tidyr" "0.8.1"

Basic information

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: 5028.
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: breeding.adults
Are baseline demographic rates specified separately for immatures?: Yes.

Population 1

Initial population values: Initial population 3579 in 2022
Productivity rate per pair: mean: 0.617 , sd: 0.152
Adult survival rate: mean: 0.907 , sd: 0.083
Immatures survival rates:
Age class 0 to 1 - mean: 0.709 , sd: 0.108 , DD: NA
Age class 1 to 2 - mean: 0.709 , sd: 0.108 , DD: NA
Age class 2 to 3 - mean: 0.709 , sd: 0.108 , DD: NA
Age class 3 to 4 - mean: 0.76 , sd: 0.093 , DD: NA

Age class 4 to 5 - mean: 0.805 , sd: 0.083 , DD: NA

Impacts

Number of impact scenarios: 24
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: 2023 to 2058

Impact on Demographic Rates

Scenario 1
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.000868 , se: NA

Scenario 2
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.001447 , se: NA

Scenario 3
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.002026 , se: NA

Scenario 4
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.001737 , se: NA

Scenario 5
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.002894 , se: NA

Scenario 6
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.004052 , se: NA

Scenario 7
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.004342 , se: NA

Scenario 8
All subpopulations
Impact on productivity rate mean: 0 , se: NA

Impact on adult survival rate mean: 0.007236 , se: NA

Scenario 9
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.01013 , se: NA

Scenario 10
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.008683 , se: NA

Scenario 11
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.014472 , se: NA

Scenario 12
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.020261 , se: NA

Scenario 13
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.000966 , se: NA

Scenario 14
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.00161 , se: NA

Scenario 15
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.002254 , se: NA

Scenario 16
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.001932 , se: NA

Scenario 17
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.003219 , se: NA

Scenario 18
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.004507 , se: NA

Scenario 19
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.004829 , se: NA

Scenario 20
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.008048 , se: NA

Scenario 21
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.011268 , se: NA

Scenario 22
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.009658 , se: NA

Scenario 23
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.016097 , se: NA

Scenario 24
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.022535 , se: NA

Output:

First year to include in outputs: 2023
Final year to include in outputs: 2058
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