Hornsea Project Four

Ornithological Assessment Sensitivity Report

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Prepared APEM Ltd, June 2022
Checked Faye Mc Ginn, Orsted, June 2022
Accepted Hannah Towner-Roethe, Orsted, June 2022
Approved Julian Carolan, Orsted, June 2022

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Revision Summary

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1	N/A	N/A	Submitted at Deadline 4
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Glossary

Term	Definition
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.
Confidence intervals	Range of values that with a specified certainty contains the true mean of the population that a sample was taken from. For example, 95% confidence intervals states a range of values with a 95% certainty those values contain the population mean.
Design-based Abundance Estimates	An estimated total abundance of identified targets (in the case of this report gannets) within a given area ("design- based" because the approach relies on the survey design providing representative sampling and assuming transects can be considered independent samples from a uniform distribution) based on the raw observations recorded within a survey.
Displacement	The potential for birds and other animals to avoid an area due to the presence of the wind turbines or from vessel activity.
Macro Avoidance	Avoidance response prior to entry of the OWF array area.
Meso Avoidance	Avoidance response within the OWF array area.
Micro Avoidance	avoidance response within 10 m of the rotor swept zone of individual wind turbine generators.
MRSea	Statistical package to model spatial count data and predict spatial abundances; developed by the Centre for Research into Ecological and Environmental Modelling (CREEM) specifically for dealing with data collected for offshore wind farm projects.

Acronyms

Term	Definition
BDMPS	Biologically Defined Minimum Population Scale
BEIS	Business, Energy and Industrial Strategy
BTO	British trust for Ornithology
CFPS	Counterfactual of Final Population Size
CPGR	Counterfactual of Population Growth Rate
CRM	Collision Risk Modelling
DCO	Development Consent Order
EIA	Environmental Impact Assessment
EP	Evidence Plan
ExA	Examining Authority
FAME	Future of the Atlantic Marine Environment project
HRA	Habitats Regulations Assessment
JNCC	Joint Nature Conservation Committee
ORJIP	Offshore Renewables Joint Industry Programme
OWF	Offshore Wind Farm
RSPB	Royal Society for the Protection of Birds
sCRM	Stochastic Collision Risk Modelling
SD	Standard Deviation
SofS	Secretary of State
WTG	Wind Turbine Generator

1 Introduction

1.1.1.1 In the Applicant's comments on Relevant Representations submitted at Deadline 1 (**REP1-038**) and in summary of Natural England's Relevant Representation (**RR-029**), the Applicant committed to submit an Assessment Sensitivity Report presenting the Applicant and SNCB position on ornithology assessment parameters.

1.1.1.2 The objective of this report is to provide the Examining Authority (ExA) and Secretary of State (SoS) for Business, Energy and Industrial Strategy (BEIS) the relevant information pertaining to the Applicant and SNCB position in relation to all assessment parameters for ornithology.

1.2 Background

1.2.1.1 A continued theme in relation to the assessment of potential impacts on seabirds from offshore wind farm (OWF) projects is the issue of balancing the inclusion of precaution in assessments and addressing of uncertainty, whilst trying to present a realistic and scientifically robust assessment incorporating the most up to date and accurate evidence-led approaches. Due to the sheer complexity of offshore ornithology assessments, which include multiple different input parameters, variability and uncertainty are inherent within the assessments and treatment of such needs to be carefully considered to minimise under and over precaution, particularly when considering cumulative and in-combination assessments.

1.2.1.2 The treatment of such uncertainty and variability within assessments often leads to differing of preferred assessment approaches between Applicants and Statutory Nature Conservation Bodies (SNCBs), with SNCBs requesting a precautionary approach be taken for each respective parameter within the assessment. The issue with this approach, however, is the accumulation of precaution for each individual component of the assessment process can lead to a wholly unrealistic and significantly over inflated impact value for project level assessments and result in overly precautionary conclusions being drawn. This is then further exacerbated when project alone assessments are added together within cumulative or in-combination assessments with other consented and planned projects.

1.2.1.3 The primary aim of this report is to identify the multiple components of different offshore ornithology impact assessments where sources of uncertainty and / or variability exist and the scale to which these affect the overall assessment. This is being undertaken to provide the ExA and SoS with confidence that the Applicant's approach to offshore ornithology impact assessments can be considered suitably precautionary and presents a realistic scenario. It is also hoped that this process demonstrating the inherent issues with cumulative and in-combination assessments for OWFs that currently inflate potential impact values as a consequence of precaution being added in at multiple stages and duplicated across different projects that are amassed.

1.2.1.4 This report will also provide an update to the assessments presented within **Volume A2 Chapter 5 Offshore and Intertidal Ornithology** (**APP-017**) and **2.2: Report to Inform**

Appropriate Assessment (APP-167 & APP-178), due to the emergence of further new evidence or guidance since Hornsea Four's DCO Submission.

1.2.1.5 This report is in two parts:

- **Part1:** Literature review summarising where the Applicant has identified uncertainty and / or variability in assessment parameters, including contextualising all uncertainty identified.
- **Part2:** Presentation of how the uncertainty and / or variability in each of the assessment parameters effects the overall impact assessment process and the Applicant's recommendation of how best for this to be treated to ensure a suitably precautionary assessment.

2 Part 1: Identification of sources of uncertainty/ variability and updates to Assessments

2.1 BDMPS Breeding Bio-season Population Estimates

2.1.1.1 The Applicant consulted with Natural England on the most appropriate method for calculation of the breeding Biologically Defined Minimum Population Scale (BDMPS) bio-seasons for all species scoped in for assessment ((agreement OFF-ORN-2.1– as set out in Evidence Plan Logs which are appendices to the Hornsea Four Evidence Plan (B1.1.1: Evidence Plan (APP-130)). Details of the approach taken is presented in Section 5.7 of Volume A2 Chapter 5 Offshore and Intertidal Ornithology (APP-017). During the final consultation meeting (EP#15) prior to the Hornsea Four DCO Application, Natural England proposed a different calculation method for BDMPS breeding bio-seasons. This revised method is reiterated in Natural England's Relevant Representations (RR-029; RR-029-APDX:B-3). The Applicant sought clarification regarding this matter, to which Natural England provided a clarification note on 22ND March 2022 (included within Appendix A) ahead of their originally proposed Deadline 2 submission.

2.1.1.2 The Applicant welcomes the note and explanation as to how Natural England derived breeding season population estimates for use in estimating the annual impacts at the BDMPS scale. Utilising these revised breeding season BDMPS values to assess the annual total impacts from Hornsea Four alone and cumulatively with other plans and projects would lead to a reduced overall effect for guillemot and puffin, which would mean the current effect levels are precautionary.

2.1.1.3 In both cases, the breeding BDMPS bio-season value calculated following Natural England's method is higher than that which the Applicant used. For guillemot, Natural England generated a population of 2,045,078, whilst the Applicant used 936,876. For puffin, Natural England generated a population of 868,689, whilst the Applicant used 260,726.

2.1.1.4 The Applicant does note, however, that when considering annual impacts, birds from both the UK and overseas should be accounted for. In order to fulfil this the Applicant suggests that, as well as the revised breeding population from UK colonies that reside within the species-specific BDMPS area, additional bird populations from outside the UK should also be accounted for in order to reflect the spread of potential impacts across the entire population of birds residing within the BDMPS area across the different bio-seasons. The Applicant has provided in Table 1 a revised annual impact value using Natural England's new breeding BDMPS value plus the additional overseas populations expected based on the value presented in Appendix A of Furness (2015) for the overseas total for each species. For some species the non-breeding BDMPS population in Furness (2015) might be higher than the revised annual population calculated in **Table 1**. In these instances, the Applicant would recommend keeping the annual assessments against the largest non-breeding BDMPS population total over the revised annual total.

2.1.1.5 Breeding season BDMPS values following the Applicant's DCO Application method, Natural England's method and a revised annual impact value using Natural England's breeding BDMPS method incorporating overseas individuals is presented in **Table 1**.

2.1.1.6 As presented in the **Ornithology EIA and HRA Annex** (**G5.25**), assessments for Hornsea Four alone and cumulatively have been undertaken using the breeding and annual values presented in **Table 1**, where applicable.

Table 1: Calculated breeding season and annual BDMPS values for species assessed for Hornsea Four.

Species	Applicant's DCO Application breeding BDMPS population*	Natural England's breeding BDMPS method population**	Revised annual BDMPS population
Gannet	139,302	400,326	445,503***
Kittiwake	439,902	839,456	1,237,264
Great black-backed gull	55,114	25,826	88,562***
Guillemot	936,876	2,045,078	2,139,238
Razorbill	282,582	158,031	574,910***
Puffin	260,726	868,689	938,585

Table Note: * Values derived from **Table 5.14** of **Volume A2 Chapter 5 Offshore and Intertidal Ornithology** (**APP-017**). ** Values derived following the method detailed in **Appendix A**. *** Value calculated lower than non-breeding BDMPS population in Furness (2015) for the species.

2.2 Collision Risk Modelling

2.2.1.1 There is potential risk to birds from offshore wind farms through collision with wind turbines and associated infrastructure. As detailed in **A5.5.3 ES Volume A5 Annex 5.3 Offshore Ornithology Collision Risk Modelling** (**APP-076**), the Applicant, Natural England and the Royal Society for the Protection of Birds (RSPB) agreed on the use of the Marine Scotland developed stochastic Collision Risk Model (sCRM) (Donovan, 2018) in order to assess the risk of collision from Hornsea Four to seabirds ((agreement **OFF-ORN-2.7, 2.16 & 2.38**– as set out in Evidence Plan Logs which are appendices to the Hornsea Four Evidence Plan (**B1.1.1: Evidence Plan** (**APP-130**)). The rationale for model selection is detailed in **A5.5.3 ES Volume A5 Annex 5.3 Offshore Ornithology Collision Risk Modelling** (**APP-076**).

2.2.1.2 Five species were selected and agreed between the Applicant, Natural England and the RSPB to be modelled for collision risk ((agreement **OFF-ORN-2.11**– as set out in Evidence Plan Logs which are appendices to the Hornsea Four Evidence Plan (**B1.1.1: Evidence Plan** (**APP-130**)), which were:

Gannet, Morus bassanus;

Kittiwake, Rissa tridactyla;
Herring gull, Larus argentatus;
Lesser black-backed gull, Larus fuscus (at the request of Natural England); and
Great black-backed gull, Larus marinus.

2.2.1.3 Within the model the input parameters where potential variability exist are presented below and described in detail within the following sections:

Avoidance rates;
Species biometrics;
Flight speeds;
Nocturnal activity factors;
Seabird density; and
Flight height data.

2.2.2 Avoidance Rates

2.2.2.1 For the assessment of collision risk to seabirds presented within the Hornsea Four **Volume A2 Chapter 5 Offshore and Intertidal Ornithology** (**APP-017**), the Applicant used the avoidance rates presented in a joint response from the UK SNCBs to the Marine Scotland Science avoidance rate review (JNCC et al, 2014) as advocated by and agreed with Natural England for all species assessed, the response being to the source data on avoidance rates by Cook et al. (2014). Since this guidance was published, a more recent paper on seabird avoidance rates was published by Bowgen & Cook (2018), which provides higher avoidance rates for gannet and kittiwake than previously published. Those provided by this latter paper accounted for strong evidence of macro avoidance of OWFs in gannet behaviour from multiple studies. It also suggested the use of a new species-specific avoidance rate for kittiwake using monitoring data from an active OWF over the grouped generic value previously suggested for kittiwake in the joint SNCBs response note (JNCC et al, 2014). The Applicant initially proposed the use of the latest avoidance rates from Bowgen & Cook (2018) for use in assessment of collision risk for Hornsea Four following on from the use of it within other OWF collision risk assessments, however Natural England disagreed with this approach, stating their advice hadn't changed from the joint SNCBs response note (JNCC, 2014).

2.2.2.2 A further recent study since the joint SNCBs response note (JNCC et al, 2014) was drafted on the calculation of avoidance rates has also been produced by Offshore Renewables Joint Industry Programme (ORJIP) (Skov et al. 2018), which aimed to calculate an empirical avoidance rate based on recorded macro (avoidance response prior to entry of the OWF array area out to a 3 km buffer), meso (avoidance response within the OWF array area) and micro avoidance (avoidance response within 10 m of the rotor swept zone of individual wind turbine generators (WTGs)) recorded. The incorporation of these additional avoidance responses resulted in significantly higher avoidance rates than previously advocated in the joint SNCBs response note (JNCC et al, 2014) (**Table 2**).

2.2.2.3 The RSPB primarily agreed with the avoidance rates advocated in the joint SNCBs (JNCC et al, 2014) response note, with the exception of the recommended avoidance rate for gannet.

As detailed in the RSPB's Relevant Representations (**RR-029**; **RR-033-K**) the RSPB stated the following:

2.2.2.4 *"Whilst the RSPB agrees with almost all of the SNCB's avoidance rates (JNCC et al, 2014), we differ with regard to gannet. We are content that 98.9% is suitable for non-breeding birds, but do not agree that this figure should be applied to the breeding season due to the lack of available evidence relating to breeding birds. GPS tracking of gannets breeding on the Bass Rock between 2010 and 2021 has shown variation in the two-dimensional foraging behaviour of birds across the breeding season (prior to chick-rearing, and during chick-rearing), between sexes, and between years (Cleasby et al. 2015a, Lane et al. 2020, Lane and Hamer 2021). Three-dimensional tracking of gannets during chick-rearing has revealed that flight height and flight speed both vary according to behaviour, sex and wind conditions (Cleasby et al. 2015b, Lane et al. 2019, Lane et al. 2020,) and similar patterns have been recorded in other seabirds (Masden et al. 2021). As the misspecification of these parameters contributes to the model error component of avoidance rate (Johnston et al., 2021) such variability should result in differential avoidance rates."*

2.2.2.5 The Applicant acknowledges the RSPB's comment and as detailed in the Applicant's **G2.9 gannet displacement and mortality evidence review** (**REP2-045**) the Applicant concluded that a difference in behaviour was observed for gannet between the breeding and non-breeding seasons, in terms of macro avoidance and displacement rates. This change in behaviour, however, does not equate to a need to reduce the avoidance rate of gannet in the breeding season. The current joint SNCB's response note (JNCC et al, 2014) advocated avoidance rate of 0.989 is already an inherently precautionary value as stated within the note itself as follows:

2.2.2.6 *"We note that the northern gannet avoidance rate represents, in reality, an 'all gull' avoidance rate, due to the absence of species-specific within windfarm avoidance data. We agree it is inappropriate to combine a within wind farm avoidance rate for this species based on the rates established for gulls with the gannet-specific macro-avoidance rate of 0.64, as this would result in a non-evidence based total avoidance rate higher than for any of the other groups considered. However, we agree that, without a within windfarm avoidance component for gannets, and acknowledging their more marked tendency to exhibit macro-avoidance behaviour; it is reasonable to ascribe to gannets the lowest of the total avoidance rates determined for any of the other groups (i.e. the 'all gull'category). In the absence of gannet-specific data for all elements of avoidance, this is also appropriately precautionary."*

2.2.2.7 Similarly, within the more recent Bowgen & Cook (2018) and Skov et al. (2018) papers, the evidence of strong macro-avoidance for gannet was the rationale for a suitable minimum avoidance rate of 0.995 to use for this species in relation to Band Option 2 within the Band (2012) Collision Risk Model (CRM).

2.2.2.8 The Applicant was advised after the final drafts of the Hornsea Four DCO Application were completed (in late August 2021) that Natural England had commissioned a new research paper on avoidance rates from the British trust for Ornithology (BTO). As part of their research the BTO undertook an analysis that combined avoidance rates from various sites as presented in Cook et al. (2014) with those derived from the ORJIP study (Bowgen & Cook 2018) and any additional sites, where the appropriate data were available, in order to provide avoidance rates based on data across a range of sites where possible. This paper was circulated to the Applicant as a report entitled *Additional analysis to inform SNCB recommendations regarding collision risk modelling - BTO Research Report No.739* (Cook, 2021).

2.2.2.9 The Applicant was advised that Natural England and the other SNCBs were then to work on producing a joint advice note on CRM, including avoidance rates. It was suggested likely that the rates recommended in the 2021 BTO review would be adopted in their formal joint SNCBs advice note, and in advance of that note, they recommend that the avoidance rates in Table A2 of the BTO report (Cook, 2021) were to be used in impact assessments.

2.2.2.10 The Applicant reviewed these data, but as they were provided after all the collision risk assessments had been completed for the Hornsea Four DCO Application did not apply them. Following this, in October 2021, Natural England alerted the Applicant that the data used to inform the report and the R code used to formulate the updated avoidance rates had errors in them. In particular, concerns had been raised surrounding the inclusion of one of the post-construction studies within the report and the coding within the modelling of all the data.

2.2.2.11 Following these concerns Natural England and the other SNCBs withdrew their advice on the use of the Cook (2021) avoidance rates commenting that '*Having carefully considered the issues raised we have concluded that they present reasonable grounds for the exclusion of that study from the findings of the report. Accordingly, Natural England has concluded that it is not appropriate to use the recommended rates in the BTO report. Therefore our advice is that CRM modelling should use the avoidance rates previously advised by SNCBs i.e. those presented in the 2014 SNCB advice note (JNCC et al, 2014) based on Cook et al (2014)*'. Natural England also stated that they were working hard to identify a course of action to ensure that any future joint SNCBs recommendations regarding avoidance rates are robust and can be adopted with confidence by stakeholders.

2.2.2.12 The Applicant is aware that a revision to the Cook (2021) paper is pending in 2022 (date unconfirmed) and a further update to the current joint SNCBs response note (JNCC et al, 2014) will follow, but is unaware of when these revised papers will be made publicly available.

2.2.2.13 Therefore, the Applicant continues to use the range of avoidance rates available, for which a summary of the possible variability in avoidance rates and source references are presented in **Table 2**. The difference in terms of impact values these rates have on the overall assessment is presented in Part 2 of this report (**Section 3**).

Table 2: Summary of the potential variability in avoidance rates for use in collision risk modelling.

Species	Value	Reference
Gannet (BO2)	0.989 ± 0.002	JNCC (2014)
	0.995	Bowgen & Cook (2018)
	0.999 ± 0.003	Skov et al. (2018)
Kittiwake (BO2)	0.989 ± 0.002	JNCC (2014)
	0.990	Bowgen & Cook (2018)
	0.998 ± 0.006	Skov et al. (2018)
Kittiwake (BO3)	0.980	Bowgen & Cook (2018)
Herring gull (BO2)	0.995 ± 0.001	JNCC (2014)
	0.995	Bowgen & Cook (2018)
	0.999 ± 0.005	Skov et al. (2018)
Herring gull (BO3)	0.990 ± 0.002	JNCC (2014)
	0.993	Bowgen & Cook (2018)
Lesser black-backed gull (BO2)	0.995 ± 0.001	JNCC (2014)
	0.995	Bowgen & Cook (2018)
	0.998 ± 0.006	Skov et al. (2018)
Lesser black-backed gull (BO3)	0.989 ± 0.002	JNCC (2014)
	0.993	Bowgen & Cook (2018)
Great black-backed gull (BO2)	0.995 ± 0.001	JNCC (2014)
	0.995	Bowgen & Cook (2018)
	0.996 ± 0.011	Skov et al. (2018)
Great black-backed gull (BO3)	0.989 ± 0.002	JNCC (2014)
	0.993	Bowgen & Cook (2018)

2.2.3 Species Biometrics

2.2.3.1 Within the sCRM (Donovan, 2018) pre-formulated species biometrics (body length and wingspan) values are included with Standard Deviations (SDs) around the central estimates, which are based on those presented in Robinson (2005). The use of these SDs to model variation around seabird biometrics was discussed during the Evidence Plan (EP) process. It was agreed with Natural England and the RSPB that due to the uncertainty around the calculation of the SDs within the sCRM the central estimate value was to be used for all assessment without any variability (agreement **OFF-ORN-2.32**– as set out in Evidence Plan Logs which are appendices to the Hornsea Four Evidence Plan (**B1.1.1: Evidence Plan** (**APP-130**)). Although individual birds of the same species size may differ considerably, comparatively to the single value used, due to the significant amount of data used to derive the single figure the value can be considered suitably representative of a species with high confidence and therefore, no variation is required to be modelled for species biometrics in Part 2 of this report.

2.2.4 Flight Speeds

2.2.4.1 It is highly likely that the speed at which a bird flies is highly dependent on both wind speed and the type of flight behaviour exhibited, for example a seabird's flight speed when commuting or during migratory flights are likely to differ from when a species is actively foraging. Within both the Band (2012) CRM and Marine Scotland sCRM (Donovan, 2018) an increase in flight speed leads to an increase in collision risk. Within the guidance document for the Band (2012) CRM, one area of uncertainty identified related to species biometrics, including flight speed due to the parameters not being a single fixed value. The author (Bill Band) stated within the guidance (Band, 2012) that uncertainty relating to species biometrics and flight speed could affect the predicted impact by up to ±20%. The guidance provided one recommendation suggesting running the model with variable flight behaviours (migratory vs foraging flights) depending on the likely behaviour exhibited within the OWF at different times of the year.

2.2.4.2 The flight speeds advocated by Natural England and agreed for use by the Applicant within the Hornsea Four collision risk modelling ((agreement **OFF-ORN-2.19 & 2.33**– as set out in Evidence Plan Logs which are appendices to the Hornsea Four Evidence Plan (**B1.1.1: Evidence Plan** (**APP-130**)) are derived from Pennycuick (1997) and Alerstam et al. (2007), which recorded observed flight speeds of species on commuting and migratory flights with no association to an OWF. A more recent study on bird flight speeds within an operational OWF has been undertaken (Skov et al. 2018), which calculated average flight speeds of birds within the OWF using rangefinders fitted to WTGs. The results of this study recorded slower flight speeds than currently advocated for collision risk modelling.

2.2.4.3 Kittiwake specific flight speeds are presented in Coulson (2011) and Masden (2015). Coulson (2011) recorded kittiwakes travelling at an average flight speed whilst commuting in relatively calm conditions and light winds of 43 km/h (11.94 m/s) without any influence of tail-wind assistance, reducing down to 25 km/h (6.94 m/s) in strong headwinds. Coulson (2011) also conducted a literature review of kittiwake flight speeds, which resulted in a wide range of flight speeds with peak values cited around 40-45 km/h (11.11 – 12.5 m/s), similar to that of his own research. Although a maximum record of 85-90 km/h (23.61 – 25.00 m/s) was found, Coulson dismissed this value as being unrealistic and down to an error value. No information within Coulson (2011) is provided on whether the flight speeds recorded were during migratory or commuting flights. Within the Masden (2015) avian collision risk model report a number of example assessments for kittiwakes are presented. These examples used data from the RSPB's Future of the Atlantic Marine Environment (FAME) research, collected from GPS tagged birds. Using these tagging data an overall average kittiwake flight speed was calculated as 7.26 ± 1.5 m/s. it should be noted that the RSPB FAME tagging data was collected during the breeding season and therefore does not account for any migratory flights.

2.2.4.4 A summary of the varying recorded flight speeds for different seabird species and the source references for each are presented in **Table 3**. The difference in terms of impact values these rates have on the overall assessment is presented in Part 2 (**Section 3**) of this report.

Table 3: Summary of the potential variability in seabird flight speed values.

Species	Value (m/s)	Reference
Gannet	14.90	Pennycuick (1997) and Alerstam et al. (2007)
	13.33 ± 4.24	Skov et al. (2018)
Kittiwake	13.10	Pennycuick (1997) and Alerstam et al. (2007)
	8.71 ± 3.16	Skov et al. (2018)
	11.94 (6.94 – 25.00*)	Coulson (2011)
	7.26 ± 1.50	Masden (2015)
Herring gull	12.80	Pennycuick (1997) and Alerstam et al. (2007)
	9.68 ± 3.47	Skov et al. (2018)
Lesser black-backed gull	13.10	Pennycuick (1997) and Alerstam et al. (2007)
	10.13 ± 3.93	Skov et al. (2018)
Great black-backed gull	13.70	Pennycuick (1997) and Alerstam et al. (2007)
	9.78 ± 3.65	Skov et al. (2018)
Large gulls combined	9.80 ± 3.63	Skov et al. (2018)

Table Note: *Coulson (2011) concluded that the value cited of 85 - 90 km/h (23.61 – 25.00 m/s) seemed unrealistic.

2.2.5 Nocturnal Activity Factor

2.2.5.1 Although the five seabird species scoped in for assessment of collision risk for Hornsea Four can be considered as being primarily diurnally active there may be some instances where these species might be active pre-dawn and post-dusk. Collision risk models account for this nocturnal activity through the inclusion of a nocturnal activity factor, which can be specified within the sCRM based on the species estimated activity levels during these periods of the day. The nocturnal activity factors currently advocated by Natural England are included within the Applicant's collision risk modelling ((agreement **OFF-ORN-2.20** & **2.34**– as set out in Evidence Plan Logs, which are appendices to the Hornsea Four Evidence Plan (**B1.1.1: Evidence Plan** (**APP-130**)) are derived from the scoring index for nocturnal activity presented in Garthe and Hüppop (2004) based on literature review and personal observations. These index values were then converted into a nocturnal activity factor as follows; 1 = 0%, 2 = 25%, 3 = 50%, 4 = 75%, 5 = 100%. More recent studies of nocturnal activity (MacArthur Green, APEM & Royal HaskoningDHV 2015; Masden 2015; Skov et al. 2018) have found significantly lower nocturnal activity than those presented in Garthe and Hüppop (2004), especially during the breeding season. A review of evidence in support of nocturnal activities rates for seabirds was undertaken for the East Anglia Three OWF (APEM & Royal HaskoningDHV 2015). This reviewed nocturnal activity based on the deployment of tracking loggers in both the breeding and non-breeding season, which provided evidence that activity levels recorded were significantly lower than currently advocated (Table 4). Within the accompanying guidance document for the Masden (2015) CRM, the nocturnal activity factor was derived from the RSPB FAME based on GPS tagging of kittiwakes, which provided a nocturnal activity factor of 0.033 (3%) ± 0.0045. The ORJIP collision avoidance study (Skov et al. 2018) also collected night and daytime video during the non-breeding season in the winter months (where nocturnal activity was anticipated to be higher) to compare day and night activity rates. Due to the difficulty in identifying to species level in the night-time video a general seabird activity factor of <3% was calculated.

2.2.5.2 A summary of the varying species nocturnal activity rates for different species and the source reference for each are presented in **Table 4**. The difference in terms of impact values these rates have on the overall assessment is presented in Part 2 (**Section 3**) of this report.

Table 4: Summary of the potential variability in nocturnal activity values.

Species	Value (%)	Reference
Gannet	25	Garthe and Hüppop (2004)
	0 for breeding birds and 2 for non-breeding birds	MacArthur Green, APEM & Royal HaskoningDHV (2015)
Kittiwake	50	Garthe and Hüppop (2004)
	0 for breeding birds and 12 for non-breeding birds	MacArthur Green, APEM & Royal HaskoningDHV (2015)
	3	Masden (2015)
Herring gull	50	Garthe and Hüppop (2004)
	25 for breeding birds and 25* for non-breeding birds	MacArthur Green, APEM & Royal HaskoningDHV (2015)
Lesser black-backed gull	50	Garthe and Hüppop (2004)
	25 for breeding birds and 25* for non-breeding birds	MacArthur Green, APEM & Royal HaskoningDHV (2015)
Great black-backed gull	50	Garthe and Hüppop (2004)
	25 for breeding birds and 25* for non-breeding birds	MacArthur Green, APEM & Royal HaskoningDHV (2015)
Seabird	<3%	Skov et al. (2018)

Table Note: * Precautionary value based on lack of empirical evidence providing a more appropriate value.

2.2.6 Seabird Density

2.2.6.1 As detailed within **A5.5.3 ES Volume A5 Annex 5.3 Offshore Ornithology Collision Risk Modelling** (**APP-076**) a mean density estimate of flying seabirds was calculated based on two years of 24 months of site-specific surveys in order to assess for potential collision risk from Hornsea Four. The Applicant also presented SD values alongside the mean, which were calculated in order to model potential variability in the modelled density estimates as intended within the sCRM (Donovan, 2018).

2.2.6.2 The difference in terms of impact values the variability using the SD around the mean seabird density has on the overall assessment is presented in the revised collision risk assessments in **Ornithology EIA and HRA Annex** (**G5.25**).

2.2.7 Flight Height Data

2.2.7.1 The Applicant's position, which is reflected in the approach taken by other experts undertaking collision risk modelling for OWFs, is that the use of 95% CIs around generic flight heights are unsuitable for assessment. This is due to the Johnston et al. (2014) datasets being comprised from an extensive number of studies, therefore providing confidence that the maximum likelihood values for each species are a reflective value of a species average flight behaviour. Conversely due to the numerous studies included, if assessments use the 95% CIs these values are likely to be affected by outlying uncharacteristic flight behaviours (many in relation to studies from OWFs that are either onshore or in nearshore environments that are very different in nature to Hornsea Four.

2.2.7.2 Within the Johnston et al. (2014) paper the flight heights are shown to be positively skewed, demonstrating flight height distributions were strongly weighted near the sea surface, but less so for large gull species.

2.2.7.3 The model fit (r2) for flight height distribution is very strong (over 80%) for species including gannet and kittiwake, therefore including outlying flight heights without context may reflect outliers. Such outliers are likely to represent non-typical behaviours or responses to other activities such as survey vessels collecting the data. Therefore, the use of the best model fit data most accurately represent bird behaviour at sea and therefore the range of risk that may be used to estimate collision risk.

2.2.7.4 Therefore, the Applicant considers that inclusion of 95% flight height Confidence Intervals within the assessment adds further uncertainty and unreliability into the results reducing confidence in the overall CRM outputs for assessment purposes. Nevertheless, for Natural England's preferred approach to collision risk assessment, presented within the **Ornithology EIA and HRA Annex** (**G5.25**), the upper and lower 95% CI flight height data have been used to model Natural England's minimum and maximum collision risk predicted impacts.

2.3 Displacement Analysis

2.3.1.1 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 Hornsea Four is proposed to be developed. 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 Hornsea Four and may be susceptible to displacement from such a development. Displacement may contribute to individual birds experiencing fitness consequences, which at an extreme level could lead to the mortality of individuals.

2.3.1.2 Seabird species vary in their response to the presence of operational infrastructure associated with OWFs, such as WTGs and shipping activity related to maintenance activities. The potential seabird species affected by displacement impacts from the Hornsea Four array area were consulted and agreed upon through the EP Process ((agreement **OFF-ORN-2.10**– as set out in Evidence Plan Logs, which are appendices to the Hornsea Four Evidence Plan (**B1.1.1: Evidence Plan** (**APP-130**)) as the following:

- Gannet;
- Guillemot, *Uria aalge*;
- Razorbill, *Alca torda*; and

- Puffin, *Fratercula arctica*.

2.3.1.3 The SNCB's 'matrix approach' was agreed as the most appropriate method of analysing displacement for the four species scoped in for assessment following the updated Joint SNCB (2022) guidance note. Applicable displacement and mortality rates were consulted on with Natural England and the RSPB through the EP process, in which the Applicant presented a rate of up to 50% displacement and up to 1% mortality rate for auks (guillemot, razorbill and puffin) and 60-80% displacement and up to 1% mortality for gannet. Both of the Applicant's ranges for displacement were supported by initial reviews of data sets. Natural England disagreed with these displacement and mortality rates, recommending a wider range of 30-70% displacement and 1-10% mortality for auks and 60-80% displacement and 1-10% mortality for gannets, citing a lack of empirical evidence relating to displacement and mortality rates for both. However, Natural England did recommend that narrowing of those ranges could be possible through the provision of suitable evidence from further literature reviews based on empirical datasets (agreement **OFF-ORN-2.49**, **2.50** & **2.51**– as set out in Evidence Plan Logs, which are appendices to the Hornsea Four Evidence Plan (**B1.1.1: Evidence Plan** (**APP-130**)). This advice is in line with the Joint SNCB (2022) guidance on displacement, which states:

2.3.1.4 "For those species lacking in empirical data on likely displacement levels resulting from OWF construction, there is potential utility in using the scores in order to maintain consistency of approach across different developments (where appropriate). For example, for auk species the SNCBs would typically advise a displacement level of 30-70% (Guillemot and Razorbill have a 'Disturbance Susceptibility' score of 3)."

2.3.1.5 In response to this advice provided by Natural England the Applicant undertook an extensive review of empirical datasets from 21 post-consent monitoring studies for auks and 25 post-consent monitoring studies for gannet with the detailed results presented in **G1.47 Auk Displacement and Mortality Evidence Review** (**REP1-069**) and **G2.9 Gannet Displacement and Mortality Evidence Review** (**REP2-045**).

2.3.1.6 For auks, Displacement effects varied from strong attraction to strong avoidance, however, OWFs could be separated into two groups: 1) OWFs with inferred avoidance or displacement rates higher than 50%, 2) OWFs with no significant displacement effect or suggested weak avoidance of <25% displacement. Further interrogation of these datasets suggesting displacement rates of over 50% were associated with low count data, which included high zero counts within the data set (i.e. where datasets included very low or no auks from pre-construction and / or post-construction surveys), which due to the statistical analysis method used to analyse the datasets at the time were unable to manage such zero-inflated data sets producing misleading displacement rates. The results of this study found that the current range of 30-70% advocated in the joint SNCB's (2022) guidance for auks had been compiled without due regard to the quality of the study or confidence in the derived displacement rates, furthermore it did not account for studies that have shown no significant displacement effect, attraction or likely habituation over time. The conclusion of the

Applicant's own empirical study recommends that a revised displacement rate of 0-50% would be a realistic range to be applied for the assessment of Hornsea Four.

2.3.1.7 For gannet, the empirical study identified seasonal differences in the rate of displacement with a significantly lower displacement rate in the breeding season compared to the non-breeding season across the data. Displacement rates for the breeding season in general ranged from 40-60%, with the lower assigned rate being precautionary. For the non-breeding season, the displacement rate ranged from 60-75%, which excludes low confidence studies and OWF with higher rates that have certain design metrics.

2.3.1.8 Since the drafting of both reports a further post-consent monitoring study has been published for the OWFs in the Belgian North Sea (Degraer et al., 2021). This area of development is composed of a row of nine closely adjacent OWFs and together with five OWFs in the Dutch Borssele zone of the North Sea form a contiguous complex of OWFs with various WTG designs and layouts. Construction in this area commenced in 2008 at the Thorntonbank Phase I site, with all three phases being operational by 2012 with a second OWF, Bigh Bank, operational in 2010. Post-construction surveys have been conducted between these two sites from 2010 to 2018 and displacement assessments based on five years and six years data for Bligh Bank and Thorntobank, respectively. Displacement rates reported at these OWFs were 98% and 82% for gannet at Thorntonbank and Bligh Bank, respectively and 60% and 75% for guillemot at Thorntonbank and Bligh Bank, respectively. However, the area as a whole has seen continued development with only very short periods without construction activities until the final OWF became operational at the end 2020. Therefore, displacement rates reported for these OWFs may not truly reflect an operational phase if birds are subjected to disturbance effects from construction activities in the area.

2.3.1.9 Evidence to support this is suggested from the post-construction monitoring reports in year five and six which presented evidence of habituation of gannets at Bligh Bank and Thorntonbank, respectively, showing displacement effects decreasing from up to 3 km to >0.5 km from the array area (Vanermen et al., 2019). This behavioural change coincided with a period of 10 months during which survey data was collected at a time when no ongoing construction activities were occurring in the wider area. With the completion of the remaining OWFs in this complex at the end of 2020 the phase of development can now be accurately considered an operational phase. During 2021 a new monitoring strategy commenced aiming to assess the complete operational Belgian OWF zone by means of ship-based surveys five times a year. Results from the first survey conducted in February 2021 show considerable change in behaviour of auks and gannets to the OWFs (Degraer et al., 2021). Overall, densities inside the OWF zone were about twice as high compared to densities outside (4.59 versus 2.36 birds/km² respectively) for razorbill. Common guillemot occurred more homogenously spread across the study area, with comparable densities inside and outside the OWF zone (1.2 and 1.0 birds/km² respectively). Gannet densities were higher outside the OWF zone but were the highest densities to be recorded inside an array area (0.29 and 0.80 birds/km^2, respectively). Therefore, emerging data from one of the most intensely studied OWF areas suggests there is evidence of habituation of both gannets and auks to operational OWFs, which becomes apparent only if there are no disturbance from construction activities in the wider area.

2.3.1.10 For auks and gannets, both studies (**REP1-069** and **REP2-045**) identified population simulation modeling to predict population level consequence of displaced seabirds. The results of the simulation concluded that when considering the potential displacement impacts from Hornsea Four a mortality rate of up to 1% can be considered suitably precautionary, given the projects location in relation to nearest colony, proposed WTG design and array area design of the project and species behaviour. The studies also reviewed empirical evidence of consequent displacement mortality by analysing Heligoland seabird colony monitoring data, to understand if any population effects were detectable for either auks or gannet, as a consequence of the presence of nearby OWFs, which have been on operation since 2015. For gannet and auks, since operation the colony has showed no significant change in growth rates (both auks and gannet from the colony exhibiting continued growth). Should mortality rates at this colony be as high as 10% in relation to displacement from the nearby OWFs then this would almost certainly be detectable, but at this is not the case it provides evidence that reinforces the unsuitability of a mortality rate of up to 10%.

2.3.1.11 A summary of the Applicant's and the SNCB's advocated displacement and mortality rates for auks and gannet and the source reference for each are presented in **Table 5**. The difference in terms of impact values these rates have on the overall assessment is presented in Part 2 (**Section 3**) of this report.

Table 5: Summary of the Applicant's and SNCB's advocated displacement and mortality rates.

Species	Displacement Rate (%)	Reference	Mortality Rate (%)	Reference
Gannet (Applicant's position)	40-60% breeding season 60-75% non-breeding season	G2.9 Gannet Displacement and Mortality Evidence Review (REP2-045)	0-1%	G2.9 Gannet Displacement and Mortality Evidence Review (REP2-045)
Gannet (SNCB's position)	60-80%	Joint SNCB (2022)	1-10%	Joint SNCB (2022), though the source would appear to be from a workshop with no evidence provided in support.
Auks* (Applicant's position)	0-50%	G1.47 Auk Displacement and Mortality Evidence Review (REP1-069)	0-1%	G1.47 Auk Displacement and Mortality Evidence Review (REP1-069)
Auks* (SNCB's position)	30-70%	Joint SNCB (2022)	1-10%	Joint SNCB (2022), though the source would appear to be from a workshop with no evidence provided in support.

Table Note: * auk refers to guillemot, razorbill and puffin.

2.4 Combined Collision Risk and Displacement

2.4.1.1 In line with current best practice for assessing the risk from OWFs to gannets the Applicant assessed for both collision risk and disturbance and displacement impacts both separately and combined. The current method of assessing the two predicted impacts combined is to simply add the two predicted impacts (or range of impacts) together. It is acknowledged by SNCBs that when simply combining the two impact values together this leads to an overinflated total predicted impact value. This overly inflated impact value is a consequence of the fact if a gannet is displaced from an OWF it is not possible for that individual to subsequently collide with a WTG. The reverse of this is that if a gannet is enters an OWF it may be at risk from collision with a WTG, but by entering the OWF would not be subject to displacement. Following the current method may lead to potential implications for consenting risk and planning with consequences for both project specific, cumulative and in-combination assessments of gannet included within past, current and future Environmental Impact Assessments (EIAs) and Habitats Regulations Assessments (HRAs), respectively.

2.4.1.2 As detailed in Section 2.2 the BTO (Cook, 2021) published a revised paper on avoidance rates for use in CRM (subsequently withdrawn due to reasons explained in Section 2.2), which provided a logical solution to this inherent issue of overinflating impacts for gannet, especially when combining collision risk with displacement consequent mortality rates. The paper proposed that by including macro avoidance within collision risk modelling for gannet the issue of double counting impacts could be resolved. In simple terms macro avoidance is a species avoidance response prior to entering an the OWF, which in this context a gannet's decision to avoid the OWF entirely, which at this level is also otherwise known as displacement. Macro avoidance in the context of displacement from an OWF can be incorporated within collision risk modelling via two mechanisms, through increasing the overall avoidance rate in the sCRM or by directly reducing the monthly flying gannet density estimates which are fed into the sCRM by the predicted levels of displacement for the species (**Table 5**). Should the current displacement range for gannets be applied to flying gannet densities ahead of input into the sCRM then those values would reduce by 60-80%, demonstrating how significant the level of over-inflation is likely to be if applied in this manner.

2.4.1.3 The Applicant is aware that Natural England are currently in the process of producing a new guidance note with a method to assess the combined impacts of both displacement and collision risk for gannet. It is understood that the aim of this guidance note is to address the risk of assessing collision impacts on birds that may have already been subject to displacement, therefore reducing any double counting or over-inflation of impacts as a consequence of combining the two. In advance of Natural England's guidance note the Applicant discussed the most appropriate method for inclusion of macro avoidance within collision risk assessments for gannet at an Ornithology Technical Panel meeting held on the 25th May 2022 with Natural England. The recommendation was to apply a 70% (the central value of Natural England's displacement range for this species) reduction in the monthly flying gannet density estimates used for collision risk modelling. Part 2 (**Section 3**) of this report provides revised collision risk modelling for gannet which includes reduced monthly flying gannet density estimates to account for macro avoidance to demonstrate the differences this would make to project alone and cumulatively.

2.5 Apportionment to FFC SPA

2.5.1.1 The process of apportioning predicted impacts from Hornsea Four to seabird qualifying features from the FFC SPA were consulted on through the EP process (agreement **OFF-ORN-6.1** & **6.2** – as set out in Evidence Plan Logs which are appendices to the Hornsea Four Evidence Plan (**B1.1.1: Evidence Plan** (**APP-130**)) with the methods and results presented in **B2.2 Report to Inform Appropriate Assessment Part 11: Appendix H: Offshore Ornithology Flamborough and Filey Coast (FFC) Special Protection Area (SPA) Population Viability Analysis** (**APP-177**). The apportionment process the Applicant developed were applied to the named qualifying features of the FFC SPA that were screened in for assessment within the RIAA (**APP-167**)- were as follows:

- Gannet;
- Kittiwake;
- Guillemot; and
- Razorbill.

2.5.2 Breeding Season Apportionment

2.5.2.1 When apportioning potential impacts during the breeding season it was agreed with both Natural England and the RSPB (agreement **OFF-ORN-6.2** – as set out in Evidence Plan Logs which are appendices to the Hornsea Four Evidence Plan (**B1.1.1: Evidence Plan** (**APP-130**)) that the best method would be to follow the SNH apportionment guidance (SNH, 2018) to apportion impact values to key receptors within mean max foraging range. Details of the SNH (2018) breeding season apportionment methodology are presented in Appendix B of **B2.2 Report to Inform Appropriate Assessment Part 11: Appendix H: Offshore Ornithology Flamborough and Filey Coast (FFC) Special Protection Area (SPA) Population Viability Analysis** (**APP-177**), including the apportionment results for all species assessed.

2.5.2.2 Although Natural England agreed with the SNH (2018) tool being used to apportion potential impact values, they requested that apportionment should be 100% of all impact values apportioned to the FFC SPA, due to likely being the only SPA within mean-max foraging distance (Woodward et al, 2019). Although this was found to be true for guillemot and razorbill, this was not the case for kittiwake whereby over 20 smaller colonies were also found to be within mean max foraging range. For gannet, Bass Rock and St Abbs Head SPA were also found to be within mean-max foraging range. However, as gannets are known to show 'space partitioning' between adjacent colonies (Wakefield et al. 2013), which results in limited overlap between foraging areas, a precautionary approach was taken and 100% of gannets were apportioned to the FFC SPA. It should be noted however that recent tracking data studies from Bass Rock show that gannets from the colony do enter the Hornsea Four array area during the breeding season, although this is calculated to be outside of their core foraging range (Lane et al. 2020).

2.5.2.3 As well as breeding SPA birds being present within the Hornsea Four array area, immature birds and breeding adults on a breeding sabbatical are likely to be present and therefore need to be accounted for when apportioning impacts.

2.5.2.4 For deriving the proportion of potential juvenile and immature birds within Hornsea Four during the breeding season, the Applicant initially reviewed the site-specific age ratios recorded within the aerial digital surveys. However, as presented in Appendix D of **Volume A5, Annex 5.1: Offshore and Intertidal Ornithology Baseline Characterisation Report** (**APP-074**) due to lack of age specific records, the Applicant ruled out the use of site-specific survey data to calculate age ratios on the basis of concern over reliability of these data fo that purpose.

2.5.2.5 In Natural England's Relevant Representation (**RR-029**; **RR-029-APDX:B-44**) the recommendation was made that all 'adult type' birds should be apportioned as adults. This approach suggested is highly likely to lead to inaccuracies in the apportionment process.

2.5.2.6 In relation to kittiwake only first winter juvenile birds are readily distinguishable from other age categories due to the distinct 'W pattern' across the wings and black tail-band (Svensson et al. 2009). This pattern, however, is lost by the time a kittiwake reaches its second winter moult whereby the bird is near indistinguishable from an adult bird. As presented in Coulson (2011), the modal age of kittiwakes first breeding is four years old, although the age of first breeding has been documented as late as 10 years old. This clearly shows that by treating all 'adult type' birds as breeding adults is highly likely to lead to over apportionment of impacts to breeding adult birds for kittiwakes.

2.5.2.7 In relation to auk species, the identification of first winter juvenile birds is primarily only possible in the immediate post-dispersal months whereby first winter birds are accompanied by adult males, the key indicator between first winter birds and adult males being the difference in size. Following a first summer moult differences between juvenile and adult birds are subtle and not possible to identify in surveys. The average age of first breeding in guillemots is six years old (Horswill & Robinson, 2015) and for razorbill is five years old (Horswill & Robinson, 2015). Furness (2015) also states that 80% of immature guillemots and 90% of immature razorbills from the FFC SPA remain in the North Sea and English Channel BDMPS area throughout the non-breeding bio-seasons. This clearly shows that by treating all 'adult type' birds as breeding adults is highly likely to lead to over apportionment of impacts to breeding adult birds for auk species. Conversely, relying on the site-specific data from a small number of months to represent age ratios that are only possible when juveniles are being accompanied by adult males will lead to an inaccurate 50% split between juvenile and adult birds.

2.5.2.8 For the reasons stated above, the Applicant used the data contained within Furness (2015) to calculate age ratios as used for non-breeding season apportionment, which 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.

2.5.2.9 Furthermore, not all adult birds within Hornsea Four can be classified as 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 advocated by Marine Scotland based on expert opinion 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 were applied for use in this assessment of designated features from FFC SPA during the breeding season.

2.5.3 Non-breeding Season Apportionment

2.5.3.1 When apportioning potential impacts to the FFC SPA during the non-breeding bio-seasons it was agreed with both Natural England and the RSPB (agreement **OFF-ORN-6.1** – as set out in Evidence Plan Logs which are appendices to the Hornsea Four Evidence Plan (**B1.1.1: Evidence Plan** (**APP-130**)) to use Furness (2015) to apportion impacts during the non-breeding seasons, as detailed in **B2.2 Report to Inform Appropriate Assessment Part 11: Appendix H: Offshore Ornithology Flamborough and Filey Coast (FFC) Special Protection Area (SPA) Population Viability Analysis** (**APP-177**). This is the standard approach to apportionment in the non-breeding season and has been applied by other recent OWF developments such as East Anglia One North and Norfolk Boreas (SPR, 2019; Vattenfall, 2019).

2.5.3.2 During further consultation Natural England then requested that for auks, in particular guillemot, an alternative apportionment method should be considered by the Applicant due to Natural England's concerns relating to the large number of auks passing through the array area in post-breeding dispersal months of August and September (agreement **OFF-ORN-**

6.12 – as set out in Evidence Plan Logs which are appendices to the Hornsea Four Evidence Plan (**B1.1.1: Evidence Plan** (**APP-130**)). The Applicant, agreed to this request and came up with a weighted apportionment method for the guillemot non-breeding season as detailed in **B2.2 Report to Inform Appropriate Assessment Part 11: Appendix H: Offshore Ornithology Flamborough and Filey Coast (FFC) Special Protection Area (SPA) Population Viability Analysis** (**APP-177**).

2.5.3.3 For the post-breeding dispersal months of August and September the Applicant followed a similar apportionment process to that in the breeding season accounting for higher values of breeding birds being likely to be from the FFC SPA, but also the likely proportion of non-breeding and sabbaticals birds and also accounting for the proportion of other non FFC SPA breeding adult birds which could be present. As it is not possible to determine exactly how many guillemots within Hornsea Four are non-FFC SPA breeding adults the Applicant undertook a literature review (Camphuysen 2002; Harris et al. 2015; Dunn et al. 2020) on guillemot post-breeding dispersal to inform expert judgement of 25% being from other colonies. Since this review a further paper has been published (Buckingham et al. 2022) which provides details of auk dispersal from birds tagged primarily from Scottish colonies.

2.5.3.4 However, the number of successfully recovered tags from birds breeding at colonies immediately to the north of Hornsea Four (including the Farne Islands, Coquet Island and the Isle of May) was low overall. The limited data set provided limits any justification to use these data on a blanket scale for all individuals dispersing from the main sites that contributed to the data sets. It also lacked any tagged birds from FFC SPA, which would have been more relevant to whether birds from this site move into the Hornsea Four array area or not. Despite these limitations, the core colony distributions (50% kernel density contours) show that auk disperse significant distances in such a short space of time, particularly guillemots, whereby birds from Whinnyfold and East Caithness includes areas to the west of Hornsea Four.

2.5.3.5 This new paper therefore, aids to reinforce the Applicant's expert judgement of 25% of adult birds being non-FFC SPA birds. There is also significant evidence from other OWF baseline datasets and post-consent monitoring reports from projects across the southern North Sea that also present trends of auk peak counts in the months of August and September, demonstrating that birds from many other colonies move into this region during these post-breeding dispersal months.

2.5.3.6 In the absence of an alternative means of assessment being provided by Natural England, the Applicant maintains that the assessment method taken for guillemot non-breeding season apportionment is suitably precautionary comparatively to following the standard apportionment method as presented in Part 2 of this report.

2.5.4 FFC SPA Gannet and Kittiwake Breeding Bio-season Component Months

2.5.4.1 In relation to applicable component breeding season months the Applicant interrogated the site-specific survey data to ensure consistency between the behaviours exhibited in the survey data correlate with the correct non-breeding, migratory and breeding seasons described in Furness (2015). As presented within Appendix C of **Volume A5, Annex 5.1: Offshore and Intertidal Ornithology Baseline Characterisation Report** (**APP-074**) the site-specific rose diagrams suggest the most applicable breeding bio-season to be the migration-free bio-season for kittiwake and gannet, as birds are more aligned to north-south flight directions suggesting migratory movements outside of the migration free breeding bio-season. Whereas within the migration-free breeding bio-season birds were recorded flying in east-west directions suggesting foraging flights to and from the FFC SPA.

2.5.4.2 Furthermore, the Applicant also reviewed the breeding season component months of it's sister project Hornsea Three to ensure a similar pattern conclusion was reached. In the Secretary of States (SofS) HRA (BEIS, 2020) for Hornsea Three, the ExA and the SofS accepted the Applicant's use of the migration-free breeding season for gannet and kittiwake, based on their evidence, plus Langston et al. (2013) and Cleasby et al. (2018) tracking studies. SofS HRA section 5.3.1 concluded:

2.5.4.3 "Given the above, the Secretary of State agrees with the conclusions of the ExA that the use of the longer breeding season to apportion impacts to the gannet and kittiwake populations at Flamborough and Filey Coast SPA is not justified and therefore, in this case, favours the Applicant's preferred shorter breeding season."

2.5.4.4 Hornsea Four sits in a similar area of the southern North Sea that is also subject to migratory pulses of seabirds throughout the spring and autumn when birds move to and from their breeding colonies further north (both to UK and continental locations). The migratory patterns and timing of gannets, kittiwakes, guillemots and razorbills through the southern North Sea are similar when considering their routes and interaction with other projects within the Hornsea Zone, so the Applicant's consideration of migratory birds should remain an important factor in order to apportion birds appropriately from Hornsea Four and to understand the risk to FFC SPA and other colonies accordingly.

2.6 Population Viability Analysis

2.6.1.1 In order to better understand the effect the predicted impacts from Hornsea Four alone, cumulatively and in-combination with other projects might have on seabird populations, population viability analysis (PVA) was undertaken as detailed in **A5.5.4 Environmental Statement Volume A5 Annex 5.4 Offshore Ornithology Population Viability Analysis** (**APP-077**) for EIA level impacts and **B2.2 Report to Inform Appropriate Assessment Part 11: Appendix H: Offshore Ornithology Flamborough and Filey Coast (FFC) Special Protection Area (SPA) Population Viability Analysis** (**APP-177**) for HRA level impacts apportioned to the FFC SPA. PVA can be a robust method for predicting population level impacts, as long demographic and environmental parameters are accurately incorporated and the correct outputs are used to infer predicted effects. If parameters are specified incorrectly or a less appropriate output is used to infer effects then the results can lead to significant under or over estimation of potential population level effects as a consequence.

2.6.1.2 The Applicant undertook all PVAs using the Natural England Seabird PVA Tool (Mobbs et al. 2020). This was agreed between the Applicant and Natural England through the EP process through multiple consultations on the modelling approach and most appropriate demographic parameters to include within the tool, both at an EIA and HRA (FFC SPA colony specific) levels (agreement **OFF-ORN-2.27-2.31**, **2.42** & **2.46** – as set out in Evidence Plan Logs which are appendices to the Hornsea Four Evidence Plan (**B1.1.1: Evidence Plan** (**APP-**

130)). Natural England recommended that the model should be run excluding density dependence due to the concern relating to accurately incorporating density dependence within the model.

2.6.2 'Burn-In' Period

2.6.2.1 In Natural England's Relevant Representations (RR-029; RR-029-APDX:B-59) a query was raised as to why a 'burn in' period was not included within modelling. The use of 'burn-in' had not previously been raised by Natural England when consulting on running the model, as the initial guidance paper for the Natural England Seabird PVA Tool (Mobbs et al. 2020) suggested it was not ready for inclusion. However, following receiving Natural England's Relevant Representations the Applicant has subsequently further consulted with Natural England and agreed (REP2-083) to include a 'burn-in' period within any updated PVAs, which are presented in Part 2 (Section 3) of this report.

2.7 Counterfactual of Final Population Size and Population Growth Rate

2.7.1.1 Natural England's and the RSPB queried the Applicant's rationale for not presenting the Counterfactual of Final Population Size (CFPS) alongside the Counterfactual of Population Growth Rate (CPGR) within their Relevant Representations (RR-029; RR-029-APDX:B-60; RR-033-F) The Applicant provided a full verbal explanation to the Examining Authority on this topic during Issue Specific Hearing 5 on Ornithology EIA matters and Issue Specific Hearing 6 on HRA matters.

2.7.1.2 In summary, the Applicant's reasoning for not presenting the CFPS is to avoid misinterpretation of predicted population level effects caused by the low confidence in the CFPS output. This is because CFPS and CPGR are not equally appropriate for model interpretation when modelling in the absence of density dependence. A density independent population has no constraint on increased growth or any form of recovery in decline. This means that a density independent population with a positive growth rate will grow exponentially and a negative growth population with eventually decline into extinction, for which the reality of both instances occurring in a natural population are recognised as being wholly unrealistic. This is due to a natural population not being physically able to exhibit exponential growth due to constraints on natural resources such as prey availability and nesting space. Similarly, a natural population in decline will eventually stabilise and possibly recover due to reduced competition for prey and nesting space. Therefore, in a simulation which excludes these natural constraints on population growth and decline the difference between the baseline and impacted populations will diverge by an increasing amount as the simulation duration increases, meaning that the CFPS is time sensitive and becomes less accurate with increasing simulation time. Furthermore, due to the absence of density dependence, neither the baseline nor impacted population projections are likely to be credible since seabird populations are constrained by environmental and demographic variables, resulting in unrealistic population predictions for both the baseline (unimpacted) and impacted scenario modelled.

2.7.1.3 There is also significant uncertainty relating to the interpretation of the CFPS. This is because the CFPS is a highly subjective output, with no way to validate what such predicted reductions in population size (as a consequence of predicted impacts) are likely to have on a specified population. The CFPS output might appear to show a significant reduction in population size comparatively to the baseline population to a non-specialist, but this could be easily misconstrued to assume the population is therefore in population decline, which might not necessarily be the case.

2.7.1.4 In contrast, the CPGR is time and growth trend (positive or negative) insensitive and therefore, is less prone to the effects of increasing deviation between the impacted and unimpacted population in the absence of density dependence controls, making it a more reliable output in the absence of density dependence within the model. The outputs of the CFGR can also be readily cross examined against known recent and historic population growth rates of differing populations to provide an informed decision on the likely impact such an effect may have on the colony long term. An example of this is presented in Natural England's assessment of predicted impacts on the gannet population of the FFC SPA as presented in *Natural England's comments in relation to the Norfolk Boreas updated ornithological assessment, submitted at Deadline 2* (Natural England, 2020), whereby the PVA predicted CPGR were cross examined against the population growth rates of 22 differing gannet colonies across Britain, the Channel Islands and Ireland Natural England, 2020).

2.7.1.5 On this basis the Applicant continues to advocate that the CPGR should solely be relied upon when interpreting density independent PVA modelling.

2.7.2 Demographic Rates

2.7.2.1 Through the EP Process the Applicant agreed with Natural England and the RPSB (agreement **OFF-ORN-2.42** – as set out in Evidence Plan Logs which are appendices to the Hornsea Four Evidence Plan (**B1.1.1: Evidence Plan** (**APP-130**)) that the most appropriate demographic rates for survival and EIA level productivity were those presented in Horswill & Robinson (2015). For FFC SPA productivity rates, the most reliable data source was agreed with Natural England and the RSPB as the site-specific colony monitoring data, albeit with differing opinion on years for inclusions for kittiwake (as captured In Natural England's Risk and Issues Log (**REP3-054**)).

2.7.2.2 Following the use of the agreed demographic rates the Applicant has since reviewed a recent paper on validating PVA models by comparing the known growth trends with that predicted for the baseline population within the model as recommended in Horswill et al. (2022). This paper highlights that population trends of the baseline simulated population within PVAs may not correlate with the known population growth trends, which could affect the accuracy of the PVA outputs as a consequence. The Applicant notes that this is particularly the case for razorbill and kittiwake, whereby for both species the PVA simulated a negative population growth, though for both species the PVA in relation to FFC SPA populations should follow a positive growth rate.

2.7.2.3 The resulting population growth trends resulting from such PVA simulations could be due to the survival rate data for both species being primarily from the Ilse of May and Skomer colonies, which might differ to the FFC SPA or the wider BDMPS populations. Furthermore, for kittiwake the calculated colony specific productivity rate might in fact not be truly representative of the colony as whole, as suggested by Coulson (2017) a minimum productivity rate of 0.8 is suggested for a colony to remain stable, whereas the calculated FFC SPA productivity rate is lower.

2.7.2.4 On this basis the Applicant proposes to undertake revised PVA modelling, which will include model validation steps to increase the accuracy of the outputs, the results of which are presented in Part 2 (**Section 3**) of this report.

3 Part 2: Sensitivity assessment of assessment tool parameters

3.1 Collision Risk Modelling (CRM)

3.1.1.1 Part 2 presents the CRM variability investigated during the sensitivity assessment using the parameters values identified in Part 1. As detailed in **A5.5.3 ES Volume A5 Annex 5.3 Offshore Ornithology Collision Risk Modelling (APP-076)**, the Applicant, Natural England and the Royal Society for the Protection of Birds (RSPB) agreed on the use of the Marine Scotland developed stochastic Collision Risk Model (sCRM) (Donovan, 2018) in order to assess the risk of collision from Hornsea Four to seabirds ((agreement OFF-ORN-2.7, 2.16 & 2.38– as set out in Evidence Plan Logs which are appendices to the Hornsea Four Evidence Plan (**B1.1.1: Evidence Plan (APP-130)**). The rationale for model selection is detailed in **A5.5.3 ES Volume A5 Annex 5.3 Offshore Ornithology Collision Risk Modelling (APP-076)**. Here, the same model is used to consider how the use of updated model input parameters, based primarily on the results of the latest post-consent monitoring studies, may affect output estimates that subsequently inform population level assessments. This work can help inform project and future evidence-based considerations to ensure recommended approaches are not overly precautionary.

3.1.1.2 The same five species selected and agreed between the Applicant, Natural England and the RSPB to be modelled for collision risk ((agreement OFF-ORN-2.11– as set out in Evidence Plan Logs which are appendices to the Hornsea Four Evidence Plan (**B1.1.1: Evidence Plan (APP-130)**), are used within this sensitivity assessment. These species include gannet, kittiwake, herring gull, lesser black-backed gull and great black-backed gull.

3.1.1.3 As detailed in **Section 2.2**, the parameters within the sensitivity assessment where variability exists are; avoidance rates, flight speeds and nocturnal activity factors for all five species

3.1.1.4 For gannet, the resulting variation in predicted collision impacts due to the inclusion of macro avoidance within CRM assessments is also presented.

3.1.1.5 Both the Applicant's and Natural England's preferred central (mean) input parameters (input parameters following the Applicant's and Natural England's preferred approaches are presented in the **Ornithology EIA and HRA Annex** (**G5.25**) have been used as a benchmark to which comparisons have been made by adjusting single input parameters at a time in order to calculate what effect this has on the annual predicted collision mortality rates. An additional collision risk assessment has also been undertaken when using the 'latest evidence' input parameters combined together, in order to compare what effect this has on predicted annual collisions in comparison to the Applicant's and Natural England's current approaches.

3.1.2 Gannet CRM Variability Results

Table 6: Annual predicted collisions for gannet with modelling variability applied around avoidance rate.

Parameter	Approach	Avoidance Rate Value	Impact Value - Collision Mortality Rates (Mean)	Variation in Predicted Collisions (Impact Variation)	Reference
Avoidance rate (BO2)	Applicant's (Current advocated value)	0.989	17.26	N/A	JNCC (2014)
	Natural England's (Current advocated value)		22.29	N/A	
	Applicant's	0.995	7.84	-9.42 (-54.58%)	Bowgen & Cook (2018)
	Natural England's		10.13	-12.16 (-54.55%)	
	Applicant's	0.999	1.57	-15.69 (-90.90%)	Skov et al. (2018)
	Natural England's		2.03	-20.26 (-90.89%)	

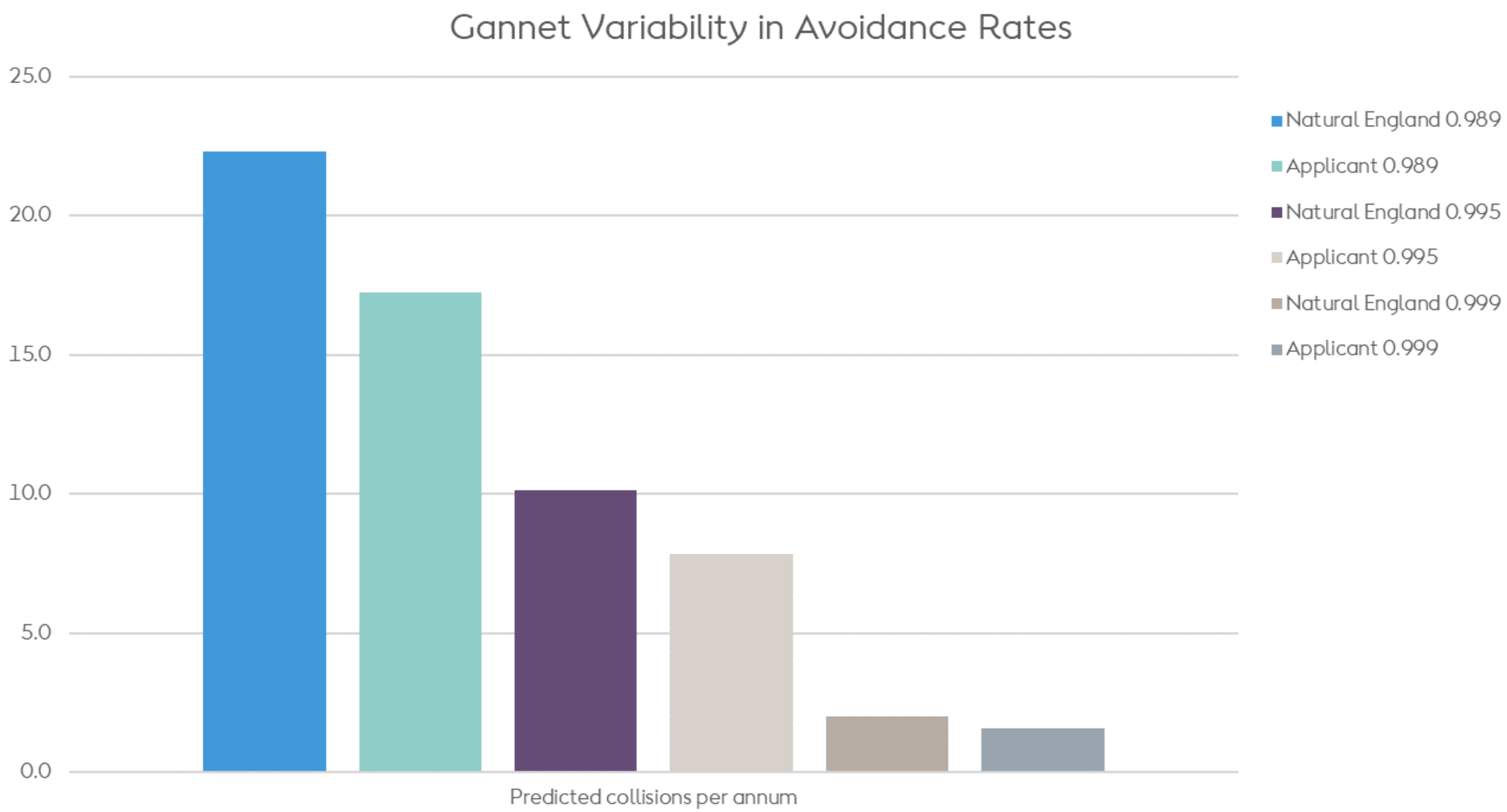

Figure 1: Graphical representation of annual predicted collisions for gannet with modelling variability applied around avoidance rate.

Table 7: Annual predicted collisions for gannet with modelling variability applied around flight speed.

Parameter	Approach	Flight Speed Value (ms^{-1})	Impact Value – Collision Mortality Rates (Mean)	Variation in Predicted Collisions (Impact Variation)	Reference
Flight speeds (BO2)	Applicant's (Current advocated value)	13.33	17.26	N/A	Skov et al. (2018)
	Natural England's (Current advocated value)	14.90	22.29	N/A	Pennycuick (1997) and Alerstam et al. (2007)
	Applicant's	13.33	17.26	N/A	Skov et al. (2018)
	Natural England's		20.93	-1.36 (-6.10%)	

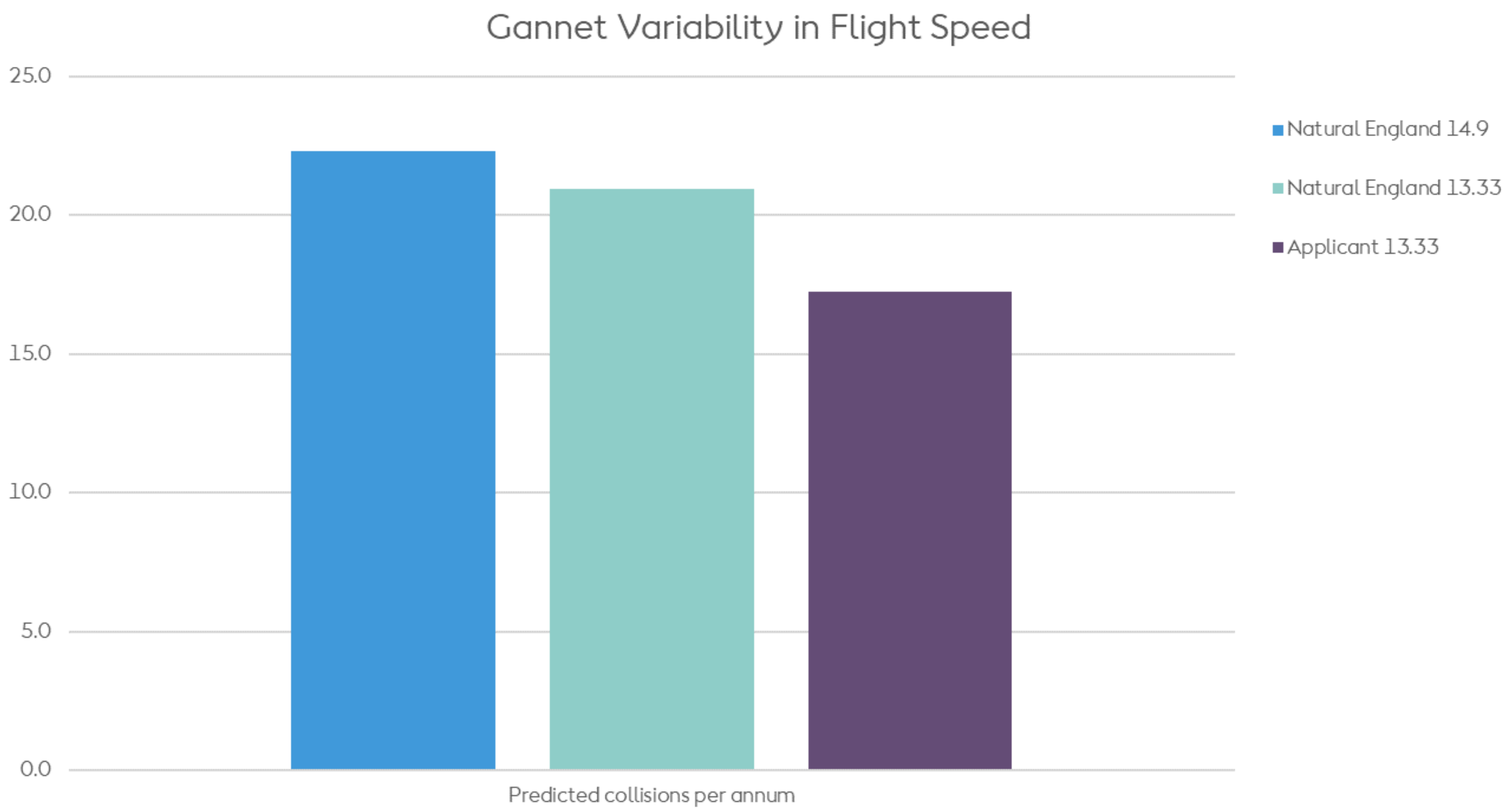

Figure 2: Graphical representation of annual predicted collisions for gannet with modelling variability applied around flight speed.

Table 8: Annual predicted collisions for gannet with modelling variability applied around nocturnal activity.

Parameter	Approach	Nocturnal Activity Value	Impact Value – Collision Mortality Rates (Mean)	Variation in Predicted Collisions (Impact Variation)	Reference
Nocturnal Activity (BO2)	Applicant's (Current advocated value)	0.00	17.26	N/A	
	Natural England's (Current advocated value)	0.25	22.29	N/A	Garthe and Hüppop (2004)
	Applicant's	0.0117	17.43	+0.17 (+0.98%)	MacArthur Green, APEM & Royal HaskoningDHV (2015)
	Natural England's		18.56	-3.73 (-16.73%)	
	Applicant's	0.03	17.70	+0.44 (+2.55%)	Skov et al. (2018)
	Natural England's		18.85	-3.44 (-15.43%)	

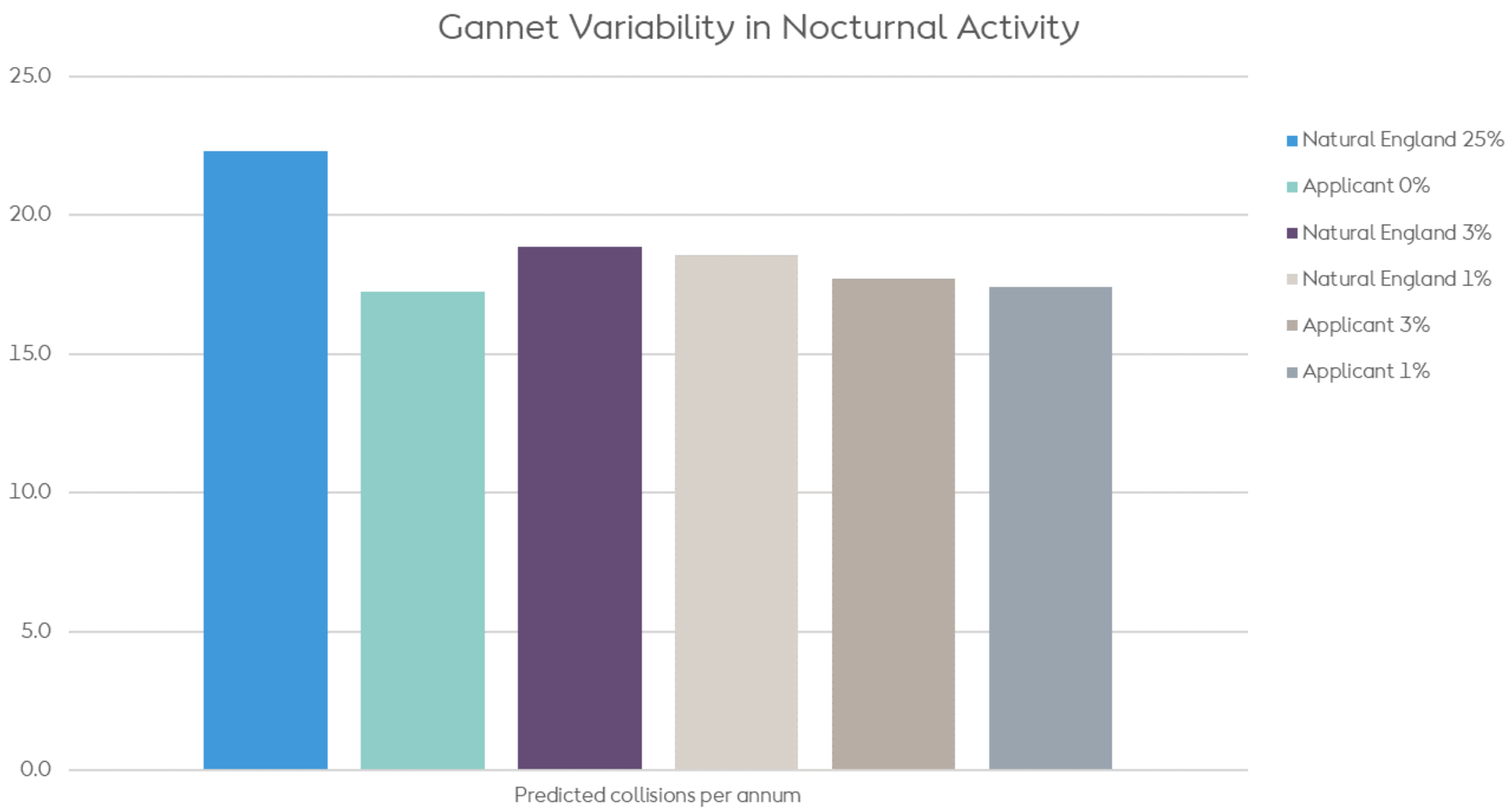

Figure 3: Graphical representation of annual predicted collisions for gannet with modelling variability applied around nocturnal activity.

Table 9: Annual predicted collisions for gannet with modelling variability applied to multiple input parameters around collision risk modelling.

Parameter	Approach	Avoidance Rates (AR), Flight Speeds (FS) (ms^{-1}) and Nocturnal Activity (NA) Values	Impact Value – Collision Mortality Rates (Mean)	Variation in Predicted Collisions (Impact Variation)
Avoidance rate (BO2), Flight Speed & Nocturnal Activity	Applicant's (Current advocated value)	AR 0.989; FS 13.33; NA 0.00	17.26	N/A
	Natural England's (Current advocated value)	AR 0.989; FS 14.90; NA 0.25	22.29	N/A
	Latest Evidence	AR 0.999; FS 13.33; NA 0.0117	1.59	Applicant's: -15.67 (-90.79%) Natural England's: -20.70 (-92.87%).

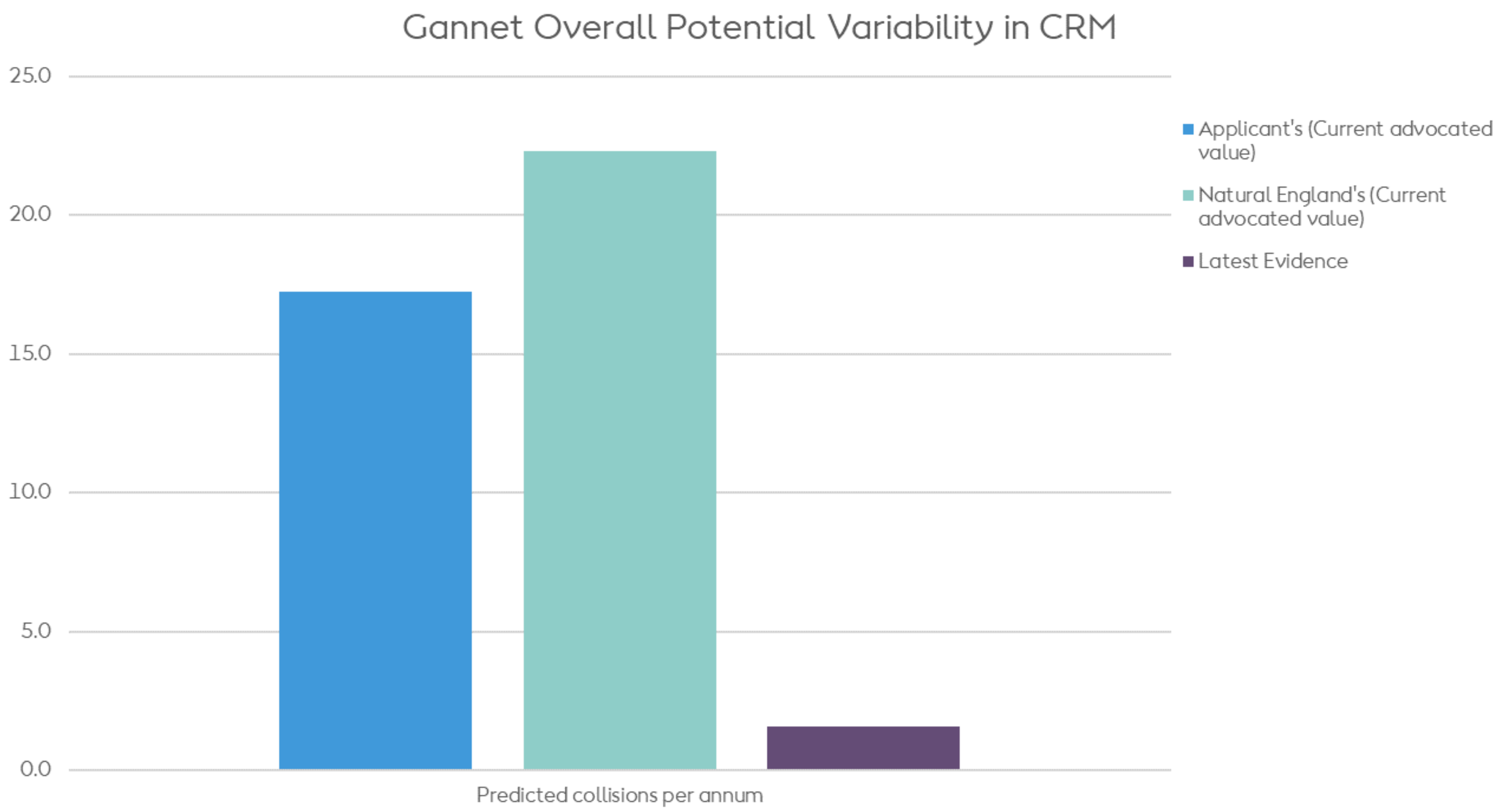

Figure 4: Graphical representation of annual predicted collisions for gannet with modelling variability applied to multiple input parameters around collision risk modelling.

Table 10: Annual predicted collisions for gannet when including macro avoidance within assessments

Approach	Impact Value – Collision Mortality Rates (Mean)	Variation in Predicted Collisions (Impact Variation)
Applicant's (Current advocated value)	17.3	N/A
Natural England's (Current advocated value)	22.3	N/A
Applicant's approach including macro avoidance	5.4	-11.8 (-68.79%)
Natural England's approach including macro avoidance	6.9	-15.4 (-69.06%)

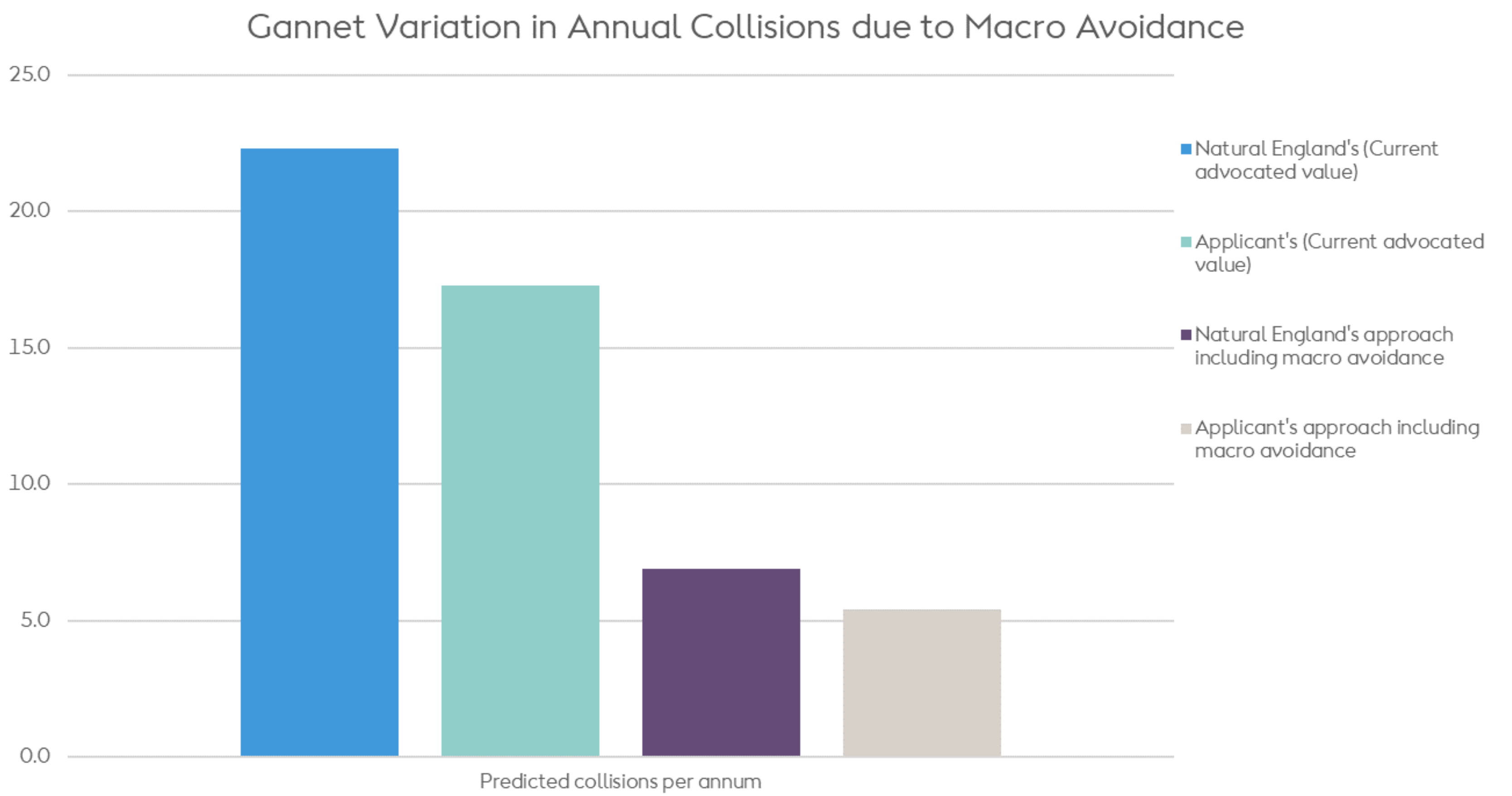

Figure 5: Graphical representation of annual predicted collisions for gannet when applying macro avoidance to modelling.

3.1.3 Kittiwake CRM Variability Results

Table 11: Annual predicted collisions for kittiwake with modelling variability applied around avoidance rate.

Parameter	Approach	Avoidance Rate Value	Impact Value – Collision Mortality Rates (Mean)	Variation in Predicted Collisions (Impact Variation)	Reference
Avoidance rate (BO2)	Applicant's (Current advocated value)	0.989	80.62	N/A	JNCC (2014)
	Natural England's (Current advocated value)		92.95	N/A	
	Applicant's	0.990	73.29	-7.33 (-9.09%)	Bowgen & Cook (2018)
	Natural England's		84.50	-8.45 (-9.09%)	
	Applicant's	0.998	14.66	-65.96 (-81.82%)	Skov et al. (2018)
	Natural England's		16.90	-76.05 (-81.82%)	
Avoidance rate (BO3)	Applicant's	0.980	20.54	-60.08 (-74.52%)	Bowgen & Cook (2018)
	Natural England's		23.68	-69.27 (-74.52%)	

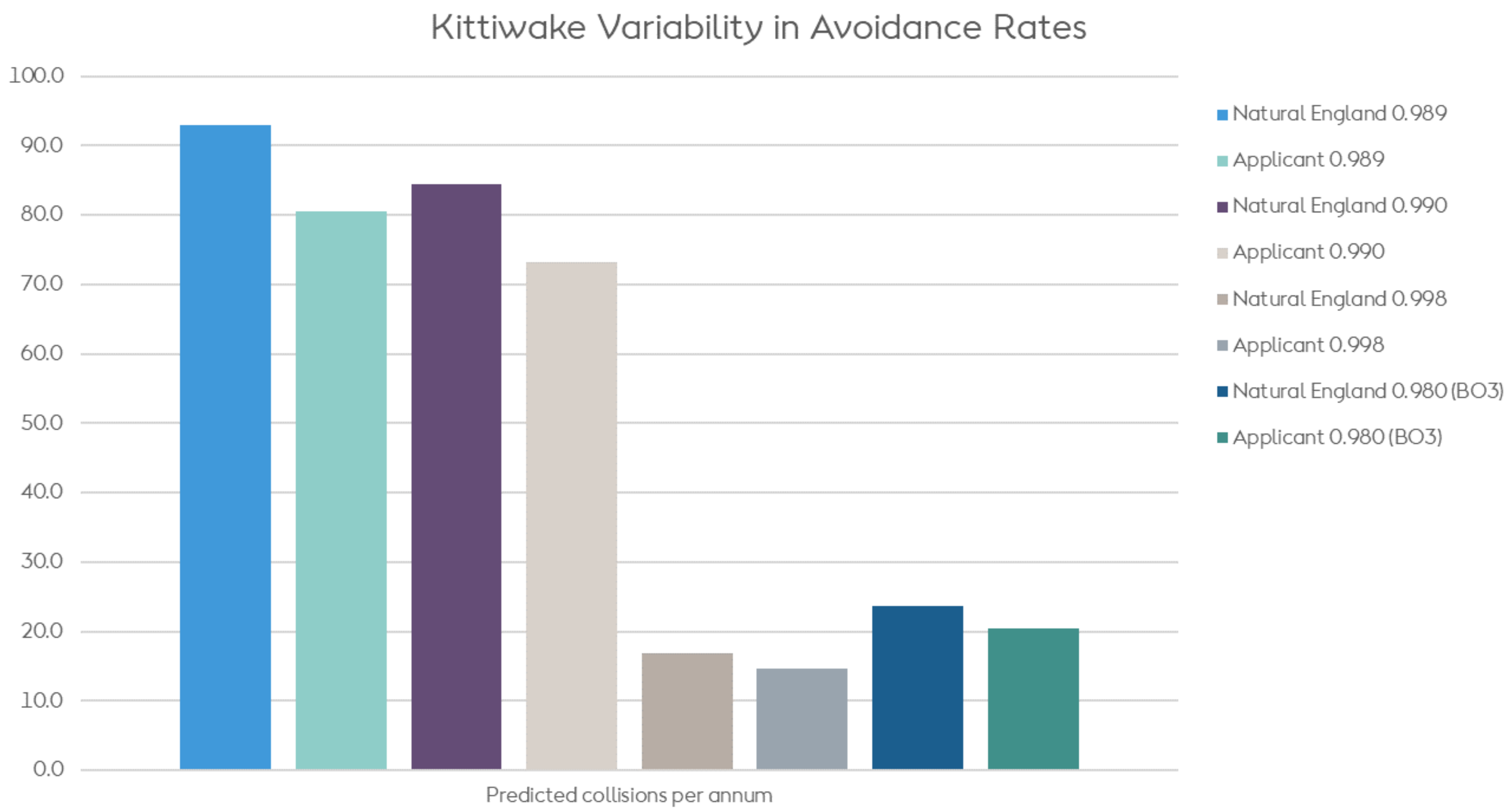

Figure 6: Graphical representation of annual predicted collisions for kittiwake with modelling variability applied around avoidance rate.

Table 12: Annual predicted collisions for kittiwake with modelling variability applied around flight speed.

<table>
<tr><th>Parameter</th><th>Approach</th><th>Flight Speed Value (ms-1)</th><th>Impact Value – Collision Mortality Rates (Mean)</th><th>Variation in Predicted Collisions (Impact Variation)</th><th>Reference</th></tr>
<tr><td rowspan="8">Flight speeds (BO2)</td><td>Applicant's (Current advocated value)</td><td rowspan="2">13.10</td><td>80.62</td><td>N/A</td><td rowspan="2">Pennycuick (1997) and Alerstam et al. (2007</td></tr>
<tr><td>Natural England's (Current advocated value)</td><td>92.95</td><td>N/A</td></tr>
<tr><td>Applicant's</td><td rowspan="2">7.26</td><td>54.07</td><td>-26.55 (-32.93%)</td><td rowspan="2">Masden (2015)</td></tr>
<tr><td>Natural England's</td><td>62.34</td><td>-30.61 (-32.93%)</td></tr>
<tr><td>Applicant's</td><td rowspan="2">8.71</td><td>60.51</td><td>-20.11 (-24.94%)</td><td rowspan="2">Skov et al. (2018)</td></tr>
<tr><td>Natural England's</td><td>69.76</td><td>-23.19 (-24.95%)</td></tr>
<tr><td>Applicant's</td><td rowspan="2">11.94</td><td>75.26</td><td>-5.36 (-6.65%)</td><td rowspan="2">Coulson (2011)</td></tr>
<tr><td>Natural England's</td><td>86.76</td><td>-6.19 (-6.66%)</td></tr>
</table>

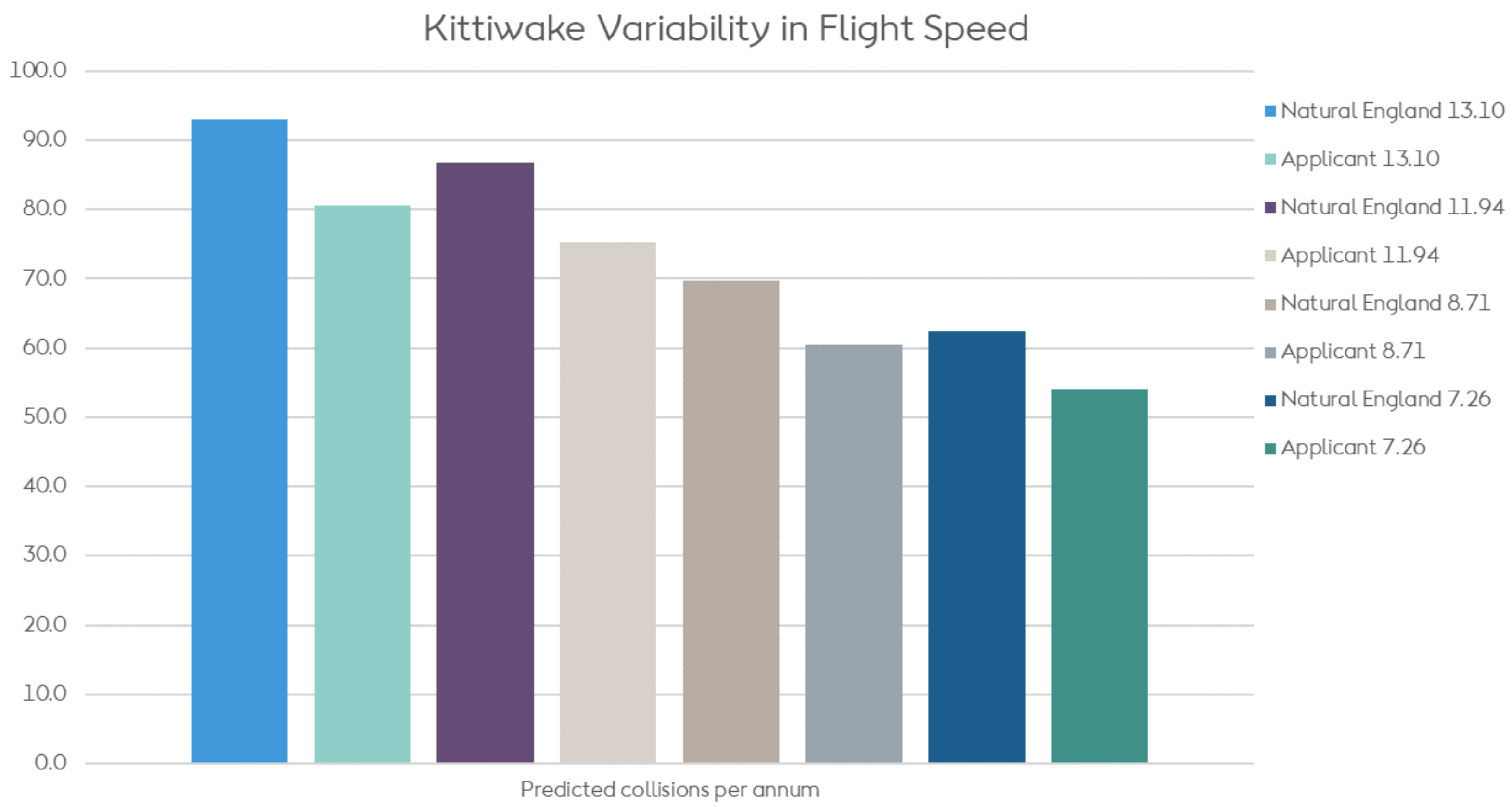

Figure 7: Graphical representation of annual predicted collisions for kittiwake with modelling variability applied around flight speed.

Table 13: Annual predicted collisions for kittiwake with modelling variability applied around nocturnal activity.

Parameter	Approach	Nocturnal Activity Value	Impact Value – Collision Mortality Rates (Mean)	Variation in Predicted Collisions (Impact Variation)	Reference
Nocturnal Activity (BO2)	Applicant's (Current advocated value)	0.25	80.62	N/A	Garthe and Hüppop (2004)
	Natural England's (Current advocated value)	0.50	92.95	N/A	
	Applicant's	0.03	69.77	-10.85 (-13.46%)	Masden (2015) & Skov et al. (2018)
	Natural England's		69.77	-23.18 (-24.94%)	
	Applicant's	0.09	72.73	-7.89 (-9.79%)	MacArthur Green, APEM & Royal HaskoningDHV (2015)
	Natural England's		72.73	-20.22 (-21.75%)	

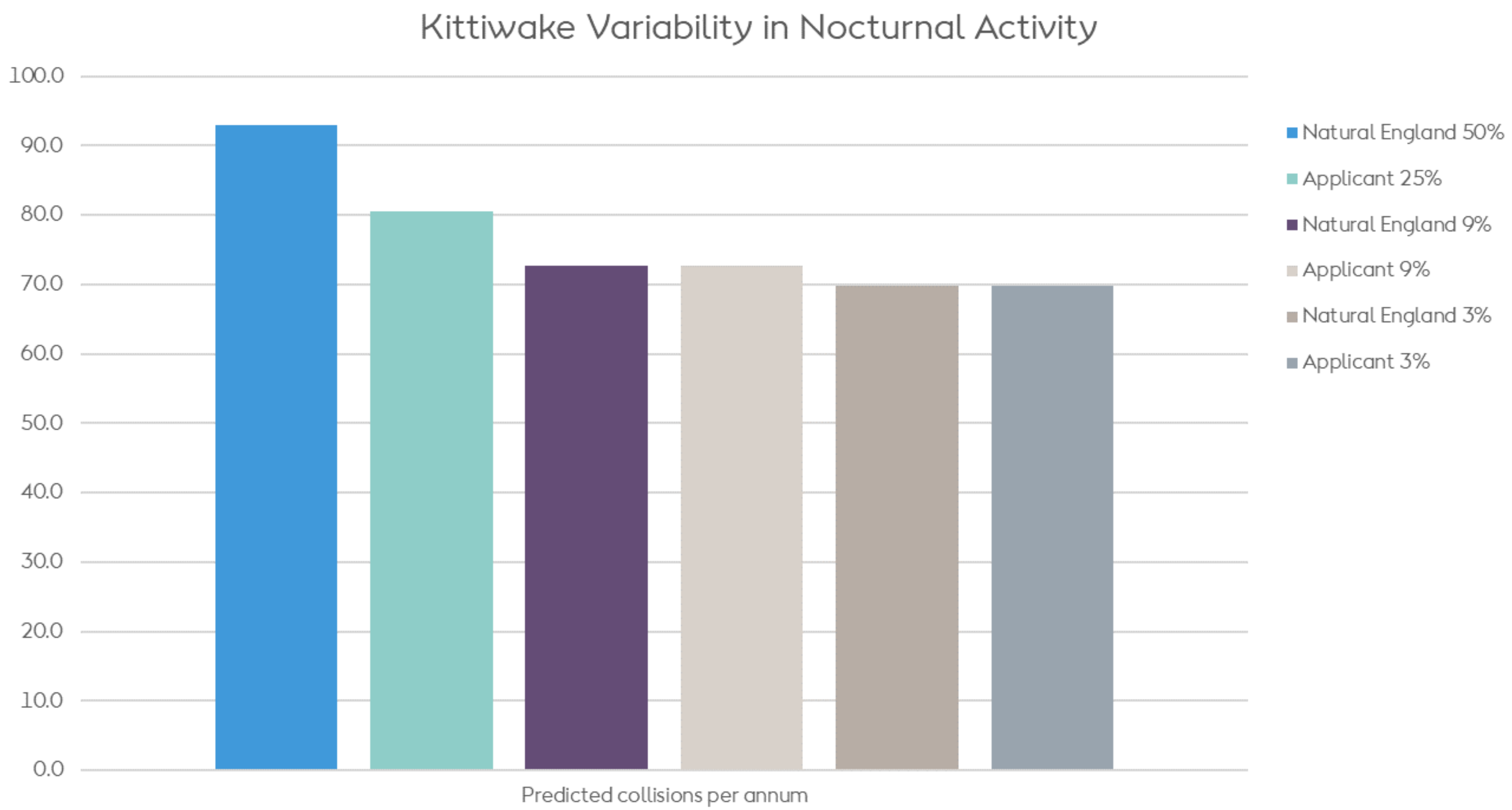

Figure 8: Graphical representation of annual predicted collisions for kittiwake with modelling variability applied around nocturnal activity

Table 14: Annual predicted collisions for kittiwake with modelling variability applied to multiple parameters around collision risk modelling.

Parameter	Approach	Avoidance Rates (AR), Flight Speeds (FS) (ms^{-1}) and Nocturnal Activity (NA) Values	Impact Value – Collision Mortality Rates (Mean)	Variation in Predicted Collisions (Impact Variation)
Avoidance rate (BO2), Flight Speed & Nocturnal Activity	Applicant's (Current advocated value)	AR 0.989; FS 13.10; NA 0.25	N/A	N/A
	Natural England's (Current advocated value)	AR 0.989; FS 13.10; NA 0.50	N/A	N/A
	Latest Evidence	AR 0.998; FS 7.26; NA 0.03	8.51	Applicant's: -72.11 (-89.44%) Natural England's: -84.44 (-90.84%)

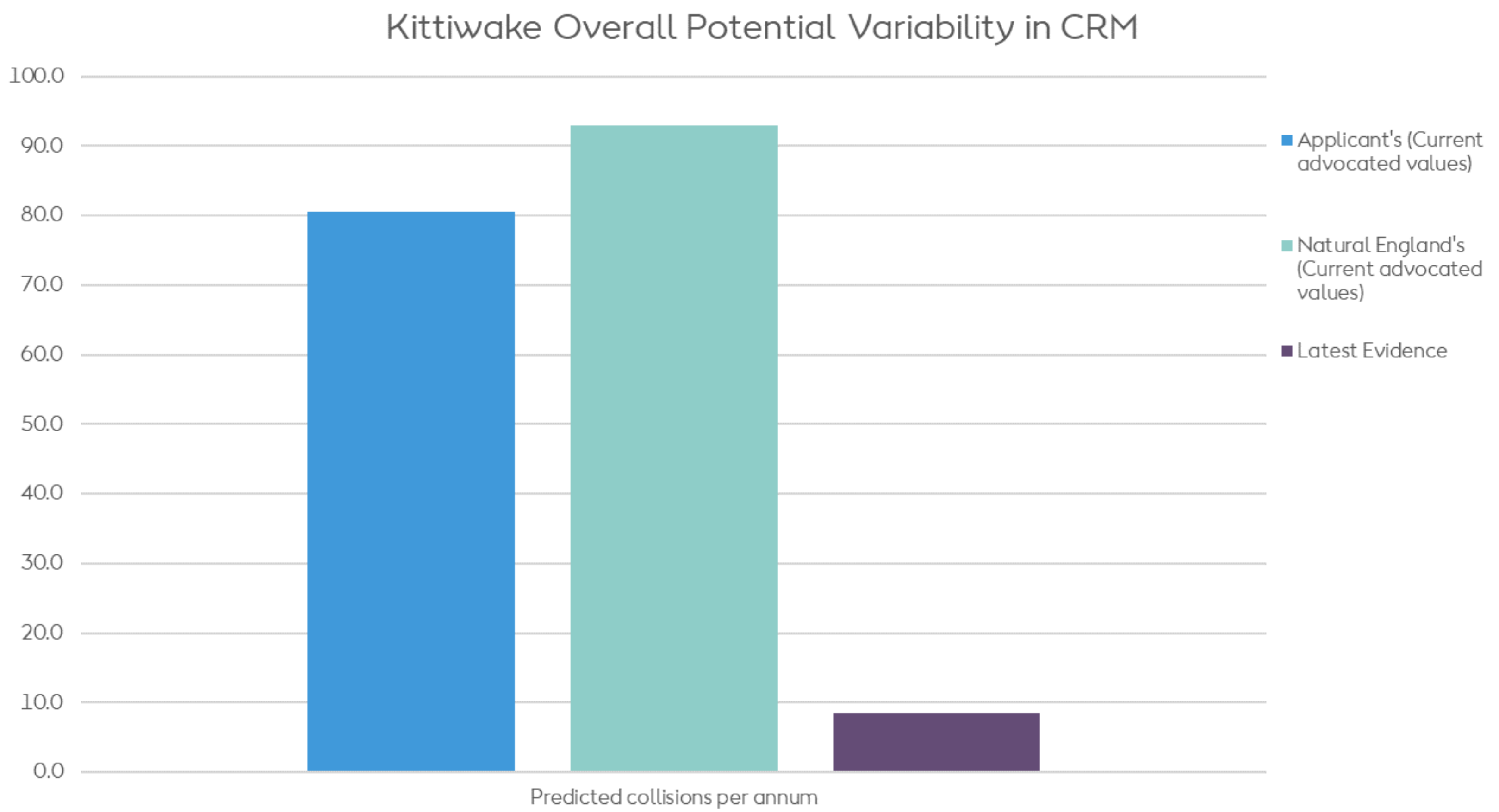

Figure 9: Graphical representation of annual predicted collisions for kittiwake with modelling variability applied to multiple input parameters around collision risk modelling.

3.1.4 Herring Gull CRM Variability Results

Table 15: Annual predicted collisions for herring gull with modelling variability applied around avoidance rate.

Parameter	Approach	Avoidance Rate Value	Impact Value – Collision Mortality Rates (Mean)	Variation in Predicted Collisions (Impact Variation)	Reference
Avoidance rate (BO2	Applicant's (Current advocated value)	0.995	1.48	N/A	JNCC (2014)
	Natural England's (Current advocated value)		1.74	N/A	
	Applicant's	0.999	0.30	-1.18 (-79.73%)	Skov et al. (2018)
	Natural England's		0.35	-1.39 (-79.86%)	
Avoidance rate (BO3)	Applicant's (Current advocated value)	0.990	0.74	N/A	JNCC (2014)
	Natural England's (Current advocated value)		0.86	N/A	
	Applicant's	0.993	0.52	-0.22 (-29.73%)	Bowgen & Cook (2018)
	Natural England's		0.61	-0.25 (-29.07%)	

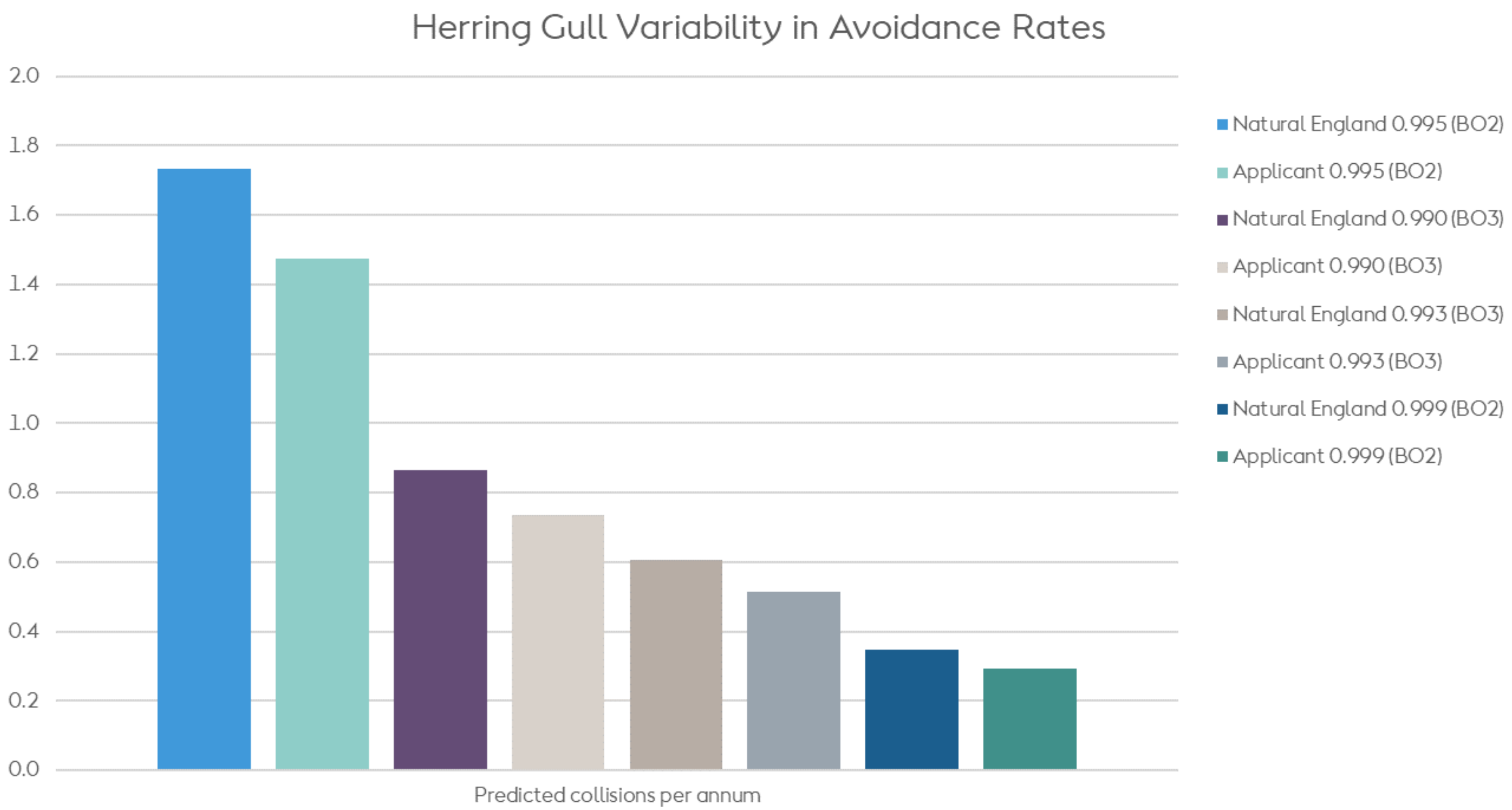

Figure 10: Graphical representation of annual predicted collisions for herring gull with modelling variability applied around avoidance rate.

Table 16: Annual predicted collisions for herring gull with modelling variability applied around flight speed.

Parameter	Approach	Flight Speed Value (ms^{-1})	Impact Value – Collision Mortality Rates (Mean)	Variation in Predicted Collisions (Impact Variation)	Reference
Flight speeds (BO2)	Applicant's (Current advocated value)	12.80	1.48	N/A	Pennycuick (1997) and Alerstam et al. (2007)
	Natural England's (Current advocated value)		1.74	N/A	
	Applicant's	9.68	1.24	-0.24 (-16.22%)	Skov et al. (2018)
	Natural England's		1.46	-0.28 (-16.09%)	
	Applicant's	9.80	1.25	-0.23 (-15.54%)	Skov et al. (2018)
	Natural England's		1.47	-0.27 (-15.52%)	
Flight speeds (BO3)	Applicant's (Current advocated value)	12.80	0.74	N/A	Pennycuick (1997) and Alerstam et al. (2007)
	Natural England's (Current advocated value)		0.86	N/A	
	Applicant's	9.68	0.68	-0.06 (-8.12%)	Skov et al. (2018)
	Natural England's		0.80	-0.06 (-6.98%)	
	Applicant's	9.80	0.68	-0.06 (-8.12%)	Skov et al. (2018)
	Natural England's		0.80	-0.06 (-6.98%)	

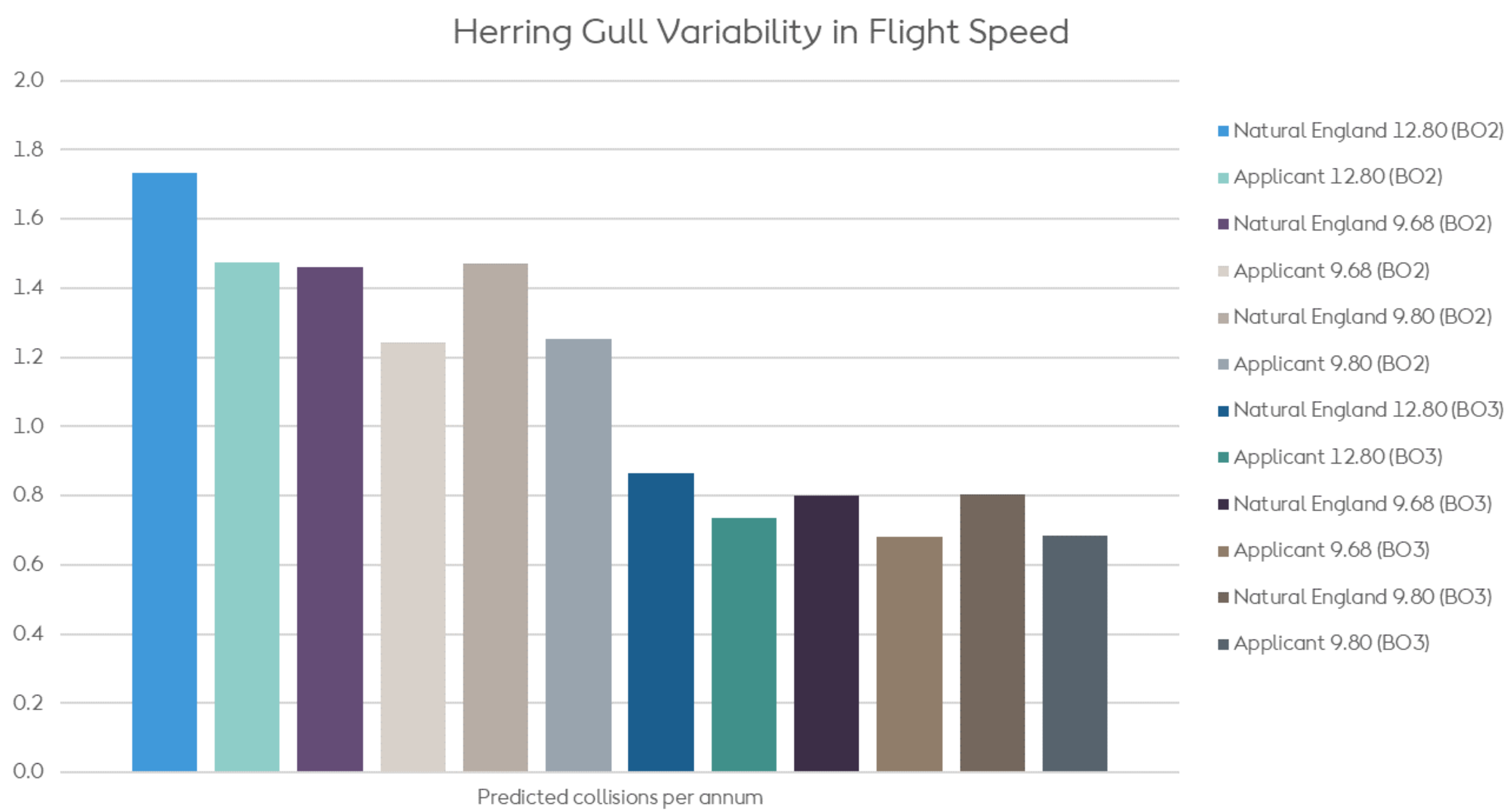

Figure 11: Graphical representation of annual predicted collisions for herring gull with modelling variability applied around flight speed.

Table 17: Annual predicted collisions for herring gull with modelling variability applied around nocturnal activity.

Parameter	Approach	Nocturnal Activity Value	Impact Value – Collision Mortality Rates (Mean)	Variation in Predicted Collisions (Impact Variation)	Reference
Nocturnal Activity (BO2)	Applicant's (Current advocated value)	0.25	1.48	N/A	MacArthur Green, APEM & Royal HaskoningDHV (2015)
	Natural England's (Current advocated value)	0.50	1.74	N/A	Garthe and Hüppop (2004)
	Applicant's	0.25	1.48	N/A	MacArthur Green, APEM & Royal HaskoningDHV (2015)
	Natural England's		1.48	-0.26 (-14.94%)	
	Applicant's	0.03	1.25	-0.23 (-15.54%)	Skov et al. (2018)
	Natural England's		1.25	-0.49 (-28.16%)	
Nocturnal Activity (BO3)	Applicant's (Current advocated value)	0.25	0.74	N/A	MacArthur Green, APEM & Royal HaskoningDHV (2015)
	Natural England's (Current advocated value)	0.50	0.86	N/A	Garthe and Hüppop (2004)
	Applicant's	0.25	0.74	N/A	MacArthur Green, APEM & Royal HaskoningDHV (2015)
	Natural England's		0.74	-0.12 (-13.95%)	
	Applicant's	0.03	0.62	-0.12 (-16.22%)	Skov et al. (2018)
	Natural England's		0.62	-0.24 (-27.91%)	

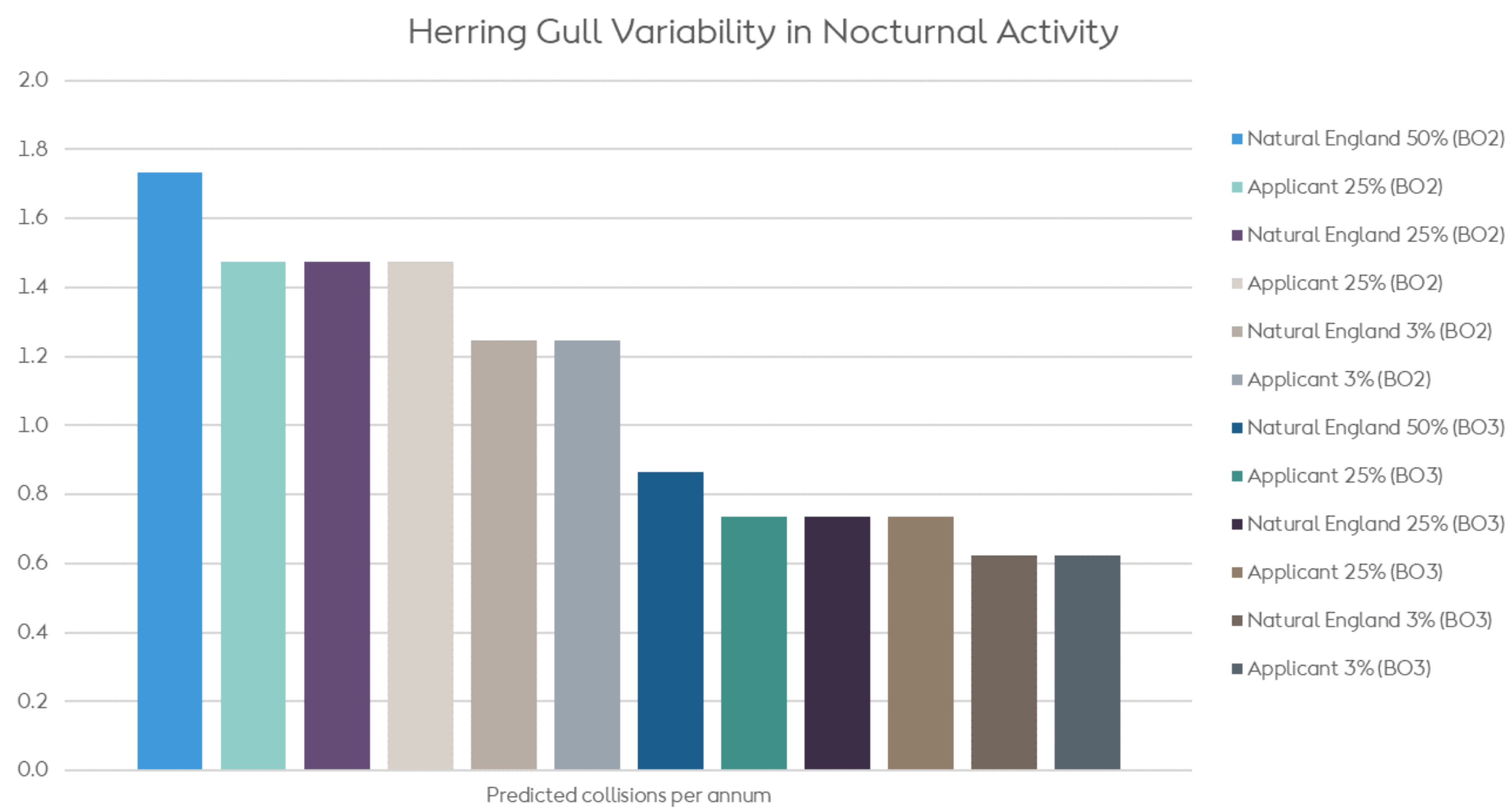

Figure 12: Graphical representation of annual predicted collisions for herring gull with modelling variability applied around nocturnal activity.

Table 18: Annual predicted collisions for herring gull with modelling variability applied to multiple input parameters around collision risk modelling.

Parameter	Approach	Avoidance Rates (AR), Flight Speeds (FS) (ms^{-1}) and Nocturnal Activity (NA) Values	Impact Value – Collision Mortality Rates (Mean)	Variation in Predicted Collisions (Impact Variation)
Avoidance rate (BO2), Flight Speed & Nocturnal Activity	Applicant's (Current advocated value)	AR 0.995; FS 12.80; NA 0.50	N/A	N/A
	Natural England's (Current advocated value)	AR 0.995; FS 12.80; NA 0.25	N/A	N/A
	Latest Evidence	AR 0.999; FS 9.68; NA 0.03	0.21	Applicant's: -1.27 (-85.81%) Natural England's: -1.53 (-87.93%)
Avoidance rate (BO3), Flight Speed & Nocturnal Activity	Applicant's (Current advocated value)	AR 0.990; FS 12.80; NA 0.25	N/A	N/A
	Natural England's (Current advocated value)	AR 0.990; FS 12.80; NA 0.50	N/A	N/A
	Latest Evidence	AR 0.993; FS 9.68; NA 0.03	0.40	Applicant's -0.34: (-22.97%) Natural England's: -0.46 (-53.49%)

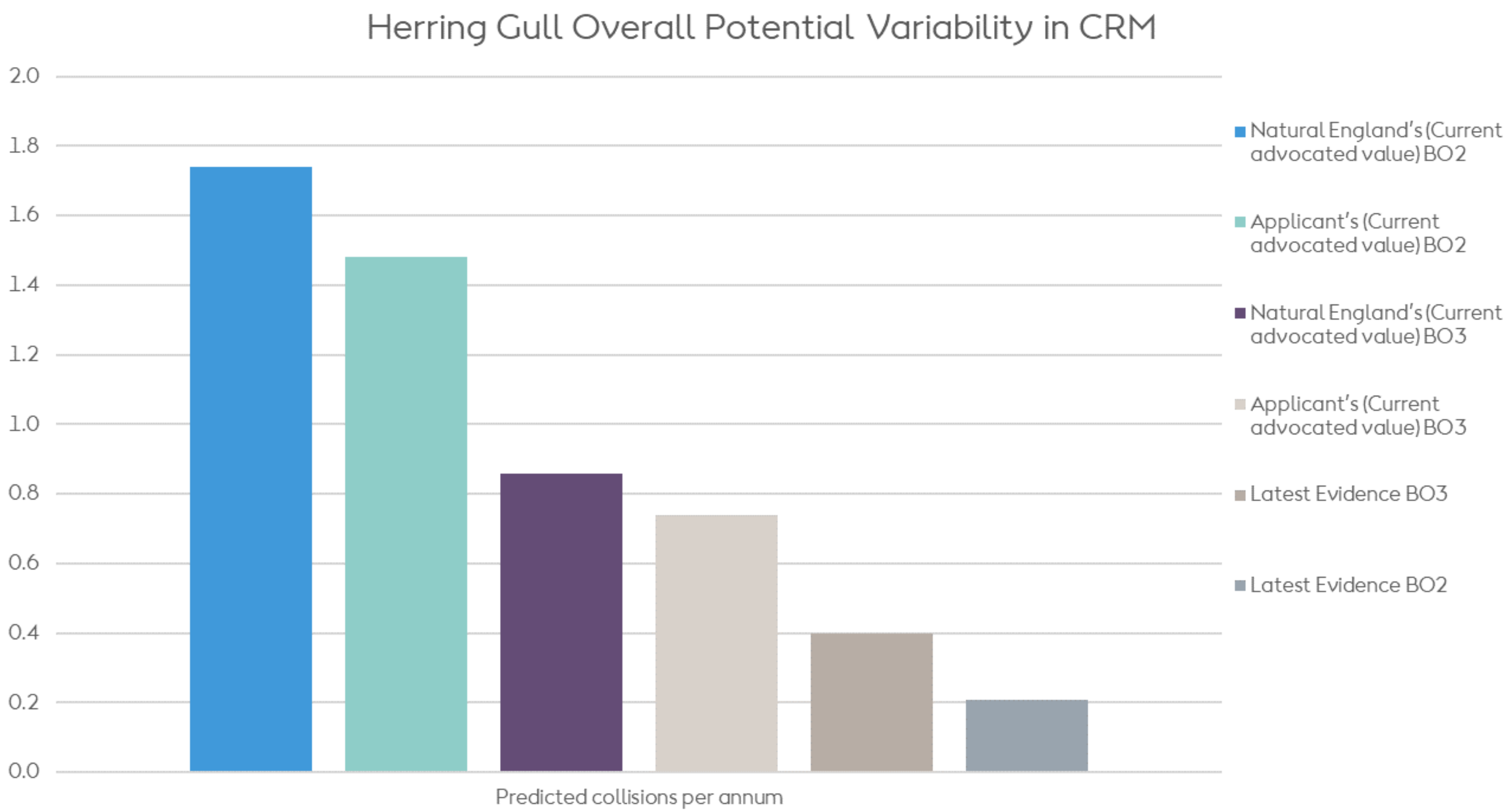

Figure 13: Graphical representation of annual predicted collisions for herring gull with modelling variability applied to multiple input parameters around collision risk modelling.

3.1.5 Lesser Black-backed Gull CRM Variability Results

Table 19: Annual predicted collisions for lesser black-backed gull with modelling variability applied around avoidance rate.

Parameter	Approach	Avoidance Rate Value	Impact Value – Collision Mortality Rates (Mean)	Variation in Predicted Collisions (Impact Variation)	Reference
Avoidance rate (BO2	Applicant's (Current advocated value)	0.995	0.78	N/A	JNCC (2014)
	Natural England's (Current advocated value)		0.85	N/A	
	Applicant's	0.998	0.31	-0.47 (-60.26%)	Skov et al. (2018)
	Natural England's		0.34	-0.51 (-60.00%)	
Avoidance rate (BO3)	Applicant's (Current advocated value)	0.989	0.39	N/A	JNCC (2014)
	Natural England's (Current advocated value)		0.43	N/A	
	Applicant's	0.993	0.25	-0.14 (-35.90%)	Bowgen & Cook (2018)
	Natural England's		0.27	-0.16 (-37.21%)	

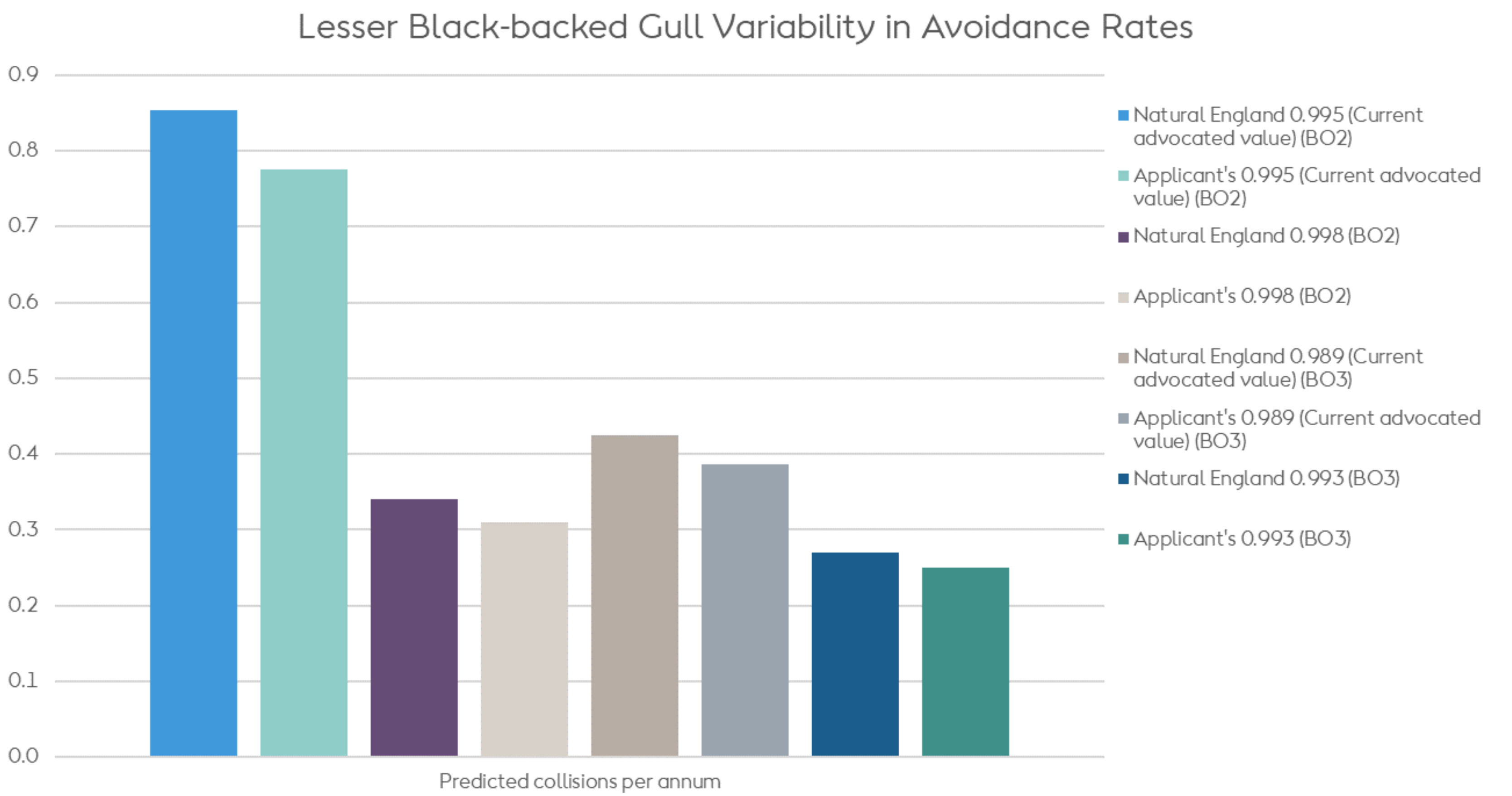

Figure 14: Graphical representation of annual predicted collisions for lesser black-backed gull with modelling variability applied around avoidance rate.

Table 20: Annual predicted collisions for lesser black-backed gull with modelling variability applied around flight speed.

<table>
<tr><th>Parameter</th><th>Approach</th><th>Flight Speed Value</th><th>Impact Value – Collision Mortality Rates (Mean)</th><th>Variation in Predicted Collisions (Impact Variation)</th><th>Reference</th></tr>
<tr><td rowspan="6">Flight speeds (BO2)</td><td>Applicant's (Current advocated value)</td><td rowspan="2">13.10</td><td>0.78</td><td>N/A</td><td rowspan="2">Pennycuick (1997) and Alerstam et al. (2007)</td></tr>
<tr><td>Natural England's (Current advocated value)</td><td>0.85</td><td>N/A</td></tr>
<tr><td>Applicant's</td><td rowspan="2">10.13</td><td>0.65</td><td>-0.13 (-16.67%)</td><td rowspan="2">Skov et al. (2018)</td></tr>
<tr><td>Natural England's</td><td>0.73</td><td>-0.12 (-14.12%)</td></tr>
<tr><td>Applicant's</td><td rowspan="2">9.80</td><td>0.65</td><td>-0.13 (-16.67%)</td><td rowspan="2">Skov et al. (2018)</td></tr>
<tr><td>Natural England's</td><td>0.71</td><td>-0.14 (-16.47%)</td></tr>
<tr><td rowspan="6">Flight speeds (BO3)</td><td>Applicant's (Current advocated value)</td><td rowspan="2">13.10</td><td>0.39</td><td>N/A</td><td rowspan="2">Pennycuick (1997) and Alerstam et al. (2007)</td></tr>
<tr><td>Natural England's (Current advocated value)</td><td>0.43</td><td>N/A</td></tr>
<tr><td>Applicant's</td><td rowspan="2">10.13</td><td>0.36</td><td>-0.03 (-8.33%)</td><td rowspan="2">Skov et al. (2018)</td></tr>
<tr><td>Natural England's</td><td>0.40</td><td>-0.03 (-6.98%)</td></tr>
<tr><td>Applicant's</td><td rowspan="2">9.80</td><td>0.36</td><td>-0.03 (-6.98%)</td><td rowspan="2">Skov et al. (2018)</td></tr>
<tr><td>Natural England's</td><td>0.39</td><td>-0.04 (-9.30%)</td></tr>
</table>

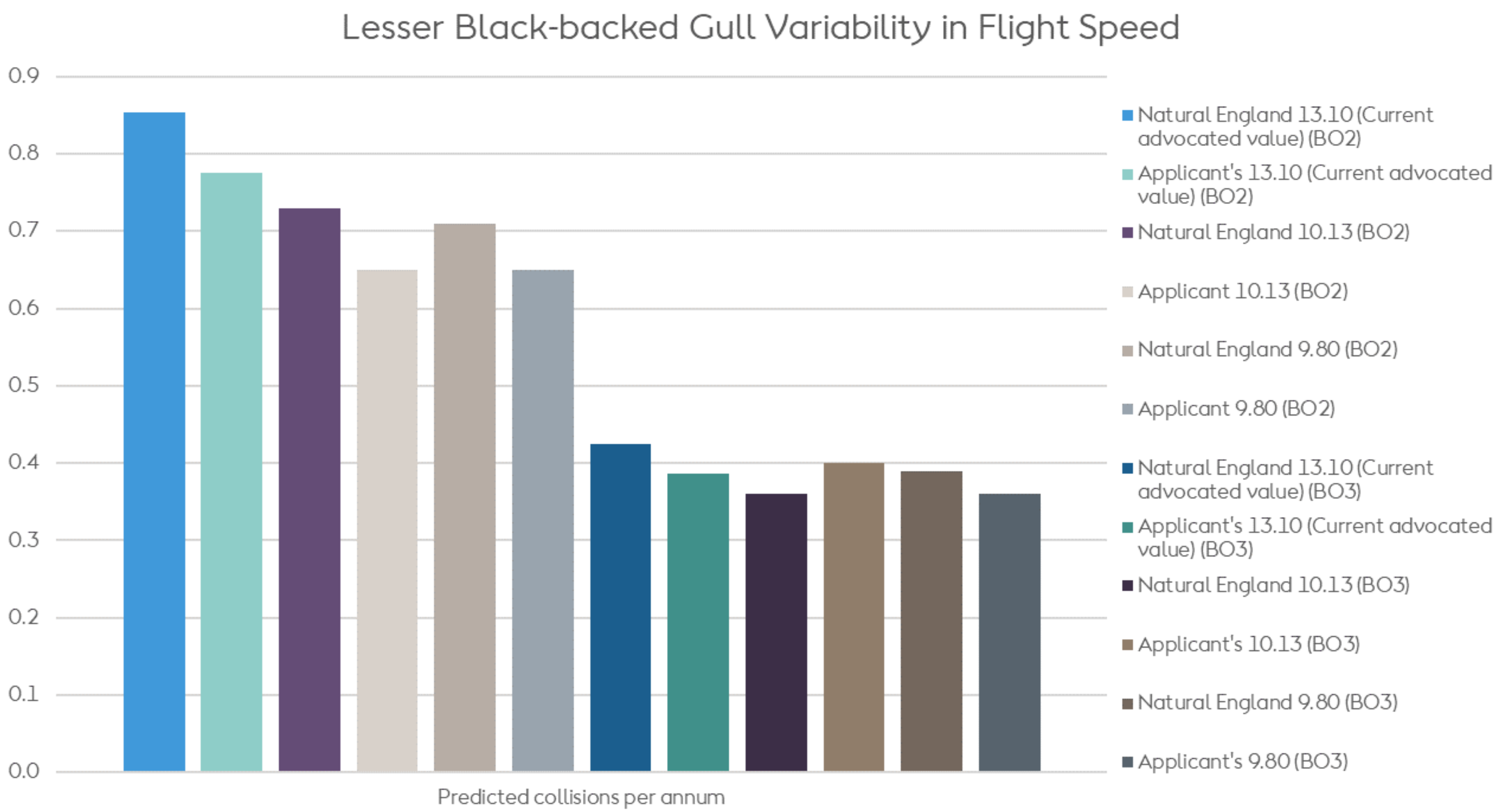

Figure 15: Graphical representation of annual predicted collisions for lesser black-backed gull with modelling variability applied around flight speed.

Table 21: Annual predicted collisions for lesser black-backed gull with modelling variability applied around nocturnal activity.

Parameter	Approach	Nocturnal Activity Value	Impact Value – Collision Mortality Rates (Mean)	Variation in Predicted Collisions (Impact Variation)	Reference
Nocturnal Activity (BO2)	Applicant's (Current advocated value)	0.25	0.78	N/A	MacArthur Green, APEM & Royal HaskoningDHV (2015)
	Natural England's (Current advocated value)	0.50	0.85	N/A	Garthe and Hüppop (2004)
	Applicant's	0.25	0.78	-0.00 (-0.00%)	MacArthur Green, APEM & Royal HaskoningDHV (2015)
	Natural England's		0.78	-0.07 (-8.24%)	
	Applicant's	0.03	0.71	-0.07 (-8.97%)	Skov et al. (2018)
	Natural England's		0.71	-0.14 (-16.47%)	
Nocturnal Activity (BO3)	Applicant's (Current advocated value)	0.25	0.39	N/A	MacArthur Green, APEM & Royal HaskoningDHV (2015)
	Natural England's (Current advocated value)	0.50	0.43	N/A	Garthe and Hüppop (2004)
	Applicant's	0.25	0.39	N/A	MacArthur Green, APEM & Royal HaskoningDHV (2015)
	Natural England's		0.39	-0.04 (-9.30%)	
	Applicant's	0.03	0.35	-0.04 (-10.26%)	Skov et al. (2018)
	Natural England's		0.35	-0.08 (-18.60%)	

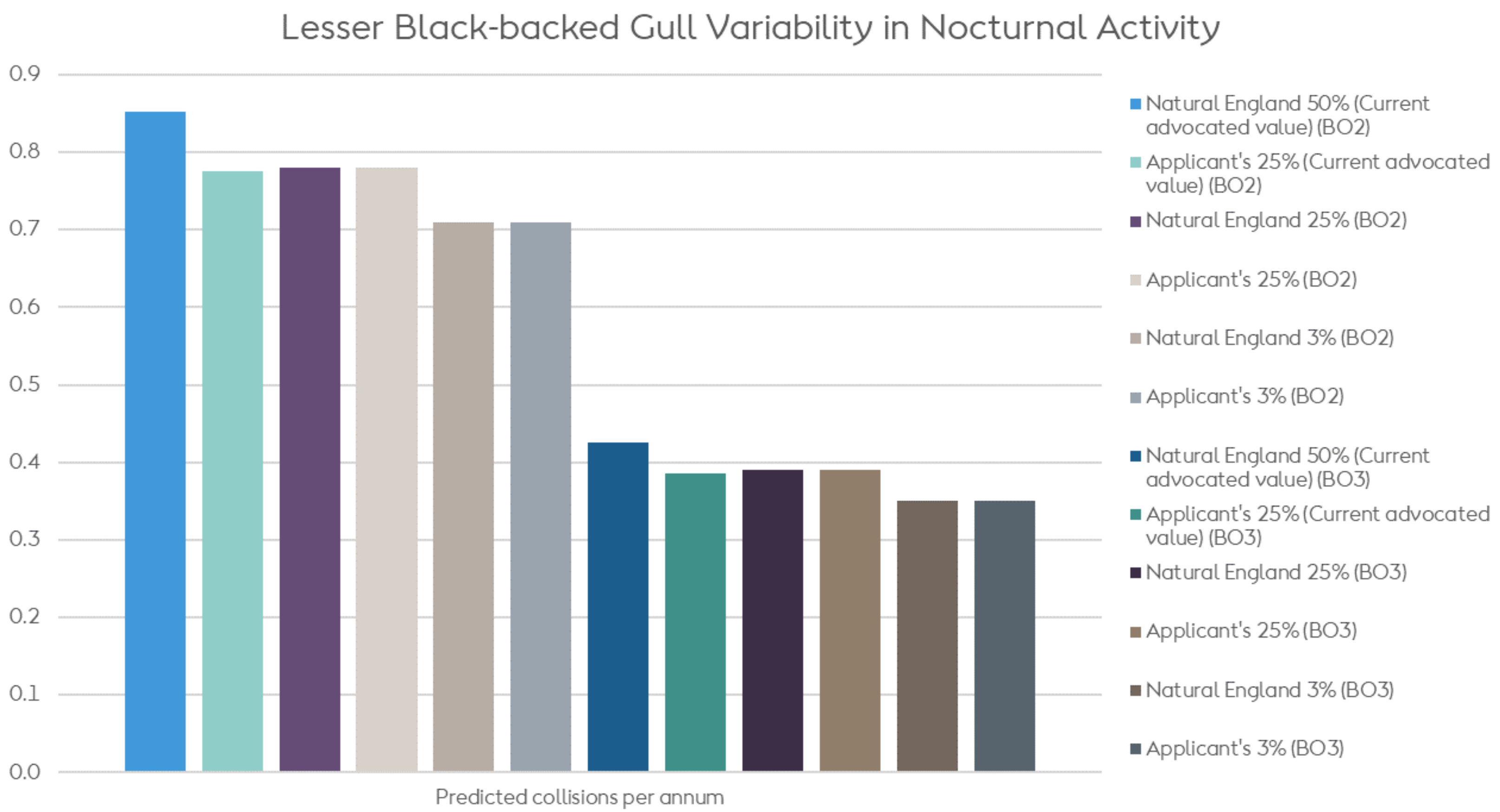

Figure 16: Graphical representation of annual predicted collisions for lesser black-backed gull with modelling variability applied around nocturnal activity.

Table 22: Annual predicted collisions for lesser black-backed gull with modelling variability applied to multiple impact parameters around collision risk modelling.

Parameter	Approach	Avoidance Rates (AR), Flight Speeds (FS) (ms^{-1}) and Nocturnal Activity (NA) Values	Impact Value – Collision Mortality Rates (Mean)	Variation in Predicted Collisions (Impact Variation)
Avoidance rate (BO2), Flight Speed & Nocturnal Activity	Applicant's (Current advocated value)	AR 0.995; FS 12.80; NA 0.50	N/A	N/A
	Natural England's (Current advocated value)	AR 0.995; FS 12.80; NA 0.25	N/A	N/A
	Latest Evidence	AR 0.998; FS 9.80; NA 0.03	0.24	Applicant's: -0.54 (-69.23%) Natural England's: -0.61 (-71.76%)
Avoidance rate (BO3), Flight Speed & Nocturnal Activity	Applicant's (Current advocated value)	AR 0.989; FS 12.80; NA 0.25	N/A	N/A
	Natural England's (Current advocated value)	AR 0.989; FS 12.80; NA 0.50	N/A	N/A
	Latest Evidence	AR 0.993; FS 9.80; NA 0.03	0.21	Applicant's: -0.57 (-73.08%) Natural England's: -0.64 (-75.29%)

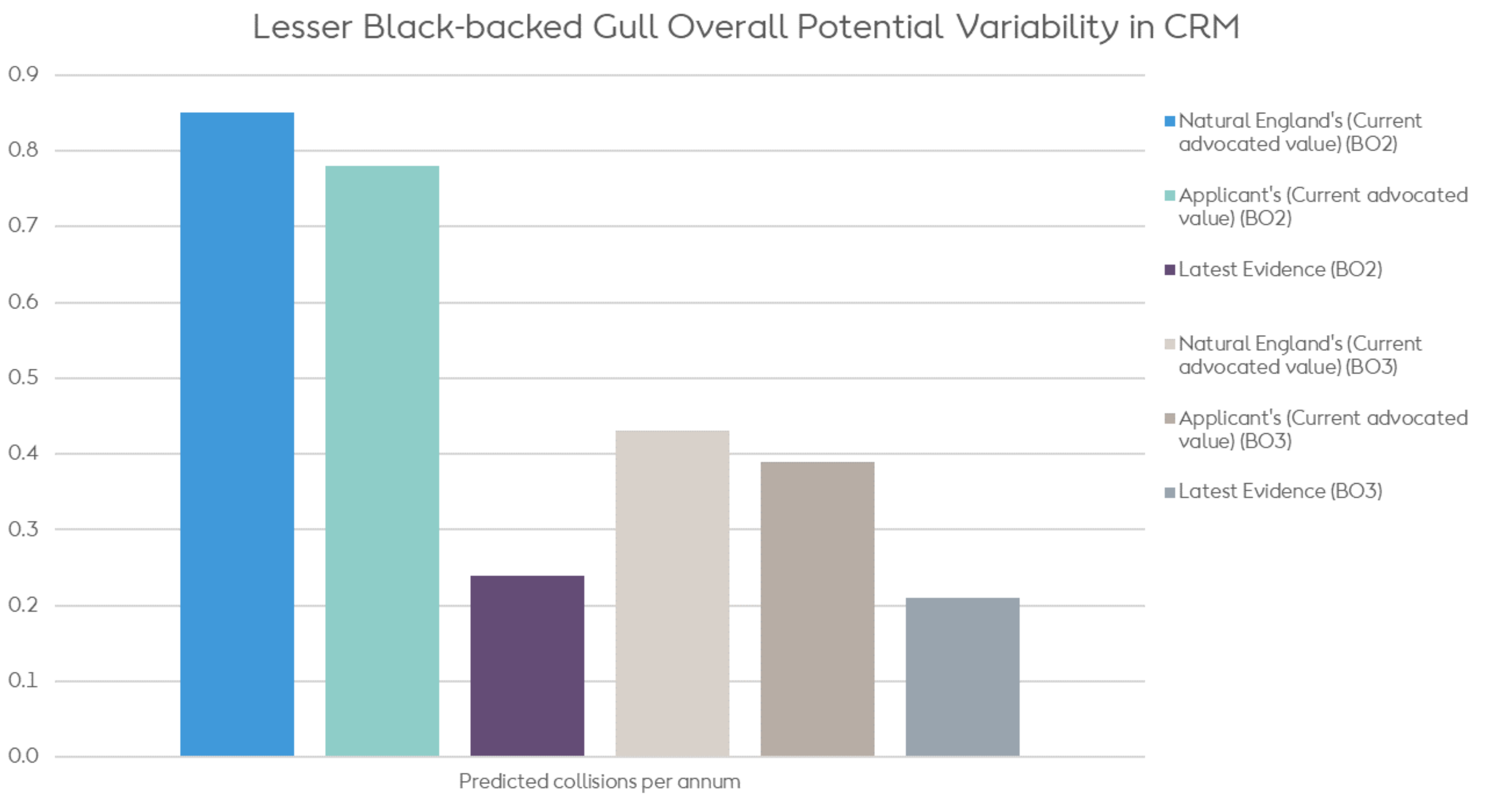

Figure 17: Graphical representation of annual predicted collisions for lesser black-backed gull with modelling variability applied to multiple input parameters around collision risk modelling.

3.1.6 Great Black-backed Gull CRM Variability Results

Table 23: Annual predicted collisions for great black-backed gull with modelling variability applied around avoidance rate.

Parameter	Approach	Avoidance Rate Value	Impact Value – Collision Mortality Rate (Mean)	Variation in Predicted Collisions (Impact Variation)	Reference
Avoidance rate (BO2	Applicant's (Current advocated value)	0.995	7.44	N/A	JNCC (2014)
	Natural England's (Current advocated value)		9.59	N/A	
	Applicant's	0.996	5.95	-1.49 (-20.03%)	Skov et al. (2018)
	Natural England's		7.68	-1.91 (-19.92%)	
Avoidance rate (BO3)	Applicant's (Current advocated value)	0.989	4.40	N/A	JNCC (2014)
	Natural England's (Current advocated value)		5.67	N/A	
	Applicant's	0.993	2.80	-1.60 (-36.36%)	Bowgen & Cook (2018)
	Natural England's		3.61	-2.06 (-36.33%)	

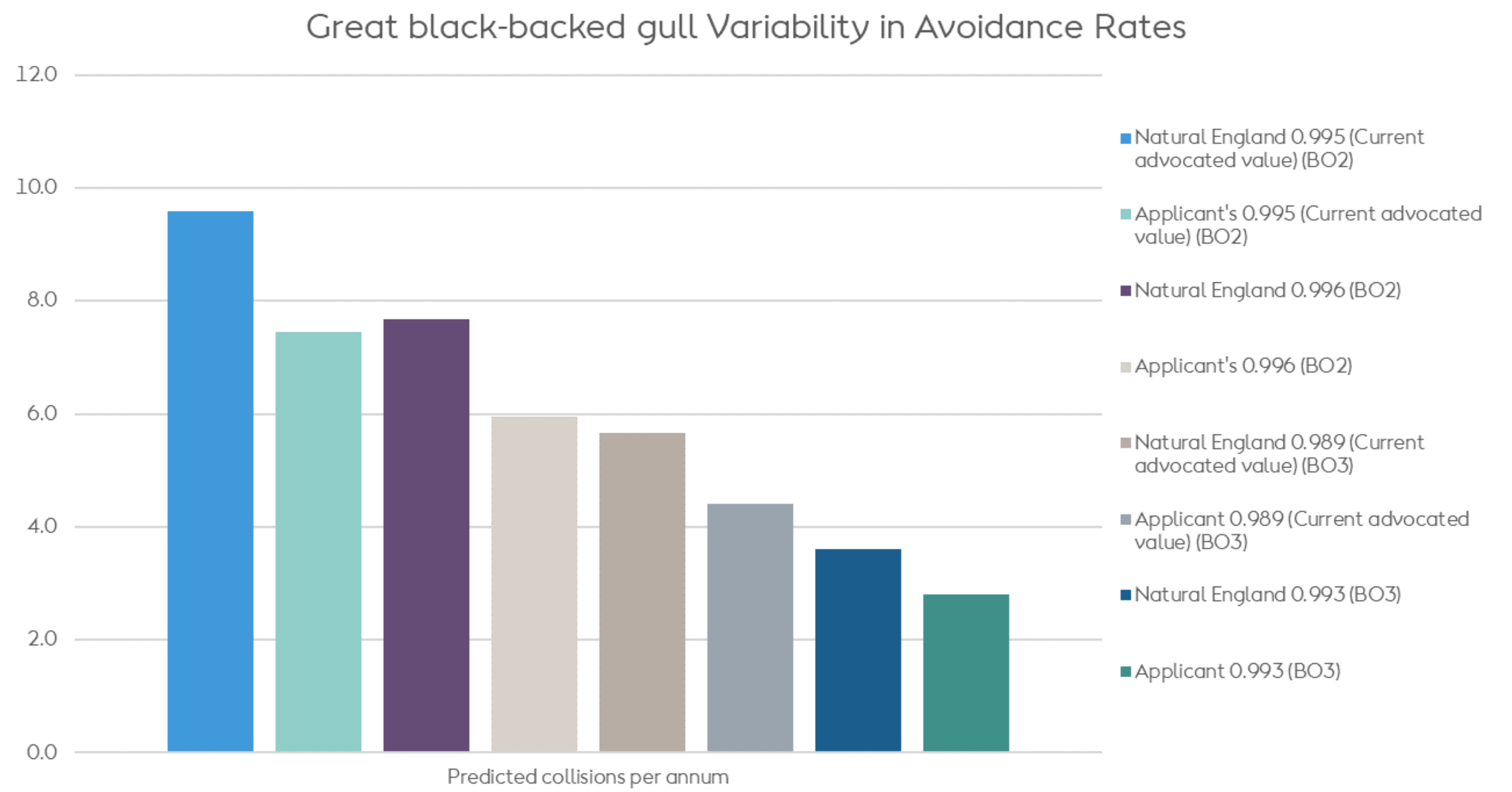

Figure 18: Graphical representation of annual predicted collisions for great black-backed gull with modelling variability applied around avoidance rate.

Table 24: Annual predicted collisions for great black-backed gull with modelling variability applied around flight speed.

Parameter	Approach	Flight Speed Value (ms^{-1})	Impact Value – Collision Mortality Rates (Mean)	Variation in Predicted Collisions (Impact Variation)	Reference
Flight speeds (BO2)	Applicant's (Current advocated value)	13.70	7.44	N/A	Pennycuick (1997) and Alerstam et al. (2007)
	Natural England's (Current advocated value)		9.59	N/A	
	Applicant's	9.78	6.12	-1.32 (-17.74%)	Skov et al. (2018)
	Natural England's		7.88	-1.71 (-17.83%)	
	Applicant's	9.80	6.11	-1.33 (-17.88%)	Skov et al. (2018)
	Natural England's		7.89	-1.70 (-17.73%)	
Flight speeds (BO3)	Applicant's (Current advocated value)	13.70	4.40	N/A	Pennycuick (1997) and Alerstam et al. (2007)
	Natural England's (Current advocated value)		5.67	N/A	
	Applicant's	9.78	4.03	-0.37 (-8.41%)	Skov et al. (2018)
	Natural England's		5.20	-0.47 (-8.29%)	
	Applicant's	9.80	4.04	-0.36 (-8.18%)	Skov et al. (2018)
	Natural England's		5.21	-0.46 (-8.11%)	

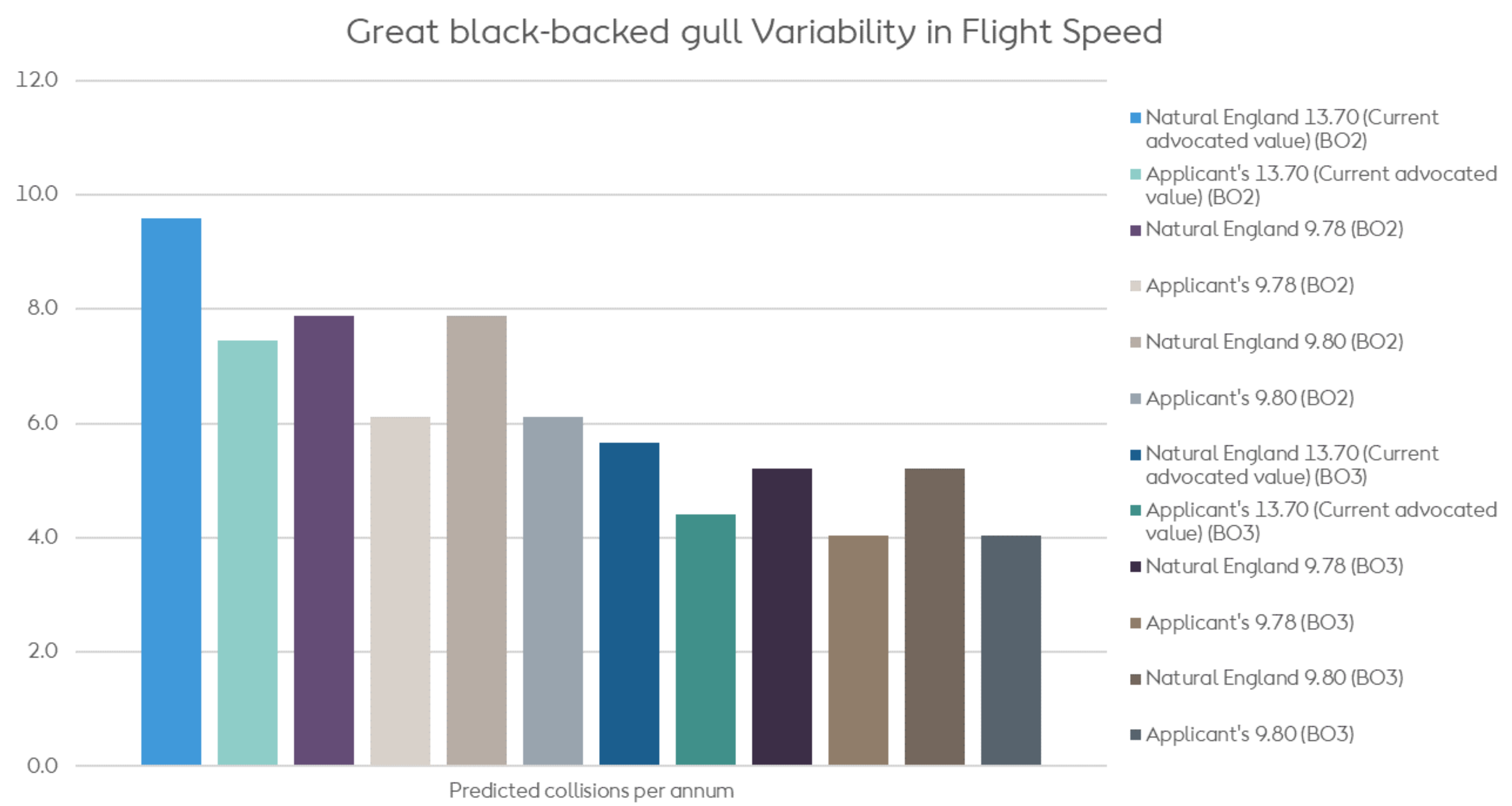

Figure 19: Graphical representation of annual predicted collisions for great black-backed gull with modelling variability applied around flight speed.

Table 25: Annual predicted collisions for great black-backed gull with modelling variability applied around nocturnal activity.

Parameter	Approach	Nocturnal Activity Value	Impact Value – Collision Mortality Rates (Mean)	Variation in Predicted Collisions (Impact Variation)	Reference
Nocturnal Activity (BO2)	Applicant's (Current advocated value)	0.25	7.44	N/A	MacArthur Green, APEM & Royal HaskoningDHV (2015)
	Natural England's (Current advocated value)	0.50	9.59	N/A	Garthe and Hüppop (2004)
	Applicant's	0.25	7.44	-0.00 (-0.00%)	MacArthur Green, APEM & Royal HaskoningDHV (2015)
	Natural England's		7.44	-2.15 (-22.42%)	
	Applicant's	0.03	5.54	-1.9 (-25.54%)	Skov et al. (2018)
	Natural England's		5.54	-4.05 (-42.23%)	
Nocturnal Activity (BO3)	Applicant's (Current advocated value)	0.25	4.40	N/A	MacArthur Green, APEM & Royal HaskoningDHV (2015)
	Natural England's (Current advocated value)	0.50	5.67	N/A	Garthe and Hüppop (2004)
	Applicant's	0.25	4.40	N/A	MacArthur Green, APEM & Royal HaskoningDHV (2015)
	Natural England's		4.34	-1.33 (-23.45%)	
	Applicant's	0.03	3.27	-1.13 (-25.68%)	Skov et al. (2018)
	Natural England's		3.27	-2.40 (-42.32%)	

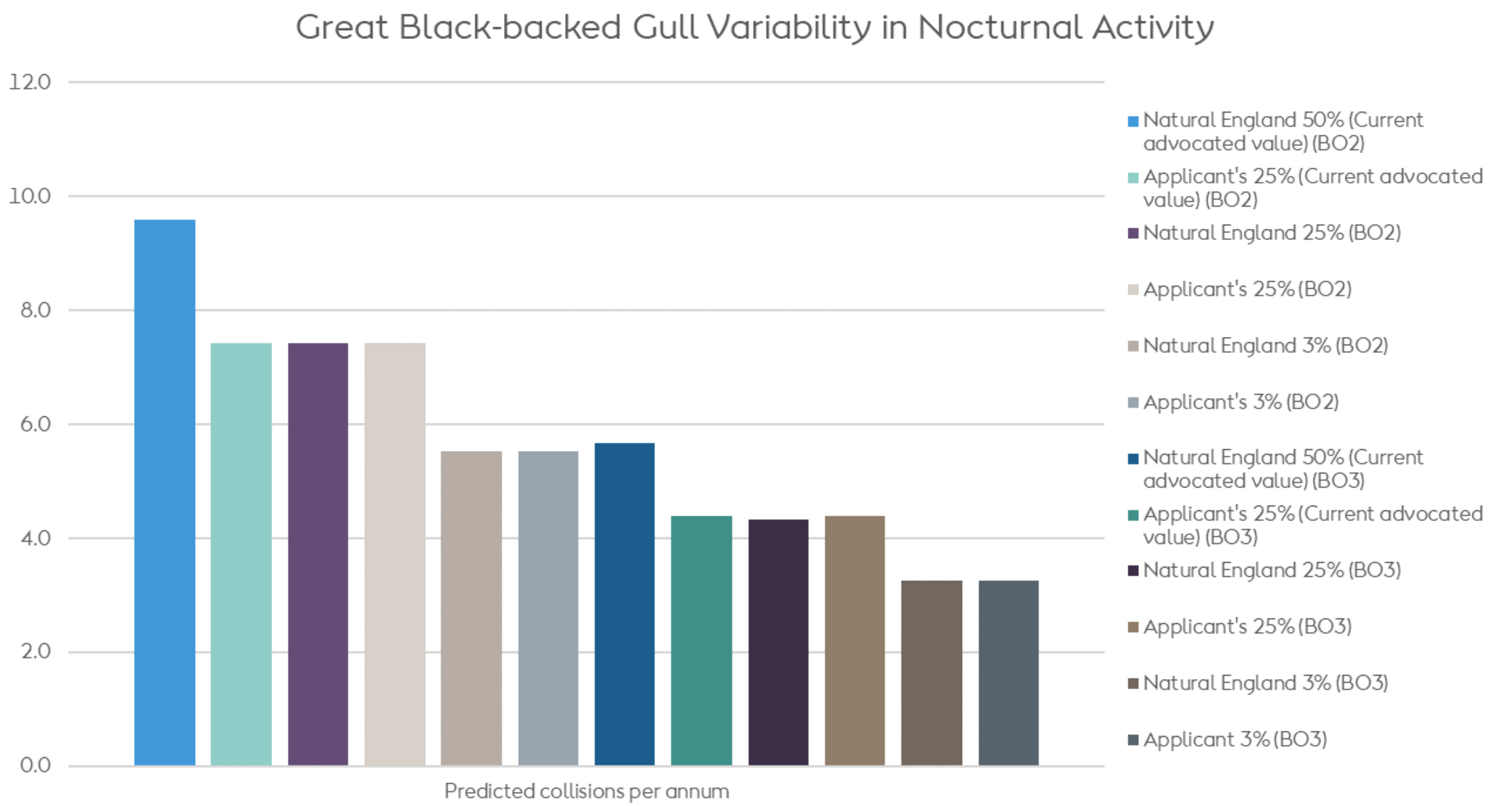

Figure 20: Graphical representation of annual predicted collisions for great black-backed gull with modelling variability applied around nocturnal activity.

Table 26: Annual predicted collisions for great black-backed gull with modelling variability applied to multiple input parameters around collision risk modelling.

Parameter	Approach	Avoidance Rates (AR), Flight Speed (FS) (ms^{-1}) and Nocturnal Activity (NA) Values	Impact Value – Collision Mortality Rates (Mean)	Variation in Predicted Collisions (Impact Variation)
Avoidance rate (BO2), Flight Speed & Nocturnal Activity	Applicant's (Current advocated value)	AR 0.995; FS 13.70; NA 0.50	N/A	N/A
	Natural England's (Current advocated value)	AR 0.995; FS 13.70; NA 0.25	N/A	N/A
	Latest Evidence	AR 0.996; FS 9.78; NA 0.03	3.64	Applicant's: -3.80 (-51.08%) Natural England's: -5.95 (-62.04%)
Avoidance rate (BO3), Flight Speed & Nocturnal Activity	Applicant's (Current advocated value)	AR 0.989; FS 13.70; NA 0.25	N/A	N/A
	Natural England's (Current advocated value)	AR 0.989; FS 13.70; NA 0.50	N/A	N/A
	Latest Evidence	AR 0.993; FS 9.78; NA 0.03	1.91	Applicant's: -2.49 (-56.59%) Natural England's: -3.76 (-66.31%)

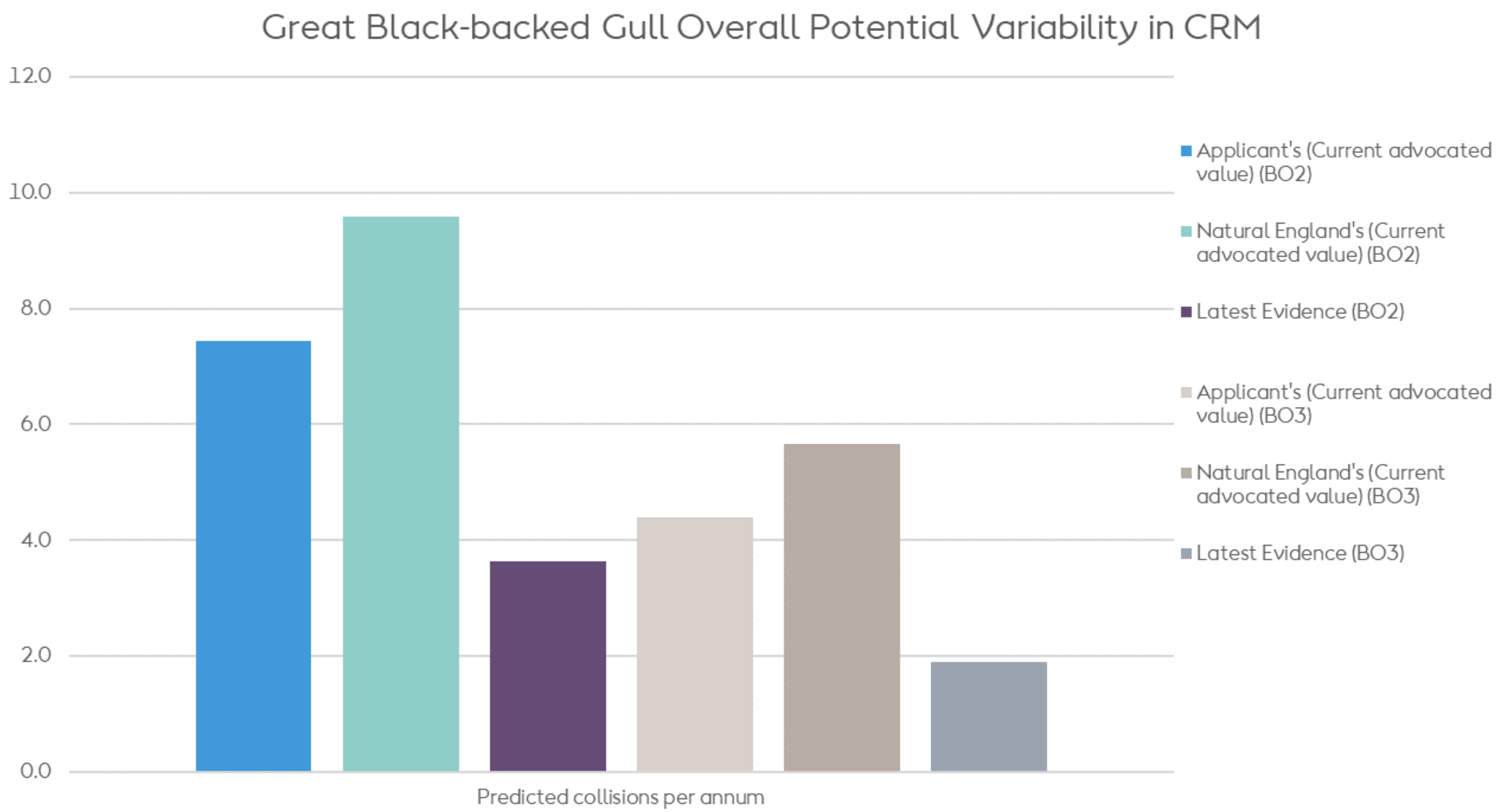

Figure 21: Graphical representation of annual predicted collisions for great black-backed gull with modelling variability applied to multiple input parameters around collision risk modelling.

3.2 Displacement Analysis

3.2.1.1 Part 2 presents the variability in displacement assessment as described in **Section 2.3**, due to disagreement in the most suitable displacement and mortality range for assessment of gannet and auk species following the Applicant's and Natural England's preferred approaches.

3.2.1.2 **Table 27** and **Table 28** below provide example assessments of gannet and razorbill (auk species) displacement assessments following the Applicant's and Natural England's advocated ranges alongside using the resulting displacement and mortality range concluded from the Applicant's review of all current evidence in relation to displacement effects from OWFs.

Table 27: Gannet variability in displacement analysis and variance in upper and lower assessment limits.

Hornsea Four Predicted Impacts Alone							
Approach	**Annual Abundance (Individuals)**	**Lower Displacement Limit**		**Upper Displacement Limit**		**Variation in Predicted Impacts**	
		Displacement and mortality rates	*Predicted mortality (per annum)*	*Displacement and mortality rates*	*Predicted mortality (per annum)*	*Lower Limit*	*Upper Limit*
Applicant's (Current advocated range)	2,167	60% Disp; 1% Mort	13.0	80% Disp; 1% Mort	17.3	N/A	N/A
Natural England's (Current advocated range)		60% Disp; 1% Mort	13.0	80% Disp; 10% Mort	173.4	N/A	N/A
Latest Evidence		Breeding 40% Disp & Non-breeding 60% Disp; 1% Mort	11.1	Breeding 60% Disp & Non-breeding 75% Disp; 1% Mort	14.8	Applicant's/Natural England's: -1.9 (-14.62%)	Applicant's: -2.5 (-14.45%) Natural England's: -158.60 (-91.46%)

Hornsea Four Predicted Impacts Cumulatively with all UK North Sea and English Channel Tier 1 & 2 Projects							
Approach	**Annual Abundance (Individuals)**	**Lower Displacement Limit**		**Upper Displacement Limit**		**Variation in Predicted Impacts**	
		Displacement and mortality rates	*Predicted mortality (per annum)*	*Displacement and mortality rates*	*Predicted mortality (per annum)*	*Lower Limit*	*Upper Limit*
Applicant's (Current advocated range)	49,396	60% Disp; 1% Mort	296.4	80% Disp; 1% Mort	395.2	N/A	N/A
Natural England's (Current advocated range)		60% Disp; 1% Mort	296.4	80% Disp; 10% Mort	3951.7	N/A	N/A
Latest Evidence		Breeding 40% Disp & Non-breeding 60% Disp; 1% Mort	252.7	Breeding 60% Disp & Non-breeding 75% Disp; 1% Mort	337.7	Applicant's/Natural England's: -43.7 (-14.74%)	Applicant's: -57.5 (-14.5%)

							Natural England's: -3614.0 (-91.45%)

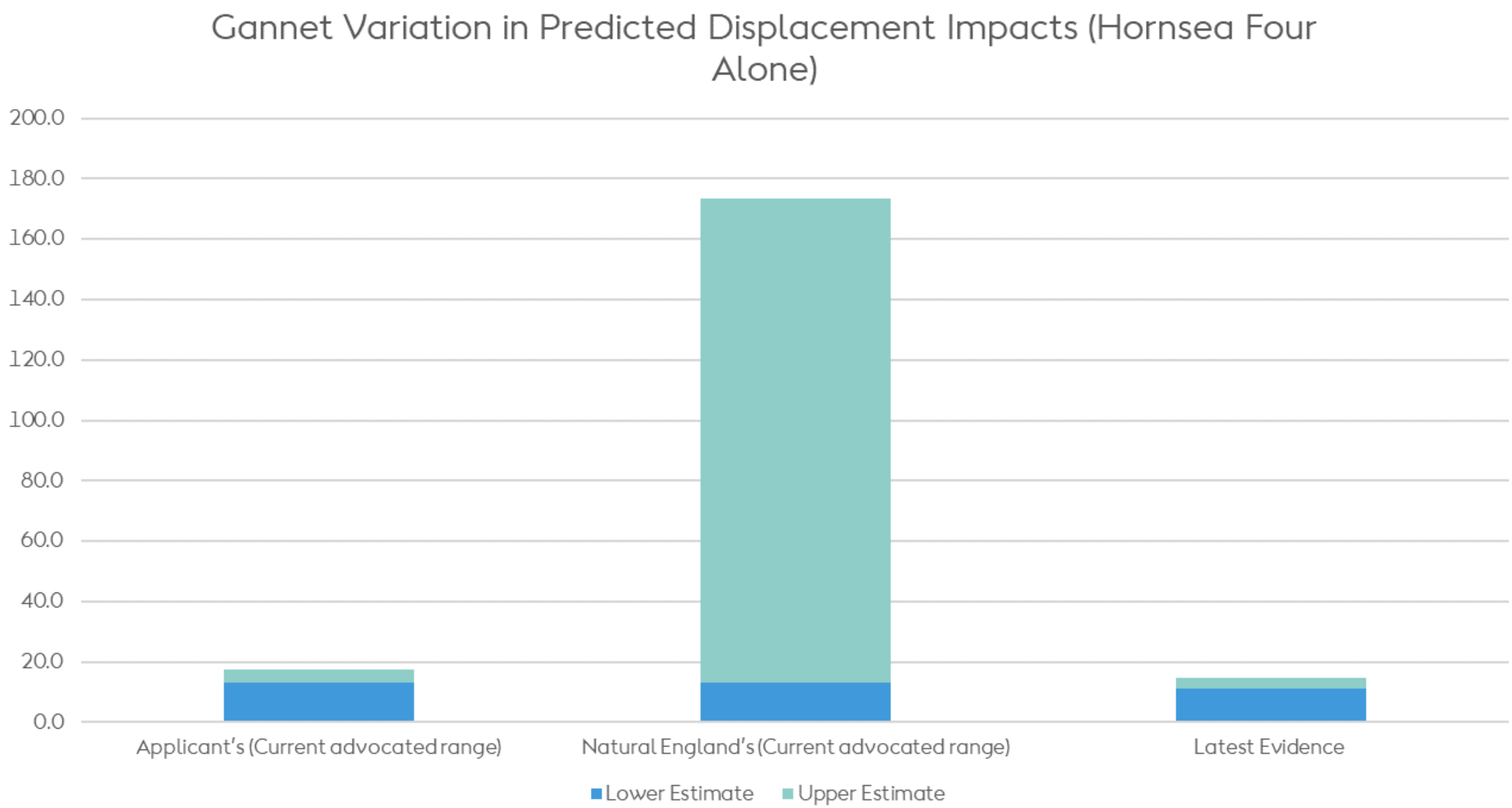

Figure 22: Gannet graphical representation of difference in the predicted displacement range impacts from Hornsea Four alone.

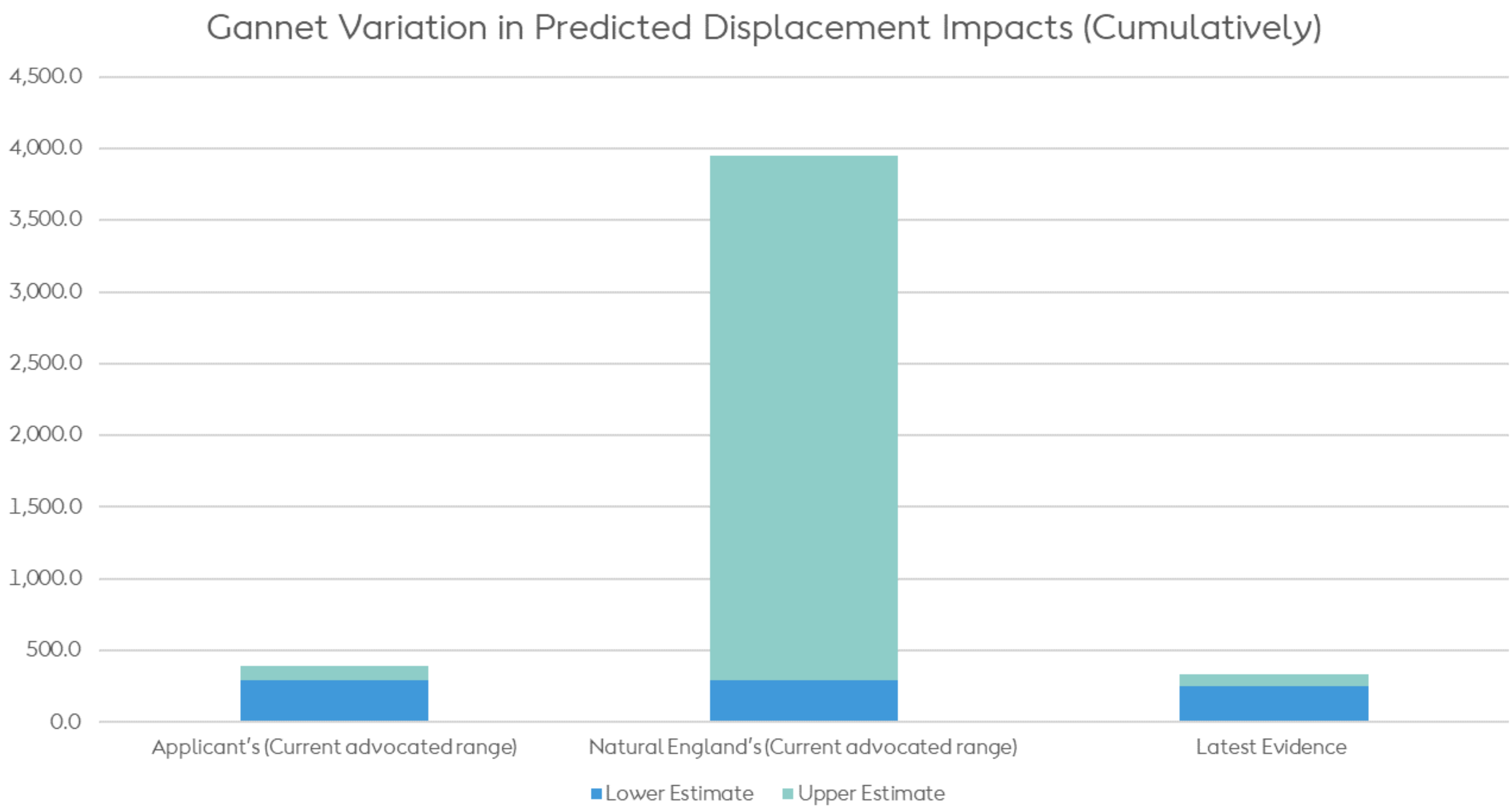

Figure 23: Gannet graphical representation of difference in the predicted displacement range impacts from Hornsea Four cumulatively with other Tier 1 & 2 projects within the UK North Sea and English Channel.

Table 28: Razorbill variability in displacement analysis and variance in upper and lower assessment limits.

Hornsea Four Predicted Impacts Alone							
Approach	**Annual Abundance (Individuals)**	**Lower Displacement Limit**		**Upper Displacement Limit**		**Variation in Predicted Impacts**	
		Displacement and mortality rates	*Predicted mortality (per annum)*	*Displacement and mortality rates*	*Predicted mortality (per annum)*	*Lower Limit*	*Upper Limit*
Applicant's (Current advocated range)	5,600	50% Disp; 1% Mort	28	50% Disp; 1% Mort	28	N/A	N/A
Natural England's (Current advocated range)		30% Disp; 1% Mort	16.8	70% Disp; 10% Mort	392	N/A	N/A
Latest Evidence		25% Disp; 0.5% Mort	7	50% Disp; 1% Mort	28	Applicant's: -21 (-75%) Natural England's: -9.8 (-58.3%)	Applicant's: 0 Natural England's: -364 (-92.9%)
Hornsea Four Predicted Impacts Cumulatively with all UK North Sea and English Channel Tier 1 & 2 Projects							
Approach	**Annual Abundance (Individuals)**	**Lower Displacement Limit**		**Upper Displacement Limit**		**Variation in Predicted Impacts**	
		Displacement and mortality rates	*Predicted mortality (per annum)*	*Displacement and mortality rates*	*Predicted mortality (per annum)*	*Lower Limit*	*Upper Limit*
Applicant's (Current advocated range)	138,607	50% Disp; 1% Mort	693	50% Disp; 1% Mort	693	N/A	N/A

Natural England's (Current advocated range)		30% Disp; 1% Mort	415.8	70% Disp; 10% Mort	9,702.50	N/A	N/A
Latest Evidence		25% Disp; 0.5% Mort	173.3	50% Disp; 1% Mort	693	Applicant's: -519.7 (-75%) Natural England's: -242.5 (-58.3%)	Applicant's: 0 Natural England's: -9,009.5 (-92.9%)

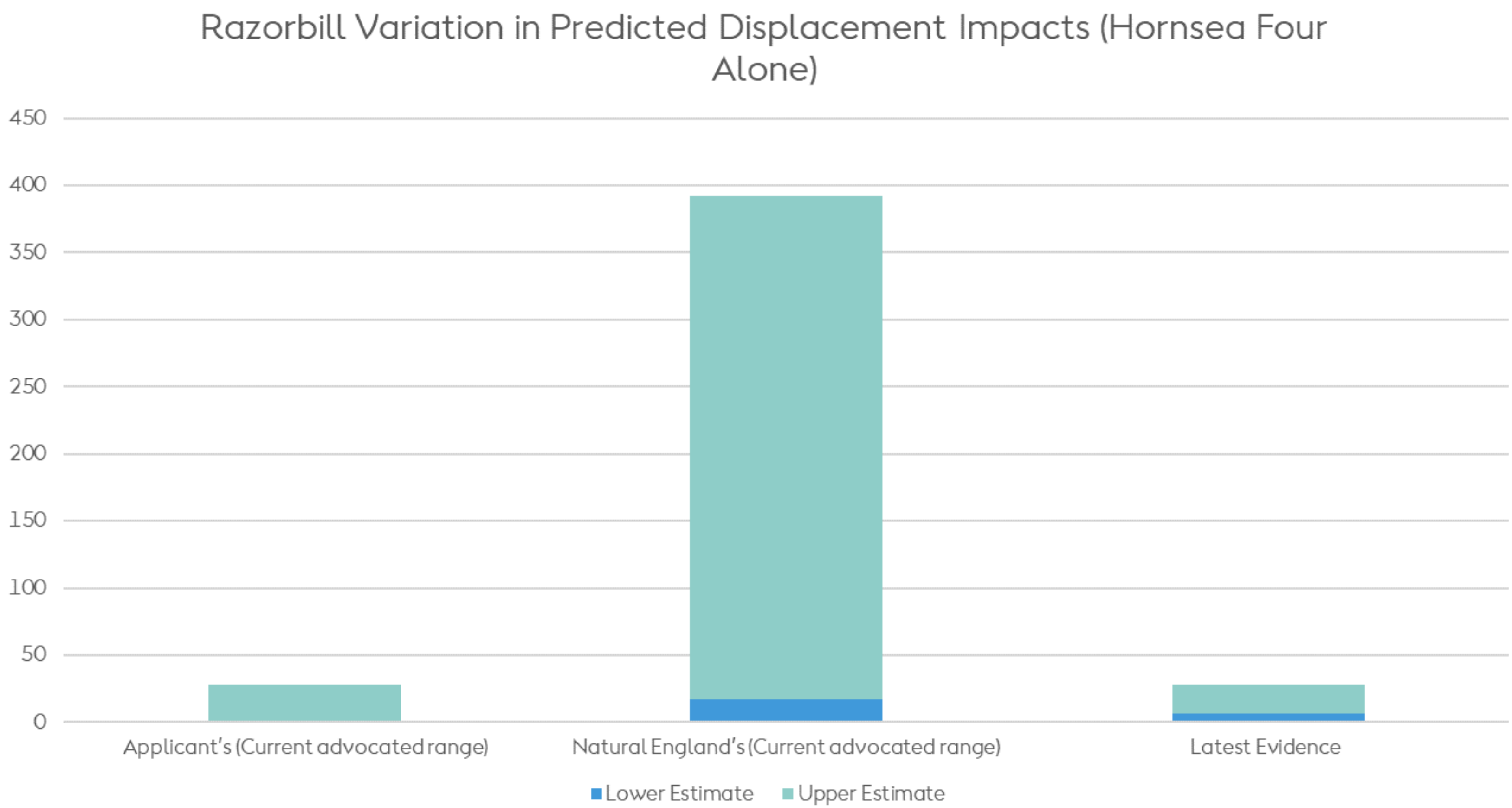

Figure 24: Razorbill graphical representation of difference in the predicted displacement range impacts from Hornsea Four alone.

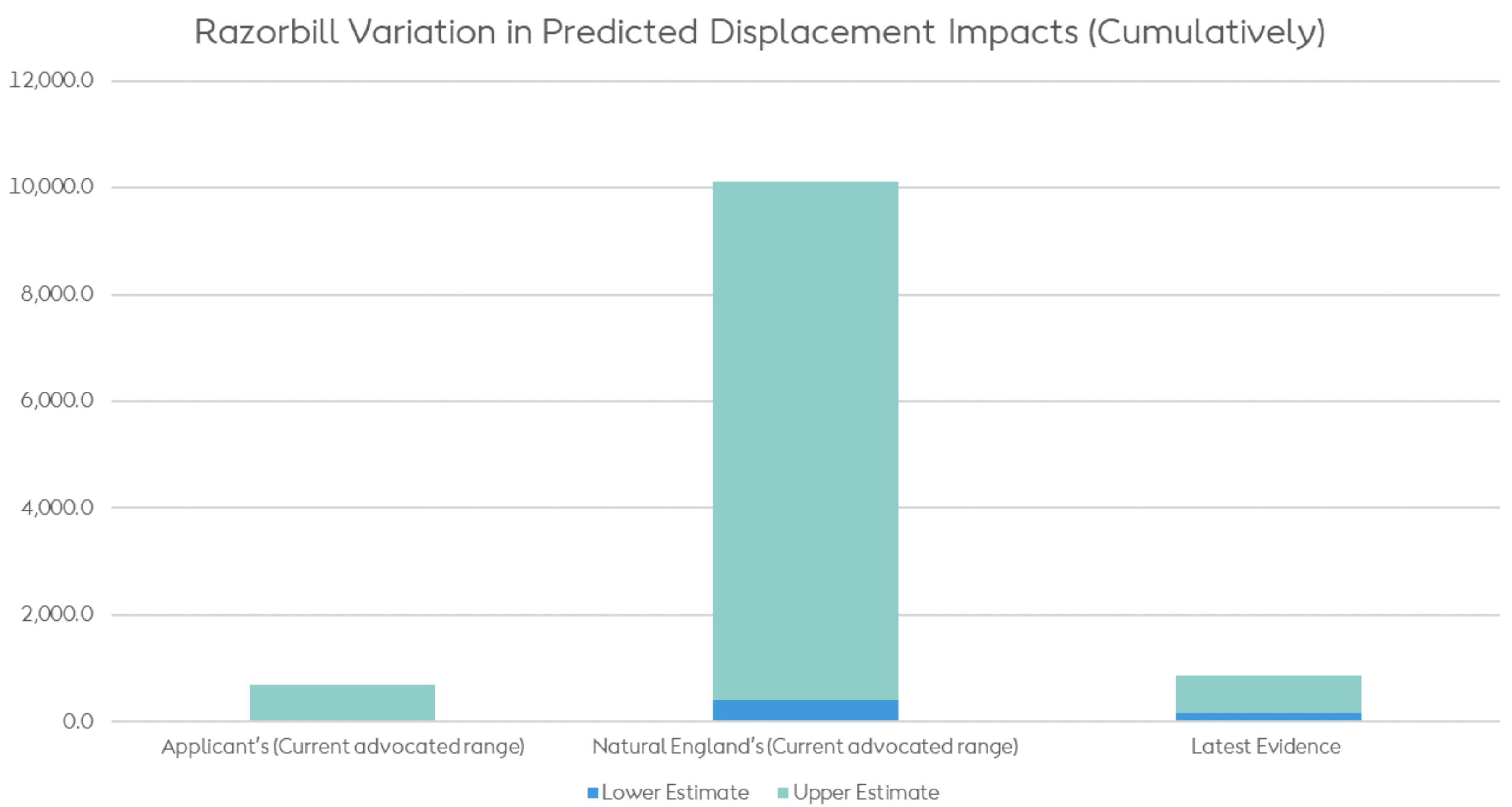

Figure 25: Gannet graphical representation of difference in the predicted displacement range impacts from Hornsea Four cumulatively with other Tier 1 & 2 projects within the UK North Sea and English Channel.

3.3 Discussion on Variability in Impact Assessments

3.3.1 Gannet

3.3.1.1 As presented in **Section 3.1**, the alteration of a single CRM input parameter for gannet resulted in a variation in collision mortality rates of between approximately -90% and +2.5% comparatively for the Applicant's approach and -90% to -6% for Natural England's approach. When accounting for variation in all CRM input parameters based on the latest evidence gathered from post-consent monitoring (**Table 9**) this resulted in a variation in collision risk mortality rates of approximately -90% for the Applicant's approach and -93% for Natural England's Approach. This demonstrates that applying precautionary values to all input parameters multiplies up into significantly precautionary CRM outputs. It also demonstrates that when considering small changes to the input parameters following the most recent evidence and applying these within the sCRM for gannet this may lead to significant reductions in the overall risk level, particularly when all are applied together.

3.3.1.2 If the variations in the input parameters modelled in **Section 3.1** were to be applied to the current cumulative predicted impact values for all other Tier 1 & 2 projects within the UK North Sea and English Channel BDMPS (derived from the **Ornithology EIA and HRA Annex** (**G5.25**), then this would result in a significant reduction from the current predicted cumulative collision mortality rates. Following the application of such input parameter changes then the overall cumulative mortality rates would reduce from 2,986.6 a slight increase to 3,061.3 (increase of +2.5%) and a maximum reduction of 275.1 (reduction of 90%) mortalities per annum following the Applicant's Approach and from 2,991.6 to a minimum reduction of 2,807.4 (reduction of 6%) up to a maximum reduction of 213.3 (reduction 93%) mortalities per annum following Natural England's approach.

3.3.1.3 As presented in **Table 10**, regardless of the different approaches taken for estimating collision risk mortality levels using any variations in input parameters in the sCRM for gannet the inclusion of macro avoidance resulted in a reduction of approximately 69% to predicted collision impacts. Therefore, it is evident that all previous CRM undertaken for this species across all other Tier 1 & 2 projects within the UK North Sea and English Channel BDMPS over-estimate collision mortality rates for this species. When applying a macros avoidance to the current cumulative predicted impact value for all Tier 1 & 2 projects within the North Sea and English Channel BDMPS (derived from the **Ornithology EIA and HRA Annex** (**G5.25**), then this would result in a significant reduction from 2,986.6 to a maximum reduction of 925.8 mortalities per annum following the Applicant's Approach and from 2,991.6 to 927.4 mortalities per annum following Natural England's approach.

3.3.1.4 As presented in **Table 27**, the adjustment of displacement and mortality rates according to the latest evidence for gannet, results in a reduction of approximately 15% to predicted mortality at the lower displacement limit for both the Applicant's approach and for Natural England's when considering Hornsea Four displacement alone. For the upper displacement limit, the adjustment of displacement and mortality rates results in a reduction of approximately 14% to predicted mortality following the Applicant's approach and a 91%

reduction compared to Natural England's approach when considering Hornsea Four displacement alone.

3.3.1.5 Applying the same displacement and mortality rates to the current cumulative predicted mortality values for all Tier 1 & 2 projects within the UK North Sea and English Channel BDMPS (derived from the **Ornithology EIA and HRA Annex** (**G5.25**) would result in a 15% reduction in predicted mortality at the lower displacement limit for both the Applicant's approach and Natural England's. At the upper displacement limit, the adjustment of displacement and mortality parameters results in a 15% reduction in predicted mortality following the Applicant's approach and a 91% reduction in predicted mortality following Natural England's approach.

3.3.2 Kittiwake

3.3.2.1 As presented in **Section 3.1**, the alteration of a single CRM input parameter for kittiwake resulted in a variation in collision mortality rates of between approximately -82% and -7% comparatively for the Applicant's approach and -82% to -7% for Natural England's approach. When accounting for variation in all CRM input parameters based on the latest evidence gathered from post-consent monitoring (**Table 14**) this resulted in a variation in collision risk mortality rates of approximately -89% for the Applicant's approach and -91% for Natural England's Approach. This demonstrates that when applying precautionary values to all input parameters it multiplies up to materially altering the CRM outputs. It also demonstrates that when considering small changes to the input parameters following the most recent evidence and applying these within the sCRM for kittiwake this may lead to material changes to the overall risk level for this species, particularly when all are applied together.

3.3.2.2 If the variations in the input parameters modelled in **Section 3.1** were to be applied to the current cumulative predicted impact values for all Tier 1 & 2 projects within the UK North Sea BDMPS (derived from the **Ornithology EIA and HRA Annex** (**G5.25**), then this would result in a significant reduction from the current predicted cumulative collision mortality rates. Following the application of such input parameter changes then the overall cumulative mortality rates would reduce from 4,026.3 to a minimum reduction of 3,758.6 (reduction of 7%) up to a maximum reduction of 425.2 (reduction of 89%) mortalities per annum following the Applicant's Approach and from 4,038.6 to a minimum reduction of 3,769.6 (reduction of 7%) up to a maximum reduction of 370.5 (reduction of 91%) mortalities per annum following Natural England's approach.

3.3.3 Herring Gull

3.3.3.1 As presented in **Section 3.1**, the alteration of a single CRM input parameter for herring gull resulted in a variation in collision mortality rates of between approximately -80% and -8% comparatively for the Applicant's approach and -80% to -7% for Natural England's approach. When accounting for variation in all CRM input parameters based on the latest evidence gathered from post-consent monitoring (**Table 18**) this resulted in a variation in collision risk mortality rates of approximately -86% and -23% for the Applicant's approach and -88% and -53% for Natural England's Approach. This demonstrates that when applying precautionary values to all input parameters it multiplies up to significantly altering the CRM outputs. It also demonstrates that when considering small changes to the input parameters following the most recent evidence and applying these within the sCRM for herring gull this may lead to significant changes to the overall risk level for this species, particularly when all are applied together.

3.3.3.2 If the variations in the input parameters modelled in **Section 3.1** were applied to the current cumulative predicted impact value for all Teir 1 & 2 projects in the UK North Sea and English Channel BDMPS (derived from the SPR (2021)), then this would result in a reduction from the current predicted cumulative collision mortality rates. Following the application of such input parameter changes then the overall cumulative mortality rates would reduce from 757.0 to a minimum reduction of 695.5 (reduction of 8%) up to a maximum reduction of 107.4 (reduction of 86%) mortalities per annum following the Applicant's Approach and from 757.0 to a minimum reduction of 704.2 (reduction of 7%) up to a maximum reduction of 91.4 (reduction of 88%) mortalities per annum following Natural England's approach.

3.3.4 Lesser Black-backed Gull

3.3.4.1 As presented in **Section 3.1**, the alteration of a single CRM input parameter for lesser black-backed gull resulted in a variation in collision mortality rates of between approximately -60% to -0% comparatively for the Applicant's approach and -60% to -7% for Natural England's approach. When accounting for variation in all CRM input parameters based on the latest evidence gathered from post-consent monitoring (**Table 26**) this resulted in a variation in collision risk mortality rates of approximately -73% and -69% for the Applicant's approach and -75% and -72% for Natural England's Approach. This demonstrates that when applying precautionary values to all input parameters it multiplies up to significantly altering the CRM outputs. It also demonstrates that when considering small changes to the input parameters following the most recent evidence and applying these within the sCRM for lesser black-backed gull this may lead to significant changes to the overall risk level for this species, particularly when all are applied together.

3.3.4.2 If the variations in the input parameters modelled in **Section 3.1** were applied to the current cumulative predicted impact value for all Tier 1 & 2 projects in the UK North Sea and English Channel BDMPS (derived from SPR (2021)), then this would result in a reduction from the current predicted cumulative collision mortality rates. Following the application of such input parameter changes then the overall cumulative mortality rates would reduce from 532.5 to a minimum reduction of 532.5 (no reduction) up to a maximum reduction of 143.3 (reduction of 73%) mortalities per annum following the Applicant's Approach and from 532.5 to a minimum reduction of 495.3 (reduction of 7%) up to a maximum reduction of 131.6 (reduction of 75%) mortalities per annum following Natural England's approach.

3.3.5 Great Black-backed Gull

3.3.5.1 As presented in **Section 3.1** the alteration of a single CRM input parameter for great black-backed gull resulted in a variation in collision mortality rates of between approximately -36% to -0% comparatively for the Applicant's approach and 42% to -8% for Natural England's approach. When accounting for variation in all parameters following input parameters based on the latest evidence gathered from post-consent monitoring (**Table 26**) this resulted in a variation in collision risk mortality rates of approximately -57% and -51% for the Applicant's approach and -66% and -62% for Natural England's Approach. This demonstrates that when applying precautionary values to all input parameters it multiplies up to significantly altering the CRM outputs. It also demonstrates that when considering small changes to the input parameters following the most recent evidence and applying these within the sCRM for great black-backed gull this may lead to significant changes to the overall risk level for this species, particularly when all are applied together.

3.3.5.2 If the variations in the input parameters modelled in **Section 3.1**were applied to the current cumulative predicted impact value for all Tier 1 & 2 projects in the North Sea BDMPS (derived from the **Ornithology EIA and HRA Annex** (**G5.25**), then this would result in a reduction from the current predicted cumulative collision mortality rates. Following the application of such input parameter changes then the overall cumulative mortality rates would reduce from 984.5 to a minimum reduction of 984.5 (no reduction) up to a maximum reduction of 427.4 (reduction of 57%) mortalities per annum following the Applicant's Approach and from 985.8 to a minimum reduction of 905.9 (reduction of 8%) up to a maximum reduction of 332.1 (reduction of 66%) mortalities per annum following Natural England's approach.

3.3.6 Razorbill (auk species)

3.3.6.1 As presented in **Table 28**, the adjustment of displacement and mortality rates according to the latest evidence for razorbill results in a reduction of approximately 75% to the predicted mortality at the lower displacement limit for the Applicant's approach and a reduction of 58% in comparison to Natural England's approach when considering Hornsea Four displacement alone. For the upper displacement limit, the adjustment of displacement and mortality rates results in no change to predicted mortality following the Applicant's approach, but approximately a 93% reduction compared to Natural England's approach when considering Hornsea Four displacement alone.

3.3.6.2 Applying the same displacement and mortality rates to the current cumulative predicted mortality values for all Tier 1 & 2 projects within the UK North Sea and English Channel BDMPS (derived from the **Ornithology EIA and HRA Annex** (**G5.25**) would result in a reduction of approximately 75% in predicted mortality at the lower displacement limit for the Applicant's approach and 58% in comparison to Natural England's approach. At the upper displacement limit, the adjustment of displacement and mortality parameters results in no change in predicted mortality following the Applicant's approach but approximately 93% reduction in predicted mortality compared to Natural England's approach.

3.3.7 Summary

3.3.7.1 As detailed in part 1 (**Section 2**), for each stage of the overall EIA and HRA assessments, variability exists due to environmental stochasticity and uncertainty in relation to current knowledge of seabird ecology and their interactions with OWFs. For EIA and HRA assessments the SNCB's recommended approach to account for areas of uncertainty is to ensure that a precautionary approach is taken for each stage and input parameter modelled. However, this approach is recommended without due consideration of how the accumulation of the most precautionary approach might lead to an overall assessment which is a significant over estimation of predicted impacts. Taking the precautionary approach for each input parameter within an assessment does not necessarily account for the latest evidence from academic and / or post-consent monitoring studies, significant changes in technology such as improved turbine designs or differences between environmental variables between study sites which may result in an overall low confidence in the precautionary values applied. Furthermore, the accumulation of precaution is further compounded into further over estimation when considering multiple projects at a cumulative and in-combination level.

3.3.7.2 The results from Part 2 (**Section 3**) reinforce the need to reconsider where precaution is provided in assessments, due to the significant differences (in some instances up to a 90% difference in predicted impacts) that may result from minor alterations of a single input parameter to the final predicted impacts. An example of this is from current and previous assessments of gannet not considering the inclusion of macro avoidance within collision risk assessments, despite supporting evidence of macro avoidance behaviour in gannets being cited in Cook et al. (2014) and more recently reaffirmed by APEM's in-depth review of gannet displacement and mortality evidence review (**REP2-045**). As presented in **Table 10**, the alteration of a single variable to account for macro avoidance within assessments led to a reduction of ~69% in predicted impacts, which at a cumulative level resulted in a reduction of from roughly 3,000 predicted mortalities per annum to less than 1,000 mortalities per annum from all OWFs within the UK North Sea and English Channel.

3.3.7.3 The conclusion from the sensitivity assessment for CRM using the different values from the Applicant and the latest evidence to determine input parameter values showed that estimates using Natural England's advocated values may be outdated and overly precautionary. This is particularly the case when each precautionary input parameter is added into the CRM, therefore multiplying the levels of precaution in the output values. Additionally, results indicate that further consideration of which collision risk model option is used is required, as any quantification of total risk is most influenced by this choice. This is increasingly significant in terms of subsequent comparisons with PVA outputs, related scope of apportionment and subsequent compensation discussions as well as cumulative effects considerations for future expansion and development of other nearby projects.

3.3.7.4 Across all species, the use of updated parameterisation using values derived from the latest evidence from recent post-consent monitoring studies resulted in decreased annual predicted collisions. The current parameterisation values advocated by Natural England resulted in the highest estimates of predicted collisions in all scenarios. The Applicant's advocated values tended to return predicted collision estimates between the mean and upper end of the predicted range of collisions, predominantly due to the Applicant's current values using the same or similar to Natural England for many input parameters.

3.3.7.5 The evidence base for using the Applicant's input values for CRM is strong and each of the proposed differences, in comparison to Natural England's values, are minimal individually and are still considered to contain precaution. In future assessments of collision risk it is likely that some of all of the latest evidence from post-consent monitoring projects examining collision risk will also be incorporated, such as macro avoidance for gannets, resulting in support for further reductions in predicted collisions. This sensitivity analysis therefore supports the Applicant's approach within the **Ornithology EIA and HRA Annex** (**G5.25**) for Hornsea Four, as it incorporates a series of input parameters that continue to offer precaution, but do not overly inflate the values.

3.3.7.6 Presented within the sensitivity assessment of collision risk is the use of the Band Option 3 (BO3) model for large gull species, which are currently not agreed as suitable for use by Natural England. However, the use of BO3 provides a method to account for the skewed distribution of seabird flight heights between the lowest and the highest levels of the rotor swept area. This model option provides a more realistic account of bird risk within the rotor swept area in comparison to BO2, which applies a uniform distribution of all flying birds within the lowest and highest levels of rotors, increasing the risk to all seabirds subject to CRM. Therefore, the outputs of using BO3, in comparison to Band Option 2 (BO2), indicate that the predicted collision mortality rates are significantly reduced, by up to 50% for some species. Given the use of the BO3 is arguably more evidence based (relying on the use of flight heights and post-consent sources to quantify the CRM input parameter values) in comparison to the percentage at collision risk height that informs BO2, then greater consideration and weighting towards the use of BO3 when predicting collisions for large gull species and other species would be welcomed by the Applicant.

3.3.7.7 There appears to be strong correlation between flight speeds and model outputs, suggesting that the underlying model processes are operating as would be expected. Behaviour of seabirds around wind farm developments had significant knowledge gaps when the initial parameterisation of the Band CRM models was made. Utilising post-consent evidence-based parameters would be a logical step for improving how reflective the CRM outputs are in predicting actual collision mortality rates within the real world.

3.4 Revised Population Viability Analysis (PVA)

3.4.1 Population Viability Assessment (PVA) Validation

3.4.1.1 As detailed in Part 1 (**Section 2.6**), prior to rerunning PVA the intention was to first validate the model to ensure that the demographic rates used for modelling are representative of the trends naturally exhibited in the population or colony being analysed to ensure the PVA is as robust as possible (in the absence of density dependance). In order to validate the model, historic population / colony size data is required to compare the models baseline population against.

3.4.1.2 At an EIA level, when assessing impacts against the relevant species' BDMPS and Biogeographic populations, the derivation of historic population size was not feasible due to counts not being conducted for the discrete populations as defined in Furness (2015).

3.4.1.3 For PVA modeling at the HRA level, when assessing impacts against the relevant qualifying species' colony from designated sites such as the FFC SPA, the colony has been consistently monitored since 1969 which allows for validation to be undertaken. A summary of the historic colony counts for the qualifying features of the FFC SPA are presented in **Table 29**. The starting, or initial, population was set to the 2000 colony count for each feature in order to allow for comparison with recent exhibited colony trends.

3.4.1.4 Due to the absence of colony monitoring data for puffin, model validation was not possible.

3.4.1.5 Summaries of the model logs presenting the input demographic rates for the validation analysis is provided in **Appendix B**. with the exception of productivity rate, the demographic values are the models preformulated values which are based on the literature review conducted by Horswill & Robinson (2015). Productivity rates incorporated are based on values derived from the colony productivity monitoring for each feature as detailed in **B2.2 Report to Inform Appropriate Assessment Part 11: Appendix H: Offshore Ornithology Flamborough and Filey Coast (FFC) Special Protection Area (SPA) Population Viability Analysis (APP-177)**, except for kittiwake which is based on Natural England's Relevant Representation **(RR-029)** recommendation of 0.580 (±0.096).

Table 29: Flamborough Head and Bempton Cliffs historic colony counts for qualifying features.

Species	Colony Count Year (breeding adults)				
	1969	*1987*	*2000*	*2008*	*2017*
Gannet	42	1,560	5,104	12,772	26,784
Kittiwake	61,594	170,790	85,164	75,234	91,008
Guillemot	12,570	32,578	47,215	59,817	84,647
Razorbill	1,724	7,688	8,463	14,956	27,967

3.4.2 Gannet Validation Results

3.4.2.1 As presented in **Figure 26**, the baseline population trend produced from the PVA model follows the same positive exponential growth trend of that exhibited by the colony data, albeit at a reduced growth rate. The PVA model used preformulated demographic rates with a productivity rate per pair of 0.823.

3.4.2.2 Potentially, the current data inputs within the density independent PVA model are not suitable for reflecting known population trends. Two possibilities exist; either the data available for informing the PVA model are outdated or overly influenced from demographic rates from outside the FFC SPA population. This results in the PVA outputs predicting well below observed population counts and indicating significant uncertainty in future population status. Or alternatively, local population dynamics (source-sink, immigration-emigration between colonies outside the FFC SPA) lead to observed counts varying significantly from model expectations, and therefore the current PVA methods cannot solely be relied upon for assessing likely population trends within the context of wind farm developments.

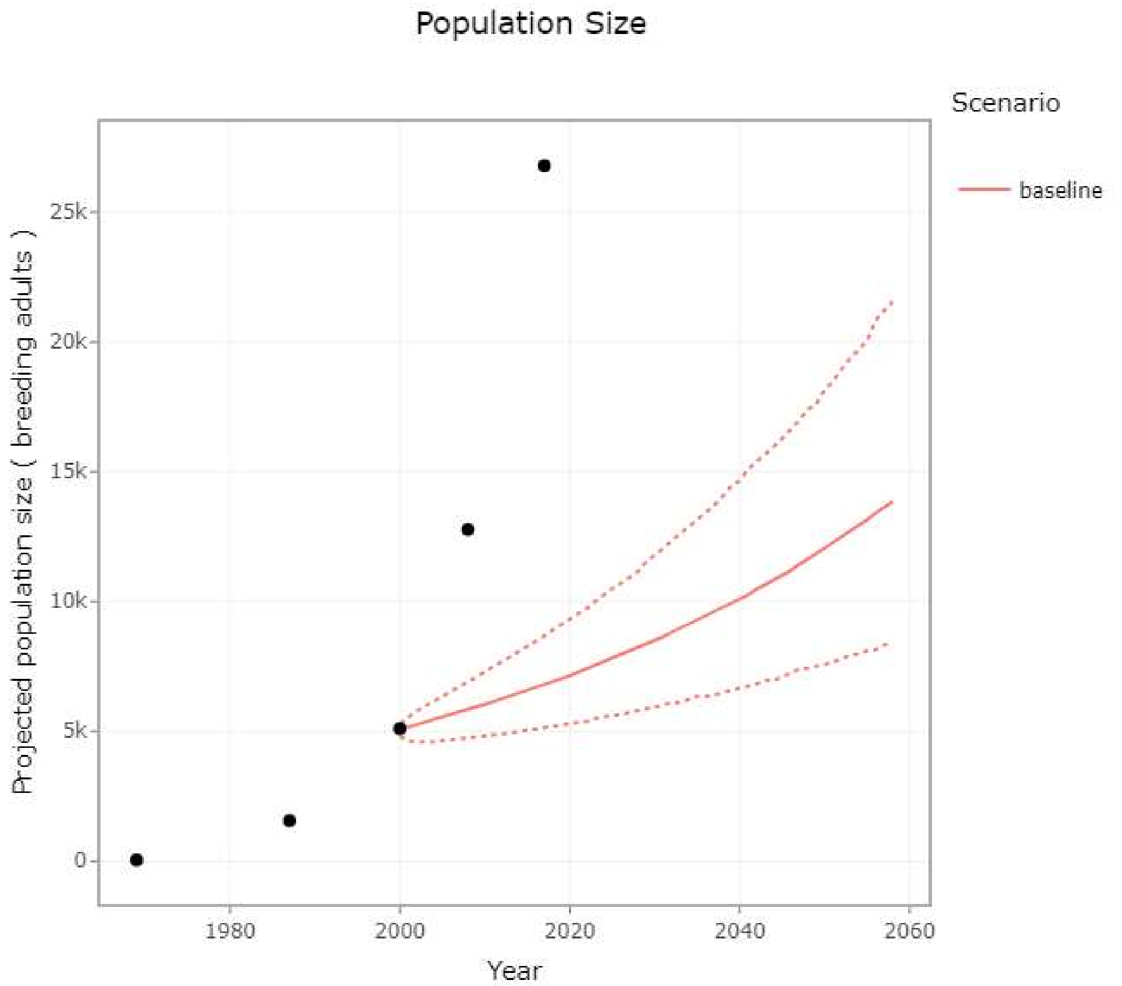

Figure 26: FFC SPA gannet baseline PVA model validation.

3.4.3 Kittiwake Validation Results

3.4.3.1 As presented in **Figure 27**, the baseline population trend produced from the PVA model when using the preformulated demographic rates and a productivity rate of 0.580 results in a negative population decline, whereas with the exception of the outlier count from 1987 then overall the colony shows a positive growth trend.

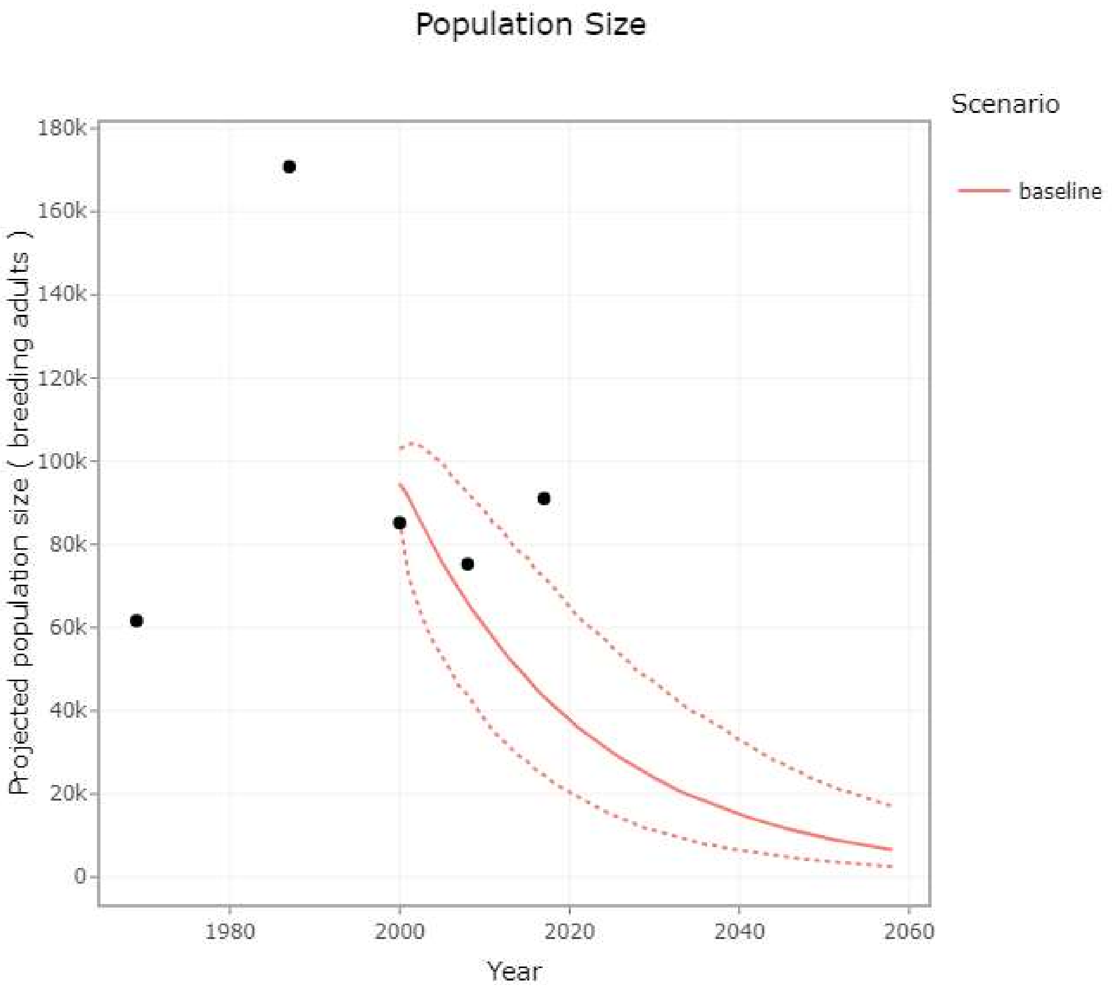

Figure 27: FFC SPA kittiwake baseline PVA model validation.

3.4.3.2 As detailed in Part 1 (**Section 2.6**), one cause for the poor correlation between the baseline and actual colony trend could be due to the productivity rate used within the model being unrepresentative. As suggested by Coulson (2017) for a kittiwake colony to remain stable a minimum productivity rate of 0.800 is required, similarly as defined in Horswill & Robinson (2015) the productivity rate for the East of the UK is defined as 0.819, reinforcing the possibility that a value of 0.580 is not representative of the FFC SPA. A second model validation was therefore run using a productivity rate of 0.800, with the model output presented in Figure 28. When using a productivity rate of 0.800 the baseline shows a positive growth trend, which aligns with the observed FFC SPA colony growth exhibited.

3.4.3.3 The Applicant therefore considers that when undertaking PVA analysis for kittiwake from the FFC SPA, models should be set up using a productivity rate of 0.800 instead of 0.580.

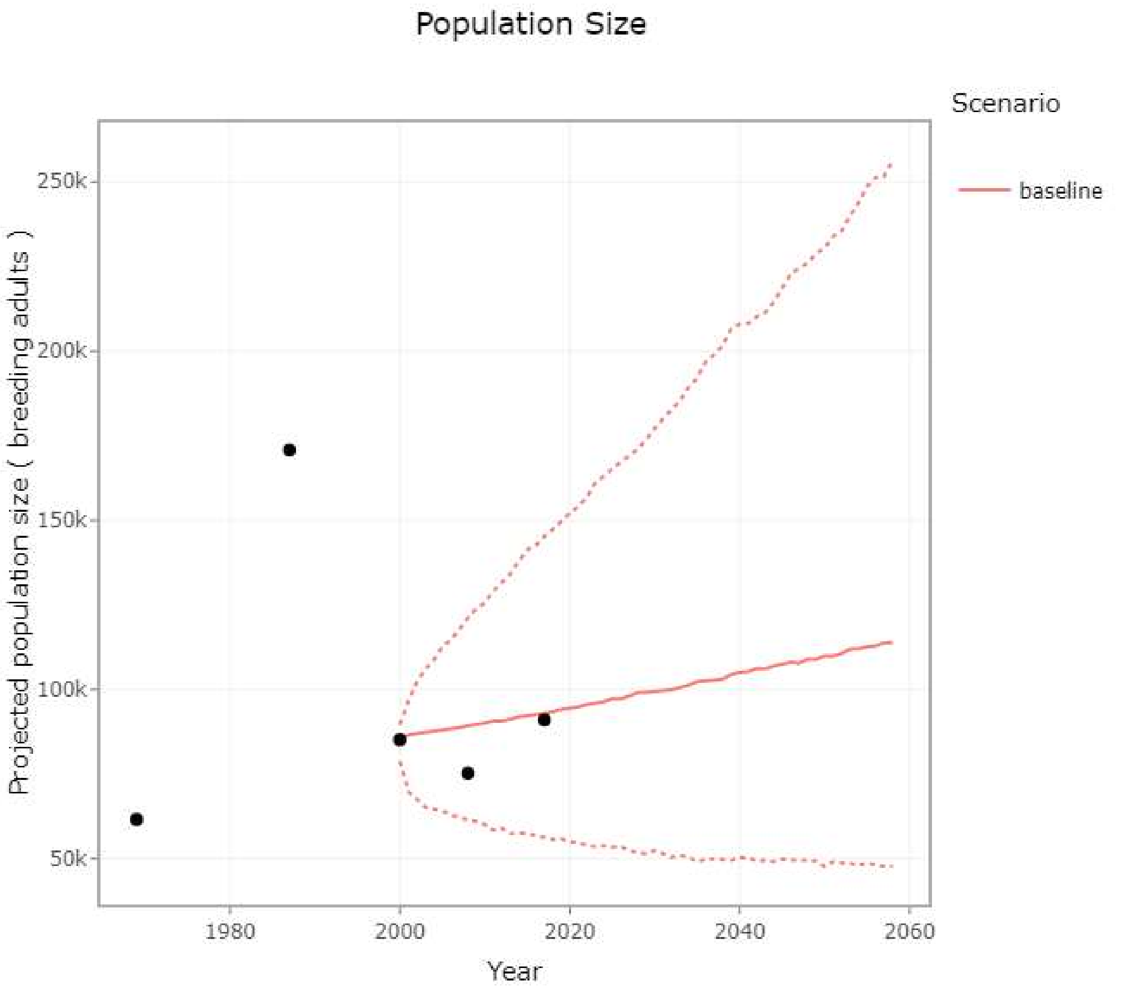

Figure 28: FFC SPA kittiwake baseline PVA model validation, incorporating a productivity rate of 0.8.

3.4.4 Guillemot Validation Results

3.4.4.1 As presented in Figure 29, the baseline population trend produced from the model matches closely with the actual exhibited colony growth trend. Therefore, the demographic rates used for guillemot (productivity rate per pair 0.716 and adult survival rate of 0.94) can be considered appropriate for analysis.

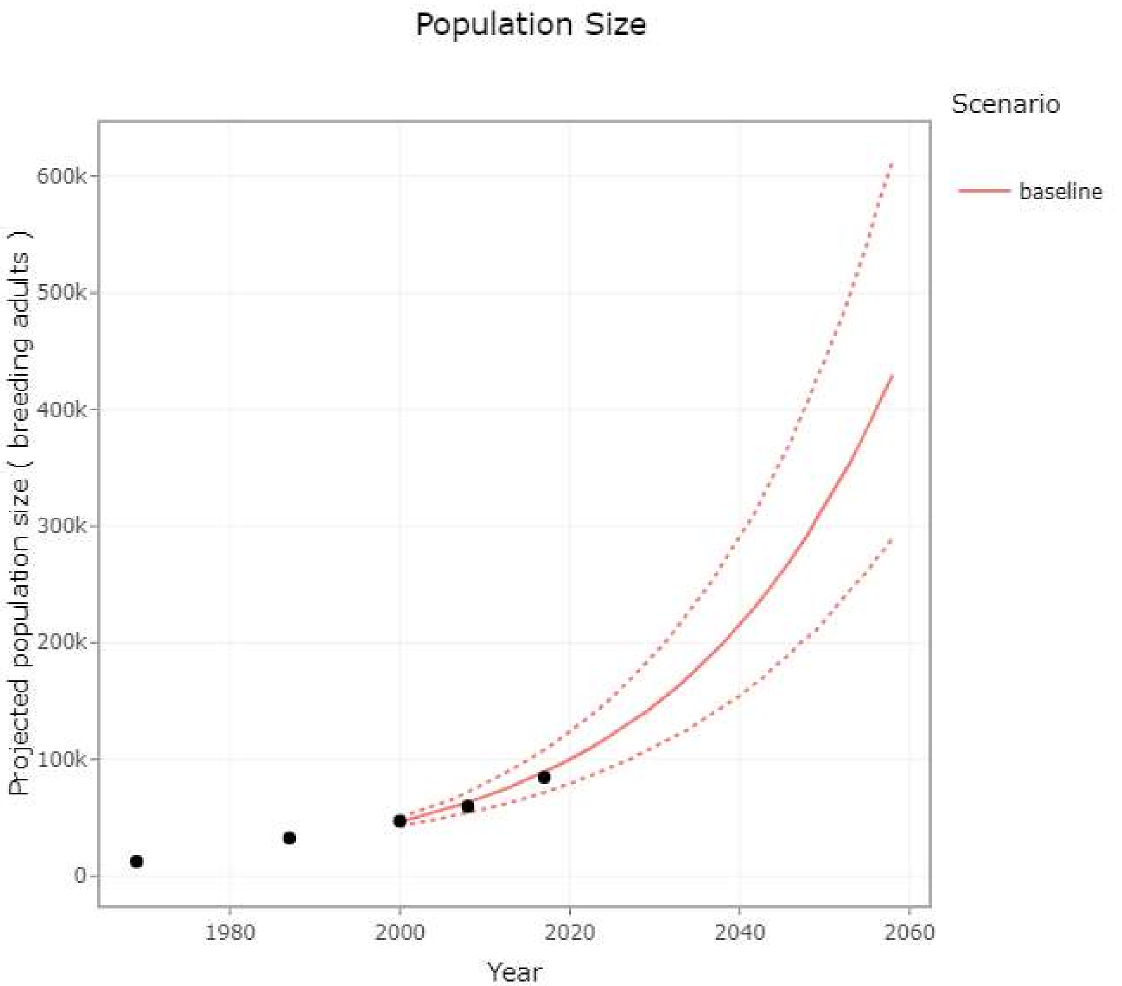

Figure 29: FFC SPA guillemot baseline PVA model validation.

3.4.5 Razorbill Validation Results

3.4.5.1 As presented in **Figure 30**, the baseline population trend produced from the PVA model when using the preformulated demographic rates, including productivity rate per pair of 0.641 results in a negative population decline. This is in contrast to observed counts where the colony trend shows a significant positive growth trend over a prolonged period of time at the FFC SPA colony (compound growth rate of +7.78% per annum between 2000 – 2017).

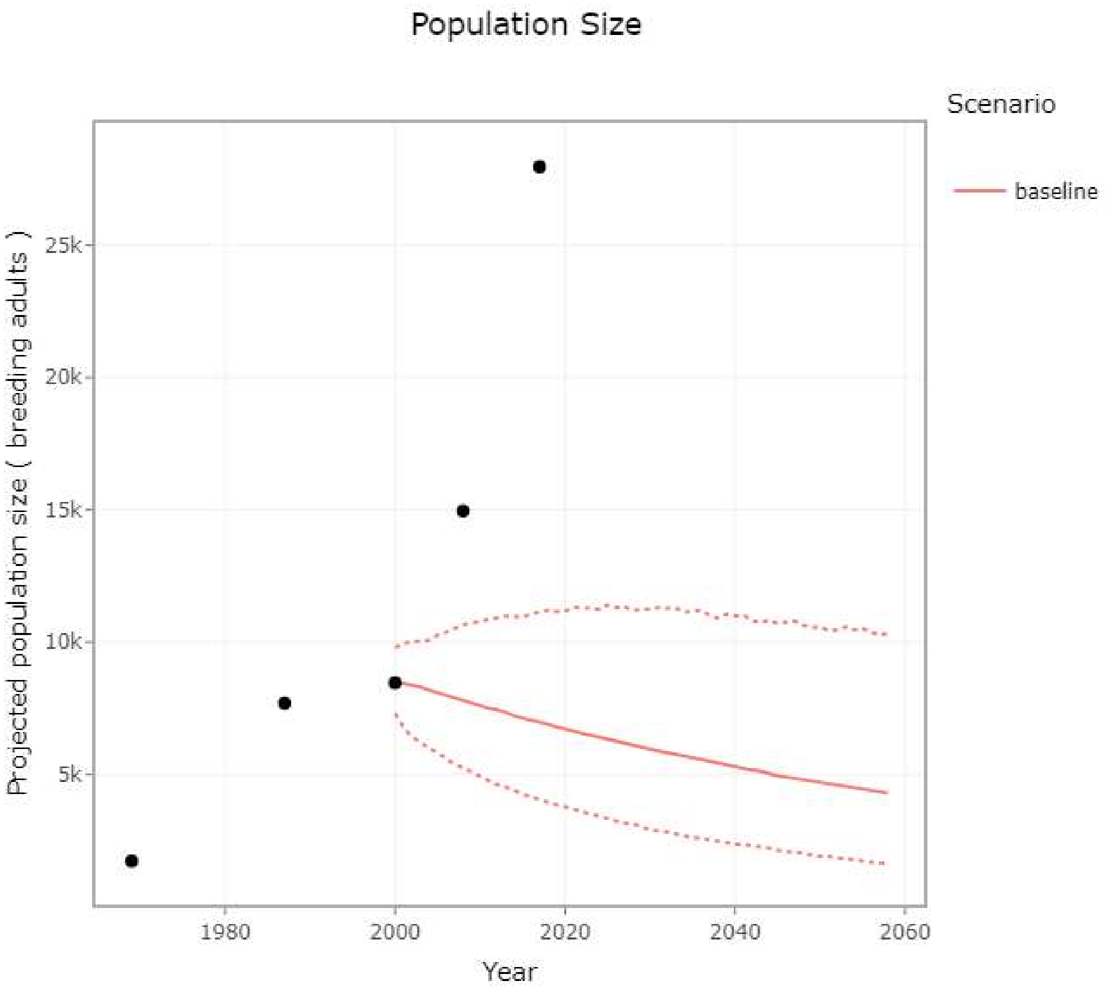

Figure 30: FFC SPA razorbill baseline PVA model validation.

3.4.5.2 The productivity rate used within a revised PVA model of 0.641 is higher than the national average productivity rate of 0.570 as derived by Horswill & Robinson (2015) and is of a similar value to that of the mid and south UK regional rates. This suggests that the productivity rate used is likely representative of the FFC SPA colony that has been increasing over the last 20 years. As detailed within Horswill & Robinson (2015), the juvenile survival rates for razorbill have a score of 2 (out of 6 for representation), suggesting that the poor correlation exhibited in Figure 30 could be due to the survival rates not being representative. A second model validation was, therefore, run using the survival rates cited for guillemot due to the two species having similar population dynamic and ecological traits, but guillemots having improved data representation, with the model output presented in Figure 31. When using guillemot survival rates the baseline population trend produced from the model now correlates closer to the actual exhibited FFC SPA colony growth trend.

3.4.5.3 The Applicant, therefore, considers that when undertaking PVA analysis for razorbill from the FFC SPA models should be set up using both razorbill survival rates and a second analysis substituted with guillemot survival rates.

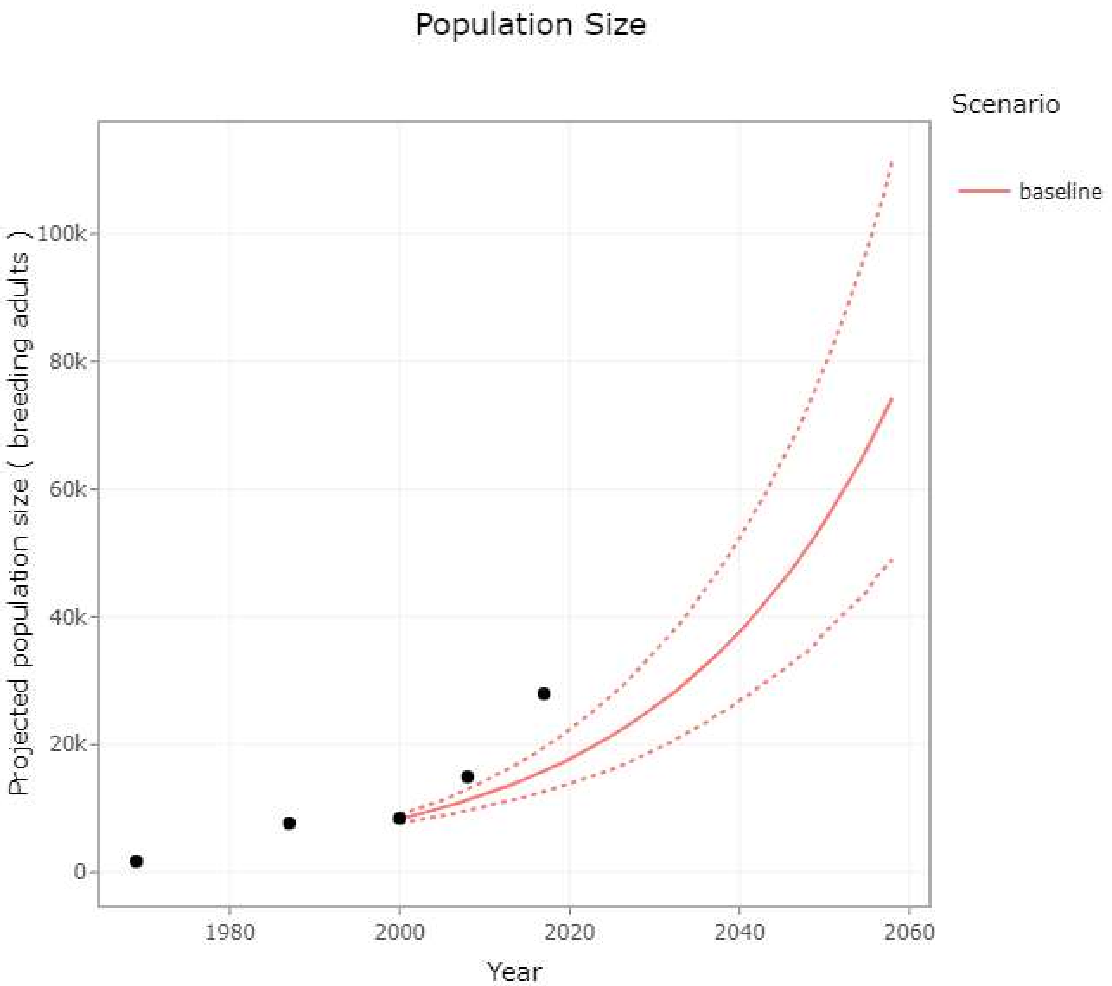

Figure 31: FFC SPA razorbill baseline PVA model validation using guillemot survival rates.

3.4.6 EIA Level Revised Population Viability Analysis Results (PVA)

3.4.6.1 The results of the revised PVA for EIA level impacts against relevant BDMPS and UK biogeographic populations are presented within this section of the report. For all species, a range of generic impact values have been assessed to ensure the applicability of results should there be any future subsequent changes in impact levels for the project alone and cumulatively. For all results model logs are presented in **Appendix C** which details the demographic rates and model scenarios analysed.

Table 30: Gannet UK North Sea and English Channel BDMPS population modelling results.

UK North Sea and English Channel BDMPS			
Increase in mortality (per annum)	Total mortality (per annum)	Density independent counterfactual of growth rate (after 35 years)	Reduction in Growth Rate (per annum)
5	85,333	1.000	0.00%
10	85,338	1.000	0.00%
15	85,343	1.000	0.00%
20	85,348	1.000	0.01%
30	85,358	1.000	0.01%
40	85,368	1.000	0.01%
50	85,378	1.000	0.01%
100	85,428	1.000	0.03%
125	85,453	1.000	0.03%
3,000	88,328	0.992	0.78%
3,100	88,428	0.992	0.80%
3,200	88,528	0.992	0.83%
3,300	88,628	0.991	0.86%
3,400	88,728	0.991	0.88%
3,500	88,828	0.991	0.91%
3,600	88,928	0.991	0.93%
3,700	89,028	0.990	0.96%
3,800	89,128	0.990	0.99%
3,900	89,228	0.990	1.01%
4,000	89,328	0.990	1.04%
5,000	90,328	0.987	1.30%
6,000	91,328	0.984	1.56%
7,000	92,328	0.982	1.82%
8,000	93,328	0.979	2.07%

Table 31: Gannet UK Biogeographic population modelling results.

UK Biogeographic Population			
Increase in mortality (per annum)	Total mortality (per annum)	Density independent counterfactual of growth rate (after 35 years)	Reduction in Growth Rate (per annum)
5	220,665	1.000	0.00%
10	220,670	1.000	0.00%
15	220,675	1.000	0.00%
20	220,680	1.000	0.00%
30	220,690	1.000	0.00%
40	220,700	1.000	0.00%
50	220,710	1.000	0.00%
100	220,760	1.000	0.01%
125	220,785	1.000	0.01%
3,000	223,660	0.997	0.30%
3,100	223,760	0.997	0.31%
3,200	223,860	0.997	0.32%
3,300	223,960	0.997	0.33%
3,400	224,060	0.997	0.34%
3,500	224,160	0.996	0.35%
3,600	224,260	0.996	0.36%
3,700	224,360	0.996	0.37%
3,800	224,460	0.996	0.38%
3,900	224,560	0.996	0.39%
4,000	224,660	0.996	0.40%
5,000	225,660	0.995	0.50%
6,000	226,660	0.994	0.60%
7,000	227,660	0.993	0.70%
8,000	228,660	0.992	0.80%

Table 32: Kittiwake UK North Sea BDMPS population modelling results.

UK North Sea BDMPS			
Increase in mortality (per annum)	Total mortality (per annum)	Density independent counterfactual of growth rate (after 35 years)	Reduction in Growth Rate (per annum)
50	193,063	1.000	0.01%
75	193,088	1.000	0.01%
100	193,113	1.000	0.01%
125	193,138	1.000	0.01%
150	193,163	1.000	0.02%
175	193,188	1.000	0.02%
200	193,213	1.000	0.02%
225	193,238	1.000	0.02%
3,500	196,513	0.996	0.35%
3,600	196,613	0.996	0.36%
3,700	196,713	0.996	0.37%
3,800	196,813	0.996	0.39%
3,900	196,913	0.996	0.39%
4,000	197,013	0.996	0.41%
4,100	197,113	0.996	0.42%
4,200	197,213	0.996	0.43%
4,300	197,313	0.996	0.44%
4,400	197,413	0.996	0.45%
4,500	197,513	0.995	0.46%

Table 33: Kittiwake UK Biogeographic population modelling results.

UK Biogeographic Population			
Increase in mortality (per annum)	Total mortality (per annum)	Density independent counterfactual of growth rate (after 35 years)	Reduction in Growth Rate (per annum)
50	795,650	1.000	0.00%
75	795,675	1.000	0.00%
100	795,700	1.000	0.00%
125	795,725	1.000	0.00%
150	795,750	1.000	0.00%
175	795,775	1.000	0.00%
200	795,800	1.000	0.01%
225	795,825	1.000	0.01%
3,500	799,100	0.999	0.09%
3,600	799,200	0.999	0.09%
3,700	799,300	0.999	0.09%
3,800	799,400	0.999	0.09%
3,900	799,500	0.999	0.10%
4,000	799,600	0.999	0.10%
4,100	799,700	0.999	0.10%
4,200	799,800	0.999	0.10%
4,300	799,900	0.999	0.11%
4,400	800,000	0.999	0.11%
4,500	800,100	0.999	0.11%

Table 34: Great black-backed gull UK North Sea BDMPS population modelling results.

UK North Sea BDMPS			
Increase in mortality (per annum)	Total mortality (per annum)	Density independent counterfactual of growth rate (after 35 years)	Reduction in Growth Rate (per annum)
5	14,629	1.000	0.01%
10	14,634	1.000	0.01%
15	14,639	1.000	0.02%
20	14,644	1.000	0.03%
30	14,654	1.000	0.04%
40	14,664	0.999	0.05%
50	14,674	0.999	0.07%
75	14,699	0.999	0.10%
100	14,724	0.999	0.13%
900	15,524	0.988	1.19%
925	15,549	0.988	1.22%
950	15,574	0.987	1.25%
975	15,599	0.987	1.29%
1,000	15,624	0.987	1.32%
1,025	15,649	0.986	1.35%
1,050	15,674	0.986	1.38%
1,075	15,699	0.986	1.42%
1,100	15,724	0.986	1.45%
1,150	15,774	0.985	1.52%
1,200	15,824	0.984	1.58%

Table 35: Great black-backed gull UK Biogeographic population modelling results.

UK Biogeographic Population			
Increase in mortality (per annum)	Total mortality (per annum)	Density independent counterfactual of growth rate (after 35 years)	Reduction in Growth Rate (per annum)
5	37,605	1.000	0.00%
10	37,610	1.000	0.01%
15	37,615	1.000	0.01%
20	37,620	1.000	0.01%
30	37,630	1.000	0.02%
40	37,640	1.000	0.02%
50	37,650	1.000	0.03%
75	37,675	1.000	0.04%
100	37,700	0.999	0.05%
900	38,500	0.995	0.46%
925	38,525	0.995	0.47%
950	38,550	0.995	0.49%
975	38,575	0.995	0.50%
1,000	38,600	0.995	0.51%
1,025	38,625	0.995	0.53%
1,050	38,650	0.995	0.54%
1,075	38,675	0.994	0.55%
1,100	38,700	0.994	0.56%
1,150	38,750	0.994	0.59%
1,200	38,800	0.994	0.62%

Table 36: Guillemot UK North Sea and English Channel BDMPS population modelling results.

UK North Sea and English Channel BDMPS			
Increase in mortality (per annum)	Total mortality (per annum)	Density independent counterfactual of growth rate (after 35 years)	Reduction in Growth Rate (per annum)
75	295,290	1.000	0.00%
100	295,315	1.000	0.01%
125	295,340	1.000	0.01%
150	295,365	1.000	0.01%
175	295,390	1.000	0.01%
200	295,415	1.000	0.01%
225	295,440	1.000	0.01%
250	295,465	1.000	0.01%
300	295,515	1.000	0.02%
350	295,565	1.000	0.02%
400	295,615	1.000	0.02%
450	295,665	1.000	0.02%
550	295,765	1.000	0.03%
600	295,815	1.000	0.03%
650	295,865	1.000	0.03%
1,000	296,215	0.999	0.05%
1,500	296,715	0.999	0.08%
2,000	297,215	0.999	0.11%
2,500	297,715	0.999	0.13%
3,000	298,215	0.998	0.16%
3,500	298,715	0.998	0.18%
4,000	299,215	0.998	0.21%
4,500	299,715	0.998	0.24%
5,000	300,215	0.997	0.26%
5,500	300,715	0.997	0.29%
7,500	302,715	0.996	0.39%
10,000	305,215	0.995	0.53%
15,000	310,215	0.992	0.79%
20,000	315,215	0.989	1.05%
30,000	325,215	0.984	1.58%

Table 37: Guillemot UK Biogeographic population modelling results.

UK Biogeographic Population			
Increase in mortality (per annum)	Total mortality (per annum)	Density independent counterfactual of growth rate (after 35 years)	Reduction in Growth Rate (per annum)
75	569,325	1.000	0.00%
100	569,350	1.000	0.00%
125	569,375	1.000	0.00%
150	569,400	1.000	0.00%
175	569,425	1.000	0.00%
200	569,450	1.000	0.01%
225	569,475	1.000	0.01%
250	569,500	1.000	0.01%
300	569,550	1.000	0.01%
350	569,600	1.000	0.01%
400	569,650	1.000	0.01%
450	569,700	1.000	0.01%
550	569,800	1.000	0.02%
600	569,850	1.000	0.02%
650	569,900	1.000	0.02%
1,000	570,250	1.000	0.03%
1,500	570,750	1.000	0.04%
2,000	571,250	0.999	0.05%
2,500	571,750	0.999	0.07%
3,000	572,250	0.999	0.08%
3,500	572,750	0.999	0.10%
4,000	573,250	0.999	0.11%
4,500	573,750	0.999	0.12%
5,000	574,250	0.999	0.14%
5,500	574,750	0.999	0.15%
7,500	576,750	0.998	0.20%
10,000	579,250	0.997	0.27%
15,000	584,250	0.996	0.41%
20,000	589,250	0.995	0.55%
30,000	599,250	0.992	0.82%

Table 38: Razorbill UK North Sea and English Channel BDMPS population modelling results.

UK North Sea and English Channel BDMPS			
Increase in mortality (per annum)	Total mortality (per annum)	Density independent counterfactual of growth rate (after 35 years)	Reduction in Growth Rate (per annum)
5	114,237	1.000	0.00%
25	114,257	1.000	0.00%
50	114,282	1.000	0.01%
75	114,307	1.000	0.01%
100	114,332	1.000	0.02%
150	114,382	1.000	0.03%
400	114,632	0.999	0.08%
500	114,732	0.999	0.10%
600	114,832	0.999	0.12%
700	114,932	0.999	0.14%
800	115,032	0.998	0.16%
900	115,132	0.998	0.18%
1,000	115,232	0.998	0.20%
1,250	115,482	0.998	0.25%
1,500	115,732	0.997	0.30%
1,750	115,982	0.997	0.35%
2,000	116,232	0.996	0.40%
3,000	117,232	0.994	0.60%
4,000	118,232	0.992	0.80%
5,000	119,232	0.990	1.00%
6,000	120,232	0.988	1.20%
7,000	121,232	0.986	1.40%
8,000	122,232	0.984	1.60%
9,000	123,232	0.982	1.80%
10,000	124,232	0.980	2.00%

Table 39: Razorbill UK Biogeographic population modelling results.

UK Biogeographic Population			
Increase in mortality (per annum)	Total mortality (per annum)	Density independent counterfactual of growth rate (after 35 years)	Reduction in Growth Rate (per annum)
5	329,456	1.000	0.00%
25	329,476	1.000	0.00%
50	329,501	1.000	0.00%
75	329,526	1.000	0.01%
100	329,551	1.000	0.01%
150	329,601	1.000	0.01%
400	329,851	1.000	0.03%
500	329,951	1.000	0.03%
600	330,051	1.000	0.04%
700	330,151	1.000	0.05%
800	330,251	0.999	0.06%
900	330,351	0.999	0.06%
1,000	330,451	0.999	0.07%
1,250	330,701	0.999	0.09%
1,500	330,951	0.999	0.10%
1,750	331,201	0.999	0.12%
2,000	331,451	0.999	0.14%
3,000	332,451	0.998	0.21%
4,000	333,451	0.997	0.28%
5,000	334,451	0.997	0.35%
6,000	335,451	0.996	0.42%
7,000	336,451	0.995	0.48%
8,000	337,451	0.994	0.55%
9,000	338,451	0.994	0.62%
10,000	339,451	0.993	0.69%

Table 40: Puffin UK North Sea and English Channel BDMPS population modelling results.

UK North Sea and English Channel BDMPS			
Increase in mortality (per annum)	Total mortality (per annum)	Density independent counterfactual of growth rate (after 35 years)	Reduction in Growth Rate (per annum)
5	164,257	1.000	0.00%
10	164,262	1.000	0.00%
15	164,267	1.000	0.00%
20	164,272	1.000	0.00%
100	164,352	1.000	0.01%
125	164,377	1.000	0.02%
150	164,402	1.000	0.02%
175	164,427	1.000	0.02%
200	164,452	1.000	0.03%
225	164,477	1.000	0.03%
250	164,502	1.000	0.03%
275	164,527	1.000	0.03%
300	164,552	1.000	0.04%
350	164,602	1.000	0.04%
400	164,652	0.999	0.05%
450	164,702	0.999	0.06%
500	164,752	0.999	0.06%
600	164,852	0.999	0.08%
700	164,952	0.999	0.09%
800	165,052	0.999	0.10%
900	165,152	0.999	0.11%
1,000	165,252	0.999	0.13%
1,500	165,752	0.998	0.19%
2,000	166,252	0.997	0.25%
2,500	166,752	0.997	0.31%
3,000	167,252	0.996	0.38%
3,500	167,752	0.996	0.44%

Table 41: Puffin UK Biogeographic population modelling results.

UK Biogeographic Population			
Increase in mortality (per annum)	Total mortality (per annum)	Density independent counterfactual of growth rate (after 35 years)	Reduction in Growth Rate (per annum)
5	2,072,005	1.000	0.00%
10	2,072,010	1.000	0.00%
15	2,072,015	1.000	0.00%
20	2,072,020	1.000	0.00%
100	2,072,100	1.000	0.00%
125	2,072,125	1.000	0.00%
150	2,072,150	1.000	0.00%
175	2,072,175	1.000	0.00%
200	2,072,200	1.000	0.00%
225	2,072,225	1.000	0.00%
250	2,072,250	1.000	0.00%
275	2,072,275	1.000	0.00%
300	2,072,300	1.000	0.00%
350	2,072,350	1.000	0.00%
400	2,072,400	1.000	0.00%
450	2,072,450	1.000	0.00%
500	2,072,500	1.000	0.01%
600	2,072,600	1.000	0.01%
700	2,072,700	1.000	0.01%
800	2,072,800	1.000	0.01%
900	2,072,900	1.000	0.01%
1,000	2,073,000	1.000	0.01%
1,500	2,073,500	1.000	0.02%
2,000	2,074,000	1.000	0.02%
2,500	2,074,500	1.000	0.03%
3,000	2,075,000	1.000	0.03%
3,500	2,075,500	1.000	0.04%

3.4.7 FFC SPA Revised Population Viability Analysis Results (PVA)

3.4.7.1 The results of the revised PVA for FFC SPA potential impacts are presented within this section of the report. For all qualifying features, a range of generic impact values have been assessed to ensure the applicability of results should there be any future subsequent changes in impact levels for the project alone and in-combination. For all results model logs are presented in **Appendix D** which details the demographic rates and model scenarios analysed.

Table 42: Gannet FFC SPA population modelling results.

FFC SPA			
Increase in mortality (per annum)	Total mortality (per annum)	Density independent counterfactual of growth rate (after 35 years)	Reduction in Growth Rate (per annum)
5	2,175	1.000	0.02%
10	2,180	1.000	0.04%
15	2,185	0.999	0.07%
20	2,190	0.999	0.09%
30	2,200	0.999	0.13%
40	2,210	0.998	0.18%
50	2,220	0.998	0.22%
75	2,245	0.997	0.33%
100	2,270	0.996	0.44%
125	2,295	0.994	0.55%
150	2,320	0.993	0.66%
175	2,345	0.992	0.77%
200	2,370	0.991	0.88%
225	2,395	0.990	0.99%
250	2,420	0.989	1.10%
275	2,445	0.988	1.21%
300	2,470	0.987	1.33%
325	2,495	0.986	1.43%
350	2,520	0.985	1.55%
375	2,545	0.983	1.65%
400	2,570	0.982	1.77%
425	2,595	0.981	1.88%
450	2,620	0.980	1.99%
475	2,645	0.979	2.10%
500	2,670	0.978	2.21%
600	2,770	0.974	2.65%
700	2,870	0.969	3.09%
800	2,970	0.965	3.53%
900	3,070	0.960	3.97%
1,000	3,170	0.956	4.41%

Table 43: Kittiwake FFC SPA population modelling results.

FFC SPA			
Increase in mortality (per annum)	Total mortality (per annum)	Density independent counterfactual of growth rate (after 35 years)	Reduction in Growth Rate (per annum)
5	15,053	1.000	0.01%
10	15,058	1.000	0.01%
15	15,063	1.000	0.02%
20	15,068	1.000	0.02%
30	15,078	1.000	0.04%
40	15,088	1.000	0.05%
50	15,098	0.999	0.06%
75	15,123	0.999	0.09%
100	15,148	0.999	0.12%
125	15,173	0.998	0.15%
150	15,198	0.998	0.18%
175	15,223	0.998	0.21%
200	15,248	0.998	0.24%
225	15,273	0.997	0.27%
250	15,298	0.997	0.30%
275	15,323	0.997	0.33%
300	15,348	0.996	0.36%
325	15,373	0.996	0.39%
350	15,398	0.996	0.42%
375	15,423	0.996	0.45%
400	15,448	0.995	0.48%
425	15,473	0.995	0.51%
450	15,498	0.995	0.54%
475	15,523	0.994	0.57%
500	15,548	0.994	0.60%

Table 44: Kittiwake FFC SPA population modelling results using a productivity rate of 0.8.

FFC SPA			
Increase in mortality (per annum)	Total mortality (per annum)	Density independent counterfactual of growth rate (after 35 years)	Reduction in Growth Rate (per annum)
5	15,053	1.000	0.01%
10	15,058	1.000	0.01%
15	15,063	1.000	0.02%
20	15,068	1.000	0.02%
30	15,078	1.000	0.04%
40	15,088	1.000	0.05%
50	15,098	0.999	0.06%
75	15,123	0.999	0.09%
100	15,148	0.999	0.12%
125	15,173	0.998	0.15%
150	15,198	0.998	0.18%
175	15,223	0.998	0.21%
200	15,248	0.998	0.24%
225	15,273	0.997	0.27%
250	15,298	0.997	0.30%
275	15,323	0.997	0.33%
300	15,348	0.996	0.36%
325	15,373	0.996	0.40%
350	15,398	0.996	0.43%
375	15,423	0.995	0.46%
400	15,448	0.995	0.49%
425	15,473	0.995	0.52%
450	15,498	0.995	0.55%
475	15,523	0.994	0.58%
500	15,548	0.994	0.61%

Table 45: Guillemot FFC SPA population modelling results.

FFC SPA			
Increase in mortality (per annum)	Total mortality (per annum)	Density independent counterfactual of growth rate (after 35 years)	Reduction in Growth Rate (per annum)
10	7,437	1.000	0.01%
15	7,442	1.000	0.01%
20	7,447	1.000	0.02%
30	7,457	1.000	0.03%
40	7,467	1.000	0.04%
50	7,477	1.000	0.05%
75	7,502	0.999	0.07%
100	7,527	0.999	0.09%
125	7,552	0.999	0.11%
150	7,577	0.999	0.14%
175	7,602	0.998	0.16%
200	7,627	0.998	0.18%
225	7,652	0.998	0.21%
250	7,677	0.998	0.23%
275	7,702	0.997	0.25%
300	7,727	0.997	0.28%
325	7,752	0.997	0.30%
350	7,777	0.997	0.32%
375	7,802	0.997	0.34%
400	7,827	0.996	0.37%
425	7,852	0.996	0.39%
450	7,877	0.996	0.41%
475	7,902	0.996	0.44%
500	7,927	0.995	0.46%
750	8,177	0.993	0.69%
1,000	8,427	0.991	0.92%
1,250	8,677	0.989	1.15%
1,500	8,927	0.986	1.38%
1,750	9,177	0.984	1.61%
2,000	9,427	0.982	1.84%
2,250	9,677	0.979	2.07%
2,500	9,927	0.977	2.30%
2,750	10,177	0.975	2.53%
3,000	10,427	0.972	2.76%
3,250	10,677	0.970	2.99%
3,500	10,927	0.968	3.22%
4,000	11,427	0.963	3.68%
4,500	11,927	0.959	4.14%
5,000	12,427	0.954	4.60%

Table 46: Razorbill FFC SPA population modelling results.

FFC SPA			
Increase in mortality (per annum)	Total mortality (per annum)	Density independent counterfactual of growth rate (after 35 years)	Reduction in Growth Rate (per annum)
5	4,258	1.000	0.01%
10	4,263	1.000	0.03%
15	4,268	1.000	0.04%
20	4,273	0.999	0.06%
30	4,283	0.999	0.09%
40	4,293	0.999	0.12%
50	4,303	0.999	0.15%
75	4,328	0.998	0.22%
100	4,353	0.997	0.29%
125	4,378	0.996	0.37%
150	4,403	0.996	0.44%
175	4,428	0.995	0.51%
200	4,453	0.994	0.58%
225	4,478	0.993	0.66%
250	4,503	0.993	0.73%
275	4,528	0.992	0.80%
300	4,553	0.991	0.87%
325	4,578	0.991	0.95%
350	4,603	0.990	1.02%
375	4,628	0.989	1.09%
400	4,653	0.988	1.17%
425	4,678	0.988	1.24%
450	4,703	0.987	1.31%
475	4,728	0.986	1.38%
500	4,753	0.985	1.46%
550	4,803	0.984	1.60%
600	4,853	0.983	1.75%
650	4,903	0.981	1.89%
700	4,953	0.980	2.04%
750	5,003	0.978	2.19%

Table 47: Razorbill FFC SPA population modelling results using guillemot survival rate demographics.

FFC SPA			
Increase in mortality (per annum)	Total mortality (per annum)	Density independent counterfactual of growth rate (after 35 years)	Reduction in Growth Rate (per annum)
5	4,258	1.000	0.01%
10	4,263	1.000	0.03%
15	4,268	1.000	0.04%
20	4,273	0.999	0.05%
30	4,283	0.999	0.08%
40	4,293	0.999	0.11%
50	4,303	0.999	0.14%
75	4,328	0.998	0.21%
100	4,353	0.997	0.28%
125	4,378	0.997	0.35%
150	4,403	0.996	0.42%
175	4,428	0.995	0.49%
200	4,453	0.994	0.55%
225	4,478	0.994	0.62%
250	4,503	0.993	0.69%
275	4,528	0.992	0.76%
300	4,553	0.992	0.83%
325	4,578	0.991	0.90%
350	4,603	0.990	0.97%
375	4,628	0.990	1.04%
400	4,653	0.989	1.11%
425	4,678	0.988	1.18%
450	4,703	0.988	1.25%
475	4,728	0.987	1.32%
500	4,753	0.986	1.39%
550	4,803	0.985	1.53%
600	4,853	0.983	1.66%
650	4,903	0.982	1.80%
700	4,953	0.981	1.94%
750	5,003	0.979	2.08%

Table 48: Puffin FFC SPA population modelling results.

FFC SPA			
Increase in mortality (per annum)	Total mortality (per annum)	Density independent counterfactual of growth rate (after 35 years)	Reduction in Growth Rate (per annum)
1	323	1.000	0.03%
3	325	0.999	0.10%
5	327	0.998	0.17%
7	329	0.998	0.23%
10	332	0.997	0.33%
15	337	0.995	0.49%
20	342	0.993	0.66%
25	347	0.992	0.82%
30	352	0.990	0.99%
35	357	0.988	1.15%
40	362	0.987	1.32%
45	367	0.985	1.48%
50	372	0.984	1.64%
55	377	0.982	1.81%
60	382	0.980	1.97%
65	387	0.979	2.14%
70	392	0.977	2.31%
75	397	0.975	2.47%
80	402	0.974	2.63%
85	407	0.972	2.80%

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Vanermen, N., Courtens, W., Van De Walle, M., Verstraete, H., & Stienen, E. (2019). Seabird monitoring at the Thornton Bank offshore wind farm: Final displacement results after 6 years of post-construction monitoring and an explorative Bayesian analysis of common guillemot displacement using INLA. In Environmental impacts of offshore wind farms in the Belgian part of the North Sea: Marking a decade of monitoring, research and innovation (pp. 85-116).

Appendix A Calculation of BDMPS breeding season population for common guillemot and Atlantic puffin

4.1.1.1 In response to Natural England's Relevant Reps detailed comment (Volume A2, Chapter 5: Offshore & Intertidal Ornithology. Point 3 Table 5.14 and 5.7.4.4 - 5.7.4.9), the Applicant has responded with a request for clarification:

RR-029-APDX:B-3

4.1.1.2 "The Applicant also acknowledges that Natural England have provided their advocated largest BDMPS values, though it is unclear how guillemot and puffin have been calculated and what sources were used to define these values, as they are not aligned with other recently consented projects values for the same species as agreed with Natural England. The Applicant is currently seeking out clarification on the methods employed and the values provided by Natural England on how they have calculated their largest BDMPS values for guillemot and puffin (Clarification will be provided in Deadline 2)."

4.1.1.3 In the case of guillemot and puffin the breeding season BDMPS populations are larger than the non-breeding season estimates presented in Furness (2015), and Natural England therefore advise that these are used in the EIA assessment. This was first raised with the Applicant during our written advice on the draft ES, associated annexes, and RIAA documents provided 21 June 2021. Natural England note that the values advised in the Relevant Reps have also previously been provided for the EA1N/EA2 (REP11-027) and Hornsea Project Two (REP6-017) projects. Natural England also note that these populations are larger than those proposed by the Applicant, resulting in a larger 1% natural mortality threshold for EIA.

Calculation of breeding season BDMPS population

4.1.1.4 Natural England can confirm that the breeding season BDMPS populations were calculated using the data in Appendix A of Furness (2015). The numbers of breeding adults and immatures from each individual SPA populations or non-SPA colony with a foraging range within the respective BDMPS region were summed to generate a total breeding population.

4.1.1.5 For guillemot the values presented in Appendix A: Table 62 were used to generate a population estimate of 2,045,078. For puffin the values from Appendix A: Table 68 were used to generate a population estimate of 868,689.

Appendix B PVA Model logs for FFC SPA Validation Test

FFC SPA gannet PVA validation log

Set up

The log file was created on: 2022-06-08 09:50:41 using Tool version 2, with R version 3.5.1, PVA package version: 4.18 (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: validation.
Model to use for environmental stochasticity: betagamma.
Model for density dependence: nodd.
Include demographic stochasticity in model?: Yes.
Number of simulations: 5000.
Random seed: 3542.
Years for burn-in: 10.
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 5104 in 2000
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: 0.

Output:
First year to include in outputs: NA
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

Validation data
42 in 1969
1560 in 1987
5104 in 2000
12772 in 2008
26784 in 2017

FFC SPA kittiwake PVA validation log

Set up
The log file was created on: 2022-06-08 10:14:10 using Tool version 2, with R version 3.5.1, PVA package version: 4.18 (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: validation.
Model to use for environmental stochasticity: betagamma.
Model for density dependence: nodd.
Include demographic stochasticity in model?: Yes.
Number of simulations: 5000.
Random seed: 3542.
Years for burn-in: 10.
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 85164 in 2000
Productivity rate per pair: mean: 0.58 , sd: 0.096
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: 0.

Output:
First year to include in outputs: NA
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

Validation data
61594 in 1969
170790 in 1987
85164 in 2000
75234 in 2008
91008 in 2017

FFC SPA kittiwake PVA validation log (variation in productivity rate to 0.8)

Set up
The log file was created on: 2022-06-08 10:30:26 using Tool version 2, with R version 3.5.1, PVA package version: 4.18 (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: validation.
Model to use for environmental stochasticity: betagamma.
Model for density dependence: nodd.
Include demographic stochasticity in model?: Yes.
Number of simulations: 5000.
Random seed: 3542.
Years for burn-in: 10.
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 85164 in 2000
Productivity rate per pair: mean: 0.8 , sd: 0
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: 0.

Output:
First year to include in outputs: NA
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

Validation data
61594 in 1969
170790 in 1987
85164 in 2000
75234 in 2008
91008 in 2017

FFC SPA guillemot PVA validation log

Set up
The log file was created on: 2022-06-08 10:18:28 using Tool version 2, with R version 3.5.1, PVA package version: 4.18 (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: validation.
Model to use for environmental stochasticity: betagamma.
Model for density dependence: nodd.
Include demographic stochasticity in model?: Yes.
Number of simulations: 5000.
Random seed: 3542.
Years for burn-in: 10.
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 47215 in 2000
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: 0.

Output:

First year to include in outputs: NA
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

Validation data
12570 in 1969
32578 in 1987
47215 in 2000
59817 in 2008
84647 in 2017

FFC SPA razorbill PVA validation log

Set up
The log file was created on: 2022-06-08 10:23:09 using Tool version 2, with R version 3.5.1, PVA package version: 4.18 (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: validation.
Model to use for environmental stochasticity: betagamma.
Model for density dependence: nodd.
Include demographic stochasticity in model?: Yes.
Number of simulations: 5000.
Random seed: 3542.
Years for burn-in: 10.
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 8463 in 2000
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: 0.

Output:
First year to include in outputs: NA

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

Validation data
1724 in 1969
7688 in 1987
8463 in 2000
14956 in 2008
27967 in 2017

FFC SPA razorbill PVA validation log (variation in survival rates)

Set up
The log file was created on: 2022-06-08 11:16:42 using Tool version 2, with R version 3.5.1, PVA package version: 4.18 (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: validation.
Model to use for environmental stochasticity: betagamma.
Model for density dependence: nodd.
Include demographic stochasticity in model?: Yes.
Number of simulations: 5000.
Random seed: 7915.
Years for burn-in: 10.
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 8463 in 2000
Productivity rate per pair: mean: 0.641 , sd: 0.068
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

Impacts
Number of impact scenarios: 0.

Output:
First year to include in outputs: NA

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

Validation data
1724 in 1969
7688 in 1987
8463 in 2000
14956 in 2008
27967 in 2017

Appendix C PVA Model logs for Revised EIA (UK BDMPS & UK Biogeographic) modelling

Gannet UK North Sea & English Channel BDMPS PVA Log

Set up
The log file was created on: 2022-06-10 16:13:07 using Tool version 2, with R version 3.5.1, PVA package version: 4.18 (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: 8867.
Years for burn-in: 10.
Case study selected: None.

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

Population 1
Initial population values: Initial population 456298 in 2022
Productivity rate per pair: mean: 0.7 , sd: 0.082
Adult survival rate: mean: 0.919 , sd: 0.042
Immatures survival rates:
Age class 0 to 1 - mean: 0.424 , sd: 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

Name: 5
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 1.1e-05 , se: NA

Name: 10
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 2.2e-05 , se: NA

Name: 15
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 3.3e-05 , se: NA

Name: 20
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 4.4e-05 , se: NA

Name: 30
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 6.6e-05 , se: NA

Name: 40
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 8.8e-05 , se: NA

Name: 50
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.00011 , se: NA

Name: 100
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.000219 , se: NA

Name: 125
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.000274 , se: NA

Name: 3000
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.006575 , se: NA

Name: 3100
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.006794 , se: NA

Name: 3200
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.007013 , se: NA

Name: 3300
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.007232 , se: NA

Name: 3400
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.007451 , se: NA

Name: 3500
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.00767 , se: NA

Name: 3600
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.00789 , se: NA

Name: 3700
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.008109 , se: NA

Name: 3800
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.008328 , se: NA

Name: 3900
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.008547 , se: NA

Name: 4000
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.008766 , se: NA

Name: 5000
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.010958 , se: NA

Name: 6000
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.013149 , se: NA

Name: 7000
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.015341 , se: NA

Name: 8000
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.017532 , 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?: whole.population
Target population size to use in calculating impact metrics: NA
Quasi-extinction threshold to use in calculating impact metrics: NA

Gannet UK Biogeographic PVA Log

Set up
The log file was created on: 2022-06-11 14:18:26 using Tool version 2, with R version 3.5.1, PVA package version: 4.18 (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: 6777.
Years for burn-in: 10.
Case study selected: None.

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

Population 1
Initial population values: Initial population 1180000 in 2022
Productivity rate per pair: mean: 0.7 , sd: 0.082
Adult survival rate: mean: 0.919 , sd: 0.042
Immatures survival rates:
Age class 0 to 1 - mean: 0.424 , sd: 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

Name: 5
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 4e-06 , se: NA

Name: 10
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 8e-06 , se: NA

Name: 15
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 1.3e-05 , se: NA

Name: 20
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 1.7e-05 , se: NA

Name: 30
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 2.5e-05 , se: NA

Name: 40
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 3.4e-05 , se: NA

Name: 50
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 4.2e-05 , se: NA

Name: 100
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 8.5e-05 , se: NA

Name: 125
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.000106 , se: NA

Name: 3000
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.002542 , se: NA

Name: 3100
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.002627 , se: NA

Name: 3200
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.002712 , se: NA

3300
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.002797 , se: NA

Name: 3400
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.002881 , se: NA

Name: 3500
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.002966 , se: NA

Name: 3600
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.003051 , se: NA

Name: 3700
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.003136 , se: NA

Name: 3800
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.00322 , se: NA

Name: 3900
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.003305 , se: NA

Name: 4000
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.00339 , se: NA

Name: 5000
All subpopulations
Impact on productivity rate mean: 0 , se: NA

Impact on adult survival rate mean: 0.004237 , se: NA

Name: 6000
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.005085 , se: NA

Name: 7000
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.005932 , se: NA

Name: 8000
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.00678 , 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?: whole.population
Target population size to use in calculating impact metrics: NA
Quasi-extinction threshold to use in calculating impact metrics: NA

Kittiwake UK North Sea BDMPS PVA Log

Set up
The log file was created on: 2022-06-11 09:06:37 using Tool version 2, with R version 3.5.1, PVA package version: 4.18 (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: 9435.
Years for burn-in: 10.
Case study selected: None.

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

Population 1
Initial population values: Initial population 1237264 in 2022
Productivity rate per pair: mean: 0.819 , sd: 0.332
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: 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

Name: 50
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 4e-05 , se: NA

Name: 75
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 6.1e-05 , se: NA

Name: 100
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 8.1e-05 , se: NA

Name: 125
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.000101 , se: NA

Name: 150
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.000121 , se: NA

Name: 175
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.000141 , se: NA

Name: 200
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.000162 , se: NA

Name: 225
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.000182 , se: NA

Name: 3500
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.002829 , se: NA

Name: 3600
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.00291 , se: NA

Name: 3700
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.00299 , se: NA

Name: 3800
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.003071 , se: NA

Name: 3900
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.003152 , se: NA

Name: 4000
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.003233 , se: NA

Name: 4100
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.003314 , se: NA

Name: 4200
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.003395 , se: NA

Name: 4300
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.003475 , se: NA

Name: 4400
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.003556 , se: NA

Name: 4500
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.003637 , 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?: whole.population
Target population size to use in calculating impact metrics: NA
Quasi-extinction threshold to use in calculating impact metrics: NA

Kittiwake UK Biogeographic PVA Log

Set up
The log file was created on: 2022-06-11 14:58:08 using Tool version 2, with R version 3.5.1, PVA package version: 4.18 (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: 6777.
Years for burn-in: 10.
Case study selected: None.

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

Population 1
Initial population values: Initial population 5100000 in 2022
Productivity rate per pair: mean: 0.69 , sd: 0.296
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: 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

Name: 50
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 1e-05 , se: NA

Name: 75
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 1.5e-05 , se: NA

Name: 100
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 2e-05 , se: NA

Name: 125
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 2.5e-05 , se: NA

Name: 150
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 2.9e-05 , se: NA

Name: 175
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 3.4e-05 , se: NA

Name: 200
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 3.9e-05 , se: NA

Name: 225
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 4.4e-05 , se: NA

Name: 3500
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.000686 , se: NA

Name: 3600
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.000706 , se: NA

Name: 3700
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.000725 , se: NA

Name: 3800
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.000745 , se: NA

Name: 3900
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.000765 , se: NA

Name: 4000
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.000784 , se: NA

Name: 4100
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.000804 , se: NA

Name: 4200
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.000824 , se: NA

Name: 4300
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.000843 , se: NA

Name: 4400
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.000863 , se: NA

Name: 4500
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.000882 , 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?: whole.population
Target population size to use in calculating impact metrics: NA
Quasi-extinction threshold to use in calculating impact metrics: NA

Great black-backed gull UK North Sea BDMPS PVA Log

Set up
The log file was created on: 2022-06-11 12:58:22 using Tool version 2, with R version 3.5.1, PVA package version: 4.18 (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: 6777.
Years for burn-in: 10.
Case study selected: None.

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

Population 1
Initial population values: Initial population 91399 in 2022
Productivity rate per pair: mean: 1.139 , sd: 0.533
Adult survival rate: mean: 0.834 , sd: 0.034
Immatures survival rates:
Age class 0 to 1 - mean: 0.798 , sd: 0.092 , DD: NA
Age class 1 to 2 - mean: 0.834 , sd: 0.034 , DD: NA
Age class 2 to 3 - mean: 0.834 , sd: 0.034 , DD: NA
Age class 3 to 4 - mean: 0.834 , sd: 0.034 , DD: NA
Age class 4 to 5 - mean: 0.834 , sd: 0.034 , DD: NA

Impacts
Number of impact scenarios: 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

Name: 5
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 5.5e-05 , se: NA

Name: 10
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.000109 , se: NA

Name: 15
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.000164 , se: NA

Name: 20
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.000219 , se: NA

Name: 30
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.000328 , se: NA

Name: 40
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.000438 , se: NA

Name: 50
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.000547 , se: NA

Name: 75
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.000821 , se: NA

Name: 100
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.001094 , se: NA

Name: 900
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.009847 , se: NA

Name: 925
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.01012 , se: NA

Name: 950
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.010394 , se: NA

Name: 975
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.010668 , se: NA

Name: 1000
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.010941 , se: NA

Name: 1025
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.011215 , se: NA

Name: 1050
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.011488 , se: NA

Name: 1075
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.011762 , se: NA

Name: 1100
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.012035 , se: NA

Name: 1150
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.012582 , se: NA

Name: 1200
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.013129 , 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?: whole.population

Target population size to use in calculating impact metrics: NA
Quasi-extinction threshold to use in calculating impact metrics: NA

Great black-backed gull UK Biogeographic PVA Log

Set up

The log file was created on: 2022-06-11 14:00:05 using Tool version 2, with R version 3.5.1, PVA package version: 4.18 (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: 6777.
Years for burn-in: 10.
Case study selected: None.

Baseline demographic rates

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

Population 1

Initial population values: Initial population 235000 in 2022
Productivity rate per pair: mean: 1.139 , sd: 0.533
Adult survival rate: mean: 0.834 , sd: 0.034
Immatures survival rates:
Age class 0 to 1 - mean: 0.798 , sd: 0.092 , DD: NA
Age class 1 to 2 - mean: 0.834 , sd: 0.034 , DD: NA

Age class 2 to 3 - mean: 0.834 , sd: 0.034 , DD: NA
Age class 3 to 4 - mean: 0.834 , sd: 0.034 , DD: NA
Age class 4 to 5 - mean: 0.834 , sd: 0.034 , DD: NA

Impacts
Number of impact scenarios: 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

Name: 5
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 2.1e-05 , se: NA

Name: 10
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 4.3e-05 , se: NA

Name: 15
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 6.4e-05 , se: NA

Name: 20
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 8.5e-05 , se: NA

Name: 30
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.000128 , se: NA

Name: 40
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.00017 , se: NA

Name: 50

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

Name: 75
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.000319 , se: NA

Name: 100
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.000426 , se: NA

Name: 900
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.00383 , se: NA

Name: 925
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.003936 , se: NA

Name: 950
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.004043 , se: NA

Name: 975
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.004149 , se: NA

Name: 1000
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.004255 , se: NA

Name: 1025
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.004362 , se: NA

Name: 1050
All subpopulations

Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.004468 , se: NA

Name: 1075
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.004574 , se: NA

Name: 1100
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.004681 , se: NA

Name: 1150
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.004894 , se: NA

Name: 1200
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.005106 , 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?: whole.population
Target population size to use in calculating impact metrics: NA
Quasi-extinction threshold to use in calculating impact metrics: NA

Guillemot UK North Sea and English Channel BDMPS PVA Log

Set up
The log file was created on: 2022-06-11 09:46:57 using Tool version 2, with R version 3.5.1, PVA package version: 4.18 (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: 9435.
Years for burn-in: 10.
Case study selected: None.

Baseline demographic rates
Species chosen to set initial values: Common Guillemot.
Region type to use for breeding success data: Global.
Available colony-specific survival rate: National. Sector to use within breeding success region: Global.
Age at first breeding: 6.
Is there an upper constraint on productivity in the model?: Yes, constrained to 1 per pair.
Number of subpopulations: 1.
Are demographic rates applied separately to each subpopulation?: No.
Units for initial population size: all.individuals
Are baseline demographic rates specified separately for immatures?: Yes.

Population 1
Initial population values: Initial population 2139238 in 2022
Productivity rate per pair: mean: 0.672 , sd: 0.147
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: 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

Name: 75
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 3.5e-05 , se: NA

Name: 100
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 4.7e-05 , se: NA

Name: 125
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 5.8e-05 , se: NA

Name: 150
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 7e-05 , se: NA

Name: 175
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 8.2e-05 , se: NA

Name: 200
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 9.3e-05 , se: NA

Name: 225
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.000105 , se: NA

Name: 250
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.000117 , se: NA

Name: 300
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.00014 , se: NA

Name: 350
All subpopulations
Impact on productivity rate mean: 0 , se: NA

Impact on adult survival rate mean: 0.000164 , se: NA

Name: 400
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.000187 , se: NA

Name: 450
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.00021 , se: NA

Name: 550
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.000257 , se: NA

Name: 600
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.00028 , se: NA

Name: 650
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.000304 , se: NA

Name: 1,000
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.000467 , se: NA

Name: 1,500
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.000701 , se: NA

Name: 2,000
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.000935 , se: NA

Name: 2,500
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.001169 , se: NA

Name: 3,000
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.001402 , se: NA

Name: 3,500
All subpopulations
Impact on productivity rate mean: 0 , se: NA

Impact on adult survival rate mean: 0.001636 , se: NA

Name: 4,000
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.00187 , se: NA

Name: 4,500
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.002104 , se: NA

Name: 5,000
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.002337 , se: NA

Name: 5,500
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.002571 , se: NA

Name: 7,500
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.003506 , se: NA

Name: 10,000
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.004675 , se: NA

Name: 15,000
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.007012 , se: NA

Name: 20,000
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.009349 , se: NA

Name: 30,000
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.014024 , 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?: whole.population
Target population size to use in calculating impact metrics: NA
Quasi-extinction threshold to use in calculating impact metrics: NA

Guillemot UK Biogeographic PVA Log

Set up
The log file was created on: 2022-06-11 15:36:28 using Tool version 2, with R version 3.5.1, PVA package version: 4.18 (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: 6777.
Years for burn-in: 10.
Case study selected: None.

Baseline demographic rates
Species chosen to set initial values: Common Guillemot.
Region type to use for breeding success data: Global.
Available colony-specific survival rate: National. Sector to use within breeding success region: Global.
Age at first breeding: 6.
Is there an upper constraint on productivity in the model?: Yes, constrained to 1 per pair.
Number of subpopulations: 1.
Are demographic rates applied separately to each subpopulation?: No.
Units for initial population size: all.individuals
Are baseline demographic rates specified separately for immatures?: Yes.

Population 1
Initial population values: Initial population 4125000 in 2022
Productivity rate per pair: mean: 0.672 , sd: 0.147
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: 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

Name: 75
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 1.8e-05 , se: NA

Name: 100
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 2.4e-05 , se: NA

Name: 125
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 3e-05 , se: NA

Name: 150
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 3.6e-05 , se: NA

Name: 175
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 4.2e-05 , se: NA

Name: 200
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 4.8e-05 , se: NA

Name: 225
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 5.5e-05 , se: NA

Name: 250
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 6.1e-05 , se: NA

Name: 300
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 7.3e-05 , se: NA

Name: 350
All subpopulations
Impact on productivity rate mean: 0 , se: NA

Impact on adult survival rate mean: 8.5e-05 , se: NA

Name: 400
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 9.7e-05 , se: NA

Name: 450
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.000109 , se: NA

Name: 550
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.000133 , se: NA

Name: 600
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.000145 , se: NA

Name: 650
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.000158 , se: NA

Name: 1000
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.000242 , se: NA

Name: 1500
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.000364 , se: NA

Name: 2000
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.000485 , se: NA

Name: 2500
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.000606 , se: NA

Name: 3000
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.000727 , se: NA

Name: 3500
All subpopulations
Impact on productivity rate mean: 0 , se: NA

Impact on adult survival rate mean: 0.000848 , se: NA

Name: 4000
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.00097 , se: NA

Name: 4500
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.001091 , se: NA

Name: 5000
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.001212 , se: NA

Name: 5500
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.001333 , se: NA

Name: 7500
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.001818 , se: NA

Name: 10000
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.002424 , se: NA

Name: 15000
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.003636 , se: NA

Name: 20000
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.004848 , se: NA

Name: 30000
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.007273 , 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?: whole.population
Target population size to use in calculating impact metrics: NA
Quasi-extinction threshold to use in calculating impact metrics: NA

Razorbill UK North Sea and English Channel BDMPS PVA Log

Set up
The log file was created on: 2022-06-11 10:34:56 using Tool version 2, with R version 3.5.1, PVA package version: 4.18 (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: 9435.
Years for burn-in: 10.
Case study selected: None.

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

Population 1
Initial population values: Initial population 591874 in 2022
Productivity rate per pair: mean: 0.57 , sd: 0.247
Adult survival rate: mean: 0.895 , sd: 0.067
Immatures survival rates:
Age class 0 to 1 - mean: 0.63 , sd: 0.209 , DD: NA
Age class 1 to 2 - mean: 0.63 , sd: 0.209 , DD: NA
Age class 2 to 3 - mean: 0.895 , sd: 0.067 , DD: NA
Age class 3 to 4 - mean: 0.895 , sd: 0.067 , DD: NA
Age class 4 to 5 - mean: 0.895 , sd: 0.067 , DD: NA

Impacts
Number of impact scenarios: 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

Name: 5
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 8e-06 , se: NA

Name: 25
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 4.2e-05 , se: NA

Name: 50
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 8.4e-05 , se: NA

Name: 75
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.000127 , se: NA

Name: 100
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.000169 , se: NA

Name: 150
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.000253 , se: NA

Name: 400
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.000676 , se: NA

Name: 500
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.000845 , se: NA

Name: 600
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.001014 , se: NA

Name: 700
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.001183 , se: NA

Name: 800
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.001352 , se: NA

Name: 900
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.001521 , se: NA

Name: 1,000
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.00169 , se: NA

Name: 1,250
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.002112 , se: NA

Name: 1,500
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.002534 , se: NA

Name: 1,750
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.002957 , se: NA

Name: 2,000
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.003379 , se: NA

Name: 3,000
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.005069 , se: NA

Name: 4,000
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.006758 , se: NA

Name: 5,000
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.008448 , se: NA

Name: 6,000
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.010137 , se: NA

Name: 7,000
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.011827 , se: NA

Name: 8,000
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.013516 , se: NA

Name: 9,000
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.015206 , se: NA

Name: 10,000
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.016895 , 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?: whole.population
Target population size to use in calculating impact metrics: NA
Quasi-extinction threshold to use in calculating impact metrics: NA

Razorbill UK Biogeographic PVA Log

Set up
The log file was created on: 2022-06-11 16:51:20 using Tool version 2, with R version 3.5.1, PVA package version: 4.18 (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: 6777.
Years for burn-in: 10.
Case study selected: None.

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

Population 1
Initial population values: Initial population 1707000 in 2022
Productivity rate per pair: mean: 0.57 , sd: 0.247
Adult survival rate: mean: 0.895 , sd: 0.067
Immatures survival rates:
Age class 0 to 1 - mean: 0.63 , sd: 0.209 , DD: NA
Age class 1 to 2 - mean: 0.63 , sd: 0.209 , DD: NA
Age class 2 to 3 - mean: 0.895 , sd: 0.067 , DD: NA
Age class 3 to 4 - mean: 0.895 , sd: 0.067 , DD: NA
Age class 4 to 5 - mean: 0.895 , sd: 0.067 , DD: NA

Impacts
Number of impact scenarios: 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

Name: 5
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 3e-06 , se: NA

Name: 25
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 1.5e-05 , se: NA

Name: 50
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 2.9e-05 , se: NA

Name: 75
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 4.4e-05 , se: NA

Name: 100
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 5.9e-05 , se: NA

Name: 150
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 8.8e-05 , se: NA

Name: 400
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.000234 , se: NA

Name: 500
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.000293 , se: NA

Name: 600
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.000351 , se: NA

Name: 700
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.00041 , se: NA

Name: 800
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.000469 , se: NA

Name: 900
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.000527 , se: NA

Name: 1000
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.000586 , se: NA

Name: 1250
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.000732 , se: NA

Name: 1500
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.000879 , se: NA

Name: 1750
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.001025 , se: NA

Name: 2000
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.001172 , se: NA

Name: 3000
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.001757 , se: NA

Name: 4000
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.002343 , se: NA

Name: 5000
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.002929 , se: NA

Name: 6000
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.003515 , se: NA

Name: 7000
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.004101 , se: NA

Name: 8000
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.004687 , se: NA

Name: 9000
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.005272 , se: NA

Name: 10000
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.005858 , 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?: whole.population
Target population size to use in calculating impact metrics: NA
Quasi-extinction threshold to use in calculating impact metrics: NA

Puffin UK North Sea and English Channel BDMPS PVA Log

Set up
The log file was created on: 2022-06-11 11:48:35 using Tool version 2, with R version 3.5.1, PVA package version: 4.18 (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: 6777.
Years for burn-in: 10.
Case study selected: None.

Baseline demographic rates
Species chosen to set initial values: Atlantic Puffin.
Region type to use for breeding success data: Global.
Available colony-specific survival rate: National. Sector to use within breeding success region: Global.
Age at first breeding: 5.
Is there an upper constraint on productivity in the model?: Yes, constrained to 1 per pair.
Number of subpopulations: 1.
Are demographic rates applied separately to each subpopulation?: No.
Units for initial population size: all.individuals
Are baseline demographic rates specified separately for immatures?: Yes.

Population 1
Initial population values: Initial population 938585 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: 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

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

Name: 10
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 1.1e-05 , se: NA

Name: 15
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 1.6e-05 , se: NA

Name: 20
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 2.1e-05 , se: NA

Name: 100
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.000107 , se: NA

Name: 125
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.000133 , se: NA

Name: 150
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.00016 , se: NA

Name: 175
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.000186 , se: NA

Name: 200
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.000213 , se: NA

Name: 225
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.00024 , se: NA

Name: 250
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.000266 , se: NA

Name: 275
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.000293 , se: NA

Name: 300
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.00032 , se: NA

Name: 350
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.000373 , se: NA

Name: 400
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.000426 , se: NA

Name: 450
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.000479 , se: NA

Name: 500
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.000533 , se: NA

Name: 600
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.000639 , se: NA

Name: 700
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.000746 , se: NA

Name: 800
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.000852 , se: NA

Name: 900
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.000959 , se: NA

Name: 1000
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.001065 , se: NA

Name: 1500
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.001598 , se: NA

Name: 2000
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.002131 , se: NA

Name: 2500
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.002664 , se: NA

Name: 3000
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.003196 , se: NA

Name: 3500
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.003729 , 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?: whole.population
Target population size to use in calculating impact metrics: NA
Quasi-extinction threshold to use in calculating impact metrics: NA

Puffin UK Biogeographic PVA Log

Set up
The log file was created on: 2022-06-12 10:01:08 using Tool version 2, with R version 3.5.1, PVA package version: 4.18 (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: 5364.
Years for burn-in: 10.
Case study selected: None.

Baseline demographic rates
Species chosen to set initial values: Atlantic Puffin.
Region type to use for breeding success data: Global.
Available colony-specific survival rate: National. Sector to use within breeding success region: Global.
Age at first breeding: 5.
Is there an upper constraint on productivity in the model?: Yes, constrained to 1 per pair.
Number of subpopulations: 1.
Are demographic rates applied separately to each subpopulation?: No.
Units for initial population size: all.individuals
Are baseline demographic rates specified separately for immatures?: Yes.

Population 1
Initial population values: Initial population 11840000 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: 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

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

Name: 10
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 1e-06 , se: NA

Name: 15
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 1e-06 , se: NA

Name: 20
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 2e-06 , se: NA

Name: 100
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 8e-06 , se: NA

Name: 125
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 1.1e-05 , se: NA

Name: 150
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 1.3e-05 , se: NA

Name: 175
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 1.5e-05 , se: NA

Name: 200
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 1.7e-05 , se: NA

Name: 225
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 1.9e-05 , se: NA

Name: 250
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 2.1e-05 , se: NA

Name: 275
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 2.3e-05 , se: NA

Name: 300
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 2.5e-05 , se: NA

Name: 350
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 3e-05 , se: NA

Name: 400
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 3.4e-05 , se: NA

Name: 450
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 3.8e-05 , se: NA

Name: 500
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 4.2e-05 , se: NA

Name: 600
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 5.1e-05 , se: NA

Name: 700
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 5.9e-05 , se: NA

Name: 800
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 6.8e-05 , se: NA

Name: 900
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 7.6e-05 , se: NA

Name: 1000
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 8.4e-05 , se: NA

Name: 1500
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.000127 , se: NA

Name: 2000
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.000169 , se: NA

Name: 2500
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.000211 , se: NA

Name: 3000
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.000253 , se: NA

Name: 3500
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.000296 , 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?: whole.population
Target population size to use in calculating impact metrics: NA
Quasi-extinction threshold to use in calculating impact metrics: NA

Appendix D PVA Model logs for Revised FFC SPA modelling

FFC SPA gannet PVA log

Set up

The log file was created on: 2022-06-08 16:59:12 using Tool version 2, with R version 3.5.1, PVA package version: 4.18 (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: 3865.
Years for burn-in: 10.
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

Name: 5
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.000187 , se: NA

Name: 10
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.000373 , se: NA

Name: 15
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.00056 , se: NA

Name: 20
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.000747 , se: NA

Name: 30
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.00112 , se: NA

Name: 40
All subpopulations
Impact on productivity rate mean: 0 , se: NA

Impact on adult survival rate mean: 0.001493 , se: NA

Name: 50
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.001867 , se: NA

Name: 75
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.0028 , se: NA

Name: 100
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.003734 , se: NA

Name: 125
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.004667 , se: NA

Name: 150
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.0056 , se: NA

Name: 175
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.006534 , se: NA

Name: 200
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.007467 , se: NA

Name: 225
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.008401 , se: NA

Name: 250
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.009334 , se: NA

Name: 275
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.010267 , se: NA

Name: 300
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.011201 , se: NA

Name: 325
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.012134 , se: NA

Name: 350
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.013068 , se: NA

Name: 375
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.014001 , se: NA

Name: 400
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.014934 , se: NA

Name: 425
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.015868 , se: NA

Name: 450
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.016801 , se: NA

Name: 475
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.017734 , se: NA

Name: 500
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.018668 , se: NA

Name: 600
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.022401 , se: NA

Name: 700
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.026135 , se: NA

Name: 800
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.029869 , se: NA

Name: 900
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.033602 , se: NA

Name: 1000
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.037336 , 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

FFC SPA kittiwake PVA log

Set up

The log file was created on: 2022-06-08 17:45:17 using Tool version 2, with R version 3.5.1, PVA package version: 4.18 (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: 3865.
Years for burn-in: 10.
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: 0.58 , sd: 0.096
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: 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

Name: 5
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 4.9e-05 , se: NA

Name: 10
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 9.7e-05 , se: NA

Name: 15
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.000146 , se: NA

Name: 20
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.000194 , se: NA

Name: 30
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.000291 , se: NA

Name: 40
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.000388 , se: NA

Name: 50
All subpopulations

Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.000485 , se: NA

Name: 75
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.000728 , se: NA

Name: 100
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.00097 , se: NA

Name: 125
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.001213 , se: NA

Name: 150
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.001455 , se: NA

Name: 175
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.001698 , se: NA

Name: 200
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.00194 , se: NA

Name: 225
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.002183 , se: NA

Name: 250
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.002426 , se: NA

Name: 275
All subpopulations
Impact on productivity rate mean: 0 , se: NA

Impact on adult survival rate mean: 0.002668 , se: NA

Name: 300
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.002911 , se: NA

Name: 325
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.003153 , se: NA

Name: 350
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.003396 , se: NA

Name: 375
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.003638 , se: NA

Name: 400
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.003881 , se: NA

Name: 425
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.004123 , se: NA

Name: 450
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.004366 , se: NA

Name: 475
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.004609 , se: NA

Name: 500
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.004851 , 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

FFC SPA kittiwake PVA log (variation in productivity rate to 0.8)

Set up

The log file was created on: 2022-06-08 17:56:08 using Tool version 2, with R version 3.5.1, PVA package version: 4.18 (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: 3865.
Years for burn-in: 10.
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: 0.8 , sd: 0
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: 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

Name: 5
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 4.9e-05 , se: NA

Name: 10
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 9.7e-05 , se: NA

Name: 15
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.000146 , se: NA

Name: 20
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.000194 , se: NA

Name: 30
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.000291 , se: NA

Name: 40
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.000388 , se: NA

Name: 50
All subpopulations

Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.000485 , se: NA

Name: 75
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.000728 , se: NA

Name: 100
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.00097 , se: NA

Name: 125
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.001213 , se: NA

Name: 150
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.001455 , se: NA

Name: 175
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.001698 , se: NA

Name: 200
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.00194 , se: NA

Name: 225
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.002183 , se: NA

Name: 250
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.002426 , se: NA

Name: 275
All subpopulations
Impact on productivity rate mean: 0 , se: NA

Impact on adult survival rate mean: 0.002668 , se: NA

Name: 300
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.002911 , se: NA

Name: 325
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.003153 , se: NA

Name: 350
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.003396 , se: NA

Name: 375
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.003638 , se: NA

Name: 400
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.003881 , se: NA

Name: 425
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.004123 , se: NA

Name: 450
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.004366 , se: NA

Name: 475
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.004609 , se: NA

Name: 500
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.004851 , 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

FFC SPA guillemot PVA log

Set up
The log file was created on: 2022-06-08 19:03:16 using Tool version 2, with R version 3.5.1, PVA package version: 4.18 (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: 3865.
Years for burn-in: 10.
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: 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

Name: 10
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 8.2e-05 , se: NA

Name: 15
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.000123 , se: NA

Name: 20
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.000164 , se: NA

Name: 30
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.000246 , se: NA

Name: 40
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.000329 , se: NA

Name: 50
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.000411 , se: NA

Name: 75
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.000616 , se: NA

Name: 100
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.000821 , se: NA

Name: 125
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.001027 , se: NA

Name: 150
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.001232 , se: NA

Name: 175
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.001437 , se: NA

Name: 200
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.001643 , se: NA

Name: 225
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.001848 , se: NA

Name: 250
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.002053 , se: NA

Name: 275
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.002259 , se: NA

Name: 300

All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.002464 , se: NA

Name: 325
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.002669 , se: NA

Name: 350
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.002875 , se: NA

Name: 375
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.00308 , se: NA

Name: 400
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.003285 , se: NA

Name: 425
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.003491 , se: NA

Name: 450
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.003696 , se: NA

Name: 475
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.003901 , se: NA

Name: 500
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.004107 , se: NA

Name: 750
All subpopulations

Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.00616 , se: NA

Name: 1000
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.008213 , se: NA

Name: 1250
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.010267 , se: NA

Name: 1500
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.01232 , se: NA

Name: 1750
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.014373 , se: NA

Name: 2000
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.016427 , se: NA

Name: 2250
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.01848 , se: NA

Name: 2500
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.020533 , se: NA

Name: 2750
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.022587 , se: NA

Name: 3000
All subpopulations
Impact on productivity rate mean: 0 , se: NA

Impact on adult survival rate mean: 0.02464 , se: NA

Name: 3250
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.026693 , se: NA

Name: 3500
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.028746 , se: NA

Name: 4000
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.032853 , se: NA

Name: 4500
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.03696 , se: NA

Name: 5000
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.041066 , 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

FFC SPA razorbill PVA log

Set up
The log file was created on: 2022-06-09 07:35:07 using Tool version 2, with R version 3.5.1, PVA package version: 4.18 (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: 9360.
Years for burn-in: 10.
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: 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

Name: 5
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.000123 , se: NA

Name: 10
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.000247 , se: NA

Name: 15
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.00037 , se: NA

Name: 20
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.000494 , se: NA

Name: 30
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.000741 , se: NA

Name: 40
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.000988 , se: NA

Name: 50

All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.001234 , se: NA

Name: 75
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.001852 , se: NA

Name: 100
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.002469 , se: NA

Name: 125
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.003086 , se: NA

Name: 150
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.003703 , se: NA

Name: 175
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.00432 , se: NA

Name: 200
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.004938 , se: NA

Name: 225
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.005555 , se: NA

Name: 250
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.006172 , se: NA

Name: 275
All subpopulations

Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.006789 , se: NA

Name: 300
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.007406 , se: NA

Name: 325
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.008024 , se: NA

Name: 350
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.008641 , se: NA

Name: 375
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.009258 , se: NA

Name: 400
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.009875 , se: NA

Name: 425
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.010492 , se: NA

Name: 450
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.011109 , se: NA

Name: 475
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.011727 , se: NA

Name: 500
All subpopulations
Impact on productivity rate mean: 0 , se: NA

Impact on adult survival rate mean: 0.012344 , se: NA

Name: 550
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.013578 , se: NA

Name: 600
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.014813 , se: NA

Name: 650
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.016047 , se: NA

Name: 700
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.017281 , se: NA

Name: 750
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.018516 , 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

FFC SPA razorbill PVA log (variation in survival rates)

Set up

The log file was created on: 2022-06-09 09:23:27 using Tool version 2, with R version 3.5.1, PVA package version: 4.18 (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: 9360.
Years for burn-in: 10.
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: 0.94 , 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

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

Name: 5
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.000123 , se: NA

Name: 10
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.000247 , se: NA

Name: 15
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.00037 , se: NA

Name: 20
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.000494 , se: NA

Name: 30
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.000741 , se: NA

Name: 40
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.000988 , se: NA

Name: 50

All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.001234 , se: NA

Name: 75
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.001852 , se: NA

Name: 100
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.002469 , se: NA

Name: 125
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.003086 , se: NA

Name: 150
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.003703 , se: NA

Name: 175
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.00432 , se: NA

Name: 200
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.004938 , se: NA

Name: 225
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.005555 , se: NA

Name: 250
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.006172 , se: NA

Name: 275
All subpopulations

Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.006789 , se: NA

Name: 300
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.007406 , se: NA

Name: 325
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.008024 , se: NA

Name: 350
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.008641 , se: NA

Name: 375
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.009258 , se: NA

Name: 400
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.009875 , se: NA

Name: 425
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.010492 , se: NA

Name: 450
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.011109 , se: NA

Name: 475
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.011727 , se: NA

Name: 500
All subpopulations
Impact on productivity rate mean: 0 , se: NA

Impact on adult survival rate mean: 0.012344 , se: NA

Name: 550
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.013578 , se: NA

Name: 600
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.014813 , se: NA

Name: 650
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.016047 , se: NA

Name: 700
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.017281 , se: NA

Name: 750
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.018516 , 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

FFC SPA puffin PVA log

Set up
The log file was created on: 2022-06-13 07:56:19 using Tool version 2, with R version 3.5.1, PVA package version: 4.18 (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: 5904.
Years for burn-in: 10.
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: 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

Name: 1
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.000279 , se: NA

Name: 3
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.000838 , se: NA

Name: 5
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.001397 , se: NA

Name: 7
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.001956 , se: NA

Name: 10
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.002794 , se: NA

Name: 15
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.004191 , se: NA

Name: 20

All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.005588 , se: NA

Name: 25
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.006985 , se: NA

Name: 30
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.008382 , se: NA

Name: 35
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.009779 , se: NA

Name: 40
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.011176 , se: NA

Name: 45
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.012573 , se: NA

Name: 50
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.01397 , se: NA

Name: 55
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.015367 , se: NA

Name: 60
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.016764 , se: NA

Name: 65
All subpopulations

Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.018161 , se: NA

Name: 70
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.019559 , se: NA

Name: 75
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.020956 , se: NA

Name: 80
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.022353 , se: NA

Name: 85
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.02375 , 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