MacArthur Green

West of Orkney Windfarm

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West of Orkney Windfarm

Offshore Ornithology Additional Information

Appendix 9 - EIA: PVA at regional population scales for Project alone and cumulative impacts

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1 INTRODUCTION

1.1 Project summary

1. Offshore Wind Power Limited (OWPL) ('the Applicant') is proposing the development of the West of Orkney Windfarm ('the Project'), an Offshore Wind Farm (OWF), located at least 23 kilometres (km) from the north coast of Scotland and 28 km from the west coast of Hoy, Orkney (**Figure 1-1**).

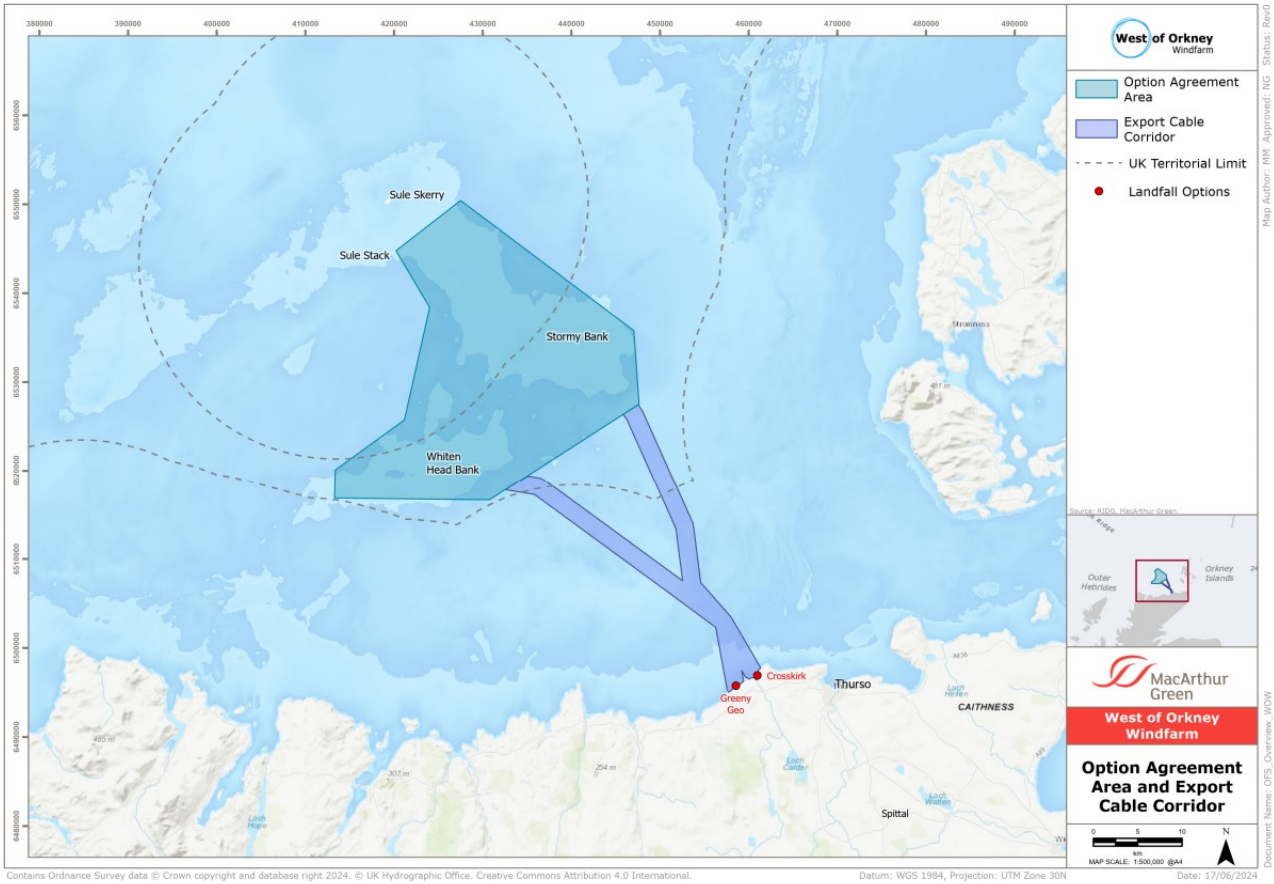

Figure 1-1. Map showing location of the West of Orkney Windfarm Option Agreement Area (OAA) and Export Cable Corridor (ECC) which together, comprise the Offshore Project Area.

2. The Offshore Project will comprise up to 125 wind turbine generators (WTGs) with fixed-bottom foundations and up to five Offshore Substation Platforms (OSPs). The area within which the WTGs, OSPs and associated infrastructure will be located is the Option Agreement Area (OAA). The OAA covers an area of 657 km^2. The export cables will be located within the Export Cable Corridor (ECC), with landfall options at Greeny Geo and/or Crosskirk in Caithness (**Figure 1-1**). The OAA and ECC together comprise the offshore Project area.

3. The Applicant submitted an application for consent under Section 36 of the Electricity Act 1989 and Marine Licences under Part 4 of the Marine (Scotland) Act 2010 and the Marine and Coastal Access Act 2009 to Scottish Ministers in September 2023 for the offshore components of the Project seaward of Mean High Water Springs (MHWS).

4. In accordance with relevant EIA Regulations[1], an Offshore Environmental Impact Assessment (EIA) Report was submitted to Marine Directorate – Licensing Operations Team (MD-LOT) as part of the Applicant's consent application (the 'Offshore EIA Report'). A Report to Information Appropriate Assessment (RIAA) was also submitted as part of the Offshore Application to provide the Competent Authority (MD-LOT) with the information required to assist them in undertaking an Appropriate Assessment (AA) for the offshore Project as required under the Conservation (Natural Habitats & c.) Regulations 1994 (as amended), the Conservation of Marine Habitats and Species Regulations 2017 and The Conservation of Habitats and Species Regulations 2017 (as amended) (hereafter referred to as the 'Habitats Regulations').

5. Following the review of the Applicant's application, and upon receipt of representations from consultees, MD-LOT issued a request for Additional Information on offshore ornithology. This report is part of the Ornithology Additional Information (OAI).

1.2 Relationship between the original application and the OAI

6. The Ornithology Additional Information (OAI) (see **Introduction to the Additional Ornithology Information** for structure of OAI and list of all reports) includes:

- an **Addendum to the Offshore EIA Report** in the form of a revised EIA chapter for Offshore and Intertidal Ornithology. All ornithology information in this report should be read in place of information in the original EIA chapter;
- an **Addendum to the RIAA**. All ornithology information in this report should be read in place of information in the original RIAA (with the exception of information on pre-application consultation);
- a set of nine technical appendices. This **Appendix 9 - EIA: PVA at regional population scales for Project alone and cumulative impacts** is one of the nine technical appendices. These reports entirely replace the original Supporting Study 12: Offshore Ornithology Technical Supporting Study.

7. NatureScot's pre- and post-application Project-specific advice and online guidance notes[2] were followed throughout the OAI. To demonstrate this, reference to NatureScot's guidance and advice is made throughout the OAI, either in the text or in separate text boxes.

[1] *The relevant EIA Regulations include the Electricity Works (Environmental Impact Assessment) (Scotland) Regulations 2017, the Marine Works (Environmental Impact Assessment) (Scotland) Regulations 2017, and the Marine Works (Environmental Impact Assessment) Regulations 2007.*

[2] *Guidance Note 1: Guidance to support Offshore Wind Applications: Marine Ornithology - Overview | NatureScot*

1.3 Purpose of this Report

8. Collision and displacement mortality were estimated for the Project (see **Appendix 3 - EIA and HRA: Collision Risk Modelling Technical Report** and **Appendix 4 - EIA and HRA: Displacement Technical Report** for details). The consequences of this additional mortality on the regional populations, which were defined in **Appendix 7 - EIA: Calculation of mortalities and change in survival rate at regional population scales for Project alone and cumulative impacts,** were assessed using Population Viability Analysis (PVA) methods, as described in this report. A summary of methods and key results are presented in the **Addendum to the Offshore EIA Report**, with mortalities and population response to that mortality considered in detail, as well as a conclusion on the potential for that mortality to result in a significant impact.

9. This report uses the estimated changes in survival for regional (EIA) populations, arising from impacts from the Project alone and cumulatively with other OWFs, to assess potential changes in population size and growth rate. Mortalities and change in annual survival rate for regional populations are presented in **the Appendix 7 - EIA: Calculation of mortalities and change in survival rate at regional population scales for Project alone and cumulative impacts.**

1.4 Terminology

10. The following terminology is used in this report:

- Option Agreement Area (OAA): this is the area within which WTGs and other offshore Project infrastructure will be installed;
- Export Cable Corridor (ECC) is the area from the OAA to the landfall site in which the export cable will be placed;
- Offshore Project area comprises the OAA and ECC;
- OAA plus 2 km buffer: This includes a 2 km wide 'zone of influence' around the OAA, allowing for changes in bird behaviour (e.g. disturbance/displacement) in the vicinity of the OAA;
- OAA plus 4 km buffer: the OAA plus 4 km buffer was the area used for characterising baseline seabird numbers and distribution for the Project (see **Appendix 1 - EIA and HRA: Baseline Site Characterisation Technical Report**);
- WTG: Wind Turbine Generator.

2 METHODS

2.1 Threshold for Determining Whether a PVA is Required

11. A key part of impact assessment is to understand how populations might respond to predicted mortality arising from OWF developments. It is this population response to predicted OWF mortality that determines whether a proposed plan or project could significantly impact a population.

12. NatureScot Guidance Note 11[3] provides recommendations on how to quantify population response to OWF mortality, using PVA. Whilst this guidance note refers to SPAs and in-combination impacts, as part of assessments to inform HRA, the same guidance applies to EIA.

NatureScot Guidance Note 11:
The impacts of collision and distributional responses, such as displacement, will need to be considered in the context of relevant SPA breeding colonies particularly where the assessed effects exceed a change to the adult annual survival rate of 0.02 percentage point change. For example, if a survival rate was estimated at 80% and this decreased to 79.98% when including the impacts of apportioned collision or distributional responses, a PVA should be undertaken. Where apportioned impacts are large and / or the SPA populations are small, it is likely that population models will be required to establish whether or not there could be long-term impacts on population viability.

NatureScot Consultation Meeting 21 May 2024:
Thresholds for PVA
Use a 2 step process:
1. Does the project alone result in an estimated increase in baseline annual mortality >= 0.02%?
a. If no (i.e. <0.02%) then PVA for project alone is not required.
b. If yes, then PVA required for project alone.
2. Do cumulative impacts result in an estimated increase in baseline annual mortality >= 0.02%?
a. If no (i.e. <0.02%), then no cumulative PVA is required;
b. If yes (i.e. >=0.02%) & project alone mortality >0.2 birds per annum, then cumulative PVA is required; but if project alone mortality <0.2 birds per annum, then cumulative PVA is not required.

13. Where predicted mortality, and change in annual survival rate, is small, a PVA is not required to assess population response to impacts. However, when impacts are larger, a PVA is required to predict how population growth rate and population size, might change in the presence of impacts, compared with no mortality.

14. The need for a PVA was determined using change in annual survival rate (for all individuals in a population, not just adult survival, due to individuals of all age classes being assessed under EIA). The predicted collision and displacement mortality (Project alone or cumulative) was divided by the regional population estimate (broadly defined as the sum of the populations

[3] *Guidance Note 11: Guidance to support Offshore Wind Applications: Marine Ornithology - Recommendations for Seabird Population Viability Analysis (PVA) | NatureScot.*

of birds from all colonies within foraging range of the Project. This was then multiplied by 100 to give the percentage point change in annual survival rate due to collision and displacement mortality.

15. A PVA was run for all cases where Project alone or cumulative mortality resulted in a change in annual survival of >= 0.02%. In all cases Project alone mortality was >0.2 birds per annum.

16. The following species were included in the EIA assessment:

- Kittiwake
- Great black-backed gull
- Arctic tern
- Great skua
- Guillemot
- Razorbill
- Puffin
- Fulmar
- Gannet

17. Full details of the impacts from the Project alone and cumulatively can be found in **Sections 7** and **8** of the **Addendum to the Offshore EIA Report.**

2.2 Population Modelling

2.2.1 Type of Model

NatureScot Guidance Note 11*:*

The Natural England (NE) PVA tool (Searle et al. 2019) should be used to undertake Population Viability Analyses. This uses a Leslie Matrix Model, which is an age-structured model, populated by life-history parameters to estimate population size over a set time period.

18. PVA is an approach to assessing projected future changes to population size and growth rate, using numerical population models. Typically, PVA is used to compare various metrics of a population, such as size or growth rate, under a range of conditions, e.g. to compare population size projected into the future under current (baseline population) conditions with predicted population size in the presence of additional OWF mortality (impacted population; Searle *et al.*, 2019).

19. The Natural England (NE) commissioned PVA tool (Searle *et al.*, 2019), (the 'NE PVA tool') was used for this assessment, as recommended in NatureScot Guidance Note 11. The NE PVA tool is a version of a matrix model (Caswell, 1989). This model is written using the R programming

language (R Core Team, 2023) and can be used either from within R or via an online interface[4]. Owing to the large number of models that were required for the Project assessment (15 for EIA and Cumulative Impact Assessment (CIA)), the former option was used. The most recently available version of the R scripts (Version 4.15, 19 February 2020) was used for this analysis[5].

2.2.2 Time Periods

NatureScot Guidance Note 11:
We request that the modelling of impacts is undertaken over two or three time periods:

25 years (and the intended lease period if different)
50 years

20. Tabulated outputs are provided at three time points from the simulated projections, after 25, 35 and 50 years. NatureScot Guidance Note 11 advises presenting outputs from 25 and 50 year projects as well as the intended period of operation, which for the Project, was 35 years. On 4 June 2024, in a consultation meeting, NatureScot confirmed that a 60 year project was not required, despite this being the period of seabed lease for the Project.

21. It is recommended that an initial 'burn-in' period of at least five years is included in a model simulation to allow aspects such as age distributions to equilibrate prior to the simulated period of interest (Searle *et al*., 2019). However, for small population sizes this was found to be not possible as the models would fail to complete the burn-in phase. In these cases, it was necessary to omit the burn-in phase. However, this is not considered likely to have had a material effect on the results obtained.

22. Projections were run from a starting year of 2027 to an end year of 2077. Collision and displacement impacts were applied from the starting year for 35 years, i.e. to 2062 (as agreed with NatureScot in a consultation meeting on 4 June 2024).

2.2.3 Starting Population Size

NatureScot Guidance Note 11:

The most up to date population data (i.e. most will be available within the SMP database) should be used to determine the baseline populations. This should be undertaken at the designated site level, e.g. at the SPA level for HRA.

23. Starting population sizes were regional population size, broadly defined as the sum of all populations from colonies within foraging range of the Project (see **Appendix 7 - EIA: Cumulative mortalities for regional populations** for more details).

[4] http://ec2-34-243-66-127.eu-west-1.compute.amazonaws.com/shiny/seabirds/PVATool_Nov2022/R. /
[5] https://github.com/naturalengland/Seabird_PVA_Tool/releases/latest.

24. Starting population size is presented for each PVA in **Table 2-1** (EIA regional population size). Full details on which colonies contributed to the regional population totals can be found in **Section 6.5.4** of the **Addendum to the Offshore EIA Report.** Colony size information used to estimate regional population size is presented in **Annex 1S: SPA and regional population sizes**.

Table 2-1. Regional population size used as starting population size in PVAs for EIA. Reference population comprised all-aged individuals (i.e. including immatures and non-breeding birds) from all colonies within foraging range of the Project OAA plus 2 km buffer.

Species	Population size
Black-legged kittiwake	414,355
Great black-backed gull	3,402
Arctic tern	1,438
Great skua	53,517
Common guillemot	980,165
Razorbill	140,698
Atlantic puffin	1,145,207
Norther fulmar	1,138,694
Northern gannet	926,447

2.2.4 Demographic Rates

NatureScot Guidance Note 11:

We recommend the use of Horswill and Robinson (2015) for species demographic data for use within population modelling. The input values used should be reported, and justification should be provided if any different values occur, for example, if site specific data are available.

25. As agreed with NatureScot on 25 June 2024, the demographic rates used for each species were those built into the online PVA, with productivity selected as *Region: Country* and *Sector: Scotland* and survival as *National*. These rates were derived from Horswill and Robinson (2015), and in some instances that source was used to supplement the rates (e.g. for kittiwake adult survival the standard deviation in Horswill and Robinson 2015, 0.051, was used in preference to the value in the online PVA of 0.077 as the latter appears to be erroneous use of the immature value; use of Horswill and Robinson (2015) as the most reliable source of demographic rates was agreed with NatureScot in a consultation meeting on the 25 June 2024).

26. For fulmar, sub-adult survival rates (up to age eight) appears to be incorrect in the NE PVA tool with a rate of 0.26 for each sub-adult age class. It was agreed on review of the source of these data (Horswill & Robinson, 2015) that the value of 0.26 is in fact the composite rate from fledging to 8 years. Assuming a constant annual survival rate across this period the

annual rate is 0.845, derived as 0.26 raised to the power 1/8. This value was used in the fulmar PVA, as agreed with NatureScot (consultation meeting, 25 June 2024).

27. Great skua and Arctic tern demographic rates are not available automatically in the NE PVA tool. Consequently, survival rates, productivity rates and age of first breeding were taken from Horswill & Robinson (2015). This was discussed and agreed with NatureScot at a consultation meeting on 25 June 2024. All demographic rates used are presented in the input tables in the Results section below, as requested in NatureScot Guidance Note 11. Demographic rates are summarised below in **Table 2-2**.

Table 2-2. Demographic rates used in PVAs.

Species	Black-legged kittiwake	Northern gannet	Great black-backed gull	Common guillemot	Razorbill	Atlantic puffin	Arctic tern	Great skua	Norther fulmar
Age at first breeding	4	5	5	6	5	5	4	5	9
Productivity rate per pair - mean	0.586	0.679	0.930	0.501	0.440	0.415	0.38	0.651	0.419
Productivity rate per pair – SD	0.370	0.092	0.432	0.208	0.188	0.212	0.325	0.308	0.127
Adult survival rate – Mean	0.854	0.919	0.93	0.94	0.895	0.907	0.837	0.882	0.936
Adult survival rate - SD	0.051	0.042	0.1	0.025	0.067	0.083	0.035	0.038	0.055
Immatures survival rates 0 to 1 mean	0.790	0.424	0.93	0.560	0.63	0.709	0.837	0.939	0.845
Immatures survival rates 0 to 1 SD	0.077	0.045	0.1	0.058	0.067	0.108	0.035	0.038	0.055
Immatures survival rates 1 to 2 mean	0.854	0.829	0.93	0.792	0.63	0.709	0.837	0.939	0.845
Immatures survival rates 1 to 2 SD	0.077	0.026	0.1	0.152	0.067	0.108	0.035	0.038	0.055
Immatures survival rates 2 to 3 mean	0.854	0.891	0.93	0.917	0.895	0.709	0.837	0.939	0.845
Immatures survival rates 2 to 3 SD	0.077	0.019	0.1	0.098	0.067	0.108	0.035	0.038	0.055
Immatures survival rates 3 to 4 mean	0.854	0.895	0.93	0.938	0.895	0.76	0.837	0.939	0.845
Immatures survival rates 3 to 4 SD	0.077	0.019	0.1	0.107	0.067	0.093	0.035	0.038	0.055
Immatures survival rates 4 to 5 mean	-	0.919	0.93	0.94	0.895	0.805	-	0.939	0.845
Immatures survival rates 4 to 5 SD	-	0.042	0.1	0.025	0.067	0.083	-	0.038	0.055
Immatures survival rates 5 to 6 mean	-	-	-	0.94	-	-	-	-	0.845
Immatures survival rates 5 to 6 SD	-	-	-	0.025	-	-	-	-	0.055
Immatures survival rates 6 to 7 mean	-	-	-	-	-	-	-	-	0.845
Immatures survival rates 6 to 7 SD	-	-	-	-	-	-	-	-	0.055
Immatures survival rates 7 to 8 mean	-	-	-	-	-	-	-	-	0.845
Immatures survival rates 7 to 8 SD	-	-	-	-	-	-	-	-	0.055
Immatures survival rates 8 to 9 mean	-	-	-	-	-	-	-	-	0.845
Immatures survival rates 8 to 9 SD	-	-	-	-	-	-	-	-	0.055

2.2.5 Stochasticity and Density Dependence

28. The PVAs were run as stochastic models that incorporate environmental and demographic variability in the input parameters, with 1,000 simulations for each model scenario. A matched runs approach was used where impacted populations had the same stochastic variation as unimpacted (baseline) populations for each individual simulation run.

29. No density dependent regulation was applied to these simulations. NatureScot confirmed, by email (dated 9 July 2024) that they were content with use of a density-independent model. This means that average demographic rates remain the same irrespective of population growth or decline, in contrast with the natural processes of resource constraint which prevent unlimited (i.e. exponential) growth and also tend to buffer declining populations through reduced competition.

30. The results for each regional species population include the complete set of input parameters to permit model validation if required (although it should be noted that the random seed specified is applicable to the R based version and is not transferable to the online version).

2.2.6 PVA Metrics to be Presented

NatureScot Guidance Note 11:

We advise the two ratio metrics that compare impacted and un-impacted populations should be applied in both EIA and HRA. The two metrics that should be used are generally termed 'Counterfactual (ratio) of final population size' and 'Counterfactual (ratio) of population growth-rate'.

In addition to the ratio metrics, other metrics, e.g. predicted final population size, can be supplied for context, and output graphs of PVA runs should be supplied where possible.

31. The counterfactuals of population growth rate (C-PGR, the average annual rate of change over the projected period) and population size (C-PS) and the 50th quantiles for unimpacted and impacted populations[6] are provided for each scenario run, at 25, 35 and 50 year projections.

32. As requested in NatureScot Guidance Note 11, a graph for each model run is also provided which presents all of the different scenarios on the same axes to allow straightforward comparison of impacted and unimpacted predictions. The figure presents population size against time, allowing population size at any point in time under both baseline and impacted scenarios, to be read.

33. The C-PGR and C-PS are provided as the median, mean, standard deviation and 95% confidence intervals. Although the two counterfactual measures may appear to be equally informative with respect to understanding the population consequences of impacts, which

[6] *the quantile from the unimpacted population that matched the 50% quantile for the impacted population and the quantile from the impacted population that match the 50% quantile for the unimpacted population, respectively.*

one is more appropriate depends on whether density dependent regulation has been included. Consideration of the properties of density dependent and density independent population projections illustrates why this is: a population regulated by density dependent feedback will maintain itself around an equilibrium level. Since there is no long-term growth or decline for such a population, when an impact is applied the population growth rate will only change in the short term, following which the population will once again settle at a new, lower, equilibrium size. Hence the change in growth rate (i.e. C-PGR) is of limited value for understanding the effect of an impact. In contrast, the change in population size (C-PS) provides useful information on how much smaller the population will be in the presence of the impact. When a population is simulated without regulation (i.e. density independent), the population will grow or decline exponentially. The baseline and impacted predictions will both change in this manner but the difference between the two will increase with duration as the baseline population grows more rapidly. Hence, the time point when the differences are considered is critical to the C-PS value obtained and how this is interpreted. However, the average growth rate of a density independent population is constant and therefore, a comparison of the baseline and impacted growth rates is insensitive to the duration over which the comparison is made. Thus, for density independent PVA, as presented here, the C-PGR is the more robust and reliable metric to use.

34. In the current assessment, only density independent models have been used, and therefore the C-PGR is considered to be the more reliable metric for interpreting the results. However, following NatureScot Guidance Note 11, C-PS is also presented for each PVA scenario.

2.3 PVA Scenarios

35. PVA scenarios were developed to take into account the following:

- Kittiwake, Arctic tern and gannet have both collision and displacement impact pathways;
- Guillemot, razorbill, puffin and fulmar have only displacement impact pathways; and
- Great skua and great black-backed gull have only collision pathways.

36. Two estimates of collision mortality were generated, one under a Worst Case Scenario (WCS) and the other under a Most Likely Scenario (MLS) (see **Appendix 3 - EIA and HRA: Collision Risk Modelling Technical Report** for more details). For each scenario, the number of WTGs did not change, but size of WTG increased under the WCS, compared to the MLS. Due to the number of WTGs not changing, collision mortality estimates under both scenarios were very similar. See **Appendix 3 - EIA and HRA: Collision Risk Modelling Technical Report** for more information, including estimated collision mortality for MLS and WCS for each species.

37. The Applicant decided to present PVA outputs based on only WCS collision mortality due to the MLS and WCS predicted collisions being so similar. PVA outputs would not be substantially different under the two scenarios, meaning that conclusions on significance of effect would not change. Consequently, only a single mortality rate (WCS) was used to model collision impacts in the PVAs.

38. Two estimates of displacement mortality were generated. There is uncertainty around the proportion of birds that may die as a consequence of being displaced and so NatureScot advise using two mortality rates for most species (see NatureScot Guidance Note 8[7]). The estimated annual low and high impact displacement mortality were assessed in PVAs, as two separate scenarios. See **Appendix 4 - EIA and HRA: Displacement Technical Report** for more details.

39. NatureScot requested (consultation meeting, 11 June 2024) that the cumulative assessment present two scenarios, one including Berwick Bank Offshore Wind Farm ('Berwick Bank') impacts and the other excluding Berwick Bank impacts. These two scenarios were run through PVAs and are presented.

40. Project alone and cumulative impacts were modelled using a single collision scenario (WCS) and two displacement scenarios (high and low displacement mortality). Details of the PVA scenarios run for each species are provided below.

41. Nine PVA scenarios were modelled for kittiwake and gannet:

- West of Orkney[8] alone low displacement;
- West of Orkney alone high displacement;
- West of Orkney alone WCS collisions;
- West of Orkney alone WCS collisions plus low displacement;
- West of Orkney alone WCS collisions plus high displacement;
- Cumulative, low displacement plus WCS collisions excluding Berwick Bank;
- Cumulative, high displacement plus WCS collisions excluding Berwick Bank;
- Cumulative, low displacement plus WCS collisions including Berwick Bank; and
- Cumulative, high displacement plus WCS collisions including Berwick Bank.

42. Six PVA scenarios were modelled for the guillemot, razorbill and puffin:

- West of Orkney alone low displacement;
- West of Orkney alone high displacement;
- Cumulative, low displacement excluding Berwick Bank;
- Cumulative, high displacement excluding Berwick Bank.
- Cumulative, low displacement including Berwick Bank; and
- Cumulative, high displacement including Berwick Bank.

[7] *Guidance Note 8: Guidance to support Offshore Wind Applications: Marine Ornithology Advice for assessing the distributional responses, displacement and barrier effects of Marine birds | NatureScot.*

[8] *West of Orkney = the Project.*

43. Two PVA scenarios were modelled for great black-backed gull:

- West of Orkney alone WCS collisions; and
- Cumulative WCS collisions.

44. Two PVA scenarios were modelled for fulmar:

- West of Orkney alone low displacement; and
- West of Orkney alone high displacement.

45. Five PVA scenarios were modelled for Arctic tern:

- West of Orkney alone low displacement;
- West of Orkney alone high displacement;
- West of Orkney alone WCS collisions;
- West of Orkney alone WCS collisions plus low displacement;
- West of Orkney alone WCS collisions plus high displacement;

46. One PVA scenario was modelled for great skua:

- West of Orkney alone WCS collisions.

3 RESULTS

47. Information for each PVA is presented below, for each species, firstly for Project alone impacts (**Section 3.1**) and then for cumulative impacts (**Section 3.2** For each PVA, an input and an output table, along with a plot of population size over time, are presented.). Outputs were also presented in the **Addendum to the Offshore EIA Report**. All tables follow the same structure. The input and output tables for the kittiwake regional population PVA is used as an example to explain information presented in the tables for each PVA (**Table 3-1** and Error! Reference source not found.).

Table 3-1. Example input table to explain information presented for each PVA. Explanation is given in red text.

Baseline parameters	Settings	Impact parameters	Values
Reference name – species	Kittiwake	Number of scenarios of impact – see PVA Scenarios section above	5
Type – a simulation model run	Simulation	Are impacts applied separately to each subpopulation – no sub populations were included	FALSE
Case studies – not a case study example run	None	Are impacts specified separately for immatures – no, immatures have the same mortality rate as adults in the PVA	FALSE
Model to use for environmental stochasticity – type of distribution from which values are selected	Beta/Gamma	Are standard errors of impacts available	FALSE
Choose model for density dependence – model is density independent	No density dependence	Should random seeds be matched for impact scenarios – this ensures matched runs	TRUE
Include demographic stochasticity in model – model includes demographic stochasticity	TRUE	Impacts are specified as – the relative change in population size and growth rate	Relative
Number of simulations	1000	Years in which impacts are assumed to begin	2027
Random seed – number used to create the same set of parameter values selected from the stochastic distributions	1971	Years in which impacts are assumed to end	2062
Years for burn in	5	Scenario A name – West of Orkney Windfarm alone, with low displacement impacts	WoW Disp low
Species	Black-legged kittiwake	Scenario A Impact on productivity rate per pair mean – assumes no impacts to productivity, only to survival	0
Age at first breeding	4	Scenario A Impact on adult survival rate – change to adult survival rate due to collision and displacement impacts	1.674942e-05
Is there an upper constraint on productivity in the model – stochastic variation in brood size is capped at 2 chicks per pair	TRUE	Scenario A Impact on immature survival rate mean – immature survival is impacted to the same extent as adult survival	-
Maximum brood size per pair chicks will be constrained to be no greater than	2	Scenario B name - West of Orkney Windfarm alone, with high displacement impacts	WoW Disp high
Number of subpopulations – no sub populations are considered	1	Scenario B Impact on productivity rate per pair mean – assumes no impacts to productivity, only to survival	0
Units for initial population size	breeding.adults	Scenario B Impact on adult survival rate – change to adult survival rate due to collision and displacement impacts	5.033033e-05
Are baseline demographic rates specified separately for immatures – adult survival rate is different to immature survival rate	TRUE	Scenario B Impact on immature survival rate mean immature survival is impacted to the same extent as adult survival	-

Baseline parameters	Settings	Impact parameters	Values
Initial population size – starting population size, which is the number of breeding adults in that regional population	414,355	Scenario C name West of Orkney Windfarm with Collision mortality (CRM)	WoW CRM WCS
Year – value is set to 2023 for all populations despite the population being counted in different years	2023	Scenario C Impact on productivity rate per pair mean	0
Productivity rate per pair mean	0.5860126	Scenario C Impact on adult survival rate	9.759031e-05
Productivity rate per pair standard deviation	0.3704002	Scenario C Impact on immature survival rate mean	-
Adult survival rate Mean	0.854	Scenario D name West of Orkney Windfarm with Collision mortality (CRM) and low displacement impacts	WoW Disp low + WCS CRM
Adult survival rate standard deviation	0.051	Scenario D Impact on productivity rate per pair mean	0
Immatures survival rates 0 to 1 mean	0.79	Scenario D Impact on adult survival rate	0.0001143397
Immatures survival rates 0 to 1 standard deviation	0.077	Scenario D Impact on immature survival rate mean	-
Immatures survival rates 1 to 2 mean	0.854	Scenario E name West of Orkney Windfarm with Collision mortality (CRM) and high displacement impacts	WoW Disp high + CRM WCS
Immatures survival rates 1 to 2 standard deviation	0.077	Scenario E Impact on productivity rate per pair mean	0
Immatures survival rates 2 to 3 mean	0.854	Scenario E Impact on adult survival rate	0.0001479206
Immatures survival rates 2 to 3 standard deviation	0.077	Scenario E Impact on immature survival rate mean	-
Immatures survival rates 3 to 4 mean	0.854		
Immatures survival rates 3 to 4 standard deviation	0.077		
Immatures survival rates 4 to 5 mean adults start breeding at 4 years old so move to the adult age class	-		
Immatures survival rates 4 to 5 standard deviation	-		
Immatures survival rates 5 to 6 mean adults start breeding at 4 years old so move to the adult age class	-		
Immatures survival rates 5 to 6 standard deviation	-		
Units for output	breeding.adults		

Table 3-2. Example output table (from kittiwake PVA) to explain information presented for each PVA.

Total annual collision and displacement mortality for that reginal population (from WoW alone, or cumulatively, including/excluding Berwick Bank

Decrease in adult survival rate in presence of collision and displacement mortality, compared with baseline survival rate

Counterfactual of population growth rate (median, mean standard deviation, lower and upper 95% confidence interval

Counterfactual of population size (median, mean standard deviation, lower and upper 95% confidence interval

Scenario	Mortality	Increase in mortality rate	Year	C-PGR					C-PS					50% Quantiles	
				Med.	Mean	SD	LCI	UCI	Med.	Mean	SD	LCI	UCI	Q-UNIMP-50%	Q-IMP-50%
WoW Disp low	6.9	0.00001674942	25	1.0000	1.0000	0.0002	0.9997	1.0003	0.9997	0.9996	0.0042	0.9913	1.0081	50.2	49.9
WoW Disp high	20.9	0.00005033033	25	0.9999	0.9999	0.0002	0.9996	1.0003	0.9982	0.9983	0.0044	0.9893	1.0072	49.7	50.3
WoW CRM WCS	40.4	0.00009759031	25	0.9999	0.9999	0.0002	0.9996	1.0002	0.9969	0.9970	0.0043	0.9887	1.0059	49.4	50.7
WoW Disp low + WCS CRM	47.4	0.00011433973	25	0.9999	0.9999	0.0002	0.9995	1.0002	0.9967	0.9965	0.0043	0.9876	1.0051	49.5	50.6
WoW Disp high + CRM WCS	61.3	0.00014792063	25	0.9998	0.9998	0.0002	0.9995	1.0001	0.9953	0.9954	0.0041	0.9875	1.0039	49.4	50.8
WoW Disp low	6.9	0.00001674942	35	1.0000	1.0000	0.0001	0.9997	1.0002	0.9992	0.9993	0.0048	0.9899	1.0095	50.1	49.9
WoW Disp high	20.9	0.00005033033	35	0.9999	0.9999	0.0001	0.9997	1.0002	0.9977	0.9977	0.0051	0.9874	1.0079	50.0	50.1
WoW CRM WCS	40.4	0.00009759031	35	0.9999	0.9999	0.0001	0.9996	1.0002	0.9957	0.9958	0.0051	0.9860	1.0062	49.8	50.3
WoW Disp low + WCS CRM	47.4	0.00011433973	35	0.9999	0.9999	0.0001	0.9996	1.0001	0.9953	0.9952	0.0050	0.9854	1.0051	49.6	50.2
WoW Disp high + CRM WCS	61.3	0.00014792063	35	0.9998	0.9998	0.0001	0.9995	1.0001	0.9936	0.9936	0.0048	0.9835	1.0035	49.7	50.3
WoW Disp low	6.9	0.00001674942	50	1.0000	1.0000	0.0001	0.9998	1.0002	0.9990	0.9993	0.0059	0.9875	1.0111	50.3	49.8
WoW Disp high	20.9	0.00005033033	50	1.0000	1.0000	0.0001	0.9997	1.0002	0.9975	0.9977	0.0063	0.9854	1.0101	49.6	50.3
WoW CRM WCS	40.4	0.00009759031	50	0.9999	0.9999	0.0001	0.9997	1.0002	0.9956	0.9958	0.0062	0.9837	1.0087	49.8	50.3
WoW Disp low + WCS CRM	47.4	0.00011433973	50	0.9999	0.9999	0.0001	0.9997	1.0001	0.9953	0.9952	0.0061	0.9827	1.0076	49.7	50.4
WoW Disp high + CRM WCS	61.3	0.00014792063	50	0.9999	0.9999	0.0001	0.9997	1.0001	0.9937	0.9939	0.0060	0.9824	1.0068	49.7	50.6

See PVA Scenarios above for more information.
WoW alone: only West of Orkney impacts
CRM WCS: collision mortality included
Low: low displacement mortality scenario
High: high displacement mortality scenario

Year since start of PVA projection

50% quantiles of impacted and unimpacted populations

3.1 PVAs run for Regional Populations – Project Alone

3.1.1 Kittiwake

Table 3-3. PVA Inputs: Kittiwake WoW alone – Regional population

Baseline parameters	Settings	Impact parameters	Values
Reference name	Kittiwake WoW alone – Regional population	Number of scenarios of impact	5
Type	Simulation	Are impacts applied separately to each subpopulation	FALSE
Case studies	None	Are impacts specified separately for immatures	FALSE
Model to use for environmental stochasticity	Beta/Gamma	Are standard errors of impacts available	FALSE
Choose model for density dependence	No density dependence	Should random seeds be matched for impact scenarios	TRUE
Include demographic stochasticity in model	TRUE	Impacts are specified as	Relative
Number of simulations	1000	Years in which impacts are assumed to begin	2027
Random seed	1971	Years in which impacts are assumed to end	2062
Years for burn in	5	Scenario A name	WoW Disp low
Species	Black-legged kittiwake	Scenario A Impact on productivity rate per pair mean	0
Age at first breeding	4	Scenario A Impact on adult survival rate	1.674942e-05
Is there an upper constraint on productivity in the model	TRUE	Scenario A Impact on immature survival rate mean	-
Maximum brood size per pair chicks will be constrained to be no greater than	2	Scenario B name	WoW Disp high
Number of subpopulations	1	Scenario B Impact on productivity rate per pair mean	0
Units for initial population size	Breeding.adults	Scenario B Impact on adult survival rate	5.033033e-05
Are baseline demographic rates specified separately for immatures	TRUE	Scenario B Impact on immature survival rate mean	-
Initial population size	414355	Scenario C name	WoW CRM WCS
Year	2023	Scenario C Impact on productivity rate per pair mean	0
Productivity rate per pair mean	0.5860126	Scenario C Impact on adult survival rate	9.759031e-05
Productivity rate per pair standard deviation	0.3704002	Scenario C Impact on immature survival rate mean	-
Adult survival rate Mean	0.854	Scenario D name	WoW Disp low + WCS CRM
Adult survival rate standard deviation	0.051	Scenario D Impact on productivity rate per pair mean	0
Immatures survival rates 0 to 1 mean	0.79	Scenario D Impact on adult survival rate	0.0001143397
Immatures survival rates 0 to 1 standard deviation	0.077	Scenario D Impact on immature survival rate mean	-
Immatures survival rates 1 to 2 mean	0.854	Scenario E name	WoW Disp high + CRM WCS

Baseline parameters	Settings	Impact parameters	Values
Immatures survival rates 1 to 2 standard deviation	0.077	Scenario E Impact on productivity rate per pair mean	0
Immatures survival rates 2 to 3 mean	0.854	Scenario E Impact on adult survival rate	0.0001479206
Immatures survival rates 2 to 3 standard deviation	0.077	Scenario E Impact on immature survival rate mean	-
Immatures survival rates 3 to 4 mean	0.854		
Immatures survival rates 3 to 4 standard deviation	0.077		
Immatures survival rates 4 to 5 mean	-		
Immatures survival rates 4 to 5 standard deviation	-		
Immatures survival rates 5 to 6 mean	-		
Immatures survival rates 5 to 6 standard deviation	-		
Units for output	Breeding.adults		

Table 3-4. PVA Outputs: Kittiwake WoW alone – Regional population

Scenario	Mortality	Increase in mortality rate	Year	C-PGR					C-PS					50% Quantiles	
				Med.	Mean	SD	LCI	UCI	Med.	Mean	SD	LCI	UCI	Q-UNIMP-50%	Q-IMP-50%
WoW Disp low	6.9	0.00001674942	25	1.0000	1.0000	0.0002	0.9997	1.0003	0.9997	0.9996	0.0042	0.9913	1.0081	50.2	49.9
WoW Disp high	20.9	0.00005033033	25	0.9999	0.9999	0.0002	0.9996	1.0003	0.9982	0.9983	0.0044	0.9893	1.0072	49.7	50.3
WoW CRM WCS	40.4	0.00009759031	25	0.9999	0.9999	0.0002	0.9996	1.0002	0.9969	0.9970	0.0043	0.9887	1.0059	49.4	50.7
WoW Disp low + WCS CRM	47.4	0.00011433973	25	0.9999	0.9999	0.0002	0.9995	1.0002	0.9967	0.9965	0.0043	0.9876	1.0051	49.5	50.6
WoW Disp high + CRM WCS	61.3	0.00014792063	25	0.9998	0.9998	0.0002	0.9995	1.0001	0.9953	0.9954	0.0041	0.9875	1.0039	49.4	50.8
WoW Disp low	6.9	0.00001674942	35	1.0000	1.0000	0.0001	0.9997	1.0002	0.9992	0.9993	0.0048	0.9899	1.0095	50.1	49.9
WoW Disp high	20.9	0.00005033033	35	0.9999	0.9999	0.0001	0.9997	1.0002	0.9977	0.9977	0.0051	0.9874	1.0079	50.0	50.1
WoW CRM WCS	40.4	0.00009759031	35	0.9999	0.9999	0.0001	0.9996	1.0002	0.9957	0.9958	0.0051	0.9860	1.0062	49.8	50.3
WoW Disp low + WCS CRM	47.4	0.00011433973	35	0.9999	0.9999	0.0001	0.9996	1.0001	0.9953	0.9952	0.0050	0.9854	1.0051	49.6	50.2
WoW Disp high + CRM WCS	61.3	0.00014792063	35	0.9998	0.9998	0.0001	0.9995	1.0001	0.9936	0.9936	0.0048	0.9835	1.0035	49.7	50.3
WoW Disp low	6.9	0.00001674942	50	1.0000	1.0000	0.0001	0.9998	1.0002	0.9990	0.9993	0.0059	0.9875	1.0111	50.3	49.8
WoW Disp high	20.9	0.00005033033	50	1.0000	1.0000	0.0001	0.9997	1.0002	0.9975	0.9977	0.0063	0.9854	1.0101	49.6	50.3
WoW CRM WCS	40.4	0.00009759031	50	0.9999	0.9999	0.0001	0.9997	1.0002	0.9956	0.9958	0.0062	0.9837	1.0087	49.8	50.3
WoW Disp low + WCS CRM	47.4	0.00011433973	50	0.9999	0.9999	0.0001	0.9997	1.0001	0.9953	0.9952	0.0061	0.9827	1.0076	49.7	50.4
WoW Disp high + CRM WCS	61.3	0.00014792063	50	0.9999	0.9999	0.0001	0.9997	1.0001	0.9937	0.9939	0.0060	0.9824	1.0068	49.7	50.6

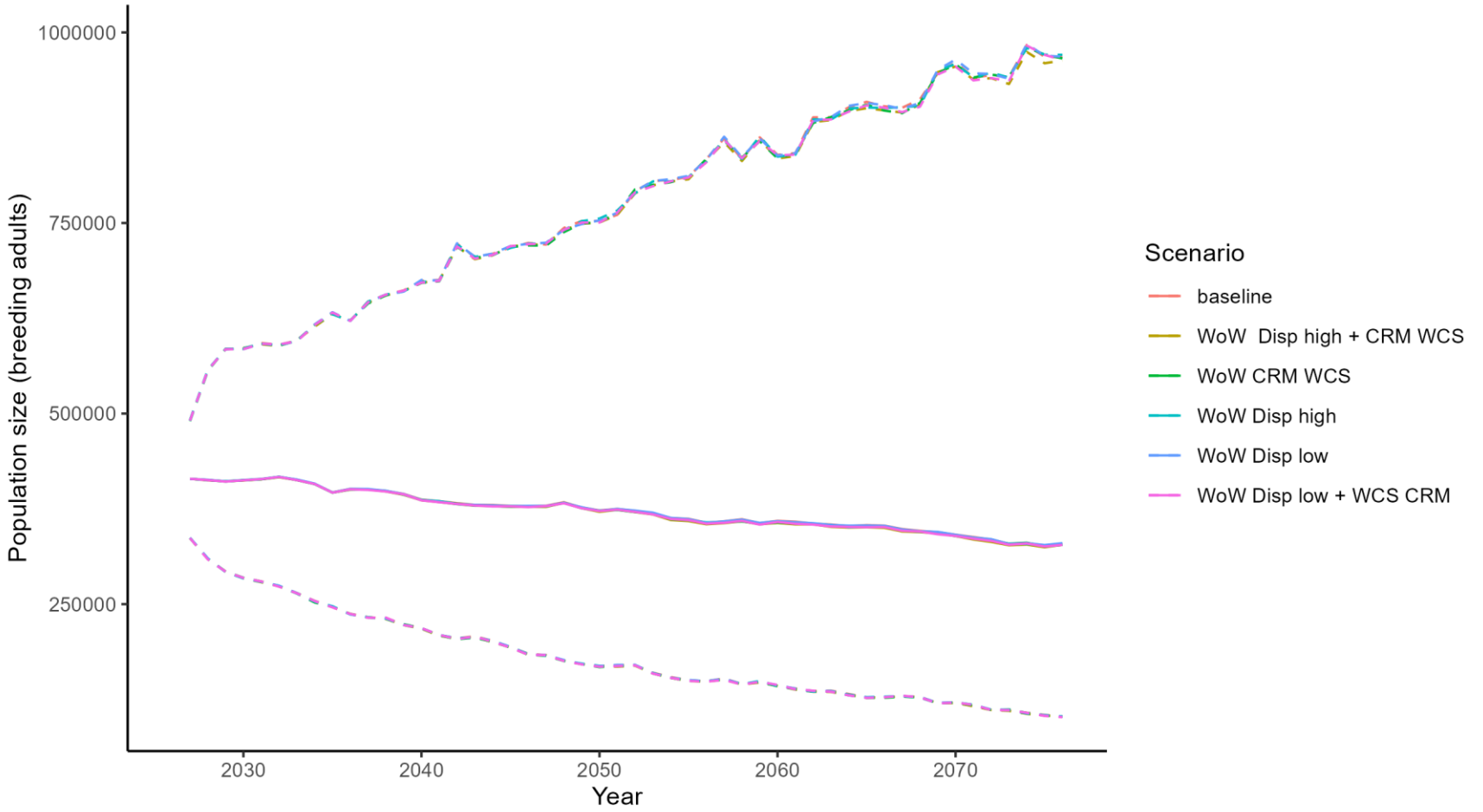

Figure 3-1. Kittiwake WoW alone – Regional population. Baseline = unimpacted population. WOW = West of Orkney Windfarm. Disp High = high displacement. Disp Low = low displacement. CRM WCS = collision mortality. Some trajectories are obscured in the plot due to being very similar to other trajectories.

3.1.2 Great Black-backed Gull

Table 3-5. PVA Inputs: Great black-backed gull WoW alone – Regional population

Baseline parameters	Settings	Impact parameters	Values
Reference name	Great black-backed gull WoW alone – Regional population	Number of scenarios of impact	1
Type	Simulation	Are impacts applied separately to each subpopulation	FALSE
Case studies	None	Are impacts specified separately for immatures	FALSE
Model to use for environmental stochasticity	Beta/Gamma	Are standard errors of impacts available	FALSE
Choose model for density dependence	No density dependence	Should random seeds be matched for impact scenarios	TRUE
Include demographic stochasticity in model	TRUE	Impacts are specified as	Relative
Number of simulations	1000	Years in which impacts are assumed to begin	2027
Random seed	1971	Years in which impacts are assumed to end	2062
Years for burn in	5	Scenario A name	WoW CRM WCS
Species	Great black-backed gull	Scenario A Impact on productivity rate per pair mean	0
Age at first breeding	5	Scenario A Impact on adult survival rate	0.0003598499
Is there an upper constraint on productivity in the model	TRUE	Scenario A Impact on immature survival rate mean	-
Maximum brood size per pair chicks will be constrained to be no greater than	3	Scenario B name	WoW Disp high
Number of subpopulations	1	Scenario B Impact on productivity rate per pair mean	0
Units for initial population size	Breeding.adults	Scenario B Impact on adult survival rate	0
Are baseline demographic rates specified separately for immatures	TRUE	Scenario B Impact on immature survival rate mean	-
Initial population size	3402	Scenario C name	WoW CRM WCS
Year	2023	Scenario C Impact on productivity rate per pair mean	0
Productivity rate per pair mean	0.9302198	Scenario C Impact on adult survival rate	0
Productivity rate per pair standard deviation	0.4328549	Scenario C Impact on immature survival rate mean	-
Adult survival rate Mean	0.93	Scenario D name	WoW Disp low + WCS CRM
Adult survival rate standard deviation	0.1	Scenario D Impact on productivity rate per pair mean	0
Immatures survival rates 0 to 1 mean	0.93	Scenario D Impact on adult survival rate	0
Immatures survival rates 0 to 1 standard deviation	0.1	Scenario D Impact on immature survival rate mean	-
Immatures survival rates 1 to 2 mean	0.93	Scenario E name	WoW Disp high + CRM WCS
Immatures survival rates 1 to 2 standard deviation	0.1	Scenario E Impact on productivity rate per pair mean	0

Baseline parameters	Settings	Impact parameters	Values
Immatures survival rates 2 to 3 mean	0.93	Scenario E Impact on adult survival rate	0
Immatures survival rates 2 to 3 standard deviation	0.1	Scenario E Impact on immature survival rate mean	-
Immatures survival rates 3 to 4 mean	0.93		
Immatures survival rates 3 to 4 standard deviation	0.1		
Immatures survival rates 4 to 5 mean	0.93		
Immatures survival rates 4 to 5 standard deviation	0.1		
Immatures survival rates 5 to 6 mean	-		
Immatures survival rates 5 to 6 standard deviation	-		
Units for output	Breeding.adults		

Table 3-6. PVA Outputs: Great black-backed gull WoW alone – Regional population

Scenario	Mortality	Increase in mortality rate	Year	C-PGR					C-PS					50% Quantiles	
				Med.	Mean	SD	LCI	UCI	Med.	Mean	SD	LCI	UCI	Q-UNIMP-50%	Q-IMP-50%
WoW CRM WCS	1.2	0.0003598499	25	0.9996	0.9996	0.0006	0.9986	1.0007	0.9896	0.9899	0.0154	0.9598	1.0210	48.6	50.8
WoW CRM WCS	1.2	0.0003598499	35	0.9996	0.9996	0.0004	0.9989	1.0004	0.9849	0.9859	0.0153	0.9570	1.0172	48.1	50.9
WoW CRM WCS	1.2	0.0003598499	50	0.9997	0.9997	0.0003	0.9992	1.0003	0.9853	0.9859	0.0152	0.9570	1.0165	49.3	50.2

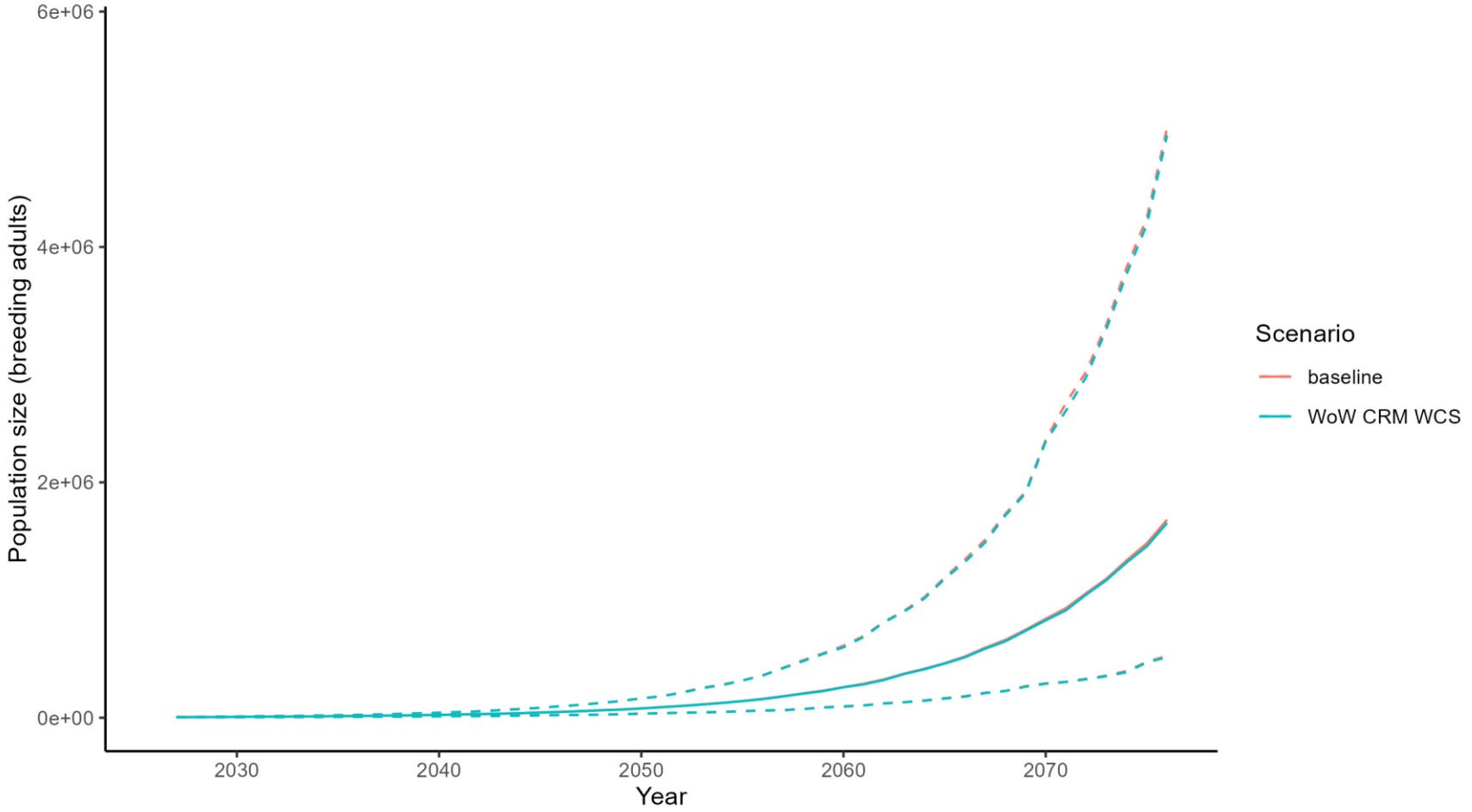

Figure 3-2. Great black-backed gull WoW alone – Regional population. Baseline = unimpacted population. WOW = West of Orkney Windfarm. CRM WCS = collision mortality. Some trajectories are obscured in the plot due to being very similar to other trajectories.

3.1.3 Arctic Tern

Table 3-7. PVA Inputs: Arctic tern WoW alone – Regional population

Baseline parameters	Settings	Impact parameters	Values
Reference name	Arctic tern WoW alone – Regional population	Number of scenarios of impact	5
Type	Simulation	Are impacts applied separately to each subpopulation	FALSE
Case studies	None	Are impacts specified separately for immatures	FALSE
Model to use for environmental stochasticity	Beta/Gamma	Are standard errors of impacts available	FALSE
Choose model for density dependence	No density dependence	Should random seeds be matched for impact scenarios	TRUE
Include demographic stochasticity in model	TRUE	Impacts are specified as	Relative
Number of simulations	1000	Years in which impacts are assumed to begin	2027
Random seed	1971	Years in which impacts are assumed to end	2062
Years for burn in	0	Scenario A name	WoW Disp low
Species	Arctic tern	Scenario A Impact on productivity rate per pair mean	0
Age at first breeding	4	Scenario A Impact on adult survival rate	0.0007673407
Is there an upper constraint on productivity in the model	TRUE	Scenario A Impact on immature survival rate mean	-
Maximum brood size per pair chicks will be constrained to be no greater than	1	Scenario B name	WoW Disp high
Number of subpopulations	1	Scenario B Impact on productivity rate per pair mean	0
Units for initial population size	Breeding.adults	Scenario B Impact on adult survival rate	0.001326072
Are baseline demographic rates specified separately for immatures	TRUE	Scenario B Impact on immature survival rate mean	-
Initial population size	1438	Scenario C name	WoW CRM WCS
Year	2023	Scenario C Impact on productivity rate per pair mean	0
Productivity rate per pair mean	0.38	Scenario C Impact on adult survival rate	0.0002990066
Productivity rate per pair standard deviation	0.325	Scenario C Impact on immature survival rate mean	-
Adult survival rate Mean	0.837	Scenario D name	WoW Disp low + WCS CRM
Adult survival rate standard deviation	0.035	Scenario D Impact on productivity rate per pair mean	0
Immatures survival rates 0 to 1 mean	0.837	Scenario D Impact on adult survival rate	0.001066347
Immatures survival rates 0 to 1 standard deviation	0.035	Scenario D Impact on immature survival rate mean	-
Immatures survival rates 1 to 2 mean	0.837	Scenario E name	WoW Disp high + CRM WCS
Immatures survival rates 1 to 2 standard deviation	0.035	Scenario E Impact on productivity rate per pair mean	0
Immatures survival rates 2 to 3 mean	0.837	Scenario E Impact on adult survival rate	0.001625079
Immatures survival rates 2 to 3 standard deviation	0.035	Scenario E Impact on immature survival rate mean	-
Immatures survival rates 3 to 4 mean	0.837		

Baseline parameters	Settings	Impact parameters	Values
Immatures survival rates 3 to 4 standard deviation	0.035		
Immatures survival rates 4 to 5 mean	-		
Immatures survival rates 4 to 5 standard deviation	-		
Immatures survival rates 5 to 6 mean	-		
Immatures survival rates 5 to 6 standard deviation	-		
Units for output	Breeding.adults		

Table 3-8. PVA Outputs: Arctic tern WoW alone – Regional population

Scenario	Mortality	Increase in mortality rate	Year	C-PGR					C-PS					50% Quantiles	
				Med.	Mean	SD	LCI	UCI	Med.	Mean	SD	LCI	UCI	Q-UNIMP-50%	Q-IMP-50%
WoW Disp low	1.1	0.0007673407	25	0.9991	0.9991	0.0047	0.9900	1.0084	0.9805	0.9854	0.1226	0.7641	1.2405	48.2	52.4
WoW Disp high	1.9	0.0013260722	25	0.9986	0.9985	0.0048	0.9892	1.0084	0.9675	0.9705	0.1233	0.7517	1.2358	47.0	54.3
WoW CRM WCS	0.4	0.0002990066	25	0.9998	0.9997	0.0046	0.9900	1.0088	0.9958	1.0000	0.1209	0.7784	1.2601	49.4	50.4
WoW Disp low + WCS CRM	1.5	0.0010663474	25	0.9988	0.9987	0.0046	0.9899	1.0085	0.9702	0.9742	0.1202	0.7625	1.2408	47.3	53.6
WoW Disp high + CRM WCS	2.3	0.0016250788	25	0.9981	0.9981	0.0048	0.9882	1.0076	0.9491	0.9595	0.1214	0.7326	1.2190	46.3	55.4
WoW Disp low	1.1	0.0007673407	35	0.9993	0.9993	0.0049	0.9898	1.0089	0.9810	0.9898	0.1750	0.6863	1.3881	47.8	53.3
WoW Disp high	1.9	0.0013260722	35	0.9985	0.9985	0.0050	0.9886	1.0079	0.9444	0.9634	0.1752	0.6666	1.3302	45.1	56.1
WoW CRM WCS	0.4	0.0002990066	35	0.9998	0.9999	0.0048	0.9898	1.0098	0.9939	1.0103	0.1782	0.6914	1.4289	49.4	51.9
WoW Disp low + WCS CRM	1.5	0.0010663474	35	0.9989	0.9988	0.0048	0.9892	1.0083	0.9585	0.9727	0.1745	0.6810	1.3575	45.1	55.9
WoW Disp high + CRM WCS	2.3	0.0016250788	35	0.9980	0.9981	0.0049	0.9886	1.0081	0.9309	0.9480	0.1702	0.6560	1.3479	44.5	55.2
WoW Disp low	1.1	0.0007673407	50	0.9993	0.9992	0.0059	0.9878	1.0103	0.9630	1.0062	0.3159	0.5347	1.7085	48.1	52.9
WoW Disp high	1.9	0.0013260722	50	0.9986	0.9987	0.0058	0.9873	1.0103	0.9300	0.9752	0.2948	0.5208	1.6739	47.1	54.5
WoW CRM WCS	0.4	0.0002990066	50	0.9999	0.9998	0.0056	0.9885	1.0112	1.0000	1.0323	0.3168	0.5650	1.7500	49.6	51.7
WoW Disp low + WCS CRM	1.5	0.0010663474	50	0.9992	0.9991	0.0057	0.9867	1.0103	0.9590	0.9961	0.3045	0.5000	1.6977	48.1	53.2
WoW Disp high + CRM WCS	2.3	0.0016250788	50	0.9987	0.9986	0.0058	0.9870	1.0096	0.9377	0.9720	0.2937	0.5118	1.6472	45.0	56.0

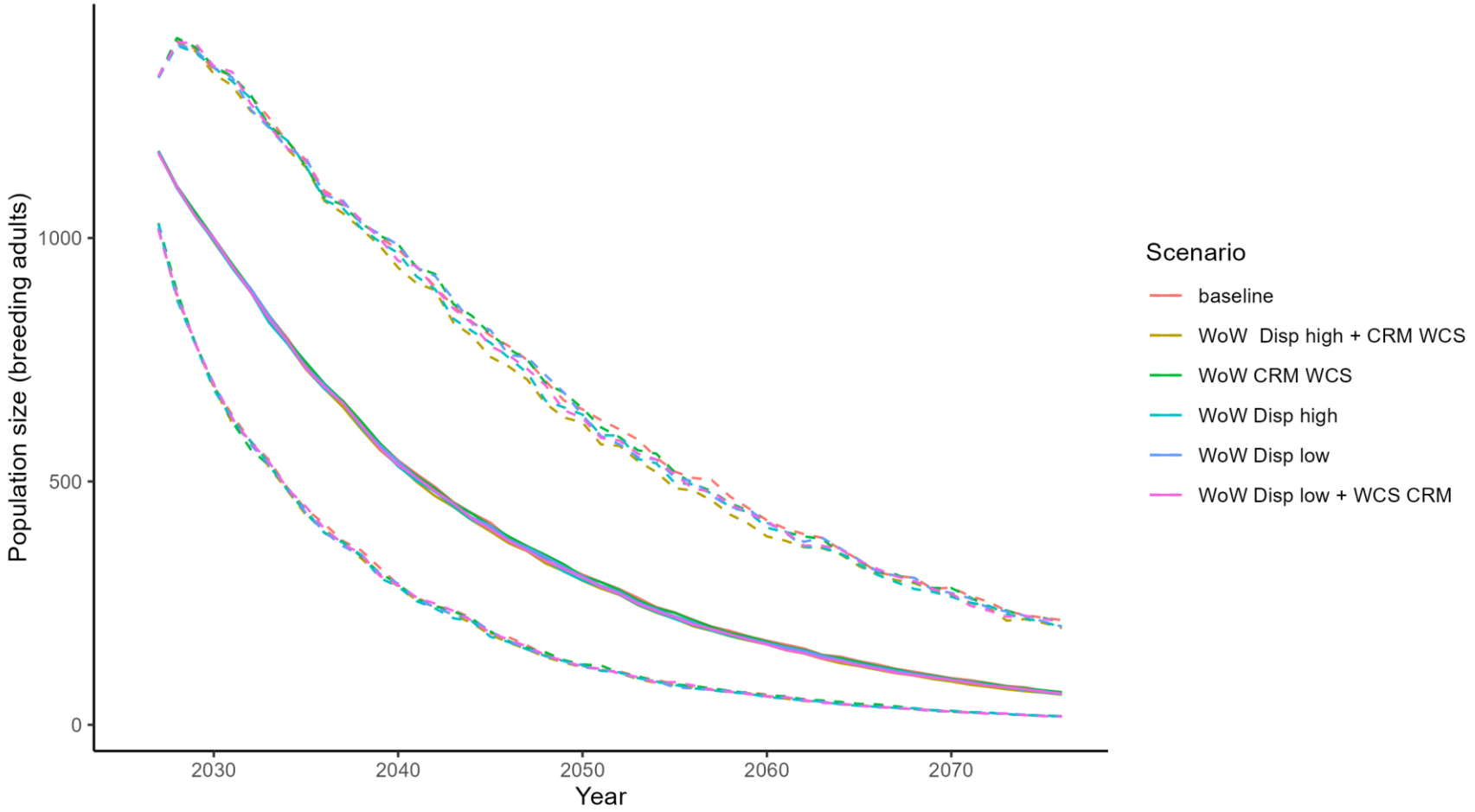

Figure 3-3. Arctic tern WoW alone – Regional population. Baseline = unimpacted population. WOW = West of Orkney Windfarm. Disp High = high displacement. Disp Low = low displacement. CRM WCS = collision mortality. Some trajectories are obscured in the plot due to being very similar to other trajectories.

3.1.4 Great Skua

Table 3-9. PVA Inputs: Great skua WoW alone – Regional population

Baseline parameters	Settings	Impact parameters	Values
Reference name	Great skua WoW alone – Regional population	Number of scenarios of impact	1
Type	Simulation	Are impacts applied separately to each subpopulation	FALSE
Case studies	None	Are impacts specified separately for immatures	FALSE
Model to use for environmental stochasticity	Beta/Gamma	Are standard errors of impacts available	FALSE
Choose model for density dependence	No density dependence	Should random seeds be matched for impact scenarios	TRUE
Include demographic stochasticity in model	TRUE	Impacts are specified as	Relative
Number of simulations	1000	Years in which impacts are assumed to begin	2027
Random seed	1971	Years in which impacts are assumed to end	2062
Years for burn in	5	Scenario A name	WoW CRM WCS
Species	Great skua	Scenario A Impact on productivity rate per pair mean	0
Age at first breeding	5	Scenario A Impact on adult survival rate	7.100538e-06
Is there an upper constraint on productivity in the model	TRUE	Scenario A Impact on immature survival rate mean	-
Maximum brood size per pair chicks will be constrained to be no greater than	1	Scenario B name	WoW Disp high
Number of subpopulations	1	Scenario B Impact on productivity rate per pair mean	0
Units for initial population size	Breeding.adults	Scenario B Impact on adult survival rate	0
Are baseline demographic rates specified separately for immatures	TRUE	Scenario B Impact on immature survival rate mean	-
Initial population size	53517	Scenario C name	WoW CRM WCS
Year	2023	Scenario C Impact on productivity rate per pair mean	0
Productivity rate per pair mean	0.651	Scenario C Impact on adult survival rate	0
Productivity rate per pair standard deviation	0.308	Scenario C Impact on immature survival rate mean	-
Adult survival rate Mean	0.882	Scenario D name	WoW Disp low + WCS CRM
Adult survival rate standard deviation	0.038	Scenario D Impact on productivity rate per pair mean	0
Immatures survival rates 0 to 1 mean	0.939	Scenario D Impact on adult survival rate	0
Immatures survival rates 0 to 1 standard deviation	0.038	Scenario D Impact on immature survival rate mean	-
Immatures survival rates 1 to 2 mean	0.939	Scenario E name	WoW Disp high + CRM WCS
Immatures survival rates 1 to 2 standard deviation	0.038	Scenario E Impact on productivity rate per pair mean	0
Immatures survival rates 2 to 3 mean	0.939	Scenario E Impact on adult survival rate	0
Immatures survival rates 2 to 3 standard deviation	0.038	Scenario E Impact on immature survival rate mean	-
Immatures survival rates 3 to 4 mean	0.939		
Immatures survival rates 3 to 4 standard deviation	0.038		

Baseline parameters	Settings	Impact parameters	Values
Immatures survival rates 4 to 5 mean	0.938999999999		
Immatures survival rates 4 to 5 standard deviation	3.799999999999		
Immatures survival rates 5 to 6 mean	-		
Immatures survival rates 5 to 6 standard deviation	-		
Units for output	Breeding.adults		

Table 3-10. PVA Outputs: Great skua WoW alone – Regional population

Scenario	Mortality	Increase in mortality rate	Year	C-PGR					C-PS					50% Quantiles	
				Med.	Mean	SD	LCI	UCI	Med.	Mean	SD	LCI	UCI	Q-UNIMP-50%	Q-IMP-50%
WoW CRM WCS	0.4	0.000007100538	25	1	1	0.0002	0.9996	1.0004	1.0002	1.0001	0.0055	0.9895	1.0109	50.2	49.9
WoW CRM WCS	0.4	0.000007100538	35	1	1	0.0001	0.9997	1.0003	0.9999	1.0000	0.0057	0.9894	1.0115	49.8	50.3
WoW CRM WCS	0.4	0.000007100538	50	1	1	0.0001	0.9998	1.0002	0.9999	1.0000	0.0059	0.9890	1.0114	50.2	49.8

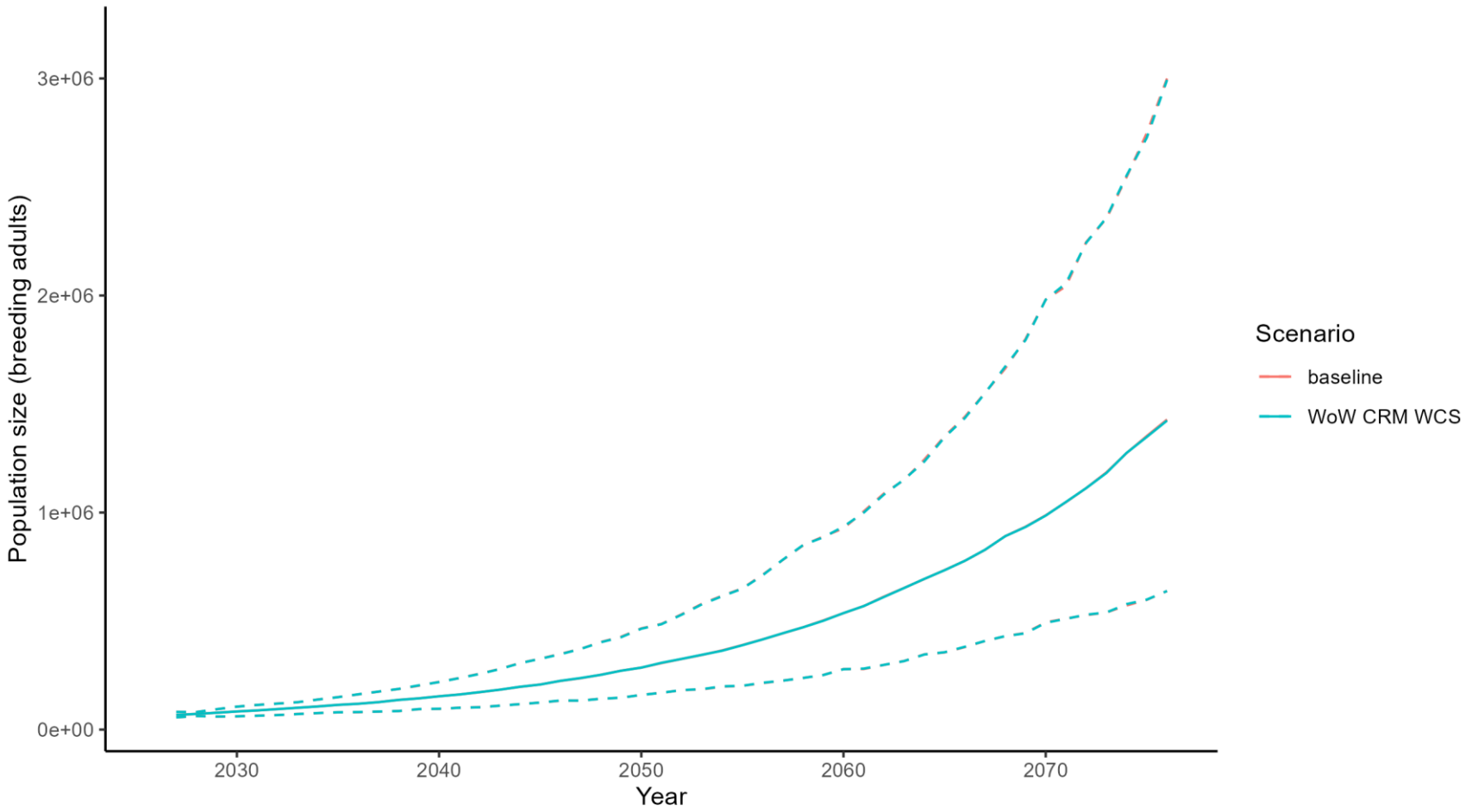

Figure 3-4. Great skua WoW alone – Regional population. Baseline = unimpacted population. WOW = West of Orkney Windfarm. CRM WCS = collision mortality. Some trajectories are obscured in the plot due to being very similar to other trajectories.

3.1.5 Guillemot

Table 3-11. PVA Inputs: Guillemot WoW alone – Regional population

Baseline parameters	Settings	Impact parameters	Values
Reference name	Guillemot WoW alone – Regional population	Number of scenarios of impact	2
Type	Simulation	Are impacts applied separately to each subpopulation	FALSE
Case studies	None	Are impacts specified separately for immatures	FALSE
Model to use for environmental stochasticity	Beta/Gamma	Are standard errors of impacts available	FALSE
Choose model for density dependence	No density dependence	Should random seeds be matched for impact scenarios	TRUE
Include demographic stochasticity in model	TRUE	Impacts are specified as	Relative
Number of simulations	1000	Years in which impacts are assumed to begin	2027
Random seed	1971	Years in which impacts are assumed to end	2062
Years for burn in	5	Scenario A name	WoW Disp low
Species	Common guillemot	Scenario A Impact on productivity rate per pair mean	0
Age at first breeding	6	Scenario A Impact on adult survival rate	0.0001733381
Is there an upper constraint on productivity in the model	TRUE	Scenario A Impact on immature survival rate mean	-
Maximum brood size per pair chicks will be constrained to be no greater than	1	Scenario B name	WoW Disp high
Number of subpopulations	1	Scenario B Impact on productivity rate per pair mean	0
Units for initial population size	Breeding.adults	Scenario B Impact on adult survival rate	0.0003247411
Are baseline demographic rates specified separately for immatures	TRUE	Scenario B Impact on immature survival rate mean	-
Initial population size	980165	Scenario C name	WoW CRM WCS
Year	2023	Scenario C Impact on productivity rate per pair mean	0
Productivity rate per pair mean	0.5017244	Scenario C Impact on adult survival rate	0
Productivity rate per pair standard deviation	0.2080057	Scenario C Impact on immature survival rate mean	-
Adult survival rate Mean	0.94	Scenario D name	WoW Disp low + WCS CRM
Adult survival rate standard deviation	0.025	Scenario D Impact on productivity rate per pair mean	0
Immatures survival rates 0 to 1 mean	0.56	Scenario D Impact on adult survival rate	0
Immatures survival rates 0 to 1 standard deviation	0.058	Scenario D Impact on immature survival rate mean	-
Immatures survival rates 1 to 2 mean	0.792	Scenario E name	WoW Disp high + CRM WCS
Immatures survival rates 1 to 2 standard deviation	0.152	Scenario E Impact on productivity rate per pair mean	0
Immatures survival rates 2 to 3 mean	0.917	Scenario E Impact on adult survival rate	0
Immatures survival rates 2 to 3 standard deviation	0.098	Scenario E Impact on immature survival rate mean	-
Immatures survival rates 3 to 4 mean	0.938		

Baseline parameters	Settings	Impact parameters	Values
Immatures survival rates 3 to 4 standard deviation	0.107		
Immatures survival rates 4 to 5 mean	0.94		
Immatures survival rates 4 to 5 standard deviation	2.500000000000		
Immatures survival rates 5 to 6 mean	0.94		
Immatures survival rates 5 to 6 standard deviation	2.500000000000		
Units for output	Breeding.adults		

Table 3-12. PVA Outputs: Guillemot WoW alone – Regional population

Scenario	Mortality	Increase in mortality rate	Year	C-PGR					C-PS					50% Quantiles	
				Med.	Mean	SD	LCI	UCI	Med.	Mean	SD	LCI	UCI	Q-UNIMP-50%	Q-IMP-50%
WoW Disp low	169.9	0.0001733381	25	0.9998	0.9998	0.0001	0.9997	0.9999	0.9951	0.9951	0.0016	0.9918	0.9981	48.8	50.7
WoW Disp high	318.3	0.0003247411	25	0.9996	0.9996	0.0001	0.9995	0.9998	0.9907	0.9907	0.0016	0.9876	0.9939	46.9	51.9
WoW Disp low	169.9	0.0001733381	35	0.9998	0.9998	0.0001	0.9997	0.9999	0.9932	0.9932	0.0018	0.9896	0.9966	48.8	51.7
WoW Disp high	318.3	0.0003247411	35	0.9996	0.9996	0.0001	0.9995	0.9997	0.9871	0.9871	0.0019	0.9833	0.9907	47.7	53.1
WoW Disp low	169.9	0.0001733381	50	0.9999	0.9999	0.0000	0.9998	0.9999	0.9932	0.9932	0.0021	0.9893	0.9972	48.8	51.3
WoW Disp high	318.3	0.0003247411	50	0.9997	0.9997	0.0000	0.9997	0.9998	0.9871	0.9871	0.0021	0.9831	0.9912	47.2	52.0

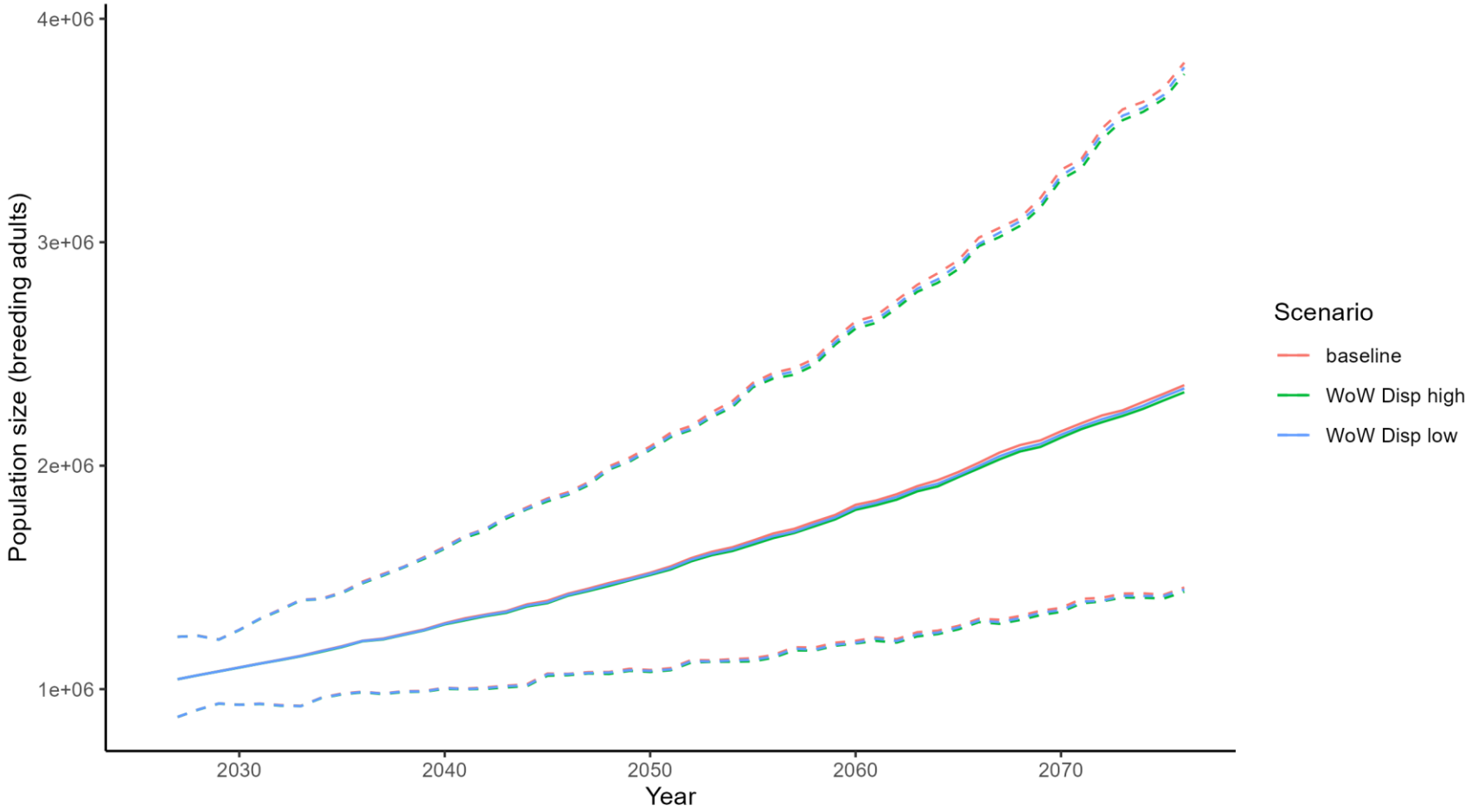

Figure 3-5. Guillemot WoW alone – Regional population. Baseline = unimpacted population. WOW = West of Orkney Windfarm. Disp High = high displacement. Disp Low = low displacement. Some trajectories are obscured in the plot due to being very similar to other trajectories.

3.1.6 Razorbill

Table 3-13. PVA Inputs: Razorbill WoW alone – Regional population

Baseline parameters	Settings	Impact parameters	Values
Reference name	Razorbill WoW alone – Regional population	Number of scenarios of impact	2
Type	Simulation	Are impacts applied separately to each subpopulation	FALSE
Case studies	None	Are impacts specified separately for immatures	FALSE
Model to use for environmental stochasticity	Beta/Gamma	Are standard errors of impacts available	FALSE
Choose model for density dependence	No density dependence	Should random seeds be matched for impact scenarios	TRUE
Include demographic stochasticity in model	TRUE	Impacts are specified as	Relative
Number of simulations	1000	Years in which impacts are assumed to begin	2027
Random seed	1971	Years in which impacts are assumed to end	2062
Years for burn in	5	Scenario A name	WoW Disp low
Species	Razorbill	Scenario A Impact on productivity rate per pair mean	0
Age at first breeding	5	Scenario A Impact on adult survival rate	2.076033e-05
Is there an upper constraint on productivity in the model	TRUE	Scenario A Impact on immature survival rate mean	-
Maximum brood size per pair chicks will be constrained to be no greater than	1	Scenario B name	WoW Disp high
Number of subpopulations	1	Scenario B Impact on productivity rate per pair mean	0
Units for initial population size	Breeding.adults	Scenario B Impact on adult survival rate	3.865749e-05
Are baseline demographic rates specified separately for immatures	TRUE	Scenario B Impact on immature survival rate mean	-
Initial population size	140698	Scenario C name	WoW CRM WCS
Year	2023	Scenario C Impact on productivity rate per pair mean	0
Productivity rate per pair mean	0.4401746	Scenario C Impact on adult survival rate	0
Productivity rate per pair standard deviation	0.1886934	Scenario C Impact on immature survival rate mean	-
Adult survival rate Mean	0.895	Scenario D name	WoW Disp low + WCS CRM
Adult survival rate standard deviation	0.067	Scenario D Impact on productivity rate per pair mean	0
Immatures survival rates 0 to 1 mean	0.63	Scenario D Impact on adult survival rate	0
Immatures survival rates 0 to 1 standard deviation	0.067	Scenario D Impact on immature survival rate mean	-
Immatures survival rates 1 to 2 mean	0.63	Scenario E name	WoW Disp high + CRM WCS
Immatures survival rates 1 to 2 standard deviation	0.067	Scenario E Impact on productivity rate per pair mean	0
Immatures survival rates 2 to 3 mean	0.895	Scenario E Impact on adult survival rate	0
Immatures survival rates 2 to 3 standard deviation	0.067	Scenario E Impact on immature survival rate mean	-
Immatures survival rates 3 to 4 mean	0.895		
Immatures survival rates 3 to 4 standard deviation	0.067		

Baseline parameters	Settings	Impact parameters	Values
Immatures survival rates 4 to 5 mean	0.895000000000		
Immatures survival rates 4 to 5 standard deviation	6.700000000000		
Immatures survival rates 5 to 6 mean	-		
Immatures survival rates 5 to 6 standard deviation	-		
Units for output	Breeding.adults		

Table 3-14. PVA Outputs: Razorbill WoW alone – Regional population

Scenario	Mortality	Increase in mortality rate	Year	C-PGR					C-PS					50% Quantiles	
				Med.	Mean	SD	LCI	UCI	Med.	Mean	SD	LCI	UCI	Q-UNIMP-50%	Q-IMP-50%
WoW Disp low	2.9	0.00002076033	25	1	1	0.0003	0.9993	1.0006	0.9994	0.9993	0.0084	0.9822	1.0157	50.1	49.9
WoW Disp high	5.4	0.00003865749	25	1	1	0.0003	0.9993	1.0006	0.9989	0.9989	0.0088	0.9812	1.0160	49.5	50.4
WoW Disp low	2.9	0.00002076033	35	1	1	0.0003	0.9993	1.0006	1.0000	0.9996	0.0109	0.9773	1.0196	49.9	50.1
WoW Disp high	5.4	0.00003865749	35	1	1	0.0003	0.9993	1.0006	0.9987	0.9988	0.0112	0.9767	1.0214	49.5	50.6
WoW Disp low	2.9	0.00002076033	50	1	1	0.0003	0.9994	1.0006	0.9998	0.9997	0.0164	0.9678	1.0319	49.7	50.5
WoW Disp high	5.4	0.00003865749	50	1	1	0.0003	0.9994	1.0006	0.9998	0.9996	0.0159	0.9683	1.0299	49.7	50.6

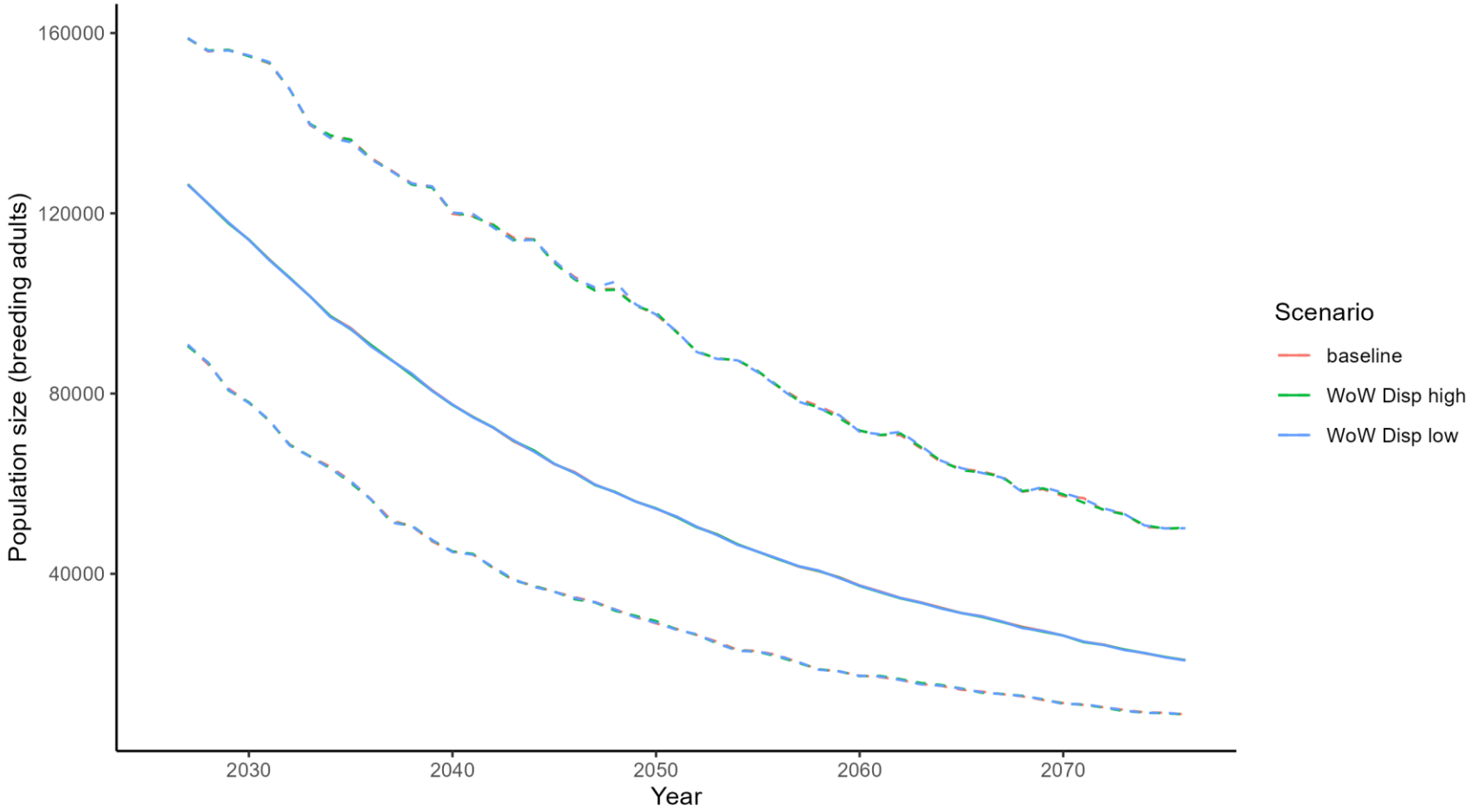

Figure 3-6. Razorbill WoW alone – Regional population. Baseline = unimpacted population. WOW = West of Orkney Windfarm. Disp High = high displacement. Disp Low = low displacement. Some trajectories are obscured in the plot due to being very similar to other trajectories.

3.1.7 Puffin

Table 3-15. PVA Inputs: Puffin WoW alone – Regional population

Baseline parameters	Settings	Impact parameters	Values
Reference name	Puffin WoW alone – Regional population	Number of scenarios of impact	2
Type	Simulation	Are impacts applied separately to each subpopulation	FALSE
Case studies	None	Are impacts specified separately for immatures	FALSE
Model to use for environmental stochasticity	Beta/Gamma	Are standard errors of impacts available	FALSE
Choose model for density dependence	No density dependence	Should random seeds be matched for impact scenarios	TRUE
Include demographic stochasticity in model	TRUE	Impacts are specified as	Relative
Number of simulations	1000	Years in which impacts are assumed to begin	2027
Random seed	1971	Years in which impacts are assumed to end	2062
Years for burn in	5	Scenario A name	WoW Disp low
Species	Atlantic puffin	Scenario A Impact on productivity rate per pair mean	0
Age at first breeding	5	Scenario A Impact on adult survival rate	9.404411e-05
Is there an upper constraint on productivity in the model	TRUE	Scenario A Impact on immature survival rate mean	-
Maximum brood size per pair chicks will be constrained to be no greater than	1	Scenario B name	WoW Disp high
Number of subpopulations	1	Scenario B Impact on productivity rate per pair mean	0
Units for initial population size	Breeding.adults	Scenario B Impact on adult survival rate	0.000171672
Are baseline demographic rates specified separately for immatures	TRUE	Scenario B Impact on immature survival rate mean	-
Initial population size	1145207	Scenario C name	WoW CRM WCS
Year	2023	Scenario C Impact on productivity rate per pair mean	0
Productivity rate per pair mean	0.4154966	Scenario C Impact on adult survival rate	0
Productivity rate per pair standard deviation	0.2120927	Scenario C Impact on immature survival rate mean	-
Adult survival rate Mean	0.907	Scenario D name	WoW Disp low + WCS CRM
Adult survival rate standard deviation	0.083	Scenario D Impact on productivity rate per pair mean	0
Immatures survival rates 0 to 1 mean	0.709	Scenario D Impact on adult survival rate	0
Immatures survival rates 0 to 1 standard deviation	0.108	Scenario D Impact on immature survival rate mean	-
Immatures survival rates 1 to 2 mean	0.709	Scenario E name	WoW Disp high + CRM WCS
Immatures survival rates 1 to 2 standard deviation	0.108	Scenario E Impact on productivity rate per pair mean	0
Immatures survival rates 2 to 3 mean	0.709	Scenario E Impact on adult survival rate	0
Immatures survival rates 2 to 3 standard deviation	0.108	Scenario E Impact on immature survival rate mean	-
Immatures survival rates 3 to 4 mean	0.76		
Immatures survival rates 3 to 4 standard deviation	0.093		

Baseline parameters	Settings	Impact parameters	Values
Immatures survival rates 4 to 5 mean	0.805000000000		
Immatures survival rates 4 to 5 standard deviation	8.300000000000		
Immatures survival rates 5 to 6 mean	-		
Immatures survival rates 5 to 6 standard deviation	-		
Units for output	Breeding.adults		

Table 3-16. PVA Outputs: Puffin WoW alone – Regional population

Scenario	Mortality	Increase in mortality rate	Year	C-PGR					C-PS					50% Quantiles	
				Med.	Mean	SD	LCI	UCI	Med.	Mean	SD	LCI	UCI	Q-UNIMP-50%	Q-IMP-50%
WoW Disp low	107.7	0.00009404411	25	0.9999	0.9999	0.0001	0.9996	1.0001	0.9972	0.9972	0.0033	0.9906	1.0037	49.6	50.3
WoW Disp high	196.6	0.00017167198	25	0.9998	0.9998	0.0001	0.9996	1.0000	0.9948	0.9948	0.0033	0.9882	1.0016	49.5	50.7
WoW Disp low	107.7	0.00009404411	35	0.9999	0.9999	0.0001	0.9996	1.0001	0.9960	0.9960	0.0044	0.9872	1.0049	49.4	50.3
WoW Disp high	196.6	0.00017167198	35	0.9998	0.9998	0.0001	0.9996	1.0000	0.9928	0.9928	0.0043	0.9842	1.0017	49.4	50.9
WoW Disp low	107.7	0.00009404411	50	0.9999	0.9999	0.0001	0.9997	1.0002	0.9963	0.9960	0.0068	0.9826	1.0096	50.0	50.2
WoW Disp high	196.6	0.00017167198	50	0.9999	0.9999	0.0001	0.9996	1.0001	0.9927	0.9927	0.0064	0.9798	1.0052	49.8	50.2

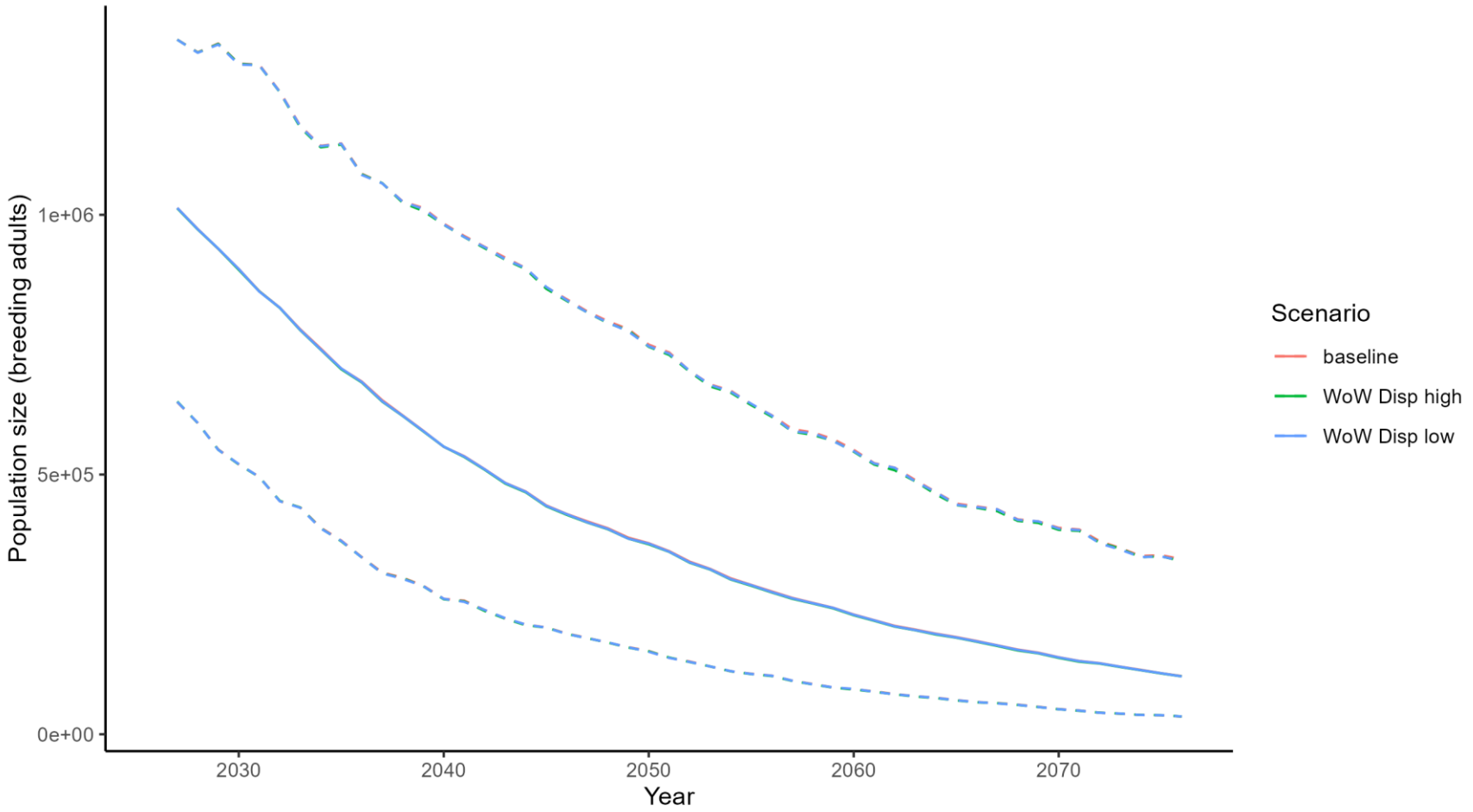

Figure 3-7. Puffin WoW alone – Regional population. Baseline = unimpacted population. WOW = West of Orkney Windfarm. Disp High = high displacement. Disp Low = low displacement. Some trajectories are obscured in the plot due to being very similar to other trajectories.

3.1.8 Fulmar

Table 3-17. PVA Inputs: Fulmar WoW alone – Regional population

Baseline parameters	Settings	Impact parameters	Values
Reference name	Fulmar WoW alone – Regional population	Number of scenarios of impact	2
Type	Simulation	Are impacts applied separately to each subpopulation	FALSE
Case studies	None	Are impacts specified separately for immatures	FALSE
Model to use for environmental stochasticity	Beta/Gamma	Are standard errors of impacts available	FALSE
Choose model for density dependence	No density dependence	Should random seeds be matched for impact scenarios	TRUE
Include demographic stochasticity in model	TRUE	Impacts are specified as	Relative
Number of simulations	1000	Years in which impacts are assumed to begin	2027
Random seed	1971	Years in which impacts are assumed to end	2062
Years for burn in	5	Scenario A name	WoW Disp low
Species	Norther fulmar	Scenario A Impact on productivity rate per pair mean	0
Age at first breeding	9	Scenario A Impact on adult survival rate	1.343645e-05
Is there an upper constraint on productivity in the model	TRUE	Scenario A Impact on immature survival rate mean	-
Maximum brood size per pair chicks will be constrained to be no greater than	1	Scenario B name	WoW Disp high
Number of subpopulations	1	Scenario B Impact on productivity rate per pair mean	0
Units for initial population size	Breeding.adults	Scenario B Impact on adult survival rate	4.030935e-05
Are baseline demographic rates specified separately for immatures	TRUE	Scenario B Impact on immature survival rate mean	-
Initial population size	1138694	Scenario C name	WoW CRM WCS
Year	2023	Scenario C Impact on productivity rate per pair mean	0
Productivity rate per pair mean	0.419	Scenario C Impact on adult survival rate	0
Productivity rate per pair standard deviation	0.127	Scenario C Impact on immature survival rate mean	-
Adult survival rate Mean	0.936	Scenario D name	WoW Disp low + WCS CRM
Adult survival rate standard deviation	0.055	Scenario D Impact on productivity rate per pair mean	0
Immatures survival rates 0 to 1 mean	0.845	Scenario D Impact on adult survival rate	0
Immatures survival rates 0 to 1 standard deviation	0.055	Scenario D Impact on immature survival rate mean	-
Immatures survival rates 1 to 2 mean	0.845	Scenario E name	WoW Disp high + CRM WCS
Immatures survival rates 1 to 2 standard deviation	0.055	Scenario E Impact on productivity rate per pair mean	0
Immatures survival rates 2 to 3 mean	0.845	Scenario E Impact on adult survival rate	0
Immatures survival rates 2 to 3 standard deviation	0.055	Scenario E Impact on immature survival rate mean	-
Immatures survival rates 3 to 4 mean	0.845		
Immatures survival rates 3 to 4 standard deviation	0.055		

Baseline parameters	Settings	Impact parameters	Values
Immatures survival rates 4 to 5 mean	0.844999999999		
Immatures survival rates 4 to 5 standard deviation	5.5E-2		
Immatures survival rates 5 to 6 mean	0.844999999999		
Immatures survival rates 5 to 6 standard deviation	5.5E-2		
Units for output	Breeding.adults		

Table 3-18. PVA Outputs: Fulmar WoW alone – Regional population

Scenario	Mortality	Increase in mortality rate	Year	C-PGR					C-PS					50% Quantiles	
				Med.	Mean	SD	LCI	UCI	Med.	Mean	SD	LCI	UCI	Q-UNIMP-50%	Q-IMP-50%
WoW Disp low	15.3	0.00001343645	25	1	1	0.0001	0.9998	1.0001	0.9996	0.9996	0.0019	0.9958	1.0036	49.9	50.0
WoW Disp high	45.9	0.00004030935	25	1	1	0.0001	0.9998	1.0001	0.9988	0.9988	0.0019	0.9949	1.0026	49.5	50.1
WoW Disp low	15.3	0.00001343645	35	1	1	0.0001	0.9999	1.0001	0.9996	0.9996	0.0024	0.9949	1.0043	49.9	50.2
WoW Disp high	45.9	0.00004030935	35	1	1	0.0001	0.9998	1.0001	0.9985	0.9985	0.0023	0.9938	1.0031	49.9	50.2
WoW Disp low	15.3	0.00001343645	50	1	1	0.0001	0.9999	1.0001	0.9995	0.9996	0.0030	0.9934	1.0054	50.1	49.9
WoW Disp high	45.9	0.00004030935	50	1	1	0.0001	0.9999	1.0001	0.9985	0.9985	0.0029	0.9929	1.0041	50.0	49.9

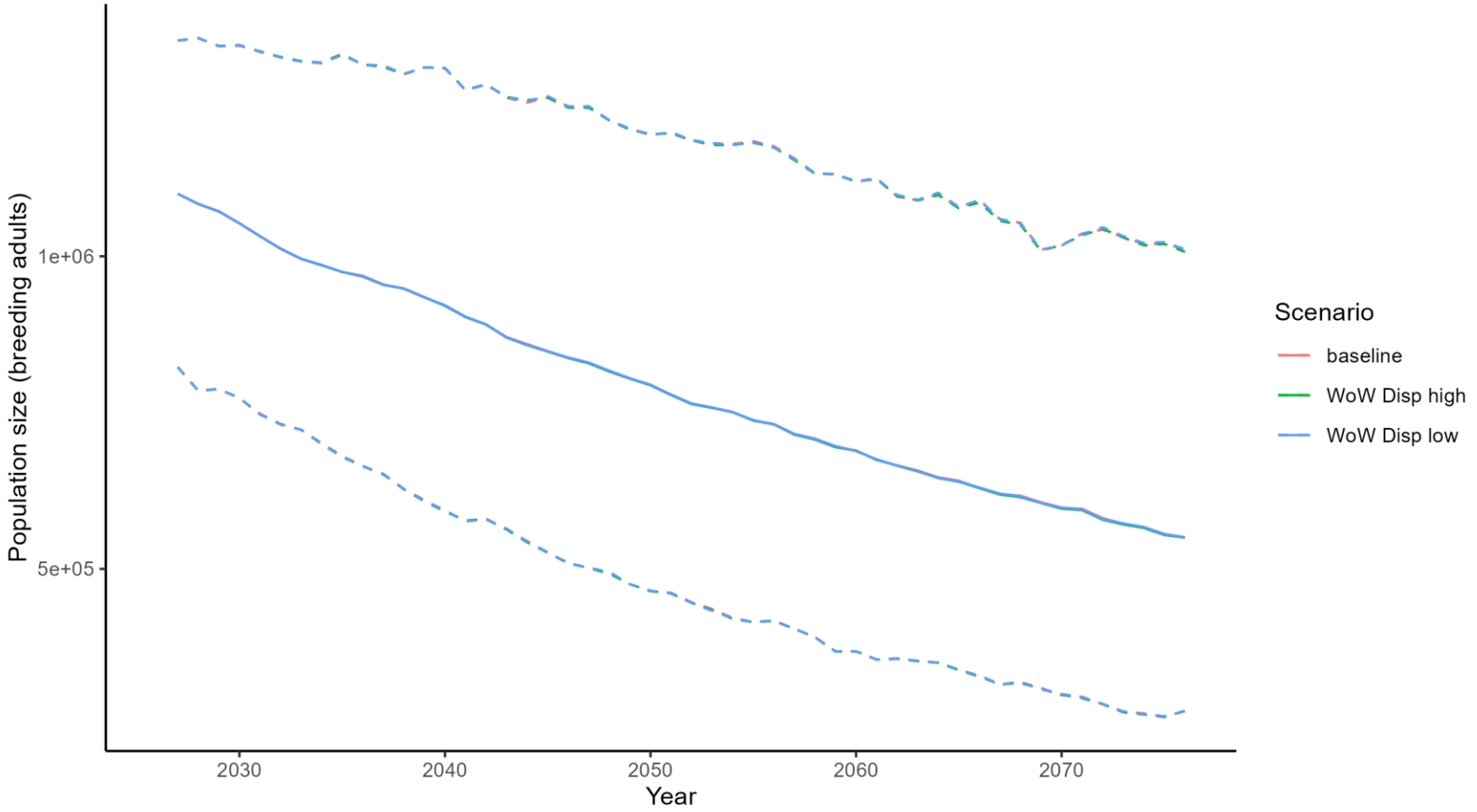

Figure 3-8. Fulmar WoW alone – Regional population. Baseline = unimpacted population. WOW = West of Orkney Windfarm. Disp High = high displacement. Disp Low = low displacement. Some trajectories are obscured in the plot due to being very similar to other trajectories.

3.1.9 Gannet

Table 3-19. PVA Inputs: Gannet WoW alone – Regional population

Baseline parameters	Settings	Impact parameters	Values
Reference name	Gannet WoW alone – Regional population	Number of scenarios of impact	5
Type	Simulation	Are impacts applied separately to each subpopulation	FALSE
Case studies	None	Are impacts specified separately for immatures	FALSE
Model to use for environmental stochasticity	Beta/Gamma	Are standard errors of impacts available	FALSE
Choose model for density dependence	No density dependence	Should random seeds be matched for impact scenarios	TRUE
Include demographic stochasticity in model	TRUE	Impacts are specified as	Relative
Number of simulations	1000	Years in which impacts are assumed to begin	2027
Random seed	1971	Years in which impacts are assumed to end	2062
Years for burn in	5	Scenario A name	WoW Disp low
Species	Northern gannet	Scenario A Impact on productivity rate per pair mean	0
Age at first breeding	5	Scenario A Impact on adult survival rate	1.791791e-05
Is there an upper constraint on productivity in the model	TRUE	Scenario A Impact on immature survival rate mean	-
Maximum brood size per pair chicks will be constrained to be no greater than	1	Scenario B name	WoW Disp high
Number of subpopulations	1	Scenario B Impact on productivity rate per pair mean	0
Units for initial population size	Breeding.adults	Scenario B Impact on adult survival rate	5.342992e-05
Are baseline demographic rates specified separately for immatures	TRUE	Scenario B Impact on immature survival rate mean	-
Initial population size	926447	Scenario C name	WoW CRM WCS
Year	2023	Scenario C Impact on productivity rate per pair mean	0
Productivity rate per pair mean	0.6798639	Scenario C Impact on adult survival rate	4.864821e-05
Productivity rate per pair standard deviation	0.0920597	Scenario C Impact on immature survival rate mean	-
Adult survival rate Mean	0.919	Scenario D name	WoW Disp low + WCS CRM
Adult survival rate standard deviation	0.042	Scenario D Impact on productivity rate per pair mean	0
Immatures survival rates 0 to 1 mean	0.424	Scenario D Impact on adult survival rate	6.656612e-05
Immatures survival rates 0 to 1 standard deviation	0.045	Scenario D Impact on immature survival rate mean	-
Immatures survival rates 1 to 2 mean	0.829	Scenario E name	WoW Disp high + CRM WCS
Immatures survival rates 1 to 2 standard deviation	0.026	Scenario E Impact on productivity rate per pair mean	0
Immatures survival rates 2 to 3 mean	0.891	Scenario E Impact on adult survival rate	0.0001020781
Immatures survival rates 2 to 3 standard deviation	0.019	Scenario E Impact on immature survival rate mean	-
Immatures survival rates 3 to 4 mean	0.895		
Immatures survival rates 3 to 4 standard deviation	0.019		

Baseline parameters	Settings	Impact parameters	Values
Immatures survival rates 4 to 5 mean	0.919000000000		
Immatures survival rates 4 to 5 standard deviation	4.200000000000		
Immatures survival rates 5 to 6 mean	-		
Immatures survival rates 5 to 6 standard deviation	-		
Units for output	Breeding.adults		

Table 3-20. PVA Outputs: Gannet WoW alone – Regional population

Scenario	Mortality	Increase in mortality rate	Year	C-PGR					C-PS					50% Quantiles	
				Med.	Mean	SD	LCI	UCI	Med.	Mean	SD	LCI	UCI	Q-UNIMP-50%	Q-IMP-50%
WoW Disp low	16.6	0.00001791791	25	1.0000	1.0000	0.0001	0.9998	1.0001	0.9995	0.9995	0.0022	0.9954	1.0036	50.0	49.8
WoW Disp high	49.5	0.00005342992	25	0.9999	0.9999	0.0001	0.9998	1.0001	0.9985	0.9985	0.0021	0.9941	1.0026	49.9	50.0
WoW CRM WCS	45.1	0.00004864821	25	1.0000	0.9999	0.0001	0.9998	1.0001	0.9986	0.9986	0.0021	0.9945	1.0026	49.9	50.1
WoW Disp low + WCS CRM	61.7	0.00006656612	25	0.9999	0.9999	0.0001	0.9998	1.0001	0.9980	0.9980	0.0022	0.9939	1.0020	49.0	50.3
WoW Disp high + CRM WCS	94.6	0.00010207812	25	0.9999	0.9999	0.0001	0.9997	1.0000	0.9970	0.9969	0.0022	0.9927	1.0011	48.9	50.5
WoW Disp low	16.6	0.00001791791	35	1.0000	1.0000	0.0001	0.9999	1.0001	0.9994	0.9993	0.0024	0.9945	1.0040	49.4	50.1
WoW Disp high	49.5	0.00005342992	35	0.9999	0.9999	0.0001	0.9998	1.0001	0.9977	0.9977	0.0024	0.9928	1.0020	49.4	50.7
WoW CRM WCS	45.1	0.00004864821	35	0.9999	0.9999	0.0001	0.9998	1.0001	0.9979	0.9980	0.0024	0.9933	1.0030	49.4	50.5
WoW Disp low + WCS CRM	61.7	0.00006656612	35	0.9999	0.9999	0.0001	0.9998	1.0001	0.9971	0.9972	0.0025	0.9926	1.0021	49.1	50.7
WoW Disp high + CRM WCS	94.6	0.00010207812	35	0.9999	0.9999	0.0001	0.9998	1.0000	0.9957	0.9957	0.0025	0.9909	1.0006	49.1	50.7
WoW Disp low	16.6	0.00001791791	50	1.0000	1.0000	0.0001	0.9999	1.0001	0.9992	0.9993	0.0029	0.9938	1.0051	49.9	50.0
WoW Disp high	49.5	0.00005342992	50	1.0000	1.0000	0.0001	0.9999	1.0001	0.9977	0.9977	0.0029	0.9924	1.0034	49.5	50.6
WoW CRM WCS	45.1	0.00004864821	50	1.0000	1.0000	0.0001	0.9999	1.0001	0.9981	0.9981	0.0029	0.9924	1.0038	49.6	50.3
WoW Disp low + WCS CRM	61.7	0.00006656612	50	0.9999	0.9999	0.0001	0.9998	1.0001	0.9970	0.9971	0.0030	0.9912	1.0032	49.2	50.6
WoW Disp high + CRM WCS	94.6	0.00010207812	50	0.9999	0.9999	0.0001	0.9998	1.0000	0.9956	0.9957	0.0030	0.9899	1.0016	49.2	50.9

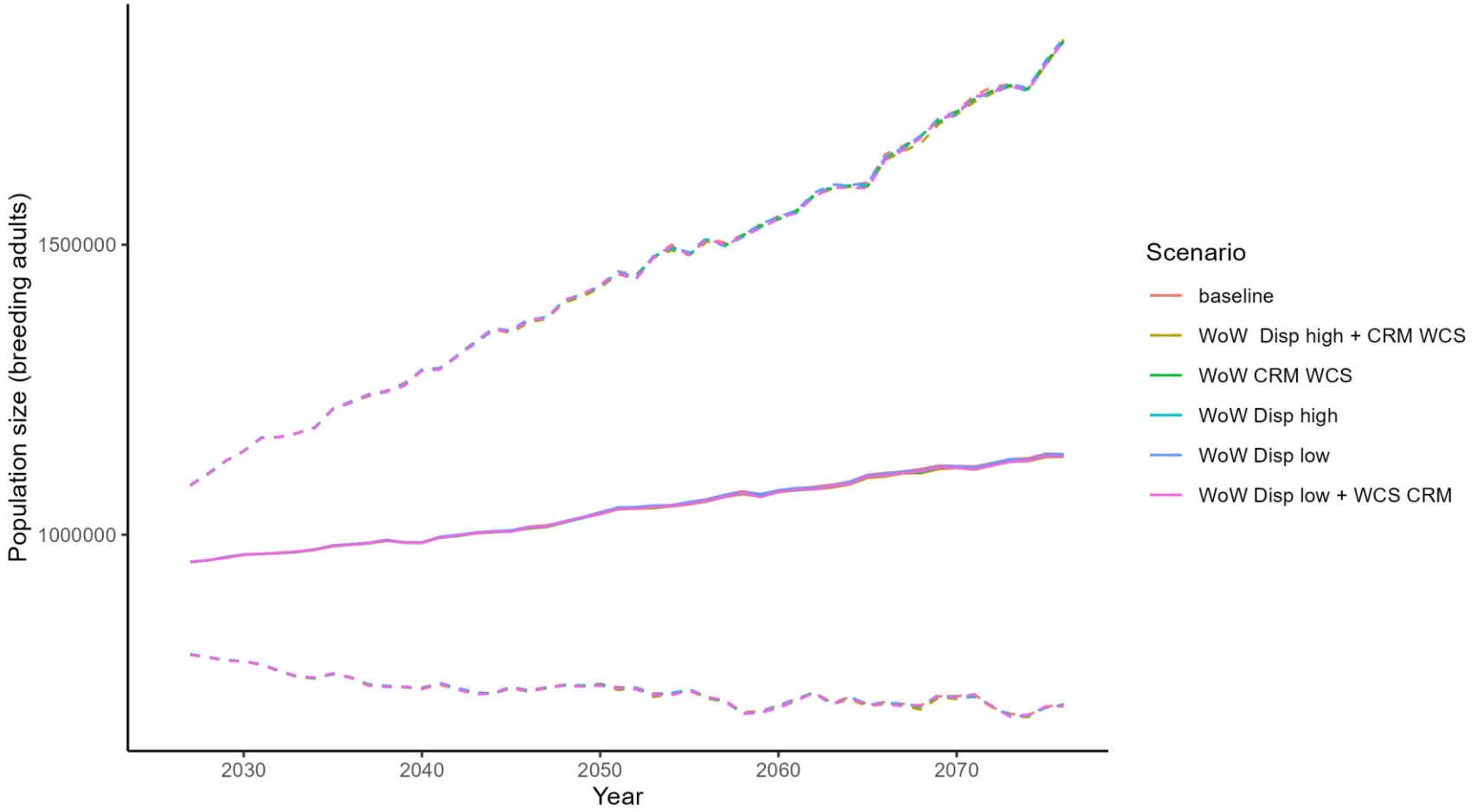

Figure 3-9. Gannet WoW alone – Regional population. Baseline = unimpacted population. WOW = West of Orkney Windfarm. Disp High = high displacement. Disp Low = low displacement. CRM WCS = collision mortality. Some trajectories are obscured in the plot due to being very similar to other trajectories.

3.2 PVAs Run for Regional Populations – Cumulative

3.2.1 Kittiwake

Table 3-21. PVA Inputs: Kittiwake CIA – Regional population

Baseline parameters	Settings	Impact parameters	Values
Reference name	Kittiwake CIA – Regional population	Number of scenarios of impact	4
Type	Simulation	Are impacts applied separately to each subpopulation	FALSE
Case studies	None	Are impacts specified separately for immatures	FALSE
Model to use for environmental stochasticity	Beta/Gamma	Are standard errors of impacts available	FALSE
Choose model for density dependence	No density dependence	Should random seeds be matched for impact scenarios	TRUE
Include demographic stochasticity in model	TRUE	Impacts are specified as	Relative
Number of simulations	1000	Years in which impacts are assumed to begin	2027
Random seed	1971	Years in which impacts are assumed to end	2062
Years for burn in	5	Scenario A name	CIA Disp low + CRM WCS ex BB
Species	Black-legged kittiwake	Scenario A Impact on productivity rate per pair mean	0
Age at first breeding	4	Scenario A Impact on adult survival rate	0.002929857
Is there an upper constraint on productivity in the model	TRUE	Scenario A Impact on immature survival rate mean	-
Maximum brood size per pair chicks will be constrained to be no greater than	2	Scenario B name	CIA Disp high + CRM WCS ex BB
Number of subpopulations	1	Scenario B Impact on productivity rate per pair mean	0
Units for initial population size	Breeding.adults	Scenario B Impact on adult survival rate	0.003308759
Are baseline demographic rates specified separately for immatures	TRUE	Scenario B Impact on immature survival rate mean	-
Initial population size	414355	Scenario C name	CIA Disp low + CRM WCS inc BB
Year	2023	Scenario C Impact on productivity rate per pair mean	0
Productivity rate per pair mean	0.5860126	Scenario C Impact on adult survival rate	0.003361854
Productivity rate per pair standard deviation	0.3704002	Scenario C Impact on immature survival rate mean	-
Adult survival rate Mean	0.854	Scenario D name	CIA Disp high + CRM WCS inc BB
Adult survival rate standard deviation	0.051	Scenario D Impact on productivity rate per pair mean	0
Immatures survival rates 0 to 1 mean	0.79	Scenario D Impact on adult survival rate	0.003953135
Immatures survival rates 0 to 1 standard deviation	0.077	Scenario D Impact on immature survival rate mean	-
Immatures survival rates 1 to 2 mean	0.854	Scenario E name	
Immatures survival rates 1 to 2 standard deviation	0.077	Scenario E Impact on productivity rate per pair mean	
Immatures survival rates 2 to 3 mean	0.854	Scenario E Impact on adult survival rate	

Baseline parameters	Settings	Impact parameters	Values
Immatures survival rates 2 to 3 standard deviation	0.077	Scenario E Impact on immature survival rate mean	
Immatures survival rates 3 to 4 mean	0.854		
Immatures survival rates 3 to 4 standard deviation	0.077		
Immatures survival rates 4 to 5 mean	-		
Immatures survival rates 4 to 5 standard deviation	-		
Immatures survival rates 5 to 6 mean	-		
Immatures survival rates 5 to 6 standard deviation	-		
Units for output	Breeding.adults		

Table 3-22. PVA Outputs: Kittiwake CIA – Regional population

Scenario	Mortality	Increase in mortality rate	Year	C-PGR					C-PS					50% Quantiles	
				Med.	Mean	SD	LCI	UCI	Med.	Mean	SD	LCI	UCI	Q-UNIMP-50%	Q-IMP-50%
CIA Disp low + CRM WCS ex BB	1,214	0.002929857	25	0.9965	0.9965	0.0002	0.9962	0.9969	0.9137	0.9136	0.0039	0.9059	0.9216	39.5	60.1
CIA Disp high + CRM WCS ex BB	1,371	0.003308759	25	0.9961	0.9961	0.0002	0.9958	0.9964	0.9033	0.9031	0.0042	0.8948	0.9112	38.7	61.1
CIA Disp low + CRM WCS inc BB	1,393	0.003361854	25	0.9960	0.9960	0.0002	0.9957	0.9963	0.9015	0.9014	0.0040	0.8938	0.9087	38.5	61.3
CIA Disp high + CRM WCS inc BB	1,638	0.003953135	25	0.9953	0.9953	0.0002	0.9950	0.9956	0.8853	0.8851	0.0039	0.8771	0.8926	36.6	62.8
CIA Disp low + CRM WCS ex BB	1,214	0.002929857	35	0.9965	0.9965	0.0001	0.9962	0.9968	0.8826	0.8824	0.0045	0.8732	0.8907	39.2	60.5
CIA Disp high + CRM WCS ex BB	1,371	0.003308759	35	0.9961	0.9961	0.0001	0.9958	0.9964	0.8685	0.8683	0.0047	0.8586	0.8775	37.7	61.7
CIA Disp low + CRM WCS inc BB	1,393	0.003361854	35	0.9960	0.9960	0.0001	0.9957	0.9963	0.8663	0.8663	0.0045	0.8574	0.8752	37.6	62.1
CIA Disp high + CRM WCS inc BB	1,638	0.003953135	35	0.9953	0.9953	0.0001	0.9950	0.9956	0.8448	0.8446	0.0046	0.8357	0.8531	36.0	63.7
CIA Disp low + CRM WCS ex BB	1,214	0.002929857	50	0.9975	0.9975	0.0001	0.9973	0.9978	0.8825	0.8823	0.0056	0.8710	0.8933	40.4	59.1
CIA Disp high + CRM WCS ex BB	1,371	0.003308759	50	0.9972	0.9972	0.0001	0.9970	0.9975	0.8684	0.8684	0.0055	0.8582	0.8794	38.9	60.2
CIA Disp low + CRM WCS inc BB	1,393	0.003361854	50	0.9972	0.9972	0.0001	0.9969	0.9974	0.8665	0.8663	0.0054	0.8550	0.8767	38.7	60.4
CIA Disp high + CRM WCS inc BB	1,638	0.003953135	50	0.9967	0.9967	0.0001	0.9964	0.9969	0.8447	0.8446	0.0056	0.8338	0.8555	36.6	63.0

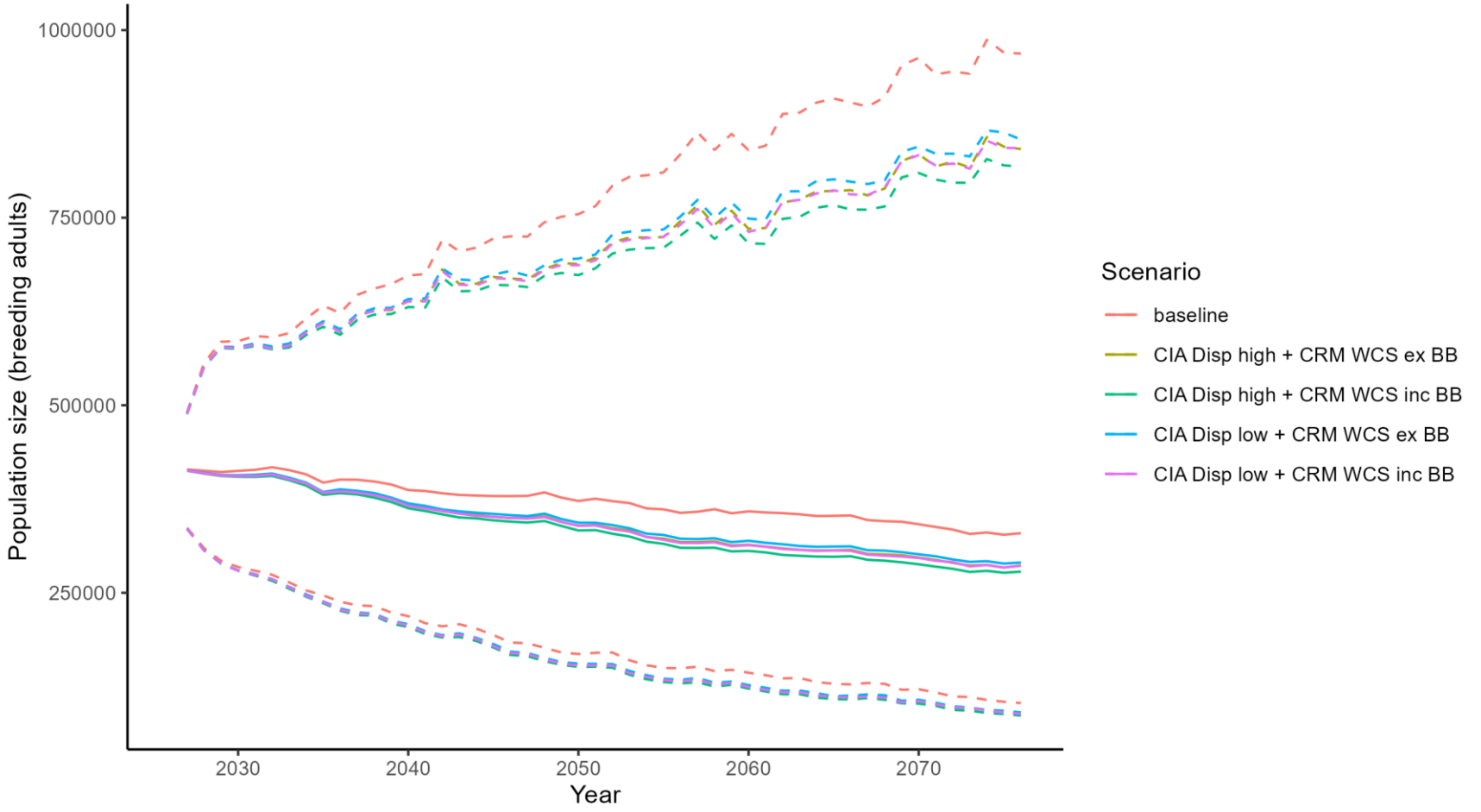

Figure 3-10. Kittiwake CIA – Regional population. Baseline = unimpacted population. CIA = cumulative impact assessment. Disp High = high displacement. Disp Low = low displacement. CRM WCS = collision mortality. Ex BB = impacts excluding Berwick Bank OWF. Inc BB = impacts including Berwick Bank OWF. Some trajectories are obscured in the plot due to being very similar to other trajectories.

3.2.2 Great Black-backed Gull

Table 3-23. PVA Inputs: Great black-backed gull CIA – Regional population

Baseline parameters	Settings	Impact parameters	Values
Reference name	Great black-backed gull CIA – Regional population	Number of scenarios of impact	1
Type	Simulation	Are impacts applied separately to each subpopulation	FALSE
Case studies	None	Are impacts specified separately for immatures	FALSE
Model to use for environmental stochasticity	Beta/Gamma	Are standard errors of impacts available	FALSE
Choose model for density dependence	No density dependence	Should random seeds be matched for impact scenarios	TRUE
Include demographic stochasticity in model	TRUE	Impacts are specified as	Relative
Number of simulations	1000	Years in which impacts are assumed to begin	2027
Random seed	1971	Years in which impacts are assumed to end	2062
Years for burn in	5	Scenario A name	CIA CRM WCS
Species	Great black-backed gull	Scenario A Impact on productivity rate per pair mean	0
Age at first breeding	5	Scenario A Impact on adult survival rate	0.00919973
Is there an upper constraint on productivity in the model	TRUE	Scenario A Impact on immature survival rate mean	-
Maximum brood size per pair chicks will be constrained to be no greater than	3	Scenario B name	
Number of subpopulations	1	Scenario B Impact on productivity rate per pair mean	
Units for initial population size	Breeding.adults	Scenario B Impact on adult survival rate	
Are baseline demographic rates specified separately for immatures	TRUE	Scenario B Impact on immature survival rate mean	
Initial population size	3402	Scenario C name	
Year	2023	Scenario C Impact on productivity rate per pair mean	
Productivity rate per pair mean	0.9302198	Scenario C Impact on adult survival rate	
Productivity rate per pair standard deviation	0.4328549	Scenario C Impact on immature survival rate mean	
Adult survival rate Mean	0.93	Scenario D name	
Adult survival rate standard deviation	0.1	Scenario D Impact on productivity rate per pair mean	
Immatures survival rates 0 to 1 mean	0.93	Scenario D Impact on adult survival rate	
Immatures survival rates 0 to 1 standard deviation	0.1	Scenario D Impact on immature survival rate mean	
Immatures survival rates 1 to 2 mean	0.93	Scenario E name	
Immatures survival rates 1 to 2 standard deviation	0.1	Scenario E Impact on productivity rate per pair mean	
Immatures survival rates 2 to 3 mean	0.93	Scenario E Impact on adult survival rate	

Baseline parameters	Settings	Impact parameters	Values
Immatures survival rates 2 to 3 standard deviation	0.1	Scenario E Impact on immature survival rate mean	
Immatures survival rates 3 to 4 mean	0.93		
Immatures survival rates 3 to 4 standard deviation	0.1		
Immatures survival rates 4 to 5 mean	0.93		
Immatures survival rates 4 to 5 standard deviation	0.1		
Immatures survival rates 5 to 6 mean	-		
Immatures survival rates 5 to 6 standard deviation	-		
Units for output	Breeding.adults		

Table 3-24. PVA Outputs: Great black-backed gull CIA – Regional population

Scenario	Mortality	Increase in mortality rate	Year	C-PGR					C-PS					50% Quantiles	
				Med.	Mean	SD	LCI	UCI	Med.	Mean	SD	LCI	UCI	Q-UNIMP-50%	Q-IMP-50%
CIA CRM WCS	31.3	0.00919973	25	0.9901	0.9901	0.0006	0.9889	0.9913	0.7715	0.7714	0.0129	0.7466	0.7978	25.8	73.9
CIA CRM WCS	31.3	0.00919973	35	0.9901	0.9901	0.0004	0.9892	0.9909	0.6980	0.6980	0.0119	0.6748	0.7214	22.2	77.5
CIA CRM WCS	31.3	0.00919973	50	0.9930	0.9930	0.0003	0.9924	0.9936	0.6981	0.6980	0.0119	0.6749	0.7214	26.3	72.4

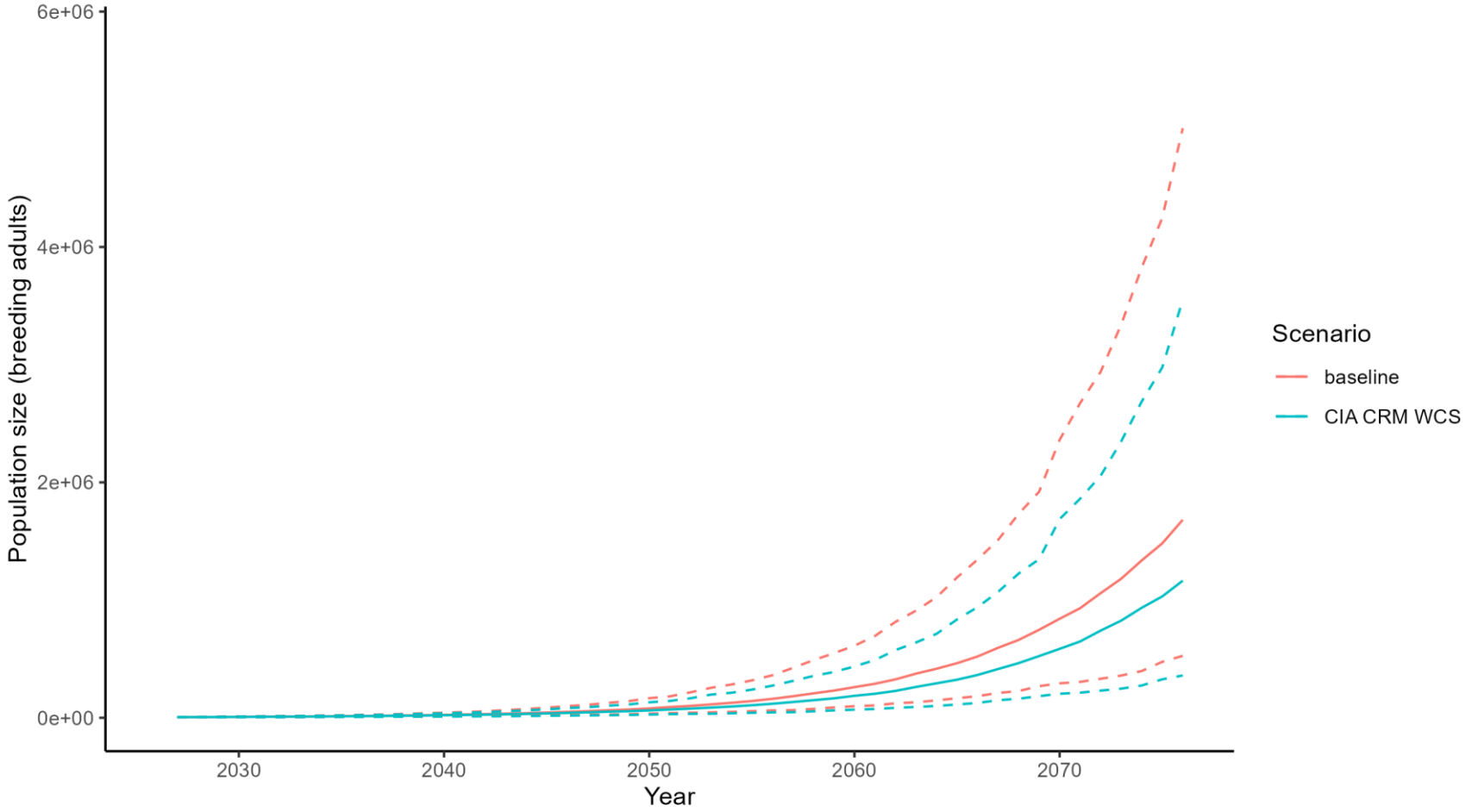

Figure 3-11. Great black-backed gull CIA – Regional population. Baseline = unimpacted population. CIA = cumulative impact assessment. CRM WCS = collision mortality. Some trajectories are obscured in the plot due to being very similar to other trajectories.

3.2.3 Guillemot

Table 3-25. PVA Inputs: Guillemot CIA – Regional population

Baseline parameters	Settings	Impact parameters	Values
Reference name	Guillemot CIA – Regional population	Number of scenarios of impact	2
Type	Simulation	Are impacts applied separately to each subpopulation	FALSE
Case studies	None	Are impacts specified separately for immatures	FALSE
Model to use for environmental stochasticity	Beta/Gamma	Are standard errors of impacts available	FALSE
Choose model for density dependence	No density dependence	Should random seeds be matched for impact scenarios	TRUE
Include demographic stochasticity in model	TRUE	Impacts are specified as	Relative
Number of simulations	1000	Years in which impacts are assumed to begin	2027
Random seed	1971	Years in which impacts are assumed to end	2062
Years for burn in	5	Scenario A name	CIA Disp low ex BB
Species	Common	Scenario A Impact on productivity rate per pair mean	0
Age at first breeding	6	Scenario A Impact on adult survival rate	0.00133141
Is there an upper constraint on productivity in the model	TRUE	Scenario A Impact on immature survival rate mean	-
Maximum brood size per pair chicks will be constrained to be no greater than	1	Scenario B name	CIA Disp high ex BB
Number of subpopulations	1	Scenario B Impact on productivity rate per pair mean	0
Units for initial population size	Breeding.adults	Scenario B Impact on adult survival rate	0.00259854
Are baseline demographic rates specified separately for immatures	TRUE	Scenario B Impact on immature survival rate mean	-
Initial population size	980165	Scenario C name	
Year	2023	Scenario C Impact on productivity rate per pair mean	
Productivity rate per pair mean	0.5017244	Scenario C Impact on adult survival rate	
Productivity rate per pair standard deviation	0.2080057	Scenario C Impact on immature survival rate mean	
Adult survival rate Mean	0.94	Scenario D name	
Adult survival rate standard deviation	0.025	Scenario D Impact on productivity rate per pair mean	
Immatures survival rates 0 to 1 mean	0.56	Scenario D Impact on adult survival rate	
Immatures survival rates 0 to 1 standard deviation	0.058	Scenario D Impact on immature survival rate mean	
Immatures survival rates 1 to 2 mean	0.792	Scenario E name	
Immatures survival rates 1 to 2 standard deviation	0.152	Scenario E Impact on productivity rate per pair mean	
Immatures survival rates 2 to 3 mean	0.917	Scenario E Impact on adult survival rate	
Immatures survival rates 2 to 3 standard deviation	0.098	Scenario E Impact on immature survival rate mean	
Immatures survival rates 3 to 4 mean	0.938		
Immatures survival rates 3 to 4 standard deviation	0.107		

Baseline parameters	Settings	Impact parameters	Values
Immatures survival rates 4 to 5 mean	0.94		
Immatures survival rates 4 to 5 standard deviation	2.500000000000		
Immatures survival rates 5 to 6 mean	0.94		
Immatures survival rates 5 to 6 standard deviation	2.500000000000		
Units for output	Breeding.adults		

Table 3-26. PVA Outputs: Guillemot CIA – Regional population

Scenario	Mortality	Increase in mortality rate	Year	C-PGR					C-PS					50% Quantiles	
				Med.	Mean	SD	LCI	UCI	Med.	Mean	SD	LCI	UCI	Q-UNIMP-50%	Q-IMP-50%
CIA Disp low ex BB	1,305	0.00133141	25	0.9985	0.9985	0.0001	0.9984	0.9986	0.9623	0.9623	0.0016	0.9592	0.9652	41.9	58.9
CIA Disp high ex BB	2,547	0.00259854	25	0.9971	0.9971	0.0001	0.9970	0.9972	0.9278	0.9278	0.0016	0.9246	0.9310	33.8	66.8
CIA Disp low ex BB	1,305	0.00133141	35	0.9985	0.9985	0.0001	0.9984	0.9986	0.9481	0.9481	0.0018	0.9446	0.9515	39.3	60.1
CIA Disp high ex BB	2,547	0.00259854	35	0.9971	0.9971	0.0001	0.9970	0.9972	0.9012	0.9012	0.0017	0.8977	0.9046	28.9	69.5
CIA Disp low ex BB	1,305	0.00133141	50	0.9990	0.9990	0.0000	0.9989	0.9990	0.9479	0.9479	0.0020	0.9440	0.9517	41.0	58.4
CIA Disp high ex BB	2,547	0.00259854	50	0.9980	0.9980	0.0000	0.9979	0.9980	0.9007	0.9007	0.0020	0.8969	0.9045	32.3	66.0

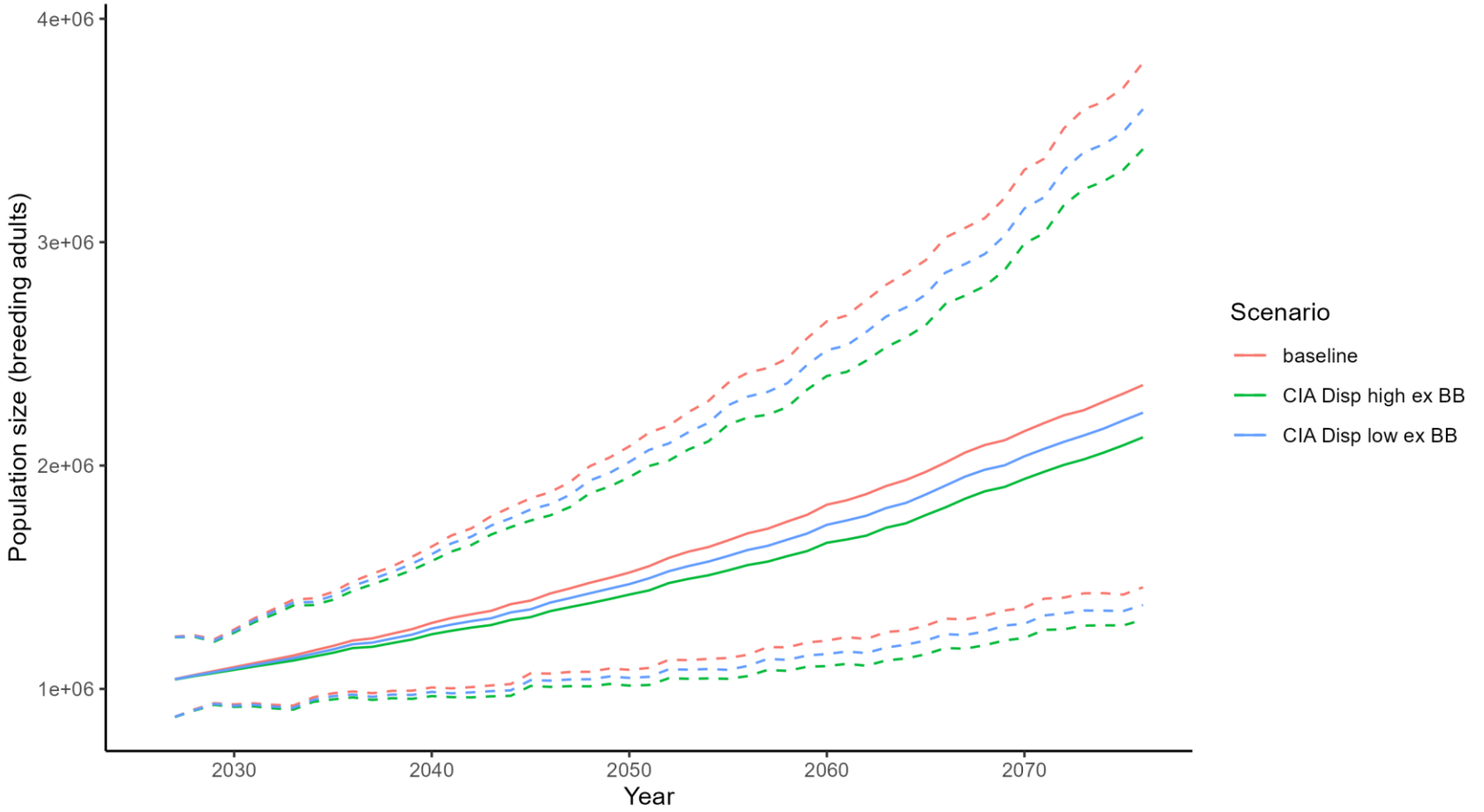

Figure 3-12. Guillemot CIA – Regional population. Baseline = unimpacted population. CIA = cumulative impact assessment. Disp High = high displacement. Disp Low = low displacement. Ex BB = impacts excluding Berwick Bank OWF. Inc BB = impacts including Berwick Bank OWF. Some trajectories are obscured in the plot due to being very similar to other trajectories.

3.2.4 Razorbill

Table 3-27. PVA Inputs: Razorbill CIA – Regional population

Baseline parameters	Settings	Impact parameters	Values
Reference name	Razorbill CIA – Regional population	Number of scenarios of impact	4
Type	Simulation	Are impacts applied separately to each subpopulation	FALSE
Case studies	None	Are impacts specified separately for immatures	FALSE
Model to use for environmental stochasticity	Beta/Gamma	Are standard errors of impacts available	FALSE
Choose model for density dependence	No density dependence	Should random seeds be matched for impact scenarios	TRUE
Include demographic stochasticity in model	TRUE	Impacts are specified as	Relative
Number of simulations	1000	Years in which impacts are assumed to begin	2027
Random seed	1971	Years in which impacts are assumed to end	2062
Years for burn in	5	Scenario A name	CIA Disp low ex BB
Species	Razorbill	Scenario A Impact on productivity rate per pair mean	0
Age at first breeding	5	Scenario A Impact on adult survival rate	0.002338348
Is there an upper constraint on productivity in the model	TRUE	Scenario A Impact on immature survival rate mean	-
Maximum brood size per pair chicks will be constrained to be no greater than	1	Scenario B name	CIA Disp high ex BB
Number of subpopulations	1	Scenario B Impact on productivity rate per pair mean	0
Units for initial population size	Breeding.adults	Scenario B Impact on adult survival rate	0.005998679
Are baseline demographic rates specified separately for immatures	TRUE	Scenario B Impact on immature survival rate mean	-
Initial population size	140698	Scenario C name	CIA Disp low inc BB
Year	2023	Scenario C Impact on productivity rate per pair mean	0
Productivity rate per pair mean	0.4401746	Scenario C Impact on adult survival rate	0.002544463
Productivity rate per pair standard deviation	0.1886934	Scenario C Impact on immature survival rate mean	-
Adult survival rate Mean	0.895	Scenario D name	CIA Disp high inc BB
Adult survival rate standard deviation	0.067	Scenario D Impact on productivity rate per pair mean	0
Immatures survival rates 0 to 1 mean	0.63	Scenario D Impact on adult survival rate	0.006538844
Immatures survival rates 0 to 1 standard deviation	0.067	Scenario D Impact on immature survival rate mean	-
Immatures survival rates 1 to 2 mean	0.63	Scenario E name	
Immatures survival rates 1 to 2 standard deviation	0.067	Scenario E Impact on productivity rate per pair mean	
Immatures survival rates 2 to 3 mean	0.895	Scenario E Impact on adult survival rate	
Immatures survival rates 2 to 3 standard deviation	0.067	Scenario E Impact on immature survival rate mean	
Immatures survival rates 3 to 4 mean	0.895		
Immatures survival rates 3 to 4 standard deviation	0.067		

Baseline parameters	Settings	Impact parameters	Values
Immatures survival rates 4 to 5 mean	0.895000000000		
Immatures survival rates 4 to 5 standard deviation	6.700000000000		
Immatures survival rates 5 to 6 mean	-		
Immatures survival rates 5 to 6 standard deviation	-		
Units for output	Breeding.adults		

Table 3-28. PVA Outputs: Razorbill CIA – Regional population

Scenario	Mortality	Increase in mortality rate	Year	C-PGR					C-PS					50% Quantiles	
				Med.	Mean	SD	LCI	UCI	Med.	Mean	SD	LCI	UCI	Q-UNIMP-50%	Q-IMP-50%
CIA Disp low ex BB	329	0.002338348	25	0.9973	0.9973	0.0003	0.9966	0.9979	0.9315	0.9313	0.0084	0.9147	0.9479	40.8	58.1
CIA Disp high ex BB	844	0.005998679	25	0.9930	0.9930	0.0004	0.9922	0.9937	0.8329	0.8326	0.0080	0.8158	0.8477	28.2	71.8
CIA Disp low inc BB	358	0.002544463	25	0.9970	0.9970	0.0003	0.9963	0.9976	0.9254	0.9252	0.0083	0.9085	0.9413	40.1	58.1
CIA Disp high inc BB	920	0.006538844	25	0.9924	0.9923	0.0004	0.9916	0.9931	0.8193	0.8190	0.0079	0.8026	0.8343	26.6	74.1
CIA Disp low ex BB	329	0.002338348	35	0.9973	0.9973	0.0003	0.9966	0.9979	0.9063	0.9061	0.0106	0.8856	0.9265	38.3	59.5
CIA Disp high ex BB	844	0.005998679	35	0.9930	0.9930	0.0003	0.9922	0.9936	0.7762	0.7756	0.0095	0.7553	0.7945	24.6	73.9
CIA Disp low inc BB	358	0.002544463	35	0.9970	0.9970	0.0003	0.9964	0.9976	0.8984	0.8982	0.0101	0.8784	0.9169	37.7	60.3
CIA Disp high inc BB	920	0.006538844	35	0.9924	0.9923	0.0003	0.9917	0.9930	0.7587	0.7583	0.0093	0.7394	0.7760	22.8	75.7
CIA Disp low ex BB	329	0.002338348	50	0.9981	0.9981	0.0003	0.9974	0.9987	0.9056	0.9055	0.0145	0.8758	0.9341	39.3	58.7
CIA Disp high ex BB	844	0.005998679	50	0.9950	0.9950	0.0003	0.9943	0.9956	0.7753	0.7751	0.0131	0.7475	0.7997	26.8	71.5
CIA Disp low inc BB	358	0.002544463	50	0.9979	0.9979	0.0003	0.9972	0.9985	0.8981	0.8974	0.0147	0.8658	0.9260	38.3	58.9
CIA Disp high inc BB	920	0.006538844	50	0.9946	0.9946	0.0003	0.9939	0.9952	0.7581	0.7579	0.0129	0.7327	0.7828	25.6	73.9

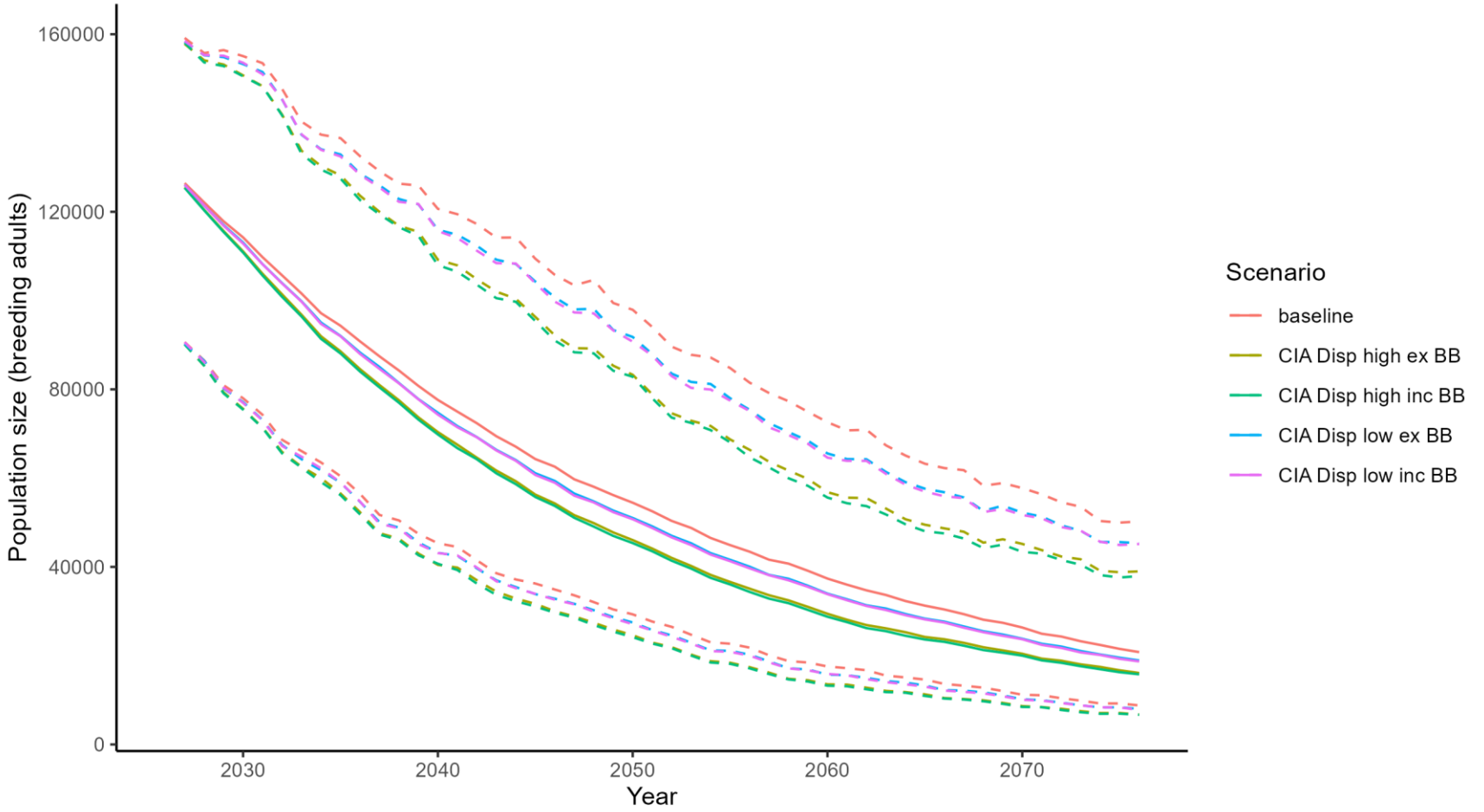

Figure 3-13. Razorbill CIA – Regional population. Baseline = unimpacted population. CIA = cumulative impact assessment. Disp High = high displacement. Disp Low = low displacement. Ex BB = impacts excluding Berwick Bank OWF. Inc BB = impacts including Berwick Bank OWF. Some trajectories are obscured in the plot due to being very similar to other trajectories.

3.2.5 Puffin

Table 3-29. PVA Inputs: Puffin CIA – Regional population

Baseline parameters	Settings	Impact parameters	Values
Reference name	Puffin CIA – Regional population	Number of scenarios of impact	4
Type	Simulation	Are impacts applied separately to each subpopulation	FALSE
Case studies	None	Are impacts specified separately for immatures	FALSE
Model to use for environmental stochasticity	Beta/Gamma	Are standard errors of impacts available	FALSE
Choose model for density dependence	No density dependence	Should random seeds be matched for impact scenarios	TRUE
Include demographic stochasticity in model	TRUE	Impacts are specified as	Relative
Number of simulations	1000	Years in which impacts are assumed to begin	2027
Random seed	1971	Years in which impacts are assumed to end	2062
Years for burn in	5	Scenario A name	CIA Disp low ex BB
Species	Atlantic puffin	Scenario A Impact on productivity rate per pair mean	0
Age at first breeding	5	Scenario A Impact on adult survival rate	0.00035627
Is there an upper constraint on productivity in the model	TRUE	Scenario A Impact on immature survival rate mean	-
Maximum brood size per pair chicks will be constrained to be no greater than	1	Scenario B name	CIA Disp high ex BB
Number of subpopulations	1	Scenario B Impact on productivity rate per pair mean	0
Units for initial population size	Breeding.adults	Scenario B Impact on adult survival rate	0.00077366
Are baseline demographic rates specified separately for immatures	TRUE	Scenario B Impact on immature survival rate mean	-
Initial population size	1145207	Scenario C name	CIA Disp low inc BB
Year	2023	Scenario C Impact on productivity rate per pair mean	0
Productivity rate per pair mean	0.4154966	Scenario C Impact on adult survival rate	0.00040255
Productivity rate per pair standard deviation	0.2120927	Scenario C Impact on immature survival rate mean	-
Adult survival rate Mean	0.907	Scenario D name	CIA Disp high inc BB
Adult survival rate standard deviation	0.083	Scenario D Impact on productivity rate per pair mean	0
Immatures survival rates 0 to 1 mean	0.709	Scenario D Impact on adult survival rate	0.00091337
Immatures survival rates 0 to 1 standard deviation	0.108	Scenario D Impact on immature survival rate mean	-
Immatures survival rates 1 to 2 mean	0.709	Scenario E name	
Immatures survival rates 1 to 2 standard deviation	0.108	Scenario E Impact on productivity rate per pair mean	
Immatures survival rates 2 to 3 mean	0.709	Scenario E Impact on adult survival rate	
Immatures survival rates 2 to 3 standard deviation	0.108	Scenario E Impact on immature survival rate mean	
Immatures survival rates 3 to 4 mean	0.76		
Immatures survival rates 3 to 4 standard deviation	0.093		

Baseline parameters	Settings	Impact parameters	Values
Immatures survival rates 4 to 5 mean	0.805000000000		
Immatures survival rates 4 to 5 standard deviation	8.300000000000		
Immatures survival rates 5 to 6 mean	-		
Immatures survival rates 5 to 6 standard deviation	-		
Units for output	Breeding.adults		

Table 3-30. PVA Outputs: Puffin CIA – Regional population

Scenario	Mortality	Increase in mortality rate	Year	C-PGR					C-PS					50% Quantiles	
				Med.	Mean	SD	LCI	UCI	Med.	Mean	SD	LCI	UCI	Q-UNIMP-50%	Q-IMP-50%
CIA Disp low ex BB	408	0.00035627	25	0.9996	0.9996	0.0001	0.9993	0.9998	0.9893	0.9893	0.0033	0.9825	0.9958	48.7	51.0
CIA Disp high ex BB	886	0.00077366	25	0.9991	0.9991	0.0001	0.9988	0.9993	0.9767	0.9768	0.0033	0.9704	0.9829	47.3	51.8
CIA Disp low inc BB	461	0.00040255	25	0.9995	0.9995	0.0001	0.9993	0.9998	0.9879	0.9878	0.0033	0.9811	0.9941	48.8	51.3
CIA Disp high inc BB	1,046	0.00091337	25	0.9989	0.9989	0.0001	0.9987	0.9992	0.9728	0.9727	0.0033	0.9660	0.9788	47.2	52.2
CIA Disp low ex BB	408	0.00035627	35	0.9996	0.9996	0.0001	0.9993	0.9998	0.9852	0.9851	0.0045	0.9765	0.9942	48.5	51.2
CIA Disp high ex BB	886	0.00077366	35	0.9991	0.9991	0.0001	0.9988	0.9993	0.9679	0.9678	0.0043	0.9593	0.9764	47.0	52.3
CIA Disp low inc BB	461	0.00040255	35	0.9995	0.9995	0.0001	0.9993	0.9998	0.9832	0.9831	0.0043	0.9744	0.9910	48.5	51.3
CIA Disp high inc BB	1,046	0.00091337	35	0.9989	0.9989	0.0001	0.9987	0.9992	0.9627	0.9625	0.0044	0.9534	0.9714	46.2	52.7
CIA Disp low ex BB	408	0.00035627	50	0.9997	0.9997	0.0001	0.9994	1.0000	0.9848	0.9850	0.0065	0.9717	0.9983	49.4	51.0
CIA Disp high ex BB	886	0.00077366	50	0.9994	0.9994	0.0001	0.9991	0.9996	0.9679	0.9676	0.0062	0.9547	0.9790	47.8	52.4
CIA Disp low inc BB	461	0.00040255	50	0.9997	0.9997	0.0001	0.9994	0.9999	0.9831	0.9828	0.0065	0.9693	0.9950	49.1	51.0
CIA Disp high inc BB	1,046	0.00091337	50	0.9993	0.9992	0.0001	0.9990	0.9995	0.9625	0.9621	0.0064	0.9480	0.9739	47.3	52.6

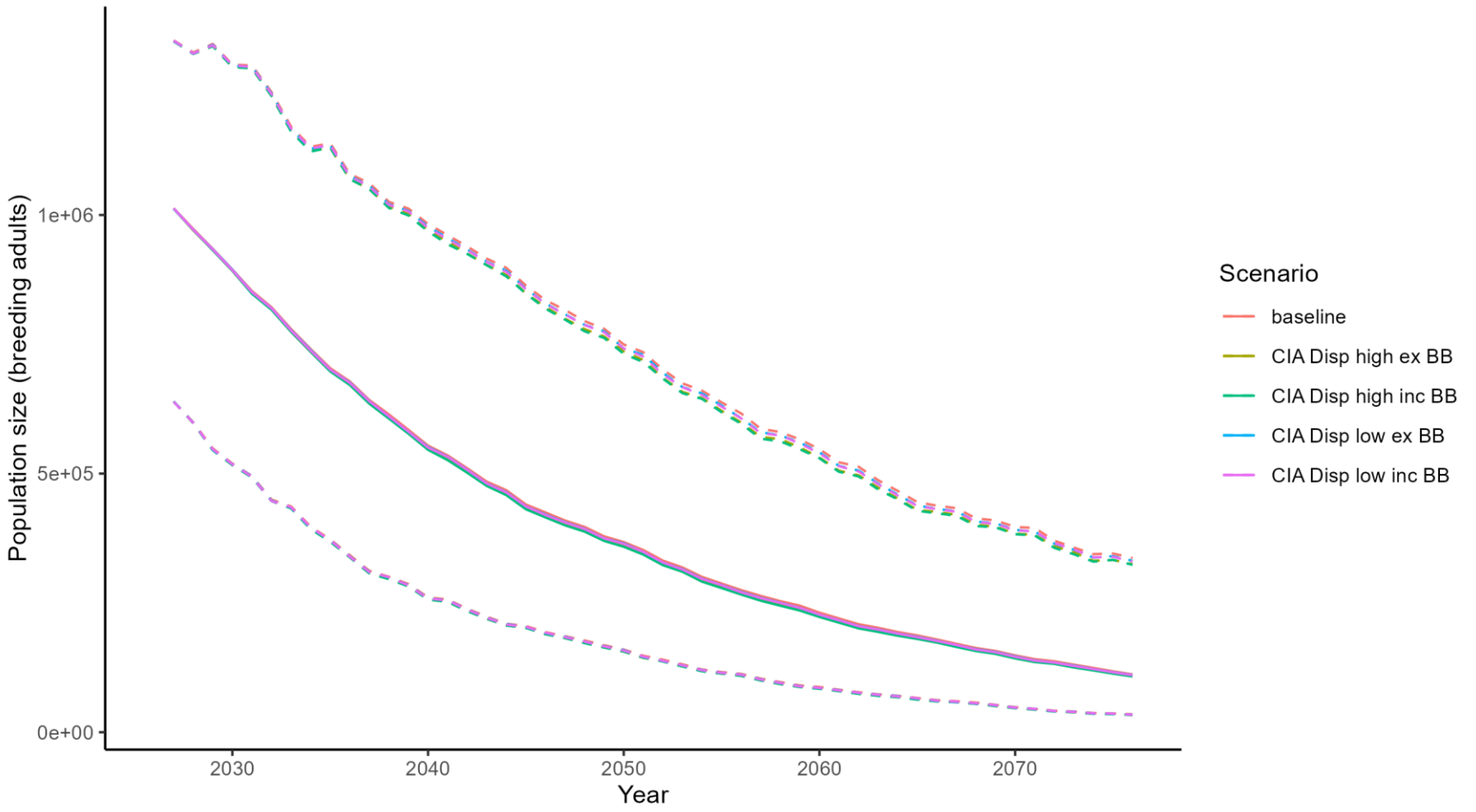

Figure 3-14. Puffin CIA – Regional population. Baseline = unimpacted population. CIA = cumulative impact assessment. Disp High = high displacement. Disp Low = low displacement. Ex BB = impacts excluding Berwick Bank OWF. Inc BB = impacts including Berwick Bank OWF. Some trajectories are obscured in the plot due to being very similar to other trajectories.

3.2.6 Gannet

Table 3-31. PVA Inputs: Gannet CIA – Regional population

Baseline parameters	Settings	Impact parameters	Values
Reference name	Gannet CIA – Regional population	Number of scenarios of impact	4
Type	Simulation	Are impacts applied separately to each subpopulation	FALSE
Case studies	None	Are impacts specified separately for immatures	FALSE
Model to use for environmental stochasticity	Beta/Gamma	Are standard errors of impacts available	FALSE
Choose model for density dependence	No density dependence	Should random seeds be matched for impact scenarios	TRUE
Include demographic stochasticity in model	TRUE	Impacts are specified as	Relative
Number of simulations	1000	Years in which impacts are assumed to begin	2027
Random seed	1971	Years in which impacts are assumed to end	2062
Years for burn in	5	Scenario A name	CIA Disp low + CRM WCS ex BB
Species	Northern gannet	Scenario A Impact on productivity rate per pair mean	0
Age at first breeding	5	Scenario A Impact on adult survival rate	0.00194722
Is there an upper constraint on productivity in the model	TRUE	Scenario A Impact on immature survival rate mean	-
Maximum brood size per pair chicks will be constrained to be no greater than	1	Scenario B name	CIA Disp high + CRM WCS ex BB
Number of subpopulations	1	Scenario B Impact on productivity rate per pair mean	0
Units for initial population size	Breeding.adults	Scenario B Impact on adult survival rate	0.00258407
Are baseline demographic rates specified separately for immatures	TRUE	Scenario B Impact on immature survival rate mean	-
Initial population size	926447	Scenario C name	CIA Disp low + CRM WCS inc BB
Year	2023	Scenario C Impact on productivity rate per pair mean	0
Productivity rate per pair mean	0.6798639	Scenario C Impact on adult survival rate	0.00220304
Productivity rate per pair standard deviation	0.0920597	Scenario C Impact on immature survival rate mean	-
Adult survival rate Mean	0.919	Scenario D name	CIA Disp high + CRM WCS inc BB
Adult survival rate standard deviation	0.042	Scenario D Impact on productivity rate per pair mean	0
Immatures survival rates 0 to 1 mean	0.424	Scenario D Impact on adult survival rate	0.00293811
Immatures survival rates 0 to 1 standard deviation	0.045	Scenario D Impact on immature survival rate mean	-
Immatures survival rates 1 to 2 mean	0.829	Scenario E name	
Immatures survival rates 1 to 2 standard deviation	0.026	Scenario E Impact on productivity rate per pair mean	
Immatures survival rates 2 to 3 mean	0.891	Scenario E Impact on adult survival rate	
Immatures survival rates 2 to 3 standard deviation	0.019	Scenario E Impact on immature survival rate mean	
Immatures survival rates 3 to 4 mean	0.895		
Immatures survival rates 3 to 4 standard deviation	0.019		

Baseline parameters	Settings	Impact parameters	Values
Immatures survival rates 4 to 5 mean	0.919000000000		
Immatures survival rates 4 to 5 standard deviation	4.200000000000		
Immatures survival rates 5 to 6 mean	-		
Immatures survival rates 5 to 6 standard deviation	-		
Units for output	Breeding.adults		

Table 3-32. PVA Outputs: Gannet CIA – Regional population

Scenario	Mortality	Increase in mortality rate	Year	C-PGR					C-PS					50% Quantiles	
				Med.	Mean	SD	LCI	UCI	Med.	Mean	SD	LCI	UCI	Q-UNIMP-50%	Q-IMP-50%
CIA Disp low + CRM WCS ex BB	1,804	0.00194722	25	0.9977	0.9977	0.0001	0.9976	0.9979	0.9425	0.9424	0.0021	0.9382	0.9465	37.3	63.4
CIA Disp high + CRM WCS ex BB	2,394	0.00258407	25	0.9970	0.9970	0.0001	0.9968	0.9971	0.9243	0.9242	0.0020	0.9203	0.9283	32.0	66.8
CIA Disp low + CRM WCS inc BB	2,041	0.00220304	25	0.9974	0.9974	0.0001	0.9973	0.9976	0.9350	0.9351	0.0020	0.9311	0.9391	35.5	64.7
CIA Disp high + CRM WCS inc BB	2,722	0.00293811	25	0.9966	0.9966	0.0001	0.9964	0.9967	0.9144	0.9143	0.0021	0.9100	0.9184	30.7	70.2
CIA Disp low + CRM WCS ex BB	1,804	0.00194722	35	0.9977	0.9977	0.0001	0.9976	0.9979	0.9210	0.9210	0.0023	0.9162	0.9255	33.1	63.4
CIA Disp high + CRM WCS ex BB	2,394	0.00258407	35	0.9970	0.9970	0.0001	0.9968	0.9971	0.8962	0.8963	0.0023	0.8919	0.9010	30.1	69.0
CIA Disp low + CRM WCS inc BB	2,041	0.00220304	35	0.9974	0.9974	0.0001	0.9973	0.9975	0.9110	0.9110	0.0023	0.9065	0.9153	31.8	65.8
CIA Disp high + CRM WCS inc BB	2,722	0.00293811	35	0.9966	0.9966	0.0001	0.9964	0.9967	0.8831	0.8830	0.0024	0.8780	0.8875	27.0	70.8
CIA Disp low + CRM WCS ex BB	1,804	0.00194722	50	0.9984	0.9984	0.0001	0.9983	0.9985	0.9205	0.9204	0.0027	0.9153	0.9256	36.6	63.5
CIA Disp high + CRM WCS ex BB	2,394	0.00258407	50	0.9978	0.9978	0.0001	0.9977	0.9980	0.8956	0.8956	0.0027	0.8900	0.9008	33.2	67.5
CIA Disp low + CRM WCS inc BB	2,041	0.00220304	50	0.9982	0.9982	0.0001	0.9980	0.9983	0.9104	0.9103	0.0027	0.9051	0.9152	35.8	65.4
CIA Disp high + CRM WCS inc BB	2,722	0.00293811	50	0.9975	0.9975	0.0001	0.9974	0.9977	0.8823	0.8822	0.0028	0.8766	0.8873	31.2	69.4

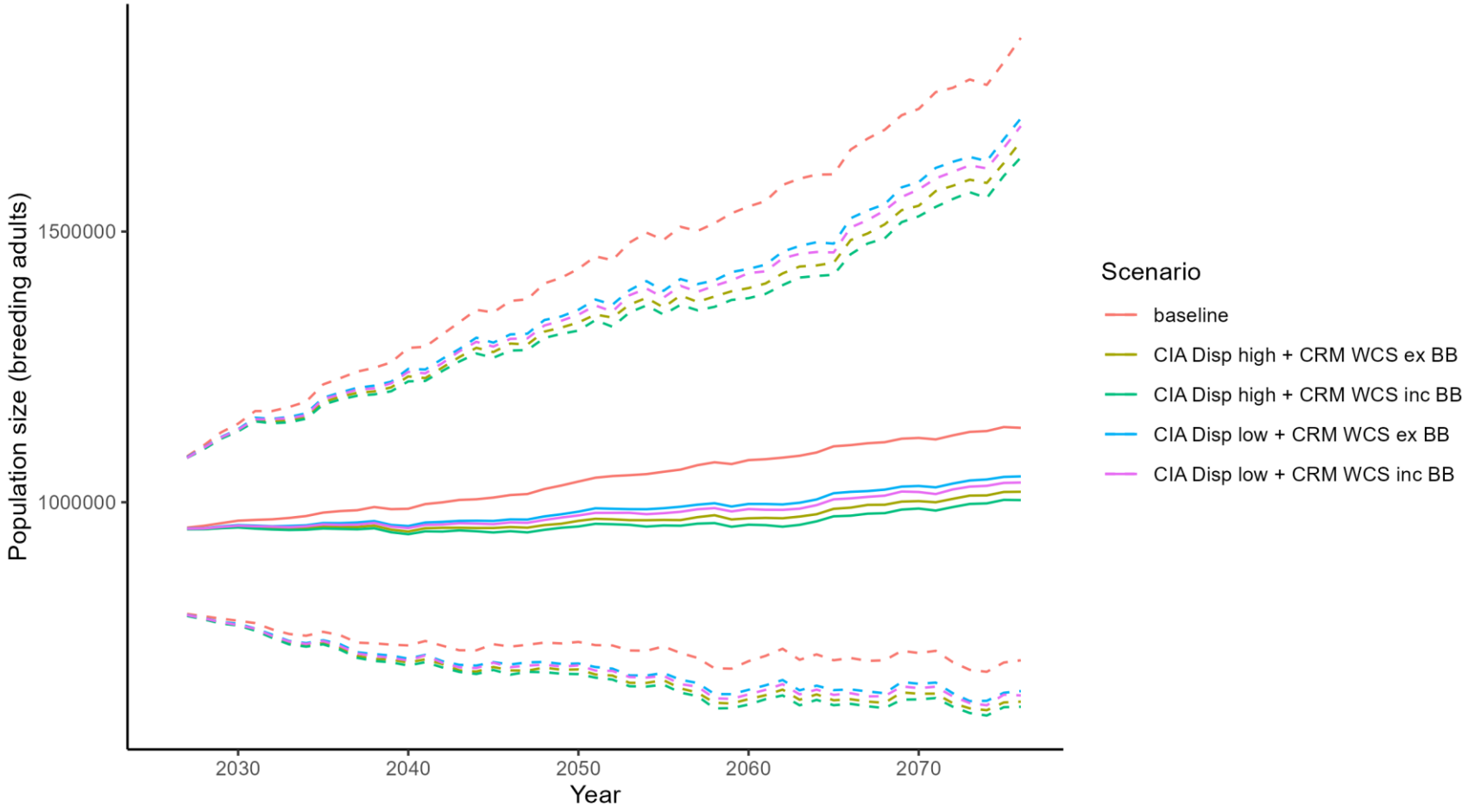

Figure 3-15. Gannet CIA – Regional population. Baseline = unimpacted population. CIA = cumulative impact assessment. Disp High = high displacement. Disp Low = low displacement. CRM WCS = collision mortality. Ex BB = impacts excluding Berwick Bank OWF. Inc BB = impacts including Berwick Bank OWF. Some trajectories are obscured in the plot due to being very similar to other trajectories.

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