LLŶR FLOATING OFFSHORE WIND PROJECT

Llŷr 1 Floating Offshore Wind Farm

Environmental Statement

Volume 6: Appendix 22F – Marine Ornithology Population Modelling

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Prepared by: Llŷr Floating Wind Ltd

FLOVENTIS ENERGY

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Acronyms and abbreviations

Acronym or Abbreviation	Definition	Acronym or Abbreviation	Definition
%	Percentage	PVA	Population Viability Analysis
CEH	Centre for Ecology and Hydrology	RIAA	Report to Inform Appropriate Assessment
CGR	Counterfactual Growth Rate	SD	Standard Deviation
CPS	Counterfactual Population Size	SMP	Seabird Monitoring Programme
EIA	Environmental Impact Assessment	SNCB	Statutory Nature Conservation Body
HRA	Habitats Regulation Assessment	SPA	Special Protection Area
JNCC	Joint Nature Conservation	SSSI	Special Site of Specific Interest
LCL	Lower Confidence Limit	SSSP	Skomer, Skokholm and Seas Off Pembrokeshire
NE	Natural England	UCL	Upper Confidence Limit
NRW	Natural Resources Wales		

Glossary of project terms

Term	Definition
The Applicant	The developer of the Project, Llŷr Floating Wind Limited
Array	All wind turbine generators, inter array cables, mooring lines, floating sub-structures and supporting subsea infrastructure within the Array Area, as defined, when considered collectively, excluding the offshore export cable(s).
Array Area	The area within which the wind turbine generators, inter array cables, mooring lines, floating sub-structures and supporting subsea infrastructure will be located
Barrier effects	Barrier effects may occur when birds that would have previously flown through an area (e.g., on the way to feeding, resting or nesting areas) either have to cease flying, or alter their flight paths due to the presence of an offshore wind farm which may affect energetic costs.
Collision risk	Risk that a bird entering the ‘risk window’, the sweep of the turbine blades, could be struck.
Displacement	Displacement is a reduction in the number of birds using / visiting the Array Area or its surroundings. Birds that would normally utilise the Array Area and surrounding sea may be disturbed or displaced from the area due to the presence of the wind turbine generators, resulting in an effective loss of available habitat for sensitive species.
Floventis Energy	A joint venture company between Cierco Ltd and SBM Offshore Ltd of which Llŷr Floating Wind Limited is a wholly owned subsidiary.
Landfall	The location where the offshore export cable(s) from the Array Area, as defined, are brought onshore and connected to the onshore export cables (as defined) via the transition joint bays (TJB).
Llŷr 1	The proposed Project, for which the Applicant is applying for Section 36 and Marine Licence consents. Including all offshore and onshore infrastructure and activities, and all project phases.

Term	Definition
Marine Licence	A licence required under the Marine and Coastal Access Act 2009 for marine works which is administered by Natural Resources Wales (NRW) Marine Licensing Team (MLT) on behalf of the Welsh Ministers.
Offshore Development Area	The footprint of the offshore infrastructure and associated temporary works, comprised of the Array Area and the Offshore Export Cable Corridor, as defined, that forms the offshore boundary for the S36 Consent and Marine Licence application
Offshore Export Cable	The cable(s) that transmit electricity produced by the WTGs to landfall.
Offshore Export Cable Corridor (OfECC)	The area within which the offshore export cable circuit(s) will be located, from the Array Area to the Landfall.
Onshore Development Area	The footprint of the onshore infrastructure and associated temporary works, comprised of the Onshore Export Cable Corridor and the Onshore Substation, as defined, and including new access routes and visibility splays, that forms the onshore boundary for the planning application.
Onshore Export Cable(s)	The cable(s) that transmit electricity from the landfall to the onshore substation
Onshore Export Cable Corridor (OnECC)	The area within which the onshore export cable circuit(s) will be located.
proposed Project	All aspects of the Llŷr 1 development (i.e. the onshore and offshore components).
Onshore Substation	Located within the Onshore Development Area, converts high voltage generated electricity into low voltage electricity that can be used for the grid and domestic consumption.
Section 36 consent	Consent to construct and operate an offshore generating station, under Section 36 (S.36) of the Electricity Act 1989. This includes deemed planning permission for onshore works.

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22. APPENDIX 22F: MARINE ORNITHOLOGY POPULATION MODELLING

22.1 Introduction

1. This **Technical Appendix 22F: Marine Ornithology Population Modelling** presents the method for, and results obtained from, modelling the population consequences of potential impacts to seabirds arising from the Llŷr 1 Floating Offshore Wind Farm (hereafter referred to as 'the proposed Project'). This population modelling informs the assessments and conclusions presented in the **Environmental Statement (ES) Volume 3, Chapter 22 Marine Ornithology** and in **Appendix 8E: Habitats Regulations Assessment (HRA) Report to Inform Appropriate Assessment (RIAA)**.

2. **Chapter 22: Marine Ornithology** includes a summary of the statutory advice and pre-application liaison carried out with Natural Resources Wales Advisory (NRW (A)) and the Joint Nature Conservation Committee (JNCC) as well as the wider stakeholder liaison (including with the Royal Society for the Protection of Birds and the Wildlife Trusts) for this receptor group (**Table 22-4,** scoping and **Table 22-5**, pre-application consultation, as presented in **Chapter 22: Marine Ornithology**).

3. In line with this pre-application advice from NRW (A) and JNCC, population viability analysis (PVA) has been undertaken, where required, using the tool commissioned by Natural England (NE), and developed by the Centre for Hydrology and Ecology (CEH) (Searle *et al.,* 2019; updated 2022). This provides a standard mathematical model which uses the key demographic rates estimated for a population (typically survival and productivity), to forecast future population trend and population size (see **Section 22.2** for further detail on method).

4. Collision risk and displacement / barrier effects are the two types of impact arising from offshore wind farms where semi-quantitative methods have been developed to estimate potential seabird mortalities. For the proposed Project this impact modelling is set out in **Technical Appendix 22C: Marine Ornithology Collision Risk Modelling** and **Technical Appendix 22D: Marine Ornithology Displacement Assessment**.

5. **Technical Appendix 22E: Marine Ornithology Project Alone and Cumulative Impact Scenarios** sets out the detail for determining which species and populations require PVA, the comparison of estimated mortalities (for the proposed Project alone and cumulatively with other projects) against the 1% baseline mortality thresholds for reference populations (both EIA and HRA), as advised by NRW (A) and JNCC.

6. From this work, it is determined that PVA is required for:

   - common guillemot (*Uria aalge*; hereafter 'guillemot') at Skomer, Skokholm and Seas Off Pembrokeshire (SSSP) Special Area of Protection (SPA), and Castlemartin Range Special Site of Scientific Interest (SSSI);
   - Atlantic puffin (*Fratercula arctica*; hereafter 'puffin') at SSSP SPA; and
   - northern gannet (*Morus bassanus*; hereafter 'gannet') at Grassholm SPA.

22.2 Methods

7. The NE PVA tool (Searle *et al.,* 2019) uses a stochastic Leslie Matrix Model (Caswell, 2000) to estimate population size, using species-specific age and life-history data (NatureScot, 2023). A Leslie matrix is a discrete, age-structured model of population growth that is widely used in ecology (Leslie, 1945). It simulates the progression of a population over time: at each time step (i.e., one year) abundance is predicted based on the previous year's abundance and vital rates (i.e. survival, growth and reproduction).

8. All PVA modelling was undertaken through the web-based 'R-Shiny' package in the R computer programming language using Tool v2; Code: v4.18, Interface: v1.7.

22.2.1. Modelled Populations

9. The focal species and populations to address using PVA are presented in **Table 22F-1**. The reference point is the population (the colony count) most closely contemporaneous with the date of the survey programme (**Appendix 22A: Marine Ornithology Baseline**), as this is the 'time stamp' for the data on which impact quantification is based. The proposed Project survey programme ran monthly from March 2020 to March 2022 (24 surveys; **Appendix 22A**) and so the closest available counts to this 'time stamp' have been used. Count data is available and provides a good match for guillemot and puffin where colonies are regularly counted, however, the gannet population at Grassholm is less frequently counted and therefore the count data used is slightly older.

10. Note that while this 'time stamp' match holds for the proposed Project (project alone), this is not the case for all wind farms under consideration in the cumulative assessment. This is a known limitation of the modelling as it currently stands (see also **Section 22.2.2** addressing model duration).

Table 22F-1. Species and SPAs considered in PVA and their respective population sizes

Species	SPA	Initial population size (breeding individuals)[1]	Year of census	Source
Guillemot	SSSP	44,099	2021/22	SMP database
	Castlemartin Range SSSI	22,591	2021/22	SMP database
Puffin	SSSP	33,619	2021/22	SMP database
Gannet	Grassholm	72,022	2015	SMP database

[1] *Colony counts taken from the Seabird Monitoring Programme (SMP) database.*

22.2.2. Model 'Burn In' and Impact Period

11. The 'burn in' function of the NE PVA tool has been used to derive the 'whole' population (stable age-classes) from the SPA count of breeding adults. A 'burn in' period of five years was used, as advised by NRW (A) and JNCC. It is this 'whole' population against which impacts are applied, without any forward projection of the population baseline.

12. The consent period being applied for in relation to the proposed Project is 30 years; equating to the operational period of the wind farm (the length of time over which collision risk and displacement impacts may occur). Therefore a 30-year impact period was applied directly after model 'burn in', and results were obtained at the end of the 30 years modelled without a further 'recovery period' being added.

13. Neither model 'burn in' nor impact or recovery periods, should be thought of in 'real time' (i.e., against specified years or dates). The modelling is an approximation of reality, given that variable year-on-year impacts cannot be applied over the model period. This is a known limitation of the current version of the tool (Searle *et al.,* 2019 (updated 2022)), relevant to cumulative assessment, (where different operational start and end dates cannot be applied for the range of wind farms included for consideration).

22.2.3. *Demographic Parameters*

14. For each species modelled, the NE PVA tool contains a choice of demographic rates to use within the modelling. These demographic rates are derived from Horswill & Robinson (2015) and the JNCC Seabird Monitoring Programme (SMP). The rates are aggregated to national or regional level, with the addition of some colony-specify rates where available. The following rates were selected for this assessment, as presented in **Table 22F-2**

- guillemot; colony-specific survival rates for 'Skomer (1985-2011)' and colony-specific breeding success rates for 'Skokholm and Skomer SPA; Skomer';
- puffin; colony-specific survival rates for 'Skomer (1972-2008)' and colony-specific breeding success rates for 'Skokholm and Skomer SPA; Skomer'; and
- gannet; 'National' survival rates and colony-specific breeding success rates for the 'Grassholm SPA; Grassholm'.

15. The NE PVA tool uses the demographic information to parameterise a stochastic Leslie matrix model, the uncertainty/variance associated with the demographic rates allow probabilistic outputs which account for the influence of environmental and demographic stochasticity on the populations annually.

16. Demographic rates are likely to be subject to density-dependence, as the number of individuals in a population increases or declines. However, a lack of research and data on this topic mean it is not currently possible to include it as part of the PVA assessment. Following NRW (A) advice (note of 17 February 2023) as well as available guidance from NE on this matter (Parker *et al.,* 2022), density-independent modelling has been used for the PVAs presented in this report.

Table 22F-2. Summary of demographic rates for PVA species (from the NE PVA tool, based on SMP data)

Demographic	Guillemot		Puffin		Gannet	
	Mean	SD	Mean	SD	Mean	SD
Adult survival	0.930	0.043	0.906	0.047	0.919	0.042
Productivity (per pair)	0.687	0.078	0.754	0.070	0.744	0.066
Age of recruitment	6		5		5	
Brood size (per pair)*	1		1		1	
Survival 0 → 1	0.560	0.058	0.892**	0.108	0.424	0.045
Survival 1 → 2	0.792	0.152	0.892**	0.108	0.829	0.026
Survival 2 → 3	0.917	0.098	0.892**	0.108	0.891	0.019
Survival 3 → 4	0.938	0.107	0.760	0.093	0.895	0.019
Survival 4 → 5	0.930	0.043	0.805	0.083	0.919	0.042
Survival 5 → 6	0.930	0.043				

**Brood size (per pair) parameter does not have a standard deviation as it was set to a maximum of one.*

***Survival between 0- and 3-year-old birds set to 0.892 as advised by NRW (A) (Table 22-2, Chapter 22)*

22.2.4. Age Classes

17. Within the PVA tool, survival rate can be set as age-dependent or the same across all age groups. For the baseline scenario, the default survival values from the age dependent function provided in the NE PVA tool were used.

18. For the stochastic Leslie matrix within the tool, there are six age classes used for gannets and puffins (one adult and five juvenile / immature) and seven for guillemot (one adult and six juvenile / immature).

22.2.5. Modelled Impact Scenarios

19. **Appendix 22E: Marine Ornithology Project Alone and Cumulative Impact Scenarios** sets out how these impact scenarios for PVA have been derived for each species and population modelled; guillemot (**Table 22F-3 and Table 22F-4**), puffin **(Table 22F-5**) and gannet (**Table 22F-6**).

20. Within the modelling, the additional mortality is calculated as a proportion of the starting population. Following NRW(A) and JNCC advice, for the guillemot and puffin PVAs it was applied to the adult age class only, while for gannet, the mortality was apportioned across adult and immature age-classes using the proportions obtained from the digital aerial survey observations (**Appendix 22A: Marine Ornithology Baseline**). Following NRW(A) and JNCC advice, no allowance is made for sabbatical birds.

21. Note the guillemot project-alone impacts are the only ones where upper and lower confidence intervals are available as a measure of uncertainty around the mean displacement mortality estimates. This is because guidance on the treatment of uncertainty is still under development by the statutory nature conservation bodies (SNCBs) and these measures are only now being requested of projects. Therefore, none of the operational and / or consented wind farms that are included for cumulative assessment have this information available. Please see **Appendix 22E: Marine Ornithology Project Alone and Cumulative Impact Scenarios** for further detail, as well as **Annex B** of **Appendix 22A: Marine Ornithology Baseline**.

Guillemot – SSSP SPA

Table 22F-3. Modelled impact scenarios for guillemot – SSSP SPA

Scenario	Impacts modelled* Displacement	Impact on adult survival rates	Impact on productivity rates	Annual mortalities (numbers of birds)	
				Adults	Chicks
Proposed Project-alone impact scenarios					
1	Llŷr - SeabORD	0.000370426	0.000819728	16.33	18.00
2a	Llŷr - matrix 30% / 1%	0.000090025		3.97	
2b	*Llŷr - matrix 30% / 1% LCL*	*0.000070977*		*3.13*	
2c	*Llŷr - matrix 30% / 1% UCL*	*0.000110660*		*4.88*	
3a	Llŷr - matrix 60% / 3%	0.000540829		23.85	
3b	*Llŷr - matrix 60% / 3% LCL*	*0.000426087*		*18.79*	
3c	*Llŷr - matrix 60% / 3% UCL*	*0.000664187*		*29.29*	
4a	Llŷr - matrix 70% / 10%	0.002103222		92.75	
4b	*Llŷr - matrix 70% / 10% LCL*	*0.001656954*		*73.07*	
4c	*Llŷr - matrix 70% / 10% UCL*	*0.002583279*		*113.92*	
Cumulative impact scenarios (proposed Project, Erebus, White Cross)					
5	Cumulative - SeabORD	0.000612337	0.002326471	27.00	51.33
6	Cumulative - matrix 30% / 1%	0.000520873		22.97	
7	Cumulative - matrix 60% / 3%	0.003035216		133.85	
8	Cumulative - matrix 70% / 10%	0.011672600		514.75	

**Upper and lower confidence intervals are presented in italics; available for the project-alone impact scenarios, as discussed.*

Guillemot – Castlemartin Range SSSI

Table 22F-4. Modelled impact scenarios for guillemot – Castlemartin Range SSSI

Scenario	Impacts modelled * Displacement	Impact on adult survival rates	Impact on productivity rates	Annual mortalities (numbers of birds)	
				Adults	Chicks
Proposed Project-alone impact scenarios					
1	Llŷr - SeabORD	0.000442608	0.000890000	10.00	10.00
2a	Llŷr - matrix 30% / 1%	0.000127927		2.89	
2b	*Llŷr - matrix 30% / 1% LCL*	*0.000100482*		*2.27*	
2c	*Llŷr - matrix 30% / 1% UCL*	*0.000157142*		*3.55*	
3a	Llŷr - matrix 60% / 3%	0.000767562		17.34	
3b	*Llŷr - matrix 60% / 3% LCL*	*0.000603338*		*13.63*	
3c	*Llŷr - matrix 60% / 3% UCL*	*0.000944624*		*21.34*	
4a	Llŷr - matrix 70% / 10%	0.002985702		67.45	
4b	*Llŷr - matrix 70% / 10% LCL*	*0.002347395*		*53.03*	
4c	*Llŷr - matrix 70% / 10% UCL*	*0.003672702*		*82.97*	
Cumulative impact scenarios (proposed Project, Erebus, White Cross)					
5	Cumulative - SeabORD	0.000516377	0.002040000	11.67	19.67
6	Cumulative - matrix 30% / 1%	0.000358363		8.10	
7	Cumulative - matrix 60% / 3%	0.002150178		48.57	
8	Cumulative - matrix 70% / 10%	0.008362540		188.92	

**Upper and lower confidence intervals are presented in italics; available for the project-alone guillemot impact scenarios, as discussed.*

Puffin – SSSP SPA

Table 22F-5. Modelled impact scenarios for puffin – SSSP SPA

Scenario	Impacts modelled Displacement	Impact on adult survival rates	Impact on productivity rates	Annual mortalities (numbers of birds)	
				Adults	Chicks
Proposed Project-alone impact scenarios					
1	proposed Project - SeabORD	0.000604859	0.000922307	20.33	15.50
Cumulative impact scenarios (proposed Project, Erebus, White Cross)					
2	Cumulative - SeabORD	0.001105602	0.001724157	37.17	29.00
3	Cumulative - matrix 30% / 1%	0.000193343		6.50	
4	Cumulative - matrix 60% / 3%	0.000892055		29.99	
5	Cumulative - matrix 70% / 10%	0.003320444		111.63	

Gannet – Grassholm SPA - CRM and Displacement

Table 22F-6. Modelled impact scenarios for gannet – Grassholm SPA

Scenario	Impacts modelled Collision risk and displacement	Impact on adult survival rates	Impact on immature survival rates	Annual mortalities (numbers of birds)	
				Adults	Immatures
Cumulative impact scenarios ***Only cumulative scenario 4 exceeds the threshold, however, the other scenarios (1-3) are modelled for context. Annex E sets out how these figures are derived.*** ***No project-alone modelling has been undertaken as under this scenario the impacts fall well below the 1% baseline mortality threshold (58 adult birds).***					
1	Cumulative - CRM + matrix 60% / 1%	0.000266777	0.000006066	19.21	0.22
2	Cumulative - CRM + matrix 70% / 1%	0.000271267	0.000006509	19.54	0.23
3	Cumulative - CRM + matrix 70% / 3%	0.000391451	0.000012761	28.19	0.45
4	Cumulative - CRM + matrix 80% / 10%	0.000890621	0.000039117	64.14	1.39

22.3 Results

22. The key outputs from the NE PVA tool are the counterfactual of population size (CPS) and the counterfactual of growth rate (CGR) (Searle *et al.,* 2019; NatureScot, 2023). These are the ratios of the impacted to unimpacted (baseline) scenarios, which the SNCBs advise are used in the consideration of modelled population consequences (Cook and Robinson, 2016).

23. Testing the sensitivities of these metrics has suggested that counterfactual of growth rate is useful to illustrate impacts regardless of population status or trend (Cook and Robinson, 2016; Jital *et al.,* 2017). Cook and Robinson (2016) also found CPS can be used to assess the population level effects of impacts for stable or increasing populations and may also offer a useful context for the counterfactual of growth rate.

24. Each set of PVA outputs; CGR and CPS are presented in the following tables and illustrative plots;

- guillemot: **Table 22F-7, Figure 22F-1** and **Figure 22F-2** for SSSP SPA and **Table 22F-8**, **Figure 22F-3** and **Figure 22F-4** for Castlemartin SSSI;
- puffin: **Table 22F-9** and **Figure 22F-5** for SSSP SPA; and
- gannet: **Table 22F-10** and **Figure 22F-6** for Grassholm SPA.

22.3.1. *Guillemot*

Skomer, Skokholm and the Seas Off Pembrokeshire SPA

Table 22F-7. Metrics and counterfactuals for 5,000 simulations of the guillemot PVA after 30 years of impacts – SSSP SPA

Guillemot *SSSP SPA*		Median population size at end of modelled period (adult individuals)	Median counterfactuals					
			CGR			CPS		
			Median	LCL	UCL	Median	LCL	UCL
30 years		**Baseline: 102,768**						
Proposed Project alone								
1	SeabORD	101,321	**1.000**	0.999	1.000	**0.985**	0.967	1.000
2a	Matrix 30%/1%	102,524	**1.000**	0.999	1.000	**0.997**	0.982	1.010
2b	*Matrix 30%/1% LCL*	*102,600*	*1.000*	*0.999*	*1.000*	*0.998*	*0.983*	*1.010*
2c	*Matrix 30%/1% UCL*	*102,624*	*1.000*	*0.999*	*1.000*	*0.996*	*0.981*	*1.010*
3a	Matrix 60%/3%	100,896	**0.999**	0.999	1.000	**0.981**	0.967	0.996
3b	*Matrix 60%/3% LCL*	*101,286*	*1.000*	*0.999*	*1.000*	*0.985*	*0.971*	*1.000*
3c	*Matrix 60%/3% UCL*	*100,463*	*0.999*	*0.999*	*1.000*	*0.977*	*0.963*	*0.992*
4a	Matrix 70%/10%	95,534	**0.998**	0.997	0.998	**0.929**	0.915	0.943
4b	*Matrix 70%/10% LCL*	*97,032*	*0.998*	*0.998*	*0.999*	*0.944*	*0.929*	*0.958*
4c	*Matrix 70%/10% UCL*	*93,937*	*0.997*	*0.997*	*0.998*	*0.914*	*0.900*	*0.927*
Cumulative (proposed Project, Erebus, White Cross)								
5	SeabORD	100,032	**0.999**	0.998	1.000	**0.973**	0.948	0.999
6	Matrix 30%/1%	100,961	**0.999**	0.999	1.000	**0.982**	0.967	0.997
7	Matrix 60%/3%	92,529	**0.997**	0.996	0.997	**0.899**	0.886	0.912
8	Matrix 70%/10%	68,186	**0.987**	0.986	0.987	**0.663**	0.651	0.674

Values in bold are those displayed in the following figures.

Upper and lower confidence intervals are presented in italics and only available for the Proposed Project-alone guillemot impact scenarios, as discussed.

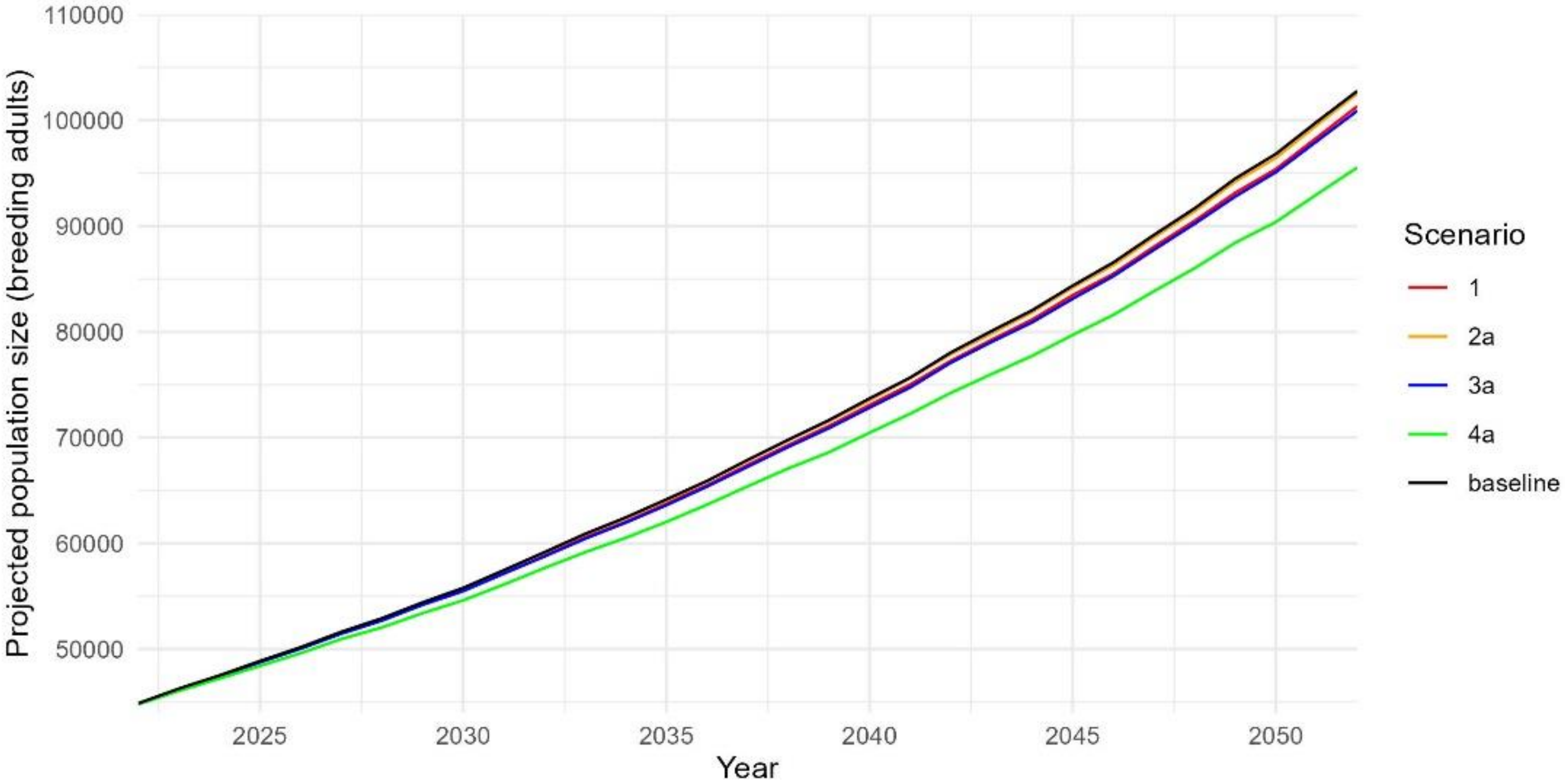

*Figure 22F-1. Median population trajectory estimated from 5,000 simulations of the PVA for each of the scenarios run for the proposed Project-alone guillemot populations at the SSSP SPA. Scenarios are labelled as in **Table 22F-7**.*

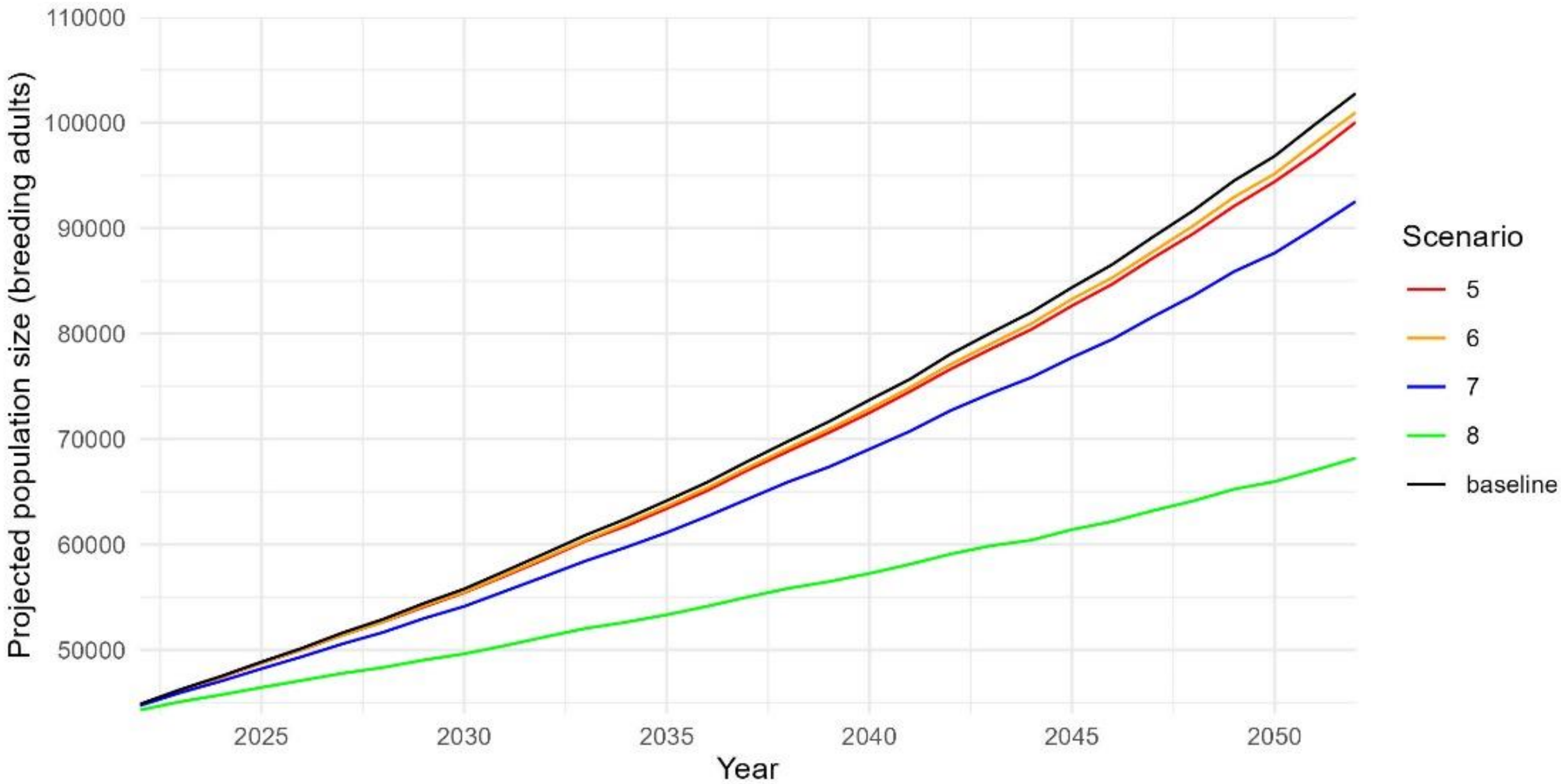

*Figure 22F-2. Median population trajectory estimated from 5,000 simulations of the PVA for each of the scenarios run for cumulative guillemot populations at the SSSP SPA. Scenarios are labelled as in **Table 22F-7**.*

Castlemartin Range SSSI

Table 22F-8. Metrics and counterfactuals for 5,000 simulations of the guillemot PVA after 30 years of impacts – Castlemartin Range SSSI

Guillemot *Castlemartin Range SSSI*		Median population size at end of modelled period (adult ind)	Median counterfactuals					
			CGR			CPS		
			Median	LCL	UCL	Median	LCL	UCL
30 years		**Baseline: 52,638**						
Proposed Project alone								
1	SeabORD	51,795	**0.999**	0.999	1.000	**0.983**	0.960	1.000
2a	Matrix 30%/1%	52,426	**1.000**	0.999	1.000	**0.996**	0.975	1.020
2b	*Matrix 30%/1% LCL*	*52,437*	*1.000*	*0.999*	*1.000*	*0.996*	*0.976*	*1.020*
2c	*Matrix 30%/1% UCL*	*52,390*	*1.000*	*0.999*	*1.000*	*0.994*	*0.975*	*1.020*
3a	Matrix 60%/3%	51,285	0.999	0.998	1.000	0.974	0.953	0.994
3b	*Matrix 60%/3% LCL*	*51,568*	*0.999*	*0.999*	*1.000*	*0.979*	*0.959*	*0.999*
3c	*Matrix 60%/3% UCL*	*50,956*	*0.999*	*0.998*	*1.000*	*0.968*	*0.948*	*0.988*
4a	Matrix 70%/10%	47,491	**0.997**	0.996	0.997	**0.901**	0.882	0.920
4b	*Matrix 70%/10% LCL*	*48,529*	*0.997*	*0.997*	*0.998*	*0.921*	*0.902*	*0.940*
4c	*Matrix 70%/10% UCL*	*46,355*	*0.996*	*0.995*	*0.997*	*0.879*	*0.861*	*0.898*
Cumulative (proposed Project, Erebus, White Cross)								
5	SeabORD	51,383	**0.999**	0.998	1.000	**0.977**	0.948	1.010
6	Matrix 30%/1%	51,999	**1.000**	0.999	1.000	**0.987**	0.967	1.010
7	Matrix 60%/3%	48,805	**0.998**	0.997	0.998	**0.928**	0.908	0.947
8	Matrix 70%/10%	39,314	**0.991**	0.990	0.991	**0.746**	0.729	0.762

Values in bold are those displayed in the following figure.

Upper and lower confidence intervals are presented in italics and only available for the proposed Project-alone guillemot impact scenarios, as discussed.

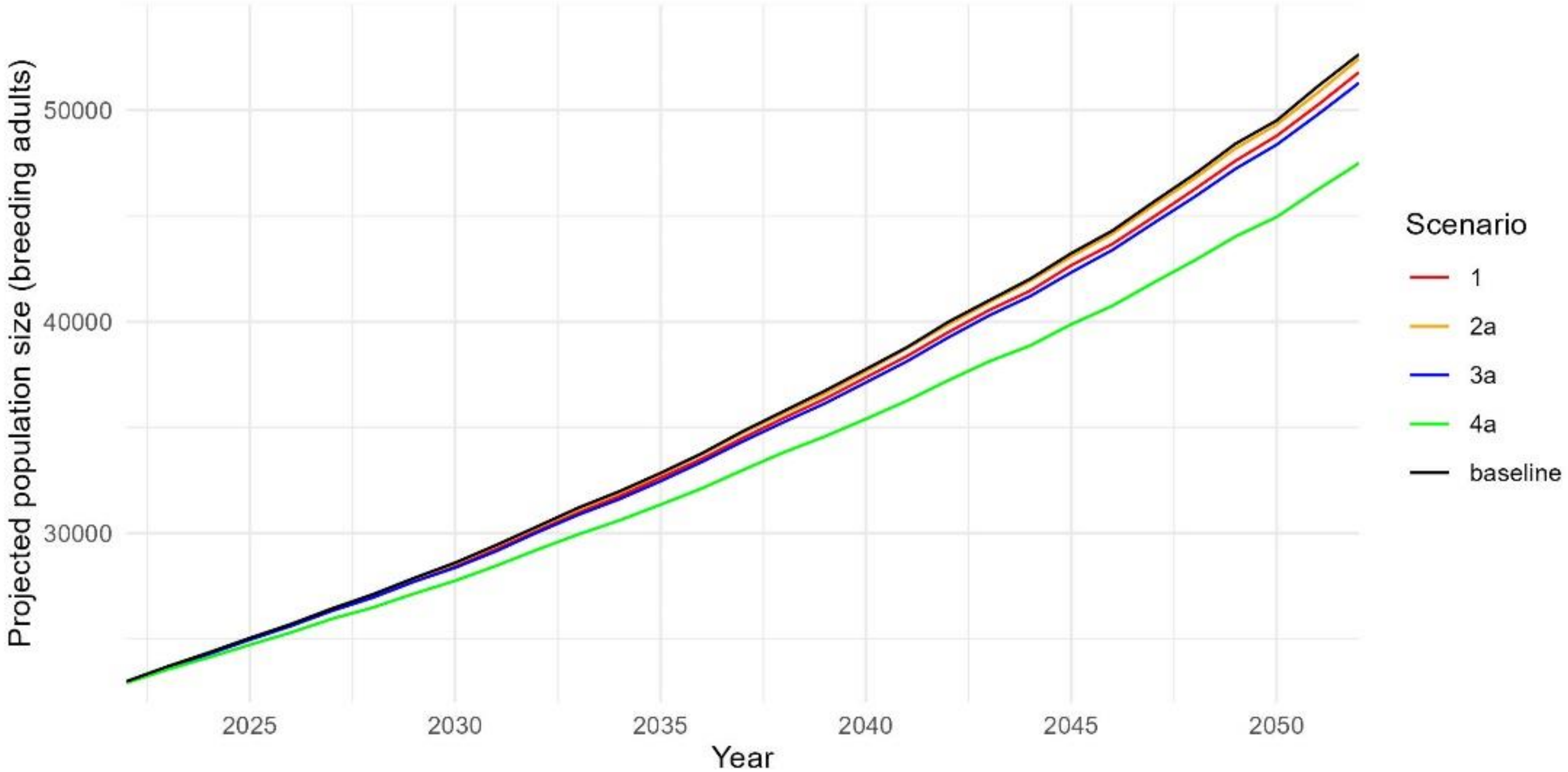

*Figure 22F-3. Median population trajectory estimated from 5,000 simulations of the PVA for each of the scenarios run for the proposed Project-alone guillemot populations at the Castlemartin Range SSSI. Scenarios are labelled as in **Table 22F-8**.*

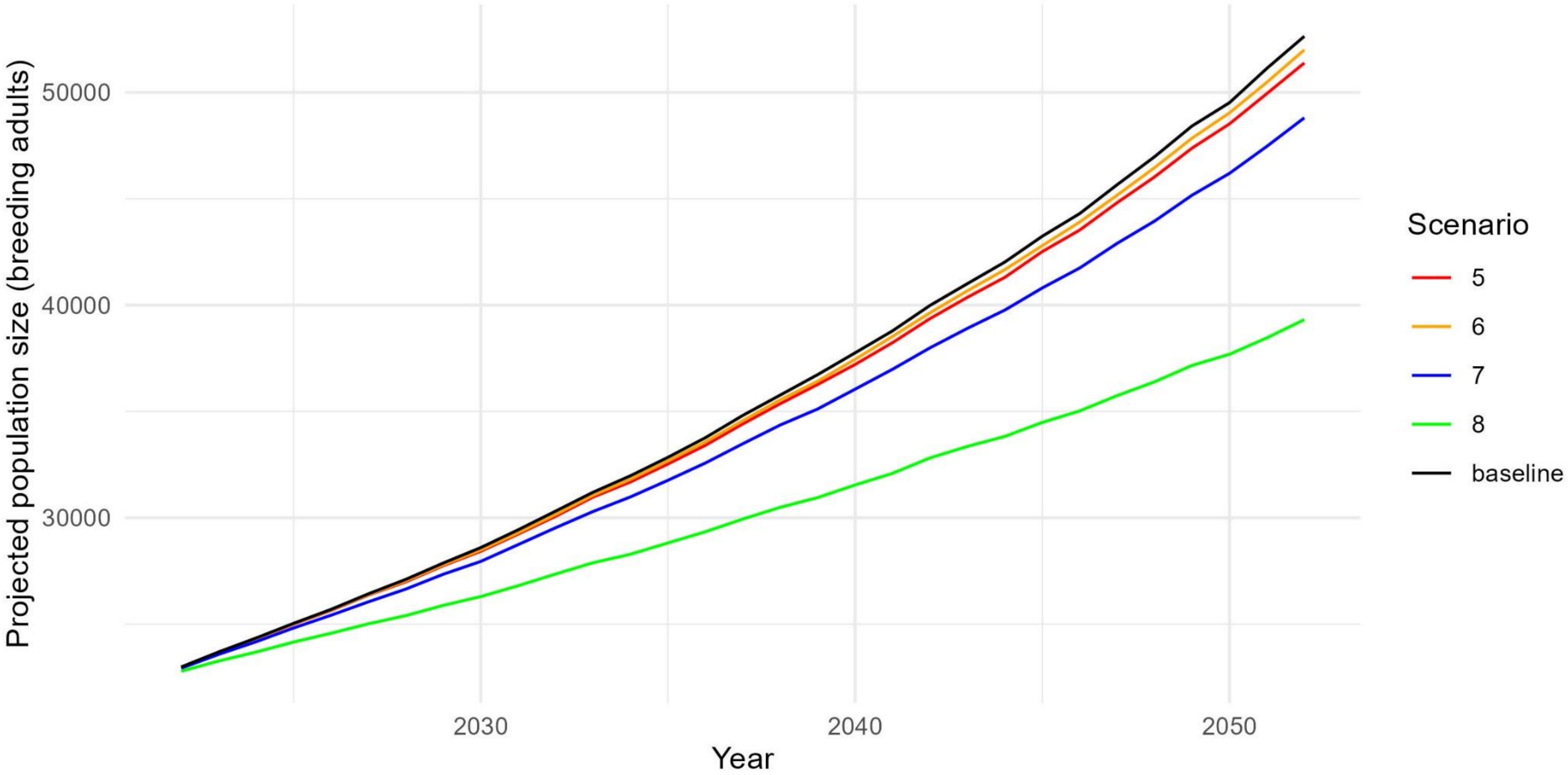

*Figure 22F-4. Median population trajectory estimated from 5,000 simulations of the PVA for each of the scenarios run for cumulative guillemot populations at the Castlemartin Range SSSI. Scenarios are labelled as in **Table 22F-8**.*

22.3.2. Puffin

Table 22F-9. Metrics and counterfactuals for 5,000 simulations of the puffin PVA after 30 years of impacts – SSSP SPA

Puffin *SSSP SPA*		Median population size at end of modelled period (adult ind)	Median counterfactuals					
			CGR			CPS		
			Median	LCL	UCL	Median	LCL	UCL
30 years		**Baseline: 122,804**						
Proposed Project alone								
1	SeabORD	119,760	**0.999**	0.998	1.000	**0.976**	0.952	1.000
Cumulative (proposed Project, Erebus, White Cross)								
2	SeabORD	117,500	**0.999**	0.997	1.000	**0.957**	0.925	0.989
3	Matrix 30%/1%	121,898	**1.000**	0.999	1.000	**0.993**	0.977	1.010
4	Matrix 60%/3%	118,830	**0.999**	0.998	1.000	**0.969**	0.953	0.985
5	Matrix 70%/10%	109,211	**0.996**	0.996	0.997	**0.889**	0.874	0.904

Values in bold are those displayed in the following figure.

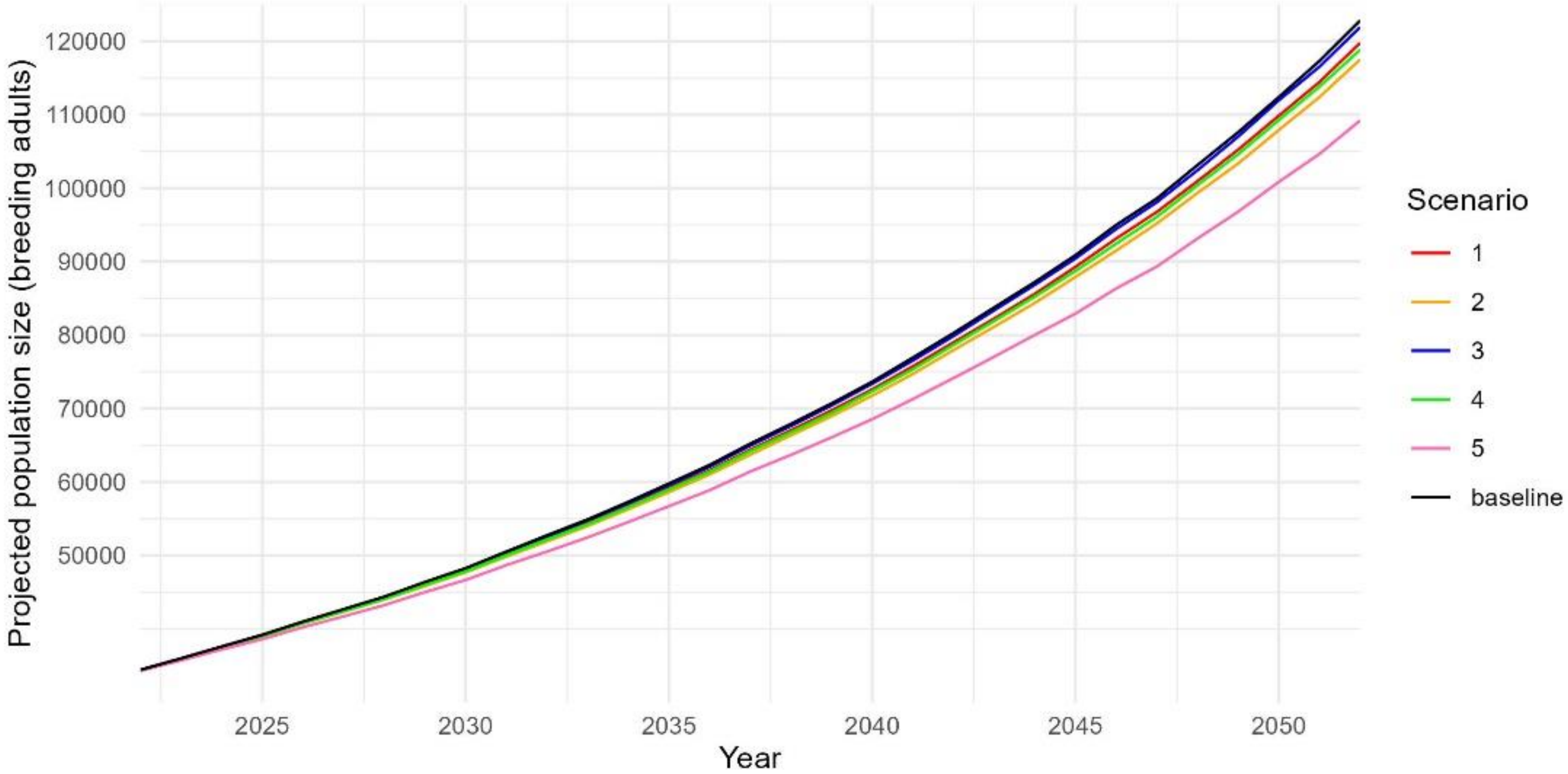

*Figure 22F-5. Median population trajectory estimated from 5,000 simulations of the PVA for each of the scenarios run for the proposed Project-alone puffin populations at the SSSP SPA. Scenarios are labelled as in **Table 22F-9**.*

22.3.3. *Gannet*

Table 22F-10. Metrics and counterfactuals for 5,000 simulations of the gannet PVA after 30 years of impacts – Grassholm SPA

Gannet *Grassholm SPA*		Median population size at end of modelled period (adult individuals)	Median counterfactuals					
			CGR			CPS		
			Median	LCL	UCL	Median	LCL	UCL
30 years		**Baseline: 98,751**						
Cumulative (proposed Project, Erebus, White Cross, Awel Y Mor, Morlais)								
1	CRM + matrix 60%/1%	98,070	**1.000**	0.999	1.000	**0.994**	0.979	1.010
2	CRM + matrix 70%/1%	98,151	**1.000**	0.999	1.000	**0.994**	0.978	1.010
3	CRM + matrix 70%/3%	97,859	**1.000**	0.999	1.000	**0.991**	0.975	1.010
4	CRM + matrix 80%/10%	96,649	**0.999**	0.999	1.000	**0.979**	0.964	0.994

Values in bold are those displayed in the following figure.

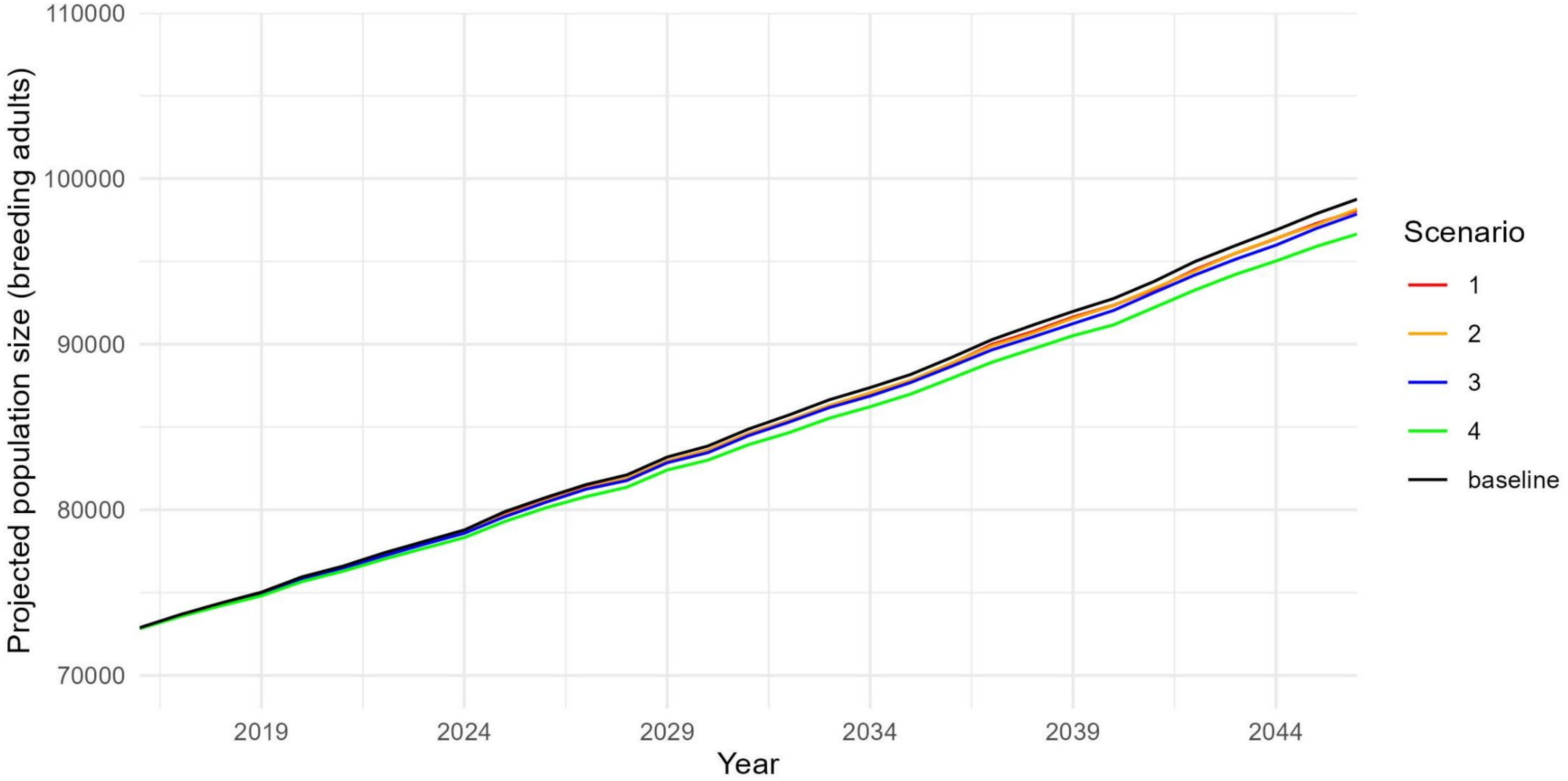

Figure 22F-6. Median population trajectory estimated from 5,000 simulations of the PVA for each of the scenarios run for cumulative gannet populations at the Grassholm SPA. Scenarios are labelled as in ***Table 22F-10****.*

22.4 Summary of PVA Outputs

25. The baseline scenarios for each population show a stable growth rate and an increasing population size, this reflects what is known about each population from the colony monitoring and colony count information available.

26. The counterfactuals (ratio) of population growth rate and population size, suggest that the estimates of mortality due to the operational phase of the proposed Project (collision risk and displacement) would not affect the viability of any of the protected seabird populations under consideration (either guillemot, puffin or gannet).

27. Cumulatively, the only impact scenarios potentially presenting a concern are those related to displacement matrix outputs where a mortality rate of 10% has been applied to derive the mortality estimates. As such, there is no available evidence that displacement would result in such mortality, and the SeabORD modelling completed for the proposed Project indicates much lower levels of risk for the auk species modelled.

28. If this is the case for auks, then it is even more true for gannet where the large foraging range of this species and its flexibility in habitat use and prey source (Furness *et al*., 2013; Woodward *et al.,* 2019) would suggest that there should be very little concern about the effects on this species of being displaced. There is very little energetic cost to gannet from being displaced (Masden *et al*., 2010), particularly where a wind farm project occupies only a small area such as is the case for the proposed Project.

29. Consideration of population consequences to guillemot at Castlemartin Range SSSI is addressed in **Section 28.8.2** of **Chapter 22: Marine Ornithology**. The rest of the modelling is presented to inform appropriate assessment in relation to Skomer, Skokholm and Seas Off Pembrokeshire SPA and Grassholm SPA, as set out in **Appendix 8E: HRA RIAA**.

22.5 References

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