Bowdun Offshore Wind Farm, Offshore EIA Report

Volume 3, Technical Appendix 11.7: Offshore Ornithology Population Viability Analysis Technical Report

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Contents

1 Introduction 1
1.1 Background 1
2 Methodology 13
2.1 Overview 13
2.2 Modelling Approach 13
2.3 Simulation Parameters 14
2.4 Model Parametrisation 15
2.5 Input Parameters 18
3 PVA Results 25
3.2 Collision Risk 25
3.3 Displacement 37
3.4 Combined Collision Risk and Displacement 66
4 Conclusion 88
References 91

List of Tables

Table 1.1: Summary of EIA Impacts of the Proposed Development Alone. 5
Table 1.2: Summary of Species Requiring PVA for the Cumulative Projects 8
Table 2.1: Demographic Rates for Key Species Used in Population Viability Analysis, Derived from Horswill and Robinson (2015). Standard Deviations are Provided in Parentheses 16
Table 2.2: Biologically Defined Population Scales for Use in the Assessment (Burnell *et al.*, 2023; Furness, 2015) 17
Table 2.3: Input Parameters for Proposed Development Alone PVA Assessment 18
Table 2.4: Input Parameters for Cumulative PVA Assessment 20
Table 3.1: Outputs of PVA for Cumulative Assessment of Collision Risk Impacts for Great Black-backed Gull in the Non-breeding Season. CIs Given in Parentheses 26
Table 3.2: Outputs of PVA for Cumulative Assessment of Collision Risk Impacts for Great Black-backed Gull Annually. CIs Given in Parentheses 26
Table 3.3: Outputs of PVA for Proposed Development Alone Assessment of Collision Risk Impacts for Herring Gull in the Breeding Season CIs Given in Parentheses 28
Table 3.4: Outputs of PVA for Proposed Development Alone Assessment of Collision Risk Impacts for Herring Gull Annually CIs Given in Parentheses 28
Table 3.5: Outputs of PVA for Cumulative Assessment of Collision Risk Impacts for Herring Gull During the Breeding Season. CIs Given in Parentheses 30
Table 3.6: Outputs of PVA for Cumulative Assessment of Collision Risk Impacts for Herring Gull During the Non-breeding Season. CIs Given in Parentheses 31
Table 3.7: Outputs of PVA for Cumulative Assessment of Collision Risk Impacts for Herring Gull Annually. CIs Given in Parentheses 32
Table 3.8: Outputs of PVA for Proposed Development Alone Assessment of Collision Risk Impacts for Arctic Tern in the Breeding Season. CIs Given in Parentheses 35
Table 3.9: Outputs of PVA for Proposed Development Alone Assessment of Displacement Impacts for Guillemot in the Breeding Season. CIs Given in Parentheses 38
Table 3.10: Outputs of PVA for Proposed Development Alone Assessment of Displacement Impacts for Guillemot in the Non-breeding Season. CIs Given in Parentheses 39
Table 3.11: Outputs of PVA for Proposed Development Alone Assessment of Displacement Impacts for Guillemot Annually. CIs Given in Parentheses 40
Table 3.12: Outputs of PVA for Cumulative Assessment of Displacement Impacts for Guillemot During the Breeding Season. CIs Given in Parentheses 42
Table 3.13: Outputs of PVA for Cumulative Assessment of Displacement Impacts for Guillemot During the Non-breeding Season. CIs Given in Parentheses 43
Table 3.14: Outputs of PVA for Cumulative Assessment of Displacement Impacts for Guillemot Annually. CIs Given in Parentheses 45
Table 3.15: Outputs of PVA for Proposed Development Alone Assessment of Displacement Impacts for Razorbill in the Breeding Season. CIs Given in Parentheses 49
Table 3.16: Outputs of PVA for Proposed Development Alone Assessment of Displacement Impacts for Razorbill Annually. CIs Given in Parentheses 50
Table 3.17: Outputs of PVA for Cumulative Assessment of Displacement Impacts for Razorbill in the Breeding Season. Cis Given in Parentheses 52
Table 3.18: Outputs of PVA for Cumulative Assessment of Displacement Impacts for Razorbill in the Non-breeding Season. CIs Given in Parentheses 53
Table 3.19: Outputs of PVA for Cumulative Assessment of Displacement Impacts for Razorbill Annually. CIs Given in Parentheses 55
Table 3.20: Outputs of PVA for Cumulative Assessment of Displacement Impacts for Puffin During the Breeding Season. CIs Given in Parentheses 60
Table 3.21: Outputs of PVA for Cumulative Assessment of Displacement Impacts for Puffin During the Non-breeding Season. CIs Given in Parentheses 61
Table 3.22: Outputs of PVA for Cumulative Assessment of Displacement Impacts for Puffin Annually. CIs Given in Parentheses 63
Table 3.23: Outputs of PVA for Cumulative Assessment of Combined Collision and Displacement Impacts for Gannet During the Breeding Season. CIs Given in Parentheses 68
Table 3.24: Outputs of PVA for Cumulative Assessment of Combined Collision and Displacement Impacts for Gannet During the Non-breeding Season. CIs Given in Parentheses 69
Table 3.25: Outputs of PVA for Cumulative Assessment of Combined Collision and Displacement Impacts for Gannet Annually. CIs Given in Parentheses 71

Table 3.26: Outputs of PVA for Cumulative Assessment of Combined Collision and Displacement Impacts for Kittiwake During the Breeding Season. CIs Given in Parentheses 76
Table 3.27: Outputs of PVA for Cumulative Assessment of Combined Collision and Displacement Impacts for Kittiwake During the Non-breeding Season. CIs Given in Parentheses 79
Table 3.28: Outputs of PVA for Cumulative Assessment of Combined Collision and Displacement Impacts for Kittiwake Annually. CIs Given in Parentheses 83

List of Figures

Figure 1.1: Proposed Development Site Boundary 4
Figure 3.1: Population Projection for Cumulative Assessment of Collision Risk Impacts for Great Black-backed Gull in the Non-Breeding Season and Annually. Simulated Population Size with 95% CI are Presented 27
Figure 3.2: Population Projection for Proposed Development Alone Assessment of Collision Risk Impacts for Herring Gull for the Breeding Season and Annually. Simulated Population Size with 95% CI are Presented 29
Figure 3.3: Population Projection for Cumulative Assessment Including Berwick Bank of Collision Risk Impacts for Herring Gull. Simulated Population Size with 95% CI are Presented 33
Figure 3.4: Population Projection for Cumulative Assessment Excluding Berwick Bank of Collision Risk Impacts for Herring Gull. Simulated Population Size with 95% CI are Presented 34
Figure 3.5: Population Projection for Proposed Development Alone Assessment of Collision Risk Impacts for Arctic Tern in the Breeding Season. Simulated Population Size with 95% CI are Presented 36
Figure 3.6: Population Projection for Proposed Development Alone Assessment of Displacement Impacts for Guillemot. Simulated Population Size with 95% CI are Presented 41
Figure 3.7: Population Projection for Cumulative Assessment Including Berwick Bank of Displacement Impacts for Guillemot. Simulated Population Size with 95% CI are Presented 47
Figure 3.8: Population Projection for Cumulative Assessment Excluding Berwick Bank of Displacement Impacts for Guillemot. Simulated Population Size with 95% CI are Presented 48
Figure 3.9: Population Projection for Proposed Development Alone Assessment of Displacement Impacts for Razorbill in the Breeding Season and Annually. Simulated Population Size with 95% CI are Presented 51
Figure 3.10: Population Projection for Cumulative Assessment of Displacement Impacts for Razorbill Including Berwick Bank Impacts. Simulated Population Size with 95% CI are Presented 57
Figure 3.11: Population Projection for Cumulative Assessment of Displacement Impacts for Razorbill Excluding Berwick Bank Impacts. Simulated Population Size with 95% CI are Presented 58
Figure 3.12: Population Projection for Cumulative Assessment of Displacement Impacts for Puffin Including Berwick Bank Impacts. Simulated Population Size with 95% CI are Presented 65
Figure 3.13: Population Projection for Cumulative Assessment of Displacement Impacts for Puffin Excluding Berwick Bank Impacts. Simulated Population Size with 95% CI are Presented 66
Figure 3.14: Population Projection for Cumulative Assessment of Combined Collision Risk and Displacement Impacts for Gannet Including Berwick Bank Impacts. Simulated Population Size with 95% CI are Presented 73
Figure 3.15: Population Projection for Cumulative Assessment of Combined Collision Risk and Displacement Impacts for Gannet Excluding Berwick Bank Impacts. Simulated Population Size with 95% CI are Presented 74
Figure 3.16: Population Projection for Cumulative Assessment of Combined Collision Risk and Displacement Impacts for Kittiwake Including Berwick Bank Impacts. Simulated Population Size with 95% CI are Presented 86
Figure 3.17: Population Projection for Cumulative Assessment of Combined Collision Risk and Displacement Impacts for Kittiwake Excluding Berwick Bank Impacts. Simulated Population Size with 95% CI are Presented 87

Glossary

Defined term	Definition
Array Area	The Array Area is the area in which the Offshore Generation Assets will be located.
Barrier Effects	The effect by which an animal or bird has to make longer transits between a breeding or roosting location to an area of foraging. An Offshore Wind Farm (OWF) could act as a barrier in which a species has to fly around to reach the other side, some species are unlikely to travel through or over.
Bowdun Offshore Wind Farm Limited (BOWFL)	A Special Purpose Vehicle (SPV) (legal entity) for the purpose of developing the Project. BOWFL are the Applicant for the Offshore Application.
Collision (Ornithology and Bat)	The effect by which a bird, or bat, may be impacted by direct collision. Birds passing through an OWF are at risk of colliding with the Wind Turbines (moving and stationary parts).
Displacement	An impact that occurs when an animal is forced away from an area of habitual usage. This can be temporary (i.e. a ship moving) or permanent (i.e. the placement of offshore infrastructure).
Effect	Term used to express the consequence of an impact (i.e. the result of change or changes on specific environmental resources or receptors). The significance of an effect is determined by correlating the magnitude of the impact with the importance, or sensitivity of the receptor or resource in accordance with defined significance criteria.
Environmental Impact Assessment (EIA)	Process for the assessment of likely significant environmental effects of a project on the physical, biological and human environment during construction, Operation and Maintenance (O&M) and decommissioning.
Export Cable Corridor	The area seaward of MHWS which connects the Array Area with the Landfall within which the Offshore Export Cables will be installed.
Impact	A change caused by an action that occurs during a project's lifetime.
Inter-Array Cables (IAC)	Cables which link the Wind Turbines to each other and with the OSPs.
Interconnector Cables	Cables which will connect individual OSPs to each other to provide redundancy against cable failure elsewhere.
Landfall	The area in which the Offshore Export Cables make landfall and is also the transitional area between the Offshore Transmission Assets and the Onshore Transmission Assets. Located in the Intertidal Area at Benholm.
Offshore Export Cables	Subsea cables used to transmit electricity generated offshore by the Wind Turbines from the OSPs to shore. The Transition Joint Bay (TJB) is the location where the Offshore Export Cables terminate, and the onshore cabling begins.
Offshore Substation Platform(s) (OSPs)	OSPs comprise the support structure, topside and electrical components used for collecting and/or converting electricity generated by the Wind Turbines for transmission by the Offshore Export Cables.

Defined term	Definition
Operation and Maintenance (O&M)	The phase of the Proposed Development following completion of construction. This phase of development includes routine inspections, repairs and replacement of infrastructure and equipment (including Interconnector Cables and IACs), Scour Protection replenishment or replacement, major component replacement, painting and/or other coating works, removal of marine growth, and replacement of access ladders.
Population Viability Analysis (PVA)	Numerical modelling of a population which looks at the difference between the baseline (counterfactual) and impacted scenarios. PVA is used to understand how the population growth rate and population size is affected by the predicted impact.
Project (the)	An overarching term for the Bowdun Offshore Wind Farm (Bowdun OWF) comprising the offshore and onshore infrastructure required to generate and transmit electricity from the Array Area to the onshore GCP. The Project includes the Offshore Generation Assets, the Offshore Transmission Assets and the Onshore Transmission Assets.
Proposed Development	Term used to define the Offshore Infrastructure associated with the Project seaward of MHWS for which consent is being sought. Further details of the parameters are included in Volume 1, Chapter 3: Project Description.
Significance	Effect factor that is determined by the magnitude of impact along with the sensitivity of the receptor.
Thistle Wind Partners (TWP)	Company established for the development of the Project.
Wind Turbines	Structures comprising of a tubular tower, rotor blades, and a nacelle which houses the Wind Turbine generator.

Acronyms

Acronym	Definition
BDMPS	Biologically Defined Minimum Population Scales
CI	Confidence Interval
CPGR	Counterfactual of the Population Growth Rate
CPS	Counterfactual of Population Size
EIA	Environmental Impact Assessment
LiDAR	Light Detection and Ranging
MD-LOT	Marine Directorate – Licensing Operations Team
MLS	Most Likely Scenario
OWF	Offshore Wind Farm
O&M	Operation and Maintenance
PVA	Population Viability Analysis
sCRM	Stochastic Collision Risk Model
SD	Standard Deviation
TWP	Thistle Wind Partners Limited
UK	United Kingdom
WCS	Worst Case Scenario

Table of Units

Units	Definition
%	Percent
km	Kilometre
km^2	Square kilometre

1 Introduction

1.1 Background

1.1.1 This Offshore Ornithology Technical Report presents the Population Viability Analysis (PVA) results for offshore elements of the Bowdun Offshore Wind Farm (OWF) Project (hereafter referred to as the Proposed Development). The Proposed Development covers the Option Lease Area comprises of the Array Area, which is located in the E3 Plan Option Area detailed in the Scottish Sectoral Marine Plan (Scottish Government, 2020), and the Export Cable Corridor. The Array Area is located 38 km from the Aberdeenshire coast at its closest point, covering an area of 187 km^2 (see Figure 1.1). The Proposed Development will comprise of Wind Turbines (fixed foundations), Inter-Array Cables, Offshore Substation Platforms, Interconnector Cables, Offshore Export Cables and any necessary scour/cable protection. The Export Cable Corridor will include a maximum of three High Voltage Alternating Current Offshore Export Cables, each with a length of up to 70 km and will make Landfall at Benholm, Aberdeenshire.

1.1.2 These PVA results contribute to the Environmental Impact Assessment (EIA) for the Proposed Development and cumulatively with other OWFs in the surrounding area. Those included in the cumulative assessment were projects that overlapped with a species' mean-maximum foraging range plus one standard deviation (SD) during the breeding season and situated within the Biologically Defined Minimum Population Scale (BDMPS) region for that species during the non-breeding and migration periods. Specific details regarding these projects can be found in Volume 2, Chapter 11: Offshore Ornithology

1.1.3 For the purpose of the PVA assessment, the term 'displacement' is used throughout this report to encompass both habitat and prey displacement effects and barrier effects. This accords with NatureScot (2023a) guidance which considers barrier effects alongside displacement as 'distributional responses'. This is because distinguishing between barrier effects and displacement effects can be challenging for breeding seabirds foraging in the region.

1.1.4 The population-level impacts from estimated mortalities (notably from collision risk and displacement) need to be considered for seabirds in relation to their seasonal populations. One method to estimate the potential effect that developments alone or cumulatively (alongside other relevant projects) may have on a population is through PVA. PVA uses demographic parameters and predicted impacts on survival rates to model unimpacted, or ‘baseline’, scenarios and impacted scenarios separately. Comparisons can then be made between scenarios, termed ‘counterfactuals’, to predict the potential impact on metrics such as population size and growth rate, which can be used to assess the significance of the anticipated additional mortality associated with the Proposed Development. Assessing the acceptability of the impact involves evaluating biological responses alongside statutory, policy, and other relevant considerations. There is no universally defined threshold for what constitutes

an 'acceptable' level of impact; rather, determinations will be population-specific and guided by a comprehensive analysis of these factors.

1.1.5 The impacts from the Proposed Development and the calculated changes in survival rate are presented in Table 1.1. To calculate changes in survival rate, estimated mortalities for displacement and collision risk were taken from Volume 3, Technical Appendix 11.3: Offshore Ornithology Displacement Technical Report and Volume 3, Technical Appendix 11.4: Offshore Ornithology Collision Risk Model Technical Report respectively. For both collision risk and displacement, it is estimated that the highest number of mortalities will occur during the operation and maintenance (O&M) phase. Therefore, only values from the O&M phase have been taken forward for PVA.

1.1.6 For all species, mean stochastic Collision Risk Modelling (sCRM) outputs using the Worst Case Scenario (WCS) and generic flight heights (Option 2 of the model; Johnston *et al.* 2014) have been used within calculations. For kittiwake, additional sCRM was carried out using site-specific Light Detection and Ranging (LiDAR) data using the Most Likely Scenario (MLS) and Option 1 of the model (see Volume 3, Technical Appendix 11.4: Offshore Ornithology Collision Risk Model Technical Report). Therefore, scenarios using both Option 1 and Option 2 of the model have been presented. Further detail on the LiDAR surveys carried are presented in Section 3.5 of Volume 3, Technical Appendix 11.1: Offshore Ornithology Baseline Characterisation Report.

1.1.7 Following NatureScot guidance (2023b), Proposed Development alone (Table 1.1) and cumulative PVAs (Table 1.2) were only undertaken when the estimated impacts resulted in decrease in survival rate equal or greater than 0.02 percentage points in mean adult survival rate.

1.1.8 Of the species considered within Table 1.1, Proposed Development alone PVAs were required for the following species:

- herring gull *Larus argentatus* (breeding season and annual);
- Arctic tern *Sterna paradisaea* (breeding season only);
- common guillemot *Uria aalge* (hereafter referred to as 'guillemot'; breeding season, non-breeding season and annual); and
- razorbill *Alca torda* (breeding season and annual).

1.1.9 As advised in the Scoping Opinion (Marine Directorate – Licensing Operations Team (MD-LOT), 2024) the cumulative assessment was conducted including and excluding impacts from Berwick Bank OWF for relevant species.

1.1.10 A cumulative assessment was not carried out for fulmar or Arctic tern, as historically both species have only recently started to be assessed within EIA. For example, at the time of writing this report only two applications, West of Orkney OWF (Offshore Wind Power Limited, 2024) and Ayre OWF (AOWFL, 2025) have included fulmar in the assessment of distributional responses and Arctic tern in the assessment of collision risk. Thus, there is insufficient information to provide an accurate assessment.

1.1.11 A summary of the predicted impacts for all species included within the cumulative assessment is given in

1.1.12 Table 1.2. Cumulative PVAs were required for the following species for all bio-seasons (breeding season, non-breeding season and annual):

- great black-backed gull *Larus marinus*;
- herring gull;
- guillemot;
- razorbill;
- puffin *Fratercula arctica*;
- gannet *Morus bassanus*; and
- kittiwake *Rissa tridactyla*.

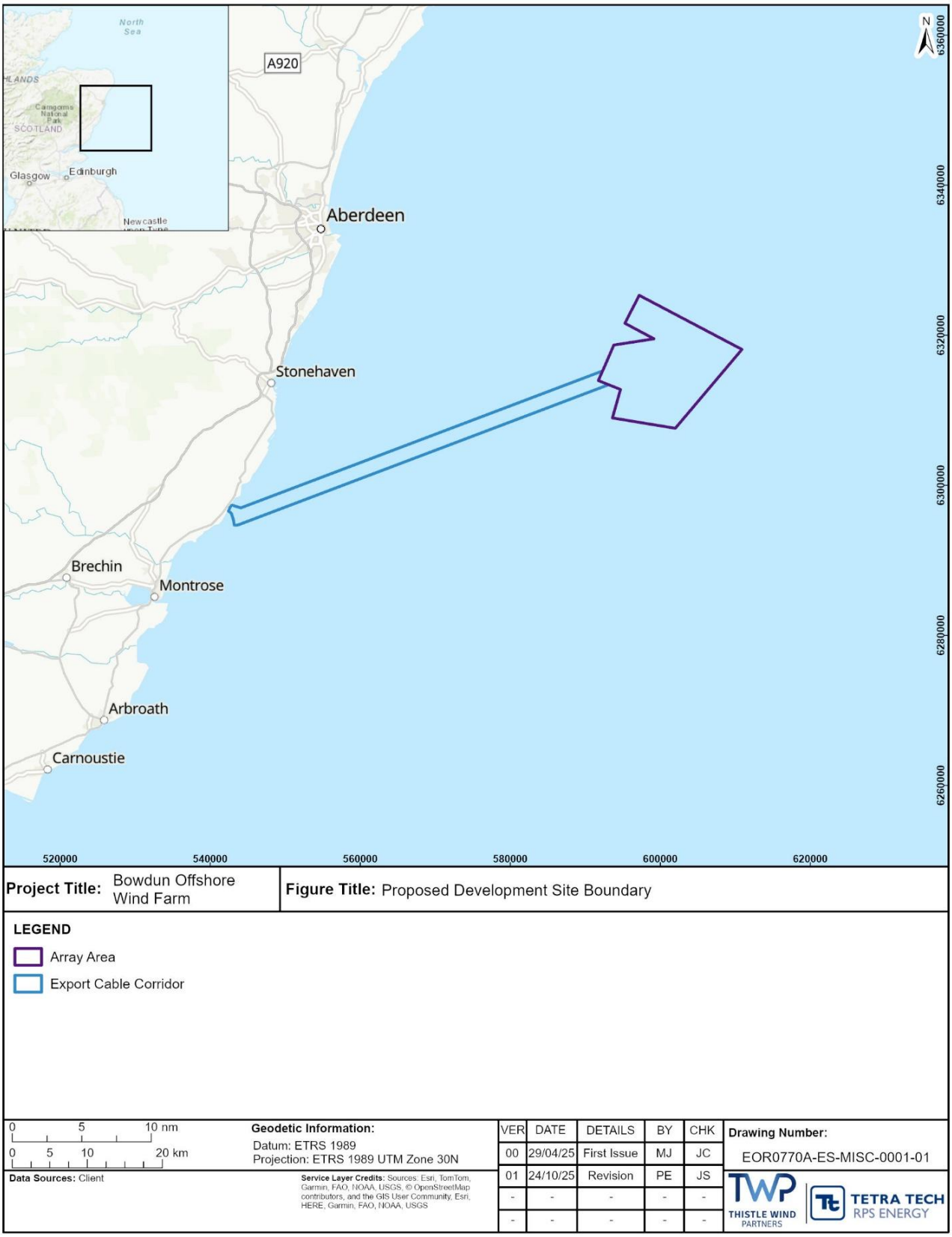

Figure 1.1: Proposed Development Site Boundary

Table 1.1: Summary of EIA Impacts of the Proposed Development Alone.

Species	Bio-season	Predicted Mortality	Decrease in Survival (Percentage Point Change)[1]	Proposed Development Alone PVA Conducted
Collision				
Gannet	Breeding	23.64 (5.32 to 55.34)	0.003 (0.001 to 0.007)	See combined collision and displacement at the bottom of this table.
	Non-breeding	1.41 (0.16 to 3.90)	0.001 (0.000 to 0.002)	
	Non-breeding (70% reduction)	0.42 (0.05 to 1.17)	0.000 (0.000 to 0.000)	
	Annual	25.05 (5.45 to 59.23)	0.003 (0.001 to 0.007)	
	Annual (70% reduction)	24.06 (5.35 to 56.51)	0.003 (0.001 to 0.007)	
Kittiwake (Option 1 and MLS)	Breeding	4.69 (2.30 to 7.25)	0.001 (0.000 to 0.001)	See combined collision and displacement at the bottom of this table.
	Non-breeding	1.24 (0.41 to 2.14)	0.000 (0.000 to 0.000)	
	Annual	5.92 (2.71 to 9.38)	0.001 (0.000 to 0.001)	
Kittiwake (Option 2 and WCS)	Breeding	37.59 (16.31 to 62.80)	0.006 (0.003 to 0.010)	See combined collision and displacement at the bottom of this table.
	Non-breeding	9.98 (3.18 to 18.53)	0.002 (0.001 to 0.003)	
	Annual	47.57 (19.48 to 81.32)	0.008 (0.003 to 0.013)	
Great black-backed gull	Breeding	0.00 (0.00 to 0.00)	0.000 (0.000 to 0.000)	×
	Non-breeding	2.30 (0.34 to 5.21)	0.003 (0.000 to 0.006)	×
	Annual	2.30 (0.34 to 5.21)	0.003 (0.000 to 0.006)	×

Species	Bio-season	Predicted Mortality	Decrease in Survival (Percentage Point Change)[1]	Proposed Development Alone PVA Conducted
Herring gull	Breeding	32.15 (9.72 to 68.53)	**0.080** (**0.024** to **0.171**)	✓
	Non-breeding	1.46 (0.21 to 3.28)	0.002 (0.000 to 0.005)	×
	Annual	33.61 (9.93 to 71.81)	**0.056** (0.017 to **0.120**)	✓
Arctic tern	Breeding	2.24 (0.05 to 11.25)	**0.044** (0.001 to **0.223**)	✓[a]
	Non-breeding	0.19 (0.00 to 0.95)	0.000 (0.000 to 0.001)	×
	Annual	2.43 (0.05 to 12.20)	0.001 (0.000 to 0.007)	×
Displacement				
Fulmar	Breeding	2 to 5	0.000 to 0.000	×
	Non-breeding	1 to 2	0.000 to 0.000	×
	Annual	3 to 7	0.000 to 0.001	×
Gannet	Breeding	4 to 13	0.001 to 0.002	See combined collision and displacement at the bottom of this table.
	Non-breeding	1 to 2	0.000 to 0.001	
	Annual	5 to 15	0.001 to 0.002	
Kittiwake	Breeding	5 to 16	0.001 to 0.003	See combined collision and displacement at the bottom of this table.
	Non-breeding	1 to 4	0.000 to 0.001	
	Annual	6 to 20	0.001 to 0.003	

Species	Bio-season	Predicted Mortality	Decrease in Survival (Percentage Point Change)[1]	Proposed Development Alone PVA Conducted
Guillemot	Breeding	287 to 479	**0.115** to **0.191**	✓
	Non-breeding	109 to 328	**0.044** to **0.131**	✓
	Annual	396 to 807	**0.158** to **0.322**	✓
Razorbill	Breeding	48 to 80	**0.053** to **0.089**	✓
	Non-breeding	4 to 13	0.002 to 0.006	×
	Annual	52 to 93	**0.024** to **0.043**	✓
Puffin	Breeding	7 to 11	0.001 to 0.002	×
	Non-breeding	4 to 13	0.002 to 0.005	×
	Annual	11 to 24	0.002 to 0.005	×
Combined Collision and Displacement[2]				
Gannet	Breeding	28 to 37	0.003 to 0.004	×
	Non-breeding	1 to 3	0.000 to 0.001	×
	Annual	29 to 39	0.003 to 0.005	×
Kittiwake (Option 1 MLS)	Breeding	10 to 20	0.002 to 0.003	×
	Non-breeding	2 to 5	0.000 to 0.001	×
	Annual	12 to 25	0.002 to 0.004	×

Species	Bio-season	Predicted Mortality	Decrease in Survival (Percentage Point Change)[1]	Proposed Development Alone PVA Conducted
Kittiwake (Option 2 WCS)	Breeding	43 to 54	0.007 to 0.009	×
	Non-breeding	11 to 14	0.002 to 0.002	×
	Annual	54 to 67	0.009 to 0.011	×
a[u] Proposed Development Alone PVA was run with no burn-in (see Paragraph 2.3.2) **[1] Confidence Intervals (CIs) are provided in parentheses and any decrease in survival equal to, or greater than 0.02 is denoted in bold.** **[2] The non-breeding season 70% reduction values have been taken forward for the assessment of gannet**				

Table 1.2: Summary of Species Requiring PVA for the Cumulative Projects

Species and Impact	Berwick Bank	Bio-season	Predicted Mortality	Decrease in Survival (Percentage Point Change)	Cumulative PVA Conducted
Collision					
Gannet	Included	Breeding	966.10	**0.115**	See combined collision and displacement at the bottom of this table.
		Non-breeding	160.44	**0.065**	
		Annual	1,126.54	**0.134**	
	Excluded	Breeding	842.46	**0.100**	
		Non-breeding	155.86	**0.063**	
		Annual	998.32	**0.119**	
Kittiwake (Option 1 MLS)	Included	Breeding	1,267.95	**0.210**	See combined collision and displacement at the bottom of this table.
		Non-breeding	1,723.93	**0.275**	
		Annual	2,991.87	**0.477**	

Species and Impact	Berwick Bank	Bio-season	Predicted Mortality	Decrease in Survival (Percentage Point Change)	Cumulative PVA Conducted
	Excluded	Breeding	875.31	**0.145**	
		Non-breeding	1,455.56	**0.232**	
		Annual	2,330.86	**0.371**	
Kittiwake (Option 2 WCS)	Included	Breeding	1,300.85	**0.215**	
		Non-breeding	1,732.67	**0.276**	
		Annual	3,033.52	**0.483**	
	Excluded	Breeding	908.21	**0.150**	
		Non-breeding	1,464.30	**0.233**	
		Annual	2,372.51	**0.378**	
Great black-backed gull	N/A	Breeding	18.19	**4.996**	x[1]
		Non-breeding	979.83	**1.072**	✓
		Annual	998.01	**1.092**	✓
Herring gull	Included	Breeding	104.11	**0.260**	✓
		Non-breeding	53.06	**0.089**	✓
		Annual	157.17	**0.263**	✓
	Excluded	Breeding	52.51	**0.131**	✓
		Non-breeding	44.66	**0.075**	✓
		Annual	97.17	**0.162**	✓
Displacement					
Gannet	Included	Breeding	238 to 713	**0.028** to **0.085**	See combined collision and displacement at the bottom of this table.
		Non-breeding	274 to 823	**0.110** to **0.331**	
		Annual	512 to 1,535	**0.061** to **0.182**	

Species and Impact	Berwick Bank	Bio-season	Predicted Mortality	Decrease in Survival (Percentage Point Change)	Cumulative PVA Conducted
	Excluded	Breeding	204 to 613	**0.024** to **0.073**	
		Non-breeding	262 to 786	**0.105** to **0.316**	
		Annual	466 to 1,399	**0.055** to **0.166**	
Kittiwake	Included	Breeding	249 to 748	**0.041** to **0.124**	See combined collision and displacement at the bottom of this table.
		Non-breeding	519 to 1,556	**0.083** to **0.248**	
		Annual	768 to 2,304	**0.122** to **0.367**	
	Excluded	Breeding	186 to 558	**0.031** to **0.092**	
		Non-breeding	444 to 1,331	**0.071** to **0.212**	
		Annual	630 to 1,889	**0.100** to **0.301**	
Guillemot	Included	Breeding	3,083 to 5,138	**1.231** to **2.051**	✓
		Non-breeding	1,042 to 3,125	**0.416** to **1.247**	✓
		Annually	4,125 to 8,263	**1.646** to **3.299**	✓
	Excluded	Breeding	1,748 to 2,913	**0.698** to **1.163**	✓
		Non-breeding	777 to 2,330	**0.310** to **0.930**	✓
		Annually	2,525 to 5,243	**1.008** to **2.093**	✓
Razorbill	Included	Breeding	479 to 799	**0.529** to **0.882**	✓
		Non-breeding	1,088 to 3,263	**0.498** to **1.493**	✓
		Annually	1,567 to 4,062	**0.717** to **1.858**	✓
	Excluded	Breeding	406 to 677	**0.499** to **0.748**	✓
		Non-breeding	981 to 2,944	**0.499** to **1.346**	✓
		Annually	1,388 to 3,622	**0.635** to **1.657**	✓

Species and Impact	Berwick Bank	Bio-season	Predicted Mortality	Decrease in Survival (Percentage Point Change)	Cumulative PVA Conducted
Puffin	Included	Breeding	807 to 1,345	**0.159** to **0.265**	✓
		Non-breeding	258 to 774	**0.111** to **0.334**	✓
		Annually	1,065 to 2,119	**0.210** to **0.418**	✓
	Excluded	Breeding	726 to 1,210	**0.143** to **0.238**	✓
		Non-breeding	205 to 614	**0.088** to **0.265**	✓
		Annually	931 to 1,824	**0.183** to **0.359**	✓
Combined Collision and Displacement					
Gannet	Included	Breeding	1,204 to 1,679	**0.143** to **0.199**	✓
		Non-breeding	435 to 983	**0.175** to **0.396**	✓
		Annual	1,638 to 2,662	**0.195** to **0.316**	✓
	Excluded	Breeding	1,047 to 1,456	**0.124** to **0.173**	✓
		Non-breeding	418 to 941	**0.168** to **0.379**	✓
		Annual	1,465 to 2,397	**0.174** to **0.285**	✓
Kittiwake (Option 1 MLS)	Included	Breeding	1,517 to 2,016	**0.251** to **0.333**	✓
		Non-breeding	2,243 to 3,280	**0.357** to **0.522**	✓
		Annual	3,760 to 5,296	**0.599** to **0.844**	✓
	Excluded	Breeding	1,061 to 1,433	**0.176** to **0.237**	✓
		Non-breeding	1,899 to 2,787	**0.303** to **0.444**	✓
		Annual	2,961 to 4,220	**0.472** to **0.672**	✓
Kittiwake (Option 2 WCS)	Included	Breeding	1,550 to 2,049	**0.256** to **0.339**	✓
		Non-breeding	2,251 to 3,289	**0.359** to **0.524**	✓
		Annual	3,802 to 5,338	**0.605** to **0.850**	✓

Species and Impact	Berwick Bank	Bio-season	Predicted Mortality	Decrease in Survival (Percentage Point Change)	Cumulative PVA Conducted
	Excluded	Breeding	1,094 to 1,466	**0.181** to **0.242**	✓
		Non-breeding	1,908 to 2,796	**0.304** to **0.445**	✓
		Annual	3,002 to 4,262	**0.478** to **0.679**	✓

[1]Although the cumulative scenario met the 0.02 threshold for PVA, as the Proposed Development did not contribute any mortalities during the breeding season a PVA was not carried out.

2 Methodology

2.1 Overview

2.1.1 PVA was undertaken using the Seabird PVA Tool developed by Natural England (Searle *et al*., 2019). The Seabird PVA Tool is an 'R' based tool which uses R Shiny to provide a user-friendly interface for users to access nepva R package. The tool is publicly available from the Natural England GitHub Repository[1].

2.1.2 The tool uses a stochastic Leslie Matrix and allows the user to apply impacts annually to the modelled population. Impacts can be implemented as a cull or harvest with a fixed number of mortalities, or as change in demographic rates (Searle *et al*., 2019). For the purposes of this report, the rate or survival was decreased to simulate expected impacts on seabird populations.

2.1.3 The most recent version of the tool (v.2.0, nepva R package v.4.18) available, which is based on nepva version 2 tools (Mobbs *et al*., 2020), was used to perform the analysis presented in this technical report. All analysis was conducted using R version 4.4.2 for Windows (R Core Team, 2024).

2.1.4 Following written consultation with NatureScot (see the consultation table presented in Volume 2, Chapter 11: Offshore Ornithology), impacts were further run for the expected operational lifespan of the Proposed Development (30 years) and 50 years. All runs were set with inputs to replicate those set out in the nepva online tool as detailed below.

2.2 Modelling Approach

2.2.1 All PVA models were undertaken using the 'Simulation' run type, which is used to simulate population trajectories based on the specified demographic parameters, initial population sizes and scenarios the user inputs into the model.

2.2.2 The tool includes an option to run the model as either density independent, or density dependent. Density dependence is self-evident in the natural environment, as without density dependence, populations would grow exponentially. For seabird populations, the mechanisms as to how this operates are largely uncertain. If density dependence is mis-specified in an assessment, the modelled predictions may be unreliable. Therefore, it is more typical to use density independent models for seabird assessments, despite the lack of biologically necessary density dependence. As such, density independent models lack any means by which a population can recover once it has been reduced beyond a certain point. They are therefore appropriate for impact assessment purposes on the grounds of taking a precautionary approach (Ridge *et al*., 2019). For the PVA runs undertaken within this technical report all models were therefore run using density independence.

[1] Natural England PVA Repository

2.2.3 Environmental stochasticity, which accounts for the variation arising from environmental changes affecting individuals in the same group (e.g. between-year differences in weather conditions), was incorporated in the models at the level of productivity and survival rates. For each simulated year, a value for each demographic rate was randomly generated from a probability distribution defined by the mean and SD estimates of that rate for the population under consideration.

2.2.4 Demographic stochasticity, which accounts for individual-level variation affecting transition probabilities between age-classes, was included in the models. For large populations, like the ones considered in this analysis, the effects of environmental stochasticity are deemed more important than those associated with demographic stochasticity (Morris and Doak, 2002). However, including demographic stochasticity will not cause any issues when simulating larger populations (Wildfowl and Wetlands Trust (WWT) Consulting, 2012) and hence has been included.

2.2.5 PVA outputs can either be expressed as the Counterfactual of Population Size (CPS) or the Counterfactual of the Population Growth Rate (CPGR) depending on whether density dependence is included within the model. As models within this technical report have been run using density independence, the CPGR is considered more robust and informative than the CPS. While both CPS and CPGR are provided as requested by NatureScot (2023a, 2023b), the interpretation of the density independent PVA outputs focusses on the CPGR.

2.3 Simulation Parameters

2.3.1 All PVA modelling in this technical report was undertaken with environmental and demographic stochasticity. To ensure robust results, all simulations were set to run 5,000 times (5,000 runs is regarded as the standard approach and has been utilised in several offshore wind applications such as Ossian OWF, Hornsea Four OWF, Awel Y Mor OWF, Mona and Morgan OWFs, Berwick Bank OWF and Green Volt OWF). All models were run, with results presented for a 30 year time span (the expected lifetime of the Proposed Development), alongside a 50 year span (to include the lifetime of the Proposed Development and beyond).

2.3.2 Modelling has also been undertaken including a five year 'burn-in' period within the model. A 'burn-in' period consists of a number of timesteps, or iterations, that are run but disregarded by the model. For population modelling, this allows the populations being modelled to reach a stable age structure before impacts are applied.

2.3.3 For the purpose of this Offshore EIA Report, the assessment has considered the impact on all birds and has not been corrected for birds deemed sabbaticals. Sabbatical birds are adults which are not actively breeding during a given breeding season.

2.3.4 Impacted vs unimpacted comparisons were based on a matched runs approach, whereby stochasticity is applied to the population before impacts are applied (i.e. survival and productivity rates simulated at each time step are the same for the unimpacted and impacted populations before additional impact mortalities are deducted from simulated survivals for the impacted populations). This approach has been used as previous analyses demonstrated that stochastic models using a matched runs approach were likely to be the most precautionary (Cook and Robinson, 2017). Productivity rates used within the analysis were therefore unaffected by impacts from the OWF.

2.4 Model Parametrisation

Demographic Rates

2.4.1 The survival rates and their SD for the species considered were derived from the national values presented in Horswill and Robinson (2015) (Table 2.1). Most of these values matched with those set out within the most recent version of the nepva tool. In cases where they did not, the values presented in Horswill and Robinson (2015) were used, in accordance with NatureScot advice (NatureScot, 2023b). Where no SD was provided in Horswill and Robinson (2015), a low SD of 0.001 was used.

2.4.2 Survival rates vary depending on age class, with 0 to 1 used to represent birds below the age of one, age class 1 to 2 used to represent birds aged one, age class 2 to 3 representing two-year-olds and so on. Adults are grouped together as survival rates are consistent between adult aged birds regardless of actual age (e.g. seven-year-olds have the same survival rate as eight-year-olds and so on) (Table 2.1).

Table 2.1: Demographic Rates for Key Species Used in Population Viability Analysis, Derived from Horswill and Robinson (2015). Standard Deviations are Provided in Parentheses

Species	Age at First Breeding	Eggs/ pair	Survival by Age Class (Years)								Productivity (Chicks per Pair) ± SD
			Juvenile	1 to 2	2 to 3	3 to 4	4 to 5	5 to 6	6 to 8	Adult	
Gannet	5	1	0.424 (±0.045)	0.829 (±0.026)	0.891 (±0.019)	0.895 (±0.019)	0.919 (±0.042)	-	-	0.919 (±0.042)	0.700 (±0.082)
Kittiwake	4	2	0.790 (±0.001)	0.854 (±0.077)	0.854 (±0.077)	0.854 (±0.077)	-	-	-	0.854 (±0.077)	0.690 (±0.296)
Great black-backed gull	5	3	0.930 (±0.001)	0.930 (±0.001)	0.930 (±0.001)	0.930 (±0.001)	0.930 (±0.001)	-	-	0.930 (±0.001)	1.139 (±0.533)
Herring gull	5	3	0.798 (±0.092)	0.834 (±0.079)	0.834 (±0.079)	0.834 (±0.079)	0.834 (±0.079)	-	-	0.834 (±0.079)	0.920 (±0.477)
Arctic tern	4	2	0.837 (±0.001)	0.837 (±0.001)	0.837 (±0.001)	0.837 (±0.001)	-	-	-	0.837 (0.001)	0.380 (0.325)
Guillemot	6	1	0.560 (±0.058)	0.792 (±0.152)	0.917 (±0.098)	0.939 (±0.025)	0.939 (±0.025)	0.939 (±0.025)	-	0.939 (±0.025)	0.672 (±0.147)
Razorbill	5	1	0.794 (±0.209)	0.794 (±0.209)	0.895 (±0.067)	0.895 (±0.067)	0.895 (±0.067)	-	-	0.895 (±0.067)	0.570 (±0.247)
Puffin	5	1	0.892 (±0.001)	0.892 (±0.001)	0.892 (±0.001)	0.760 (±0.093)	0.805 (±0.083)	-	-	0.906 (±0.083)	0.617 (±0.151)

Populations

2.4.3 Populations derived from the Proposed Development alone assessment were utilised for the PVA modelling. During the breeding season, populations were derived from each species' foraging range, as detailed within Volume 3, Technical Appendix 11.6: Offshore Ornithology Apportioning Technical Report. Breeding populations used within the PVAs are shown in Table 2.2 for the Proposed Development alone and for cumulative impacts.

2.4.4 During the non-breeding season, impacts are put into the context of the BDMPS for each species except herring gull and guillemot (Table 2.2).

2.4.5 The non-breeding regional population of herring gull was calculated from the herring gull foraging range with a correction factor of 0.675 to account for the influx of birds from non-United Kingdom (UK) and west coast UK colonies, using BDMPS proportions (Furness, 2015) and following advice from the Scoping Opinion (MD-LOT, 2024). For more detailed information, see Volume 3, Technical Appendix 11.6: Offshore Ornithology Apportioning Technical Report.

2.4.6 For guillemot, NatureScot (2023c) advises the use of the guillemot foraging range (Woodward *et al.*, 2019) to define the non-breeding regional population (Table 2.2).

2.4.7 For the annual regional population for each species, the largest regional population size from the breeding and non-breeding season was used.

Table 2.2: Biologically Defined Population Scales for Use in the Assessment (Burnell *et al.*, 2023; Furness, 2015)

Species	Season	Region	BDMPS (no. of birds)
Gannet	Breeding	Foraging range	841,748
	Non-breeding	UK North Sea and Channel	248,385
	Annual	UK North Sea and Channel	841,748
Kittiwake	Breeding	Foraging range	604,582
	Non-breeding	UK North Sea Waters	627,816
	Annual	UK North Sea Waters	627,816
Great black-backed gull	Breeding	Foraging range	364
	Non-breeding	UK North Sea	91,399
	Annual	UK North Sea	91,399
Herring gull	Breeding	Foraging range	40,076
	Non-breeding	Foraging range + 0.67 correction factor	59,816
	Annual	Foraging range + 0.67 correction factor	59,816
Arctic tern	Breeding	Foraging range	5,050
	Non-breeding	UK North Sea and Channel	163,930
	Annual	UK North Sea and Channel	163,930

Species	Season	Region	BDMPS (no. of birds)
Guillemot	Breeding	Foraging range	250,506
	Non-breeding	Foraging range	250,506
	Annual	Foraging range	250,506
Razorbill	Breeding	Foraging range	90,519
	Non-breeding	UK North Sea and Channel	218,622
	Annual	UK North Sea and Channel	218,622
Puffin	Breeding	Foraging range	507,599
	Non-breeding	UK North Sea and Channel	231,957
	Annual	UK North Sea and Channel	507,599

2.5 Input Parameters

2.5.1 The collision and displacement values (taken from NatureScot, 2023a) used in PVAs for Proposed Development alone (Table 2.3) and cumulative assessment (Table 2.4) used figures from the species-specific impact assessment and the Cumulative Effects Assessment presented in the Volume 2, Chapter 11: Offshore Ornithology.

2.5.2 Table 2.3 and Table 2.4 present the extent to which predicted mortality from collision risk and displacement reduce the population survival rates for the relevant species. It is these reductions in survival rates that are used in the model to inform the 'impacted' scenario.

Table 2.3: Input Parameters for Proposed Development Alone PVA Assessment

Species	Season	Impact	Decrease in Survival Rate per Annum[1]
Collision			
Herring gull	Breeding	Predicted Mean Collision Rate	0.000802
	Annual	Predicted Mean Collision Rate	0.000562
Arctic tern	Breeding	Predicted Mean Collision Rate	0.000444
Displacement[2]			
Guillemot	Breeding	60% displacement, 3% mortality	0.001147
		60% displacement, 5% mortality	0.001911
	Non-breeding	60% displacement, 1% mortality	0.000436
		60% displacement, 3% mortality	0.001309

Species	Season	Impact	Decrease in Survival Rate per Annum[1]
	Annual	60% displacement, 3% mortality	0.001583
		60% displacement, 5% mortality	0.003220
Razorbill	Breeding	60% displacement, 3% mortality	0.000532
		60% displacement, 5% mortality	0.000887
	Annual	60% displacement, 3% mortality	0.000240
		60% displacement, 5% mortality	0.000427

[1]A value of 0.0002 is equivalent to the 0.02 percentage point threshold used to determine whether a PVA was required (NatureScot, 2023c)
[2]Displacement rates recommended by NatureScot (2023a)

Table 2.4: Input Parameters for Cumulative PVA Assessment

Species	Season	Berwick Bank	Impact	Decrease in Survival Rate Per Annum[1]
Collision				
Great black-backed gull	Breeding	NA[2]	Predicted Mean Collision Rate	0.049963
	Non-breeding		Predicted Mean Collision Rate	0.010720
	Annual		Predicted Mean Collision Rate	0.010919
Herring gull	Breeding	Included	Predicted Mean Collision Rate	0.002598
		Excluded	Predicted Mean Collision Rate	0.001310
	Non-breeding	Included	Predicted Mean Collision Rate	0.000887
		Excluded	Predicted Mean Collision Rate	0.000747
	Annual	Included	Predicted Mean Collision Rate	0.002628
		Excluded	Predicted Mean Collision Rate	0.001624
Displacement[3]				
Guillemot	Breeding	Included	60% displacement, 3% mortality	0.012307
			60% displacement, 5% mortality	0.020511
		Excluded	60% displacement, 3% mortality	0.006978
			60% displacement, 5% mortality	0.011630
	Non-breeding	Included	60% displacement, 1% mortality	0.004158
			60% displacement, 3% mortality	0.012475
		Excluded	60% displacement, 1% mortality	0.003100
			60% displacement, 3% mortality	0.009301

Species	Season	Berwick Bank	Impact	Decrease in Survival Rate Per Annum[1]
	Annual	Included	Sum of breeding (3% mortality) and non-breeding mortality (1% mortality)	0.016465
			Sum of breeding (5% mortality) and non-breeding mortality (3% mortality)	0.032985
		Excluded	Sum of breeding (3% mortality) and non-breeding mortality (1% mortality)	0.010078
			Sum of breeding (5% mortality) and non-breeding mortality (3% mortality)	0.020931
Razorbill	Breeding	Included	60% displacement, 3% mortality	0.005293
			60% displacement, 5% mortality	0.008822
		Excluded	60% displacement, 3% mortality	0.004490
			60% displacement, 5% mortality	0.007483
	Non-breeding	Included	60% displacement, 1% mortality	0.004976
			60% displacement, 3% mortality	0.014927
		Excluded	60% displacement, 1% mortality	0.004489
			60% displacement, 3% mortality	0.013468
	Annual	Included	Sum of breeding (3% mortality) and non-breeding mortality (1% mortality)	0.007167
			Sum of breeding (5% mortality) and non-breeding mortality (3% mortality)	0.018580
		Excluded	Sum of breeding (3% mortality) and non-breeding mortality (1% mortality)	0.006348
			Sum of breeding (5% mortality) and non-breeding mortality (3% mortality)	0.016566
Puffin	Breeding	Included	60% displacement, 3% mortality	0.001590
			60% displacement, 5% mortality	0.002651
		Excluded	60% displacement, 3% mortality	0.001430
			60% displacement, 5% mortality	0.002384

Species	Season	Berwick Bank	Impact	Decrease in Survival Rate Per Annum[1]
	Non-breeding	Included	60% displacement, 1% mortality	0.001112
			60% displacement, 3% mortality	0.003336
		Excluded	60% displacement, 1% mortality	0.000882
			60% displacement, 3% mortality	0.002646
	Annual	Included	Sum of breeding (3% mortality) and non-breeding mortality (1% mortality)	0.002099
			Sum of breeding (5% mortality) and non-breeding mortality (3% mortality)	0.004175
		Excluded	Sum of breeding (3% mortality) and non-breeding mortality (1% mortality)	0.001833
			Sum of breeding (5% mortality) and non-breeding mortality (3% mortality)	0.003593
Combined Collision and Displacement				
Gannet	Breeding	Included	Predicted Mean Collision Rate plus displacement (70% displacement, 1% mortality)	0.001430
			Predicted Mean Collision Rate plus displacement (70% displacement, 3% mortality)	0.001994
		Excluded	Predicted Mean Collision Rate plus displacement (70% displacement, 1% mortality)	0.001244
			Predicted Mean Collision Rate plus displacement (70% displacement, 3% mortality)	0.001729
	Non-breeding	Included	Predicted Mean Collision Rate plus displacement (70% displacement, 1% mortality)	0.001750
			Predicted Mean Collision Rate plus displacement (70% displacement, 3% mortality)	0.003958
		Excluded	Predicted Mean Collision Rate plus displacement (70% displacement, 1% mortality)	0.001682
			Predicted Mean Collision Rate plus displacement (70% displacement, 3% mortality)	0.003790
	Annual	Included	Sum of breeding and non-breeding mortality (both 1% mortality)	0.001946
			Sum of breeding and non-breeding mortality (both 3% mortality)	0.003162
		Excluded	Sum of breeding and non-breeding mortality (both 1% mortality)	0.001740

Species	Season	Berwick Bank	Impact	Decrease in Survival Rate Per Annum[1]
			Sum of breeding and non-breeding mortality (both 3% mortality)	0.002848
Kittiwake (Option 1 MLS)	Breeding	Included	Predicted Mean Collision Rate plus displacement (30% displacement, 1% mortality)	0.002510
			Predicted Mean Collision Rate plus displacement (30% displacement, 3% mortality)	0.003335
		Excluded	Predicted Mean Collision Rate plus displacement (30% displacement, 1% mortality)	0.001755
			Predicted Mean Collision Rate plus displacement (30% displacement, 3% mortality)	0.002371
	Non-breeding	Included	Predicted Mean Collision Rate plus displacement (30% displacement, 1% mortality)	0.003572
			Predicted Mean Collision Rate plus displacement (30% displacement, 3% mortality)	0.005224
		Excluded	Predicted Mean Collision Rate plus displacement (30% displacement, 1% mortality)	0.003025
			Predicted Mean Collision Rate plus displacement (30% displacement, 3% mortality)	0.004439
	Annual	Included	Sum of breeding and non-breeding mortality (both 1% mortality)	0.005989
			Sum of breeding and non-breeding mortality (both 3% mortality)	0.008436
		Excluded	Sum of breeding and non-breeding mortality (both 1% mortality)	0.004716
			Sum of breeding and non-breeding mortality (both 3% mortality)	0.006722
Kittiwake (Option 2 WCS)	Breeding	Included	Predicted Mean Collision Rate plus displacement (30% displacement, 1% mortality)	0.002564
			Predicted Mean Collision Rate plus displacement (30% displacement, 3% mortality)	0.003389
		Excluded	Predicted Mean Collision Rate plus displacement (30% displacement, 1% mortality)	0.001810
			Predicted Mean Collision Rate plus displacement (30% displacement, 3% mortality)	0.002425
	Non-breeding	Included	Predicted Mean Collision Rate plus displacement (30% displacement, 1% mortality)	0.003586
			Predicted Mean Collision Rate plus displacement (30% displacement, 3% mortality)	0.005238
		Excluded	Predicted Mean Collision Rate plus displacement (30% displacement, 1% mortality)	0.003039

Species	Season	Berwick Bank	Impact	Decrease in Survival Rate Per Annum[1]
			Predicted Mean Collision Rate plus displacement (30% displacement, 3% mortality)	0.004453
	Annual	Included	Sum of breeding and non-breeding mortality (both 1% mortality)	0.006055
			Sum of breeding and non-breeding mortality (both 3% mortality)	0.008502
		Excluded	Sum of breeding and non-breeding mortality (both 1% mortality)	0.004782
			Sum of breeding and non-breeding mortality (both 3% mortality)	0.006788

[1]A value of 0.0002 is equivalent to the 0.02 percentage point threshold used to determine whether a PVA was required (NatureScot, 2023c)
[2]As Berwick Bank OWF did not impact this species, only one scenario is presented.
[3]Displacement rates recommended by NatureScot (2023a)

3 PVA Results

3.1.1 The results of the PVA modelling have been used to inform the assessment of Proposed Development alone and cumulative effects in Volume 2, Chapter 11: Offshore Ornithology as part of the Offshore EIA Report. The detailed Proposed Development alone and cumulative PVA results for each species are presented here in full, in the following sections.

3.2 Collision Risk

3.2.1 Considering their sensitivity to specific effects from the Proposed Development, great black-backed gull, herring gull and Arctic tern were assessed for impacts from collision risk only. As gannet and kittiwake were assessed for impacts due to both collision risk and displacement the results of PVAs have been presented in Section 3.4.

Great Black-backed Gull

Proposed Development Alone

3.2.2 Proposed Development alone impacts for great black-backed gull did not exceed a 0.02 percentage point decrease in survival in the breeding season, non-breeding season or annually (Table 1.1). Therefore, no Proposed Development alone PVAs have been carried out for great black-backed gull.

Cumulative

3.2.3 The results of the cumulative PVA for the great black-backed gull population are provided after a 30 year and 50 year timespan (Table 3.1 and Table 3.2; Figure 3.1). The baseline unimpacted scenario is also shown for comparison purposes.

3.2.4 Although the cumulative impacts to great black-backed gull met the 0.02 percentage point threshold for the breeding season, a PVA was not run as the Proposed Development contributed 0.00 mortalities to the cumulative total.

Table 3.1: Outputs of PVA for Cumulative Assessment of Collision Risk Impacts for Great Black-backed Gull in the Non-breeding Season. CIs Given in Parentheses

Years of operational impact	Impact Scenario	Simulated Population Size	Median Growth Rate (CI)	Median Counterfactual (CI)	
				Counterfactual of the Population Growth Rate	Counterfactual of Population Size
0	Baseline	104,869	1.147 (0.973 to 1.448)	-	-
	Impacted	103,589	1.133 (0.962 to 1.432)	0.989 (0.985 to 0.992)	0.989 (0.985 to 0.992)
30	Baseline	7,539,512	1.153 (1.131 to 1.174)	-	-
	Impacted	5,263,245	1.140 (1.118 to 1.161)	0.988 (0.988 to 0.989)	0.698 (0.692 to 0.704)
50	Baseline	128,166,099	1.153 (1.136 to 1.169)	-	-
	Impacted	70,848,570	1.139 (1.123 to 1.155)	0.988 (0.988 to 0.989)	0.554 (0.549 to 0.559)

Table 3.2: Outputs of PVA for Cumulative Assessment of Collision Risk Impacts for Great Black-backed Gull Annually. CIs Given in Parentheses

Years of operational impact	Impact Scenario	Simulated Population Size	Median Growth Rate (CI)	Median Counterfactual (CI)	
				Counterfactual of the Population Growth Rate	Counterfactual of Population Size
0	Baseline	104,869	1.147 (0.973 to 1.448)	-	-
	Impacted	103,602	1.134 (0.961 to 1.432)	0.988 (0.985 to 0.992)	0.988 (0.985 to 0.992)
30	Baseline	7,539,512	1.153 (1.131 to 1.174)	-	-
	Impacted	5,225,747	1.139 (1.118 to 1.160)	0.988 (0.988 to 0.989)	0.694 (0.687 to 0.700)
50	Baseline	128,166,099	1.153 (1.136 to 1.169)	-	-
	Impacted	70,183,315	1.139 (1.123 to 1.155)	0.988 (0.988 to 0.988)	0.548 (0.543 to 0.552)

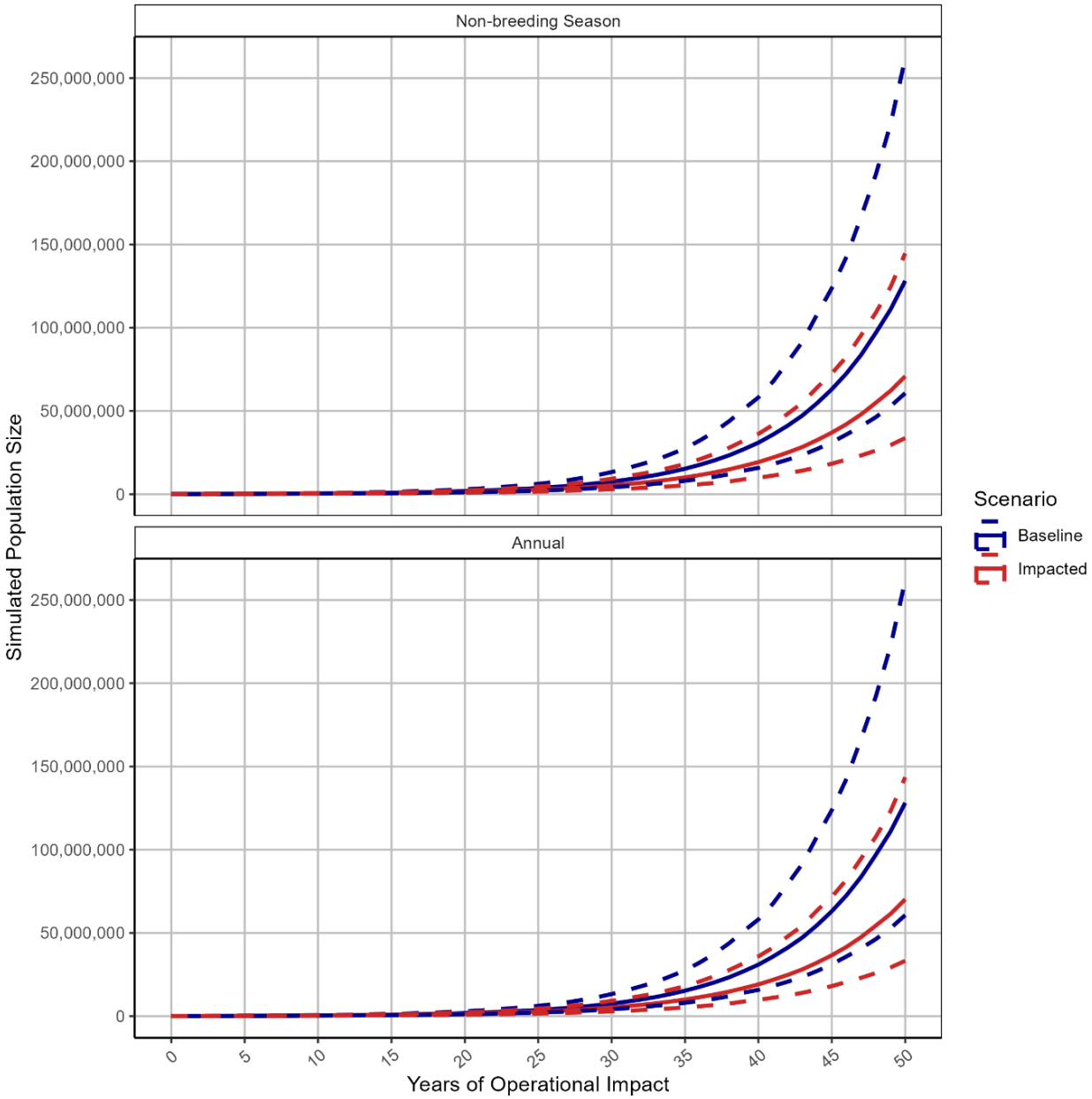

Figure 3.1: Population Projection for Cumulative Assessment of Collision Risk Impacts for Great Black-backed Gull in the Non-Breeding Season and Annually. Simulated Population Size with 95% CI are Presented

Herring Gull

Proposed Development Alone

3.2.5 Proposed Development alone impacts of collision risk for herring gull did exceed a 0.02 percentage point decrease in survival in the breeding season and annually (Table 1.1). Therefore, Proposed Development alone PVAs were run for breeding season and annual impacts of collision risk for herring gull (Table 3.3 and Table 3.4; Figure 3.2).

Table 3.3: Outputs of PVA for Proposed Development Alone Assessment of Collision Risk Impacts for Herring Gull in the Breeding Season CIs Given in Parentheses

Years of operational impact	Impact Scenario	Simulated Population Size	Median Growth Rate (CI)	Median Counterfactual (CI)	
				Counterfactual of the Population Growth Rate	Counterfactual of Population Size
0	Baseline	41,955	0.995 (0.826 to 1.260)	-	-
	Impacted	41,933	0.994 (0.827 to 1.258)	0.999 (0.991 to 1.007)	0.999 (0.977 to 1.022)
30	Baseline	47,451	1.004 (0.976 to 1.031)	-	-
	Impacted	45,909	1.003 (0.975 to 1.030)	0.999 (0.998 to 1.000)	0.971 (0.929 to 1.014)
50	Baseline	51,590	1.004 (0.982 to 1.025)	-	-
	Impacted	48,879	1.003 (0.981 to 1.024)	0.999 (0.998 to 1.000)	0.952 (0.901 to 1.004)

Table 3.4: Outputs of PVA for Proposed Development Alone Assessment of Collision Risk Impacts for Herring Gull Annually CIs Given in Parentheses

Years of operational impact	Impact Scenario	Simulated Population Size	Median Growth Rate (CI)	Median Counterfactual (CI)	
				Counterfactual of the Population Growth Rate	Counterfactual of Population Size
0	Baseline	62,586	0.995 (0.827 to 1.260)	-	-
	Impacted	62,539	0.994 (0.827 to 1.261)	0.999 (0.993 to 1.006)	0.999 (0.981 to 1.018)
30	Baseline	70,648	1.004 (0.976 to 1.031)	-	-
	Impacted	69,195	1.003 (0.976 to 1.030)	0.999 (0.998 to 1.000)	0.979 (0.944 to 1.015)
50	Baseline	76,796	1.004 (0.982 to 1.025)	-	-
	Impacted	74,104	1.003 (0.981 to 1.024)	0.999 (0.999 to 1.000)	0.965 (0.924 to 1.010)

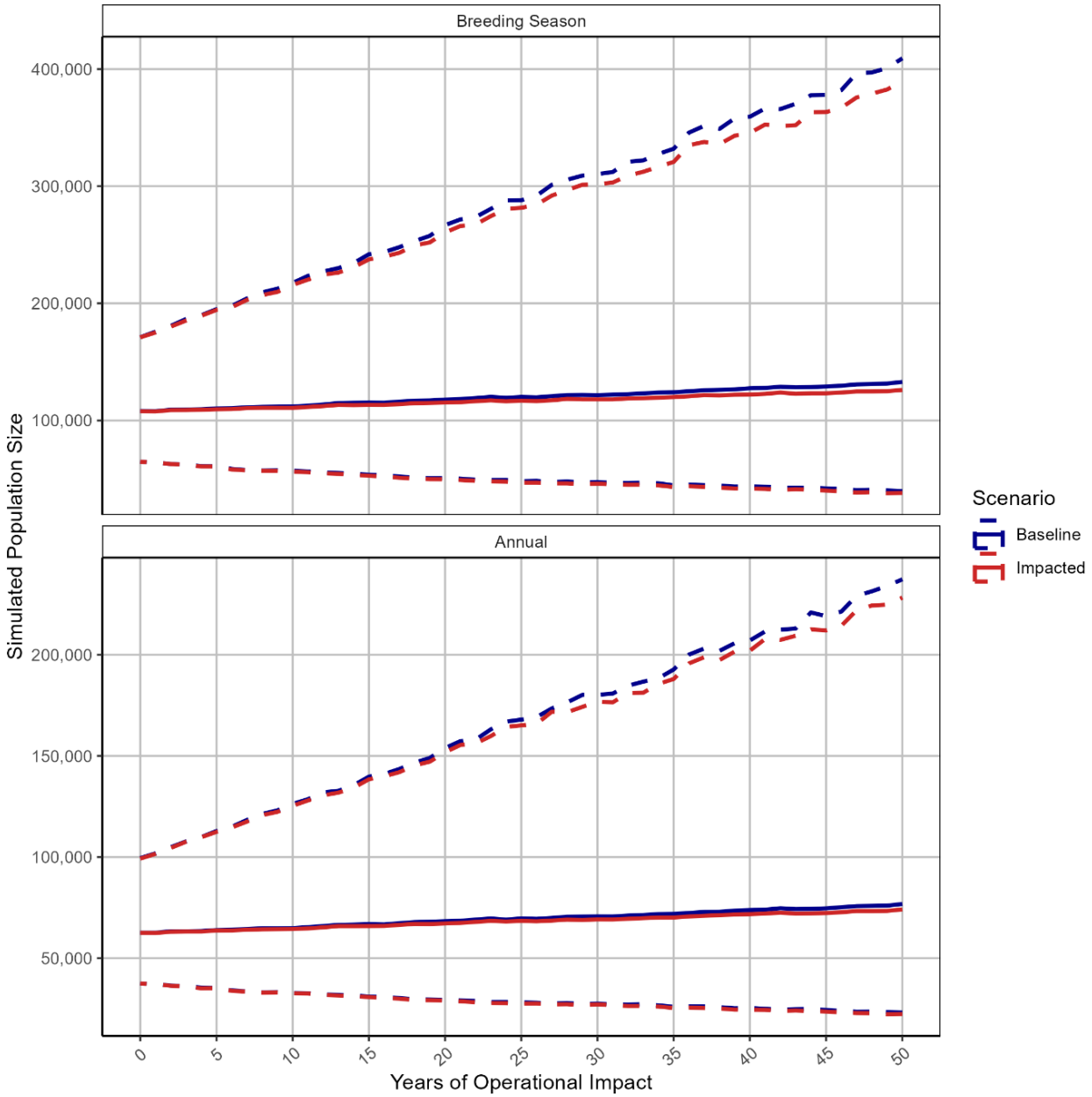

Figure 3.2: Population Projection for Proposed Development Alone Assessment of Collision Risk Impacts for Herring Gull for the Breeding Season and Annually. Simulated Population Size with 95% CI are Presented

Cumulative

3.2.6 The results of the PVA for collision risk impacts from the Proposed Development cumulatively with other OWFs on the herring gull population are provided after a 30 year and 50 year timespan (Table 3.5 to Table 3.7; Figure 3.3 and Figure 3.4). The baseline unimpacted scenario is also shown for comparison purposes.

Table 3.5: Outputs of PVA for Cumulative Assessment of Collision Risk Impacts for Herring Gull During the Breeding Season. CIs Given in Parentheses

Years Of Operational Impact	Impact Scenario	Simulated Population Size	Median Growth Rate (CI)	Median Counterfactual (CI)	
				Counterfactual of the Population Growth Rate	Counterfactual of Population Size
With Berwick Bank					
0	Baseline	41,955	0.995 (0.826 to 1.260)	-	-
	Impacted	41,818	0.992 (0.823 to 1.255)	0.997 (0.989 to 1.005)	0.997 (0.975 to 1.020)
30	Baseline	47,451	1.004 (0.976 to 1.031)	-	-
	Impacted	42,953	1.001 (0.973 to 1.028)	0.997 (0.996 to 0.998)	0.907 (0.868 to 0.950)
50	Baseline	51,590	1.004 (0.982 to 1.025)	-	-
	Impacted	43,732	1.001 (0.979 to 1.022)	0.997 (0.996 to 0.998)	0.851 (0.806 to 0.901)
Without Berwick Bank					
0	Baseline	41,955	0.995 (0.826 to 1.260)	-	-
	Impacted	41,885	0.993 (0.825 to 1.257)	0.998 (0.990 to 1.006)	0.998 (0.976 to 1.021)
30	Baseline	47,451	1.004 (0.976 to 1.031)	-	-
	Impacted	45,095	1.002 (0.975 to 1.030)	0.998 (0.997 to 1.000)	0.952 (0.910 to 0.996)
50	Baseline	51,590	1.004 (0.982 to 1.025)	-	-
	Impacted	47,469	1.002 (0.980 to 1.023)	0.998 (0.997 to 0.999)	0.922 (0.873 to 0.974)

Table 3.6: Outputs of PVA for Cumulative Assessment of Collision Risk Impacts for Herring Gull During the Non-breeding Season. CIs Given in Parentheses

Years of operational impact	Impact Scenario	Simulated Population Size	Median Growth Rate (CI)	Median Counterfactual (CI)	
				Counterfactual of the Population Growth Rate	Counterfactual of Population Size
With Berwick Bank					
0	Baseline	62,586	0.995 (0.827 to 1.260)	-	-
	Impacted	62,523	0.994 (0.826 to 1.259)	0.999 (0.992 to 1.006)	0.999 (0.980 to 1.018)
30	Baseline	70,648	1.004 (0.976 to 1.031)	-	-
	Impacted	68,305	1.003 (0.975 to 1.030)	0.999 (0.998 to 1.000)	0.967 (0.934 to 1.003)
50	Baseline	76,796	1.004 (0.982 to 1.025)	-	-
	Impacted	72,808	1.003 (0.981 to 1.024)	0.999 (0.998 to 1.000)	0.946 (0.906 to 0.990)
Without Berwick Bank					
0	Baseline	62,586	0.995 (0.827 to 1.260)	-	-
	Impacted	62,475	0.994 (0.826 to 1.259)	0.999 (0.993 to 1.006)	0.999 (0.981 to 1.018)
30	Baseline	70,648	1.004 (0.976 to 1.031)	-	-
	Impacted	68,648	1.003 (0.975 to 1.030)	0.999 (0.998 to 1.000)	0.972 (0.938 to 1.008)
50	Baseline	76,796	1.004 (0.982 to 1.025)	-	-
	Impacted	73,358	1.003 (0.981 to 1.024)	0.999 (0.998 to 1.000)	0.955 (0.913 to 0.999)

Table 3.7: Outputs of PVA for Cumulative Assessment of Collision Risk Impacts for Herring Gull Annually. CIs Given in Parentheses

Years of operational impact	Impact Scenario	Simulated Population Size	Median Growth Rate (CI)	Median Counterfactual (CI)	
				Counterfactual of the Population Growth Rate	Counterfactual of Population Size
With Berwick Bank					
0	Baseline	62,586	0.995 (0.827 to 1.260)	-	-
	Impacted	62,471	0.992 (0.823 to 1.258)	0.997 (0.990 to 1.004)	0.997 (0.979 to 1.015)
30	Baseline	70,648	1.004 (0.976 to 1.031)	-	-
	Impacted	63,962	1.001 (0.973 to 1.028)	0.997 (0.996 to 0.998)	0.906 (0.873 to 0.939)
50	Baseline	76,796	1.004 (0.982 to 1.025)	-	-
	Impacted	65,371	1.001 (0.979 to 1.022)	0.997 (0.996 to 0.998)	0.850 (0.813 to 0.888)
Without Berwick Bank					
0	Baseline	62,586	0.995 (0.827 to 1.260)	-	-
	Impacted	62,535	0.993 (0.825 to 1.256)	0.998 (0.991 to 1.005)	0.998 (0.980 to 1.016)
30	Baseline	70,648	1.004 (0.976 to 1.031)	-	-
	Impacted	66,357	1.002 (0.974 to 1.029)	0.998 (0.997 to 0.999)	0.940 (0.907 to 0.975)
50	Baseline	76,796	1.004 (0.982 to 1.025)	-	-
	Impacted	69,226	1.002 (0.980 to 1.023)	0.998 (0.997 to 0.999)	0.905 (0.865 to 0.946)

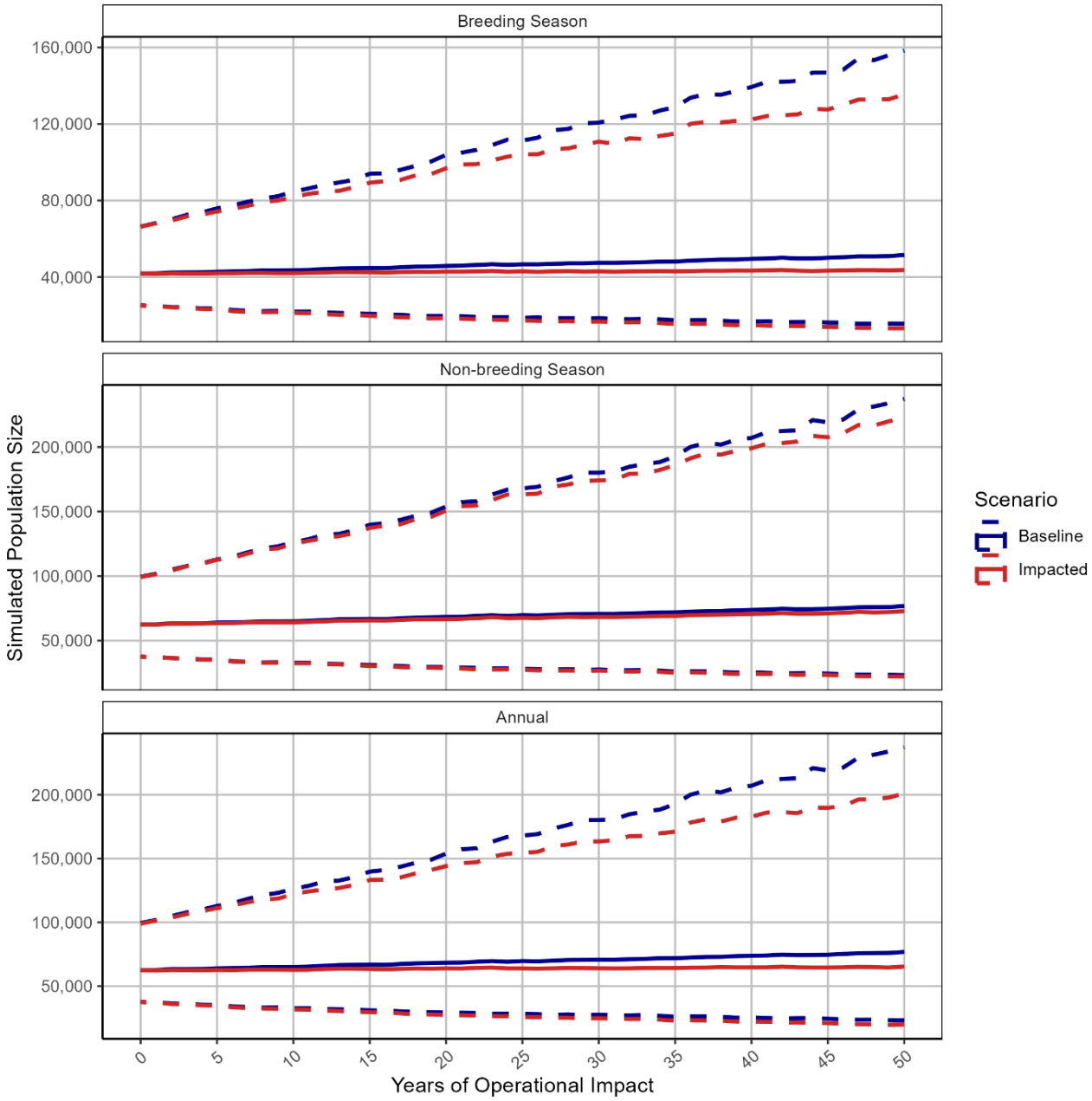

Figure 3.3: Population Projection for Cumulative Assessment Including Berwick Bank of Collision Risk Impacts for Herring Gull. Simulated Population Size with 95% CI are Presented

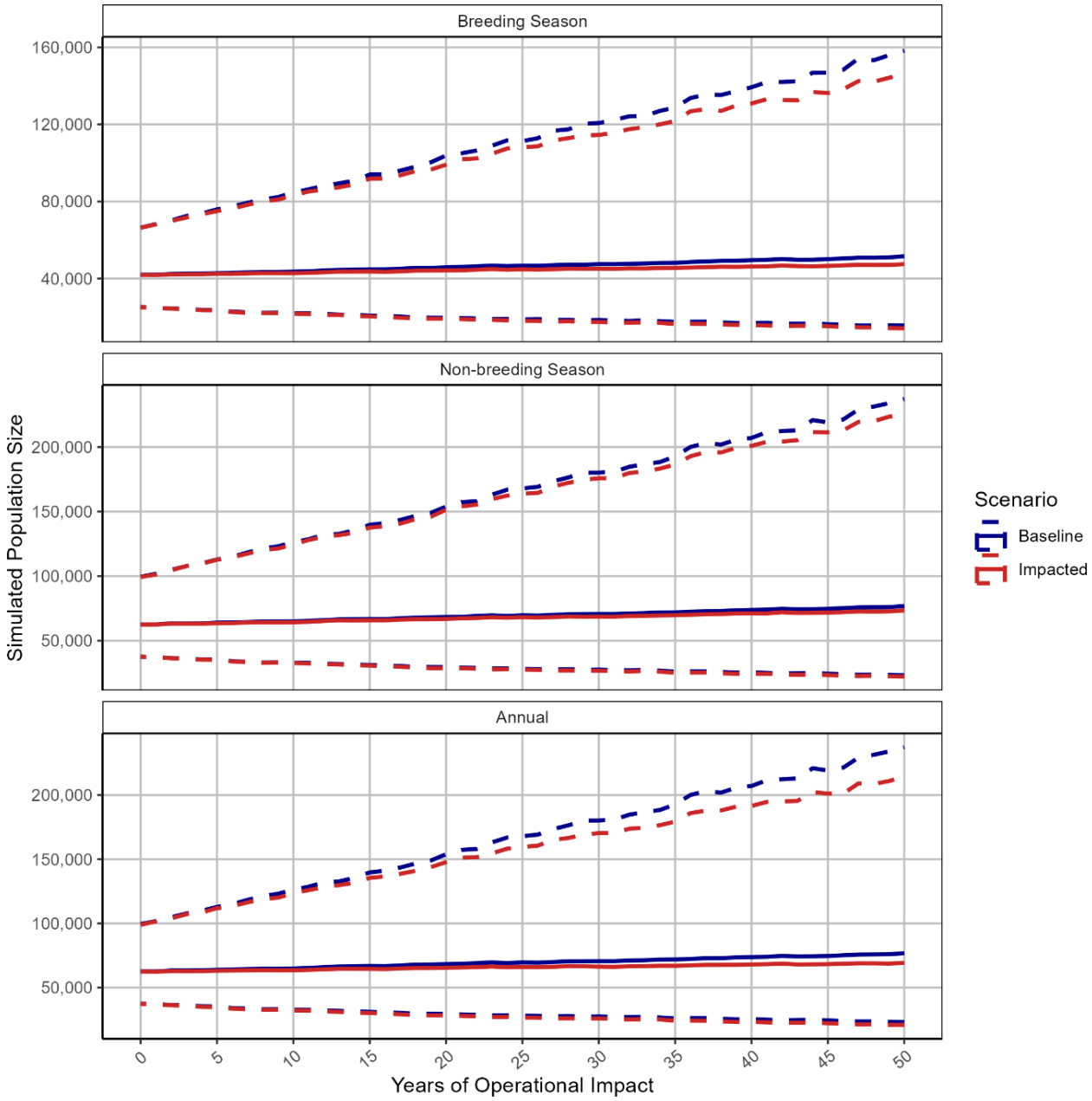

Figure 3.4: Population Projection for Cumulative Assessment Excluding Berwick Bank of Collision Risk Impacts for Herring Gull. Simulated Population Size with 95% CI are Presented

Arctic Tern

Proposed Development Alone

3.2.7 Proposed Development alone impacts of collision risk for Arctic tern did exceed a 0.02 percentage point decrease in survival in the breeding season only (Table 1.1). The results of the breeding season PVA are presented in Table 3.8 and Figure 3.5.

Table 3.8: Outputs of PVA for Proposed Development Alone Assessment of Collision Risk Impacts for Arctic Tern in the Breeding Season. CIs Given in Parentheses

Years of operational impact	Impact Scenario	Simulated Population Size	Median Growth Rate (CI)	Median Counterfactual (CI)	
				Counterfactual of the Population Growth Rate	Counterfactual of Population Size
0	Baseline	2,010	0.922 (0.837 to 1.198)	-	-
	Impacted	2,016	0.921 (0.835 to 1.194)	1.000 (0.969 to 1.033)	1.001 (0.905 to 1.103)
30	Baseline	357	0.944 (0.918 to 0.970)	-	-
	Impacted	353	0.944 (0.918 to 0.969)	0.999 (0.990 to 1.009)	0.985 (0.716 to 1.336)
50	Baseline	114	0.944 (0.922 to 0.964)	-	-
	Impacted	110	0.944 (0.921 to 0.964)	0.999 (0.988 to 1.011)	0.971 (0.519 to 1.800)

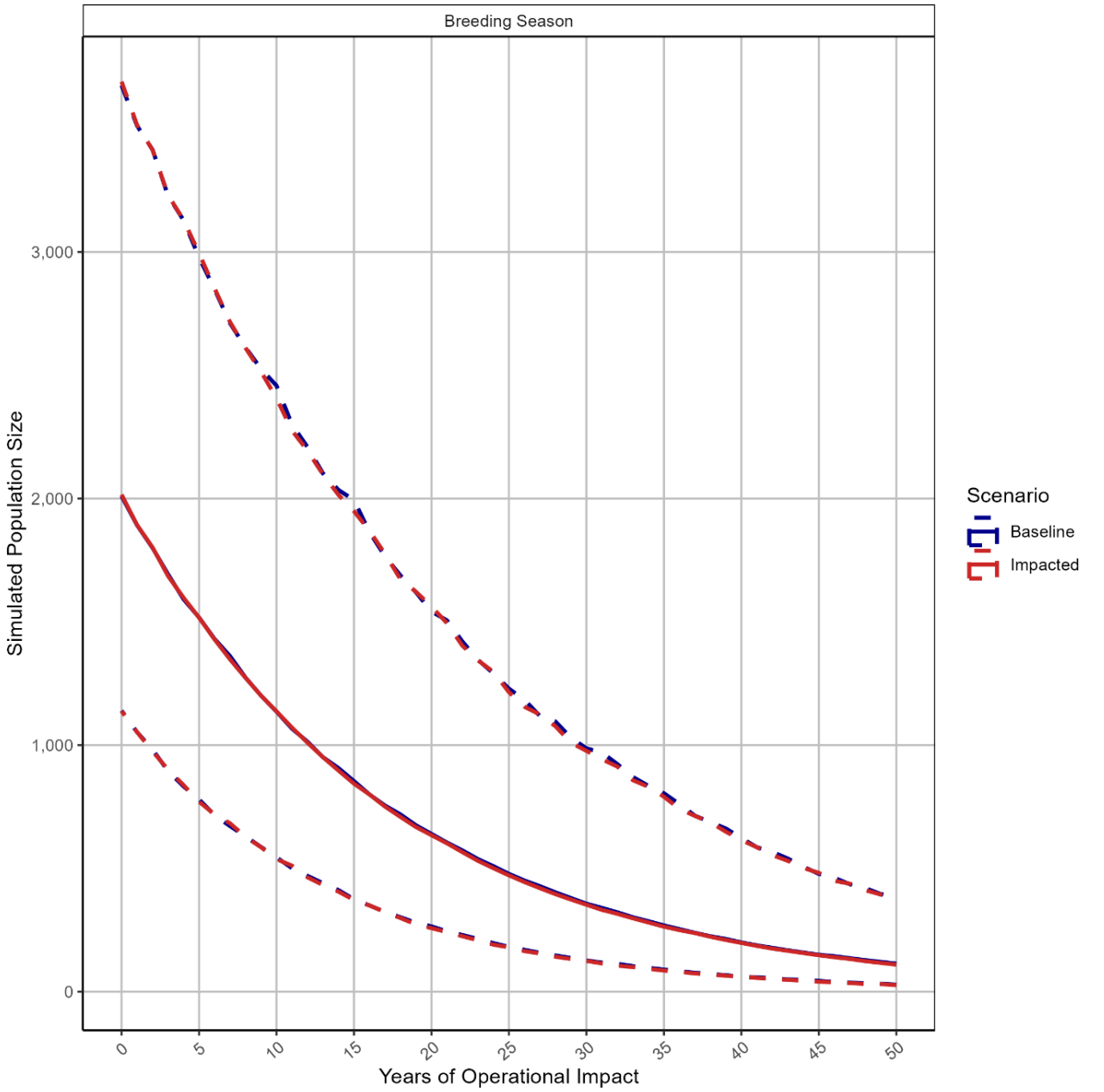

Figure 3.5: Population Projection for Proposed Development Alone Assessment of Collision Risk Impacts for Arctic Tern in the Breeding Season. Simulated Population Size with 95% CI are Presented

Cumulative

3.2.8 At the time of writing this report, only two other publicly available OWF applications were found to assess Arctic tern. West of Orkney OWF was estimated to produce a mean annual sCRM mortality of 0.43 (MacArthur Green, 2024) and Ayre OWF was estimated to produce a mean annual sCRM mortality of 1.04 (AOWFL, 2025). Due to the low number of annual mortalities and limited number of projects with assessment, cumulative PVAs were not conducted for Arctic tern.

3.3 Displacement

3.3.1 Considering their sensitivity to specific effects from the Proposed Development, guillemot, razorbill and puffin were assessed for impacts from displacement only. As gannet and kittiwake were assessed for impacts due to both collision risk and displacement the results of PVAs have been presented in Section 3.4.

3.3.2 As highlighted in Table 1.1, for each species assessed for impacts due to displacement, mortalities for a low and high displacement scenario were calculated. In cases where only the high scenario reached the 0.02 percentage point decrease in survival, PVAs have been run for both scenarios for consistency.

Guillemot

Proposed Development Alone

3.3.3 Proposed Development alone impacts of displacement for guillemot did exceed a 0.02 percentage point decrease in survival in the breeding season, non-breeding season and annually (Table 1.1). Therefore, Proposed Development alone PVAs were run for breeding season, non-breeding season and annual impacts of displacement for guillemot (Table 3.9 to Table 3.11; Figure 3.6).

Table 3.9: Outputs of PVA for Proposed Development Alone Assessment of Displacement Impacts for Guillemot in the Breeding Season. CIs Given in Parentheses

Years Of Operational Impact	Impact Scenario	Simulated Population Size	Median Growth Rate (CI)	Median Counterfactual (CI)	
				Counterfactual of the Population Growth Rate	Counterfactual of Population Size
0	Baseline	350,471	1.037 (0.933 to 1.129)	-	-
	Impacted: Low	350,003	1.035 (0.931 to 1.128)	0.999 (0.997 to 1.001)	0.999 (0.993 to 1.004)
	Impacted: High	349,588	1.034 (0.930 to 1.127)	0.998 (0.996 to 1.000)	0.998 (0.992 to 1.003)
30	Baseline	957,118	1.034 (1.024 to 1.044)	-	-
	Impacted: Low	919,304	1.033 (1.022 to 1.043)	0.999 (0.998 to 0.999)	0.961 (0.953 to 0.969)
	Impacted: High	895,618	1.032 (1.021 to 1.042)	0.998 (0.998 to 0.998)	0.936 (0.927 to 0.944)
50	Baseline	1,880,544	1.034 (1.026 to 1.042)	-	-
	Impacted: Low	1,760,712	1.033 (1.025 to 1.041)	0.999 (0.999 to 0.999)	0.936 (0.927 to 0.945)
	Impacted: High	1,684,611	1.032 (1.024 to 1.040)	0.998 (0.998 to 0.998)	0.896 (0.888 to 0.904)

Table 3.10: Outputs of PVA for Proposed Development Alone Assessment of Displacement Impacts for Guillemot in the Non-breeding Season. CIs Given in Parentheses

Years of operational impact	Impact Scenario	Simulated Population Size	Median Growth Rate (CI)	Median Counterfactual (CI)	
				Counterfactual of the Population Growth Rate	Counterfactual of Population Size
0	Baseline	350,471	1.037 (0.933 to 1.129)	-	-
	Impacted: Low	350,084	1.036 (0.932 to 1.129)	0.999 (0.997 to 1.002)	0.999 (0.994 to 1.005)
	Impacted: High	349,847	1.035 (0.931 to 1.128)	0.999 (0.996 to 1.000)	0.998 (0.993 to 1.004)
30	Baseline	957,118	1.034 (1.024 to 1.044)	-	-
	Impacted: Low	942,377	1.034 (1.023 to 1.044)	1.000 (0.999 to 1.000)	0.985 (0.977 to 0.993)
	Impacted: High	914,607	1.033 (1.022 to 1.043)	0.999 (0.998 to 0.999)	0.956 (0.947 to 0.964)
50	Baseline	1,880,544	1.034 (1.026 to 1.042)	-	-
	Impacted: Low	1,833,061	1.034 (1.025 to 1.041)	1.000 (0.999 to 1.000)	0.975 (0.966 to 0.984)
	Impacted: High	1,742,957	1.033 (1.024 to 1.040)	0.999 (0.998 to 0.999)	0.928 (0.919 to 0.936)

Table 3.11: Outputs of PVA for Proposed Development Alone Assessment of Displacement Impacts for Guillemot Annually. CIs Given in Parentheses

Years of operational impact	Impact Scenario	Simulated Population Size	Median Growth Rate (CI)	Median Counterfactual (CI)	
				Counterfactual of the Population Growth Rate	Counterfactual of Population Size
0	Baseline	350,471	1.037 (0.933 to 1.129)	-	-
	Impacted: Low	349,748	1.035 (0.931 to 1.128)	0.998 (0.996 to 1.000)	0.998 (0.993 to 1.004)
	Impacted: High	349,168	1.033 (0.929 to 1.126)	0.996 (0.994 to 0.998)	0.996 (0.991 to 1.002)
30	Baseline	957,118	1.034 (1.024 to 1.044)	-	-
	Impacted: Low	905,666	1.032 (1.022 to 1.042)	0.998 (0.998 to 0.998)	0.946 (0.938 to 0.954)
	Impacted: High	854,427	1.031 (1.020 to 1.040)	0.996 (0.996 to 0.997)	0.894 (0.885 to 0.901)
50	Baseline	1,880,544	1.034 (1.026 to 1.042)	-	-
	Impacted: Low	1,716,208	1.032 (1.024 to 1.040)	0.998 (0.998 to 0.998)	0.913 (0.904 to 0.922)
	Impacted: High	1,561,595	1.030 (1.022 to 1.038)	0.996 (0.996 to 0.997)	0.831 (0.823 to 0.839)

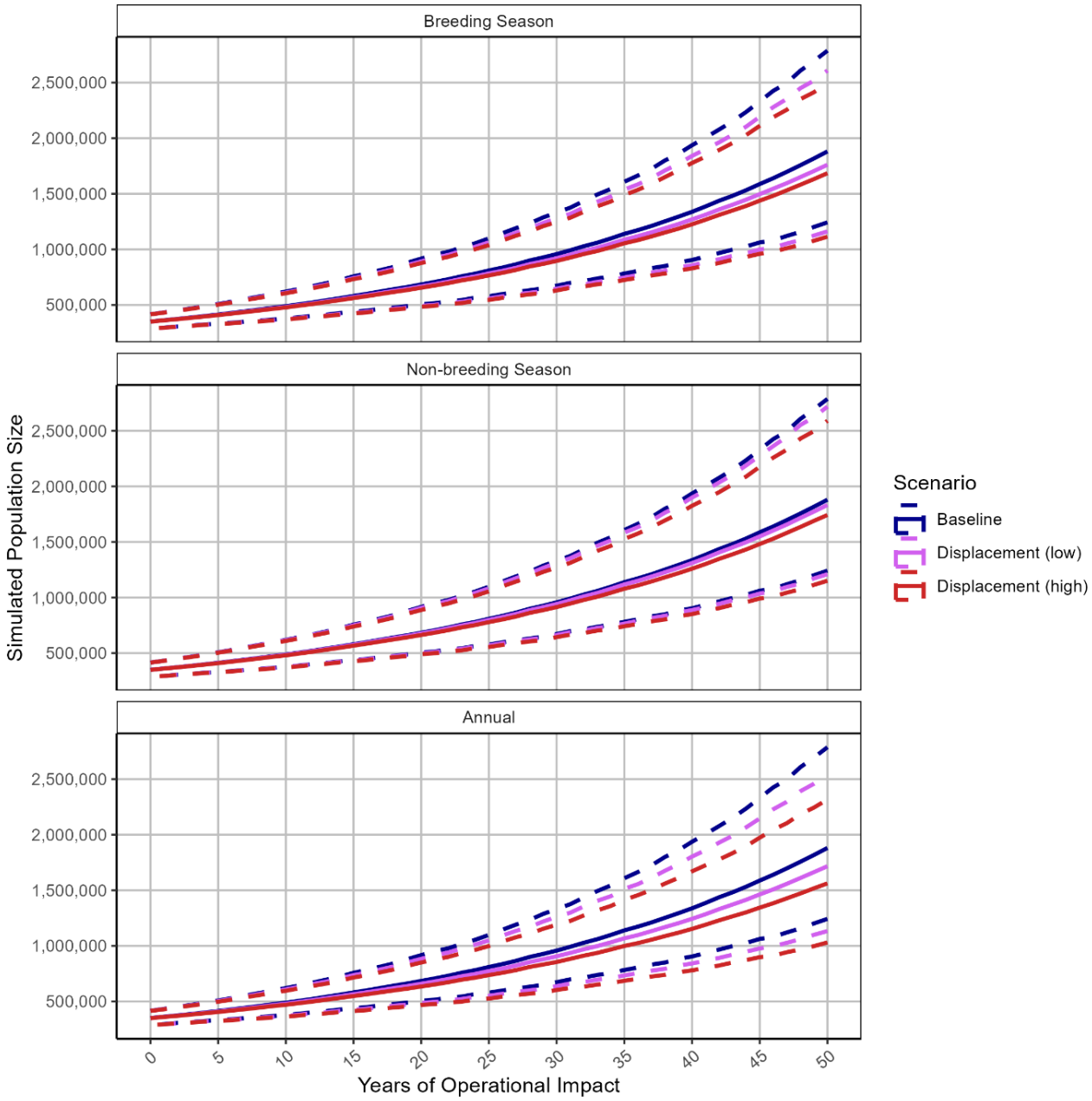

Figure 3.6: Population Projection for Proposed Development Alone Assessment of Displacement Impacts for Guillemot. Simulated Population Size with 95% CI are Presented

Cumulative

3.3.4 The results of the PVA for displacement impacts from the Proposed Development cumulatively with other OWFs on the guillemot population are provided after a 30 year and 50 year timespan (Table 3.12 to Table 3.14; Figure 3.7 and Figure 3.8). The baseline unimpacted scenario is also shown for comparison purposes.

Table 3.12: Outputs of PVA for Cumulative Assessment of Displacement Impacts for Guillemot During the Breeding Season. CIs Given in Parentheses

Years Of Operational Impact	Impact Scenario	Simulated Population Size	Median Growth Rate (CI)	Median Counterfactual (CI)	
				Counterfactual of the Population Growth Rate	Counterfactual of Population Size
With Berwick Bank					
0	Baseline	350,471	1.037 (0.933 to 1.129)	-	-
	Impacted: Low	345,553	1.022 (0.920 to 1.114)	0.986 (0.983 to 0.988)	0.986 (0.980 to 0.991)
	Impacted: High	342,230	1.012 (0.910 to 1.104)	0.976 (0.974 to 0.979)	0.977 (0.971 to 0.982)
30	Baseline	957,118	1.034 (1.024 to 1.044)	-	-
	Impacted: Low	621,097	1.020 (1.009 to 1.030)	0.986 (0.986 to 0.986)	0.649 (0.642 to 0.655)
	Impacted: High	463,772	1.010 (1.000 to 1.020)	0.977 (0.977 to 0.977)	0.485 (0.479 to 0.490)
50	Baseline	1,880,544	1.034 (1.026 to 1.042)	-	-
	Impacted: Low	922,842	1.020 (1.012 to 1.028)	0.986 (0.986 to 0.986)	0.491 (0.485 to 0.496)
	Impacted: High	571,259	1.010 (1.002 to 1.018)	0.977 (0.977 to 0.977)	0.304 (0.300 to 0.308)
Without Berwick Bank					
0	Baseline	350,471	1.037 (0.933 to 1.129)	-	-
	Impacted: Low	347,610	1.029 (0.925 to 1.121)	0.992 (0.990 to 0.994)	0.992 (0.987 to 0.997)
	Impacted: High	345,665	1.023 (0.919 to 1.115)	0.987 (0.984 to 0.989)	0.987 (0.981 to 0.992)
30	Baseline	957,118	1.034 (1.024 to 1.044)	-	-

Years Of Operational Impact	Impact Scenario	Simulated Population Size	Median Growth Rate (CI)	Median Counterfactual (CI)	
				Counterfactual of the Population Growth Rate	Counterfactual of Population Size
	Impacted: Low	749,754	1.026 (1.016 to 1.036)	0.992 (0.992 to 0.992)	0.783 (0.776 to 0.790)
	Impacted: High	635,939	1.021 (1.010 to 1.031)	0.987 (0.987 to 0.987)	0.665 (0.658 to 0.671)
50	Baseline	1,880,544	1.034 (1.026 to 1.042)	-	-
	Impacted: Low	1,257,093	1.026 (1.018 to 1.034)	0.992 (0.992 to 0.992)	0.669 (0.662 to 0.676)
	Impacted: High	960,106	1.021 (1.013 to 1.028)	0.987 (0.987 to 0.987)	0.511 (0.505 to 0.516)

Table 3.13: Outputs of PVA for Cumulative Assessment of Displacement Impacts for Guillemot During the Non-breeding Season. CIs Given in Parentheses

Years Of Operational Impact	Impact Scenario	Simulated Population Size	Median Growth Rate (CI)	Median Counterfactual (CI)	
				Counterfactual of the Population Growth Rate	Counterfactual of Population Size
With Berwick Bank					
0	Baseline	350,471	1.037 (0.933 to 1.129)	-	-
	Impacted: Low	348,822	1.032 (0.929 to 1.125)	0.995 (0.993 to 0.997)	0.995 (0.990 to 1.000)
	Impacted: High	345,507	1.022 (0.919 to 1.114)	0.986 (0.983 to 0.988)	0.986 (0.980 to 0.991)
30	Baseline	957,118	1.034 (1.024 to 1.044)	-	-
	Impacted: Low	827,290	1.029 (1.019 to 1.039)	0.995 (0.995 to 0.996)	0.865 (0.857 to 0.872)

Years Of Operational Impact	Impact Scenario	Simulated Population Size	Median Growth Rate (CI)	Median Counterfactual (CI)	
				Counterfactual of the Population Growth Rate	Counterfactual of Population Size
	Impacted: High	617,313	1.020 (1.009 to 1.030)	0.986 (0.986 to 0.986)	0.645 (0.639 to 0.651)
50	Baseline	1,880,544	1.034 (1.026 to 1.042)	-	-
	Impacted: Low	1,480,626	1.029 (1.021 to 1.037)	0.995 (0.995 to 0.995)	0.787 (0.780 to 0.795)
	Impacted: High	913,662	1.020 (1.012 to 1.027)	0.986 (0.986 to 0.986)	0.486 (0.481 to 0.491)
Without Berwick Bank					
0	Baseline	350,471	1.037 (0.933 to 1.129)	-	-
	Impacted: Low	349,111	1.033 (0.929 to 1.126)	0.996 (0.994 to 0.999)	0.996 (0.991 to 1.000)
	Impacted: High	346,744	1.026 (0.923 to 1.118)	0.989 (0.987 to 0.991)	0.989 (0.984 to 0.995)
30	Baseline	957,118	1.034 (1.024 to 1.044)	-	-
	Impacted: Low	858,140	1.031 (1.020 to 1.041)	0.997 (0.996 to 0.997)	0.897 (0.890 to 0.905)
	Impacted: High	690,781	1.023 (1.013 to 1.033)	0.990 (0.989 to 0.990)	0.722 (0.715 to 0.728)
50	Baseline	1,880,544	1.034 (1.026 to 1.042)	-	-
	Impacted: Low	1,572,833	1.031 (1.022 to 1.038)	0.997 (0.996 to 0.997)	0.837 (0.829 to 0.845)
	Impacted: High	1,100,369	1.023 (1.015 to 1.031)	0.990 (0.989 to 0.990)	0.585 (0.579 to 0.591)

Table 3.14: Outputs of PVA for Cumulative Assessment of Displacement Impacts for Guillemot Annually. CIs Given in Parentheses

Years of operational impact	Impact Scenario	Simulated Population Size	Median Growth Rate (CI)	Median Counterfactual (CI)	
				Counterfactual of the Population Growth Rate	Counterfactual of Population Size
With Berwick Bank					
0	Baseline	350,471	1.037 (0.933 to 1.129)	-	-
	Impacted: Low	343,898	1.017 (0.914 to 1.109)	0.981 (0.979 to 0.983)	0.981 (0.976 to 0.986)
	Impacted: High	337,193	0.998 (0.896 to 1.088)	0.962 (0.959 to 0.965)	0.962 (0.957 to 0.968)
30	Baseline	957,118	1.034 (1.024 to 1.044)	-	-
	Impacted: Low	535,622	1.015 (1.005 to 1.025)	0.981 (0.981 to 0.982)	0.560 (0.554 to 0.566)
	Impacted: High	296,254	0.996 (0.985 to 1.006)	0.963 (0.962 to 0.963)	0.310 (0.305 to 0.314)
50	Baseline	1,880,544	1.034 (1.026 to 1.042)	-	-
	Impacted: Low	723,484	1.015 (1.007 to 1.023)	0.981 (0.981 to 0.982)	0.385 (0.381 to 0.390)
	Impacted: High	272,900	0.996 (0.988 to 1.003)	0.963 (0.963 to 0.963)	0.145 (0.143 to 0.148)
Without Berwick Bank					
0	Baseline	350,471	1.037 (0.933 to 1.129)	-	-
	Impacted: Low	346,396	1.025 (0.922 to 1.117)	0.988 (0.986 to 0.991)	0.989 (0.983 to 0.994)
	Impacted: High	342,052	1.012 (0.910 to 1.104)	0.976 (0.973 to 0.978)	0.976 (0.970 to 0.981)
30	Baseline	957,118	1.034 (1.024 to 1.044)	-	-

Years of operational impact	Impact Scenario	Simulated Population Size	Median Growth Rate (CI)	Median Counterfactual (CI)	
				Counterfactual of the Population Growth Rate	Counterfactual of Population Size
	Impacted: Low	672,128	1.023 (1.012 to 1.033)	0.989 (0.988 to 0.989)	0.702 (0.695 to 0.709)
	Impacted: High	456,978	1.010 (0.999 to 1.020)	0.976 (0.976 to 0.977)	0.478 (0.472 to 0.483)
50	Baseline	1,880,544	1.034 (1.026 to 1.042)	-	-
	Impacted: Low	1,050,411	1.022 (1.014 to 1.030)	0.989 (0.988 to 0.989)	0.559 (0.553 to 0.565)
	Impacted: High	557,512	1.010 (1.002 to 1.018)	0.976 (0.976 to 0.977)	0.297 (0.293 to 0.300)

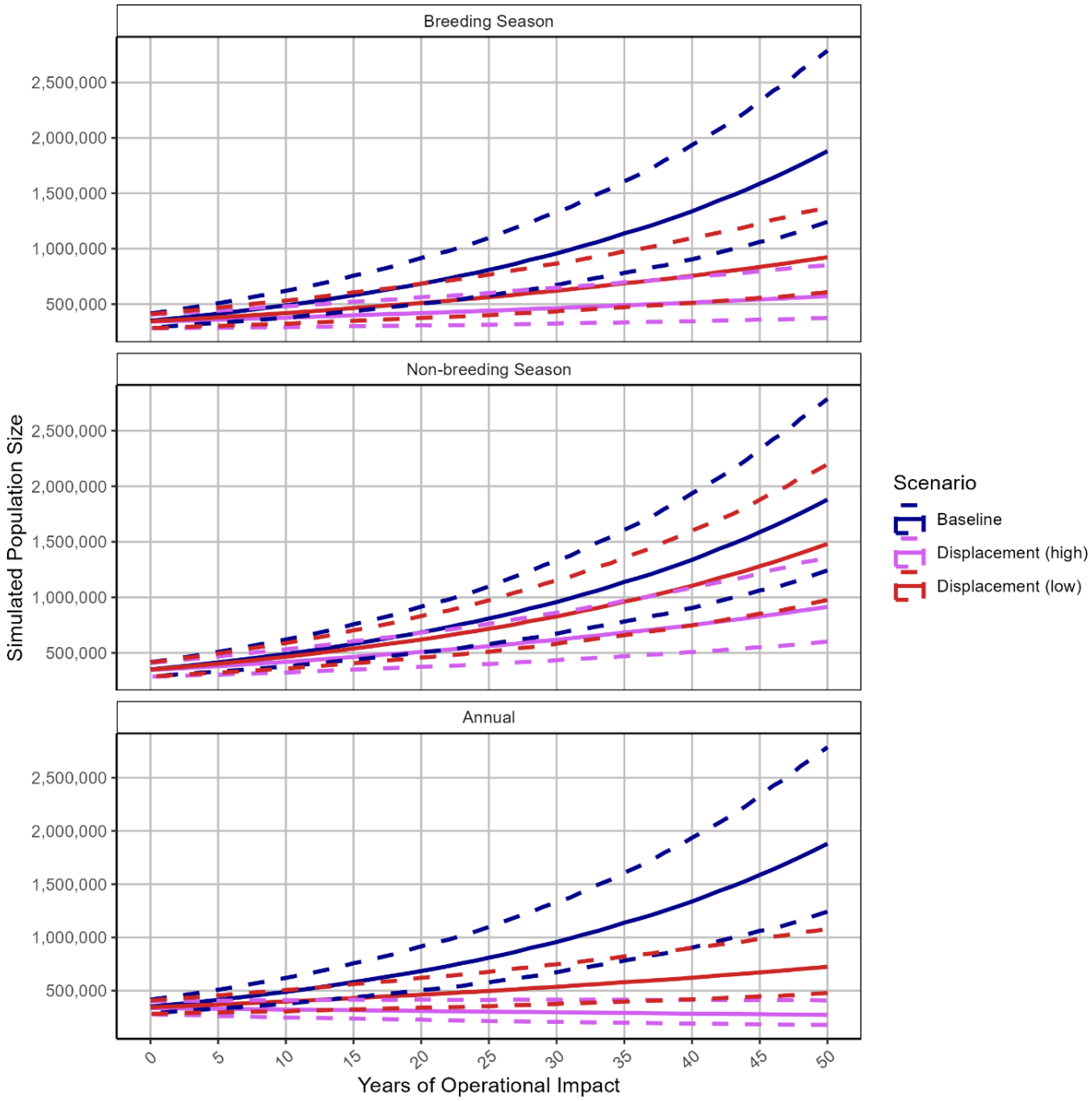

Figure 3.7: Population Projection for Cumulative Assessment Including Berwick Bank of Displacement Impacts for Guillemot. Simulated Population Size with 95% CI are Presented

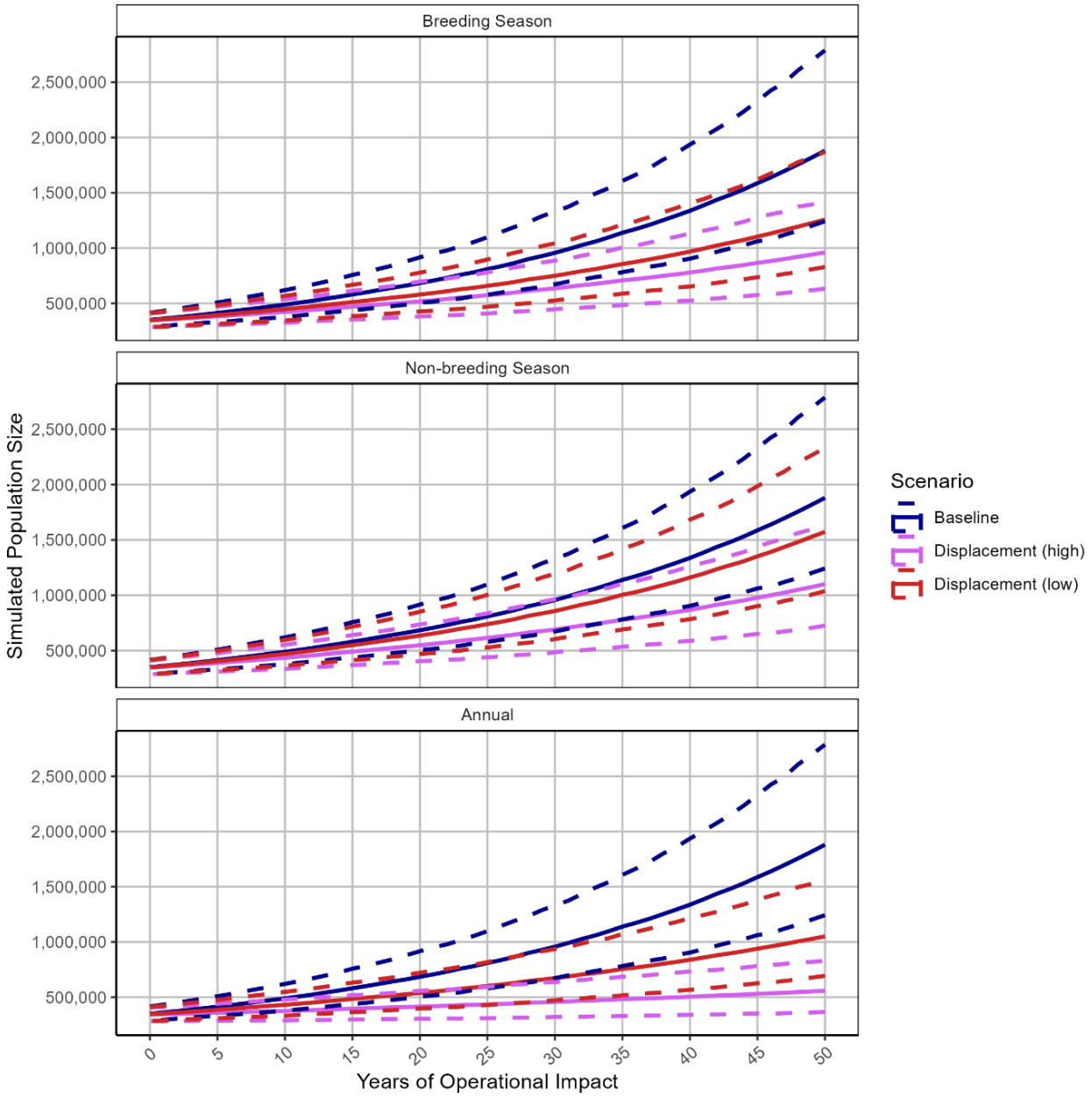

Figure 3.8: Population Projection for Cumulative Assessment Excluding Berwick Bank of Displacement Impacts for Guillemot. Simulated Population Size with 95% CI are Presented

Razorbill

Proposed Development Alone

3.3.5 Proposed Development alone impacts of displacement for razorbill did exceed a 0.02 percentage point decrease in survival in the breeding season and annually (Table 1.1). Therefore, Proposed Development alone PVAs were run for breeding season and annual impacts of displacement for razorbill (Table 3.15 and Table 3.16; Figure 3.9).

Table 3.15: Outputs of PVA for Proposed Development Alone Assessment of Displacement Impacts for Razorbill in the Breeding Season. CIs Given in Parentheses

Years Of Operational Impact	Impact Scenario	Simulated Population Size	Median Growth Rate (CI)	Median Counterfactual (CI)	
				Counterfactual of the Population Growth Rate	Counterfactual of Population Size
0	Baseline	104,274	1.017 (0.834 to 1.184)	-	-
	Impacted: Low	104,274	1.016 (0.834 to 1.183)	0.999 (0.995 to 1.004)	0.999 (0.988 to 1.011)
	Impacted: High	104,346	1.016 (0.833 to 1.183)	0.999 (0.995 to 1.003)	0.999 (0.987 to 1.011)
30	Baseline	156,072	1.014 (0.988 to 1.038)	-	-
	Impacted: Low	152,972	1.013 (0.988 to 1.037)	0.999 (0.999 to 1.000)	0.981 (0.961 to 1.001)
	Impacted: High	150,882	1.013 (0.988 to 1.037)	0.999 (0.998 to 1.000)	0.969 (0.949 to 0.989)
50	Baseline	203,662	1.014 (0.994 to 1.032)	-	-
	Impacted: Low	197,582	1.013 (0.993 to 1.032)	0.999 (0.999 to 1.000)	0.969 (0.947 to 0.992)
	Impacted: High	193,322	1.013 (0.992 to 1.031)	0.999 (0.999 to 0.999)	0.949 (0.927 to 0.973)

Table 3.16: Outputs of PVA for Proposed Development Alone Assessment of Displacement Impacts for Razorbill Annually. CIs Given in Parentheses

Years of operational impact	Impact Scenario	Simulated Population Size	Median Growth Rate (CI)	Median Counterfactual (CI)	
				Counterfactual of the Population Growth Rate	Counterfactual of Population Size
0	Baseline	282,665	1.018 (0.828 to 1.192)	-	-
	Impacted: Low	283,100	1.018 (0.829 to 1.191)	1.000 (0.997 to 1.002)	1.000 (0.990 to 1.009)
	Impacted: High	282,929	1.018 (0.828 to 1.191)	1.000 (0.997 to 1.002)	1.000 (0.990 to 1.010)
30	Baseline	421,881	1.013 (0.988 to 1.038)	-	-
	Impacted: Low	418,019	1.013 (0.988 to 1.038)	1.000 (0.999 to 1.000)	0.992 (0.977 to 1.006)
	Impacted: High	415,912	1.013 (0.988 to 1.038)	1.000 (0.999 to 1.000)	0.985 (0.971 to 0.999)
50	Baseline	557,138	1.014 (0.995 to 1.032)	-	-
	Impacted: Low	549,408	1.014 (0.994 to 1.032)	1.000 (0.999 to 1.000)	0.986 (0.971 to 1.002)
	Impacted: High	543,937	1.013 (0.994 to 1.032)	1.000 (0.999 to 1.000)	0.975 (0.960 to 0.991)

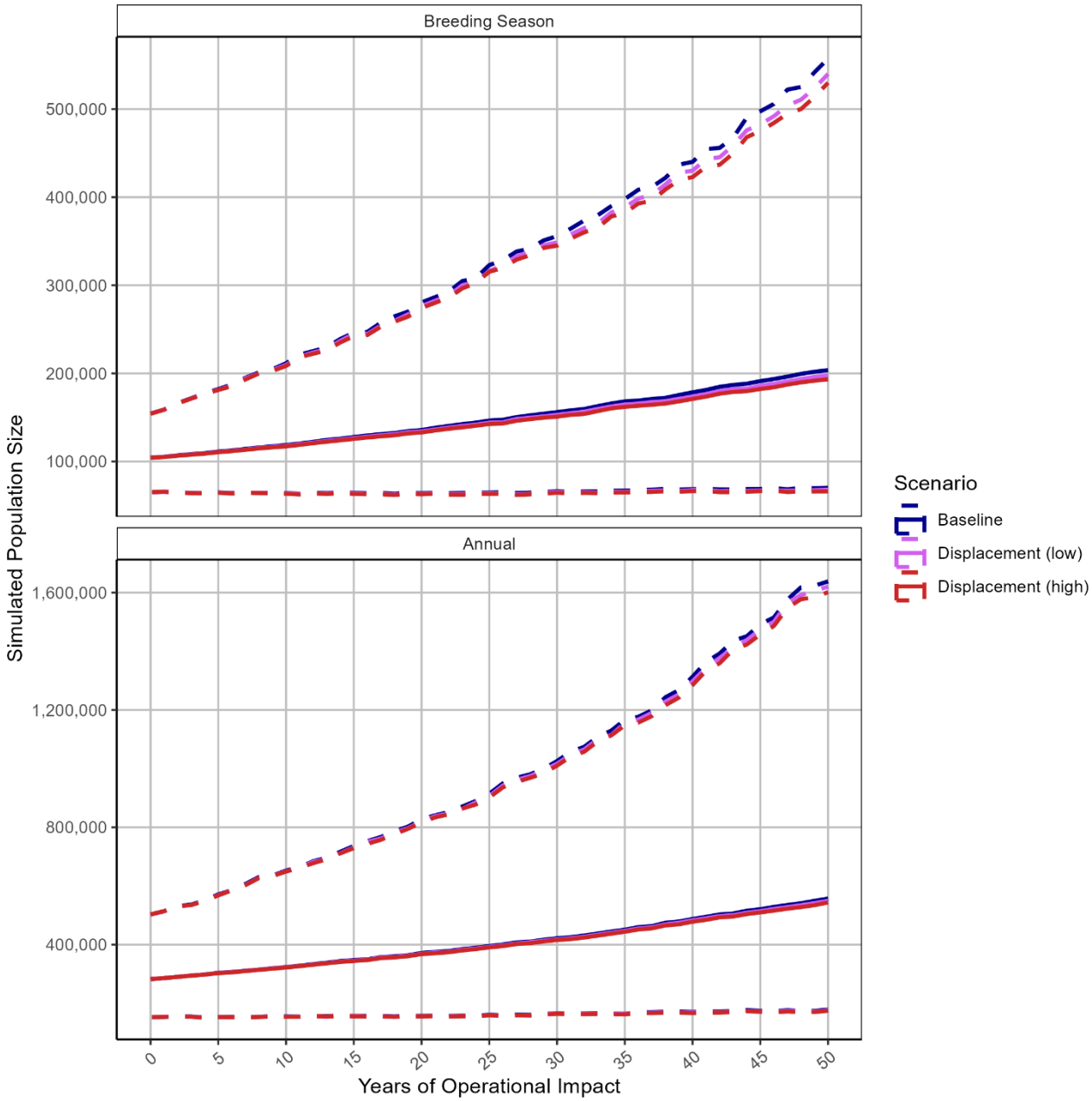

Figure 3.9: Population Projection for Proposed Development Alone Assessment of Displacement Impacts for Razorbill in the Breeding Season and Annually. Simulated Population Size with 95% CI are Presented

Cumulative

3.3.6 The results of the PVA for displacement impacts from the Proposed Development cumulatively with other OWFs on the razorbill population are provided after 30 year and 50 year timespan (Table 3.17 to Table 3.19; Figure 3.10 and Figure 3.11). The baseline unimpacted scenario is also shown for comparison purposes.

Table 3.17: Outputs of PVA for Cumulative Assessment of Displacement Impacts for Razorbill in the Breeding Season. Cis Given in Parentheses

Years Of Operational Impact	Impact Scenario	Simulated Population Size	Median Growth Rate (CI)	Median Counterfactual (CI)	
				Counterfactual of the Population Growth Rate	Counterfactual of Population Size
With Berwick Bank					
0	Baseline	104,274	1.017 (0.834 to 1.184)	-	-
	Impacted: Low	103,699	1.010 (0.828 to 1.178)	0.994 (0.990 to 0.998)	0.994 (0.982 to 1.005)
	Impacted: High	103,363	1.006 (0.824 to 1.173)	0.990 (0.986 to 0.994)	0.990 (0.979 to 1.001)
30	Baseline	156,072	1.014 (0.988 to 1.038)	-	-
	Impacted: Low	129,071	1.008 (0.982 to 1.032)	0.994 (0.993 to 0.995)	0.828 (0.810 to 0.846)
	Impacted: High	113,953	1.003 (0.978 to 1.028)	0.990 (0.989 to 0.991)	0.730 (0.714 to 0.746)
50	Baseline	203,662	1.014 (0.994 to 1.032)	-	-
	Impacted: Low	149,522	1.008 (0.987 to 1.026)	0.994 (0.993 to 0.994)	0.734 (0.714 to 0.753)
	Impacted: High	121,506	1.004 (0.983 to 1.022)	0.990 (0.989 to 0.990)	0.596 (0.579 to 0.612)
Without Berwick Bank					
0	Baseline	104,274	1.017 (0.834 to 1.184)	-	-
	Impacted: Low	103,814	1.012 (0.829 to 1.178)	0.995 (0.991 to 0.999)	0.995 (0.984 to 1.006)
	Impacted: High	103,384	1.008 (0.826 to 1.174)	0.991 (0.987 to 0.995)	0.991 (0.980 to 1.003)

Years Of Operational Impact	Impact Scenario	Simulated Population Size	Median Growth Rate (CI)	Median Counterfactual (CI)	
				Counterfactual of the Population Growth Rate	Counterfactual of Population Size
30	Baseline	156,072	1.014 (0.988 to 1.038)	-	-
	Impacted: Low	133,039	1.009 (0.983 to 1.033)	0.995 (0.994 to 0.995)	0.852 (0.834 to 0.870)
	Impacted: High	119,292	1.005 (0.980 to 1.029)	0.991 (0.991 to 0.992)	0.766 (0.748 to 0.782)
50	Baseline	203,662	1.014 (0.994 to 1.032)	-	-
	Impacted: Low	156,618	1.009 (0.988 to 1.027)	0.995 (0.994 to 0.995)	0.769 (0.749 to 0.788)
	Impacted: High	131,314	1.005 (0.985 to 1.024)	0.991 (0.991 to 0.992)	0.645 (0.627 to 0.662)

Table 3.18: Outputs of PVA for Cumulative Assessment of Displacement Impacts for Razorbill in the Non-breeding Season. CIs Given in Parentheses

Years of operational impact	Impact Scenario	Simulated Population Size	Median Growth Rate (CI)	Median Counterfactual (CI)	
				Counterfactual of the Population Growth Rate	Counterfactual of Population Size
With Berwick Bank					
0	Baseline	282,665	1.018 (0.828 to 1.192)	-	-
	Impacted: Low	281,366	1.012 (0.824 to 1.185)	0.994 (0.992 to 0.997)	0.994 (0.985 to 1.004)
	Impacted: High	278,167	1.001 (0.812 to 1.172)	0.983 (0.979 to 0.985)	0.983 (0.973 to 0.993)

Years of operational impact	Impact Scenario	Simulated Population Size	Median Growth Rate (CI)	Median Counterfactual (CI)	
				Counterfactual of the Population Growth Rate	Counterfactual of Population Size
30	Baseline	421,881	1.013 (0.988 to 1.038)	-	-
	Impacted: Low	353,315	1.008 (0.982 to 1.032)	0.994 (0.994 to 0.995)	0.838 (0.825 to 0.850)
	Impacted: High	247,494	0.996 (0.971 to 1.021)	0.983 (0.982 to 0.983)	0.586 (0.575 to 0.597)
50	Baseline	557,138	1.014 (0.995 to 1.032)	-	-
	Impacted: Low	416,921	1.008 (0.989 to 1.027)	0.994 (0.994 to 0.995)	0.748 (0.734 to 0.760)
	Impacted: High	231,768	0.997 (0.977 to 1.015)	0.983 (0.982 to 0.983)	0.416 (0.405 to 0.425)
Without Berwick Bank					
0	Baseline	282,665	1.018 (0.828 to 1.192)	-	-
	Impacted: Low	281,466	1.013 (0.824 to 1.185)	0.995 (0.992 to 0.997)	0.995 (0.985 to 1.005)
	Impacted: High	278,632	1.003 (0.814 to 1.175)	0.985 (0.981 to 0.987)	0.985 (0.975 to 0.994)
30	Baseline	421,881	1.013 (0.988 to 1.038)	-	-
	Impacted: Low	359,481	1.008 (0.983 to 1.033)	0.995 (0.994 to 0.995)	0.853 (0.840 to 0.865)
	Impacted: High	260,862	0.998 (0.973 to 1.022)	0.985 (0.984 to 0.985)	0.618 (0.606 to 0.629)
50	Baseline	557,138	1.014 (0.995 to 1.032)	-	-
	Impacted: Low	428,603	1.009 (0.989 to 1.027)	0.995 (0.995 to 0.995)	0.769 (0.756 to 0.782)
	Impacted: High	252,986	0.998 (0.979 to 1.017)	0.985 (0.984 to 0.985)	0.453 (0.442 to 0.463)

Table 3.19: Outputs of PVA for Cumulative Assessment of Displacement Impacts for Razorbill Annually. CIs Given in Parentheses

Years Of Operational Impact	Impact Scenario	Simulated Population Size	Median Growth Rate (CI)	Median Counterfactual (CI)	
				Counterfactual of the Population Growth Rate	Counterfactual of Population Size
With Berwick Bank					
0	Baseline	282,665	1.018 (0.828 to 1.192)	-	-
	Impacted: Low	280,660	1.010 (0.820 to 1.182)	0.992 (0.989 to 0.994)	0.992 (0.982 to 1.002)
	Impacted: High	276,523	0.997 (0.808 to 1.168)	0.979 (0.974 to 0.982)	0.979 (0.969 to 0.988)
30	Baseline	421,881	1.013 (0.988 to 1.038)	-	-
	Impacted: Low	327,190	1.005 (0.980 to 1.030)	0.992 (0.991 to 0.992)	0.775 (0.762 to 0.787)
	Impacted: High	216,769	0.992 (0.967 to 1.016)	0.979 (0.978 to 0.979)	0.514 (0.502 to 0.524)
50	Baseline	557,138	1.014 (0.995 to 1.032)	-	-
	Impacted: Low	365,864	1.006 (0.986 to 1.024)	0.992 (0.991 to 0.992)	0.657 (0.644 to 0.669)
	Impacted: High	186,631	0.992 (0.973 to 1.011)	0.979 (0.978 to 0.979)	0.334 (0.325 to 0.343)
Without Berwick Bank					
0	Baseline	282,665	1.018 (0.828 to 1.192)	-	-
	Impacted: Low	280,997	1.011 (0.822 to 1.184)	0.993 (0.990 to 0.995)	0.993 (0.983 to 1.003)
	Impacted: High	277,624	0.999 (0.810 to 1.170)	0.981 (0.977 to 0.984)	0.981 (0.971 to 0.991)
30	Baseline	421,881	1.013 (0.988 to 1.038)	-	-

Years Of Operational Impact	Impact Scenario	Simulated Population Size	Median Growth Rate (CI)	Median Counterfactual (CI)	
				Counterfactual of the Population Growth Rate	Counterfactual of Population Size
	Impacted: Low	336,480	1.006 (0.981 to 1.031)	0.993 (0.992 to 0.993)	0.798 (0.785 to 0.810)
	Impacted: High	233,136	0.994 (0.969 to 1.019)	0.981 (0.980 to 0.982)	0.553 (0.541 to 0.563)
50	Baseline	557,138	1.014 (0.995 to 1.032)	-	-
	Impacted: Low	384,611	1.007 (0.987 to 1.025)	0.993 (0.992 to 0.993)	0.690 (0.677 to 0.701)
	Impacted: High	209,750	0.995 (0.975 to 1.013)	0.981 (0.981 to 0.981)	0.377 (0.367 to 0.386)

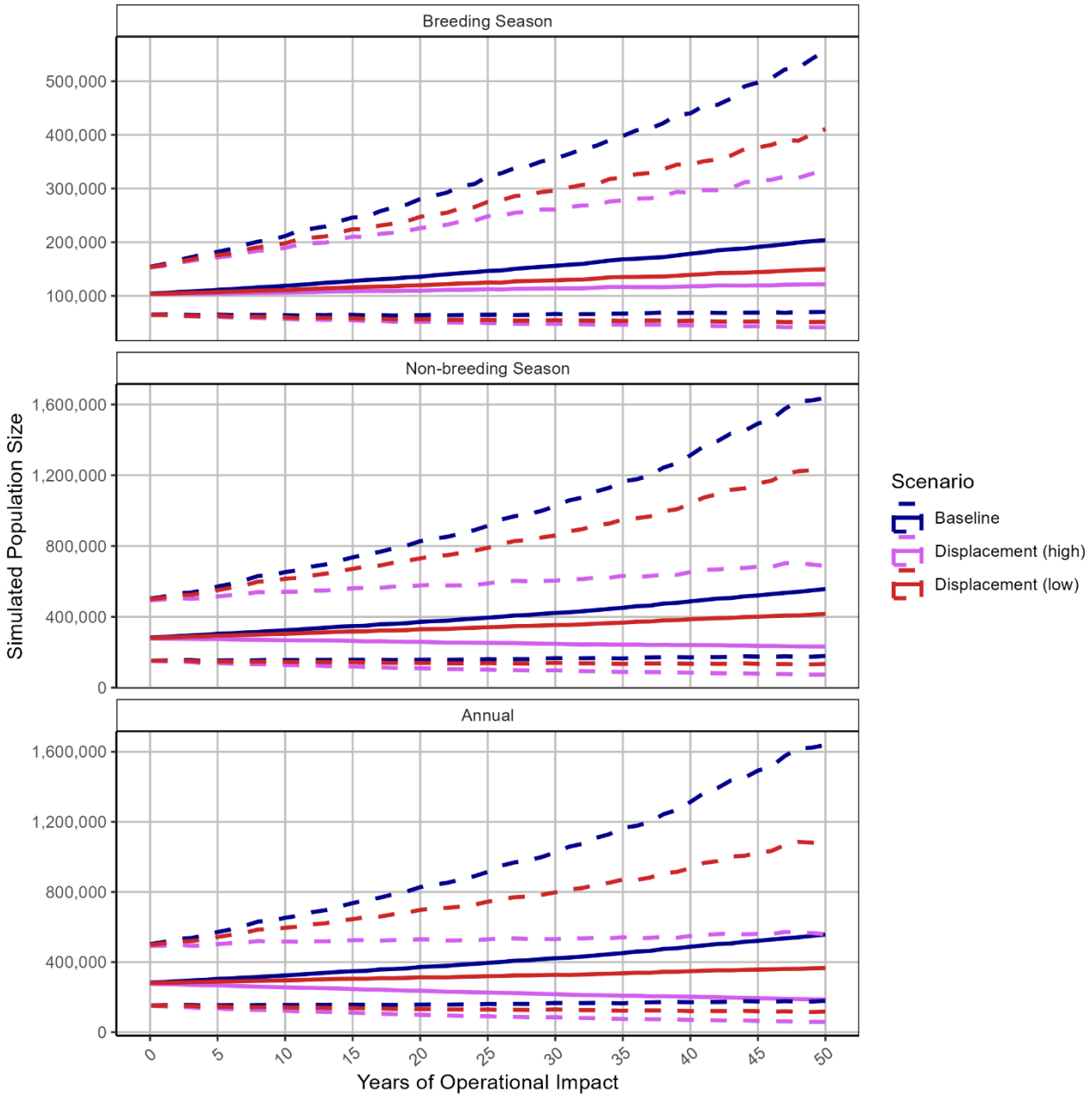

Figure 3.10: Population Projection for Cumulative Assessment of Displacement Impacts for Razorbill Including Berwick Bank Impacts. Simulated Population Size with 95% CI are Presented

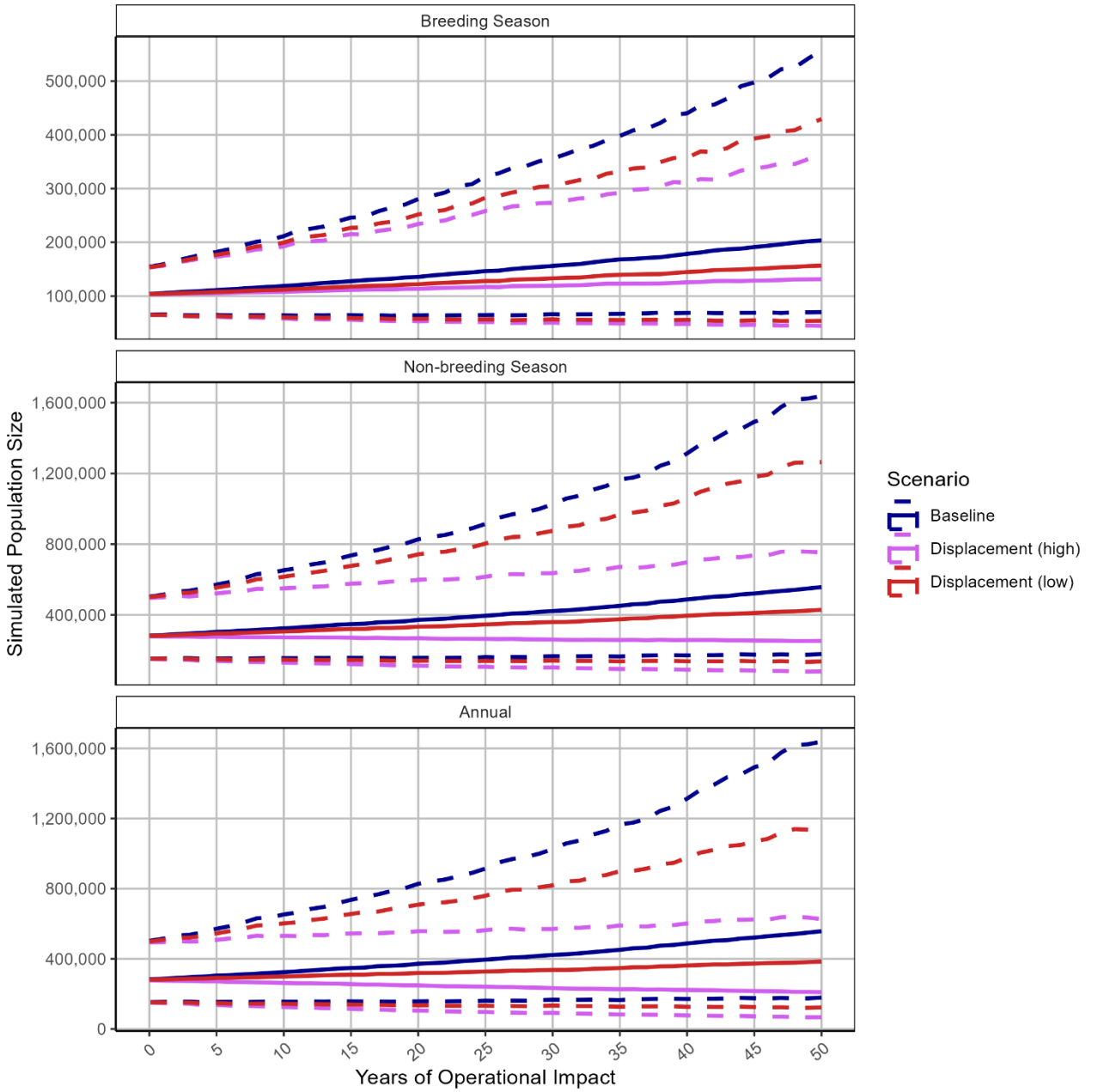

Figure 3.11: Population Projection for Cumulative Assessment of Displacement Impacts for Razorbill Excluding Berwick Bank Impacts. Simulated Population Size with 95% CI are Presented

Puffin

Proposed Development Alone

3.3.7 Proposed Development alone PVAs were not carried out for puffin as the Proposed Development alone impact of displacement did not exceed a 0.02 percentage point decrease in survival for the breeding season, non-breeding season and annually (Table 1.1).

Cumulative

3.3.8 The results of the PVA for displacement impacts from the Proposed Development cumulatively with other OWFs on the puffin population are provided after a 30 year and 50 year timespan (Table 3.20 to Table 3.22; Figure 3.12 and Figure 3.13). The baseline unimpacted scenario is also shown for comparison purposes.

Table 3.20: Outputs of PVA for Cumulative Assessment of Displacement Impacts for Puffin During the Breeding Season. CIs Given in Parentheses

Years Of Operational Impact	Impact Scenario	Simulated Population Size	Median Growth Rate (CI)	Median Counterfactual (CI)	
				Counterfactual of the Population Growth Rate	Counterfactual of Population Size
With Berwick Bank					
0	Baseline	336,573	0.962 (0.842 to 1.067)	-	-
	Impacted: Low	336,015	0.961 (0.841 to 1.065)	0.998 (0.996 to 1.001)	0.998 (0.991 to 1.005)
	Impacted: High	335,505	0.960 (0.839 to 1.064)	0.997 (0.994 to 0.999)	0.997 (0.990 to 1.004)
30	Baseline	97,840	0.960 (0.940 to 0.980)	-	-
	Impacted: Low	92,061	0.958 (0.938 to 0.978)	0.998 (0.997 to 0.999)	0.942 (0.922 to 0.961)
	Impacted: High	88,352	0.957 (0.936 to 0.977)	0.997 (0.996 to 0.997)	0.905 (0.886 to 0.923)
50	Baseline	43,085	0.960 (0.944 to 0.976)	-	-
	Impacted: Low	39,038	0.958 (0.942 to 0.974)	0.998 (0.997 to 0.999)	0.906 (0.875 to 0.936)
	Impacted: High	36,622	0.957 (0.941 to 0.973)	0.997 (0.996 to 0.997)	0.848 (0.819 to 0.877)
Without Berwick Bank					
0	Baseline	336,573	0.962 (0.842 to 1.067)	-	-
	Impacted: Low	335,580	0.961 (0.841 to 1.065)	0.998 (0.996 to 1.001)	0.998 (0.991 to 1.005)
	Impacted: High	335,458	0.960 (0.840 to 1.064)	0.997 (0.995 to 1.000)	0.997 (0.990 to 1.004)
30	Baseline	97,840	0.960 (0.940 to 0.980)	-	-

Years Of Operational Impact	Impact Scenario	Simulated Population Size	Median Growth Rate (CI)	Median Counterfactual (CI)	
				Counterfactual of the Population Growth Rate	Counterfactual of Population Size
	Impacted: Low	92,550	0.958 (0.938 to 0.978)	0.998 (0.998 to 0.999)	0.948 (0.928 to 0.967)
	Impacted: High	89,298	0.957 (0.937 to 0.977)	0.997 (0.996 to 0.998)	0.914 (0.895 to 0.932)
50	Baseline	43,085	0.960 (0.944 to 0.976)	-	-
	Impacted: Low	39,474	0.958 (0.942 to 0.974)	0.998 (0.998 to 0.999)	0.915 (0.884 to 0.946)
	Impacted: High	37,212	0.957 (0.941 to 0.973)	0.997 (0.996 to 0.998)	0.862 (0.832 to 0.892)

Table 3.21: Outputs of PVA for Cumulative Assessment of Displacement Impacts for Puffin During the Non-breeding Season. CIs Given in Parentheses

Years of operational impact	Impact Scenario	Simulated Population Size	Median Growth Rate (CI)	Median Counterfactual (CI)	
				Counterfactual of the Population Growth Rate	Counterfactual of Population Size
With Berwick Bank					
0	Baseline	106,745	0.964 (0.837 to 1.069)	-	-
	Impacted: Low	106,523	0.963 (0.836 to 1.068)	0.999 (0.994 to 1.003)	0.999 (0.983 to 1.014)
	Impacted: High	106,278	0.960 (0.833 to 1.065)	0.996 (0.991 to 1.000)	0.996 (0.981 to 1.012)
30	Baseline	31,139	0.960 (0.939 to 0.980)	-	-
	Impacted: Low	29,878	0.959 (0.938 to 0.979)	0.999 (0.998 to 1.000)	0.959 (0.924 to 0.995)

Years of operational impact	Impact Scenario	Simulated Population Size	Median Growth Rate (CI)	Median Counterfactual (CI)	
				Counterfactual of the Population Growth Rate	Counterfactual of Population Size
	Impacted: High	27,415	0.956 (0.935 to 0.977)	0.996 (0.995 to 0.997)	0.881 (0.847 to 0.915)
50	Baseline	13,823	0.960 (0.944 to 0.976)	-	-
	Impacted: Low	12,893	0.959 (0.943 to 0.975)	0.999 (0.997 to 1.000)	0.932 (0.877 to 0.989)
	Impacted: High	11,224	0.956 (0.940 to 0.972)	0.996 (0.995 to 0.997)	0.813 (0.761 to 0.863)
Without Berwick Bank					
0	Baseline	106,745	0.964 (0.837 to 1.069)	-	-
	Impacted: Low	106,606	0.963 (0.836 to 1.067)	0.999 (0.994 to 1.003)	0.999 (0.983 to 1.015)
	Impacted: High	106,427	0.960 (0.834 to 1.066)	0.997 (0.992 to 1.001)	0.997 (0.982 to 1.012)
30	Baseline	31,139	0.960 (0.939 to 0.980)	-	-
	Impacted: Low	30,126	0.959 (0.938 to 0.980)	0.999 (0.998 to 1.000)	0.967 (0.930 to 1.005)
	Impacted: High	28,199	0.957 (0.936 to 0.977)	0.997 (0.996 to 0.998)	0.905 (0.871 to 0.942)
50	Baseline	13,823	0.960 (0.944 to 0.976)	-	-
	Impacted: Low	13,085	0.959 (0.943 to 0.975)	0.999 (0.998 to 1.000)	0.946 (0.889 to 1.006)
	Impacted: High	11,675	0.957 (0.941 to 0.973)	0.997 (0.996 to 0.998)	0.848 (0.796 to 0.903)

Table 3.22: Outputs of PVA for Cumulative Assessment of Displacement Impacts for Puffin Annually. CIs Given in Parentheses

Years of operational impact	Impact Scenario	Simulated Population Size	Median Growth Rate (CI)	Median Counterfactual (CI)	
				Counterfactual of the Population Growth Rate	Counterfactual of Population Size
With Berwick Bank					
0	Baseline	336,573	0.962 (0.842 to 1.067)	-	-
	Impacted: Low	335,468	0.960 (0.840 to 1.065)	0.998 (0.995 to 1.000)	0.998 (0.990 to 1.004)
	Impacted: High	334,789	0.958 (0.837 to 1.063)	0.995 (0.992 to 0.997)	0.995 (0.988 to 1.002)
30	Baseline	97,840	0.960 (0.940 to 0.980)	-	-
	Impacted: Low	90,154	0.957 (0.937 to 0.978)	0.997 (0.997 to 0.998)	0.924 (0.904 to 0.943)
	Impacted: High	83,478	0.955 (0.935 to 0.975)	0.995 (0.994 to 0.996)	0.854 (0.835 to 0.872)
50	Baseline	43,085	0.960 (0.944 to 0.976)	-	-
	Impacted: Low	37,814	0.957 (0.941 to 0.973)	0.997 (0.997 to 0.998)	0.878 (0.847 to 0.908)
	Impacted: High	33,235	0.955 (0.939 to 0.971)	0.995 (0.994 to 0.996)	0.771 (0.743 to 0.798)
Without Berwick Bank					
0	Baseline	336,573	0.962 (0.842 to 1.067)	-	-
	Impacted: Low	335,652	0.960 (0.840 to 1.065)	0.998 (0.995 to 1.000)	0.998 (0.991 to 1.005)
	Impacted: High	334,977	0.958 (0.838 to 1.063)	0.996 (0.993 to 0.998)	0.996 (0.989 to 1.003)
30	Baseline	97,840	0.960 (0.940 to 0.980)	-	-

Years of operational impact	Impact Scenario	Simulated Population Size	Median Growth Rate (CI)	Median Counterfactual (CI)	
				Counterfactual of the Population Growth Rate	Counterfactual of Population Size
	Impacted: Low	91,208	0.958 (0.937 to 0.978)	0.998 (0.997 to 0.998)	0.933 (0.914 to 0.952)
	Impacted: High	85,235	0.956 (0.935 to 0.976)	0.996 (0.995 to 0.996)	0.873 (0.854 to 0.891)
50	Baseline	43,085	0.960 (0.944 to 0.976)	-	-
	Impacted: Low	38,444	0.958 (0.942 to 0.974)	0.998 (0.997 to 0.998)	0.892 (0.861 to 0.924)
	Impacted: High	34,380	0.956 (0.940 to 0.972)	0.996 (0.995 to 0.996)	0.800 (0.772 to 0.829)

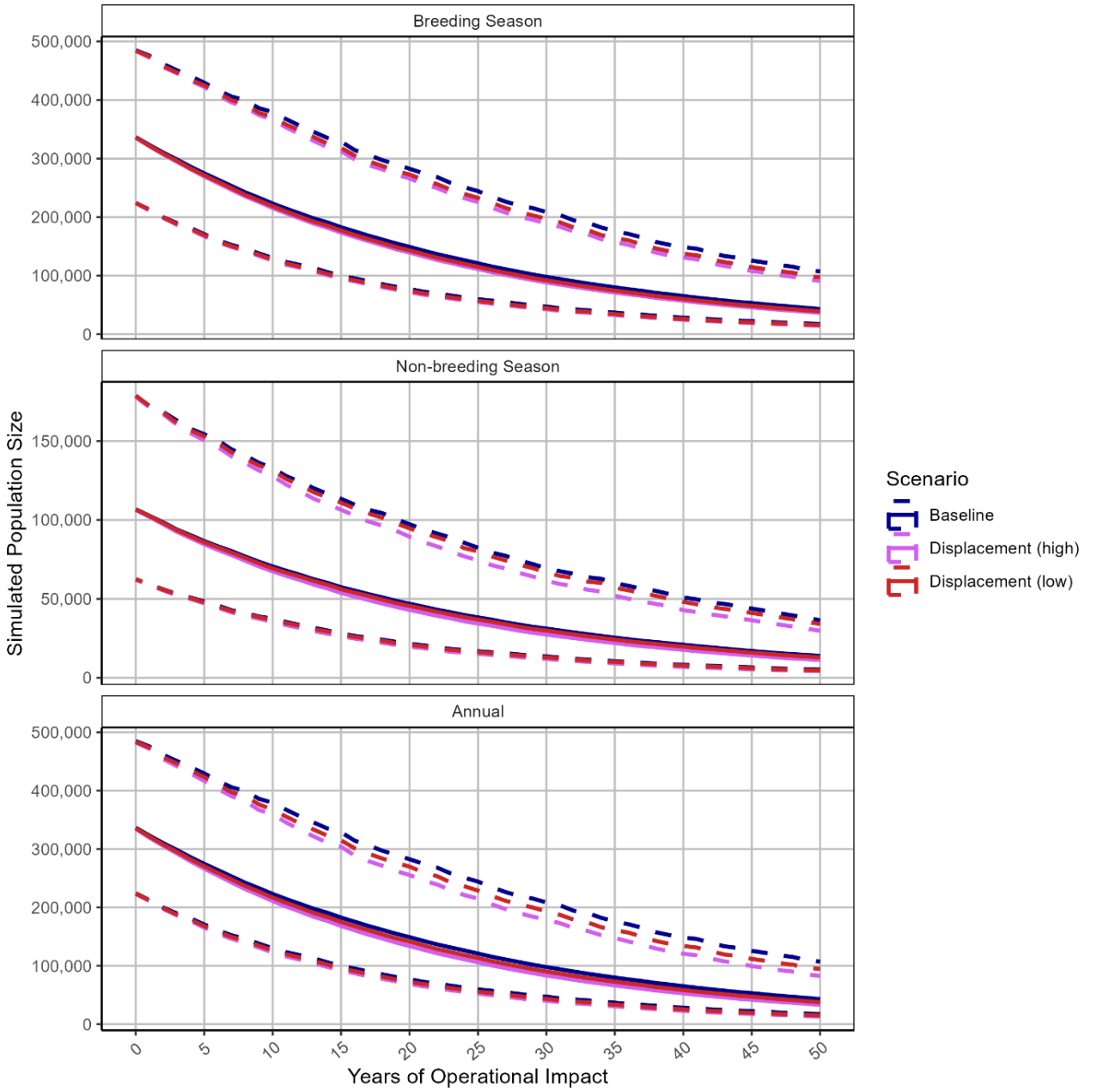

Figure 3.12: Population Projection for Cumulative Assessment of Displacement Impacts for Puffin Including Berwick Bank Impacts. Simulated Population Size with 95% CI are Presented

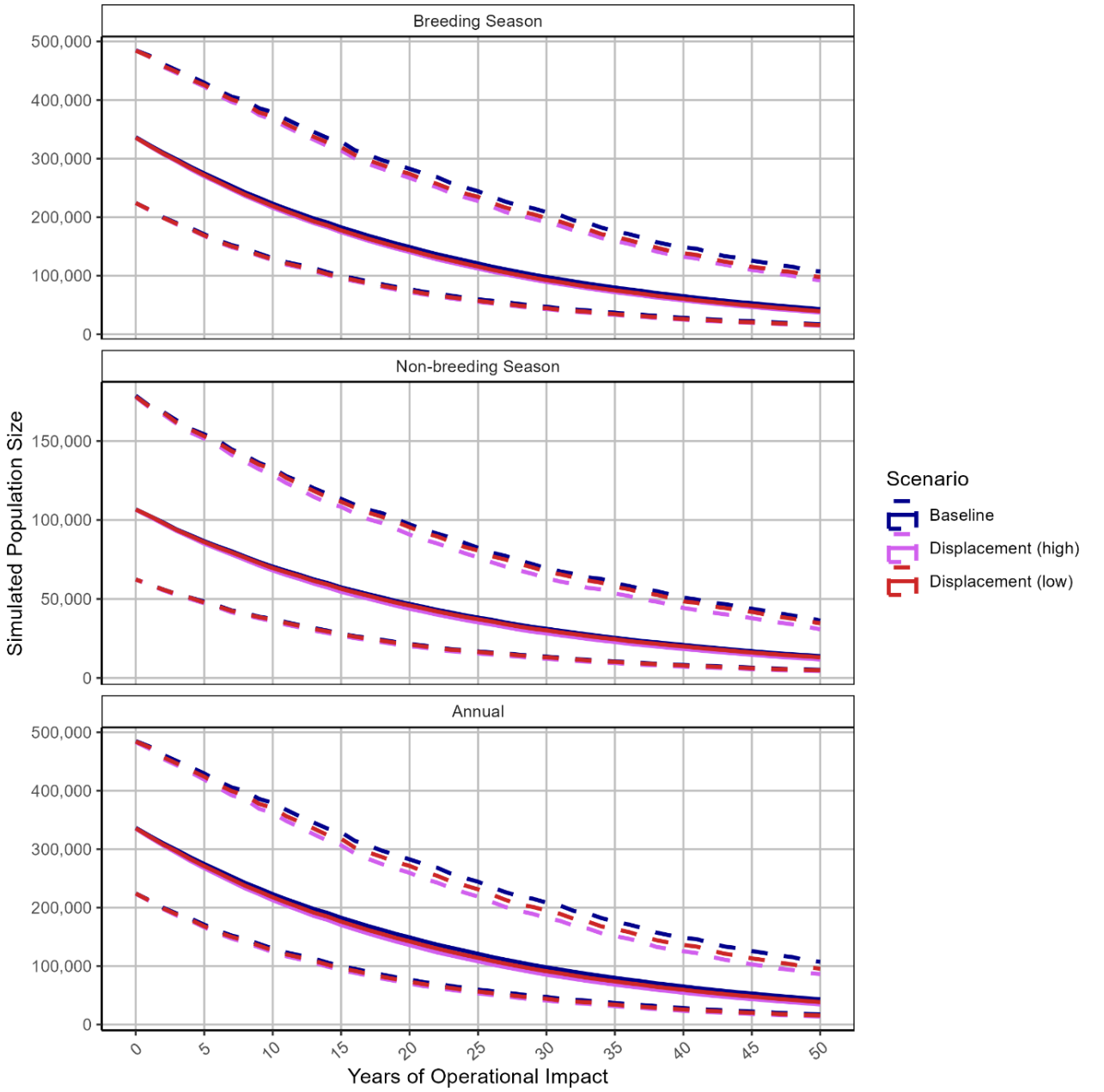

Figure 3.13: Population Projection for Cumulative Assessment of Displacement Impacts for Puffin Excluding Berwick Bank Impacts. Simulated Population Size with 95% CI are Presented

3.4 Combined Collision Risk and Displacement

Gannet

Proposed Development Alone

3.4.1 Proposed Development alone PVAs were not carried out for gannet as Proposed Development alone combined impacts of collision risk and displacement did not exceed a 0.02 percentage point decrease in survival for the breeding season, non-breeding season and annually (Table 1.1).

Cumulative

3.4.2 The results of the PVA for collision risk and displacement impacts from the Proposed Development cumulatively with other OWFs on the gannet population are provided after a 30 year and 50 year timespan (Table 3.23 to Table 3.25; Figure 3.14 and Figure 3.15. The baseline unimpacted scenario is also shown for comparison purposes.

Table 3.23: Outputs of PVA for Cumulative Assessment of Combined Collision and Displacement Impacts for Gannet During the Breeding Season. CIs Given in Parentheses

Years of operational impact	Impact Scenario	Simulated Population Size	Median Growth Rate (CI)	Median Counterfactual (CI)	
				Counterfactual of the Population Growth Rate	Counterfactual of Population Size
With Berwick Bank					
0	Baseline	916,693	1.010 (0.916 to 1.090)	-	-
	Impacted: Low	914,700	1.008 (0.915 to 1.088)	0.998 (0.997 to 1.000)	0.998 (0.994 to 1.002)
	Impacted: High	914,018	1.007 (0.914 to 1.088)	0.998 (0.996 to 0.999)	0.998 (0.993 to 1.002)
30	Baseline	1,097,475	1.006 (0.994 to 1.018)	-	-
	Impacted: Low	1,042,201	1.005 (0.992 to 1.016)	0.998 (0.998 to 0.999)	0.949 (0.942 to 0.956)
	Impacted: High	1,019,567	1.004 (0.991 to 1.015)	0.998 (0.997 to 0.998)	0.929 (0.922 to 0.936)
50	Baseline	1,238,867	1.006 (0.997 to 1.015)	-	-
	Impacted: Low	1,134,650	1.005 (0.995 to 1.014)	0.998 (0.998 to 0.998)	0.917 (0.909 to 0.925)
	Impacted: High	1,098,870	1.004 (0.994 to 1.013)	0.998 (0.997 to 0.998)	0.887 (0.879 to 0.894)
Without Berwick Bank					
0	Baseline	916,693	1.010 (0.916 to 1.090)	-	-
	Impacted: Low	915,593	1.008 (0.915 to 1.089)	0.999 (0.997 to 1.000)	0.999 (0.994 to 1.002)
	Impacted: High	914,268	1.007 (0.914 to 1.087)	0.998 (0.997 to 0.999)	0.998 (0.994 to 1.002)

Years of operational impact	Impact Scenario	Simulated Population Size	Median Growth Rate (CI)	Median Counterfactual (CI)	
				Counterfactual of the Population Growth Rate	Counterfactual of Population Size
30	Baseline	1,097,475	1.006 (0.994 to 1.018)	-	-
	Impacted: Low	1,048,600	1.005 (0.992 to 1.016)	0.999 (0.998 to 0.999)	0.955 (0.948 to 0.962)
	Impacted: High	1,030,002	1.004 (0.992 to 1.016)	0.998 (0.998 to 0.998)	0.938 (0.932 to 0.945)
50	Baseline	1,238,867	1.006 (0.997 to 1.015)	-	-
	Impacted: Low	1,148,226	1.005 (0.995 to 1.014)	0.999 (0.998 to 0.999)	0.928 (0.920 to 0.935)
	Impacted: High	1,115,359	1.004 (0.995 to 1.013)	0.998 (0.998 to 0.998)	0.901 (0.893 to 0.908)

Table 3.24: Outputs of PVA for Cumulative Assessment of Combined Collision and Displacement Impacts for Gannet During the Non-breeding Season. CIs Given in Parentheses

Years Of Operational Impact	Impact Scenario	Simulated Population Size	Median Growth Rate (CI)	Median Counterfactual (CI)	
				Counterfactual of the Population Growth Rate	Counterfactual of Population Size
With Berwick Bank					
0	Baseline	280,314	1.009 (0.912 to 1.089)	-	-
	Impacted: Low	279,934	1.007 (0.910 to 1.087)	0.998 (0.995 to 1.000)	0.998 (0.989 to 1.007)
	Impacted: High	279,090	1.004 (0.907 to 1.084)	0.995 (0.993 to 0.998)	0.995 (0.986 to 1.004)
30	Baseline	335,699	1.006 (0.994 to 1.018)	-	-

Years Of Operational Impact	Impact Scenario	Simulated Population Size	Median Growth Rate (CI)	Median Counterfactual (CI)	
				Counterfactual of the Population Growth Rate	Counterfactual of Population Size
	Impacted: Low	315,047	1.004 (0.992 to 1.016)	0.998 (0.998 to 0.998)	0.938 (0.925 to 0.951)
	Impacted: High	290,198	1.002 (0.989 to 1.013)	0.995 (0.995 to 0.996)	0.865 (0.852 to 0.877)
50	Baseline	381,141	1.006 (0.997 to 1.015)	-	-
	Impacted: Low	342,616	1.004 (0.995 to 1.013)	0.998 (0.998 to 0.998)	0.900 (0.885 to 0.914)
	Impacted: High	299,998	1.002 (0.992 to 1.011)	0.995 (0.995 to 0.996)	0.787 (0.774 to 0.800)
Without Berwick Bank					
0	Baseline	280,314	1.009 (0.912 to 1.089)	-	-
	Impacted: Low	279,690	1.006 (0.910 to 1.087)	0.998 (0.995 to 1.001)	0.998 (0.989 to 1.007)
	Impacted: High	278,936	1.004 (0.907 to 1.084)	0.995 (0.993 to 0.998)	0.995 (0.987 to 1.005)
30	Baseline	335,699	1.006 (0.994 to 1.018)	-	-
	Impacted: Low	315,446	1.004 (0.992 to 1.016)	0.998 (0.998 to 0.998)	0.940 (0.927 to 0.953)
	Impacted: High	292,303	1.002 (0.989 to 1.014)	0.996 (0.995 to 0.996)	0.870 (0.857 to 0.882)
50	Baseline	381,141	1.006 (0.997 to 1.015)	-	-
	Impacted: Low	344,061	1.004 (0.995 to 1.013)	0.998 (0.998 to 0.998)	0.904 (0.889 to 0.918)
	Impacted: High	302,957	1.002 (0.992 to 1.011)	0.996 (0.995 to 0.996)	0.795 (0.782 to 0.808)

Table 3.25: Outputs of PVA for Cumulative Assessment of Combined Collision and Displacement Impacts for Gannet Annually. CIs Given in Parentheses

Years Of Operational Impact	Impact Scenario	Simulated Population Size	Median Growth Rate (CI)	Median Counterfactual (CI)	
				Counterfactual of the Population Growth Rate	Counterfactual of Population Size
With Berwick Bank					
0	Baseline	916,693	1.010 (0.916 to 1.090)	-	-
	Impacted: Low	913,935	1.007 (0.914 to 1.088)	0.998 (0.996 to 0.999)	0.998 (0.994 to 1.002)
	Impacted: High	912,666	1.006 (0.912 to 1.086)	0.996 (0.995 to 0.998)	0.996 (0.992 to 1.000)
30	Baseline	1,097,475	1.006 (0.994 to 1.018)	-	-
	Impacted: Low	1,021,871	1.004 (0.991 to 1.015)	0.998 (0.997 to 0.998)	0.931 (0.924 to 0.938)
	Impacted: High	977,592	1.002 (0.990 to 1.014)	0.996 (0.996 to 0.996)	0.890 (0.884 to 0.897)
50	Baseline	1,238,867	1.006 (0.997 to 1.015)	-	-
	Impacted: Low	1,100,317	1.004 (0.994 to 1.013)	0.998 (0.998 to 0.998)	0.889 (0.881 to 0.897)
	Impacted: High	1,023,494	1.002 (0.993 to 1.012)	0.996 (0.996 to 0.996)	0.826 (0.819 to 0.833)
Without Berwick Bank					
0	Baseline	916,693	1.010 (0.916 to 1.090)	-	-
	Impacted: Low	914,696	1.007 (0.915 to 1.088)	0.998 (0.997 to 0.999)	0.998 (0.994 to 1.002)
	Impacted: High	913,874	1.006 (0.913 to 1.087)	0.997 (0.995 to 0.998)	0.997 (0.993 to 1.001)
30	Baseline	1,097,475	1.006 (0.994 to 1.018)	-	-

Years Of Operational Impact	Impact Scenario	Simulated Population Size	Median Growth Rate (CI)	Median Counterfactual (CI)	
				Counterfactual of the Population Growth Rate	Counterfactual of Population Size
	Impacted: Low	1,029,260	1.004 (0.992 to 1.016)	0.998 (0.998 to 0.998)	0.938 (0.931 to 0.945)
	Impacted: High	988,535	1.003 (0.990 to 1.014)	0.997 (0.996 to 0.997)	0.901 (0.894 to 0.907)
50	Baseline	1,238,867	1.006 (0.997 to 1.015)	-	-
	Impacted: Low	1,114,849	1.004 (0.995 to 1.013)	0.998 (0.998 to 0.998)	0.900 (0.893 to 0.908)
	Impacted: High	1,043,046	1.003 (0.993 to 1.012)	0.997 (0.996 to 0.997)	0.842 (0.834 to 0.849)

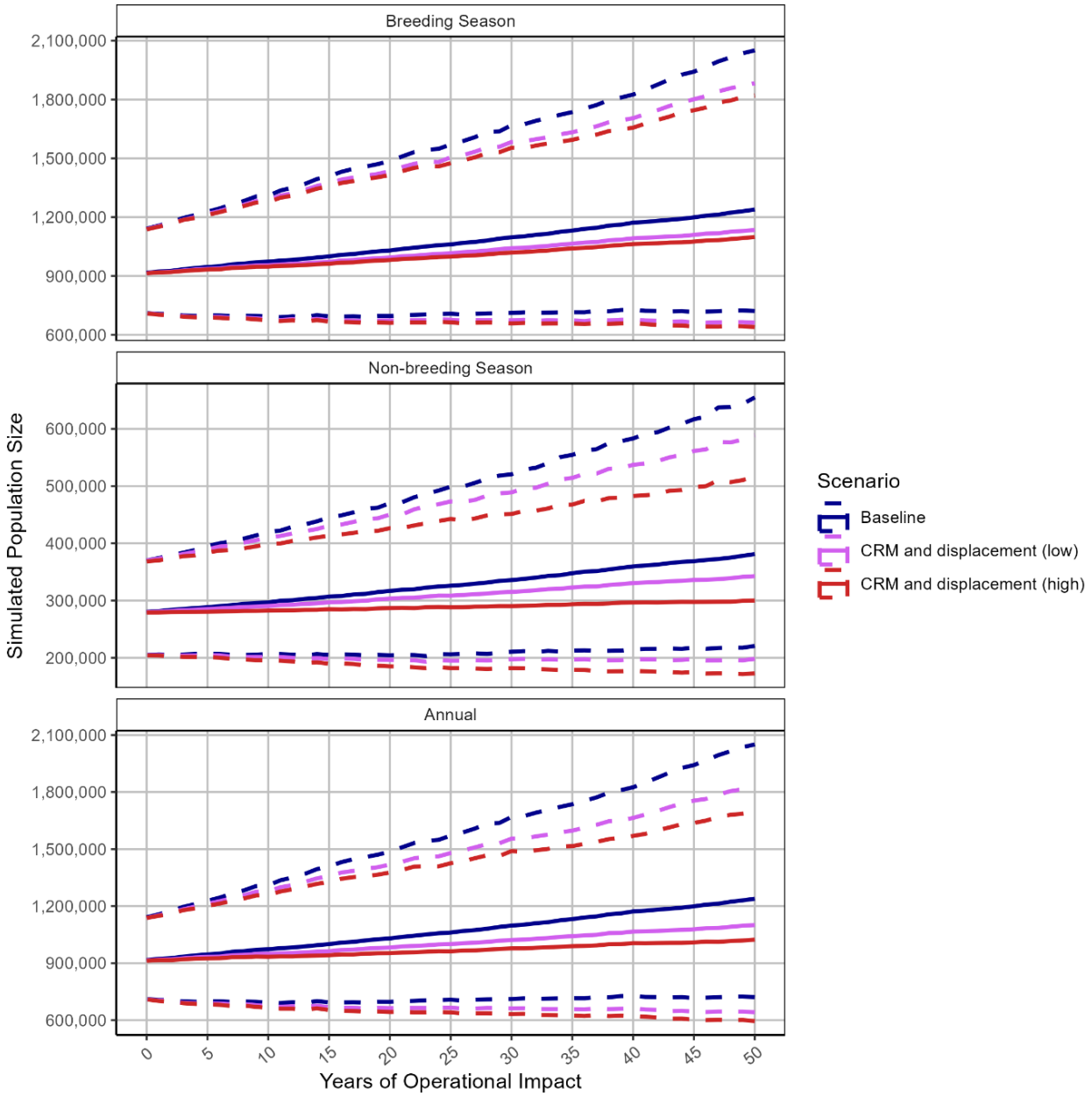

Figure 3.14: Population Projection for Cumulative Assessment of Combined Collision Risk and Displacement Impacts for Gannet Including Berwick Bank Impacts. Simulated Population Size with 95% CI are Presented

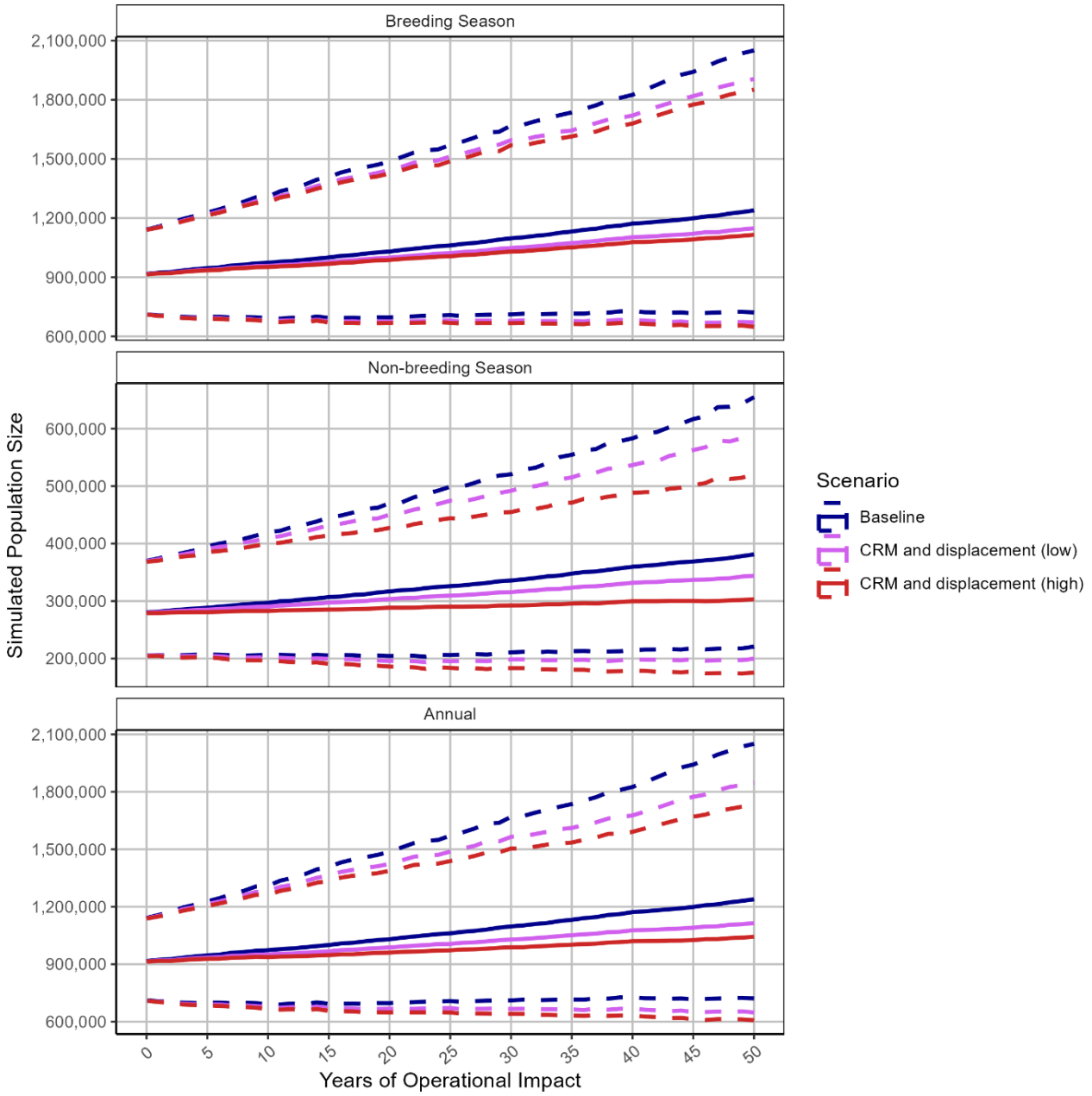

Figure 3.15: Population Projection for Cumulative Assessment of Combined Collision Risk and Displacement Impacts for Gannet Excluding Berwick Bank Impacts. Simulated Population Size with 95% CI are Presented

Kittiwake

Proposed Development Alone

3.4.3 Proposed Development alone PVAs were not carried out for kittiwake as Proposed Development alone combined impacts of collision risk and displacement did not exceed a 0.02 percentage point decrease in survival for the breeding season, non-breeding season and annually (Table 1.1).

Cumulative

3.4.4 The results of the PVA for collision risk and displacement impacts from the Proposed Development cumulatively with other OWFs on the kittiwake population are provided after a 30 year and 50 year timespan (Table 3.26 to Table 3.28; Figure 3.16 and Figure 3.17). Scenarios have been presented using the project alone collisions using both Option 1 (LiDAR data) and Option 2 (generic flight height data), see Paragraph 1.1.6. The baseline unimpacted scenario is also shown for comparison purposes.

Table 3.26: Outputs of PVA for Cumulative Assessment of Combined Collision and Displacement Impacts for Kittiwake During the Breeding Season. CIs Given in Parentheses

Years Of Operational Impact	Impact Scenario	Simulated Population Size	Median Growth Rate (CI)	Median Counterfactual (CI)	
				Counterfactual of the Population Growth Rate	Counterfactual of Population Size
With Berwick Bank – Option 1					
0	Baseline	700,406	1.012 (0.844 to 1.223)	-	-
	Impacted: Low	698,488	1.008 (0.841 to 1.219)	0.997 (0.995 to 0.999)	0.997 (0.992 to 1.002)
	Impacted: High	697,566	1.007 (0.839 to 1.219)	0.996 (0.994 to 0.998)	0.996 (0.991 to 1.001)
30	Baseline	1,041,157	1.014 (0.987 to 1.040)	-	-
	Impacted: Low	949,761	1.011 (0.984 to 1.037)	0.997 (0.997 to 0.997)	0.912 (0.902 to 0.921)
	Impacted: High	919,318	1.010 (0.983 to 1.036)	0.996 (0.996 to 0.996)	0.884 (0.875 to 0.893)
50	Baseline	1,330,229	1.013 (0.992 to 1.033)	-	-
	Impacted: Low	1,142,252	1.010 (0.989 to 1.030)	0.997 (0.997 to 0.997)	0.859 (0.849 to 0.869)
	Impacted: High	1,086,640	1.009 (0.989 to 1.029)	0.996 (0.996 to 0.996)	0.817 (0.807 to 0.827)
Without Berwick Bank – Option 1					
0	Baseline	700,406	1.012 (0.844 to 1.223)	-	-
	Impacted: Low	699,068	1.009 (0.842 to 1.221)	0.998 (0.996 to 1.000)	0.998 (0.993 to 1.003)
	Impacted: High	699,002	1.009 (0.841 to 1.220)	0.997 (0.995 to 0.999)	0.997 (0.992 to 1.003)

Years Of Operational Impact	Impact Scenario	Simulated Population Size	Median Growth Rate (CI)	Median Counterfactual (CI)	
				Counterfactual of the Population Growth Rate	Counterfactual of Population Size
30	Baseline	1,041,157	1.014 (0.987 to 1.040)	-	-
	Impacted: Low	976,550	1.012 (0.984 to 1.037)	0.998 (0.998 to 0.998)	0.938 (0.928 to 0.947)
	Impacted: High	953,424	1.011 (0.984 to 1.037)	0.997 (0.997 to 0.997)	0.917 (0.907 to 0.926)
50	Baseline	1,330,229	1.013 (0.992 to 1.033)	-	-
	Impacted: Low	1,195,055	1.011 (0.990 to 1.031)	0.998 (0.998 to 0.998)	0.899 (0.889 to 0.910)
	Impacted: High	1,152,867	1.011 (0.990 to 1.030)	0.997 (0.997 to 0.997)	0.866 (0.856 to 0.876)
With Berwick Bank – Option 2					
0	Baseline	700,406	1.012 (0.844 to 1.223)	-	-
	Impacted: Low	698,135	1.008 (0.840 to 1.220)	0.997 (0.995 to 0.999)	0.997 (0.991 to 1.002)
	Impacted: High	697,716	1.008 (0.840 to 1.218)	0.996 (0.994 to 0.998)	0.996 (0.990 to 1.001)
30	Baseline	1,041,157	1.014 (0.987 to 1.040)	-	-
	Impacted: Low	947,553	1.011 (0.983 to 1.036)	0.997 (0.997 to 0.997)	0.910 (0.900 to 0.919)
	Impacted: High	918,505	1.010 (0.982 to 1.035)	0.996 (0.996 to 0.996)	0.883 (0.874 to 0.892)
50	Baseline	1,330,229	1.013 (0.992 to 1.033)	-	-
	Impacted: Low	1,139,989	1.010 (0.989 to 1.030)	0.997 (0.997 to 0.997)	0.856 (0.846 to 0.866)
	Impacted: High	1,083,087	1.009 (0.988 to 1.029)	0.996 (0.996 to 0.996)	0.814 (0.804 to 0.824)

Years Of Operational Impact	Impact Scenario	Simulated Population Size	Median Growth Rate (CI)	Median Counterfactual (CI)	
				Counterfactual of the Population Growth Rate	Counterfactual of Population Size
Without Berwick Bank – Option 2					
0	Baseline	700,406	1.012 (0.844 to 1.223)	-	-
	Impacted: Low	699,225	1.009 (0.842 to 1.220)	0.998 (0.996 to 1.000)	0.998 (0.993 to 1.003)
	Impacted: High	698,737	1.009 (0.841 to 1.220)	0.997 (0.995 to 0.999)	0.997 (0.992 to 1.002)
30	Baseline	1,041,157	1.014 (0.987 to 1.040)	-	-
	Impacted: Low	973,636	1.011 (0.984 to 1.037)	0.998 (0.998 to 0.998)	0.936 (0.926 to 0.945)
	Impacted: High	952,567	1.011 (0.984 to 1.037)	0.997 (0.997 to 0.997)	0.915 (0.905 to 0.924)
50	Baseline	1,330,229	1.013 (0.992 to 1.033)	-	-
	Impacted: Low	1,191,327	1.011 (0.990 to 1.031)	0.998 (0.998 to 0.998)	0.896 (0.886 to 0.907)
	Impacted: High	1,148,549	1.011 (0.990 to 1.030)	0.997 (0.997 to 0.997)	0.864 (0.853 to 0.874)

Table 3.27: Outputs of PVA for Cumulative Assessment of Combined Collision and Displacement Impacts for Kittiwake During the Non-breeding Season. CIs Given in Parentheses

Years Of Operational Impact	Impact Scenario	Simulated Population Size	Median Growth Rate (CI)	Median Counterfactual (CI)	
				Counterfactual of the Population Growth Rate	Counterfactual of Population Size
With Berwick Bank – Option 1					
0	Baseline	808,757	1.008 (0.852 to 1.219)	-	-
	Impacted: Low	805,053	1.004 (0.848 to 1.214)	0.996 (0.994 to 0.998)	0.996 (0.989 to 1.003)
	Impacted: High	803,456	1.002 (0.847 to 1.211)	0.994 (0.992 to 0.996)	0.994 (0.987 to 1.001)
30	Baseline	1,198,546	1.013 (0.986 to 1.038)	-	-
	Impacted: Low	1,049,193	1.009 (0.982 to 1.034)	0.996 (0.995 to 0.996)	0.877 (0.867 to 0.887)
	Impacted: High	987,878	1.007 (0.980 to 1.032)	0.994 (0.993 to 0.994)	0.825 (0.815 to 0.834)
50	Baseline	1,562,414	1.013 (0.992 to 1.033)	-	-
	Impacted: Low	1,258,388	1.009 (0.988 to 1.029)	0.996 (0.996 to 0.996)	0.805 (0.795 to 0.816)
	Impacted: High	1,139,555	1.007 (0.986 to 1.027)	0.994 (0.994 to 0.994)	0.729 (0.718 to 0.738)

Years Of Operational Impact	Impact Scenario	Simulated Population Size	Median Growth Rate (CI)	Median Counterfactual (CI)	
				Counterfactual of the Population Growth Rate	Counterfactual of Population Size
Without Berwick Bank – Option 1					
0	Baseline	808,757	1.008 (0.852 to 1.219)	-	-
	Impacted: Low	805,690	1.005 (0.849 to 1.215)	0.996 (0.995 to 0.998)	0.996 (0.989 to 1.003)
	Impacted: High	803,918	1.003 (0.847 to 1.212)	0.995 (0.993 to 0.996)	0.995 (0.988 to 1.001)
30	Baseline	1,198,546	1.013 (0.986 to 1.038)	-	-
	Impacted: Low	1,071,302	1.009 (0.982 to 1.034)	0.996 (0.996 to 0.997)	0.895 (0.885 to 0.904)
	Impacted: High	1,016,629	1.008 (0.980 to 1.033)	0.995 (0.994 to 0.995)	0.849 (0.839 to 0.859)
50	Baseline	1,562,414	1.013 (0.992 to 1.033)	-	-
	Impacted: Low	1,300,708	1.010 (0.989 to 1.030)	0.996 (0.996 to 0.997)	0.833 (0.822 to 0.843)
	Impacted: High	1,195,750	1.008 (0.987 to 1.028)	0.995 (0.995 to 0.995)	0.764 (0.754 to 0.774)

Years Of Operational Impact	Impact Scenario	Simulated Population Size	Median Growth Rate (CI)	Median Counterfactual (CI)	
				Counterfactual of the Population Growth Rate	Counterfactual of Population Size
With Berwick Bank – Option 2					
0	Baseline	808,757	1.008 (0.852 to 1.219)	-	-
	Impacted: Low	804,795	1.004 (0.848 to 1.214)	0.996 (0.994 to 0.9987)	0.996 (0.989 to 1.003)
	Impacted: High	803,999	1.002 (0.846 to 1.212)	0.994 (0.992 to 0.996)	0.994 (0.987 to 1.001)
30	Baseline	1,198,546	1.013 (0.986 to 1.038)	-	-
	Impacted: Low	1,048,945	1.009 (0.982 to 1.034)	0.996 (0.995 to 0.996)	0.876 (0.866 to 0.886)
	Impacted: High	986,676	1.007 (0.980 to 1.032)	0.994 (0.993 to 0.994)	0.824 (0.815 to 0.833)
50	Baseline	1,562,414	1.013 (0.992 to 1.033)	-	-
	Impacted: Low	1,257,228	1.009 (0.988 to 1.029)	0.996 (0.996 to 0.996)	0.805 (0.794 to 0.815)
	Impacted: High	1,139,485	1.007 (0.986 to 1.027)	0.994 (0.994 to 0.994)	0.728 (0.718 to 0.737)
Without Berwick Bank – Option 2					
0	Baseline	808,757	1.008 (0.852 to 1.219)	-	-
	Impacted: Low	806,653	1.0054 (0.849 to 1.2145)	0.996 (0.994 to 0.998)	0.996 (0.989 to 1.003)

Years Of Operational Impact	Impact Scenario	Simulated Population Size	Median Growth Rate (CI)	Median Counterfactual (CI)	
				Counterfactual of the Population Growth Rate	Counterfactual of Population Size
	Impacted: High	804,592	1.003 (0.847 to 1.2123)	0.995 (0.993 to 0.996)	0.995 (0.988 to 1.002)
30	Baseline	1,198,546	1.013 (0.986 to 1.038)	-	-
	Impacted: Low	1,068,899	1.009 (0.982 to 1.034)	0.996 (0.996 to 0.997)	0.894 (0.884 to 0.904)
	Impacted: High	1,014,701	1.008 (0.9810 to 1.033)	0.995 (0.994 to 0.995)	0.849 (0.839 to 0.858)
50	Baseline	1,562,414	1.013 (0.992 to 1.033)	-	-
	Impacted: Low	1,302,003	1.010 (0.989 to 1.030)	0.996 (0.996 to 0.997)	0.832 (0.821 to 0.842)
	Impacted: High	1,196,185	1.008 (0.987 to 1.028)	0.995 (0.995 to 0.995)	0.764 (0.753 to 0.773)

Table 3.28: Outputs of PVA for Cumulative Assessment of Combined Collision and Displacement Impacts for Kittiwake Annually. CIs Given in Parentheses

Years Of Operational Impact	Impact Scenario	Simulated Population Size	Median Growth Rate (CI)	Median Counterfactual (CI)	
				Counterfactual of the Population Growth Rate	Counterfactual of Population Size
With Berwick Bank – Option 1					
0	Baseline	808,757	1.008 (0.852 to 1.219)	-	-
	Impacted: Low	803,289	1.001 (0.846 to 1.210)	0.993 (0.991 to 0.995)	0.993 (0.986 to 1.000)
	Impacted: High	800,470	0.998 (0.843 to 1.207)	0.990 (0.988 to 0.992)	0.990 (0.983 to 0.997)
30	Baseline	1,198,546	1.013 (0.986 to 1.038)	-	-
	Impacted: Low	959,141	1.006 (0.979 to 1.031)	0.993 (0.993 to 0.993)	0.802 (0.792 to 0.811)
	Impacted: High	876,554	1.003 (0.976 to 1.028)	0.990 (0.990 to 0.990)	0.732 (0.723 to 0.741)
50	Baseline	1,562,414	1.013 (0.992 to 1.033)	-	-
	Impacted: Low	1,088,007	1.006 (0.985 to 1.026)	0.993 (0.993 to 0.993)	0.695 (0.685 to 0.704)
	Impacted: High	937,438	1.003 (0.982 to 1.023)	0.990 (0.990 to 0.990)	0.599 (0.589 to 0.607)
Without Berwick Bank – Option 1					
0	Baseline	808,757	1.008 (0.852 to 1.219)	-	-
	Impacted: Low	804,491	1.003 (0.847 to 1.212)	0.994 (0.992 to 0.996)	0.994 (0.987 to 1.001)
	Impacted: High	802,377	1.000 (0.845 to 1.210)	0.992 (0.990 to 0.994)	0.992 (0.985 to 0.999)

Years Of Operational Impact	Impact Scenario	Simulated Population Size	Median Growth Rate (CI)	Median Counterfactual (CI)	
				Counterfactual of the Population Growth Rate	Counterfactual of Population Size
30	Baseline	1,198,546	1.013 (0.986 to 1.038)	-	-
	Impacted: Low	1,006,614	1.007 (0.980 to 1.032)	0.994 (0.994 to 0.995)	0.840 (0.831 to 0.850)
	Impacted: High	934,154	1.005 (0.978 to 1.030)	0.992 (0.992 to 0.992)	0.780 (0.771 to 0.789)
50	Baseline	11,562,414	1.013 (0.992 to 1.033)	-	-
	Impacted: Low	1,175,261	1.008 (0.987 to 1.028)	0.994 (0.994 to 0.995)	0.751 (0.742 to 0.761)
	Impacted: High	1,039,846	1.005 (0.984 to 1.025)	0.992 (0.992 to 0.992)	0.665 (0.655 to 0.674)
With Berwick Bank – Option 2					
0	Baseline	808,757	1.008 (0.852 to 1.219)	-	-
	Impacted: Low	802,800	1.001 (0.8456 to 1.210)	0.993 (0.991 to 0.995)	0.993 (0.986 to 1.000)
	Impacted: High	800,093	0.998 (0.843 to 1.208)	0.990 (0.988 to 0.992)	0.990 (0.983 to 0.997)
30	Baseline	1,198,546	1.013 (0.986 to 1.038)	-	-
	Impacted: Low	956,728	1.006 (0.979 to 1.031)	0.993 (0.993 to 0.993)	0.800 (0.790 to 0.809)
	Impacted: High	875,973	1.003 (0.976 to 1.028)	0.990 (0.990 to 0.990)	0.730 (0.721 to 0.739)
50	Baseline	1,562,414	1.013 (0.992 to 1.033)	-	-
	Impacted: Low	1,083,843	1.006 (0.985 to 1.026)	0.993 (0.993 to 0.993)	0.693 (0.683 to 0.702)
	Impacted: High	931,465	1.003 (0.982 to 1.023)	0.990 (0.990 to 0.990)	0.597 (0.587 to 0.605)

Years Of Operational Impact	Impact Scenario	Simulated Population Size	Median Growth Rate (CI)	Median Counterfactual (CI)	
				Counterfactual of the Population Growth Rate	Counterfactual of Population Size
Without Berwick Bank – Option 2					
0	Baseline	809,299	1.008 (0.852 to 1.219)	-	-
	Impacted: Low	804,543	1.003 (0.847 to 1.212)	0.994 (0.992 to 0.996)	0.994 (0.987 to 1.001)
	Impacted: High	802,679	1.000 (0.845 to 1.209)	0.992 (0.990 to 0.994)	0.992 (0.985 to 0.999)
30	Baseline	1,198,546	1.013 (0.986 to 1.038)	-	-
	Impacted: Low	1,003,814	1.007 (0.980 to 1.032)	0.994 (0.994 to 0.995)	0.838 (0.829 to 0.848)
	Impacted: High	932,366	1.005 (0.978 to 1.030)	0.992 (0.992 to 0.992)	0.779 (0.768 to 0.788)
50	Baseline	1,562,414	1.013 (0.992 to 1.033)	-	-
	Impacted: Low	1,171,361	1.007 (0.987 to 1.028)	0.994 (0.994 to 0.995)	0.748 (0.738 to 0.758)
	Impacted: High	1,036,198	1.005 (0.984 to 1.025)	0.992 (0.992 to 0.992)	0.663 (0.652 to 0.672)

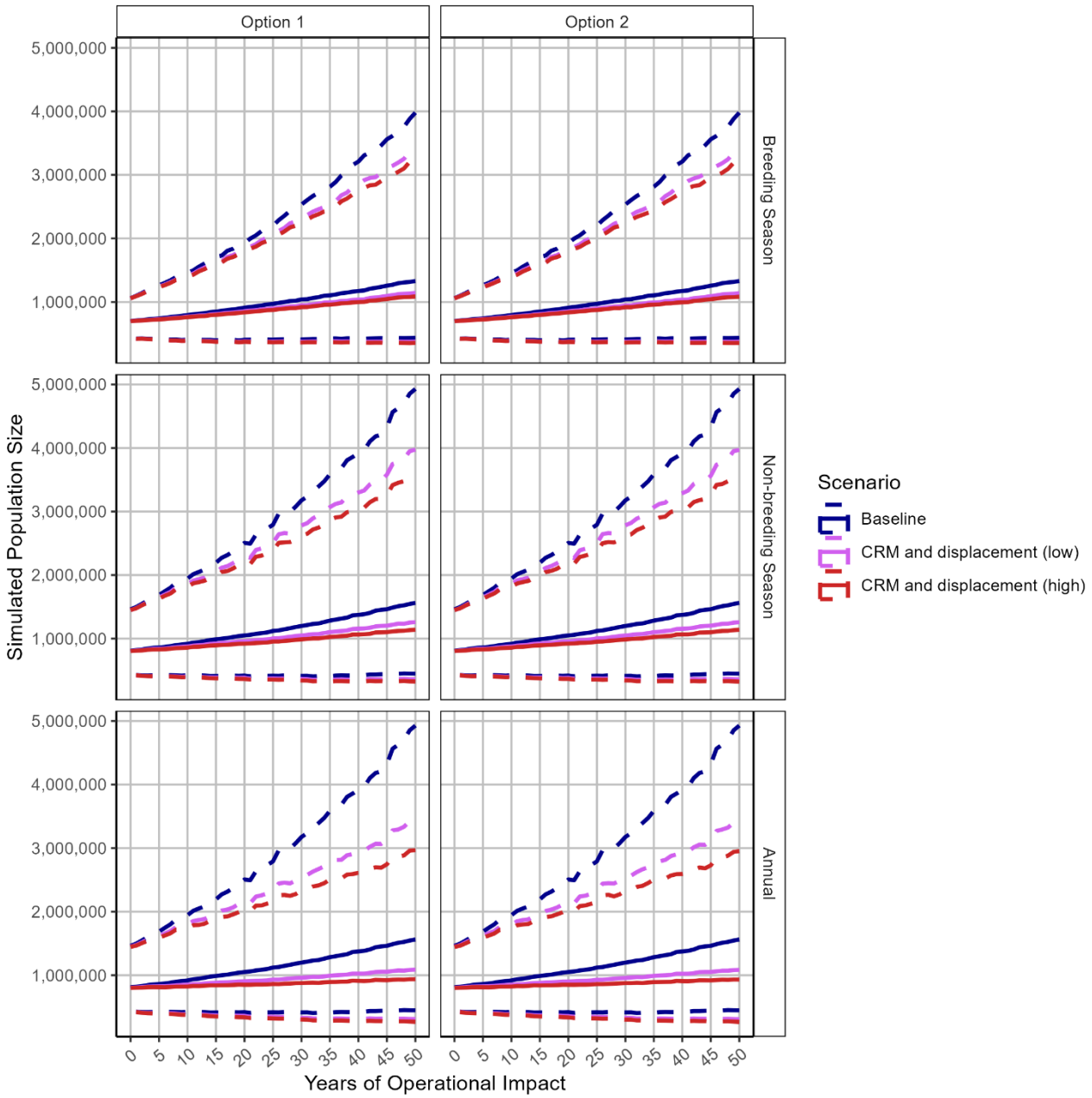

Figure 3.16: Population Projection for Cumulative Assessment of Combined Collision Risk and Displacement Impacts for Kittiwake Including Berwick Bank Impacts. Simulated Population Size with 95% CI are Presented

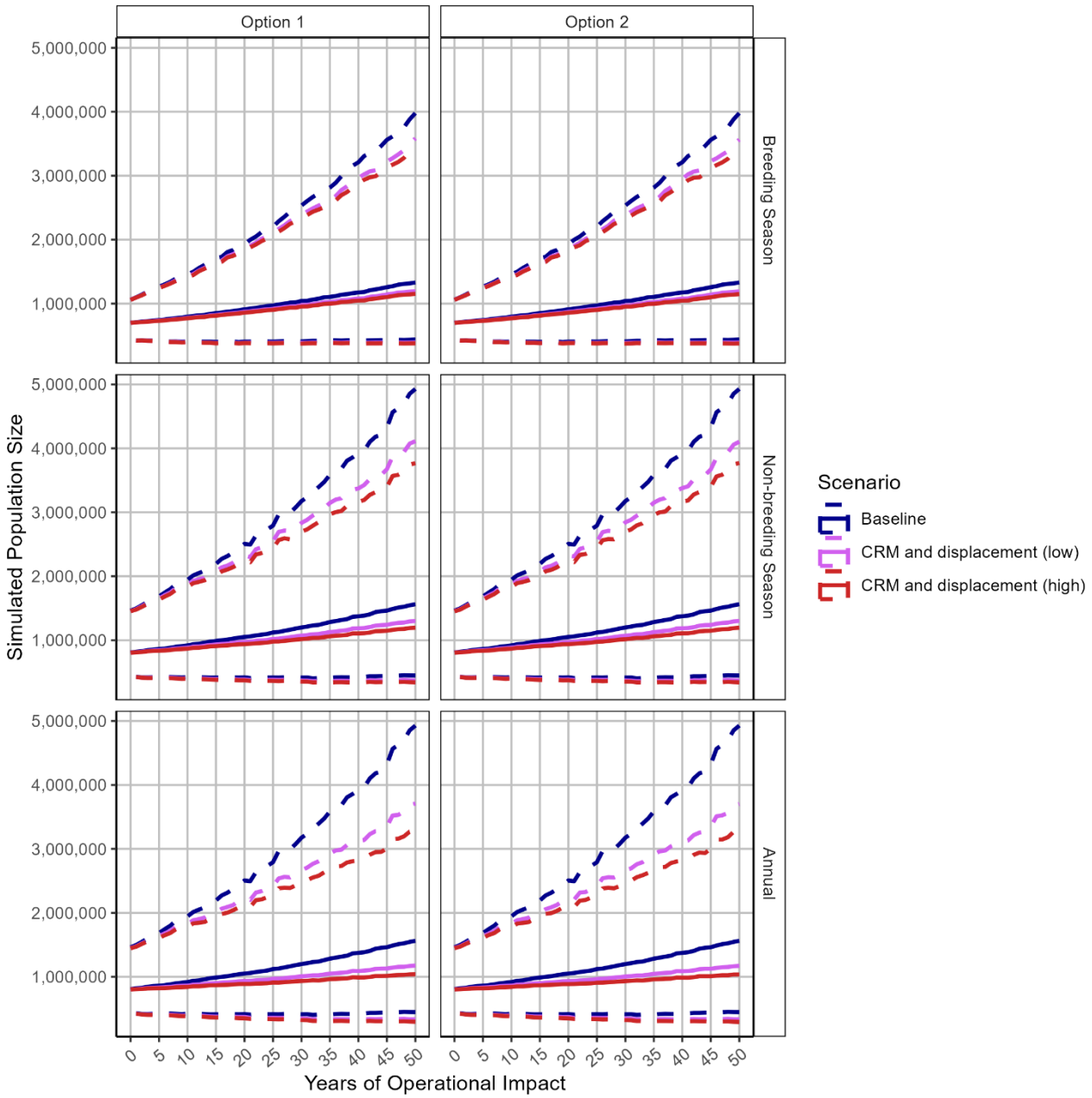

Figure 3.17: Population Projection for Cumulative Assessment of Combined Collision Risk and Displacement Impacts for Kittiwake Excluding Berwick Bank Impacts. Simulated Population Size with 95% CI are Presented

4 Conclusion

4.1.1 PVAs were required for the Proposed Development alone for four species, namely:

- herring gull;
- Arctic tern;
- guillemot; and
- razorbill.

4.1.2 The PVA results indicate that there will be no likely significant effects arising from the Proposed Development alone for these species.

4.1.3 The growth rate is expected to decrease by just 0.1% for both herring gull and Arctic tern during the Proposed Developments operational lifespan (30 years). These impacts are equivalent to a 2.1% and 1.5% decrease in population size compared to the unimpacted scenario for herring gull and Arctic tern respectively.

4.1.4 The PVAs also indicate a predicted decrease in growth rate of 0.2% to 0.4% for guillemot, during the Proposed Developments operational lifespan (30 years), equivalent to a decrease in 5.4% to 10.6% in population size. Impacts to razorbill are expected to be small, with the growth rate impacted by 0.0% (rounded to 1 decimal place) for both displacement scenarios, equivalent to a 0.8% to 1.5% decrease in population size for the low and high mortality displacement scenarios.

4.1.5 It should be noted that as density independent models were used, simulated population sizes for some species (e.g. great black-backed gull and possibly guillemot) are likely to have exceeded realistic carrying capacities. In reality, populations are limited by resources, such as prey, and would be expected to reach equilibrium. However, in some cases the baseline population for both great black-backed gull and guillemot increased by more than five times the original starting population (Table 2.2) over the 50 year period. Therefore, estimated decreases in population sizes when comparing scenarios may be larger than expected as the populations increase past realistic population sizes, instead of reaching equilibrium.

4.1.6 Cumulative PVAs were required for seven species, specifically:

- great black-backed gull;
- herring gull;
- guillemot;
- razorbill;
- puffin;
- gannet; and
- kittiwake.

4.1.7 The PVAs indicate that the cumulative impact of collision risk from the Proposed Development with other OWFs may notably impact great black-backed gull, with the growth rate expected to decrease by 1.2% (equivalent to a population decrease of 30.6%) during its operational lifespan. The predicted effect on herring gull would be much smaller with a decrease of just 0.2% and 0.3% in the growth rate when excluding and including Berwick Bank respectively. This is equivalent to a 6.0% and 9.4% decrease in population size excluding and including Berwick Bank respectively.

4.1.8 For the auk species, PVAs of cumulative effects indicate guillemot will undergo a decrease in growth rate of 1.9% to 3.7% during the Proposed Developments operational lifespan (30 years), equivalent to a population size decrease of 44.0% to 69.0%, for the low and high mortality displacement scenarios including Berwick Bank. However, it was evident that Berwick Bank contributed a significant proportion of these mortalities with impacts resulting in a 1.1% to 2.4% decrease in growth rate, equivalent to a 29.8% to 52.2% decrease in population size, for the low and high mortality displacement scenarios when Berwick Bank was excluded.

4.1.9 The growth rate of razorbill was found to decrease by 0.8% to 2.1% when including Berwick Bank and 0.7% to 1.9% when excluding Berwick Bank for the low and high displacement scenarios. For the high mortality displacement including Berwick Bank scenario, this impact is equivalent to a 48.6% decrease in population size for razorbill during the Proposed Development's operational lifespan.

4.1.10 The growth rate of puffin was found to be impacted by 0.5% for the high mortality displacement scenario, including Berwick Bank. For the high mortality displacement including Berwick Bank scenario, this impact is equivalent to a 14.6% decrease in population size for puffin.

4.1.11 Impacts from both collision risk and displacement are expected to affect gannet and kittiwake. For gannet, it is expected that the growth rate will be impacted by 0.4%, equivalent to a 11.0% decrease in population size, for the high mortality displacement scenario including Berwick Bank. The impacts on kittiwake for the same scenario (Option 2) are expected to be a 1.0% and 27.0% decrease in growth rate and population size respectively. When using results from sCRM using site-specific LiDAR data (Option 1), impacts to the growth rate are unchanged, however the impact on population size is expected to decrease to 26.8%.

4.1.12 The results of the PVAs have been used to inform the magnitude of impacts of collision and displacement on relevant seabird species in Volume 2, Chapter 11: Offshore Ornithology.

4.1.13 It should also be noted that following written consultation from MD-LOT (09 February 2026), that compensatory measures have been secured for projects such as Green Volt, Salamander, West of Orkney and Berwick Bank OWFs, certain impacts from these projects can be excluded as they have been compensated for. The impacts excluding Berwick Bank have been presented throughout this Offshore EIA, and the potential reduction of certain impacts

excluding Green Volt, Salamander and West of Orkney OWFs are discussed where relevant within Volume 2, Chapter 11: Offshore Ornithology.

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