NORTH FALLS

Offshore Wind Farm

Report to Inform Appropriate Assessment

Appendix 4.2 Population Viability Analysis

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Glossary of Acronyms

OSP	Offshore Substation Platform
OCP	Offshore Converter Platform
NFOW	North Falls Offshore Wind Ltd
WTG	Wind Turbine Generator
PVA	Population Viability Analysis
FFC	Flamborough and Filey Coast
SNCB	Statutory Nature Conservation Body
CPRG	counterfactual of population growth rate
CPS	counterfactual of population size
OWF	Offshore Wind Farm
BDMPS	Biologically Defined Minimum Population Scale
SPA	Special Protection Area
UCL	Upper Confidence Limit
LCL	Lower Confidence Limit
RIAA	Report to Inform Appropriate Assessment
SD	Standard Deviation
PEIR	Preliminary Environmental Information Report

Glossary of Terminology

Array area	The offshore wind farm area, within which the wind turbine generators, array cables, platform interconnector cable, offshore substation platform(s) and/or offshore converter platform will be located.
Array cables	Cables which link the wind turbine generators with each other, the offshore substation platform(s) and/or the offshore converter platform.
Landfall	The location where the offshore cables come ashore at Kirby Brook.
Offshore cable corridor	The corridor of seabed from array area to the landfall within which the offshore export cables will be located.
Offshore converter platform	Should an offshore connection to a third party HVDC cable be selected, an offshore converter platform would be required. This is a fixed structure located within the array area, containing HVAC and HVDC electrical equipment to aggregate the power from the wind turbine generators, increase the voltage to a more suitable level for export and convert the HVAC power generated by the wind turbine generators into HVDC power for export to shore via a third party HVDC cable.
Offshore export cables	The cables which bring electricity from the offshore substation platform(s) to the landfall, as well as auxiliary cables.
Offshore project area	The overall area of the array area and the offshore cable corridor.
Offshore substation platform(s)	Fixed structure(s) located within the array area, containing HVAC electrical equipment to aggregate the power from the wind turbine generators and increase the voltage to a more suitable level for export to shore via offshore export cables.
Platform interconnector cable	Cable connecting the offshore substation platforms (OSP); or the OSP and offshore converter platform (OCP).

The Applicant	North Falls Offshore Wind Farm Limited (NFOW).
The Project Or 'North Falls'	North Falls Offshore Wind Farm, including all onshore and offshore infrastructure.
Wind turbine generator (WTG)	Power generating device that is driven by the kinetic energy of the wind.

1 Population Viability Analysis

1. Population Viability Analysis (PVA) was carried out to investigate the potential effects of predicted mortality from collision and/or displacement at offshore wind farms (OWFs), for the following species and Special Protection Areas (SPAs):

- Lesser black-backed gull population in the Alde-Ore Estuary SPA, due to the predicted in combination impact of collision mortality exceeding 1% of the population baseline mortality rate for the breeding adult population at the SPA (Report to Inform Appropriate Assessment (RIAA) Part 4, Section 1.4.2.5.4, Document Reference: 7.1.4).
- Kittiwake at the Flamborough and Filey Coast (FFC) SPA, due to the predicted in combination impact of collision mortality exceeding 1% of the population baseline mortality rate for the breeding adult population at the SPA (RIAA Part 4, Section 1.4.4.5.5, Document Reference: 7.1.4).
- Gannet at the FFC SPA, due to the predicted in combination mortality from collision and displacement exceeding 1% of the population baseline mortality rate for the breeding adult population on the SPA (RIAA Part 4, Section 1.4.4.4.5, Document Reference: 7.1.4).
- Guillemot at the FFC SPA, due to the predicted in combination impact of displacement mortality exceeding 1% of the population baseline mortality rate for the breeding adult population on the SPA (RIAA Part 4, Section 1.4.4.6.5, Document Reference: 7.1.4).
- Razorbill at the FFC SPA, due to the predicted in combination impact of displacement mortality exceeding 1% of the population baseline mortality rate for the breeding adult population on the SPA (RIAA Part 4, Section 1.4.4.7.5, Document Reference: 7.1.4).

1.1 PVA methodology

2. PVA was undertaken using the Seabird PVA Tool developed by Natural England (Searle *et al*., 2019) via the 'Shiny App' interface, using the density independent run type.

3. Density dependence is likely to operate on seabird populations, such that growth rate varies inversely with population size (for example if an expanding population results in increased competition for food resources and/or suitable nest sites, reproductive rates would be expected to decrease). However, Natural England (2022) advises the use of density independent population models when undertaking PVA due to the lack of empirical evidence of mechanisms of density dependent regulation on seabird populations. As a consequence of density independent models not incorporating feedback between population size and demographic rates, the modelled populations can either increase to infinity (which is biologically implausible) or decrease to extinction, with predicted impacts being greater than if density dependence was assumed.

4. The PVAs also used stochastic models, as is recommended by Statutory Nature Conservation Bodies (SNCB's). These incorporate both environmental and demographic stochasticity. Environmental stochasticity accounts for the variation arising from environmental factors affecting individuals in the same group. Demographic stochasticity accounts for individual-level variation affecting the fate of individuals between age-classes. These stochastic models produce more precautionary outputs than deterministic models (Cook and Robinson, 2016).

5. Two metrics derived from the PVA outputs are recommended by Natural England to assess the level of impact on the population - i.e. the counterfactual of population growth rate (CPGR) and the counterfactual of population size (CPS). CPGR is the median of the ratio of impacted (subject to collision and/or displacement mortality from OWFs) to un-impacted (no OWF impacts) annual population growth rate. CPS is the median of the ratio of impacted to un-impacted population size at the end of the projection period. Both metrics are used to determine effects on the population in question and are integrally linked to one another because the predicted population size at the end of the projection period is a consequence of the annual growth rate. Previous work has demonstrated that the CPGR and CPS metrics are relatively insensitive to mis-specification of the demographic rates on which the population model is based and on other factors such as variation in predicted population trend (Cook and Robinson, 2016, Jitlal et al., 2017).

6. The following sections set out the input parameters and outputs for PVAs carried out for each species and SPA.

2 Lesser black-backed gull at the Alde-Ore Estuary SPA

7. PVA has been run to assess the impacts of collision mortality from North Falls alone and in combination with other OWFs within the UK North Sea and Channel Biologically Defined Minimum Population Scale (BDMPS) (Furness 2015).

2.1 Project alone inputs

8. Input parameters for the project alone impact on the lesser black-backed gull breeding adult population of Alde-Ore Estuary SPA are provided in Table 2.1 below. Annual survival rates were derived from the values for UK populations presented in Horswill and Robinson (2015). However, since there is insufficient data available on the annual survival rate of the juvenile age class for lesser black-backed gull, Horswill and Robinson (2015) recommend using the annual survival rate of juvenile herring gull as a surrogate. Therefore, the juvenile (0-1 years) survival rate used in these PVA's follows this advice. For older immature age class categories, the adult survival of lesser black-backed gulls has been used as Horswill and Robinson (2015) do not detail specific rates for these age classes. Both Mean (3.1 collision mortalities) and the upper 95% confidence limit (UCL) (10.6 collision mortalities) impacts were run for project alone analysis for comparison. The lower 95% confidence limit (LCL) was not run as the impact is zero (as shown in Table 1.23 in the RIAA Part 4 (Document Reference: 7.1.4)).

Table 2.1 Population Viability Analysis input parameters and model set up for the project alone impacts on lesser black-backed gulls in Alde Ore Estuary SPA

Parameter	Alde Ore SPA – Collision Mortality	
PVA model run type	simplescenarios	
Model to use for environmental stochasticity	betagamma	
Model for density dependence	Nod.	
Include demographic stochasticity in the model?	Yes	
Number of simulations	5000	
Random seed	10	
Years for burn-in	4	
Case study selected	None	
Species chosen to set initial values	Lesser black-backed gull	
Age at first breeding	5	
Upper constraint on productivity in the model?	Yes, constrained to 4 per pair	
Number of sub-populations	1	
Are demographic rates applied separately to each subpopulation?	No	
Units for initial population size	Breeding Adults	
Are baseline demographic rates specified separately for immatures?	Yes	
Initial population size	3760	
Productivity rate per pair	Mean 0.530, Standard Deviation (SD) 0.325	
Adult survival rate	Mean 0.885, SD 0.022	
Immature survival rate – age glass 0 to 1	Mean 0.798, SD 0.092	
Immature survival rate – age glass 1 to 2	Mean 0.885, SD 0.022	
Immature survival rate – age glass 2 to 3	Mean 0.885, SD 0.022	
Immature survival rate – age glass 3 to 4	Mean 0.885, SD 0.022	
Immature survival rate – age glass 4 to 5	Mean 0.885, SD 0.022	
Number of impact scenarios	1	
Are impacts applied separately to each subpopulation?	No	
Are impacts of scenarios specified separately for immatures?	Yes	
Are standard errors of impacts available?	No	
Should random seeds be matched for impact scenarios?	Yes	
Are impacts specified as a relative value or absolute harvest?	Relative	
Years in which impacts are assumed to begin and end	2028 - 2058	
Impact on productivity rate	0	
Impact on adult survival rate[1]	Mean 0.000825	UCI 0.002819
1. In each case the impact on adult survival is calculated using adult collision mortalities (see Table 2.3) / adult population.		

2.1.1 In Combination Inputs

9. Input parameters for the in-combination impact on the lesser black-backed gull breeding adult population of Alde-Ore Estuary SPA are provided in Table 2.2 below. PVAs were run to assess the impact of the in-combination effects on lesser black-backed gull breeding adults in Alde Ore SPA, both including and excluding the impacts for OWFs consented with compensation measures for lesser black-backed gull at the Alde-Ore Estuary SPA. Such measures for the Alde-Ore Estuary SPA aim to offset predicted mortality from collisions at OWFs by increasing the size and productivity of the breeding population. For the impacts of collisions including and excluding compensation measures, in each case PVA's have been run to show the impact from Tier 1-3 (1=operational,1=in construction and 3=consented but not yet in Construction) OWF's and 1-5 OWF's (as previously plus 4=OWFs where an application has been submitted for determination and 5=OWFs for which a Preliminary Environmental Information Report (PEIR) is available; see Section 13.8 of the ES Chapter 13 Offshore Ornithology (Document Reference: 3.1.15).

Table 2.2 Population Viability Analysis input parameters for the mean in combination impacts on lesser black-backed gulls in Alde Ore SPA

Parameter	Alde Ore SPA – including predicted collisions from OWFs with compensation	Alde Ore SPA – excluding predicted collisions from OWFs with compensation
PVA model run type	simplescenarios	simplescenarios
Model to use for environmental stochasticity	betagamma	betagamma
Model for density dependence	Nod.	Nod.
Include demographic stochasticity in the model?	Yes	Yes
Number of simulations	5000	5000
Random seed	10	10
Years for burn-in	4	4
Case study selected	None	None
Species chosen to set initial values	Lesser black-backed gull	Lesser black-backed gull
Age at first breeding	5	5
Upper constraint on productivity in the model?	Yes, constrained to 4 per pair	Yes, constrained to 4 per pair
Number of sub-populations	1	1
Are demographic rates applied separately to each subpopulation?	No	No
Units for initial population size	Breeding Adults	Breeding Adults
Are baseline demographic rates specified separately for immatures?	Yes	Yes
Initial population size	3760	3760
Productivity rate per pair	Mean 0.530, SD 0.325	Mean 0.530, SD 0.325
Adult survival rate	Mean 0.885, SD 0.022	Mean 0.885, SD 0.022

Parameter	Alde Ore SPA – including predicted collisions from OWFs with compensation	Alde Ore SPA – excluding predicted collisions from OWFs with compensation
Immature survival rate – age glass 0 to 1	Mean 0.798, SD 0.092	Mean 0.798, SD 0.092
Immature survival rate – age glass 1 to 2	Mean 0.885, SD 0.022	Mean 0.885, SD 0.022
Immature survival rate – age glass 2 to 3	Mean 0.885, SD 0.022	Mean 0.885, SD 0.022
Immature survival rate – age glass 3 to 4	Mean 0.885, SD 0.022	Mean 0.885, SD 0.022
Immature survival rate – age glass 4 to 5	Mean 0.885, SD 0.022	Mean 0.885, SD 0.022
Number of impact scenarios	2	2
Are impacts applied separately to each subpopulation?	No	No
Are impacts of scenarios specified separately for immatures?	Yes	Yes
Are standard errors of impacts available?	No	No
Should random seeds be matched for impact scenarios?	Yes	Yes
Are impacts specified as a relative value or absolute harvest?	Relative	Relative
Years in which impacts are assumed to begin and end	2028 - 2058	2028 - 2058
Impact on productivity rate	0	0
Impact on adult survival rate[1]	Tier 1-5: 0.01705 Tier 1-3: 0.01396	Tier 1-5: 0.01545 Tier 1-3: 0.01266

1. In each case the impact on adult survival is calculated using adult collision mortalities (see Table 2.4) / adult population.

2.1.2 Project alone PVA outputs

10. The outputs from the PVA for lesser black-backed gulls at Alde Ore SPA with project alone impacts applied, are provided in Table 2.3 below.

Table 2.3 Outputs for Alde-Ore Estuary SPA Lesser Black-backed Gull Population Viability Analysis with Project Alone Impacts

Scenario	Annual Predicted Mortality (number of adult birds)	Median Annual Growth Rate	Median CGPR	Median CPS	Reduction in Growth Rate	Reduction in Population Size
Baseline Impact	0	1.008	1.000	1.000	N/A	N/A
Mean Project Alone	3.1	1.007	0.999	0.981	0.1%	1.9%

Scenario	Annual Predicted Mortality (number of adult birds)	Median Annual Growth Rate	Median CGPR	Median CPS	Reduction in Growth Rate	Reduction in Population Size
Collision Mortality						
UCL Project Alone Mortality	10.6	1.006	0.998	0.951	0.2%	4.9%
1. See RIAA Part 4, Section 1.4.2.5.3, Document Reference: 7.1.4.						

2.1.3 In-combination PVA outputs

11. The outputs from the PVA for lesser black-backed gulls at Alde Ore SPA with in-combination impacts applied, for all OWFs in Tiers 1-5, and all consented OWFs (Tiers 1-3) are provided in Table 2.4.

Table 2.4 Outputs for Alde Ore SPA Lesser Black-backed Gull Population Viability Analysis with In-Combination Impacts

Scenario	Annual predicted mortality (number of adult birds)[1]	Median annual growth rate	Median CGPR	Median CPS	Reduction in growth rate	Reduction in population size
Baseline Impact	0	1.008	1.000	1.000	N/A	N/A
In combination: consented OWFs (Tier 1-3) (excluding OWFs with compensation)	47.6	0.999	0.992	0.798	0.8%	20.2%
In combination: consented OWFs (Tier 1-3) (including OWFs with compensation)	52.5	0.998	0.991	0.779	0.9%	22.1%
In-combination all OWFs Tier 1-5: (excluding OWFs with compensation measures)	58.1	0.997	0.989	0.720	1.1%	28.0%
In-combination all OWFs Tier 1-5: (including OWFs with compensation measures)	64.1	0.996	0.988	0.696	1.2%	30.4%
1. See RIAA Part 4, Section 1.4.2.5.4, Document Reference: 7.1.4.						

3 Kittiwake at the Flamborough and Filey Coast SPA

12. For kittiwake PVA has been run only for in combination predicted collisions with other OWFS within the UK North Sea BDMPS (Furness 2015), as the mean predicted collisions for the project alone are less than 1 bird per year (RIAA Part 4, Section 1.4.4.5.4, Document Reference: 7.1.4).

3.1 In combination inputs

13. PVA has been run for predicted collisions apportioned to the adult breeding population of the FFC SPA for all OWFs included in the in combination assessment, and also for all OWFs excluding those consented, subject to compensation measures to offset the impact of kittiwake collision mortality.

14. Input parameters are provided in Table 3.1 below. Survival rates were derived from the UK values presented in Horswill and Robinson (2015). This report stated immature survival rates for kittiwake were based on a study from 1959, it therefore suggests it may be more appropriate to use estimates based on other gull species with more data available. As herring gull is the only gull species in Horswill and Robinson (2015) with sufficient data to present immature survival rates with SD, these values were used for the kittiwake PVA's.

Table 3.1 Population Viability Analysis input parameters for the in-combination impacts on Kittiwake in Flamborough and Filey SPA

Parameter	FFC SPA – Mean Collision Mortality
PVA model run type	simplescenarios
Model to use for environmental stochasticity	betagamma
Model for density dependence	Nod.
Include demographic stochasticity in the model?	Yes
Number of simulations	5000
Random seed	10
Years for burn-in	4
Case study selected	None
Species chosen to set initial values	Kittiwake
Age at first breeding	4
Upper constraint on productivity in the model?	Yes, constrained to 2 per pair
Number of sub-populations	1
Are demographic rates applied separately to each subpopulation?	No
Units for initial population size	Breeding Adults
Are baseline demographic rates specified separately for immatures?	Yes
Initial population values	89,148
Productivity rate per pair	Mean 0.690, SD 0.296
Adult survival rate	Mean 0.854, SD 0.051

Parameter	FFC SPA – Mean Collision Mortality	
Immature survival rate – age glass 0 to 1	Mean 0.798, SD 0.092	
Immature survival rate – age glass 1 to 2	Mean 0.798, SD 0.092	
Immature survival rate – age glass 2 to 3	Mean 0.854, SD 0.051	
Immature survival rate – age glass 3 to 4	Mean 0.854, SD 0.051	
Number of impact scenarios	2	
Are impacts applied separately to each subpopulation?	No	
Are impacts of scenarios specified separately for immatures?	Yes	
Are standard errors of impacts available?	No	
Should random seeds be matched for impact scenarios?	Yes	
Are impacts specified as a relative value or absolute harvest?	Relative	
Years in which impacts are assumed to begin and end	2028 - 2058	
Impact on productivity rate	0	
Impact on adult survival rate[1]	No compensation 0.00496926	With compensation 0.00342128
First year to include in outputs	2028	
Final year to include in outputs	2058	
1. Impact on adult survival calculated as adult deaths from collision (see Table 3.2 below) / adult population		

3.2 In Combination PVA Outputs

15. The outputs from the PVA for kittiwake at FFC SPA with in-combination impacts applied both with and without compensation included are provided in Table 4.1 below.

Table 3.2 Outputs for Flamborough and Filey Coast SPA Kittiwake Population Viability Analysis with In-Combination Impacts

Scenario	Annual predicted mortality[1]	Median annual growth rate	Median CGPR	Median CPS	Reduction in growth rate	Reduction in population size
Baseline Impact	0	1.008	1.000	1.000	N/A	N/A
In-combination no compensation	443	1.004	0.997	0.898	0.3%	10.2%
In-combination with compensation	305	1.005	0.998	0.929	0.2%	7.1%
1. See RIAA Part 4, Section 1.4.4.5.5, Document Reference: 7.1.4						

4 Gannet at the Flamborough and Filey Coast SPA

16. PVA has been run for the combined impact of collision and displacement at North Falls alone and in combination with other OWFs within the UK North Sea Channel BDMPS (Furness 2015).

4.1 Project alone inputs

17. Input parameters for the project alone effect on the adult breeding population of gannet at FFC SPA are provided in Table 4.1 below. Survival rates were derived from the UK values presented in Horswill and Robinson (2015), however as standard deviations are not given for immature age classes, standard deviations have been taken from Royal HaskoningDHV (2023), which used the same survival rates.

Table 4.1 Population Viability Analysis input parameters for the project alone collision and displacement total impacts on Gannet in Flamborough and Filey Coast SPA

Parameter	FFC SPA – Mean Mortality	FFC SPA – UCL Mortality
PVA model run type	simplescenarios	simplescenarios
Model to use for environmental stochasticity	betagamma	betagamma
Model for density dependence	Nod.	Nod.
Include demographic stochasticity in the model?	Yes	Yes
Number of simulations	5000	5000
Random seed	10	10
Years for burn-in	4	4
Case study selected	None	None
Species chosen to set initial values	Gannet	Gannet
Age at first breeding	5	5
Upper constraint on productivity in the model?	Yes, constrained to 1 per pair	Yes, constrained to 1 per pair
Number of sub-populations	1	1
Are demographic rates applied separately to each subpopulation?	No	No
Units for initial population size	Breeding Adults	Breeding Adults
Are baseline demographic rates specified separately for immatures?	Yes	Yes
Initial population values	28,358	28,358
Productivity rate per pair	Mean 0.700, SD 0.082	Mean 0.700, SD 0.082
Adult survival rate	Mean 0.919, SD 0.042	Mean 0.919, SD 0.042
Immature survival rate – age glass 0 to 1	Mean 0.424, SD 0.045	Mean 0.424, SD 0.045
Immature survival rate – age glass 1 to 2	Mean 0.829, SD 0.026	Mean 0.829, SD 0.026

Parameter	FFC SPA – Mean Mortality	FFC SPA – UCL Mortality
Immature survival rate – age glass 2 to 3	Mean 0.891, SD 0.019	Mean 0.891, SD 0.019
Immature survival rate – age glass 3 to 4	Mean 0.895, SD 0.042	Mean 0.895, SD 0.042
Immature survival rate – age glass 4 to 5	Mean 0.919, SD 0.042	Mean 0.919, SD 0.042
Number of impact scenarios	2	2
Are impacts applied separately to each subpopulation?	No	No
Are impacts of scenarios specified separately for immatures?	Yes	Yes
Are standard errors of impacts available?	No	No
Should random seeds be matched for impact scenarios?	Yes	Yes
Are impacts specified as a relative value or absolute harvest?	Relative	Relative
Years in which impacts are assumed to begin and end	2028 - 2058	2028 - 2058
Impact on productivity rate	0	0
Impact on adult survival rate[1]	0.00003879	0.00009874
First year to include in outputs	2028	2028
Final year to include in outputs	2058	2058
1. Impact on adult survival rates calculated as adult mortalities due to collision and displacement (see Table 4.3) / adult population		

4.2 In combination inputs

Input parameters for the in-combination impact on the adult breeding population of gannets at FFC SPA are provided in Table 4.2 below. PVA's have been run to show the impact from Tier 1-3 OWF's and 1-5 OWF's.

Table 4.2 Population Viability Analysis input parameters for the in-combination collision and displacement total impacts on Gannet in Flamborough and Filey Coast SPA

Parameter	FFC SPA – All OWF's C&D	FFC SPA – Tier 1-3 C&D
PVA model run type	simplescenarios	simplescenarios
Model to use for environmental stochasticity	betagamma	betagamma
Model for density dependence	Nod.	Nod.
Include demographic stochasticity in the model?	Yes	Yes
Number of simulations	5000	5000
Random seed	10	10
Years for burn-in	4	4

Parameter	FFC SPA – All OWF's C&D	FFC SPA – Tier 1-3 C&D
Case study selected	None	None
Species chosen to set initial values	Northern Gannet	Northern Gannet
Age at first breeding	5	5
Upper constraint on productivity in the model?	Yes, constrained to 1 per pair	Yes, constrained to 1 per pair
Number of sub-populations	1	1
Are demographic rates applied separately to each subpopulation?	No	No
Units for initial population size	Breeding Adults	Breeding Adults
Are baseline demographic rates specified separately for immatures?	Yes	Yes
Initial population values	28,358	28,358
Productivity rate per pair	Mean 0.700, SD 0.082	Mean 0.700, SD 0.082
Adult survival rate	Mean 0.919, SD 0.042	Mean 0.919, SD 0.042
Immature survival rate – age glass 0 to 1	Mean 0.424, SD 0.045	Mean 0.424, SD 0.045
Immature survival rate – age glass 1 to 2	Mean 0.829, SD 0.026	Mean 0.829, SD 0.026
Immature survival rate – age glass 2 to 3	Mean 0.891, SD 0.019	Mean 0.891, SD 0.019
Immature survival rate – age glass 3 to 4	Mean 0.895, SD 0.042	Mean 0.895, SD 0.042
Immature survival rate – age glass 4 to 5	Mean 0.919, SD 0.042	Mean 0.919, SD 0.042
Number of impact scenarios	2	2
Are impacts applied separately to each subpopulation?	No	No
Are impacts of scenarios specified separately for immatures?	Yes	Yes
Are standard errors of impacts available?	No	No
Should random seeds be matched for impact scenarios?	Yes	Yes
Are impacts specified as a relative value or absolute harvest?	Relative	Relative
Years in which impacts are assumed to begin and end	2028 - 2058	2028 - 2058
Impact on productivity rate	0	0
Impact on adult survival rate[1]	0.00507793	0.0043374
First year to include in outputs	2028	2028
Final year to include in outputs	2058	2058
1. Impact on adult survival rates calculated as adult mortalities due to collision and displacement (see Table 4.4) / adult population		

4.3 Project alone PVA outputs

18. The outputs from the PVA gannet at FFC SPA with project alone impacts applied, are provided in Table 4.3 below.

Table 4.3 Outputs for Flamborough and Filey Coast SPA Gannet Population Viability Analysis with Project Alone Impacts of Collision and Displacement

Scenario	Annual predicted mortality[1]	Median annual growth rate	Median CGPR	Median CPS	Reduction in growth rate	Reduction in population size
Baseline Impact	0	1.006	1.000	1.000	N/A	N/A
Mean Project Alone Collision and displacement Mortality	1.1	1.006	1.000	0.999	0%	0.01%
UCI Project Alone C&D Mortality	2.8	1.006	1.000	0.998	0%	0.02%
1. See RIAA Part 4, Section 1.4.4.4.4, Document Reference: 7.1.4						

4.4 In combination PVA outputs

19. The outputs from the PVA for gannet at FFC SPA with in-combination impacts applied, for all OWFs in Tiers 1-5, and all consented OWFs (Tiers 1-3).

Table 4.4 Outputs for Flamborough and Filey Coast SPA Gannet Population Viability Analysis with In-Combination Impacts of Collision and Displacement

Scenario	Annual predicted mortality[1]	Median annual growth rate	Median CGPR	Median CPS	Reduction in growth rate	Reduction in population size
Baseline Impact	0	1.006	1.000	1.000	N/A	N/A
Tier 1-3 collision and displacement Mortality	123	1.003	0.997	0.904	0.3%	9.6%
All OWF's (Tier 1-5) collision and displacement Mortality	144	1.002	0.996	0.888	0.4%	11.2%
1. See RIAA Part 4, Section 1.4.4.4.5, Document Reference: 7.1.4						

5 Guillemot at the Flamborough and Filey Coast SPA

20. For guillemot, PVA has been run only for in combination predicted mortalities from displacement from OWFs within the UK North Sea and Channel BDMPS (Furness 2015), as the mean predicted mortality for the project alone is very small (mean of 1-2 birds per year, RIAA Part 4, Section 1.4.4.6.4, Document Reference: 7.1.4).

5.1 In combination inputs

21. PVA's have been run to assess the impact of in combination displacement, both including and excluding HP4 (based on Natural England's bespoke approach to seasonal apportioning for guillemot) which has been consented subject to compensation for guillemot.

22. Input parameters for the in-combination impact on the guillemot breeding adult population of FFC SPA are provided in Table 5.1 below. Survival rates were derived from the UK values presented in Horswill and Robinson (2015), however as standard deviations are not present for immature age classes, standard deviations have been taken from Royal HaskoningDHV (2022), which used the same survival rates. Productivity rate was also taken from Royal HaskoningDHV (2022) as it took a mean from more recent values than Horswill and Robinson (2015).

Table 5.1 Population Viability Analysis input parameters for the in-combination collision and displacement total impacts on guillemot in the Flamborough and Filey Coast SPA

Parameter	FFC SPA
PVA model run type	simplescenarios
Model to use for environmental stochasticity	betagamma
Model for density dependence	Nod.
Include demographic stochasticity in the model?	Yes
Number of simulations	5000
Random seed	10
Years for burn-in	4
Case study selected	None
Species chosen to set initial values	Guillemot
Age at first breeding	5
Upper constraint on productivity in the model?	Yes, constrained to 1 per pair
Number of sub-populations	1
Are demographic rates applied separately to each subpopulation?	No
Units for initial population size	Breeding Adults
Are baseline demographic rates specified separately for immatures?	Yes
Initial population values	149,978
Productivity rate per pair	Mean 0.716, SD 0.076
Adult survival rate	Mean 0.939, SD 0.015

Parameter	FFC SPA	
Immature survival rate – age glass 0 to 1	Mean 0.560, SD 0.058	
Immature survival rate – age glass 1 to 2	Mean 0.792, SD 0.152	
Immature survival rate – age glass 2 to 3	Mean 0.917, SD 0.098	
Immature survival rate – age glass 3 to 4	Mean 0.938, SD 0.107	
Immature survival rate – age glass 4 to 5	Mean 0.939, SD 0.015	
Immature survival rate – age glass 5 to 6	Mean 0.939, SD 0.015	
Number of impact scenarios	4	4
Are impacts applied separately to each subpopulation?	No	
Are impacts of scenarios specified separately for immatures?	Yes	
Are standard errors of impacts available?	No	
Should random seeds be matched for impact scenarios?	Yes	
Are impacts specified as a relative value or absolute harvest?	Relative	
Years in which impacts are assumed to begin and end	2028 - 2058	
Impact on productivity rate	0	
Impact on adult survival rate[1]	Including compensated project (HP4)	Excluding compensated project (HP4)

Parameter	FFC SPA							
	30% displacement, 1% mortality	50% displacement, 1% mortality	70% displacement, 2% mortality	70% displacement, 10% mortality	30% displacement, 1% mortality	50% displacement, 1% mortality	70% displacement, 2% mortality	70% displacement, 10% mortality
	0.0016736	0.0027937	0.0078145	0.0390791	0.0010268	0.0017136	0.0048007	0.0239969
First year to include in outputs	2028							
Final year to include in outputs	2058							
1. Impact on adult survival calculated using predicted adult mortalities from displacement (see Table 5.2) / adult population								

5.2 In combination PVA outputs

23. The outputs from the PVA for guillemot at FFC SPA with in-combination impacts applied, both including and excluding HP4, are provided in Table 5.2 below.

Table 5.2 Outputs for Flamborough and Filey Coast SPA Guillemot Population Viability Analysis with In-Combination Impacts of Collision and Displacement

Scenario		Annual predicted mortality	Median annual growth rate	Median CGPR	Median CPS	Reduction in growth rate	Reduction in population size
Baseline Impact		0	1.038	1.000	1.000	N/A	N/A
Including HP4	30% displacement, 1% mortality	251	1.037	0.999	0.966	0.1%	3.4%
	50% displacement, 1% mortality	419	1.036	0.998	0.944	0.2%	5.6%
	70% displacement, 2% mortality	1,172	1.033	0.995	0.850	0.5%	15%
	70% displacement, 10% mortality	5,861	1.012	0.974	0.447	2.6%	55.3%
Excluding HP4	30% displacement, 1% mortality	154	1.038	0.999	0.979	0.1%	2.1%
	50% displacement, 1% mortality	257	1.037	0.999	0.965	0.1%	3.5%
	70% displacement, 2% mortality	720	1.035	0.997	0.905	0.3%	9.5%
	70% displacement, 10% mortality	3,599	1.022	0.984	0.608	1.6%	39.2%
1. See RIAA Part 4, Section 1.4.4.6.5, Document Reference: 7.1.4.							

6 Razorbill at the Flamborough and Filey Coast SPA

24. For razorbill, PVA has been run only for in combination predicted mortalities from displacement from OWFs within the UK North Sea Channel BDMPS (Furness 2015), as the mean predicted mortality for the project alone is very small (mean of 1-3 birds per year, RIAA Part 4, Section 1.4.4.7.5, Document Reference: 7.1.4).

6.1 In combination inputs

25. Input parameters for the in-combination impact on the razorbill breeding adult population of Flamborough and Filey SPA are provided in Table 6.1 below. The adult survival rate and standard deviation was taken from Horswill and Robinson (2015). The immature survival rates were derived from the NE and NRW (2024), however as standard deviations are not present for immature age classes, the advice presented in this guidance was followed and a very low value used as a proxy. Productivity rate was also taken from the NE and NRW (2024).

Table 6.1 Population Viability Analysis input parameters for the in-combination collision and displacement total impacts on razorbill in the Flamborough and Filey Coast SPA

Parameter	FFC SPA
PVA model run type	simplescenarios
Model to use for environmental stochasticity	betagamma
Model for density dependence	Nod.
Include demographic stochasticity in the model?	Yes
Number of simulations	5000
Random seed	10
Years for burn-in	4
Case study selected	None
Species chosen to set initial values	Razorbill
Age at first breeding	5
Upper constraint on productivity in the model?	Yes, constrained to 1 per pair
Number of sub-populations	1
Are demographic rates applied separately to each subpopulation?	No
Units for initial population size	Breeding Adults
Are baseline demographic rates	Yes

Parameter	FFC SPA			
specified separately for immatures?				
Initial population values	61,345			
Productivity rate per pair	Mean 0.570, SD 0.247			
Adult survival rate	Mean 0.895, SD 0.067			
Immature survival rate – age glass 0 to 1	Mean 0.794, SD 0.001			
Immature survival rate – age glass 1 to 2	Mean 0.794, SD 0.001			
Immature survival rate – age glass 2 to 3	Mean 0.794, SD 0.001			
Immature survival rate – age glass 3 to 4	Mean 0.895, SD 0.067			
Immature survival rate – age glass 4 to 5	Mean 0.895, SD 0.067			
Number of impact scenarios	4			
Are impacts applied separately to each subpopulation?	No			
Are impacts of scenarios specified separately for immatures?	Yes			
Are standard errors of impacts available?	No			
Should random seeds be matched for impact scenarios?	Yes			
Are impacts specified as a relative value or absolute harvest?	Relative			
Years in which impacts are assumed to begin and end	2028 - 2058			
Impact on productivity rate	0			
Impact on adult survival rate[1]	30% displacement, 1% mortality	50% displacement, 1% mortality	70% displacement, 2% mortality	70% displacement, 10% mortality
	0.00081506	0.0013693	0.00383079	0.01918657
First year to include in outputs	2028			
Final year to include in outputs	2058			
1. Impact on adult survival calculated as predicted adult mortality from displacement (Table 6.2 / adult population				

6.2 In combination PVA outputs

26. The outputs from the PVA for razorbill at FFC SPA with in-combination impacts applied, are provided in Table 6.2 below.

Table 6.2 Outputs for Flamborough and Filey Coast SPA Razorbill Population Viability Analysis with In-Combination Impacts of Collision and Displacement

Scenario	Annual predicted mortality[1]	Median annual growth rate	Median CGPR	Median CPS	Reduction in growth rate	Reduction in population size
Baseline Impact	0	1.005	1.000	1.000	N/A	N/A
30% displacement, 1% mortality	50	1.004	0.999	0.982	0.1%	1.8%
50% displacement, 1% mortality	84	1.004	0.999	0.971	0.1%	2.9%
70% displacement, 2% mortality	235	1.002	0.997	0.919	0.3%	8.1%
70% displacement, 10% mortality	1177	0.991	0.987	0.657	1.3%	34.3%
1. See RIAA Part 4, Section 1.4.4.7.5, Document Reference: 7.1.4						

7 References

Cook, A.S.C.P. & Robinson, R.A. (2016) Testing sensitivity of metrics of seabird population response to offshore wind farm effects, JNCC Report No. 553, JNCC, Peterborough, ISSN 0963-8091.

Furness, R., 2015. Non-breeding season populations of seabirds in UK waters: Population sizes for Biologically Defined Minimum Population Scales (BDMPS). Natural England Commissioned Report 164.

Horswill, C. & Robinson R. A. (2015). Review of seabird demographic rates and density dependence. JNCC Report No. 552. Joint Nature Conservation Committee, Peterborough.

Natural England (2022). Offshore Wind Marine Environmental Assessments: Best Practice Advice for Evidence and Data Standards. Version 1 March 2022.

NE and NRW (2024). NE and NRW interim advice regarding demographic rates, EIA scale mortality and reference populations for use in offshore wind impact assessments. Undated, received by North Falls 8 March 2024.

Royal HaskoningDHV (2022). Sheringham Shoal and Dudgeon Offshore Wind Farm Extension Project Environmental Statement: Volume 3 Appendix 11.1 Offshore Ornithology Technical Report. Document Reference: 6.3.11.1.

Royal HaskoningDHV (2023). Sheringham Shoal and Dudgeon Offshore Wind Farm Extension Projects: Apportioning and HRA Updates Technical Note. Document Reference: 13.3, Revision E.

Searle, K., Mobbs, D., Daunt, F., & Butler, A. (2019) A Population Viability Analysis Modelling Tool for Seabird Species. Centre for Ecology & Hydrology report for Natural England. Natural England Commissioned Report NECR274.

HARNESSING THE POWER OF NORTH SEA WIND

North Falls Offshore Wind Farm Limited

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