Hornsea Project Four

Clarification Note on Kittiwake PVA and BDMPS Population Estimates

Deadline: 8, Date: 18 August 2022
Document Reference: G8.11
Revision: 01

Prepared APEM Ltd, August 2022
Checked APEM Ltd. August 2022
Accepted Hannah Towner-Roethe, Orsted, August 2022
Approved Julian Carolan, Orsted, August 2022

G8.11
Ver. A

Revision Summary

Rev	*Date*	*Prepared by*	*Checked by*	*Approved by*
01	14/07/2022	APEM Ltd	APEM Ltd	Julian Carolan

Revision Change Log

Rev	*Page*	*Section*	*Description*
01	N/A	N/A	Submitted into Examination at Deadline 8

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Glossary

Term	Definition
Bio-Season	Bird behaviour and abundance is recognised to differ across a calendar year, with particular months recognised as being part of different seasons. The biologically defined minimum population scales (BDMPS) bio-seasons used in this report are based on those in Furness (2015), hereafter referred to as bio-seasons. Separate bio-seasons are recognised in this technical report in order to establish the level of importance any seabird species has within the study area during any particular period of time.
Demographic Parameter	A factor that determines the population size.
Population Viability Analysis (PVA)	The process of determining the probability that a population will persist over a specified time period.
Stochasticity	The lack of any predictable order or plan.

Acronyms

Term	Definition
AEoI	Adverse Effect on Integrity
BDMPS	Biologically Defined Minimum Population Scale
FFC	Flamborough and Filey Coast
OWF	Offshore Wind Farm
PVA	Population Viability Analysis
SD	Standard Deviation
SPA	Special Protection Area

1 Email Clarification 04th July 2022

1.1 Notification of NE/JNCC Population Viability Analysis (PVA) model issue

1.1.1.1 On the 04th July 2022 Natural England notified the Applicant via an email entitled "PVA modelling bug" that an error had been brought to their attention in relation to the background code in their Seabird PVA tool. An attached written advice document was provided to the Applicant by Natural England which offered further clarity that an error occurs within the PVA model when a Standard Deviation (SD) value is specified as zero and that the model developers are currently working to resolve the issue.

1.1.1.2 In relation to the Applicant's recently submitted revised PVA modelling presented within **G4.7 Ornithological Assessment Sensitivity Report (REP5-065)**, Natural England advised the Applicant that the PVA model runs for kittiwake may be susceptible to the identified error due to an SD value of zero (in relation to the survival rate age class 0-1 and when using a productivity rate of 0.8 for the FFC SPA) being specified for some of the demographic input parameters.

1.1.1.3 Natural England provided the following recommendations for PVA reanalysis:

1.1.1.4 "Where the SD for the survival rate of the age class 0-1 has been specified as zero, Natural England recommend using the same value (0.077) as applied in recent PVAs for the Norfolk Boreas (EN010087-002896-SoS Deadline - Applicant - Updated Population Viability Analysis Flamborough and Filey Coast SPA - Updated at the request of Natural England.pdf (planninginspectorate.gov.uk)) and Vanguard (EN010079-004399-Updated Population Page 2 of 4 Viability Analysis Flamborough and Filey Coast SPA.pdf (planninginspectorate.gov.uk)) Examinations. This value is equivalent to the SDs populated for the survival rates of the other age-classes."

1.1.1.5 "Where productivity has been specified as 0.8 we advise that, in the absence of an empirically derived SD, Ørsted simply specify this as a small number that is greater than zero (e.g. 0.0000001)."

1.1.1.6 Natural England also provided reassurance to the Applicant that the issue with the PVA model will not affect Natural England's position on agreement over the baseline ornithology data for Hornsea Four, PVA conclusions for other species and Natural England's conclusions in relation to HRA / EIA. The Applicant welcomed this confirmation.

1.1.1.7 Natural England did, however, raise concern that "*it may influence interpretation of the PVA results for kittiwake with implications for determining final impact levels to inform compensation provision*" The Applicant does not agree with this statement as principally the PVA model is used to determine the 'tipping point', as previously suggested by Natural England, for when an Adverse Effect on Integrity (AEoI) may be reached in relation to predicted project impacts and so not the level of compensation required. In relation to kittiwake, as detailed in **G1.5 Kittiwake Adverse Effects on Integrity (AEoI) Conclusion (AS-023)**, based on the precedent set for other recent consented Offshore Wind Farms (OWFs) the Applicant has already agreed to conclude the position of an AEoI for in-combination predicted impacts on the kittiwake qualifying feature of the FFC SPA. This means that the PVA does not have any effect on the level of compensation required, which is instead informed by agreement on the most realistic predicted impacts from Hornsea Four. The Applicant confirms that there Is little merit in submitting a revised PVA model into

Examination and the absence of this should not deter Natural England from concluding a position on compensation requirements for Hornsea Four. Should the Examining Authority insist on the submission then the Applicant can facilitate this.

1.1.1.8 In relation to the PVA modelling undertaken for kittiwake at an EIA level against the Biologically Determined minimum Population Scale (BDMPS) and Biogeographic populations, the Applicant has rerun the modelling based on Natural England's advice to use a survival rate age class 0-1 SD value of 0.077, with the resulted included within **Appendix A** of this report. It should be noted that the revised modelling did not materially alter the results of the PVA modelling, the results of which provided outputs for a reduction in growth rate differing by less than 0.03%, which is well within the limits of natural variability expected with a stochastic model. The Revised kittiwake UK North Sea BDMPS PVA Log is provided in **Appendix B**.

1.1.1.9 The Applicant is aware that the preformulated values within the PVA tool are based on the desk study undertaken by Horswill and Robinson (2015). In relation to kittiwake Horswill and Robinson (2015) state that the age class 2- adult survival rate SD value should be 0.051, not 0.077 as currently specified within the PVA model. The Applicant therefore queries whether this is a mis-specification within the model, although noting this would not lead to materially different results from the model when considering the counterfactual outputs of a density independent PVA.

1.2 BDMPS Population Estimates

1.2.1.1 Natural England also provided a response to the Applicant's revised BDMPS breeding and annual populations used within the updated assessments within **G5.25 Ornithology Environmental Impact Assessment and Habitats Regulations Assessment Annex (REP5a-011)**. The Applicant welcomes Natural England's identification of the minor error within the razorbill and great black-backed gull annual BDMPS population values presented in Table 1 of **G4.7 Ornithological Assessment Sensitivity Report (REP5-065)**. However, as detailed within the report for the assessment of razorbill within **G5.25 Ornithology Environmental Impact Assessment and Habitats Regulations Assessment Annex (REP5a-011)**, the Applicant has used the non-breeding BDMPS population size within Furness (2015) for determining annual predicted impacts due to that being the largest estimated population size for razorbill. For great black-backed gull the Applicant has reviewed the estimated breeding and annual population sizes identified by Natural England and agree with their suggested values of 26,917 individuals in the breeding season and an annual population size of 88,653 (calculated as 88,652 by the Applicant on review). However, for great black-backed gull annual impacts assessed within **G5.25 Ornithology Environmental Impact Assessment and Habitats Regulations Assessment Annex (REP5a-011)** were done so against the non-breeding BDMPS population size due to that being the largest calculated population size.

1.2.1.2 Natural England provided additional feedback within Annex 1 of their written response stating their disagreement with how the Applicant has expanded on Natural England's breeding BDMPS population calculation method to calculate annual predicted BDMPS populations. Based on Natural England's rationale for disagreement the Applicant considers

that Natural England may have incorrectly interpreted the Applicant methodology and usage of these updated values. Natural England state:

1.2.1.3 *"Whilst we acknowledge the breeding BDMPS populations advised by Natural England do not include any birds from overseas areas, there is currently no way of estimating the proportions of birds from overseas colonies that may spend time in respective UK BDMPS areas during the breeding season with confidence."*

1.2.1.4 The Applicant agrees with Natural England that there is no current way of estimating the number of birds from overseas areas which might be within the North Sea BDMPS during the breeding season and the Applicant has therefore conducted assessments using Natural England's breeding season population calculation method as requested, which excluded overseas individuals. In accordance with Natural England's guidance, as the breeding season population size was calculated to be larger than the non-breeding season defined by Furness (2015), the Applicant has based assessments using the largest value. However, the Applicant has included a further step to the calculation to derive the annual impact population size used for assessment, which incorporates the overseas component from the non-breeding season as defined in Furness (2015), which provides account of birds from both the UK and overseas that are present with the region being assessed.

1.2.1.5 The Applicant considers that annual impact assessments should ensure that all possible birds with connectivity to the North Sea through different bio-seasons should be included when assessing annual impacts. As Natural England's method for calculating the breeding season population excludes an overseas population component this makes it unsuitable for assessment of annual impacts as it does not account for all possible connectivity that a region of sea has over a 12-month period. To rectify this issue the Applicant therefore added on the overseas population component of the non-breeding season as defined in Furness (2015) to Natural England's method for breeding season population calculation to derive an annual BDMPS population size which accounts for all possible connectivity with the North Sea region of sea over a 12-month period.

2 Email Clarification 05th July 2022

2.1.1.1 A second email clarification was sent to the Applicant by Natural England on the 05th July 2022 with the title "Table clarification" which contained the following query:

2.1.1.2 *"In Table 126 of G5.25 Ornithology EIA and HRA Annex, the mean densities used in collision risk modelling do not appear to match the new modelled estimates for flying kittiwake in the array provided in Table 4 of G5.9 Revised Ornithology Baseline. Please could you confirm which the correct values are and which have been used in the collision risk modelling?"*

2.1.1.3 The Applicant has reviewed both tables and the density estimates used for CRM and can confirm that the correct density estimates were used for informing predicted collisions for kittiwake using the final density estimates presented in Table 4 of **G5.9 Revised Ornithology Baseline (REP5a-009)**. The Applicant can confirm that the density estimates in Table 126 of **G5.25 Ornithology Environmental Impact Assessment and Habitats Regulations Assessment Annex (REP5a-011)** have been presented in the incorrect order with minor

differences in rounding to the correct monthly values, but that those used within the CRM were in the correct order.

2.1.1.4 Natural England also requested if the Applicant's CRM logs could be shared for review, which the Applicant is able to provide.

3 References

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

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

Appendix A Revised Kittiwake EIA PVA Results

Table 1: Revised kittiwake UK North Sea BDMPS population modelling results.

UK North Sea BDMPS			
Increase in mortality (per annum)	Total mortality (per annum)	Density independent counterfactual of growth rate (after 35 years)	Reduction in Growth Rate (per annum)
50	193,063	1.000	0.00%
75	193,088	1.000	0.01%
100	193,113	1.000	0.01%
125	193,138	1.000	0.01%
150	193,163	1.000	0.01%
175	193,188	1.000	0.02%
200	193,213	1.000	0.02%
225	193,238	1.000	0.02%
3,500	196,513	0.997	0.34%
3,600	196,613	0.997	0.34%
3,700	196,713	0.996	0.35%
3,800	196,813	0.996	0.36%
3,900	196,913	0.996	0.37%
4,000	197,013	0.996	0.38%
4,100	197,113	0.996	0.39%
4,200	197,213	0.996	0.40%
4,300	197,313	0.996	0.41%
4,400	197,413	0.996	0.42%
4,500	197,513	0.996	0.43%

Table 2: Revised kittiwake UK Biogeographic population modelling results.

UK Biogeographic Population			
Increase in mortality (per annum)	Total mortality (per annum)	Density independent counterfactual of growth rate (after 35 years)	Reduction in Growth Rate (per annum)
50	795,650	1.000	0.00%
75	795,675	1.000	0.00%
100	795,700	1.000	0.00%
125	795,725	1.000	0.00%
150	795,750	1.000	0.00%
175	795,775	1.000	0.00%
200	795,800	1.000	0.00%
225	795,825	1.000	0.01%
3,500	799,100	0.999	0.08%
3,600	799,200	0.999	0.08%
3,700	799,300	0.999	0.09%
3,800	799,400	0.999	0.09%
3,900	799,500	0.999	0.09%
4,000	799,600	0.999	0.09%
4,100	799,700	0.999	0.10%
4,200	799,800	0.999	0.10%
4,300	799,900	0.999	0.10%
4,400	800,000	0.999	0.10%
4,500	800,100	0.999	0.10%

Appendix B Revised Kittiwake PVA Logs

Revised kittiwake UK North Sea BDMPS PVA Log

Set up

The log file was created on: 2022-07-07 08:09:46 using Tool version 2, with R version 3.5.1, PVA package version: 4.18 (with UI version 1.7)

```
##              Package        Version
## popbio       "popbio"       "2.4.4"
## shiny        "shiny"        "1.1.0"
## shinyjs      "shinyjs"      "1.0"
## shinydashboard "shinydashboard" "0.7.1"
## shinyWidgets  "shinyWidgets"  "0.4.5"
## DT           "DT"           "0.5"
## plotly       "plotly"       "4.8.0"
## rmarkdown    "rmarkdown"    "1.10"
## dplyr        "dplyr"        "0.7.6"
## tidyr        "tidyr"        "0.8.1"
```

Basic information

PVA model run type: simplescenarios.
Model to use for environmental stochasticity: betagamma.
Model for density dependence: nodd.
Include demographic stochasticity in model?: Yes.
Number of simulations: 5000.
Random seed: 8936.
Years for burn-in: 10.
Case study selected: None.

Baseline demographic rates

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

Population 1

Initial population values: Initial population 1237264 in 2022
Productivity rate per pair: mean: 0.819 , sd: 0.332
Adult survival rate: mean: 0.854 , sd: 0.077
Immatures survival rates:

Age class 0 to 1 - mean: 0.79 , sd: 0.077 , DD: NA
Age class 1 to 2 - mean: 0.854 , sd: 0.077 , DD: NA
Age class 2 to 3 - mean: 0.854 , sd: 0.077 , DD: NA
Age class 3 to 4 - mean: 0.854 , sd: 0.077 , DD: NA

Impacts
Number of impact scenarios: 10.
Are impacts applied separately to each subpopulation?: No
Are impacts of scenarios specified separately for immatures?: No
Are standard errors of impacts available?: No
Should random seeds be matched for impact scenarios?: No
Are impacts specified as a relative value or absolute harvest?: relative
Years in which impacts are assumed to begin and end: 2023 to 2058

Impact on Demographic Rates

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Name: 4500
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.003637 , se: NA

Output:
First year to include in outputs: 2023
Final year to include in outputs: 2058
How should outputs be produced, in terms of ages?: whole.population
Target population size to use in calculating impact metrics: NA
Quasi-extinction threshold to use in calculating impact metrics: NA

Revised kittiwake UK Biogeographic PVA Log

Set up

The log file was created on: 2022-07-07 09:30:37 using Tool version 2, with R version 3.5.1, PVA package version: 4.18 (with UI version 1.7)

```
##             Package        Version
## popbio       "popbio"       "2.4.4"
## shiny        "shiny"        "1.1.0"
## shinyjs      "shinyjs"      "1.0"
## shinydashboard "shinydashboard" "0.7.1"
## shinyWidgets   "shinyWidgets"   "0.4.5"
## DT           "DT"           "0.5"
## plotly       "plotly"       "4.8.0"
## rmarkdown    "rmarkdown"    "1.10"
## dplyr        "dplyr"        "0.7.6"
## tidyr        "tidyr"        "0.8.1"
```

Basic information

PVA model run type: simplescenarios.
Model to use for environmental stochasticity: betagamma.
Model for density dependence: nodd.
Include demographic stochasticity in model?: Yes.
Number of simulations: 5000.
Random seed: 8936.
Years for burn-in: 10.
Case study selected: None.

Baseline demographic rates

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

Population 1

Initial population values: Initial population 5100000 in 2022
Productivity rate per pair: mean: 0.69 , sd: 0.296
Adult survival rate: mean: 0.854 , sd: 0.077
Immatures survival rates:
Age class 0 to 1 - mean: 0.79 , sd: 0.077 , DD: NA
Age class 1 to 2 - mean: 0.854 , sd: 0.077 , DD: NA

Age class 2 to 3 - mean: 0.854 , sd: 0.077 , DD: NA
Age class 3 to 4 - mean: 0.854 , sd: 0.077 , DD: NA

Impacts
Number of impact scenarios: 10.
Are impacts applied separately to each subpopulation?: No
Are impacts of scenarios specified separately for immatures?: No
Are standard errors of impacts available?: No
Should random seeds be matched for impact scenarios?: No
Are impacts specified as a relative value or absolute harvest?: relative
Years in which impacts are assumed to begin and end: 2023 to 2058

Impact on Demographic Rates

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Name: 4500
All subpopulations
Impact on productivity rate mean: 0 , se: NA
Impact on adult survival rate mean: 0.000882 , se: NA

Output:
First year to include in outputs: 2023
Final year to include in outputs: 2058
How should outputs be produced, in terms of ages?: whole.population
Target population size to use in calculating impact metrics: NA
Quasi-extinction threshold to use in calculating impact metrics: NA