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Norfolk Boreas Offshore Wind Farm

Updated Population Viability Analysis: Flamborough and Filey Coast SPA

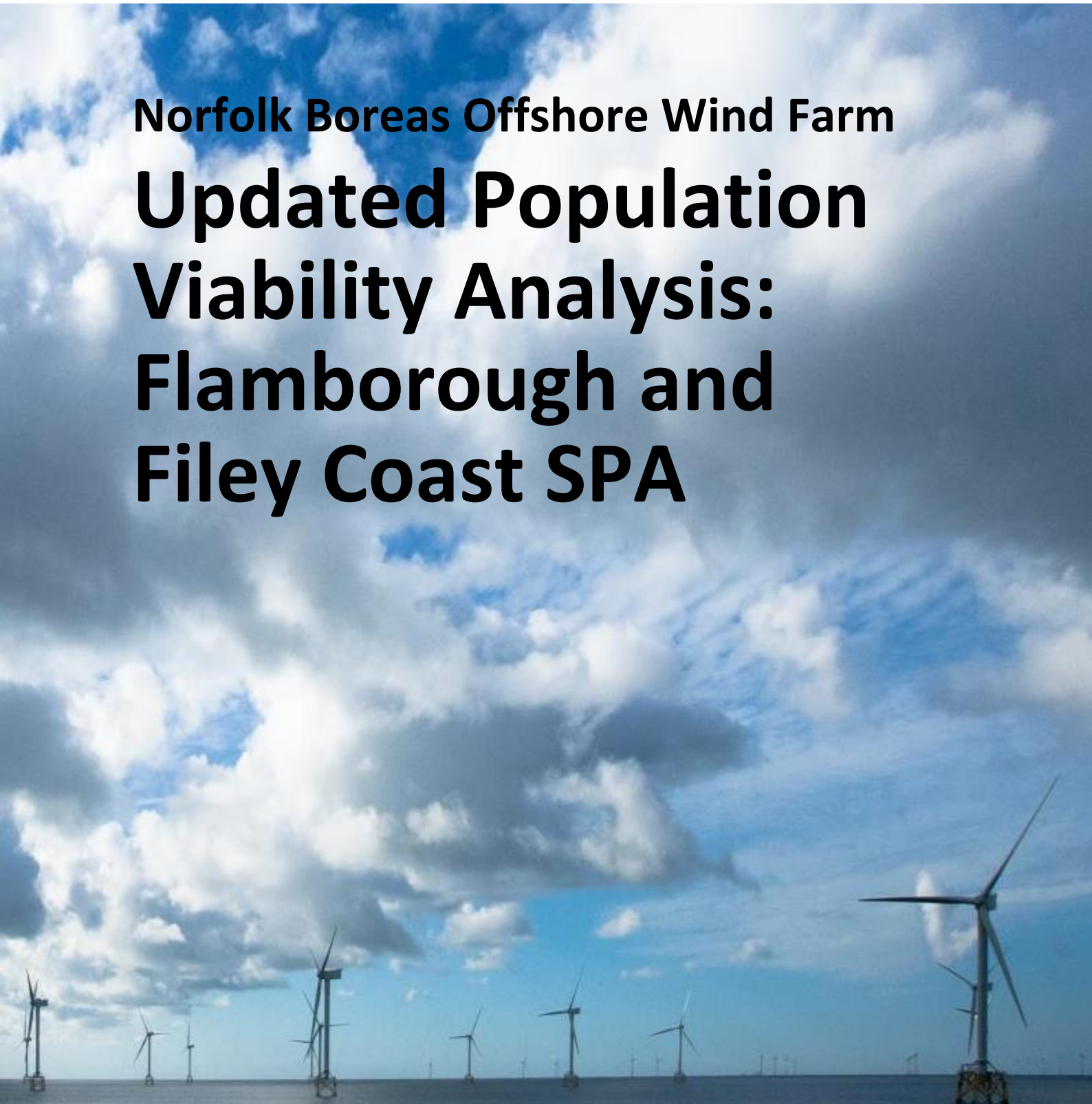

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Table of Contents

Glossary of Acronyms

BEIS	Department for Business, Energy and Industrial Strategy
DEP	Dudgeon Extension Project
FFC	Flamborough and Filey Coast
PEIR	Preliminary Environmental Information Report
PVA	Population Viability Analysis
SEP	Sheringham Extension Project
SoS	Secretary of State
SPA	Special Protection Area

1 Introduction

1. On 9th July 2021, Norfolk Boreas Limited (Applicant) received a request from the Department for Business, Energy and Industrial Strategy (BEIS), on behalf of the Secretary of State (SoS), to provide certain information in relation to consideration of Habitats Regulations Assessment (HRA) issues in respect of an application for development consent for the Norfolk Boreas Offshore Wind Farm (Norfolk Boreas). One request related to the Flamborough and Filey Coast (FFC) Special Protection Area (SPA) as follows:

   In relation to in-combination impacts on the kittiwake, razorbill, gannet, and guillemot features of the Flamborough and Filey Coast SPA, the Applicant is requested to provide the latest in-combination assessments for collision and/or displacement effects, with and without Hornsea Project Four Offshore Wind Farm, including:

   - *The predicted in-combination kittiwake collision mortalities, including the Hornsea Project Three Offshore Wind Farm in the assessment.*
   - *The results of updated PVA models for all of the above species and a comparison of the predicted SPA population sizes after 30 years, with and without the development.*

2. This document provides the additional information requested above.

3. Following consultation with Natural England and taking into account advice provided by Natural England, the Applicant has also included the preliminary collision and displacement estimates for the Dudgeon Extension Project (DEP) and Sheringham Extension Project (SEP), using the data provided for those applications in their Preliminary Environmental Information Report (PEIR), since these projects are at the same stage in the consenting process as Hornsea Project Four. Thus, where the SoS requested the following outputs:

   - *with and without Hornsea Project Four Offshore Wind Farm*

   the Applicant has provided the following:

   - *with and without Hornsea Project Four Offshore Wind Farm and the DEP and SEP wind farms.*

4. For each species a summary table of the in-combination collision and/or displacement estimates is provided followed by the outputs from Population Viability Analysis (PVA). The complete cumulative and in-combination tables are provided in Appendix 1 - Cumulative and in-combination collision and displacement tables. The PVA results were obtained using the online version of the Natural

England commissioned PVA tool[1]. Each run of this model generates a log file of the input parameters used and model settings which permits independent validation of the results obtained. These log files are provided in Appendix 2 – PVA log files.

2 Methods – density dependence

5. The Natural England PVA tool includes an option to switch the model to run as either density independent, with no connection between population size and the demographic rates (survival and productivity) or density dependent, which includes a feedback link between population size and one or more demographic rates. For example, this could take the form of a negative relationship between population size and productivity, such that as the population increases productivity decreases, and *vice versa*. In this manner the simulated population in the model is maintained around a stable level. Such feedback responses often occur in real populations due to competition between individuals for limited resources such as breeding space, breeding partners or food. There is a large amount of theoretical and empirical evidence for such population regulation, including for seabirds, although it must be acknowledged that the mechanisms and strength for how this operates in seabirds is less well understood, primarily due to the challenges of collecting the necessary data.

6. The Applicant has reviewed the Natural England PVA guidance on how density dependence is included in the online version of the tool. The density dependent function provided has been set to operate in a very weak manner, scaled to operate with a 10-fold change in population size. Comparted within the extent to which seabird populations change across periods of 30 years (as simulated here) changes of this size would be the exception rather than the norm (e.g. a population would need to increase from 10,000 individuals to 100,000, or decrease by this amount, for the full effect of density dependence to be observed). The practical consequence of this for the PVA tool is that density dependent model runs produce outputs which are largely indistinguishable from density independent outputs and little insight is gained as to how the population response to an impact varies with and without density dependence. This approach to modelling density dependence differs from that used in previous PVA for the FFC SPA (e.g. MacArthur Green 2018 as referenced in APP-201) which applied density dependence in a manner consistent with seabird populations (e.g. Cury et al. 2013). Indeed, the version of the Natural England PVA tool which can be run within the R programming environment[2] (rather than online) offers greater flexibility in this regard, with options to select different forms of density dependence which are better supported by the, albeit limited, empirical

[1] http://ec2-54-229-75-12.eu-west-1.compute.amazonaws.com/shiny/seabirds/PVATool/R/
[2] https://github.com/naturalengland/Seabird_PVA_Tool

evidence. It is not explained why these options were not included in the online version (which Natural England has advised the Applicant should use).

7. Hence, while the Applicant had intended to run the PVA models using the Natural England PVA tool under both density dependent and density independent options and provide the results for comparison, due to the way the PVA tool is currently set up it was determined that there was little additional insight to be gained from doing so. It is acknowledged that care must be taken when setting the form and strength of density dependent regulation in a population model. However, it remains the case that density independent PVA predictions are, with very few exceptions, less realistic than density dependent ones which have been based on life history theory and evidence of how seabird populations are regulated. Indeed, if density dependence is considered as a continuum, from fully density independent to strongly density dependent, density independent predictions can be considered to have the least scientific support and to provide the least reliable predictions. While this could be justified on the basis of being precautionary and basing decisions on an assessment of the worst case outcomes, the Applicant considers that such an interpretation is overly simplistic for two reasons. Firstly, density dependent PVA undertaken in an appropriate manner is still precautionary. Secondly, density independent PVA is Natural England's preferred approach not because there is supporting evidence for density independent growth but because of the challenges in estimating how density dependence operates in natural populations. In almost all instances a density independent model will be over-precautionary and will provide unrealistic predictions.

8. Inclusion of density dependence also influences consideration of which counterfactual outputs are more appropriate. PVA counterfactuals are relative measures of population metrics, derived as the impacted value divided by the unimpacted (or baseline) value. Thus, if the impact has no effect on (for example) population size, the counterfactual metric will have a value of 1, while any reduction in the metric caused by the impact will result in a counterfactual with a value less than 1. These are often presented interchangeably on both a proportional scale (i.e. between 0 and 1) and also converted into percentages.

9. The SoS requested comparisons of the SPA population sizes for the four species after 30 years with and without the development (Norfolk Boreas). This metric is referred to as the counterfactual of population size (CPS). A second informative metric from PVA analysis is the counterfactual of the population growth rate (CPGR) which compares the population's rate of annual growth with and without the impact (averaged across a period of years).

10. Although both counterfactual measures (CPS and CPGR) are provided in this report, the Applicant considers that they are not equally appropriate for model

interpretation in all cases, due to the role of density dependence. As discussed above, a density independent population has no constraint on growth. Thus, a density independent population with a positive growth rate will grow exponentially and the baseline and impacted populations will diverge by an increasing amount as the duration increases. In other words, the CPS is sensitive to the period it is measured over. But neither the baseline nor impacted population projections are likely to be credible since seabird populations are constrained by factors such as nest site availability, prey availability etc., as explained above (i.e. aspects which lead to density dependence). Hence a density independent CPS is a comparison of two unrealistic population predictions. In contrast, the CPGR is time invariant; the value is the same whether the simulation runs for 20 years, 30 years or 100 years (while the CPS for these would be very different). All else being equal, a measure with lower sensitivity to input parameters is to be preferred, which in the case of density independent PVA is the CPGR.

11. The stable state for a density dependent population is a growth rate of 1. Therefore, if the PVA model is run with density dependence then the population growth of both the baseline and impacted runs will stabilise to 1 (i.e. zero net growth), but the impacted population will have a lower (average) stable population size. In this case the CPGR is of limited utility since it will have a value of around 1 irrespective of the impact magnitude, but the CPS will provide a measure of how much smaller the impacted population is predicted to be.

12. Thus, in summary if the PVA is density independent (as here) the CPGR is considered more robust and informative, while if the PVA is density dependent then the CPS is more robust and informative.

13. For these reasons, while both CPS and CPGR are provided, the interpretation of the density independent PVA outputs focusses on the CPGR.

14. In all cases models were run for 5,000 simulations, as advised by Natural England. The full model inputs are provided in Appendix 2 – PVA log files.

3 Results

3.1 Gannet

15. The summary cumulative and in-combination gannet collision estimates are provided in Table 3.1 and the summary cumulative and in-combination displacement estimates are provided in Table 3.2.

Table 3.1 Gannet cumulative and in-combination collisions apportioned to the FFC SPA. The 'Previous OWFs' is a summed total including all wind farms in the assessment up to East Anglia THREE in England and Moray West in Scotland (full table in Appendix 1).

Wind Farm	Breeding		Autumn		Spring		Annual	
	Total	FFC SPA	Total	FFC SPA	Total	FFC SPA	Total	FFC SPA
Previous OWFs	1734.8	179.7	752.4	36.15	306.7	19.04	2794	234.7
Hornsea Project Three - revised	10	6	5	0	4	0	19	7
Norfolk Vanguard	8.2	8.2	18.6	0.89	5.3	0.33	32.1	9.4
Norfolk Boreas	**14.1**	**14.2**	**12.7**	**0.61**	**3.9**	**0.24**	**30.7**	**15.1**
East Anglia TWO	12.5	12.5	23.1	1.1	4	0.2	39.6	13.8
East Anglia ONE North	12.4	12.4	11	0.52	1.1	0.07	24.5	13
DEP and SEP (PEIR)	*3.96*	*3.96*	*6.43*	*0.31*	*0.36*	*0.02*	*10.75*	*4.29*
Hornsea 4 (PEIR)	*43.3*	*43.3*	*9.9*	*0.48*	*8.1*	*0.5*	*61.3*	*44.3*
Total exc. PEIR	**1792.0**	**233.0**	**822.8**	**39.3**	**325.0**	**19.9**	**2939.9**	**293.0**
Total inc. PEIR	**1839.3**	**280.3**	**839.1**	**40.1**	**333.5**	**20.4**	**3012.0**	**341.6**

Table 3.2 Gannet cumulative and in-combination population abundance (for displacement assessment) apportioned to the FFC SPA. The 'Previous OWFs' is a summed total including all wind farms in the assessment up to East Anglia THREE in England and Moray West in Scotland (full table in Appendix 1).

Wind Farm	Breeding		Autumn		Spring		Annual	
	Total	FFC SPA	Total	FFC SPA	Total	FFC SPA	Total	FFC SPA
Previous OWFs	17193	3807	14025	673	3288	203.8	34506	4683.8
Hornsea Project Three - revised	1333	844	984	47	524	32.5	2841	923.5
Norfolk Vanguard	271	271	2453	117.7	437	27.1	3161	415.8
Norfolk Boreas	**1229**	**1229**	**1723**	**82.7**	**526**	**32.6**	**3478**	**1344.3**
East Anglia TWO	192	192	891	42.8	192	11.9	1275	246.7
East Anglia ONE North	149	149	468	22.5	44	2.7	661	174.2
DEP and SEP (PEIR)	401	401	638	30	47	3	1086	434
Hornsea 4 (PEIR)	1892	1892	1192	57.2	659	40.9	3743	1990.1
Total exc. PEIR	**20367.0**	**6492.0**	**20544.0**	**985.7**	**5011.0**	**310.6**	**45922.0**	**7788.3**
Total inc. PEIR	**22660.0**	**8785.0**	**22374.0**	**1072.9**	**5717.0**	**354.5**	**50751.0**	**10212.4**

16. The annual mortalities entered into the PVA and the counterfactual outputs (CPS and CPGR) for the total in-combination FFC SPA gannet collision and displacement estimates (separately and combined), with and without Norfolk Boreas are provided in Table 3.3.

Table 3.3 Gannet FFC SPA mortalities and population modelling results using the Natural England PVA tool

Impact	Scenario	Norfolk Boreas (mortality included)	Adult mortality	Density independent counterfactual metric (after 30 years)	
				Growth rate	Population size
Collisions	Total exc. PEIR	0	277.9	0.9878	0.6826
		15.1	293.0	0.9871	0.6684
	Total inc. PEIR	0	326.5	0.9856	0.6384
		15.1	341.6	0.9849	0.6249
Displacement (@ 80% displaced and 1% mortality)	Total exc. PEIR	0	51.6	0.9977	0.9318
		10.8	62.3	0.9973	0.9184
	Total inc. PEIR	0	70.9	0.9969	0.9074
		10.8	81.7	0.9964	0.8943
Collisions and displacement	Total exc. PEIR	0	329.5	0.9855	0.6358
		25.9	355.3	0.9844	0.6134
	Total inc. PEIR	0	397.4	0.9825	0.5789
		25.9	423.3	0.9814	0.5582

17. The density independent PVA results indicate that the maximum reduction in growth rate was 1.86% (0.9814) for an in-combination collision and displacement mortality of 423.3. At this mortality the CPS indicates the gannet population after 30 years would be 56% (0.5582) of the baseline (unimpacted) size.

18. Comparing the in-combination collision mortality results with and without Norfolk Boreas, the population growth rate was reduced by 0.07% (0.9878-0.9871) and 0.07% (0.9856-0.9849), for simulations excluding and including PEIR projects respectively. The equivalent reductions in population size were 1.42% and 1.35%, however as noted above the CPS is considered a less reliable metric for density independent simulations.

19. Comparing the in-combination displacement mortality results with and without Norfolk Boreas, the population growth rate was reduced by 0.04% (0.9977-0.9973) and 0.05% (0.9969-0.9964), for simulations excluding and including PEIR projects respectively. The equivalent reductions in population size were 1.36% and 1.34%, however as noted above the CPS is considered a less reliable metric for density independent simulations.

20. Comparing the in-combination collision and displacement mortality results with and without Norfolk Boreas, the population growth rate was reduced by 0.11% (0.9855-0.9844) and 0.12% (0.9825-0.9814), for simulations excluding and including PEIR projects respectively. The equivalent reductions in population size were 2.24% and 2.07%, however as noted above the CPS is considered a less reliable metric for density independent simulations.

21. These PVA results compare to the observed rate at which the FFC SPA population has grown over the last 25 years, which has been at least 10% per year. A reduction of less than 2% in this rate represents a negligible risk for the population. Natural England (2019) suggested that, if the SPA population follows a similar pattern of growth to those observed at colonies of a similar age, the observed rate of growth is likely to decrease over the coming decades. Natural England (2019) does not discuss the reasons for this apparent pattern in other colonies, however it is reasonable to assume that this would occur due to increasing levels of competition for resources, in other words a density dependent response. On this basis it would be expected that the results from a density dependent PVA would be more appropriate to consider, however as discussed above there is no means at present for realistic levels of density dependence to be simulated using the Natural England PVA tool. The Applicant presented results from density dependent PVA in the original application (APP-201) which demonstrated that with a mortality of 25 the impacted population would be no more 2.2% smaller than the unimpacted one after 30 years.

22. The gannet breeding numbers at the FFC SPA have continued to increase in all counts conducted to date and the gannet population is therefore clearly in favourable conservation status. The relevant conservation objective is to maintain favourable conservation status of the gannet population, subject to natural change.

23. On the basis of the population model predictions the number of predicted collision and displacement mortalities at Norfolk Boreas in-combination with other North Sea wind farms with potential connectivity to the FFC SPA is not at a level which would trigger a risk of population decline but would only result in a slight reduction in the growth rate currently seen at this colony.

24. The contribution of Norfolk Boreas to the in-combination totals is also very small, making an additional reduction to the growth rate of no more than 0.11% and an additional reduction in CPS of 2.24%, which means that the population size would be 2.24% below the size it would reach without the wind farm .

25. Therefore, since the gannet population has very favourable status and even when assessed using precautionary methods the impacts will only slightly reduce the population growth rate, which will remain positive, it can be concluded that, even with the high degree of precaution in the assessment (see [REP2-035] and [REP6-021]), there will be no adverse effect on the integrity of FFC SPA from impacts on gannet due to in-combination collision mortality, in-combination displacement mortality and the two sources of impact combined.

3.2 Kittiwake

26. The summary cumulative and in-combination kittiwake collision estimates are provided in Table 3.4.

Table 3.4 Kittiwake cumulative and in-combination collisions apportioned to the FFC SPA. The 'Previous OWFs' is a summed total including all wind farms in the assessment up to East Anglia THREE in England and Moray West in Scotland (full table in Appendix 1). Note that figures for FFC SPA with and without Hornsea Project Three have also been provided as per the SoS request.

Wind Farm	Breeding		Autumn		Spring		Annual	
	Total	FFC SPA	Total	FFC SPA	Total	FFC SPA	Total	FFC SPA
Previous OWFs	1093.3	161.2	1446.2	78.1	1143	82.4	3682.5	321.6
Hornsea Project Three - revised	77	72 (0)	38	2 (0)	8	1 (0)	123	74 (0)
Norfolk Vanguard	21.8	18.7	16.4	0.9	19.3	1.4	57.5	21
Norfolk Boreas	**13.3**	**11.4**	**32.2**	**1.7**	**11.9**	**0.9**	**57.5**	**14**
East Anglia TWO	29.5	0	5.4	0.3	7.4	0.5	42.3	0.8
East Anglia ONE North	40.4	0	8.1	0.43	3.5	0.25	52	0.7
DEP and SEP (PEIR)	18.13	18.13	10.46	0.56	2.2	0.16	30.79	18.85
Hornsea 4 (PEIR)	153.3	153.3	34.7	1.9	9.9	0.7	197.9	155.9
Total exc. PEIR and with H3's FFC figure set to 0	**1275.3**	**191.3**	**1546.3**	**81.4**	**1193.1**	**85.5**	**4014.8**	**358.1**
Total inc. PEIR and with H3 FFC figure set to 0	**1446.7**	**362.7**	**1591.5**	**83.9**	**1205.2**	**86.3**	**4243.5**	**532.9**
Total exc. PEIR and with H3 FFC figure set to 74	-	**263.3**	-	**83.4**	-	**86.5**	-	**432.1**
Total inc. PEIR and with H3 FFC figure set to 74	-	**434.7**	-	**85.9**	-	**87.3**	-	**606.9**

27. The annual mortalities entered into the PVA and the counterfactual outputs (CPS and CPGR) for the total in-combination FFC SPA kittiwake collision estimates, with and without Norfolk Boreas are provided in Table 3.5.

Table 3.5 Kittiwake FFC SPA mortalities and population modelling results using the Natural England PVA tool

Impact	Scenario	Norfolk Boreas (mortality included)	Adult mortality	Density independent counterfactual metric (after 30 years)	
				Growth rate	Population size
Collisions	Total exc. PEIR (H3 FFC figure set to 0)	0	344.1	0.9960	0.8845
		14	358.1	0.9959	0.8801
	Total inc. PEIR (H3 FFC figure set to 0)	0	518.85	0.9940	0.8308
		14	532.85	0.9939	0.8268
	Total exc. PEIR (H3 FFC figure set to 74)	0	418.1	0.9952	0.8616
		14	432.1	0.9950	0.8572

Impact	Scenario	Norfolk Boreas (mortality included)	Adult mortality	Density independent counterfactual metric (after 30 years)	
				Growth rate	Population size
	Total inc. PEIR (H3 FFC figure set to 74)	0	592.85	0.9932	0.8094
		14	606.85	0.9930	0.8051

28. The density independent PVA results indicate that the maximum reduction in growth rate was 0.7% (0.993) for an in-combination collision mortality of 607. At this mortality the CPS indicates the kittiwake population after 30 years would be 19.5% (0.8051) of the baseline (unimpacted) size.

29. Comparing the in-combination collision mortality results with and without Norfolk Boreas when Hornsea Project Three FFC mortality was set to zero, the population growth rate was reduced by 0.016% (0.9960-0.9959) and 0.016% (0.9940-0.9939), for simulations excluding and including PEIR projects respectively. The equivalent reductions in population size were 0.44% and 0.40%, however as noted above the CPS is considered a less reliable metric for density independent simulations.

30. Comparing the in-combination collision mortality results with and without Norfolk Boreas when Hornsea Project Three FFC mortality was set to 74 (i.e. making the assumption that Hornsea Project Three does not compensate for its own mortality), the population growth rate was reduced by 0.016% (0.9952-0.9950) and 0.017% (0.9932-0.9930), for simulations excluding and including PEIR projects respectively. The equivalent reductions in population size were 0.43% and 0.43%, however as noted above the CPS is considered a less reliable metric for density independent simulations. The Applicant presented results from density dependent PVA in the original application (APP-201) which demonstrated that with a mortality of 50 (i.e. more than 3 times the revised estimate) the impacted population would be no more 0.5% smaller than the unimpacted one after 30 years.

31. The kittiwake breeding numbers at the Flamborough and Filey Coast SPA have remained relatively stable with an average of almost 44,000 pairs over the last 20 years (Lloyd et al. 2019), although between 2008 and 2017 the population grew at over 2% per year. A maximum reduction of 0.7% in the growth rate would not trigger a population decline, and the contribution from Norfolk Boreas is only 0.016% (i.e. a difference between a growth rate reduction of 0.680% and 0.696%).

32. On the basis of the population model predictions, the number of predicted collision mortalities at Norfolk Boreas in-combination with other North Sea wind farms with potential connectivity to the FFC SPA is not at a level which would trigger a risk of

population decline, since the population growth rate remains positive and would only result in a slight reduction in the growth rate currently seen at this colony.

33. The contribution of Norfolk Boreas to the in-combination totals is also very small, making an additional reduction to the growth rate of no more than 0.016% and an additional reduction in CPS of no more than 0.44%, which means that the population size would be 0.44% below the size it would reach without the wind farm.

34. Therefore, it can be concluded that, even with the high degree of precaution in the assessment (see [REP2-035] and [REP6-021]), there will be no adverse effect on the integrity of the FFC SPA from impacts on kittiwake due to in-combination collision mortality.

3.3 Guillemot

35. The summary cumulative and in-combination guillemot displacement estimates are provided in Table 3.6. These have used a displacement percentage of 70% and a mortality rate of 2%, which corresponds to Natural England's assessment that a mortality increase of no more than 0.5% would be expected (In [REP4-040] Natural England stated *"We do not expect the mortality to exceed a level where the population growth rate would decline by more than approximately 0.5% per annum"*).

Table 3.6 Guillemot cumulative and in-combination displacement apportioned to the FFC SPA, using a displacement rate of 70% and a mortality rate of 2%. The 'Previous OWFs' is a summed total including all wind farms in the assessment up to East Anglia THREE in England and Moray West in Scotland (full table of population abundances in Appendix 1).

Wind Farm	Breeding		Nonbreeding		Annual	
	Total	FFC SPA	Total	FFC SPA	Total	FFC SPA
Previous OWFs	1944.6	244.4	1833.8	80.7	3778.4	325.1
Hornsea Project Three - revised	187.2	0.0	248.8	10.9	436.0	10.9
Norfolk Vanguard	60.5	0.0	66.9	2.9	127.3	2.9
Norfolk Boreas	**108.7**	**0.0**	**192.9**	**8.5**	**301.6**	**8.5**
East Anglia TWO	29.1	0.0	23.5	1.0	52.5	1.0
East Anglia ONE North	58.6	0.0	26.4	1.2	85.0	1.2
DEP and SEP (PEIR)	50.1	0.0	121.4	5.3	171.5	5.3
Hornsea 4 (PEIR)	213.4	213.4	973.8	42.8	1187.2	256.3
Total exc. PEIR	**2388.7**	**244.4**	**2392.2**	**105.3**	**4780.9**	**349.7**
Total inc. PEIR	**2652.2**	**457.8**	**3487.4**	**153.5**	**6139.6**	**611.3**

36. The annual mortalities entered into the PVA and the counterfactual outputs (CPS and CPGR) for the total in-combination FFC SPA guillemot displacement estimates, with and without Norfolk Boreas are provided in Table 3.7.

Table 3.7 Guillemot FFC SPA mortalities and population modelling results using the Natural England PVA tool

Impact	Scenario	Norfolk Boreas (mortality included)	Adult mortality	Density independent counterfactual metric (after 30 years)	
				Growth rate	Population size
Collisions	Total exc. PEIR	0	341.2	0.9958	0.8776
		8.5	349.7	0.9957	0.8748
	Total inc. PEIR	0	602.8	0.9926	0.7937
		8.5	611.3	0.9925	0.7911

37. The density independent PVA results indicate that the maximum reduction in growth rate was 0.75% (0.9925) for an in-combination displacement mortality of 611. At this mortality the CPS indicates the guillemot population after 30 years would be 20.9% (0.7911) of the baseline (unimpacted) size.

38. Comparing the in-combination displacement mortality results with and without Norfolk Boreas, the population growth rate was reduced by 0.010% (0.9958-0.9957) and 0.010% (0.9926-0.9925), for simulations excluding and including PEIR projects respectively. The equivalent reductions in population size were 0.28% and 0.26%, however as noted above the CPS is considered a less reliable metric for density independent simulations. The Applicant presented results from density dependent PVA in the original application (APP-201) which demonstrated that with a mortality of 50 (i.e. over 5 times the revised estimate) the impacted population would be no more 0.9% smaller than the unimpacted one after 30 years.

39. The guillemot breeding numbers at the Flamborough and Filey Coast SPA have increased at every census of the colony since 1969 and the population was most recently estimated to comprise 90,861 individuals in 2017 (Lloyd et al. 2019). The average annual growth rate since 1969 has been 4%. A maximum reduction in this of 0.75% would almost certainly not be detectable. Furthermore, the contribution from Norfolk Boreas is only 0.010% (i.e. a difference between a growth rate reduction of 0.74% and 0.75%).

40. On the basis of the population model predictions, the number of predicted displacement mortalities at Norfolk Boreas in-combination with other North Sea wind farms with potential connectivity to the FFC SPA is not at a level which would trigger a risk of population decline but would only result in a slight reduction in the growth rate currently seen at this colony.

41. The contribution of Norfolk Boreas to the in-combination totals is also very small, making an additional reduction to the growth rate of no more than 0.010% and an additional reduction in the CPS of no more than 0.28%, which means that the population size would be 0.28% below the size it would reach without the wind farm.

42. Therefore, it can be concluded that, even with the high degree of precaution in the assessment (see [REP2-035] and [REP6-021]) the impacts will only slightly reduce the population growth rate which will remain positive and there will therefore be no adverse effect on the integrity of FFC SPA from impacts on guillemot due to in-combination displacement mortality.

3.4 Razorbill

43. The summary cumulative and in-combination razorbill displacement estimates are provided in Table 3.8. These have used a displacement percentage of 70% and a mortality rate of 2%, which corresponds to Natural England's assessment that a mortality increase of no more than 0.5% would be expected (In [REP4-040] Natural England stated *"We do not expect the mortality to exceed a level where the population growth rate would decline by more than approximately 0.5% per annum"*).

Table 3.8 Razorbill cumulative and in-combination displacement apportioned to the FFC SPA, using a displacement rate of 70% and a mortality rate of 2%. The 'Previous OWFs' is a summed total including all wind farms in the assessment up to East Anglia THREE in England and Moray West in Scotland (full table in Appendix 1).

Wind Farm	Breeding		Autumn		Nonbreeding		Spring		Annual	
	Total	FFC SPA	Total	FFC SPA	Total	FFC SPA	Total	FFC SPA	Total	FFC SPA
Previous OWFs	410.2	45.8	445.5	15.1	256.9	6.9	402.1	13.7	1514.7	81.5
Hornsea Project Three - revised	8.8	0.0	28.3	1.0	51.1	1.4	29.5	1.0	117.7	3.4
Norfolk Vanguard	12.3	0.0	12.1	0.4	11.7	0.3	12.9	0.4	49.1	1.2
Norfolk Boreas	**8.8**	**0.0**	**3.7**	**0.1**	**14.9**	**0.4**	**4.8**	**0.2**	**32.2**	**0.7**
East Anglia TWO	3.9	0.0	0.6	0.0	1.9	0.1	3.2	0.1	9.7	0.2
East Anglia ONE North	5.6	0.0	1.2	0.0	0.8	0.0	2.9	0.1	10.5	0.2
DEP and SEP (PEIR)	8.1	8.1	83.4	2.8	9.6	0.3	19.1	0.6	120.2	11.9
Hornsea 4 (PEIR)	14.9	0.0	60.1	2.0	18.3	0.5	5.9	0.2	99.2	2.7
Total exc. PEIR	**449.7**	**45.8**	**491.4**	**16.7**	**337.3**	**9.1**	**455.4**	**15.5**	**1733.9**	**87.1**
Total inc. PEIR	**472.8**	**53.9**	**635.0**	**21.6**	**365.3**	**9.9**	**480.4**	**16.3**	**1953.3**	**101.7**

44. The annual mortalities entered into the PVA and the counterfactual outputs (CPS and CPGR) for the total in-combination FFC SPA guillemot displacement estimates, with and without Norfolk Boreas are provided in Table 3.9.

Table 3.9 Razorbill FFC SPA mortalities and population modelling results using the Natural England PVA tool

Impact	Scenario	Norfolk Boreas (mortality included)	Adult mortality	Density independent counterfactual metric (after 30 years)	
				Growth rate	Population size
Collisions	Total exc. PEIR	0	86.4	0.9966	0.9007
		0.7	87.1	0.9966	0.9000
	Total inc. PEIR	0	101.0	0.9961	0.8851
		0.7	101.7	0.9960	0.8839

45. The density independent PVA results indicate that the maximum reduction in growth rate was 0.4% (0.996) for an in-combination displacement mortality of 102. At this mortality the CPS indicates the razorbill population after 30 years would be 11.6% (0.8839) of the baseline (unimpacted) size.

46. Comparing the in-combination displacement mortality results with and without Norfolk Boreas, the population growth rate was reduced by 0.002% (0.99663-0.99661) and 0.004% (0.99607-0.99603), for simulations excluding and including PEIR projects respectively. The equivalent reductions in population size were 0.066% and 0.12%, however as noted above the CPS is considered a less reliable metric for density independent simulations. The Applicant presented results from density dependent PVA in the original application (APP-201) which demonstrated that with a mortality of 50 (i.e. over 50 times the revised estimate) the impacted population would be no more 2.2% smaller than the unimpacted one after 30 years.

47. The razorbill breeding numbers at the Flamborough and Filey Coast SPA have increased at each census since 1969, with an average annual growth rate of nearly 6% (Lloyd et al. 2019). A maximum reduction in this of 0.4% would almost certainly be undetectable, and the contribution from Norfolk Boreas is no more than 0.004% (i.e. a difference between a growth rate reduction of 0.393% and 0.397%).

48. On the basis of the population model predictions, the number of predicted displacement mortalities at Norfolk Boreas in-combination with other North Sea wind farms with potential connectivity to the FFC SPA is not at a level which would trigger a risk of population decline but would only result in a slight reduction in the growth rate currently seen at this colony.

49. The contribution of Norfolk Boreas to the in-combination totals is also very small, making an additional reduction to the growth rate of no more than 0.004% and an additional reduction in the CPA of no more than 0.12%, which means that the population size would be 0.12% below the size it would reach without the wind farm.

50. Therefore, it can be concluded that, even with the high degree of precaution in the assessment (see [REP2-035] and [REP6-021]) the impacts will only slightly reduce the population growth rate, which will remain positive, there will be no adverse effect on the integrity of FFC SPA from impacts on razorbill due to in-combination displacement mortality.

4 References

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30 May 2019

Appendix 1 - Cumulative and in-combination collision and displacement tables

Table 0.1 Gannet cumulative and in-combination collision risk.

Tier	Wind farm	Breeding season		Autumn migration		Spring migration		Annual	
		Total	FFC SPA	Total	FFC SPA	Total	FFC SPA	Total	FFC SPA
1	Beatrice Demonstrator	0.6	0	0.9	0.04	0.7	0.05	2.2	0.1
1	Greater Gabbard	14	0	8.8	0.42	4.8	0.3	27.5	0.7
1	Gunfleet Sands	-	-	-	-	-	-	-	-
1	Kentish Flats	1.4	0	0.8	0.04	1.1	0.07	3.3	0.1
1	Kentish Flats Extension	-	-	-	-	-	-	-	-
1	Lincs	2.1	2.1	1.3	0.06	1.7	0.1	5	2.3
1	London Array	2.3	0	1.4	0.07	1.8	0.11	5.5	0.2
1	Lynn and Inner Dowsing	0.2	0.2	0.1	0.01	0.2	0.01	0.5	0.2
1	Scroby Sands	-	-	-	-	-	-	-	-
1	Sheringham Shoal	14.1	14.1	3.5	0.17	0	0	17.6	14.3
1	Teesside	4.9	2.4	1.7	0.08	0	0	6.7	2.5
1	Thanet	1.1	0	0	0	0	0	1.1	0
1	Humber Gateway	1.9	1.9	1.1	0.05	1.5	0.09	4.5	2
1	Westermost Rough	0.2	0.2	0.1	0.01	0.2	0.01	0.5	0.2
1	Hywind	5.6	0	0.8	0.04	0.8	0.05	7.2	0.1
2	Kincardine	3	0	0	0	0	0	3	0
2	Beatrice	37.4	0	48.8	2.34	9.5	0.59	95.7	2.9
2	Dudgeon	22.3	22.3	38.9	1.87	19.1	1.18	80.3	25.3
2	Galloper	18.1	0	30.9	1.48	12.6	0.78	61.6	2.3
2	Race Bank	33.7	33.7	11.7	0.56	4.1	0.25	49.5	34.5
2	Rampion	36.2	0	63.5	3.05	2.1	0.13	101.8	3.2
2	Hornsea Project One	11.5	11.5	32	1.54	22.5	1.4	66	14.4
3	Blyth Demonstration Project	3.5	0	2.1	0.1	2.8	0.17	8.4	0.3
3	Dogger Bank Creyke Beck Projects A and B	81.1	40.6	83.5	4.0	54.4	3.4	219.0	47.9
3	East Anglia ONE	3.4	3.4	131	6.3	6.3	0.4	140.7	10.1
3	European Offshore Wind Deployment Centre	4.2	0	5.1	0.25	0.1	0	9.3	0.3
3	Firth of Forth Alpha and Bravo	800.8	0	49.3	2.37	65.8	4.08	915.9	6.4
3	Inch Cape	336.9	0	29.2	1.4	5.2	0.32	371.3	1.7
3	Methil	6	0	0	0	0	0	6	0
3	Moray Firth (EDA)	80.6	0	35.4	1.7	8.9	0.55	124.9	2.3
3	Neart na Gaoithe	143	0	47	2.26	23	1.43	213	3.7
3	Dogger Bank Teesside Projects A and B	14.8	7.4	10.1	0.49	10.8	0.67	35.7	8.5
3	Triton Knoll	26.8	26.8	64.1	3.08	30.1	1.87	121	31.7
3	Hornsea Project Two	7	7	14	0.67	6	0.37	27	8
4	East Anglia THREE	6.1	6.1	33.3	1.6	9.6	0.6	49	8.3
4	Moray West	10	0	2	0.1	1	0.06	13	0.2
4	Hornsea Project Three	10	6	5	0	4	0	19	7
5	Norfolk Vanguard	8.2	8.2	18.6	0.89	5.3	0.33	32.1	9.4
5	Norfolk Boreas	14.1	14.2	12.7	0.61	3.9	0.24	30.7	15.1
5	East Anglia TWO	12.5	12.5	23.1	1.1	4.0	0.2	39.6	13.8
5	East Anglia ONE North	12.4	12.4	11.0	0.5	1.1	0.1	24.5	13.0
6	*Hornsea 4 (PEIR)*	*43.3*	*43.3*	*9.9*	*0.48*	*8.1*	*0.5*	*61.3*	*44.3*
6	*Dudgeon Extension and Sheringham Extension (PEIR)*	*4.0*	*4.0*	*6.4*	*0.3*	*0.4*	*0.02*	*10.8*	*4.3*
	Total (all projects)	**1839.3**	**280.3**	**839.1**	**40.1**	**333.5**	**20.4**	**3012.0**	**341.6**

Tier	Wind farm	Breeding season		Autumn migration		Spring migration		Annual	
		Total	FFC SPA	Total	FFC SPA	Total	FFC SPA	Total	FFC SPA
	Total (minus Hornsea Project Four & Dudgeon and Sheringham Extensions)	**1792.0**	**233.0**	**822.8**	**39.3**	**325.0**	**19.9**	**2939.9**	**293.0**

Table 0.2 Updated kittiwake cumulative and in-combination collision risk.

Tier	Wind farm	Breeding season		Autumn migration		Spring migration		Annual	
		Total	FFC SPA	Total	FFC SPA	Total	FFC SPA	Total	FFC SPA
1	Beatrice Demonstrator	0.0	0.0	2.1	0.1	1.7	0.1	3.8	0.2
1	Greater Gabbard	1.1	0.0	15.0	0.8	11.4	0.8	27.5	1.6
1	Gunfleet Sands	-	-	-	-	-	-	-	
1	Kentish Flats	0.0	0.0	0.9	0.1	0.7	0.1	1.6	0.1
1	Kentish Flats Extension	0.0	0.0	0.0	0.0	2.7	0.2	2.7	0.2
1	Lincs	0.7	0.7	1.2	0.1	0.7	0.1	2.6	0.8
1	London Array	1.4	0.0	2.3	0.1	1.8	0.1	5.5	0.3
1	Lynn and Inner Dowsing	-	-	-	-	-	-	-	
1	Scroby Sands	-	-	-	-	-	-	-	
1	Sheringham Shoal	-	-	-	-	-	-	-	
1	Teesside	38.4	0.0	24.0	1.3	2.5	0.2	64.9	1.5
1	Thanet	0.2	0.0	0.5	0.0	0.4	0.0	1.1	0.1
1	Humber Gateway	1.9	1.9	3.2	0.2	1.9	0.1	7.0	2.2
1	Westermost Rough	0.1	0.1	0.2	0.0	0.1	0.0	0.5	0.1
1	Hywind	16.6	0.0	0.9	0.1	0.9	0.1	18.3	0.1
2	Kincardine	22.0	0.0	9.0	0.5	1.0	0.1	32.0	0.6
2	Beatrice	94.7	0.0	10.7	0.6	39.8	2.9	145.2	3.5
2	Dudgeon	-	-	-	-	-	-	-	
2	Galloper	6.3	0.0	27.8	1.5	31.8	2.3	65.9	3.8
2	Race Bank	1.9	1.9	23.9	1.3	5.6	0.4	31.4	3.6
2	Rampion	54.4	0.0	37.4	2.0	29.7	2.1	121.5	4.2
2	Hornsea Project One	44.0	36.5	55.9	3.0	20.9	1.5	120.8	41.0
3	Blyth Demonstration Project	1.7	0.0	2.3	0.1	1.4	0.1	5.4	0.2
3	Dogger Bank Creyke Beck Projects A and B	288.6	55.8	135.0	7.3	295.4	21.3	719.0	84.3
3	East Anglia ONE	1.8	0.0	160.4	8.7	46.8	3.4	209.0	12.0
3	European Offshore Wind Deployment Centre	11.8	0.0	5.8	0.3	1.1	0.1	18.7	0.4
3	Firth of Forth Alpha and Bravo	153.1	0.0	313.1	16.9	247.6	17.8	713.8	34.7
3	Inch Cape	13.1	0.0	224.8	12.1	63.5	4.6	301.4	16.7
3	Methil	0.4	0.0	0.0	0.0	0.0	0.0	0.4	0.0
3	Moray Firth (EDA)	43.6	0.0	2.0	0.1	19.3	1.4	64.9	1.5
3	Neart na Gaoithe	32.9	0.0	56.1	3.0	4.4	0.3	93.4	3.4
3	Dogger Bank Teesside Projects A and B	136.9	26.4	90.7	4.9	216.9	15.6	444.5	46.9
3	Triton Knoll	24.6	24.6	139.0	7.5	45.4	3.3	209.0	35.4
3	Hornsea Project Two	16.0	13.3	9.0	0.5	3.0	0.2	28.0	14.0
4	East Anglia THREE	6.1	0.0	69.0	3.7	37.6	2.7	112.7	6.4
4	Moray West	79.0	0.0	24.0	1.3	7.0	0.5	110.0	1.8
5	Hornsea Project Three	77	0 (72)	38	0 (2)	8	0 (1)	123	0 (65-74)*
5	Norfolk Vanguard	21.8	18.7	16.4	0.9	19.3	1.4	57.5	21.0

Tier	Wind farm	Breeding season		Autumn migration		Spring migration		Annual	
		Total	FFC SPA	Total	FFC SPA	Total	FFC SPA	Total	FFC SPA
5	Norfolk Boreas	13.3	11.4	32.2	1.7	11.9	0.9	57.5	14.0
5	East Anglia TWO	29.5	0.0	5.4	0.3	7.4	0.5	42.3	0.8
5	East Anglia ONE North	40.4	0.0	8.1	0.4	3.5	0.3	51.9	0.7
6	*Hornsea 4 (PEIR)*[3]	*153.3*	*153.3*	*34.7*	*1.9*	*9.9*	*0.7*	*197.9*	*155.9*
6	*Dudgeon Extension and Sheringham Extension (PEIR)*	*18.1*	*18.1*	*10.5*	*0.6*	*2.2*	*0.2*	*30.8*	*18.9*
	Total (all projects; Hornsea Project Three FFC omitted)	**1446.7**	**362.7**	**1591.5**	**83.9**	**1205.2**	**86.4**	**4243.4**	**532.9**
	Total (minus Hornsea Project Four & Dudgeon and Sheringham Extensions; Hornsea Project Three FFC omitted)	**1275.3**	**191.3**	**1546.3**	**81.4**	**1193.1**	**85.5**	**4014.7**	**358.1**
	Total (all projects; Hornsea Project Three FFC included)	**-**	**434.7**	**-**	**85.9**	**-**	**87.3**	**-**	**606.9**
	Total (minus Hornsea Project Four & Dudgeon and Sheringham Extensions; Hornsea Project Three FFC included)	**-**	**263.3**	**-**	**83.4**	**-**	**86.5**	**-**	**432.1**

[3] Note that the FFC apportioned figures have not been provided in the Hornsea Project 4 PEIR so have been calculated using Natural England methods: 100% in breeding season, 5.4% in autumn and 7.2% in spring.

Table 0.3 Updated gannet numbers at risk of cumulative and in-combination displacement. Note these are abundance estimates, not mortalities.

Tier	Wind farm	Breeding season		Autumn migration		Spring migration		Annual	
		Total	FFC SPA	Total	FFC SPA	Total	FFC SPA	Total	FFC SPA
1	Beatrice Demonstrator	-	-	-	-	-	-	-	-
1	Greater Gabbard	252	0	69	3.3	105	6.5	426	9.8
1	Gunfleet Sands	0	0	12	0.6	9	0.6	21	1.2
1	Kentish Flats	-	-	-	-	-	-	-	-
1	Kentish Flats Extension	0	0	13	0.6	0	0	13	0.6
1	Lincs	-	-	-	-	-	-	-	-
1	London Array	-	-	-	-	-	-	-	-
1	Scroby Sands	-	-	-	-	-	-	-	-
1	Sheringham Shoal	47	47	31	1.5	2	0.1	80	48.6
1	Teesside	1	0.5	0	0	0	0	1	0.5
1	Thanet	-	-	-	-	-	-	-	-
1	Humber Gateway	-	-	-	-	-	-	-	-
1	Westermost Rough	-	-	-	-	-	-	-	-
1	Hywind	10	0	0	0	4	0.2	14	0.2
2	Kincardine	120	0	0	0	0	0	120	0
2	Beatrice	151	0	0	0	0	0	151	0
2	Dudgeon	53	53	25	1.2	11	0.7	89	54.9
2	Galloper	360	0	907	43.5	276	17.1	1543	60.6
2	Race Bank	92	92	32	1.5	29	1.8	153	95.3
2	Rampion	0	0	590	28.3	0	0	590	28.3
2	Hornsea Project One	671	671	694	33.3	250	15.5	1615	719.8
3	Blyth Demonstration Project	-	-	-	-	-	-	-	-
3	Dogger Bank Creyke Beck A	518	259	916	44	176	10.9	1610	313.9
3	Dogger Bank Creyke Beck B	637	318.5	1132	54.3	218	13.5	1987	386.3
3	East Anglia ONE	161	161	3638	174.6	76	4.7	3875	340.3
3	European Offshore Wind Deployment Centre	35	0	5	0.2	0	0	40	0.2
3	Firth of Forth Alpha	1716	0	296	14.2	138	8.6	2150	22.8
3	Firth of Forth Bravo	1240	0	368	17.7	194	12	1802	29.7
3	Inch Cape	2398	0	703	33.7	212	13.1	3313	46.8
3	Methil	23	0	0	0	0	0	23	0
3	Moray Firth (EDA)	564	0	292	14	27	1.7	883	15.7
3	Neart na Gaoithe	1987	0	552	26.5	281	17.4	2820	43.9
3	Dogger Bank Teesside A	968	484	379	18.2	226	14	1573	516.2
3	Dogger Bank Teesside B	1282	641	508	24.4	238	14.8	2028	680.2
3	Triton Knoll	211	211	15	0.7	24	1.5	250	213.2
3	Hornsea Project Two	457	457	1140	54.7	124	7.7	1721	519.4
4	East Anglia THREE	412	412	1269	60.9	524	32.5	2205	505.4
4	Moray West	2827	0	439	21.1	144	8.9	3410	30
5	Hornsea Project Three	1333	844	984	47	524	32	2843	924
5	Norfolk Vanguard	271	271	2453	117.7	437	27.1	3161	415.8
5	Norfolk Boreas	1229	1229	1723	82.7	526	32.6	3478	1344.3
5	East Anglia TWO	192	192	891	42.8	192	11.9	1275	246.7
5	East Anglia ONE North	149	149	468	22.5	44	2.7	661	174.2
6	*Hornsea 4 (PEIR)*	*1892*	*1892*	*1192*	*57.2*	*659*	*40.9*	*3743*	*1990.1*
6	*Dudgeon Extension and Sheringham Extension (PEIR)*	*401*	*401*	*638*	*30*	*47*	*3*	*1086*	*434*

Tier	Wind farm	Breeding season		Autumn migration		Spring migration		Annual	
		Total	FFC SPA	Total	FFC SPA	Total	FFC SPA	Total	FFC SPA
	Total (all projects)	**22660**	**8785**	**22374**	**1073**	**5717**	**354**	**50751**	**10213**
	Total (minus Hornsea Project Four & Dudgeon and Sheringham Extensions)	**20367**	**6492**	**20544**	**986**	**5014**	**311**	**45925**	**7789**

Table 0.4 Updated guillemot numbers at risk of cumulative and in-combination displacement. Note these are abundance estimates, not mortalities.

Tier	Wind farm	Breeding season		Nonbreeding season		Annual	
		Total	FFC SPA	Total	FFC SPA	Total	FFC SPA
1	Beatrice Demonstrator	-	-	-	-	-	-
1	Greater Gabbard	345	0	548	24.1	893	24.1
1	Gunfleet Sands	0	0	363	16	363	16
1	Kentish Flats	0	0	3	0.1	3	0.1
1	Kentish Flats Extension	0	0	4	0.2	4	
1	Lincs & LID	582	0	814	35.8	1396	35.8
1	London Array	192	0	377	16.6	569	16.6
1	Scroby Sands	-	-	-	-	-	-
1	Sheringham Shoal	390	0	715	31.5	1105	31.5
1	Teesside	267	267	901	39.6	1168	306.6
1	Thanet	18	0	124	5.5	142	5.5
1	Humber Gateway	99	99	138	6.1	237	105.1
1	Westermost Rough	347	347	486	21.4	833	368.4
1	Hywind	249	0	2136	94	2385	94
2	Kincardine	632	0	0	0	632	0
2	Beatrice	13610	0	2755	121.2	16365	121.2
2	Dudgeon	334	0	542	23.8	876	23.8
2	Galloper	305	0	593	26.1	898	26.1
2	Race Bank	361	0	708	31.2	1069	31.2
2	Rampion	10887	0	15536	683.6	26423	683.6
2	Hornsea Project One	9836	4554.1	8097	356.3	17933	4910.4
3	Blyth Demonstration Project	1220	0	1321	58.1	2541	58.1
3	Dogger Bank Creyke Beck A	5407	1892.5	6142	270.2	11549	2162.7
3	Dogger Bank Creyke Beck B	9479	3317.7	10621	467.3	20100	3785
3	East Anglia ONE	274	0	640	28.2	914	28.2
3	European Offshore Wind Deployment Centre	547	0	225	9.9	772	9.9
3	Firth of Forth Alpha	13606	0	4688	206.3	18294	206.3
3	Firth of Forth Bravo	11118	0	4112	180.9	15230	180.9
3	Inch Cape	4371	0	3177	139.8	7548	139.8
3	Methil	25	0	0	0	25	0
3	Moray Firth (EDA)	9820	0	547	24.1	10367	24.1
3	Neart na Gaoithe	1755	0	3761	165.5	5516	165.5
3	Dogger Bank Teesside A	3283	1149.1	2268	99.8	5551	1248.9
3	Dogger Bank Teesside B	5211	1823.9	3701	162.8	8912	1986.7
3	Triton Knoll	425	425	746	32.8	1171	457.8
3	Hornsea Project Two	7735	3581.3	13164	579.2	20899	4160.5
4	East Anglia THREE	1744	0	2859	125.8	4603	125.8
4	Moray West	24426	0	38174	1679.7	62600	1679.7
4	Hornsea Project Three	13374	0	17772	782	31146	782
5	Norfolk Vanguard	4320	0	4776	210.2	9096	210.2
5	Norfolk Boreas	7767	0	13777	606.2	21544	606.2
5	East Anglia TWO	2077	0	1675	73.7	3752	73.7
5	East Anglia ONE North	4183	0	1888	83.1	6071	83.1
6	*Hornsea 4 (PEIR)*	*15245*	*15245*	*69555*	*3060.4*	*84800*	*18305.4*
6	*Dudgeon Extension and Sheringham Extension (PEIR)*	*3576*	*0*	*8671*	*382*	*12247*	*382*
	Total (all projects)	**189442**	**32702**	**249100**	**10961**	**438542**	**43663**

Tier	Wind farm	Breeding season		Nonbreeding season		Annual	
		Total	FFC SPA	Total	FFC SPA	Total	FFC SPA
	Total (minus Hornsea Project Four & Dudgeon and Sheringham Extensions)	**170621**	**17457**	**170874**	**7519**	**341495**	**24975**

Table 0.5 Updated razorbill numbers at risk of cumulative and in-combination displacement. Note these are abundance estimates, not mortalities.

Tier	Wind farm	Breeding season		Autumn migration		Nonbreeding season		Spring migration		Annual	
		Total	FFC SPA	Total	FFC SPA	Total	FFC SPA	Total	FFC SPA	Total	FFC SPA
1	Beatrice Demonstrator	-	-	-	-	-	-	-	-	-	-
1	Greater Gabbard	0	0	0	0	387	10.5	84	2.8	471	13
1	Gunfleet Sands	0	0	0	0	30	0.8	0	0	30	1
1	Kentish Flats	-	-	-	-	-	-	-	-	-	-
1	Kentish Flats Extension	-	-	-	-	-	-	-	-	-	-
1	Lincs & LID	45	0	34	1.1	22	0.6	34	1.1	134	3
1	London Array	14	0	20	0.7	14	0.4	20	0.7	68	2
1	Scroby Sands	-	-	-	-	-	-	-	-	-	-
1	Sheringham Shoal	106	0	1343	45.7	211	5.7	30	1	1690	52
1	Teesside	16	0	61	2.1	2	0.1	20	0.7	99	3
1	Thanet	3	0	0	0	14	0.4	21	0.7	37	1
1	Humber Gateway	27	0	20	0.7	13	0.4	20	0.7	80	2
1	Westermost Rough	91	91	121	4.1	152	4.1	91	3.1	455	102
1	Hywind	30	0	719	24.4	10	0.3			759	25
2	Kincardine	22	0		0		0			22	0
2	Beatrice	873	0	833	28.3	555	15	833	28.3	3094	72
2	Dudgeon	256	0	346	11.8	745	20.1	346	11.8	1693	44
2	Galloper	44	0	43	1.5	106	2.8	394	13.4	587	18
2	Race Bank	28	0	42	1.4	28	0.8	42	1.4	140	4
2	Rampion	630	0	66	2.2	1244	33.6	3327	113.1	5267	149
2	Hornsea Project One	1109	534.5	4812	163.6	1518	41	1803	61.3	9242	800
3	Blyth Demonstration Project	121	0	91	3.1	61	1.6	91	3.1	364	8
3	Dogger Bank Creyke Beck A	1250	375	1576	53.6	1728	46.7	4149	141.1	8703	616
	Dogger Bank Creyke Beck B	1538	461.4	2097	71.3	2143	57.9	5119	174	10897	765
3	East Anglia ONE	16	0	26	0.9	155	4.2	336	11.4	533	17
3	European Offshore Wind Deployment Centre	161	0	64	2.2	7	0.2	26	0.9	258	3
3	Firth of Forth Alpha	5876	0			1103	29.8			6979	30
3	Firth of Forth Bravo	3698	0			1272	34.3			4970	34
3	Inch Cape	1436	0	2870	97.6	651	17.6			4957	115
3	Methil	4	0	0	0	0	0	0	0	4	0
3	Moray Firth (EDA)	2423	0	1103	37.5	30	0.8	168	5.7	3724	44
3	Neart na Gaoithe	331	0	5492	186.7	508	13.7			6331	200

Tier	Wind farm	Breeding season		Autumn migration		Nonbreeding season		Spring migration		Annual	
		Total	FFC SPA	Total	FFC SPA	Total	FFC SPA	Total	FFC SPA	Total	FFC SPA
3	Dogger Bank Teesside A	834	250.2	310	10.6	959	25.9	1919	65.2	4022	352
3	Dogger Bank Teesside B	1153	345.9	592	20.1	1426	38.5	2953	100.4	6125	505
3	Triton Knoll	40	0	254	8.6	855	23.1	117	4	1265	36
3	Hornsea Project Two	2511	1210.3	4221	143.5	720	19.4	1668	56.7	9119	1430
4	East Anglia THREE	1807	0	1122	38.1	1499	40.5	1524	51.8	5952	130
4	Moray West	2808	0	3544	120.5	184	5	3585	121.9	10121	247
4	Hornsea Project Three	630	0	2020	69	3649	99	2105	72	8404	240
5	Norfolk Vanguard	879	0	866	29.5	839	22.7	924	31.4	3508	84
5	Norfolk Boreas	630	0	263	8.9	1065	28.8	345	11.7	2303	49
5	East Anglia TWO	281	0	44.1	1.5	136.4	3.7	230	7.8	692	13
5	East Anglia ONE North	403	0	85	2.9	54	1.5	207	7	749	11
6	*Hornsea 4 (PEIR)*	*580*	*580*	*5960*	*202.6*	*685*	*18.5*	*1361*	*46.3*	*8586*	*847.4*
6	*Dudgeon Extension and Sheringham Extension (PEIR)*	*1064*	*0*	*4295*	*146*	*1310*	*35*	*420*	*14*	*7089*	*195*
	Total (all projects)	**33768**	**3848**	**45355**	**1542**	**26090**	**705**	**34312**	**1166**	**139523**	**7262**
	Total (minus Hornsea Project Four & Dudgeon and Sheringham Extensions)	**32124**	**3268**	**35100**	**1194**	**24095**	**651**	**32531**	**1106**	**123848**	**6220**

4.1 Gannet (NB 12 impact scenarios hence two log files)

Population Viability Analysis Parameter log

1 Set up

The log file was created on: 2021-08-04 12:40:50 using Tool version 2, with R version 3.5.1, PVA package version: 4.17 (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"
```

2 Basic information

This run had reference name “Gannet DI FFC SPA1_10”.
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: 50.
Years for burn-in: 0.
Case study selected: None.

3 Baseline demographic rates

Species chosen to set initial values: Northern Gannet.
Region type to use for breeding success data: Country.
Available colony-specific survival rate: National. Sector to use within breeding success region: England.
Age at first breeding: 5.
Is there an upper constraint on productivity in the model?: Yes, constrained to 1 per pair.
Number of subpopulations: 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.

4 Population 1

Initial population values: Initial population 26782 in 2025

Productivity rate per pair: mean: 0.7975 , sd: 0.06632258

Adult survival rate: mean: 0.919 , sd: 0.042

Immatures survival rates:

Age class 0 to 1 - mean: 0.424 , sd: 0.045 , DD: NA

Age class 1 to 2 - mean: 0.829 , sd: 0.026 , DD: NA

Age class 2 to 3 - mean: 0.891 , sd: 0.019 , DD: NA

Age class 3 to 4 - mean: 0.895 , sd: 0.019 , DD: NA

Age class 4 to 5 - mean: 0.919 , sd: 0.042 , DD: NA

5 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: 2026 to 2056

6 Impact on Demographic Rates

7 Scenario A - Name: mort277.9

8 All subpopulations

Impact on productivity rate mean: 0 , se: NA

Impact on adult survival rate mean: 0.01037637 , se: NA

9 Scenario B - Name: mort293

10 All subpopulations

Impact on productivity rate mean: 0 , se: NA

Impact on adult survival rate mean: 0.01094018 , se: NA

11 Scenario C - Name: mort326.5

12 All subpopulations

Impact on productivity rate mean: 0 , se: NA

Impact on adult survival rate mean: 0.01219102 , se: NA

13 Scenario D - Name: mort341.6

14 All subpopulations

Impact on productivity rate mean: 0 , se: NA

Impact on adult survival rate mean: 0.01275484 , se: NA

15 Scenario E - Name: mort51.6

16 All subpopulations

Impact on productivity rate mean: 0 , se: NA

Impact on adult survival rate mean: 0.001926667 , se: NA

17 Scenario F - Name: mort62.3

18 All subpopulations

Impact on productivity rate mean: 0 , se: NA

Impact on adult survival rate mean: 0.002326189 , se: NA

19 Scenario G - Name: mort70.9

20 All subpopulations

Impact on productivity rate mean: 0 , se: NA

Impact on adult survival rate mean: 0.0026473 , se: NA

21 Scenario H - Name: mort81.7

22 All subpopulations

Impact on productivity rate mean: 0 , se: NA

Impact on adult survival rate mean: 0.003050556 , se: NA

23 Scenario I - Name: mort329.5

24 All subpopulations

Impact on productivity rate mean: 0 , se: NA

Impact on adult survival rate mean: 0.01230304 , se: NA

25 Scenario J - Name: mort355.3

26 All subpopulations

Impact on productivity rate mean: 0 , se: NA

Impact on adult survival rate mean: 0.01326637 , se: NA

27 Output:

First year to include in outputs: 2026
Final year to include in outputs: 2056
How should outputs be produced, in terms of ages?: breeding.pairs
Target population size to use in calculating impact metrics: NA
Quasi-extinction threshold to use in calculating impact metrics: NA

Population Viability Analysis Parameter log

28 Set up

The log file was created on: 2021-08-04 12:50:11 using Tool version 2, with R version 3.5.1, PVA package version: 4.17 (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"
```

29 Basic information

This run had reference name “Gannet DI FFC SPA11_12”.
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: 50.
Years for burn-in: 0.
Case study selected: None.

30 Baseline demographic rates

Species chosen to set initial values: Northern Gannet.
Region type to use for breeding success data: Country.
Available colony-specific survival rate: National. Sector to use within breeding success region: England.
Age at first breeding: 5.
Is there an upper constraint on productivity in the model?: Yes, constrained to 1 per pair.
Number of subpopulations: 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.

31 Population 1

Initial population values: Initial population 26782 in 2025

Productivity rate per pair: mean: 0.7975 , sd: 0.06632258

Adult survival rate: mean: 0.919 , sd: 0.042

Immatures survival rates:

Age class 0 to 1 - mean: 0.424 , sd: 0.045 , DD: NA

Age class 1 to 2 - mean: 0.829 , sd: 0.026 , DD: NA

Age class 2 to 3 - mean: 0.891 , sd: 0.019 , DD: NA

Age class 3 to 4 - mean: 0.895 , sd: 0.019 , DD: NA

Age class 4 to 5 - mean: 0.919 , sd: 0.042 , DD: NA

32 Impacts

Number of impact scenarios: 2.

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: 2026 to 2056

33 Impact on Demographic Rates

34 Scenario A - Name: mort397.4

35 All subpopulations

Impact on productivity rate mean: 0 , se: NA

Impact on adult survival rate mean: 0.01483832 , se: NA

36 Scenario B - Name: mort423.3

37 All subpopulations

Impact on productivity rate mean: 0 , se: NA

Impact on adult survival rate mean: 0.01580539 , se: NA

38 Output:

First year to include in outputs: 2026
Final year to include in outputs: 2056
How should outputs be produced, in terms of ages?: breeding.pairs
Target population size to use in calculating impact metrics: NA
Quasi-extinction threshold to use in calculating impact metrics: NA

Population Viability Analysis Parameter log

1 Set up

The log file was created on: 2021-08-04 13:27:24 using Tool version 2, with R version 3.5.1, PVA package version: 4.17 (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"
```

2 Basic information

This run had reference name “Kittiwake DI FFC SPA1_8”.
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: 50.
Years for burn-in: 0.
Case study selected: None.

3 Baseline demographic rates

Species chosen to set initial values: Black-Legged Kittiwake.
Region type to use for breeding success data: Country.
Available colony-specific survival rate: National. Sector to use within breeding success region: England.
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: breeding.adults
Are baseline demographic rates specified separately for immatures?: Yes.

4 Population 1

Initial population values: Initial population 103070 in 2025

Productivity rate per pair: mean: 0.6826428 , sd: 0.3186818

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

5 Impacts

Number of impact scenarios: 8.

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: 2026 to 2056

6 Impact on Demographic Rates

7 Scenario A - Name: mort344.1

8 All subpopulations

Impact on productivity rate mean: 0 , se: NA

Impact on adult survival rate mean: 0.003338508 , se: NA

9 Scenario B - Name: mort358.1

10 All subpopulations

Impact on productivity rate mean: 0 , se: NA

Impact on adult survival rate mean: 0.003474338 , se: NA

11 Scenario C - Name: mort518.85

12 All subpopulations

Impact on productivity rate mean: 0 , se: NA

Impact on adult survival rate mean: 0.005033958 , se: NA

13 Scenario D - Name: mort532.85

14 All subpopulations

Impact on productivity rate mean: 0 , se: NA

Impact on adult survival rate mean: 0.005169788 , se: NA

15 Scenario E - Name: mort418.1

16 All subpopulations

Impact on productivity rate mean: 0 , se: NA

Impact on adult survival rate mean: 0.004056466 , se: NA

17 Scenario F - Name: mort432.1

18 All subpopulations

Impact on productivity rate mean: 0 , se: NA

Impact on adult survival rate mean: 0.004192296 , se: NA

19 Scenario G - Name: mort592.85

20 All subpopulations

Impact on productivity rate mean: 0 , se: NA

Impact on adult survival rate mean: 0.005751916 , se: NA

21 Scenario H - Name: mort606.85

22 All subpopulations

Impact on productivity rate mean: 0 , se: NA

Impact on adult survival rate mean: 0.005887746 , se: NA

23 Output:

First year to include in outputs: 2026
Final year to include in outputs: 2056
How should outputs be produced, in terms of ages?: breeding.pairs
Target population size to use in calculating impact metrics: NA
Quasi-extinction threshold to use in calculating impact metrics: NA

Population Viability Analysis Parameter log

1 Set up

The log file was created on: 2021-08-04 14:46:29 using Tool version 2, with R version 3.5.1, PVA package version: 4.17 (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"
```

2 Basic information

This run had reference name “Guillemot DI FFC SPA1_4”.
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: 50.
Years for burn-in: 0.
Case study selected: None.

3 Baseline demographic rates

Species chosen to set initial values: Common Guillemot.
Region type to use for breeding success data: Country.
Available colony-specific survival rate: National. Sector to use within breeding success region: England.
Age at first breeding: 6.
Is there an upper constraint on productivity in the model?: Yes, constrained to 1 per pair.
Number of subpopulations: 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.

4 Population 1

Initial population values: Initial population 90861 in 2025

Productivity rate per pair: mean: 0.7158556 , sd: 0.1317841

Adult survival rate: mean: 0.94 , sd: 0.025

Immatures survival rates:

Age class 0 to 1 - mean: 0.56 , sd: 0.058 , DD: NA

Age class 1 to 2 - mean: 0.792 , sd: 0.152 , DD: NA

Age class 2 to 3 - mean: 0.917 , sd: 0.098 , DD: NA

Age class 3 to 4 - mean: 0.938 , sd: 0.107 , DD: NA

Age class 4 to 5 - mean: 0.94 , sd: 0.025 , DD: NA

Age class 5 to 6 - mean: 0.94 , sd: 0.025 , DD: NA

5 Impacts

Number of impact scenarios: 4.

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: 2026 to 2056

6 Impact on Demographic Rates

7 Scenario A - Name: mort341.2

8 All subpopulations

Impact on productivity rate mean: 0 , se: NA

Impact on adult survival rate mean: 0.003755186 , se: NA

9 Scenario B - Name: mort349.7

10 All subpopulations

Impact on productivity rate mean: 0 , se: NA

Impact on adult survival rate mean: 0.003848736 , se: NA

11 Scenario C - Name: mort602.8

12 All subpopulations

Impact on productivity rate mean: 0 , se: NA

Impact on adult survival rate mean: 0.00663431 , se: NA

13 Scenario D - Name: mort611.3

14 All subpopulations

Impact on productivity rate mean: 0 , se: NA

Impact on adult survival rate mean: 0.006727859 , se: NA

15 Output:

First year to include in outputs: 2026
Final year to include in outputs: 2056
How should outputs be produced, in terms of ages?: breeding.pairs
Target population size to use in calculating impact metrics: NA
Quasi-extinction threshold to use in calculating impact metrics: NA

Population Viability Analysis Parameter log

1 Set up

51. The log file was created on: 2021-08-04 15:14:35 using Tool version 2, with R version 3.5.1, PVA package version: 4.17 (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"
```

2 Basic information

52. This run had reference name “Razorbill DI FFC SPA1_4”.
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: 50.
Years for burn-in: 0.
Case study selected: None.

3 Baseline demographic rates

53. Species chosen to set initial values: Razorbill.
Region type to use for breeding success data: Country.
Available colony-specific survival rate: National. Sector to use within breeding success region: England.
Age at first breeding: 5.
Is there an upper constraint on productivity in the model?: Yes, constrained to 1 per pair.
Number of subpopulations: 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.

4 Population 1

54. **Initial population values:** Initial population 30228 in 2025

Productivity rate per pair: mean: 0.6491944 , sd: 0.0918033

Adult survival rate: mean: 0.895 , sd: 0.067

Immatures survival rates:

Age class 0 to 1 - mean: 0.63 , sd: 0.067 , DD: NA

Age class 1 to 2 - mean: 0.63 , sd: 0.067 , DD: NA

Age class 2 to 3 - mean: 0.895 , sd: 0.067 , DD: NA

Age class 3 to 4 - mean: 0.895 , sd: 0.067 , DD: NA

Age class 4 to 5 - mean: 0.895 , sd: 0.067 , DD: NA

5 Impacts

55. Number of impact scenarios: 4.

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: 2026 to 2056

6 Impact on Demographic Rates

7 Scenario A - Name: mort86.38

8 All subpopulations

56. **Impact on productivity rate** mean: 0 , se: NA

Impact on adult survival rate mean: 0.002857615 , se: NA

9 Scenario B - Name: mort87.08

10 All subpopulations

57. **Impact on productivity rate** mean: 0 , se: NA

Impact on adult survival rate mean: 0.002880773 , se: NA

11 Scenario C - Name: mort100.9736

12 All subpopulations

58. **Impact on productivity rate** mean: 0 , se: NA

Impact on adult survival rate mean: 0.0033404 , se: NA

13 Scenario D - Name: mort101.6736

14 All subpopulations

59. **Impact on productivity rate** mean: 0 , se: NA

Impact on adult survival rate mean: 0.003363557 , se: NA

15 Output:

60. First year to include in outputs: 2026
Final year to include in outputs: 2056
How should outputs be produced, in terms of ages?: breeding.pairs
Target population size to use in calculating impact metrics: NA
Quasi-extinction threshold to use in calculating impact metrics: NA