East Anglia TWO and East Anglia ONE North Offshore Windfarms

Applicant's Comments on Relevant Representations

Appendix 4
Offshore Ornithology Precaution Note

Applicant: East Anglia TWO Limited
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Applicable to East Anglia ONE North and East Anglia TWO

Revision Summary				
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Glossary of Acronyms

BDMPS	Biologically Defined Minimum Population Size
CI	Confidence Interval
CIA	Cumulative Impact Assessment
CoP	Construction Plan
CPS	Counterfactual of Population Size
CRM	Collision Risk Modelling
DCO	Development Consent Order
DML	Deemed Marine Licence
DSLP	Development Specification and Layout Plan
EATL	East Anglia THREE Ltd
EIA	Environmental Impact Assessment
ES	Environmental Statement
ETG	Expert Topic Group
HRA	Habitats Regulations Assessment
JNCC	Joint Nature Conservation Committee
LBBG	Lesser Black-Backed gull
MHWS	Mean High Water Springs
MMO	Marine Management Organisation
MS-LOT	Marine Scotland Licensing Operations Team
NAF	Nocturnal Activity Factor
NE	Natural England
ORJIP	Offshore Renewables Joint Industry Project
PEIR	Preliminary Environmental Information Report
PINS	Planning Inspectorate
PVA	Population Viability Analysis
RSPB	Royal Society for the Protection of Birds
SNCB	Statutory Nature Conservation Authority
SPA	Special Protection Area
UK	United Kingdom

Glossary of Terminology

Applicant	East Anglia TWO Limited
East Anglia ONE North project	The proposed project consisting of up to 67 wind turbines, up to four offshore electrical platforms, up to one construction operation and maintenance platform, inter-array cables, platform link cables, up to one operational meteorological mast, up to two offshore export cables, fibre optic cables, landfall infrastructure, onshore cables and ducts, onshore substation, and National Grid infrastructure.
East Anglia TWO project	The proposed project consisting of up to 75 wind turbines, up to four offshore electrical platforms, up to one construction operation and maintenance platform, inter-array cables, platform link cables, up to one operational meteorological mast, up to two offshore export cables, fibre optic cables, landfall infrastructure, onshore cables and ducts, onshore substation, and National Grid infrastructure.
East Anglia TWO windfarm site /	The offshore area within which wind turbines and offshore platforms will be located.
East Anglia ONE North windfarm site	The offshore area within which wind turbines and offshore platforms will be located.
Generation Deemed Marine Licence (DML)	The deemed marine licence in respect of the generation assets set out within Schedule 13 of the draft DCO.
Inter-array cables	Offshore cables which link the wind turbines to each other and the offshore electrical platforms, these cables will include fibre optic cables.
Natura 2000 site	A site forming part of the network of sites made up of Special Areas of Conservation and Special Protection Areas designated respectively under the Habitats Directive and Birds Directive.
Offshore cable corridor	This is the area which will contain the offshore export cables between offshore electrical platforms and landfall.
Offshore development area	The East Anglia TWO windfarm site and offshore cable corridor (up to Mean High Water Springs).
Offshore export cables	The cables which would bring electricity from the offshore electrical platforms to the landfall. These cables will include fibre optic cables.
Offshore infrastructure	All of the offshore infrastructure including wind turbines, platforms, and cables.
Offshore platform	A collective term for the construction, operation and maintenance platform and the offshore electrical platforms.
Safety zones	A marine area declared for the purposes of safety around a renewable energy installation or works / construction area under the Energy Act 2004.
Scour protection	Protective materials to avoid sediment being eroded away from the base of the foundations as a result of the flow of water.
Transmission DML	The deemed marine licence in respect of the transmission assets set out within Schedule 14 of the draft DCO.

Executive Summary

Ornithology impact assessment for offshore windfarms is based on extensive surveys, data analysis and modelling. The marine environment is inherently highly variable and many of the analytical methods used make allowance for the associated uncertainties, through the estimate of variance around central point estimates. It is very important that these uncertainties are given consideration in impact assessment and considered as part of decision-making.

The approach to impact assessment (e.g. estimation of the baseline population size, the estimation of magnitude of impacts and the subsequent estimation of population consequences) means that there is a tendency to add precaution, or make precautionary assumptions within the estimations made at each stage of the assessment by focussing attention on the upper limits of each estimate. The end result is that the final impact conclusion is based on considerable over-estimation. This is then further compounded when individual project level impacts and their inherent precaution are added together in cumulative and in-combination assessments.

This note presents a discussion of the sources of uncertainty that lead to precaution in ornithological impact assessments, including; survey methods, data analysis, impact modelling methods and assumptions, including the issue of consented versus 'as built' projects designs, in cumulative assessment. Specific examples using data from the East Anglia TWO and East Anglia ONE North project (the Projects) assessments are used to illustrate these aspects. These examples highlight the scale of precaution that has been applied to the impact assessment as a result of following the advice received from Natural England throughout the Environmental Impact Assessment (EIA) and Habitats Regulations Assessment (HRA) processes. This has demonstrated the differences in the conclusions of an assessment based on appropriate levels of precaution with those when multiple sources of precaution are combined.

This report demonstrates that for project-alone assessments, the use of evidence-based parameters not currently accepted by Natural England, could result in reductions of over two thirds for estimated gannet mortalities. If 'as-built' project designs are used to estimate cumulative collision risk mortalities, then this change alone could result in reductions of over a third of estimated gannet mortalities. Reductions are also possible for other impacts such as displacement and the report provides several examples.

Whilst the Applicant acknowledges that the statutory agency advice has been revised with respect to individual parameters used in the assessments, reflecting new evidence (e.g. the advised collision avoidance rate for large gulls was raised from 98% to 99.5% following a detailed review study by the British Trust for Ornithology, Cook et al. 2014), and more recently Natural England has acknowledged that nocturnal activity rates used in the collision models are likely to be over-estimated for some species. However, it is clear that considerable precaution remains, particularly when the impact assessment process is viewed as a whole and there remains a need to review and improve the methods for incorporating uncertainty so as to avoid over-inflation of precaution. With respect to the Projects' assessments it is therefore very important to consider the extent of precaution applied to individual elements (following the methods advised by Natural England) and how these individual precautions have been combined throughout the assessment to reach highly over-precautionary totals.

1 Introduction

1. Offshore windfarms have the potential to adversely affect seabirds in two key ways. Avoidance of offshore infrastructure by birds can result in them having to make longer journeys to reach foraging areas or displace them from existing foraging areas. There is also potential for birds to die as a result of collision with wind turbines.

2. In EIA, the assessment of the significance of impacts of seabird displacement and collision effects is a staged process involving:

   - Data collection and analysis to estimate baseline populations at risk;
   - Detailed analysis and modelling to estimate the potential number of birds which could be affected (i.e. the magnitude of impact); and
   - Consideration of the population consequences of the predicted impact, using methods such as population viability analysis (PVA) (i.e. the significance of the impact).

3. Throughout this process there are several sources of uncertainty, including; the way in which survey data is interpreted to estimate seabird density and population sizes (e.g. extrapolation, boot-strapping and statistical spatial modelling); estimated values for seabird flight characteristics to be used in collision risk modelling (CRM) (e.g. flight height ranges, collision avoidance rates, body length etc.); and in demographic rates used in PVA models. Given the uncertainty for each of these, a level of precaution is added to every step.

4. This report provides an overview of recent relevant studies on precaution (e.g. the Skov et al. (2018) bird collision and avoidance study) and specific examples of precaution within the Projects' assessments.

5. There is increasing awareness and appreciation within the offshore wind industry that it is strategically important to consider these (and other) uncertainties in the assessment process, particularly when considered in the context of cumulative impacts (or effects in a Habitats Regulations Assessment (HRA) context) on seabirds resident in Special Protection Areas (SPAs). However, from a statutory nature conservation body (SNCB) perspective, it is necessary to apply the precautionary principal, where there is uncertainty, when determining whether or not it is possible to rule, beyond reasonable scientific doubt and in light of the best scientific knowledge in the field, that the proposal, with any required mitigation measures, will not have an adverse effect on the integrity of the SPA in question.

6. Together, these requirements can result in a tendency for assessments to focus on impacts derived from combined upper confidence estimates and worst case scenarios. Precaution applied due to uncertainty at the Project level that drives for example, the need to monitor the predictions made, is understandable. However, the aggregation of project level precaution in cumulative assessments which combine the estimated impacts of many projects (the Projects' cumulative assessments considered up to 39 projects) means the likelihood that the overall impact magnitude is not a substantial over-estimate is extremely small.

7. The inherent variability in the marine environment and the difficulty associated with data gathering means some aspects of offshore ornithology impact assessment will always be uncertain.

8. In the impact assessments submitted for the Projects, the instances of over-precaution in the methods and assumptions have been highlighted and discussed. The purpose of this paper is to explain in further detail the nature of those precautions and how they combine to affect the results of the assessment when compared with the results obtained through the adoption of more proportionate approaches to expressing combinations of uncertainty whilst still ensuring assessments are precautionary.

9. The following sections consider the sources of precaution and uncertainty through each stage of the process, including; survey data collection and analysis, collision risk modelling, displacement assessments and cumulative assessments based on consented rather than as-built project designs. The overall effect of combining all of these sources of precaution is illustrated with examples from the Projects in ***section 4***.

2 Sources of Uncertainty

2.1 Survey Data

10. The current Natural England recommended approach to collecting survey data is to designate a buffer (usually 4km) around the boundary of the offshore windfarm site and conduct boat-based or aerial surveys (lately aerial surveys collecting digital images has been the approach taken by developers). Surveys are undertaken each month for a minimum of two seasons which generally equates to 24 months where both the summer and winter seasons are scoped into the assessment. Surveys follow a series of transects spread out in order to collect data across the entire site at a sampling rate of between 10% and 20%, i.e. this is the percentage of the entire site which is observed during each survey. The number of each species observed on each survey is divided by the area surveyed to obtain the density for that survey.

11. It is assumed that the density estimate for that particular species is applicable across the entire site and is therefore multiplied by the total area to obtain abundance estimates (while spatial modelling is sometimes used to investigate finer scale variations within the survey area, this approach typically yields very similar overall abundance estimates and is therefore not commonly applied). These estimates then form the basis of the species-specific displacement and collision risk assessments by determining the likely population at risk of impacts (i.e. within the windfarm site and 4km buffer).

12. ***Plate 1*** illustrates that there can be large between-year variation in results and highlights why two seasons of data are deemed necessary for assessment. This factor itself, i.e. natural variability, introduces uncertainty to the baseline and therefore leads to the need for statistical treatment of the data to provide a density estimate that takes account of this variability.

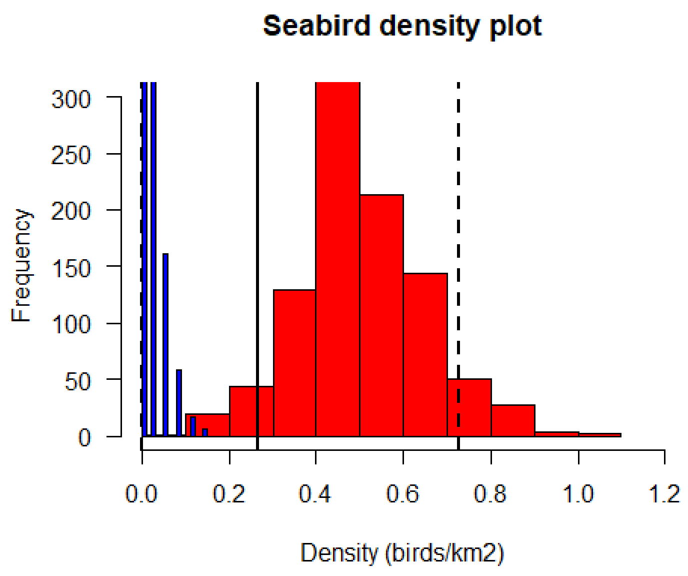

Plate 1 Kittiwake density data. Each coloured histogram is the bootstrapped sample for November (blue: 2016, red: 2017) for kittiwakes recorded in flight in surveys of East Anglia ONE North. The vertical black line is the overall mean density (solid) and the dashed lines are the 95% confidence intervals, estimated across all the data.

14. For digital aerial still images such as those collected across the Projects' windfarm sites, confidence intervals for each species were obtained using a bootstrap resampling method, as agreed with Natural England through the Evidence Plan Process. This method consists of randomly drawing images from the dataset until the same number of images as the original sample is obtained. For example, if the survey for a particular month comprised 350 images (each with a count of the seabirds recorded), the resampled dataset will also contain 350 images, drawn with replacement from the original dataset (note that 'with replacement' means that after each image has been 'selected' it is returned to the dataset and can therefore be drawn again. This is how the bootstrap method generates variation). The 'new' dataset was then analysed in exactly the same manner as the original one to obtain density and abundance estimates for each species. This process was repeated 1,000 times and the density and abundance calculated for each resampled dataset. The upper and lower 95% confidence limits were calculated across the 1,000 samples to estimate sampling variation. The width of the confidence interval (CI) obtained using this method reflects the degree of aggregation in the species, with highly aggregated species estimated with lower precision (i.e. species observed frequently as individuals will have a small range of estimated densities, while species recorded in occasional large groups will have a wide range of estimated densities).

15. Density estimates include upper and lower CIs and while there is a tendency to focus on the upper to ensure precaution, it should be highlighted that statistically

this value is no more representative of the 'real value' than the lower 95% (CI). Nonetheless, the use of the upper 95% CI on density (which is, at the time of writing, the currently recommended approach to represent uncertainty) can be heavily influenced by variation in data.

16. It is apparent from the data presented in ***Plate 1*** where the upper 95% CI is heavily influenced in this example by the second year of data, while the mean provides a more representative value for both years. This example illustrates that, by using the 95% CI value as the basis of the density for this species, we are potentially over-estimating the number of birds present from the outset of the assessment. In this case, by using the 95% CI there are over double the number of birds present when compared to the mean (and therefore potentially at risk of impact). Therefore, all assessment following on is based on a worst-case position (and potentially an unrepresentative worst case) and this should be reflected when drawing conclusions for a particular impact.

2.2 Collision Risk Modelling

17. As discussed above, seabird density is a key input parameter in the Band collision risk model which is the accepted model for estimating collision risk. The assessment is based on collision risk for each key seabird species from the Band CRM Option 2. For the Projects' assessments, CRM was run using the deterministic Band model (Band 2012). Because many of the CRM input parameters include both natural variation (e.g. seabird densities) and measurement error, multiple runs of the model were made for each species using mean values and upper and lower intervals for: flight density (upper and lower 95% confidence intervals); avoidance rate (standard deviations); and proportions at collision height (based on the generic dataset in Johnston et al. 2014a, 2014b)[1]. In addition, for some species, rates of nocturnal activity were varied, namely, gannet (Furness et al. 2018b), kittiwake, lesser black-backed gull, great black-backed gull and herring gull with Natural England acknowledging in their Relevant Representation response that gull nocturnal activity is over-estimated. Subsequently, collision predictions were provided for the mean estimates and the upper and lower confidence values for each of these parameters separately. Natural England requested (see ***Appendix 12.1*** (APP-469) of ***Chapter 12 Offshore Ornithology***) this approach on the basis that this enables uncertainty to be taken into account.

[1] Following a review of their data collection and analysis methods, the aerial survey contractors advised Scottish Power that the flight height estimates were not sufficiently reliable for use in CRM. Consequently, and in agreement with Natural England, the collision mortalities used for impact assessment were those calculated using Option 2 of the Band model however the collision estimates for Band CRM Option 1 were also included in ***Appendix 12.2*** of ***Chapter 12 Offshore Ornithology*** (APP-470) (for information only as agreed through the ETG).

18. In order to capture uncertainty in a more realistic manner, it is widely accepted that a simulation based approach, such as a stochastic approach, to CRM is required, whereby the model is run repeatedly (e.g. 1,000 times) with input parameters for each iteration of the model drawn at random from appropriate probability distributions. This generates outputs which are also expressed as probability distributions from which the mean and 95% confidence intervals can be calculated.

19. A stochastic version of the Band collision model (sCRM) is now available[2]. However, at the time the assessment was undertaken for the Projects and when this precaution note was submitted, the use of this model for windfarm assessments was still subject to discussion between the statutory nature conservation agencies and regulators, due to differences in how flight height data are treated in the stochastic CRM (sCRM) and in the deterministic Band model. The stochastic version of the Band model differs from the deterministic (Band spreadsheet) one as it allows inputs to be specified as values with a mean *and* standard deviation, rather than simply as the mean (and for some inputs a sampled probability distribution can be included). This therefore makes it possible to incorporate allowance for both natural variations (e.g. in wingspan) and parameter uncertainty (e.g. in avoidance rates) in the input parameters. The model runs multiple simulations from which summary outputs calculated across the simulations can then be presented (e.g. as median or confidence interval values) which incorporate the uncertainty in all the parameters simultaneously. If seabird densities, such as those presented in ***Plate 1*** are used then the outputs will reflect the underlying observations and enable a more transparent presentation and understanding of the uncertainty in the collision estimates than is currently possible based on the mean and 95% CI.

2.2.1 Precaution in CRM Avoidance Rates

20. Throughout the EIA process, discussions with Natural England and the RSPB at Expert Topic Group (ETG) meetings were undertaken to agree the most suitable avoidance rates to be used in the assessment of collision.

21. Recent work on avoidance rates for offshore windfarms suggests that the rates currently recommended by Natural England are over precautionary. For example, the current recommended avoidance rate for gannet is 98.9%. A study on gannet behaviour in relation to offshore windfarms (APEM 2014) gathered evidence which suggests that, during the autumn migration period, an overall wind turbine avoidance of 100% was more appropriate, although a suitably precautionary rate of 99.5% was proposed (for the autumn period at least). This indicates that gannet collision mortality estimated at 98.9% is likely to greatly overestimate the

[2] https://www2.gov.scot/Topics/marine/marineenergy/mre/current/StochasticCRM/fullreport

risk for this species. Indeed, as noted in Cook et al. (2014), all the recommended avoidance rates remain precautionary.

22. More recently, a bird collision avoidance study, funded by ORJIP, was conducted at Thanet Offshore Windfarm, between 2014 and 2016. A detection system of daylight and thermal imaging cameras recorded only six collisions of birds with rotor blades during the course of the study. These were all gulls (not all identified to species), including one kittiwake. The study provides further evidence relating to the precautionary nature of current avoidance rates and other parameters used in windfarm assessment (Skov et al. 2018). The empirical avoidance rates estimated for five seabird species are as follows: 99.9% for gannet and herring gull, 99.8% for kittiwake and lesser black-backed gull, and 99.6% for great black-backed gull (Skov et al. 2018). The predicted collision rate for gannet is consistent with the findings of the APEM (2014) study reported above, and all other empirical avoidance rates are higher than the rates currently recommended by Natural England for CRM for a given species.

23. Bowgen and Cook (2019) reviewed the findings of the above study, and recommended avoidance rates for use in the Band model of 99.5% for gannets and large gulls, and 99.0% for kittiwake (noting that these updated rates were still considered by the authors to retain precaution). Thus, for gannet and kittiwake these indicate higher avoidance than recommended by the JNCC (2014) guidance. The application of these higher rates to the assessment for the Projects was discussed at ETG meetings in January and June 2019. Natural England advised that collision risk estimates with these rates could be presented alongside those recommended by SNCBs for the assessment. For gannet and kittiwake, the assessment of collision risk therefore presents two avoidance rates, from JNCC (2014) and Bowgen and Cook (2019). Use of the more realistic, evidence based avoidance rate reduces the estimated collisions by 55.6% for gannet and 10.1% for kittiwake when taking the East Anglia TWO project alone results as an example.

24. However, although Natural England did concede at the ETG meetings that the higher avoidance rates were appropriate for projects in the same region as the ORJIP work (i.e. the Outer Thames Estuary including the former East Anglia Zone) they did not wish to see these rates applied retrospectively to projects in the cumulative assessment. Therefore, whilst for the Projects' assessments, a more realistic number of collisions is provided, this is not applied cumulatively. The tables below provide a comparison of the collision mortality estimates based on the SNCB avoidance rates and those recommended in Bowgen and Cook (2019) for gannet and kittiwake at both the Project (East Anglia TWO (see ***Table 2.1***) and East Anglia ONE North (see ***Table 2.2***) and cumulative level.

Table 2.1 Comparison of the Collision Mortality Estimates using deterministic CRM Based on NE Recommended Avoidance Rates and Bowgen and Cook recommended Avoidance Rates for Gannet and Kittiwake at the Project and Cumulative Level for East Anglia TWO.

Species	Avoidance rate (%)	Mean Annual East Anglia TWO Project Collisions	Mean Annual Cumulative Collisions
Gannet	98.9 (NE recommended)	47.02	2,576 (Common Currency[3])
	99.5 (Bowgen and Cook, 2019)	21.37	1,171[4]
Kittiwake	98.9 (NE recommended)	49.93	3,847 (Common Currency)
	99.0 (Bowgen and Cook, 2019)	45.39	3,497

Table 2.2 Comparison of the Collision Mortality Estimates using deterministic CRM Based on NE Recommended Avoidance Rates and Bowgen and Cook recommended Avoidance Rates for Gannet and Kittiwake at the Project and Cumulative Level for East Anglia ONE North

Species	Avoidance rate (%)	Mean Annual East Anglia ONE North Project Collisions	Mean Annual Cumulative Collisions
Gannet	98.9 (NE recommended)	27.27	2,576 (Common Currency[5])
	99.5 (Bowgen and Cook, 2019)	12.40	1,171[6]
Kittiwake	98.9 (NE recommended)	57.99	3,847 (Common Currency)
	99.0 (Bowgen and Cook, 2019)	52.72	3,497

25. This example clearly demonstrates the sensitivity of the assessment to one parameter (the avoidance rate) and how even small changes to this can greatly affect the assessed impact. If it is acceptable to present the results with the Bowgen and Cook (2019) avoidance rates for the project alone and these are

[3] Crown Estate Database which provides frequent updates of the current status of windfarms as they progress to construction and the subsequent updates to cumulative collision mortality estimates.
[4] To do this you need to calculate the old and new mortality rates (at each avoidance rate), that is 1-0.989 for the current and 1-0.995 for the new one. The ratio of these gives you the adjustment. From 98.9 to 99.5 the ratio is (1-0.995) / (1-0.989) = 0.454. Old CRM total (2576) x 0.454 = 1171.
[5] Crown Estate Database which provides frequent updates of the current status of windfarms as they progress to construction and the subsequent updates to cumulative collision mortality estimates.
[6] To do this you need to calculate the old and new mortality rates (at each avoidance rate), that is 1-0.989 for the current and 1-0.995 for the new one. The ratio of these gives you the adjustment. From 98.9 to 99.5 the ratio is (1-0.995) / (1-0.989) = 0.454. Old CRM total (2576) x 0.454 = 1171.

considered credible, it is reasonable to estimate how this might affect the cumulative totals and consider that within the wider judgement on significance.

2.2.2 Nocturnal Activity Factors (NAFs)

26. The nocturnal activity parameter used in the CRM defines the level of nocturnal flight activity of each seabird species, expressed in relation to daytime flight activity levels. For example, a value of 50% for the nocturnal activity factor is appropriate for a species which is half as active at night as during the day. This factor is used to enable estimation of nocturnal collision risk from survey data collected during daylight, with the total collision risk the sum of those for day and night. The values typically used for each species were derived from reviews of seabird activity reported in Garthe and Hüppop (2004). This review ranked species from 1 to 5 (1 low, 5 high) for relative nocturnal activity, and these were subsequently modified for the purposes of CRM into 1 = 0% to 5 = 100%. This approach was not anticipated by Garthe and Hüppop (2004), who considered that their 1 to 5 scores were simply categorical and were not intended to represent a scale of 0 to 100% of daytime activity (not least because the lowest score given was 1 and not 0). This is clear from their descriptions of the scores: for example, for score 1 'hardly any flight activity at night'.

27. Recently however, a number of studies have deployed loggers on seabirds, and data from those studies can provide empirical evidence of the actual nocturnal flight activity level. These studies indicate that the nocturnal activity rates derived from Garthe and Hüppop (2004) almost certainly overestimate the levels of nocturnal activity in the species studied.

28. As the relative proportion of daytime to night-time varies considerably during the year at the UK's latitude, the effect of changes in the nocturnal activity factor for CRM outputs depends on the relative abundance of birds throughout the year. The extent of mortality reduction obtained by reducing the categorical score for five species (gannet, kittiwake, lesser black-backed gull, herring gull and great black-backed gull) by 1 (i.e. from 3 to 2 for kittiwake) has been investigated previously (EATL 2015). This work revealed annual mortality estimate reductions of between 14.5% (lesser black-backed gull) and 27.7% (gannet). This indicated that current nocturnal activity factors based on arbitrary conversions of Garthe and Hüppop (2004) scores into percentages are over-estimated, and consequently CRM outputs are highly precautionary in this regard.

29. Another study which aimed to more accurately estimate nocturnal activity for gannet, by undertaking a review of evidence from tracking studies also suggests the current recommended rates are precautionary (Furness et al. 2018b). This study recommended precautionary nocturnal flight activity rates for gannet in the breeding and non-breeding seasons of 8% and 4% respectively (based upon actual average rates from the study of 7.1% and 2.3% respectively). Furthermore,

the breeding season value was very heavily influenced by the results from the smallest study in the review, which was based on three tagged birds in Shetland (Garthe et al. 1999). That study yielded a nocturnal activity rate of 20.9% (compared to daytime) but the total duration of flight activity recorded was 215 hours, which was less than 3% of the >8,000 hours covered by the remaining studies. If the average rate were to be calculated without this study, a breeding season rate of 4.3% would be obtained. Thus, the recommended rates of 8% and 4% are arguably still precautionary.

30. For kittiwake, a review and analysis of activity data from tracking studies (Furness et al. in prep.) has identified nocturnal activity rates for the breeding and non-breeding seasons respectively of 20% and 17% based on empirical evidence. This suggests that the lower limit of 25% as applied in the CRM, is precautionary.

31. In the light of this, advice from Natural England in their Section 42 comments on the PEIR indicated that CRM should use the less precautionary upper and lower nocturnal activity rates of 0% and 25% for gannet and 25% and 50% for kittiwake, lesser black-backed gull, great black-backed gull and herring gull, rather than just the higher value as used previously.

32. Reducing the nocturnal activity factor to 25% reduced collision estimates for kittiwake at East Anglia TWO by around 15.4%. Applying the same approach to other windfarms in the cumulative assessment would reduce the cumulative collision estimate by a significant amount (e.g. between 7% and 25%; note the magnitude of reduction varies depending on the time of year and windfarm latitude due to the variation in day and night length). However, in line with Natural England's recommendation, a retrospective correction for nocturnal activity applied across all projects in the cumulative assessment was not undertaken. This further emphasises the precautionary nature of the current assessment.

33. ***Table 2.3*** provides a comparison of the collision mortality estimates based on different nocturnal activity rates for the East Anglia TWO project. It should be noted that in the Projects' assessments, while various NAF rates were presented, the higher (i.e. more precautionary) NAF rates were used as the basis for assessment of each species.

Table 2.3 Comparison of Collision Mortality Estimates Based on Different Nocturnal Activity Rates for the East Anglia TWO Project Including the Percentage Reduction Achieved if the Lower Rates are Used

Species	Standard and Reduced Nocturnal Activity rates (%)	Collision Mortality Estimate	Percentage Reduction in Collisions if Reduced Nocturnal Activity Rate is Used (%, compared with current rate)
Gannet[7]	25	47.02	-
	8 -4%	37.59	20.0
	0	35.4	24.7
Kittiwake	50	49.93	-
	25	42.22	15.4
Lesser black-backed gull	50	5.18	-
	25	4.55	12.2
Herring gull	50	0.52	-
	25	0.44	15.4
Great black-backed gull	50	7.56	-
	25	6.37	15.7

34. It is clear then that while steps have been taken to reduce the overly precautionary nature of collision risk assessments e.g. through reduction in nocturnal flight activity rates, it is likely that many of these inputs and assumptions remain precautionary.

2.3 Consented and 'As-built' designs

2.3.1 Cumulative totals and headroom

35. Cumulative collision estimates are made up of the worst case mortality estimates (i.e. those based on the worst case turbine design parameters which feed into CRM) for each windfarm included in the assessment. These figures are taken from either the Environmental Statement (ES), Development Consent Order (DCO) (England and Wales), Section 36 Consent (Scotland), non-material change (NMC) application (England), varied Section 36 Consent (Scotland) or Planning Inspectorate Examination responses.

36. Windfarm applications are generally submitted at an early stage in the project design process at which point developers are unlikely to know the precise nature of the design of the windfarm. This includes for example, the number of turbines,

[7] Note that evidence-based values from Furness et al. 2018 of 8% flying activity during the breeding season (March to September) and 4% flying activity at night for gannet during the nonbreeding season (October to February) were provided..

their height above sea surface (i.e. mean high water springs (MHWS)) rotor diameters etc which all inform CRM. The approach to assessments is therefore based on an envelope of turbine parameters, known as a 'Rochdale Envelope', which provides flexibility within the consent for the final project design and ensures that developers can deploy the most up-to-date technologies. This has been a key driver in reducing costs and has helped to lower the environmental impact per MW by reducing the number of turbines required (and therefore the total rotor swept area).

37. Recently constructed windfarms (particularly those in Rounds 2 and 3) have rarely installed the total consented number or smallest model of turbines permitted within the consent because the total generating capacities can now be achieved with fewer, larger turbines which do not represent the worst case scenario. A larger number of smaller, faster rotating turbines usually results in higher collision risks than fewer, larger turbines and therefore determines the worst case scenario for assessment. This is important for cumulative collision estimations since the re-calculated collision estimates for 'as built' projects tend to be significantly lower than those for the consented design. For example, East Anglia ONE was originally assessed on the basis of 333 wind turbines, consented on the basis of up to 240 where HVDC transmission infrastructure is used and 150 where HVAC technology is deployed and has been constructed with 102. Thus, the final windfarm will have less than one third the original number of proposed (and assessed) wind turbines. Taking another example, during the Norfolk Vanguard examination a 10% reduction in predicted collision was achieved with a relatively small change in minimum turbine capacity (from 9MW to 10MW). The change in number of turbines between consented and 'as built' is often considerably greater than this, with correspondingly much larger reductions in collision risk estimates. Similar reductions are likely for other consented windfarms which have not yet been built. This is likely to further reduce the magnitude of both collision and displacement effects.

38. The Applicant has captured these differences in ***Appendix 12.3*** of ***Chapter 12 Offshore Ornithology*** (APP-471). ***Appendix 12.3*** presents the cumulative totals used in the assessment of several species alongside 'theoretical' totals for these species. The cumulative totals are generated by addition of the collision estimates for each species based upon universally accepted collision estimates for each project (i.e. the numbers which are presented in ESs, DCOs, non-material change or varied Section 36 Consents). For avoidance of doubt it is these totals that are used in the ES (and translated into the HRA) for undertaking the assessment. The 'theoretical' totals use the same numbers, but where there are known to be updates for projects for which no 'official' information is available (i.e. not covered by one of the aforementioned legally binding consents) these

numbers are used instead. Examples of projects for which no ‘official’ information is available include:

- Projects which have been constructed within the worst case assumptions of the existing consent but for which no updated ornithological assessment is available (e.g. Triton Knoll which had a NMC change from the original 288 to 90 turbines without updating the modelling); and
- Projects where a revised consent is expected but has not been determined (e.g. Seagreen).

39. By way of example, for Triton Knoll, a reduction in mortality of 151 kittiwakes would be achieved if the as built (i.e. NMC 90 turbine consent) parameters were used in the CRM as opposed to the parameters from the original consent. Across all projects ***Appendix 12.3*** of ***Chapter 12 Offshore Ornithology*** (APP-471) demonstrates that reductions in cumulative collision estimates of up to 28% could be achieved if these ‘theoretical’ totals were used in impact assessments. Moreover, it should be noted that, while a new worst case design for Seagreen Alpha and Bravo (Seagreen A+B) combined is yet to be consented, further reductions have since been achieved following an update to the ornithological assessment (see ***paragraph 43***).

40. Furthermore, a study by Trinder (2017) undertaken to investigate the overall scale of reduction for key species, identified reductions of up to 40% between the cumulative total based on the consented parameters of over 30 windfarms (i.e. the worst case) and the total which reflects the parameters used at ‘as built’ windfarms. The study presented a robust and straightforward method for undertaking this calculation based on the ratio of the key turbine parameters (consented to ‘as built’) used in CRM to calculate adjustment rates for each species for each windfarm. This work is the basis of the ‘Common Currency’ database supported by The Crown Estate which provides frequent updates of the current status of windfarms as they progress to construction.

41. While Natural England are aware of this work and that provided in ***Appendix 12.3*** of ***Chapter 12 Offshore Ornithology*** (APP-471), and have acknowledged that there will be some headroom in cumulative and in-combination assessments (noting that the extent of any potential headroom is not yet agreed)[8][9], they are

[8] Natural England Deadline 6 Submission - Comments on Norfolk Boreas approach to as-built vs consented turbine numbers and headroom in cumulative/in combination collision assessments https://infrastructure.planninginspectorate.gov.uk/wp-content/ipc/uploads/projects/EN010087/EN010087-001760-DL6%20-%20NE%20-%20Comments%20on%20Headroom.pdf
[9] Natural England, 2020. Deadline 9 Natural England’s Updated Offshore Ornithology Advice Norfolk Boreas. Available at: https://infrastructure.planninginspectorate.gov.uk/wp-content/ipc/uploads/projects/EN010087/EN010087-002099-EN010087_Boreas_D9_13_Updated%20Ornithology%20advice.pdf

reluctant to accept the 'as built' numbers for any given windfarm within cumulative impact assessments due to the perceived absence of legal certainty around the ability of developers to build out to their consented design envelopes after projects have been commissioned with a revised design.

42. To demonstrate the potential reductions in collision estimates that could be achieved if the theoretical cumulative collision estimate totals were used as opposed to those based on original consents, an example for gannet is provided.

43. For the EIA, the cumulative collision total (for the Projects) was 2,607. This assumed collisions from Seagreen A&B of 915.9. For the 'Theoretical total' shown in ***Appendix 12.3*** of ***Chapter 12 Offshore Ornithology*** (APP-471), the assumption was that Seagreen A&B collisions would reduce to 502 (based upon estimates of Seagreen A&B collisions from the Inch Cape updated EIA). When combined with potential reductions at other projects for which Natural England does not consider there to be legal certainty, the theoretical total was calculated as 1896.1. This shows a potential reduction of 27.3% of the assessed cumulative total.

44. Updated collision mortality figures for a revised design envelope for Seagreen A & B (Seagreen Ltd, 2019) are now available which were not available at the time of the Projects' EIAs. In the updated assessment (Seagreen Ltd, 2019)[10], the total gannet collisions for Seagreen A & B is 246. If this was included in the 'theoretical total', the cumulative collisions would fall to 1640, a reduction of 37% on the total used in the EIA for the Projects.

45. Whichever cumulative total is used for gannet or kittiwake (whether that presented in the Projects' EIAs or the 'theoretical total' presented in ***Appendix 12.3***, or indeed any further refinement to that), all are lower than the consented cumulative totals presented for East Anglia THREE. East Anglia THREE was the most recently consented project in England (in 2017). The total cumulative gannet number was 2,919[11]. The total cumulative kittiwake number was 3,515[11]. When considering the cumulative totals presented in the Projects' EIAs (i.e. 2,607 for gannet and 2,534.9 for kittiwake – see ***Appendix 12.3*** of ***Chapter 12 Offshore Ornithology*** (APP-181)) these represent reductions of 10.7 and 8.7% for gannet and kittiwake respectively below these previously consented levels.

[10] Note that at the time of writing the revised design envelope for Seagreen A & B remains unconsented.
[11] This is based upon the totals presented in Table 8 in the Deadline 5 submission updating the CRM. This also substitutes for Natural England's preferred case of 150 turbines over the 102 turbine version of East Anglia ONE which is the version presented in the Table.
Using this approach, the consented kittiwake total would be 3,515
https://infrastructure.planninginspectorate.gov.uk/wp-content/ipc/uploads/projects/EN010056/EN010056-001644-EA3%20-%20Revised%20CRM.pdf

46. If the cumulative totals at the time of the consent of East Anglia THREE were acceptable, then the current position presented in the Projects' EIAs would suggest that there was 'headroom' between the cumulative totals and the currently acceptable limit.

47. It is worth noting that the Projects' totals are not just based upon revisions to the projects which were included in the East Anglia THREE assessment (based on understanding from 2016), but also include collision mortality estimates for the projects that have come since then i.e. Hornsea Project Three, Norfolk Vanguard, Norfolk Boreas, East Anglia TWO and East Anglia ONE North. Therefore, even though these additional projects have added to the cumulative total, revised designs for which there is legal certainty (i.e. approved NMC applications) have reduced this total to a level such that, the cumulative collision mortalities have actually decreased whilst the number of proposed projects has increased. This is due to the very substantial reduction in collisions predicted for certain projects (e.g. in the Firth of Forth) following redesigns submitted since the East Anglia THREE consent. Clearly, if theoretical 'as-built' totals were used, this number would reduce still further.

48. It is clear that the use of collision estimates from consented rather than as built windfarms adds another layer of precaution to an already precautionary assessment process.

49. Note that it will be necessary to update the cumulative totals for the Projects during the examination. This will take account of:

- The final collision mortalities from any amended assessments for Hornsea Project Three, Norfolk Vanguard and Thanet Extension (if consented);
- Any changes for other projects currently in planning/examination (e.g. Norfolk Boreas and Hornsea Project Four); and
- Any other changes to consented projects.

2.3.2 Requirements for discharge of consent

50. Whilst it is recognised that, in theory, it is possible that developers could 'build out' to the 'full design' (i.e. the consented design), several mechanisms exist which in practice would prevent this happening (see ***Table 2.4*** for mechanisms specific to England and ***Table 2.5*** for mechanisms specific to Scotland).

51. The key aspect, which is relevant in both jurisdictions, relates to the fact that once a detailed design process has taken place, key project features will be set out within, for example, the Construction Programme and Construction Method Statement (CMS) documents (see ***Table 2.4*** and ***Table 2.5***). These documents therefore provide the plan for construction in terms of both what is built and how

it is built. These plans are in turn based upon the Rochdale Envelope of the EIA (including infrastructure design, construction methodology and duration) and must fall within the bounds of what has been assessed and what is permitted by the consent. For example, phased construction would need to have been defined and assessed in the EIA and provided for in the discharge documents, as the EIA would have needed to have taken into account duration of construction as a factor in some assessments. Consequently, once a windfarm has completed construction in accordance with the consented construction programme, further construction could not occur.

Table 2.4 Summary of Plans Required for Discharge of Consent Relevant to Project Design and Description (Relevant in England)

Plan / Document	Content and Commentary
Design Plan	This sets the limits on the design and layout of the windfarm and is approved by the MMO. Design Plans are informed by the geotechnical, bathymetric, archaeological and ecological information gathered in the preconstruction phase which also informs the type and number of foundations that can feasibly be built within the order limits. There are also constraints on the minimum distances (in-row and between rows) between turbines to prevent wake effects which can influence the number of turbines able to be constructed within a project's order limits. The design plan will present an optimised design which will maximise the use of the available seabed – areas unused will either be necessary gaps or areas where depth, geology or presence of ecological or archaeological features preclude the location of cables or foundations.
Construction programme	These place constraints on the duration and manner of construction and are approved by the MMO. As described in ***paragraph 51***these set out the physical design, construction methodology and the programme for construction and must fall within the bounds of what was assessed by the EIA.
Construction Method Statement	
Cable Laying Plan; Cable Monitoring Plan; Southern North Sea Site Integrity Plan; Marine Mammal Mitigation Protocol; Project Environment Management Plan etc	Condition 17 (Generation Assets) and Condition 13 (Transmission Assets) of the draft deemed marine licence lists the number of associated plans dependent upon the above plans which all need to be discharged prior to construction.

52. Fundamental to any assumptions on additional 'build-out' after a project is constructed at a lower capacity is whether physical space would exist for extra infrastructure. As highlighted above, the Design Plan would seek to optimise the available space and maximise project efficiency, therefore it is unlikely that large usable areas of a site would be left over.

53. Additional phases of construction after a project has been commissioned would fall outside what had been set out in the consent discharge documents. Assuming that it was physically possible to accommodate further infrastructure within the site after the discharged design has been built out (and assuming that regulators agreed that any proposed additions were within assessed limits), all of this documentation would need to be resubmitted for approval along with any accompanying studies. A good example of this is the Lynn and Inner Dowsing windfarms. The original Transport and Works Act Order for each project was for up to 30 wind turbines, however, only 27 wind turbines generators (WTG) were installed on each project due to local grid capacity. Following completion of construction, the owner of these windfarms requested permission to install an additional three wind turbines on each project (to take them up to their consented number of 30 wind turbines) during installation of wind turbines on the adjacent Lincs windfarm. However, due to Lynn and Inner Dowsing already being constructed, the addition of these wind turbines required further assessment, application and consent from the Regulator.

54. ***Plate 2*** below illustrates the conditions of the draft deemed marine licence for generation assets and the plans and documentation which are required to be submitted in order to discharge consent conditions (note that the list is the same for transmission assets albeit the condition numbering is different) for the Project. It demonstrates the extent to which offshore windfarm projects are restricted to the design set out in their consent.

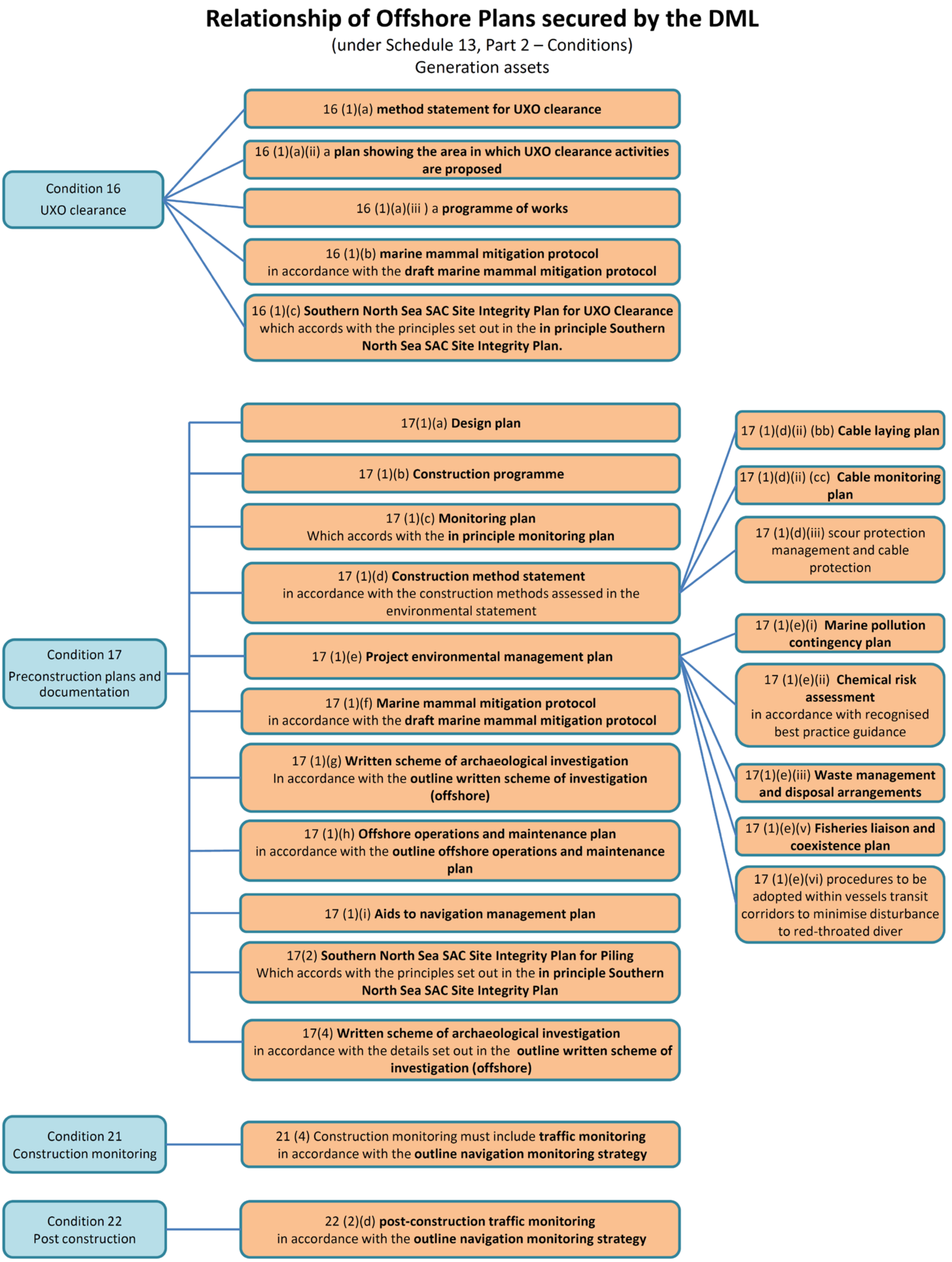

Plate 2 Offshore Plans Secured by the DML (Generation Assets)

Table 2.5 Summary of Plans Required for Discharge of Consent Relevant to Project Design and Description (Relevant in Scotland)

Plan / Document	Content and Commentary
Development Specification and Layout Plan (DSLP)	As a condition of the Section 36 consent the Scottish Ministers must approve of the proposed layout and specification of the windfarm and offshore transmission infrastructure design through a DSLP. DSLPs are informed by the geotechnical, bathymetric, archaeological and ecological information gathered in the preconstruction phase which also informs the type and number of foundations that can feasibly be built within the order limits. There are also constraints on the minimum distances (in-row and between rows) between turbines to prevent wake effects which can influence the number of turbines able to be constructed within a project's order limits. The DSLP will present an optimised design which will maximise the use of the available seabed – areas unused will either be necessary gaps or areas where depth, geology or presence of ecological or archaeological features preclude the location of cables or foundations.
Construction Programme	This places constraints on the duration and manner of construction and is approved by the Scottish Ministers.
Construction Method Statement	As described in ***paragraph 51*** these set out the physical design, construction methodology and the programme for construction and must fall within the bounds of what was assessed by the EIA.
Design Statement, Cable Plan, Piling Strategy, Vessel Management Plan, Lighting and Marking Plan, Navigational Safety Plan etc	The conditions for both the generation and transmission assets of the Section 36 Consent and Marine Licence list a number of associated plans dependent upon the above plans which all need to be discharged prior to construction.

2.3.3 Practicalities

55. In some cases, in Scotland, developers have reconsented projects (e.g. Neart na Gaoithe) because original consents were based on Rochdale Envelopes which have become uneconomic whilst projects were on hold due to judicial review proceedings in respect of their consent decisions. The most critical change to the Rochdale Envelope being the number and size of wind turbines. Therefore, although the original consents remain valid, it would make no economic sense to revert to these[12] and indeed the developers have undertaken costly reapplications which would not be justified if these original consents remained viable. Indeed, in some cases (e.g. Seagreen A & B), wind turbine purchases are

[12] This also assumes that the smaller turbines assessed for the original EIA are still manufactured.

now well underway[13]. Therefore it is unduly precautionary to maintain a position on cumulative impact based on a design that only exists as a superseded worst case design and which will evidently never be built.

56. In the example of East Anglia ONE, while the consented Rochdale Envelope for the NMC application allows for a maximum HVAC capacity of 750MW and 150 turbines, in actuality, only 102 turbines have been installed for a maximum capacity of 714MW. In theory then, this would allow for 48 extra turbines and 36MW of extra capacity. To build out to the consented capacity there would firstly need to be space for the additional turbines and cables within the site. There would not be space for 48 turbines and in any case no offshore wind turbine exists with such a small output. In fact, the 7MW turbines deployed at the site are at the lower range of turbine capacity now available. The likeliest scenario would therefore be to have turbines of the same size as those deployed which would equate to a maximum of five additional turbines, taking the maximum permitted design to 107 turbines. In addition, the constraints around construction programming as described in ***Table 2.4*** and ***Table 2.5*** would apply. This example illustrates that even if there was sufficient space *and* consent mechanisms were available, the actual buildable scenario would not approach the supposed worst case in terms of turbine numbers.

57. These factors indicate that efforts by developers to build out to consented envelopes once windfarms have been commissioned would be severely limited.

2.3.4 Summary

58. It has been demonstrated that, due to the need for windfarm developers to maintain flexibility in design options during the application phase, collision estimates reflect worst case designs, even though these are very unlikely to match the final constructed windfarm. As there is no mechanism requiring developers to update their assessments from consented to as-built designs, these effects at the individual project scale are then added together across projects in cumulative totals for assessment. Thus, cumulative totals are unnecessarily precautionary. ***Section 2.3.1*** highlights the potential overestimates involved if the as-built case is not considered.

59. Whilst this point has been acknowledged by SNCBs and NGOs it has been countered that 'as built' cannot be accepted by the regulator unless there is legal certainty in the form of an amended consent as there is still a theoretical ability to 'build out' projects where the full generation capacity has not been constructed. ***Section 2.3.2*** highlights the complexity of the mechanisms used to discharge consent conditions and why it would not be straightforward to build out even if

[13] http://www.mhivestasoffshore.com/seagreen-announces-mhi-vestas-as-preferred-supplier-for-turbines/

technically feasible and within the limits of the EIA. ***Section 2.3.3*** highlights the practical realities when considering either old consents or unused capacity. The Applicant therefore considers that given the scale of additional cumulative mortality resulting from projects which are known to have much lower potential impacts and with the barriers to 'building out', it is unreasonable for the 'as-built' position to not be reflected when drawing conclusions for cumulative impact assessment.

2.4 Displacement

60. Displacement is assessed using the same survey data as collision estimates, typically presented as mean seasonal values with 95% CI. Precaution is often applied to these outputs in the same manner as collision risk, through an over-emphasis on impacts estimated for the upper 95% CI when, from a statistical perspective it has no greater weight than the lower 95% CI. In contrast to collision risks, displacement is assessed on a seasonal rather than a monthly basis. Precaution is introduced through the use, for each season, of the highest of the monthly values, rather than a more representative value such as the mean or median across each season's constituent months. This also means that the upper 95% CI is that derived on the peak seasonal month, thereby introducing further precaution.

61. In addition, current Natural England advice is to assume displacement from the windfarm plus a buffer. However, turbines rarely fill the site completely and it is therefore likely that the actual wind farm footprint from which birds could be displaced would be smaller than that used in the EIA assessment. While it is acknowledged that the magnitude of reduction is difficult to estimate at the application stage, it nevertheless adds further precaution to the displacement assessments.

62. Natural England advice is that displacement effects estimated in different seasons should be summed to provide an annual effect for assessment which should then be assessed in relation to the largest of the component Biologically Defined Minimum Population Size (BDMPS) populations and the biogeographic population. Natural England has acknowledged that summing impacts in this manner almost certainly over-estimates the number of individuals at risk through double counting[14] (i.e. some individuals may potentially be present in more than one season), while assessing against the BDMPS almost certainly under-estimates the population from which they are drawn (which must be at least this size and is likely to be considerably larger as a consequence of turnover of individuals). Therefore, while Natural England has acknowledged that the

[14] Joint SNCB Interim Displacement Advice Note http://data.jncc.gov.uk/data/9aecb87c-80c5-4cfb-9102-39f0228dcc9a/Joint-SNCB-Interim-Displacement-AdviceNote-2017-web.pdf

methods are precautionary, the extent of this precaution is not made explicit and Natural England's conclusions are still based on this inflated impact magnitude.

2.4.1 Displacement and Mortality Rate Precaution

63. Definitive mortality rates associated with displacement are not known for any seabird and consequently Natural England advise assessment using a wide range of rates by, covering an order of magnitude of potential impacts from 1% to 10% mortality . There is no empirical evidence that displaced birds suffer any consequent mortality; any mortality due to displacement would be most likely a result of increased density in areas outside the affected area, resulting in increased competition for food where densities become elevated. Such impacts are most likely to be negligible (Dierschke et al. 2017), and below levels that could be quantified.

64. Impacts of displacement are also likely to be context-dependent. In years when food supply has been severely depleted, as for example by unsustainably high fishing mortality of sandeel stocks as has occurred several times in recent decades (ICES 2013; Lindegren et al. 2018), displacement of sandeel-dependent seabirds from optimal habitat may increase mortality. In years when food supply is good, displacement is unlikely to have any negative effect on seabird populations.

65. A detailed review of the potential effects of displacement from offshore windfarms on auks (Norfolk Vanguard Ltd 2019b) reviewed available evidence from other sources of displacement. This review noted that:

- Background auk mortality rates, which it is assumed include existing sources of human activity, are very low (10% and 6% per annum for razorbill and guillemot, respectively),
- Displacement from offshore windfarms is likely to affect at most only a proportion of birds present and is likely to decline over time (i.e. through habituation), and
- Offshore windfarms may in fact have a positive effect on prey populations (e.g. through providing enhanced habitat for fish populations) which could lead to no displacement or even attraction.

66. This suggests that impacts of displacement from offshore windfarms are unlikely to represent levels of mortality anywhere near to the 6% or 10% total annual mortality that occurs due to the combination of many natural factors plus existing human activities. This evidence-based review recommended a precautionary displacement rate of 50% for auks within an offshore windfarm and 30% within a 1km buffer, combined with a highly precautionary maximum mortality of 1%.

67. Natural England currently recommend 70% displacement and a maximum 10% mortality in auk displacement assessments which is considered to be overly precautionary. The Projects' guillemot displacement assessment results demonstrate the extent to which these highly precautionary rates impact on Project and subsequently cumulative mortality estimates. Using the currently recommended worst case rates (70% displacement and 10% mortality) predicts 117 (East Anglia TWO) or 132 (East Anglia ONE North) individuals are at risk of mortality as a result of displacement. However, using the still precautionary 50% and 1% rates, these mortalities are reduced to just 8 and 9 individuals respectively (a 93.2% reduction; see ***Table 12.28*** of ***Chapter 12 Offshore Ornithology*** (APP-060)).

68. Given that these highly precautionary rates are combined with the other additive sources of precaution in displacement assessments, there is a very high likelihood that cumulative displacement would also be far lower than the worst case totals presented in the cumulative assessment (see ***section 12.7.3.4*** of ***Chapter 12 Offshore Ornithology*** (APP-0060). Using the less precautionary evidence-based rates would mean increases in background mortality below 1% which would result in cumulative impacts of negligible significance.

69. For recent windfarm assessments, Natural England have advised that a highly precautionary 10% maximum mortality rate should be used for birds displaced by cable laying vessels. In the case of the Projects' assessments, the species considered for this impact was red-throated diver. This magnitude of impact due to vessel disturbance is not supported in the literature and given that this would equate to more than half the natural annual adult red-throated diver mortality rate (16%) as a result of what is effectively a single occasion of disturbance (see ***paragraph 65***), it is highly improbable that such a large magnitude of effect would occur. To illustrate this, it is worth considering the level of vessel traffic through the Southern North Sea and indeed within the Outer Thames Estuary SPA which has been ongoing for decades. Given the widespread nature of vessel movements from shipping and fishing it must be considered a virtual certainty that most individual red-throated divers already encounter considerably more than one vessel per winter and likely one vessel per day. If this species is as susceptible to mortality following individual instances of vessel disturbance as advised by Natural England, the designated population of 6,466 would be reduced by 10% per year (e.g. by 647 in the 'first year') over and above natural declines and would be reduced to less than 2,300 after 10 years. This should be considered against recent survey results (Irwin et al. 2019) which provide no indication that the population has decreased and potentially that the SPA population has increased since designation by almost three and a half times (from 6,466 to almost 22,000). It is therefore very difficult to reconcile Natural England's suggested magnitude of effect from vessel disturbance with the observed

population trends. Indeed, it seems much more likely that there would be no discernible effect attributed to this potential source of impact.

70. With regards to CIA, there are several other sources of precaution within the Projects' red-throated diver displacement assessments:

- Each windfarm assessment has assumed that all birds within 4km of the windfarm lease boundary are potentially affected to the same extent, whereas there is evidence that displacement declines with distance from windfarm boundaries and in some cases has been reported as zero by 2km (see ***Table 12.17*** of ***Chapter 12 Offshore Ornithology*** (APP-060). It is pertinent to note that studies at projects in the region of the Projects, recorded particularly low displacement distances i.e. Greater Gabbard (<1km), Thanet (0km), Kentish Flats (1km), Kentish Flats extension (0.5km) and London Array (<1.5km) suggesting that low levels of displacement are probably typical of the region;
- It includes an unknown degree of double counting across seasons since some individuals will be present within more than one season;
- The Norfolk Boreas, Norfolk Vanguard East and East Anglia THREE 4km buffers overlap with each other therefore including the buffer for all three sites leads to double counting birds in the overlapping areas (by approximately 15%);
- The inclusion of total displacement within the 4km buffers from both Norfolk Vanguard East and Norfolk Vanguard West is highly precautionary since no allowance is made for the division of turbines across the two windfarm sites and the consequent reduction in developed area or increase in wind turbine spacing (which has been reported as causing lower displacement Leopold et al. 2013); and
- About fifty percent of the total annual mortality is predicted to occur during the autumn and spring migration periods when the potential consequences of displacement are expected to be much lower due to the brief duration that birds spend in the area at this time (an aspect recently acknowledged by Natural England[15]).

2.4.2 Summary

71. It is clear that the assumptions made in the assessment of displacement in project-alone and subsequent cumulative assessments include significant sources of precaution, which in a number of cases are contrary to the currently available empirical evidence. The factoring of these assumptions into

[15] Natural England Norfolk Boreas Deadline 7 Submission - Response to Applicant's Comments on Deadline 4 Submissions. https://infrastructure.planninginspectorate.gov.uk/wp-content/ipc/uploads/projects/EN010087/EN010087-001974-DL7%20-%20NE%20-%20Comments%20on%20Applicants%20Comments%20on%20Deadline%204%20Responses.pdf

displacement assessments therefore yields unrealistic and overly-precautionary species-by-species mortality estimates.

2.5 Seasonal Considerations and assignment to breeding colonies

72. The assessment presented for the Projects assigns impacts to individual breeding populations. This approach requires consideration of the range over which breeding birds forage, the routes taken on migration in spring and autumn and the ranging behaviour of immature birds which have the potential to recruit to those colonies.

73. The ranges presented in Thaxter et al. (2012) are described as 'representative' of foraging seabird species and are based on a wide range of study methods used at a wide range of colonies, particularly in the UK. A recent review of foraging ranges (Woodward et al. 2019) has provided revised estimates for some species, but these make no material difference to the predicted colony connectivity presented in the Projects' assessments. The Projects lie beyond the typical breeding season foraging range for most seabirds from colonies along the English North Sea coast. The exception, in terms of distance is lesser black-backed gull breeding at the Alde-Ore Estuary SPA. While this species can cover very long distances whilst foraging, these represent the upper boundaries of such behaviour. The majority of trips will cover much shorter distances since seabirds have evolved to minimise energy expenditure and time away from the nest. If they made multiple long trips, they would simply not have enough time to provide chicks with the daily sustenance they require to survive and grow (nor be able to provide protection from predators). Therefore, maximum ranges presented by Thaxter et al. (2012) and Woodward et al. (2019) represent unusual situations that could not be sustained as typical values by breeding seabirds.

74. Whilst it is accepted that both Projects' windfarm sites are of relatively low importance for seabirds during the breeding season (due to large distances from breeding colonies), large numbers of seabirds pass through the southern North Sea on migration.. Furness (2015) defined seabird seasons with (in many cases) months included in both migration and breeding seasons, reflecting the reality that there is variation in colony attendance among individuals both within, and in particular, between colonies. As noted above, the Projects' windfarm sites are not considered of importance for breeding seabirds, and therefore the Applicant considered that it was more important to fully account for potential effects on seabird migrants in the impact assessment. This was achieved by assigning overlapping months to the migration periods rather than the breeding season (i.e. the Furness (2015) migration-free breeding seasons were used). This was further supported in the baseline data which clearly indicated peaks of seabird abundance in spring and autumn with the lowest densities observed during summer when the majority of adults will be located within the vicinity of breeding

colonies. If the Projects' windfarm sites were of importance for breeding seabirds the seasonal counts would have been expected to peak in June-July when seabirds are making multiple trips to provision chicks, rather than in the overlapping period of spring migration and early breeding season when seabirds tend to be building nests and displaying courtship behaviours. Use of the migration-free breeding period ensured that any late or early migration movements which were observed were assessed in relation to the appropriate (migratory) reference populations.

75. As noted above, one exception to this for the Projects is lesser black-backed gull, for which there is potential for breeding adults from the Alde Ore Estuary SPA population to forage on the respective windfarm sites. Hence, both the EIA and HRA for this species, followed advice from Natural England (see ***Appendix 12.1*** of ***Chapter 12 Offshore Ornithology*** (APP-181) and Information to Support Appropriate Assessment Report (PINS Reference APP-043)) and applied the full breeding season in the attribution of potential impacts to relevant populations. As an example of the difference to the impact predictions that including the migration months in the breeding season results in, the lesser black-backed gull collision estimate for the full breeding season was 5.18 (March to August), while for the migration free breeding season it is 0.91 (May to July). The assumption that all birds present in the shoulder months (March, April and August) are breeding birds makes a five-fold difference to the assessment but has little support from the available evidence.

76. This adds another layer of precaution in the assessment of impacts assigned to specific breeding populations because it is very probable that most, if not all, of the birds recorded in these 'shared months' are either late migrants heading to colonies further north or immature birds (drawn from a wide range of colonies), which are not subject to the same pressure to commence breeding and hence will be present across wider areas.

2.6 Summary

77. The sections above have detailed the various points in the assessment process (whether collision risk or displacement effects) at which precaution is introduced. In brief, the assessment uses a worst case number of birds, assesses a worst case project envelope and applies worst case assumptions to estimate impact magnitudes.

78. Small changes (such as the consideration of migration-free versus full breeding season) can produce large variations in the magnitude of impact. Whilst this approach may be useful at the project alone level to 'stress-test' the acceptability of a project, it is clear that when impacts are considered cumulatively the effect is to greatly inflate the combined magnitude of effect. When the offshore wind

industry was smaller with fewer projects to consider, this approach was practical and had little consequence in terms of consenting risk, but it is clear that with more projects now incorporated, there is an urgent need to reconsider these individual precautions and the overall level of precaution.

3 Impact Consequences

79. In the final phase of an offshore ornithology impact assessment the population consequences of a given magnitude of effect are predicted. This typically involves comparison of the estimated additional mortality with predictions obtained from population models. Note however that this is only carried out for impacts which raise background mortality rates by greater than 1% as mortality rates below this are considered to be undetectable within the range of natural variation and therefore not significant in EIA terms.

80. The population models that are used for this purpose explicitly include demographic and environmental uncertainty and overall represent one of the most robust and evidence based aspects of the impact assessment process. Outputs from these models are presented as the relative differences in population status, comparing simulated population trends obtained with and without the impact. These relative measures are referred to as counterfactuals, with the specific ones used for assessment being the counterfactual of population size and counterfactual of growth rate. These present the difference between an impacted simulation and non-impacted simulation in percentage terms. For example, if the predicted population size with the impact is 9,000 after 30 years, and without the impact is 10,000, then the counterfactual of population size would be 90% (=9,000/10,000). These metrics are preferred because they have been demonstrated to be relatively insensitive to assumptions about the rates of survival and productivity used in the models.

81. However, a key component of population demography for which Natural England and the RSPB consider there is insufficient evidence for its inclusion in the population models is density dependent regulation.

82. The term “density dependence” in the context of population models refers to the inherent regulation that occurs within populations due to competition for resources (e.g. food, mates, breeding space, etc.), the strength of which is determined (hence ‘dependent’) by the number of individuals within the area of interest (hence ‘density’). Thus, as a population increases, it can become more difficult for individuals in that population to obtain all the food and space they require to successfully reproduce. While the existence of such regulation is accepted as self-evident, since without this, populations would grow indefinitely, it is argued by Natural England and the RSPB that there is too much uncertainty about the mechanisms (how it operates and the strength of the effect) for it to be included. Indeed, it is typically stated that the risks of including mis-specified density dependent regulation will result in completely unreliable model predictions, despite the fact that omitting density dependence from a population model can only result in one of two projected population outcomes – infinity or

zero (a density independent model is incapable of any other result), and these are arguably the least realistic outcomes from a population model. It has also been stated that density independent populations models are preferable precisely because they are precautionary (which in almost all instances is the case).

83. However, the Natural England and RSPB position on density dependent models fails to acknowledge one of the primary purposes of population models, which is that they can be used to explore assumptions and uncertainty and develop methods which are robust (i.e. to test alternative hypotheses and narrow down the range of plausible options). One of the clearest outcomes from taking such an approach is that density independent models are almost without exception the least reliable option in terms of predictive power. It has been countered by Natural England and the RSPB that density dependent models can be parameterised in such a way that impact magnitude is minimised and that taking such an approach would therefore lack sufficient precaution. However, this treats the question of whether or not to include density dependence as an 'either/or' one. In fact, density dependence should be viewed on a continuum from very weak (to the point that the model is effectively density independent) to very strong (at which point a modelled population recovers from an impact with a very short delay and appears almost completely unaffected). Viewed from the perspective that density dependence is not a binary feature but one that exists within a range, it has been demonstrated that even if density dependence is applied in a weak and therefore precautionary manner (e.g. with a relatively weak and/or delayed response to declines) the counterfactual results obtained still indicate much smaller population consequences than obtained with density independent models (Trinder 2014).

84. Furthermore, as described above, density dependent regulation is typically considered as a *negative* response; as the population grows the value for one or more demographic rate declines, and vice versa, thereby maintaining the population around a central range of sizes. The RSPB has pointed out that density dependence can also be *positive*, that is as a population decreases in size, so the affected demographic rate(s) also decrease, accelerating the decline in population size (i.e. the effect snowballs). Such effects can occur, for example in smaller colonies which may be less able to defend themselves against predators (e.g. due to lower overall vigilance) and consequently can suffer elevated levels of predation, which exacerbates the problem and leads to ever increasing predation. Similarly, smaller populations may become more dispersed with the result that individuals may be less able to find mates, reducing overall reproduction. However, as noted, these effects are ones which occur in small populations. For offshore wind farm impact assessments, the populations for which PVA are used are much larger (e.g. BDMPS, biogeographic or SPA) and

almost certainly are not ones at risk of positive density dependence. It is of relevance to note that, while seabird SPA populations are typically single colonies which could theoretically be at risk of positive density dependence, these colonies have been designated precisely because they are large and contain a significant percentage of the overall population. Therefore, positive density dependence is almost certainly not a factor that needs to be taken into account in PVA for offshore windfarm impact assessment.

85. The consequence of using more precautionary density independent models for assessing impacts is that they will, in almost all circumstances, over-estimate the population effects of increases in mortality. This is because population growth in a density independent model is exponential (as there is nothing to limit growth). Since the baseline population projection will necessarily have a higher growth rate than the impacted one, after a typical PVA simulation duration (e.g. 30 years) the unimpacted baseline population can reach much larger sizes than the impacted one. That is, although both populations may be predicted to increase, and the growth rate difference may be small, the compound nature of population growth means the two projections can diverge by a large amount after a period of a few years, giving the impression of a large apparent impact. For example, the density independent baseline prediction for the kittiwake population at Flamborough and Filey Coast SPA presented in Trinder (2014) is for an increase from the starting size of 44,000 pairs to over 150,000 after 30 years, while the 30 year population obtained with the maximum modelled level of impact was 80,000. Thus, the counterfactual of population size (CPS) for this example was around 53% (80,000/150000). In other words, the population would be predicted to be 53% smaller with the impact, than without. If the 53% figure is taken without the context of how it was obtained it would appear to be a concerning result. However, both the baseline and impacted populations have increased, and in reality neither of these predicted increases in size is likely to be feasible. For example, Jovani et al. (2015) presented strong evidence that kittiwake colonies almost certainly can't exceed a size of around 50,000 pairs (i.e. the current size of the Flamborough and Filey Coast SPA population) before competition for resources prevents further expansion (i.e. above this size prey depletion near the colony means that on average additional individuals have to travel too far to obtain resources to allow successful reproduction).

86. Natural England justifies their preference for density independent PVA on the grounds that these models are precautionary. However, this precaution adds to the other sources discussed above, and the effects are compounded by all of the preceding precautionary assumptions that are made in the estimation of the impact magnitudes.

4 Synthesis

87. This report has so far demonstrated how some of the routinely applied key sources of precaution within seabird impact assessment act in an additive way to magnify the severity of collision and displacement assessments. However, it is yet to be demonstrated just how much the use of more appropriate and realistic methods reduces the predicted magnitude of impact when compared with using the most precautionary methods. This section therefore aims to illustrate this for collision risk at the Project level.

4.1 Worked Collision Examples

88. ***Table 4.1*** to ***Table 4.4*** present data from the Projects' assessments which illustrate how the precaution in collision estimates (mean vs upper 95%), nocturnal activity rates, avoidance rates and the use of consented rather than 'as built' windfarm designs combine to inflate impact predictions for kittiwake and gannet.

4.1.1 Kittiwake

Table 4.1 Comparison of Collision Mortality Estimates (Mean and Upper 95%) for Kittiwake Assessed in the East Anglia TWO ES with Recalculated Estimates Incorporating Updated Realistic Nocturnal Activity Rate and Avoidance Rates

Collision Mortality Estimate Category	Annual Mean	Annual Upper 95%	Annual Lower 95%
Assessed Collision Mortality Estimate (no. of individuals) at 50% nocturnal activity rate and using SNCB accepted avoidance rate (98.9%)	49.93	86.65	19.33
Collision mortality estimate (no. of individuals) using reduced nocturnal activity rate (25%) and using SNCB accepted avoidance rate (98.9%)	42.22	73.3	16.27
Collision mortality estimate (no. of individuals) using increased but still precautionary avoidance rate from (Bowgen and Cook, 2019) (99.0%) and 50% nocturnal activity rate	45.39	78.77	17.57
Recalculated project-alone total based on updated nocturnal activity (25%) and avoidance rate (99.0%) combined	38.38	66.63	15.06

Table 4.2 Comparison of Collision Mortality Estimates (Mean and Upper 95%) for Kittiwake Assessed in the East Anglia ONE North ES with Recalculated Estimates Incorporating Updated Realistic Nocturnal Activity Rate and Avoidance Rates

Collision Mortality Estimate Category	Annual Mean	Annual Upper 95%	Annual Lower 95%
Assessed Collision Mortality Estimate (no. of individuals) at 50% nocturnal activity rate and using SNCB accepted avoidance rate (98.9%)	57.99	94.82	28.81
Collision mortality estimate (no. of individuals) using reduced nocturnal activity rate (25%) and using SNCB accepted avoidance rate (98.9%)	49.34	80.40	24.64
Collision mortality estimate (no. of individuals) using increased but still precautionary avoidance rate (99.0%) and 50% nocturnal activity rate	52.72	86.20	26.19
Recalculated project-alone total based on updated nocturnal activity (25%) and Bowgen and Cook, 2019 avoidance rate (99.0%) combined	44.86	73.09	23.81

89. The effect of using both of these evidence-based changes reduces the annual mean Project impacts on kittiwake by 23.1% and 22.7% for East Anglia TWO and East Anglia ONE North respectively.

90. Although feasible, it is not straightforward to apply the nocturnal activity rate update cumulatively and so this has not been shown here. However, a similar reduction would be obtained for all other projects where the higher rates have been used in the collision modelling, thus the current cumulative total for kittiwake would be reduced by around 20%.

4.1.2 Gannet

Table 4.3 Comparison of Collision Mortality Estimates (Mean and Upper 95%) for Gannet Assessed in the East Anglia TWO ES with Recalculated Estimates Incorporating Updated Realistic Nocturnal Activity and Avoidance Rates

Collision Mortality Estimate Category	Annual Mean	Annual Upper 95%	Annual Lower 95%
Assessed Collision Mortality Estimate (no. of individuals) at 25% nocturnal activity rate and using SNCB accepted avoidance rate (98.9%)	47.02	75.3	26.06
Collision mortality estimate (no. of individuals) using evidence-based	37.59	57.59	20.36

Collision Mortality Estimate Category	Annual Mean	Annual Upper 95%	Annual Lower 95%
nocturnal activity rate (8% activity during the breeding season and 4% during the non-breeding season) and SNCB accepted avoidance rate (98.9%)			
Collision mortality estimate (no. of individuals) using increased but still precautionary avoidance rate (99.5%) and 25% nocturnal activity rate	21.37	34.23	11.85
Recalculated project-alone total based on updated nocturnal activity rate (8% activity during the breeding season and 4% during the non-breeding season) and avoidance rate (99.5%) combined	17.09	26.18	9.26

Table 4.4 Comparison of Collision Mortality Estimates (Mean and Upper 95%) for Gannet Assessed in the East Anglia ONE North ES with Recalculated Estimates Incorporating Updated Realistic Nocturnal Activity and Avoidance Rates

Collision Mortality Estimate Category	Annual Mean	Annual Upper 95%	Annual Lower 95%
Assessed Collision Mortality Estimate (no. of individuals) at 25% nocturnal activity rate and using SNCB accepted avoidance rate (98.9%)	27.27	50.17	9.53
Collision mortality estimate (no. of individuals) using evidence-based nocturnal activity rate (8% activity during the breeding season and 4% during the non-breeding season) and SNCB accepted avoidance rate (98.9%)	22.7	42.17	7.65
Collision mortality estimate (no. of individuals) using increased but still precautionary avoidance rate (99.5%) and 25% nocturnal activity rate	12.40	22.80	4.33
Recalculated project-alone total based on updated nocturnal activity rate (8% activity during the breeding season and 4% during the non-breeding season) and avoidance rate (99.5%) combined	10.32	19.12	3.48

91. The effect of using both of these evidence-based changes reduces the annual mean Project impacts on gannet by 63.7% and 62.2% for East Anglia TWO and East Anglia ONE North respectively.

92. Again, it is clear that a similar reduction in overall mortality estimates would be obtained at other projects where the higher rates have been used in the collision modelling, thus the current cumulative mortality estimate for gannet would be reduced by around 60%.

5 Conclusion

93. This paper illustrates the ways in which the ornithological impact assessment incorporates precaution and highlights the effect of adding multiple layers of precaution together. The result of this process is that estimates of impact magnitude are inflated for individual projects and this is compounded when applied to the cumulative assessment.

94. Thus, precautionary seabird density and population estimates are analysed using displacement and collision models with precautionary parameter estimates (such as displacement mortality and nocturnal activity), assigned to SPA populations using extended breeding seasons, and precautionary apportioning rates and then assessed using precautionary density independent population models. While each individual element of precaution may be justifiable to an extent, when these are combined it is difficult not to reach a conclusion that the outcome is a highly over-precautionary assessment. Furthermore, for many aspects of the assessment, these precautionary approaches are then combined across windfarms to estimate cumulative effects.

95. It is therefore necessary that when considering whether an effect is significant or not, particularly in the cumulative case, consideration must be given to the many sources of precaution and focus upon a single headline mortality figure is misplaced.

96. These areas of precaution are not new and there have been initiatives both by individual developers and industry-wide to address these.

97. Excluding any other areas of precaution, this paper demonstrates that refinements in design have reduced predicted cumulative collision mortality impacts by **10.7% for gannet and 8.7% for kittiwake below the consented levels** (i.e. as of East Anglia THREE in 2017), even allowing for the additional projects added since the East Anglia THREE assessment.

98. Whilst some areas of the assessment are concerned with ecology and behaviour and are subject to ongoing scientific research and monitoring, the concept of as-built against consented is a practical, physical fact for which there should be no basis for disagreement.

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