Sheringham Shoal and Dudgeon Offshore Wind Farm Extension Projects

Marine Mammals Technical Note and Addendum (Revision B) (Clean)

Revision B
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Prepared by: **Royal HaskoningDHV**		
Approved by: **Tom Morris, Equinor**	Date: July 2023	

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Glossary of Acronyms

ADDs	Acoustic Deterrent Devices
Cefas	Centre for Environment, Fisheries and Aquaculture Science
CES	Coastal East Scotland
CGNS	Celtic and Greater Noise Sea
CIA	Cumulative Impact Assessment
dB	decibel
DCO	Development Consent Order
DEL	Dudgeon Extension Limited
DEP	Dudgeon Offshore Wind Farm Extension Project
DOW	Dudgeon Offshore Wind Farm
EIA	Environmental Impact Assessment
EPP	Evidence Plan Process
EPS	European Protected Species
ES	Environmental Statement
ETG	Expert Topic Group
GNS	Greater North Sea
HDD	Horizontal Directional Drilling
IAMMWG	Inter-Agency Marine Mammal Working Group
iPCoD	Interim Population Consequences of Disturbance
km	Kilometre
MMO	Marine Management Organisation
MU	Management Unit
MW	Megawatts
NE	North East
NS	North Sea
OWF	Offshore Wind Farm
PEIR	Preliminary Environmental Information Report
PTS	Permanent Threshold Shift
RR	Relevant Representations
SCOS	Special Committee on Seals
SE	South-East

SEL	Scira Extension Limited
SEL_{ss}	single-strike Sound Exposure Level
SEP	Sheringham Offshore Wind Farm Extension Project
SIPs	Site Integrity Plans
SNS	Southern North Sea
SPL	Sound Pressure Level
SoS	Secretary of State
SOW	Sheringham Shoal Offshore Wind Farm
UK	United Kingdom

Glossary of Terms

Construction scenario	Scenario by which SEP and DEP could be built out. The options are 'sequentially' (i.e. one after another) or 'concurrently' (i.e. at the same time).
Dudgeon Offshore Wind Farm Extension Project (DEP)	The Dudgeon Offshore Wind Farm Extension onshore and offshore sites including all onshore and offshore infrastructure.
DEP offshore site	The Dudgeon Offshore Wind Farm Extension consisting of the DEP wind farm site, interlink cable corridors and offshore export cable corridor (up to mean high water springs).
DEP North array area	The wind farm site area of the DEP offshore site located to the north of the existing Dudgeon Offshore Wind Farm
DEP South array area	The wind farm site area of the DEP offshore site located to the south of the existing Dudgeon Offshore Wind Farm
DEP wind farm site	The offshore area of DEP within which wind turbines, infield cables and offshore substation platform/s will be located and the adjacent Offshore Temporary Works Area. This is also the collective term for the DEP North and South array areas.
European site	Sites designated for nature conservation under the Habitats Directive and Birds Directive. This includes candidate Special Areas of Conservation, Sites of Community Importance, Special Areas of Conservation, potential Special Protection Areas, Special Protection Areas, Ramsar sites, proposed Ramsar sites and sites compensating for damage to a European site and is defined in regulation 8 of the Conservation of Habitats and Species Regulations 2017, although some of the sites listed here are afforded equivalent policy protection under the National Planning Policy Framework (2021) (paragraph 176) and joint Defra/Welsh Government/Natural England/NRW Guidance (February 2021).
Evidence Plan Process (EPP)	A voluntary consultation process with specialist stakeholders to agree the approach, and information to support, the EIA and HRA for certain topics.
Expert Topic Group (ETG)	A forum for targeted engagement with regulators and interested stakeholders through the EPP.
Offshore cable corridors	This is the area which will contain the offshore export cables or interlink cables, including the adjacent

	Offshore Temporary Works Area.
Offshore export cable corridor	This is the area which will contain the offshore export cables between offshore substation platform/s and landfall, including the adjacent Offshore Temporary Works Area.
Offshore export cables	The cables which would bring electricity from the offshore substation platform(s) to the landfall. 220 – 230kV.
Offshore substation platform (OSP)	A fixed structure located within the wind farm site/s, containing electrical equipment to aggregate the power from the wind turbine generators and convert it into a more suitable form for export to shore.
Sheringham Shoal Offshore Wind Farm Extension Project (SEP)	The Sheringham Shoal Offshore Wind Farm Extension onshore and offshore sites including all onshore and offshore infrastructure.
SEP offshore site	Sheringham Shoal Offshore Wind Farm Extension consisting of the SEP wind farm site and offshore export cable corridor (up to mean high water springs).
SEP wind farm site	The offshore area of SEP within which wind turbines, infield cables and offshore substation platform/s will be located and the adjacent Offshore Temporary Works Area.
Simultaneous piling	A scenario where two piles are installed at the same time at different locations.
Single piling	A scenario where one pile is installed in a 24 hour period.
The Applicant	Equinor New Energy Limited. As the owners of SEP and DEP, Scira Extension Limited and Dudgeon Extension Limited are the named undertakers that have the benefit of the DCO. References in this document to obligations on, or commitments by, 'the Applicant' are given on behalf of SEL and DEL as the undertakers of SEP and DEP.

Executive Summary

1. Within Natural England's Relevant Representations [RR-063], a number of updates to the marine mammal assessments as provided within the **Environmental Statement (ES) Chapter 10** [APP-096] were requested. This Marine Mammals Technical Note and Addendum provides that requested information.
2. The key updates requested by Natural England were as follows;
   - Updates to both grey seal and harbour seal baseline information (including updated density estimates and population estimates);
   - Updates to the assessment for disturbance to (a) provide a review of the potential for disturbance to all assessed marine mammal species; (b) take account of the worst-case disturbance ranges provided within the literature; (c) provide population modelling to determine population level consequences of disturbance from piling; (d) determine requirements for mitigation of disturbance; and (e) provide updates to the assessment of disturbance from Acoustic Deterrent Devices (ADD) to incorporate actual required durations; and
   - Updates to the cumulative impact assessment to include (a) project specific data where available; (b) an assessment of both geophysical and seismic surveys as a moving noise source; (c) an assessment of the corrected number of vessels for the SEP and DEP construction scenario; (d) population modelling to determine population level consequences of disturbance from piling at all included offshore wind farms; (e) further consideration of the potential for cumulative disturbance at seal haul-out sites.
3. This note (Revision A) was submitted at Deadline 3 [REP3-115], and has now been updated for Deadline 7 (as Revision B) in line with Natural England's comments provided at Deadline 6 [REP6-029], as provided in Table **3-1 below.** This note also addresses a request made by the Marine Management Organisation within their Relevant Representations [RR-053], regarding an updated assessment of disturbance using the dose response curve approach. The updated assessments using the dose response curve approach do not result in any changes to the relevant impact significances presented in ES C**hapter 10** [APP-096] (see **Section 6.1.2.2**).

Seal baseline information

4. **Section 5** provides an update to both the grey seal and harbour seal density estimates, utilising the Carter *et al*. (2022) density estimates, which are now the most current.
5. **Section 5.1** provides detail on the method of deriving absolute density estimates from this data. For grey seal, the density estimates have slightly increased in comparison to those used within **ES Chapter 10** [APP-096], while for harbour seal, the density estimates have slightly decreased. Special Area of Conservation (SAC) specific densities have also been derived from the Carter *et al.* (2022) density data.

6. **Section 5.2** provides the updated seal population estimates, taking account of corrections for those seals not available to count during surveys. **Section 5.2** also provides detail on the method of correcting the population estimates. For grey seal, the reference population has increased in comparison to that used within **ES Chapter 10** [APP-096], while the population estimates have decreased.
7. The updated seal density and population estimates (as described above) have been used to update all quantitative seal assessments, as presented within **ES Chapter 10** [APP-096]. **Annex 2** provides all updated assessments, and **Section 6.3** summarises the updated impact significances as a result of those updates.
8. As presented in **Section 6.3**, while there are some changes in magnitude levels, there are no changes to the overall impact significances for either grey seal or harbour seal. Therefore, the conclusions of assessments as provided within **ES Chapter 10** [APP-096] remain valid.

Updates to Assessment for Disturbance

9. All assessments of disturbance to seal species have been updated using the updated density and population estimates as noted above.
10. **Section 6.1.1** provides a brief literature review of the potential for disturbance to all assessed marine mammal species. Based on this literature review, an assessment of disturbance of both seal species, based on the reported disturbance range due to offshore wind farm piling of 25km (Russell *et al*., 2016) has been provided (**Section 6.1.2.1**). This assessment concludes that the magnitude of effect could be significant for piling at either SEP alone, or at both SEP and DEP. However, it should be noted that this assessment approach is considered precautionary and not representative, as this assessment assumes all seals would be disturbed at the maximum possible disturbance range.
11. In order to provide a more realistic assessment, both seal species (as well as harbour porpoise) have been assessed under a dose response curve approach. This takes into account the individuality of reactions to noise, and the proportion of animals that would respond at different noise levels. The dose response curves are based on the best available in the literature.
12. The dose response assessment (**Section 6.1.2.2**) shows that there would not be a significant impact to harbour porpoise, grey seal or harbour seal as a result of piling at SEP and DEP together (as the worst-case).
13. Population modelling has also been undertaken for harbour porpoise, bottlenose dolphin, grey seal and harbour seal (**Section 6.1.2.3**), using the results of the assessments with the highest magnitude levels (i.e. using the results of the assessments of the disturbance range of 26km for harbour porpoise and bottlenose dolphin, and 25km for both grey and harbour seal). The results of the population modelling indicate piling at both SEP and DEP would not have the potential for any population level effect (**Section 6.1.2.3.3**).
14. Based on the results of the population modelling, and the conclusion that there would not be the potential for a population level effect, using the highest number of individuals at risk, there is no requirement for mitigation to reduce disturbance due to piling at SEP and DEP alone.

15. **Section 6.1.3** provides an updated assessment of the potential for disturbance to all marine mammal species due to ADD activation as part of the mitigation requirements. This assessment uses the actual required ADD activation ranges (based on the worst-case piling permanent auditory injury (Permanent Threshold Shift (PTS)) ranges (SPL_{peak} or SEL_{cum}) for both monopiles and pin-piles. The results of this assessment show an increased number of each marine mammal species at risk, however, there is no change to the overall impact significance levels, and therefore the conclusions of the assessment as provided in within **ES Chapter 10** [APP-096] remain valid.

Updates to Cumulative Impact Assessments (CIA)

16. **Section 6.2.1.1.1** provides a summary of the currently known project specific information and results of assessments (where available) for each offshore wind farm project included in the CIA. The offshore wind farm projects considered within this assessment are the same as considered for each marine mammal species within the **ES Chapter 10** [APP-096].
17. The offshore wind farm project specific data has been used to update the assessments presented within **ES Chapter 10** [APP-096].
18. The updated assessments for the potential for cumulative disturbance from piling at other offshore wind farms, at the same time as piling at SEP and DEP (**Section 6.2.1.1.2**), show that for harbour porpoise, bottlenose dolphin, white-beaked dolphin, grey seal and harbour seal, the number of individuals at risk of disturbance has increased when using the project specific data. The number of minke whale at risk of disturbance has decreased in comparison to the assessment provided in **ES Chapter 10** [APP-096]. For harbour porpoise, bottlenose dolphin, and grey seal, the updated assessments for cumulative disturbance from offshore wind farm piling indicate that there could be the potential for a significant effect.
19. For bottlenose dolphin (and for white-beaked dolphin) the assessments using the project specific data are considered to be highly precautionary and unrealistic, due to the approach used to determine the potential for disturbance at other offshore wind farm projects. For harbour porpoise, grey seal and harbour seal, population modelling has been undertaken for piling at cumulative projects, to determine where there is the potential for an impact at the population level.
20. The results of the population modelling for harbour porpoise, grey seal and harbour seal (**Section 6.2.1.5**) show that there would not be the potential for a population level consequence due to piling at other offshore wind farms at the same time as piling at SEP and DEP. The worst-case result was determined for harbour porpoise, with the potential for a 1.25% to 1.85% reduction in the population at the end of the 25 year modelling period, when comparing an undisturbed population to a disturbed population. This is not considered to be sufficient to significantly alter the population trajectory.
21. **Section 6.2.1.3** provides an assessment for both geophysical and seismic surveys, assuming they are a mobile source. this updated assessment has been undertaken for all marine mammal species. The results of the assessments show that while the number of marine mammals at risk of disturbance from these

surveys has increased, the overall magnitude levels remain the same or less than as assessed in the **ES Chapter 10** [APP-096], with the exception of bottlenose dolphin, grey seal and harbour seal.

22. **Section 6.2.1.4** provides an updated overall assessment for cumulative disturbance to all marine mammal species. The results of the updated assessments show that there is the potential for a significant effect to harbour porpoise, bottlenose dolphin, grey seal and harbour seal, however, as the population modelling undertaken for harbour porpoise, grey seal and harbour seal showed no potential for a population level consequence due to cumulative offshore wind farm pling, it is not expected that there would be a significant impact on any of marine mammal species. As noted above, the assessment for bottlenose dolphin (and white-beaked dolphin) is considered to be highly precautionary and unrealistic, and therefore there is not expected to be a significant cumulative disturbance impact to bottlenose dolphin.

1 Revision B Updates at Deadline 7

23. This document has been updated at Deadline 7 to seek to address comments from Natural England in REP5-093 (Point D10) and REP6-029, and from the Marine Management Organisation (MMO) in REP5-080.

24. The note has been updated to include population modelling, using iPCoD, for bottlenose dolphin, both for the Projects alone (**Section 6.1.2.3**), and cumulatively with other offshore wind farm projects (**Section 6.2.1.5**), in response to REP6-029.

25. Further information on the potential for disturbance to harbour seal at the Blakeney Point haul-out site has been provided in **Section 7.1.2.3.3**, in response to D10 of REP5-093.

26. **Annex 3** of this document has been updated to include figures to show the 5dB underwater noise contours, for all modelled piling locations and for monopiles and pin-piles (**Figures 4.1** to **4.8**), in response to REP5-080.

2 Additional Marine Mammal Information for Deadline 3

27. Revision A of this document provided the Applicant's additional marine mammal information for Deadline 3 in response to the Relevant Representation (RR) submissions from the MMO [RR-053] and Natural England [RR-063].

28. As the owners of the Sheringham Shoal Offshore Wind Farm Extension Project (SEP) and Dudgeon Offshore Wind Farm Extension Project (DEP), Scira Extension Limited (SEL) and Dudgeon Extension Limited (DEL) are the named undertakers that have the benefit of the Development Consent Order (DCO). References in this document to obligations on, or commitments by, 'the Applicant' are given on behalf of SEL and DEL as the undertakers of SEP and DEP.

3 Consultation on this Document

29. **Table 3-1** presents the Applicant's comments on Natural England's Appendix D1 [REP6-029] and MMO Responses to the Examining Authority's Third Written Questions (WQ3) [REP5-080].

Table 3-1 The Applicant's comments on Natural England's Appendix D1 [REP6-029] and MMO Responses to the Examining Authority's Third Written Questions (WQ3) [REP5-080]

ID	Stakeholder Comment	Applicant Response
Natural England's Appendix D1 [REP6-029]		
1. Summary of Advice		
1	Natural England requests further information on two aspects of the cumulative assessment and associated population modelling: • Justification for downgrading the magnitude of the assessment for bottlenose dolphin and thereby excluding the species from the population modelling; • Demonstration that the project-alone piling scenario that has been used as the worst-case scenario is indeed the worst-case. Overall, Natural England considers the population modelling fit for purpose, except for the two queries above which should be resolved. Natural England's view on the population modelling undertaken by the Applicant is presented in detail below.	1. To provide further information as to the likely population level effects of piling disturbance on bottlenose dolphin, this species is now included in the population modelling for project-alone (**Section 6.1.2.3**) and cumulatively with other projects (**Section 6.2.1.5**). 2. As the iPCoD model accounts for the number of days disturbance, with each disturbed animal retaining a residual disturbance for 24 hours after piling, the number of piling days, in addition to the number of animals disturbed per day, affects the predicted outcomes. It was found that either simultaneous piling (two piling events at the same time) or sequential piling (two monopiles installed one after the other) in a day, whilst increasing the number of animals disturbed per day, also drastically reduced the total number of piling days, when compared to only one piling event per day. This meant that a single piling scenario of one monopile per day, with DEP being constructed following SEP, resulted in the most animals disturbed overall, also maximising total residual disturbance, and is therefore the worst case. It should be noted that in cases where no discernible effect on impacted to un-impacted population size ratios is predicted, this remains unchanged, regardless of whether the model is run for SEP alone, DEP alone, or SEP and DEP in tandem or sequentially (with simultaneous piling or with 2 monopiles per day).
2. Detailed Response		
Species Assessed		
2	The Applicant has undertaken population modelling using Interim Population Consequences of Disturbance (iPCoD) for three marine mammal species; harbour porpoise, harbour seal and grey seal. Population modelling was undertaken because the residual impact	To provide further information as to the likely population level effects of piling disturbance on bottlenose dolphin, this species is now included in the population modelling for project-alone (**Section 6.1.2.3**) and cumulatively with other projects (**Section 6.2.1.5**).

ID	Stakeholder Comment	Applicant Response
	assessment concluded Major Adverse impacts for these species (see Table 4-34 of the Marine Mammals Technical Note and Addendum [REP3-115]). Despite concluding a high magnitude of bottlenose dolphins disturbed in Table 4-33, the Magnitude is presented as Low in Table 4-34 because the Applicant considers this is more appropriate. The Applicant's justification for this downgrading of the Magnitude (Paragraph 22 and Footnote 62) is not detailed or robust. Further information is needed to justify the exclusion of bottlenose dolphins from significant cumulative disturbance impact and therefore the population modelling.	
Population Parameter Inputs		
3	Natural England recognises that there is limited information on the population parameters for the specific populations being assessed. We broadly consider that the Applicant has applied reasonable population parameters as a proxy for where region-specific information is missing, as is the case for harbour and grey seals. For harbour seals specifically, Natural England has sought expert advice from the Sea Mammal Research Unit, (SMRU) at St Andrews University on the parameters used due to our concerns over the declining population in the Wash. We have been advised that the rate of decline in the Wash (24% since 2015) is similar to the rate of decline of the Scottish East Coast population (24% between 2016 and 2021). Therefore, the Applicant's approach of using the parameters from the Scottish East Coast population appears reasonable. It is difficult to predict the future of the Wash population and whether the observed decline will persist. The focus of our review of the population modelling has been on the key output of relevance to the impact assessment, namely whether there is a difference between the unimpacted and impacted population. The harbour porpoise population parameters in Table 4-7 appear to differ to the parameters presented by Sinclair et al. (2020). Sinclair et al. (2020) presented updates to the recommended demographic parameters, compared to those included in the iPCod framework. The parameters used by the Applicant for harbour porpoise appear to match the parameters in	The Applicant notes that Natural England is broadly accepting of the population parameters used within the population modelling, and that updates to the demographic parameters used for the iPCoD modelling are not required.

ID	Stakeholder Comment	Applicant Response
	the helpfile for the current iPCod framework. Whilst Natural England advises that the latest parameters should be used, we consider that updating these would not make a material difference to the outcome of the population modelling. Therefore, an update is not required in this instance. We consider that the Management Units (MUs) selected as the reference populations are broadly appropriate. An assessment at both the MU and SAC scale has been undertaken, providing context to the assessment.	
Impact inputs (project alone)		
4	The Applicant has used a worst case of one monopile and one pin pile being installed in each 24-hour period (Paragraph 106). However, it is not clear how this comprises the worst case, given that both concurrent piling (2 piles being installed at the same time) and sequential piling of two monopiles at SEP and DEP are within the project envelope for which consent is being sought. Further information is needed to demonstrate that what has been assessed is indeed the worst-case scenario. Natural England considers that the disturbance distances, and the residual days of disturbance, used by the Applicant are suitably precautionary.	See response to Point 1 above. The Applicant notes with thanks that Natural England considers that the disturbance distances, and the residual days of disturbance, used by the Applicant are suitably precautionary.
Impact inputs (cumulative)		
5	The Applicant's review of the available project data for screened in offshore wind farms projects (see Table 4-18) appears comprehensive and based on the best available information at the time. We note that projects in the pre-application phase may continue to refine and publish their project data. However, it is reasonable to implement a cut off point for new data and we consider that what is presented in Table 4-18 is acceptable.	The Applicant notes with thanks that Natural England is content with the project data included for other offshore wind projects in the cumulative effects assessment.
Model outputs and determining significance		
6	The range of forecast intervals that have been presented are appropriate. Natural England notes that there is increased uncertainty with increased time from the modelling start year. Our advice is, therefore, based on the short- to medium-term predictions.	Noted.
7	The Applicant has used a threshold of an (additional) 1% annual decline	The Applicant notes that Natural England is content with the threshold of

ID	Stakeholder Comment	Applicant Response
	due to construction works of offshore wind as resulting in a disturbed population compared to an undisturbed population (see Paragraph 213). Natural England considers that this approach for defining potential significant impacts is appropriate in most scenarios. We note that it is in line with the recent Natural Resources Wales (NRW) position statement (NRW 2023) on assessing the effects of hearing injury from underwater noise on marine mammals, where NRW state that a population decline of >1% per year (versus a modelled unimpacted reference population) would constitute a high likelihood that a significant effect and adverse effects on integrity (AEoI) cannot be ruled out.	1% annual decline due to construction works to define potential significant impacts. The Applicant draws attention to the addition of bottlenose dolphin population modelling for project-alone (**Section 6.1.2.3**) and cumulatively with other projects (**Section 6.2.1.5**), where the 1% annual decline threshold is not breached.
8	The worst-case prediction of annual decline is for harbour porpoise, which are predicted to have an annual decline of 1.78% by End 2031 (Table 4-36), equivalent to an annual decline of ~0.3%, under the in-combination scenario. Grey seal are predicted to decline up to 0.03% by End 2031. Harbour seal are predicted to have effectively the same un-impacted and impacted population mean at each forecast interval presented. These results are all not significant based on the 1% threshold mentioned earlier.	Noted and agreed.
9	It is Natural England's view that the context for the assessment of the harbour seal feature of the Wash and North Norfolk Coast SAC differs because this designated feature has an overall unfavourable conservation status. As detailed in Natural England's Relevant Representation [RR-063], the Applicant must demonstrate that the project will not hinder (neither stop nor slow) the recovery of the species in the site. This has been taken into account by Natural England in its review of the outcomes of the population modelling for harbour seal specifically.	Noted.
10	The population modelling of harbour seal, at both the MU and SAC level, from both project alone and cumulative effects (see Tables 4-12, 4-38, 5-11 and 5-29), shows effectively no difference in the size of the unimpacted population mean and the impacted population mean. Therefore, the results as presented indicate that offshore wind impacts will not cause any additional decline to the harbour seal populations assessed.	Noted and agreed.
Applicant's comments on MMO Responses to the Examining Authority's Third Written Questions (WQ3) [REP5-080]		

ID	Stakeholder Comment	Applicant Response
11	1.1.1. The MMO welcome the use of the dose response approach for assessing disturbance. The applicant makes reference to appropriate peer-reviewed literature. Specifically, the dose response relationship for harbour porpoise is based on data from Graham et al. (2017). The dose response for harbour and grey seal has been derived from data from Whyte et al. (2020).	Noted. The Applicant welcomes this position.
12	1.1.2. The MMO would like to point out that paragraph 83 of the Marine Mammal Technical Note states that "to estimate the number of animals disturbed by piling, SELSS contours at 5 decibel (dB) increments (generated by the noise modelling – see ES Appendix 10.2 - Underwater Noise Modelling Report [APP-192]) were overlain on the relevant species density surfaces to quantify the number of animals receiving each SELSS, and subsequently the number of animals likely to be disturbed based on the corresponding dose-response curve". The MMO have reviewed Appendix 10.2 and the SELss contours at 5 dB are not actually provided. The MMO request that this information is provided for review or signposting provided to where the information can be located.	**Annex 3** (**Figures 6.1** to **6.8**) has been updated at Deadline 7 to provide SELss contours at 5dB.
13	1.1.3. The MMO defer to Natural England as the marine mammal specialists for comments on whether they are content with the use of the density estimates from Waggitt et al. (2020) for harbour porpoise, and from Carter et al. (2022) for seal species.	Noted.

4 Clarifications on Assessments

4.1 Clarifications on PTS / TTS / Disturbance Effect Significances as Presented in ES and HRA

In response to Natural England's Relevant Representation [RR-063], as stated in Applicant's Response (ID 1) [REP2-051].

30. **ES Chapter 10 Sections 10.6.1.1.6** and **10.6.1.1.7.7** (**Tables 10-37** and **10-46**), as well as **Section 10.12** (**Table 10-124**) [APP-096] refer to the MMMP as mitigation for the risk of TTS due to piling, which is incorrect. While mitigation may reduce the risk of TTS, by ensuring marine mammals are outwith PTS ranges prior to piling, which would subsequently reduce the number of marine mammals at risk of TTS, this is not the purpose of the MMMP. There is no requirement for mitigation for the risk of TTS in any marine mammal species, as all potential effects were assessed as not significant.
31. The **Report to Inform Appropriate Assessment (RIAA)** [APP-059] for bottlenose dolphin, grey seal, and harbour seal, all refer to the use of the MMMP to reduce the potential for TTS onset. For bottlenose dolphin, this is stated in the **RIAA Section 8.4.2.1.2** (Tables 8-55 and 8-56) [APP-059]. For grey seal, this is stated in **RIAA Section 8.4.3.1.1** (Tables 8-66 and 8-67). For harbour seal, this is stated in **RIAA Section 8.4.4.1.1** (Tables 8-76 and 8-77).
32. As outlined with respect to **ES Chapter 10** [APP-096] above, there is no requirement for mitigation for any of these three species as a result of TTS from piling, with all assessments showing less than 5% of the reference population at risk of the temporary effect. Therefore, there is no requirement for mitigation for TTS.

5 Updated Baseline Information for Seal Species

In response to Natural England's Relevant Representation [RR-063], as stated in Applicant's Response (ID 4, 28, 29, 30, 32, 33, 65, 77, 89, 113, 118) [REP2-051].

5.1 Seal Density Estimates

33. The following updates to both the grey seal and harbour seal density estimates provide an update to the information as presented in **ES Chapter 10 Section 10.5.5** and **10.5.6** respectively, as well as **Table 10-19** [APP-096].
34. The assessments provided within the **ES Chapter 10** [APP-096] and **RIAA** [APP-059] are based on relative at-sea density data presented by Carter *et al*. (2020). Since then, an update to this data has been provided within Carter *et al*. (2022), and an update to the density estimates at each project location and area is provided in **Table 5-1** below. In addition to the relative at-sea density estimates in all UK waters, Carter *et al*. (2022) also provides density estimates for individuals associated with each designated Special Area of Conservation (SAC) for seal species. These density estimates have also been provided within **Table 5-1** below.

35. **Figure 5.1** shows the at-sea grey seal densities for the total UK seals, and **Figure 5.2** for grey seal associated with the Humber Estuary SAC. **Figure 5.3** shows the at-sea harbour seal densities for the total UK seals, and **Figure 5.4** for those associated with The Wash and North Norfolk Coast SAC.

36. As for the Carter *et al*. (2020) data, in order to generate absolute density estimates from the relative at-sea data, the total at-sea population is used for each density data set. These are noted within **Table 5-1** below, and are based on the latest counts within the latest available Special Committee on Seals report (SCOS) (2021).

37. For grey seal, the total at-sea population estimate is based on the total UK and Republic of Ireland haul-out count of 46,463 (SCOS, 2020), the correction for seal not available to count of 0.2515 (SCOS, 2021) to produce a total population estimate. This is corrected again to account for only those seals at-sea at any one time, based on the 0.8616 correction presented by Russell *et al*. (2015). The resultant at-sea total grey seal population is 159,175.

38. For grey seal within the Humber Estuary SAC, the at-sea population estimate is based on the Donna Nook haul-out site count of 3,897 (SCOS, 2020), and the same correction factors as noted above. This results in an at-sea grey seal (for only those individuals associated with the Humber Estuary SAC) population estimate of 13,351[1].

39. For grey seal, the updated density estimates for the total UK at-sea seals are slightly higher than those derived from the Carter *et al*. (2020) density data, and the density estimates for those seals from the Humber Estuary SAC are lower (**Table 5-1**).

40. For harbour seal, the total at-sea population estimate is based on the total UK and Republic of Ireland haul-out count of 35,493 (SCOS, 2021), the correction for seal not available to count of 0.72 (Lonergan *et al*., 2013) for a total population estimate. This is corrected again to account for only those seals at-sea at any one time, based on the 0.8236 correction presented by Russell *et al*. (2015). The resultant at-sea total harbour seal population is 40,600.

41. For harbour seal within The Wash and North Norfolk Coast SAC, the at-sea population estimate is based on The Wash and Blakeney Point haul-out site counts of 2,848 in total (SCOS, 2021), and the same correction factors as noted above. This results in an at-sea harbour seal (for only those individuals associated with The Wash and North Norfolk Coast SAC) population estimate of 3,258[2].

42. For harbour seal, the updated density estimates for the total UK at-sea seals are slightly lower than those derived from the Carter *et al*. (2020) density data, and the density estimates for those seals from The Wash and North Norfolk Coast SAC are lower (**Table 5-1**).

[1]Note this is lower than the total Humber Estuary SAC population as presented in Table 3-2, as the at-sea population used to convert the Carter *et al*., 2022 density estimates to absolute density estimates only accounts for those individuals that may be at sea at any one time, rather than the whole SAC population.
[2]Note this is lower than the total Wash and North Norfolk Coast SAC population as presented in Table 3-3, as the at-sea population used to convert the Carter *et al*., 2022 density estimates to absolute density estimates only accounts for those individuals that may be at sea at any one time, rather than the whole SAC population.

Table 5-1: Updated Seal Density Estimates

Project area	Grey Seal density (individuals / km^2)			Harbour Seal density (individuals / km^2)		
	ES (Table 10-19)	Updated grey seal density (total usage)	Grey seal density (Humber Estuary SAC)	ES (Table 10-19)	Updated harbour seal density (total usage)	Harbour seal density (The Wash and North Norfolk Coast SAC)
SEP wind farm site	0.853	0.901	0.421	0.274	0.260	0.202
DEP wind farm site	0.739	0.780	0.363	0.080	0.076	0.057
SEP wind farm site and cable corridor		0.756	0.344		0.272	0.213
DEP wind farm site and cable corridors (to SEP site)		0.790	0.365		0.097	0.072
SEP and DEP wind farm sites		0.834	0.389		0.157	0.032
Total for SEP, DEP, and all cables	0.735	0.777	0.354	0.189	0.180	0.137

5.2 Seal Population Estimates

43. The following updates to both the grey seal and harbour seal density estimates provide an update to the information as presented in **ES Chapter 10 Section 10.5.5** and **10.5.6** respectively, as well as **Table 10-18** [APP-096].

44. Within the **ES Chapter 10** [APP-096] and the **RIAA** [APP-059], the wider reference populations for seals included the populations from the Wadden Sea region. As noted in **The Applicant's Responses on Relevant Representations: Natural England Marine Mammals (Appendix D)** [REP2-051], the Wadden Sea population has now been removed from the wider reference populations for both species. This is due to seals from outside of UK waters not being represented within the calculations for absolute seal densities as described above, and therefore an inconsistency in the seals considered.

45. As noted above, in order to generate seal population estimates, a correction factor should be applied to the haul-out counts to generate a more accurate population number for each relevant Management Unit (MU) or population estimate. This has now been done for both seal species, based on the latest available haul-out counts. These updated population estimates are provided in **Table 5-2** and **Table 5-3** below.

46. For grey seal, the wider reference population has been updated to include the NE England and SE England MUs (**Table 5-2**). With the application of the correction factor, both the SE England MU population and the wider population estimate have significantly increased in comparison to the estimate used within the **ES Chapter 10** [APP-096]. The Humber Estuary SAC population estimate used within the **RIAA** [APP-059] Section 8 has also significantly increased.

Table 5-2 Updated Reference Population Estimates for Grey Seal

MU	ES (Table 10-18) [APP-096] and RIAA (Section 8.2.3.2.1) [APP-059]	Haul-out counts (SCOS, 2020)	Correction factor for seals not available to count	Total grey seal population estimates for assessment
North East (NE) England	6,501	6,501	0.2515 (SCOS, 2020[3])	25,849
South East (SE) England	8,667	8,667	0.2515 (SCOS, 2020)	34,461
Wider reference population	24,116	15,168	-	60,310
Humber Estuary SAC	3,897	3,897	0.2515 (SCOS, 2020)	15,495

47. For harbour seal, the reference population only includes the SE England MU (**Table 5-3**). With the application of the correction factor, the SE England MU population estimate has increased in comparison to the estimate used within the

[3]Grey seal count data was not provided in SCOS (2021) and therefore SCOS (2020) provides the latest available data

ES Chapter 10 [APP-096]. The Wash and North Norfolk Coast SAC population estimate used within the **RIAA Section 8** [APP-059] has also increased.

Table 5-3 Updated Reference Population Estimates for Harbour Seal

MU	ES (Table 10-18) [APP-096] and RIAA (Section 8.2.4.2.1) [APP-059]	Haul-out count (SCOS, 2021)	Correction for seals not available to count	Total harbour seal population (corrected for seals not available to count)
SE England	3,752	3,494	0.72 (Lonergan *et al.*, 2013)	4,853
The Wash and North Norfolk Coast SAC	2,848	2,848	0.72 (Lonergan *et al.*, 2013)	3,956

6 Updates to the Environmental Statement

48. The following sections provide updates to **ES Chapter 10** [APP-096] in line with **The Applicant's Responses on Relevant Representations: Natural England Marine Mammals (Appendix D)** [REP2-051]. Each section provides signposting to where the updates would apply within ES Chapter 10.

49. In the case of any changes in magnitude or significance levels to those as presented within ES Chapter 10, these are highlighted red within each assessment.

50. The updated assessments use the approach to determining impact significance as outlined in **ES Chapter 10 Section 10.4.3** [APP-096].

6.1 Updates to Assessment of Disturbance from Underwater Noise During Piling Activities

In response to Natural England's Relevant Representation [RR-063], as stated in Applicant's Response (ID 8, 11) [REP2-051].

51. Within the **ES Chapter 10** [APP-096] and the **Appendix 10.2 Underwater Noise Modelling Report** [APP-192], a hammer energy of 5,500kJ was assessed as the highest potential to be used for the foundation installation at SEP and DEP. While this remains the worst-case, and all assessments are based on a maximum hammer energy of 5,500kJ, there is potential for the more realistic hammer energy of 4,500kJ (as modelled in addition to the maximum hammer; provided in **Appendix 10.2 Underwater Noise Modelling Report** [APP-192]) to be the maximum required. Therefore, all assessments regarding auditory injury and disturbance are highly precautionary.

52. Within **ES Chapter 10 Section 10.3.3 (Table 10-1)** [APP-096], simultaneous piling is noted as being included within the worst-case scenario as a potential piling scenario at SEP or DEP alone, or SEP and DEP; specifically, the potential for simultaneous piling at either SEP, DEP, or at SEP and DEP at the same time. The potential for simultaneous monopiling was therefore assessed within the **ES Chapter 10** as the worst-case scenario (**Sections 10.6.1.1 and 10.6.1.2**) [APP-

096], alongside the potential for simultaneous pin-piling, or monopiling at one site simultaneously with pin-piling at the other site.

53. It should be noted that while the potential for simultaneous monopiling events cannot currently be ruled out, it is considered to be a highly unlikely piling scenario. It is currently expected that the more realistic worst-case scenario would be that of simultaneous monopiling and pin-piling, although the majority of piling events would not be undertaken simultaneously with any other piling event at SEP or DEP.

54. The final piling scenario will be confirmed post-consent and will be used to inform the final MMMP and SIP, and will likely include the worst-case of monopiling at one site, with pin-piling at another at the same time.

55. The worst-case currently remains as one monopile at SEP at the same time as one monopile at DEP, although this is considered to be highly unlikely. Therefore, with the exception of the following updates and amendments, the assessments for piling as presented within the **ES Chapter 10** (**Sections 10.6.1.1** and **10.6.1.2**) [APP-096] remain valid as the current worst-case.

6.1.1 Review of Potential Effects of Underwater Noise from Piling Activities

In response to Natural England's Relevant Representation [RR-063], as stated in Applicant's Response (ID 47) [REP2-051].

6.1.1.1 Behavioural Response of Dolphins to Piling

56. The following information is provided to supplement the assessments as provided in **ES Chapter 10 Section 10.6.1.2.2.2** [APP-096].

57. There is limited information on the behavioural response of any dolphin species to piling and to date, no studies have addressed the response of white-beaked dolphins to piling noise.

58. Within the Southall *et al*. (2007) paper, a review of the data available for mid-frequency cetaceans (which include species other than dolphins, such as sperm whale *Physeter macrocephalus* and beluga *Delphinapterus leucas*) indicate that some significant response was observed at a Sound Pressure Level (SPL) of 120 dB to 130 dB re 1µPa (rms), although the majority of individuals did not display significant behavioural response until exposed to a level of 170 dB to 180 dB re 1µPa (rms). Other mid-frequency species were observed to have no behavioural response even when exposed to a level of 170 dB to 180 dB re 1µPa (rms). It should be noted that few of the reviewed studies were based on dolphin species.

59. Graham *et al*. (2017) studied the responses of bottlenose dolphins due to both impact and vibration pile driving noise during harbour construction works in northeast Scotland. The study used passive acoustic monitoring devices to record cetacean activity, and noise recorders to measure and predict received noise levels. Local abundance and patterns of occurrence of bottlenose dolphins were also compared with a five-year baseline. The median peak-to-peak source level estimated for impact piling was 240 dB re 1 µPa (single-pulse SEL 198 dB re 1 $\mu Pa^2 s$), and the rms source level for vibration piling was 192 dB re 1 µPa (Graham *et al*., 2017).

60. The results of the study found that bottlenose dolphin were not excluded from sites in the vicinity of impact piling or vibration piling; nevertheless, some small effects were detected, where bottlenose dolphins spent a reduced period of time in the vicinity of construction works during both impact and vibration piling (Graham *et al*., 2017). Dolphins generally showed a weak behavioural response to impact piling, reducing the amount of time they spend around the construction activity during piling (Graham *et al*., 2017). Observed fine-scale behavioural responses to piling by dolphins during this study occurred at predicted received single-pulse Sound Exposure Level (SEL) values of between 104 and 136.2 dB re 1 µPa2 s (Graham *et al*., 2017).

61. During the Beatrice wind farm piling campaign in 2017, dolphin detections decreased by 50% in the Impact Areas (minimum of 53km from the piling site), and decreased by 14% in the Reference Area (minimum of 80km from the piling site), compared to baseline years (Fernandez-Betelu *et al*., 2021).

62. When impact piling was conducted at Moray East wind farm in 2019, no significant difference in dolphin detections between the study areas (Impact Area at a minimum of 45km from the piling site; Reference Area at a minimum of 78km from the piling site) was found in comparison to baseline years (Fernandez-Betelu *et al*., 2021).

63. The southern coast of the Moray Firth is the closest area to the offshore activities within this bottlenose dolphin population's range, with piling at Beatrice being 50–70km from the studied population, and Moray East 40–70 km from the population. The analyses showed that dolphins continued using the southern coast of the Moray Firth during the seismic survey and impact pile-driving (and therefore the species was not significantly affected at this distance of 40-70km) (Fernandez-Betelu *et al*., 2021).

64. Displacement distances are available for other marine mammal species (such as harbour porpoise), however there are no such studies conducted for bottlenose dolphins. However, as dolphins are generally less sensitive than harbour porpoises to underwater noise, shorter ranges of displacement would be expected (Fernandez-Betelu *et al*., 2021).

65. While there is limited evidence as to the potential disturbance ranges of dolphin species due to impact piling, the above presented information indicates that the presence of dolphins may reduce due to piling works, however, there is no indication of a significant disturbance response, with individuals remaining in the vicinity of piling works. It is expected that dolphin species are less sensitive to disturbance from underwater noise than other species (such as harbour porpoise), however, due to the limited availability of evidence for dolphin species, as a precautionary approach, they are assumed to have the same sensitivity as harbour porpoise (medium).

6.1.1.2 Behavioural Response of Minke Whale to Piling

66. The following information is provided to supplement the assessments as provided in **ES Chapter 10 Section 10.6.1.2.2.2** [APP-096].

67. There is limited information on the behavioural response of minke whale to piling. Southall *et al*. (2007) recommended that the most appropriate way to assess the

disturbance effect of a noise source on marine mammals is the use of empirical studies. The same paper presented a severity scale to apply to observed behavioural responses, and subsequent Joint Nature Conservation Committee (JNCC) guidance indicates that a score of five or more on this behavioural response severity scale could be significant. A score of five relates to extensive changes in swim speed and direction, or dive pattern, but no avoidance of the noise source, or a moderate shift in distributions, a change in group size, aggregations and separation distances, and a prolonged cessation in vocal behaviours. The higher the behavioural response score, the more likely the associated noise source is to cause a significant disturbance effect.

68. Southall *et al*. (2007) includes a summary of the observed behavioural responses from noise sources. However, the majority of the studies included were based on the responses to seismic surveys. These studies contain some relevant information for whale species behavioural responses.

69. Whale species were typically observed to respond significantly at a received level of 150dB to 160dB re 1 µPa (rms) (Malme *et al*., 1983, 1984; Richardson *et al*., 1986; Ljungblad *et al*., 1988; Todd *et al*., 1996; McCauley *et al*., 1998), with behavioural changes including:

- Visible startle responses
- Extended cessation or modification of vocal behaviour
- Brief cessation of reproductive behaviour
- Brief and minor separation of females and dependent offspring

70. For a migrating bowhead whale study, most individuals avoided a seismic survey source at distances of up to 20km (the seismic surveys used airgun arrays of up to 16 guns, and total volume of 560 to 1,500 cu. in.) (Koski & Johnson, 1987; Richardson *et al*., 1999), with significantly reduced bowhead whale presence between 20 and 30km from the source, with estimated received noise levels of 120 to 130dB re 1 µPa (rms) at that distance (Richardson *et al*., 1999). However, during foraging periods, bowhead whales did not respond at greater than 6km from the source (Richardson *et al*., 1986; Miller *et al*., 2005). Observations of behavioural changes in baleen whale species have shown avoidance reactions of up to 10km for a seismic survey, with a noise source level of 143dB 1 µPa (peak to peak) (Macdonald *et al*., 1995).

71. Dose-response functions for avoidance responses of grey whales *Eschrichtius robustus* to both continuous and impulsive noises were developed for vessel noise and seismic air guns by Malme (1984). For continuous noise sources, avoidance of grey whale started at a received level of 110-119dB re 1 µPa (L_{peak}, rms), with more than 80% of individuals responding at 130dB re 1 µPa (L_{peak}, rms), and 50% at 120dB re 1 µPa (L_{peak}, rms).

72. Higher noise levels were required for an avoidance response due to the impulsive noise source (seismic airguns), with 10% of migrating grey whales responding at 164dB re 1 µPa (L_{peak}, rms), 50% at 170dB re 1 µPa (L_{peak}, rms), and 90% at 180dB re 1 µPa (L_{peak}, rms) (Malme, 1984 cited in Tyack & Thomas, 2019). A secondary study (Malme, 1987) using 100 cu. in. air guns (with a source level of 226dB re 1µPa) for foraging grey whales found a response level (where individuals

would cease foraging activities) of 50% at 173dB re 1 µPa (L_{peak}, rms), and 10% at 163dB re 1 µPa (L_{peak}, rms).

73. There is limited information on the potential disturbance ranges of minke whale to piling, however, there are some studies that provide observed disturbance of baleen whale species to seismic surveys. Baleen whale species have been observed to respond at up to 20km during migration, with disturbance observed up to 30km from a seismic source. One study found that baleen whales are more sensitive to disturbance from continuous sources than from impulsive sources. Typically, baleen whales have been reported to avoid and respond at impulsive noise levels of 150-160 re 1µPa (rms) (Malme *et al.,* 1983, 1984; Richardson *et al.,* 1986; Ljungblad *et al.,* 1988; Todd *et al.,* 1996; McCauley *et al.,* 1998), with 50% of individuals responding at 170dB to 173dB re 1µPa (L_{peak}, rms) (Malme, 1984; Malme, 1987).

74. The studies summarised above suggest that baleen whale species (including minke whale) may be similarly sensitive to disturbance from underwater noise as harbour porpoise, and therefore a sensitivity of medium is appropriate.

6.1.1.3 Behavioural Response of Seals to Piling

75. The following information is provided to supplement the assessments as provided in **ES Chapter 10 Section 10.6.1.2.2.2** [APP-096].

76. There is limited data on seal species presented within the Southall *et al*., 2007 paper. One included study was for ringed seals *Pusa hispida*, bearded seals *Erignathus barbatus*, and spotted seals *Phoca largha* (Harris *et al*., 2001), which found some avoidance at a received noise level of 160 to 170dB re 1 µPa (rms), although a larger proportion of individuals showed no response at noise levels of up to 180dB re 1 µPa (rms). Only at much higher sound pressure levels (190 to 200dB re 1 µPa (rms)) did significant numbers of seals exhibit an avoidance response.

77. Data from tagged harbour seals in The Wash indicated that seals were not excluded from the vicinity of the Lincs windfarm during construction phase with the exception of clear evidence of avoidance during pile driving, with significantly reduced levels of seal activity at ranges of up to 25km from piling sites (Russell *et al*., 2016). However, within two hours of cessation of piling, seal distribution returned to pre-piling levels (Russell *et al*., 2016).

6.1.2 Assessments of Significance for Disturbance from Piling

6.1.2.1 Assessments of Disturbance from Piling Against Known Seal Deterrence Ranges

In response to Natural England's Relevant Representation [RR-063], as stated in Applicant's Response (ID 117) [REP2-051].

78. The following assessment provides an update to the assessments for disturbance for both grey seal and harbour seal as presented in **ES Chapter 10 Section 10.6.1.2.2.3** [APP-096].

79. Regarding both grey and harbour seal, as noted above, Russell *et al* (2016) showed that harbour seal are present in significantly reduced numbers up to a

distance of 25km during piling (or a disturbance area of 1,963.5km^2). This range has been used to determine the number of both grey and harbour seal that may be disturbed during piling at either SEP or DEP, or at SEP and DEP (**Table 6-1**). To inform this assessment, the updated density estimates and populations, as provided in **Section 5**, have been used. The following assessment does not differentiate between monopiles and pin-piles, and therefore the assessment for SEP and DEP is likely to be an overestimation given the unlikelihood of two simultaneous monopile events.

80. The magnitude of the potential impact is assessed as low to medium for grey seal, and low to high for harbour seal, for a single piling location at either SEP or DEP. For two simultaneous piling locations, the potential impact is assessed as medium magnitude for grey seal and a high magnitude for harbour seal (**Table 6-1**). Note that this does not assume any overlap between disturbance areas from the piling events and is therefore precautionary.

81. This assessment shows the potential for a significant number of seals to be disturbed due to piling events at SEP and DEP, however, this assessment assumes that all individuals would react to piling noise in the same manner, at the same noise level, and that all would be disturbed to the same distance of 25km. This does not therefore take account of any individuality in the response of seals to underwater noise, or any variation in the noise levels that an individual may respond at, or to the distance at which they may be deterred.

Table 6-1 Maximum Number of Seals (and % of Reference Population) that Could be Disturbed During Piling at SEP and DEP (Magnitudes and Significance Given in Brackets are for the Secondary MU Assessed for the Wider Population for Grey Seal)

Species	Location	25km Disturbance Range (1,963.5km^2)	
		Maximum number of individuals (% of reference population)	Magnitude
Grey seal	SEP	1,769.1 (5.13% of SE MU; or 2.93% of wider ref pop)	Medium (low)
	DEP	1,531.5 (4.44% of SE MU; or 2.54% of wider ref pop)	Low (low)
	SEP & DEP	3,300.6 (9.58% of SE MU; or 5.47% of wider ref pop)	Medium (medium)
Harbour seal	SEP	510.5 (10.52% of SE MU)	High
	DEP	149.2 (3.07% of SE MU)	Low
	SEP & DEP	659.7 (13.59% of SE MU)	High

82. The above represents a worst-case magnitude and is precautionary and is therefore presented for information only. The assessment of significance of the potential for grey seal and harbour seal disturbance due to piling is based on the more realistic dose-response curve assessment and population modelling results, as presented in the following sections.

83. As the following dose response curve assessment is based on the best current understanding of marine mammal deterrence due to piling noise, it is currently the most accurate assessment that can be made. The assessment is therefore considered to provide the most accurate results for expected disturbance to the three assessed marine mammal species. Natural England Phase III advice confirms the use of the dose response curve approach as the most realistic and current best practice (Natural England, 2022):

84. *"a dose-response curve is recommended to assess behavioural responses as a matter of best practice, where possible and relevant. This is the most recent approach, is a more realistic representation of animal response, and is based on empirical at-sea monitoring data"*.

6.1.2.2 Assessments of Disturbance from Piling using a Dose Response Curve Approach

In response to both Natural England's Relevant Representation [RR-063] and the MMO Relevant Representation [RR-053], as stated in Applicant's Response (ID 42, 47, 112) [REP2-051].

85. The following section is provided as an additional assessment to that as presented in **ES Chapter 10 (Section 10.6.1.2)** [APP-096] for the potential for disturbance effects due to piling on harbour porpoise, grey seal, and harbour seal.

6.1.2.2.1 Background to Dose-Response Curves

86. In response to MMO comment 4.4.15 [RR-053], where sufficient evidence exists (namely harbour porpoise, harbour seal and grey seal), species-specific dose-response assessment has been provided.

87. For the purposes of this assessment, the dose is the received single-strike Sound Exposure Level (SEL_{SS}). The use of SEL_{SS} in a dose-response analysis, where possible, is considered to be best practice in the latest guidance provided by Southall *et al*. (2021).

88. To estimate the number of animals disturbed by piling, SEL_{SS} contours at 5 decibel (dB) increments (generated by the noise modelling – see **Annex 3**, **Figures 6.1** to **6.8**) were overlain on the relevant species density surfaces to quantify the number of animals receiving each SEL_{SS}, and subsequently the number of animals likely to be disturbed based on the corresponding dose-response curve. For harbour porpoise, the Waggitt *et al*. (2020) density estimates were used. As August was the month with the greatest harbour porpoise densities within the SEP and DEP sites, density estimates from this month were used to provide a conservative result. For both seal species, the Carter *et al*. (2022) density estimates were used.

89. The dose-response relationship used for harbour porpoise was developed by Graham *et al*. (2017) using data collected on harbour porpoises during Phase 1 of piling at the Beatrice Offshore Wind Farm. This dose response relationship is displayed in **Plate 6-1**. Following the development of this dose-response relationship, further study revealed that the responses of harbour porpoises to piling noise diminishes over the construction period (Graham *et al*., 2019). Therefore, the use of the dose-response relationship related to an initial piling

event for all subsequent piling events in this assessment can be considered precautionary.

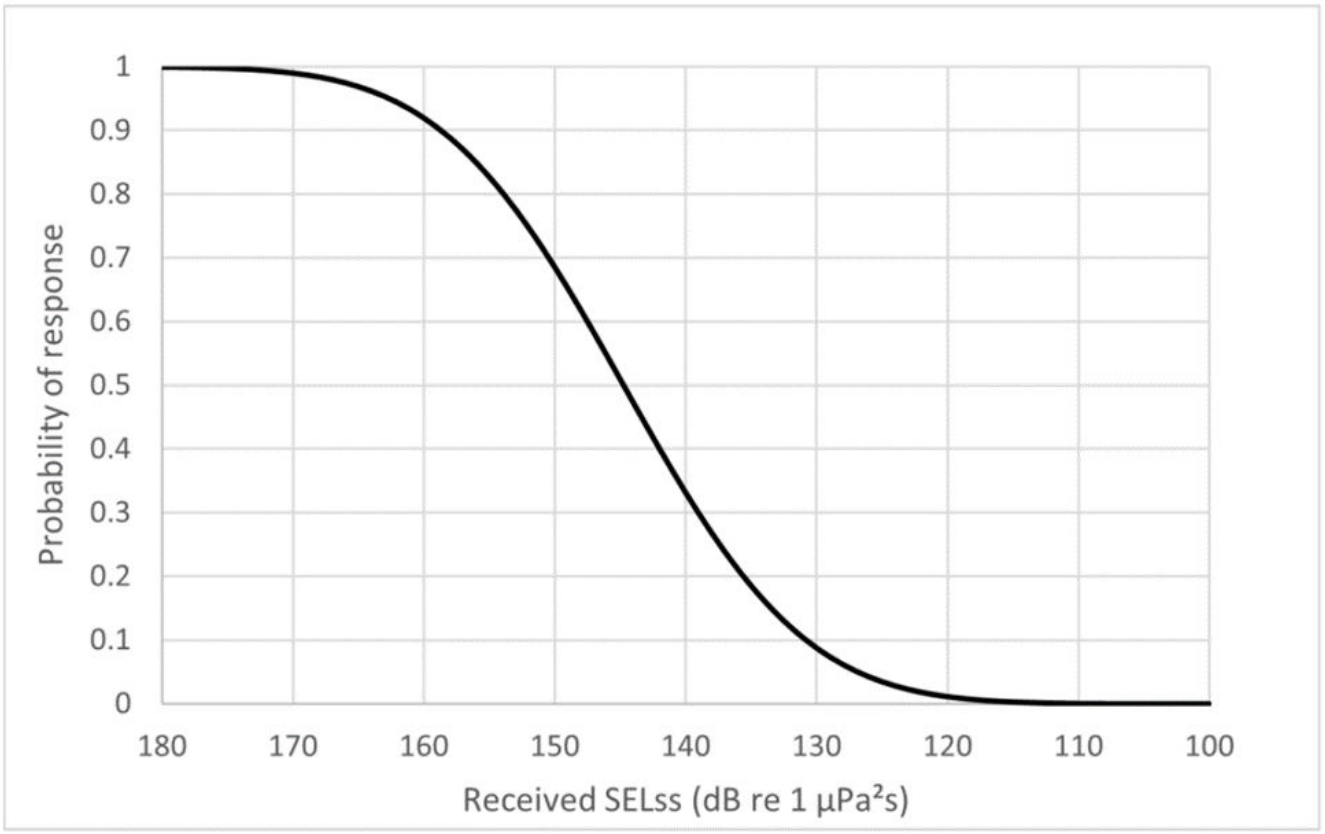

Plate 6-1: Dose-response relationship developed by Graham et al. (2017) used for harbour porpoise in this assessment

90. For both harbour seal and grey seal, a dose-response relationship that is derived from harbour seal telemetry data collected during several months of piling at the Lincs Offshore Wind Farm has been used (Whyte *et al*., 2020). As indicated in **Plate 6-2**, the greatest SEL_{SS} considered in the Whyte *et al*. (2020) study was 180 dB re 1 μPa^2s. This assessment has therefore conservatively assumed that at SEL_{SS} greater than 180 dB re 1 μPa^2s, all seals will be disturbed. The dose-response curve for harbour seal has been used for grey seal, as both species have similar hearing audiograms.

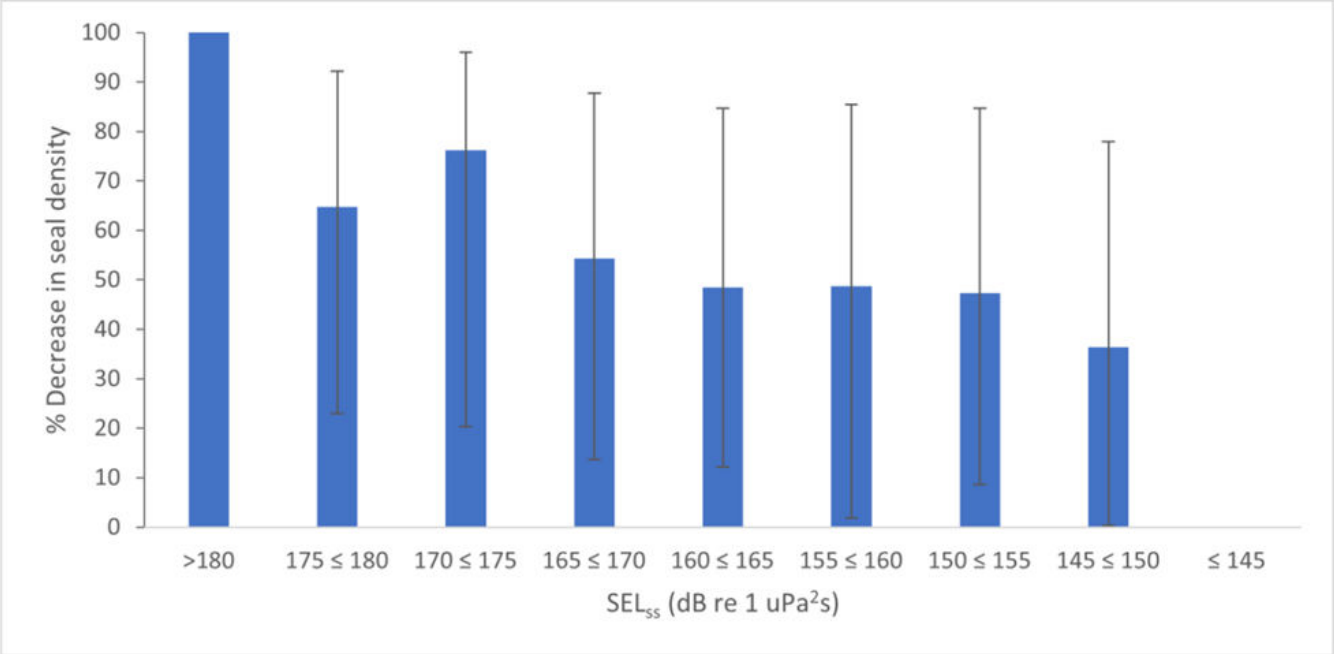

Plate 6-2: Dose-response behavioural disturbance data for harbour seal derived from the data collected and analysed by Whyte et al. (2020). This data has been used for harbour and grey seals in this assessment

6.1.2.2.2 Dose-Response Curve Assessment

91. The assessment is based on SEL_{ss} for the worst-case of monopile with maximum diameter of up to 16m and maximum hammer energy of up to 5,500kJ at SEP, DEP and SEP and DEP together[4].

92. A single strike of a pile occurring simultaneously in both SEP and DEP will cause overlapping noise in the space between the two projects. Animals that would have been disturbed in these areas by SEP or DEP alone, will not be disturbed twice. However, the assessment of animals disturbed by simultaneous piling in SEP and DEP conservatively sums the maximum number of animals disturbed by each project alone. Therefore, the assessment for SEP and DEP together is likely an overestimation of the number of individuals that would be disturbed.

93. The estimated numbers (and percentage of the relevant reference population) of harbour porpoise, grey seal, and harbour seal that could be disturbed as a result of underwater noise during piling are presented in **Table 6-2**.

94. For harbour porpoise the reference population is the North Sea (NS) MU of 346,601 individuals (Inter-Agency Marine Mammal Working Group (IAMMWG), 2022).

95. For grey seal the reference population is the SE England MU of 34,461 individuals, as well as the wider reference population of 60,310 for the SE England and NE England MUs (**Table 5-2**).

[4]Dose response curve analysis utilises SEL_{ss} 5dB noise contours, and therefore is only possible to be undertaken for a single strike of a hammer

96. For harbour seal the reference population is the SE England MU of 4,853 individuals (**Table 5-3**).

97. For the species assessed, the magnitude is assessed as negligible to low, with a maximum of 2.6% of the relevant MU reference population predicted to be disturbed (**Table 6-2** and **Figures 6.9** to **6.14**).

98. It should be noted that this dose-response analysis is carried out in relation to pile driving noise only, and therefore does not account for the use of ADD which may reduce localised marine mammal densities prior to piling. This assessment can therefore be considered conservative.

Table 6-2: Number of Individuals (and % of Reference Population) that Could be Disturbed During Piling at SEP and DEP based on the Dose-Response Curve (Magnitudes and Significance Given in Brackets are for the Secondary MU Assessed for the Wider Population for Grey Seal)

Species	Location	Number of individuals disturbed (% of reference population)	Magnitude (temporary effect)
Harbour porpoise	SEP	582 harbour porpoise (0.17% of NS MU)	Negligible
	DEP	804 harbour porpoise (0.23% of North Sea MU)	Negligible
	SEP & DEP	1,386 harbour porpoise (0.40% of North Sea MU)	Negligible
Grey seal	SEP	338 grey seal (0.98% of SE England MU; 0.56% of the wider reference population)	Negligible (Negligible)
	DEP	374 grey seal (1.09% of SE England MU; 0.62% of the wider reference population)	Low (Negligible)
	SEP & DEP	712 grey seal (2.07% of SE England MU; 1.18 % of the wider reference population)	Low (Low)
Harbour seal	SEP	84 harbour seal (1.73% of SE England MU)	Low
	DEP	43 harbour seal (0.89% of SE England MU)	Negligible
	SEP & DEP	127 harbour seal (2.62% of SE England MU)	Low

6.1.2.2.3 Impact Significance

99. The following sections provide an update to the impact significance of disturbance to harbour porpoise, grey seal and harbour seal presented in **ES Chapter 10 Section 10.6.1.2** [APP-096]. For both seal species, the impact significances for disturbance from piling as presented in the ES are based on those as assessed for the potential for TTS (**ES Chapter 10 Section 10.6.1.1.4** for SEP or DEP, and **ES Chapter 10 Section 10.6.1.1.7** for SEP and DEP) [APP-096].

100. The assessment of disturbance for harbour porpoise, grey seal and harbour seal, as presented in **ES Chapter 10** (and summarised in **Table 6-3** below) resulted in an impact significance of minor adverse for SEP or DEP, and for SEP and DEP, for harbour porpoise and both seal species.

101. The updated assessments using the dose response curve approach also result in an impact significance of minor adverse for all species, for either piling at SEP, DEP or at and SEP and DEP (**Table 6-3**). Therefore, no mitigation is required.

Table 6-3: Assessment of Impact Significance for Disturbance in Harbour Porpoise, Grey Seal and Harbour Seal from Underwater Noise During Piling of Monopile, Based on a Dose Response Curve Approach (Magnitudes and Significance Given in Brackets are for the Secondary MU Assessed for the Wider Population for Grey Seal)

Species	Location	Sensitivity	Impact assessment as presented in ES Chapter 10 (Table 10-52 and Table 10-53 for SEP or DEP, and Table 10-58 and Table 10-59 for SEP and DEP for harbour porpoise; and Table 10-37 for SEP or DEP; Table 10-46 for SEP and DEP for grey and harbour seal, based on the assessments for TTS as a proxy for disturbance) [APP-096]				Updated Assessment Based on Dose Response			
			Magnitude	Significance	Mitigation	Residual Impact	Magnitude	Significance	Mitigation	Residual Impact
Harbour porpoise – using the EDR approach	SEP	Medium	Negligible for both monopile and pin-pile	Minor adverse	SIP (Section 10.3.4.2 of ES Chapter 10)	**Minor adverse**	Negligible	Minor adverse	None required	**Minor adverse**
	DEP		Low for monopile Negligible for pin-pile	Minor adverse		**Minor adverse**	Negligible	Minor adverse		**Minor adverse**
	SEP & DEP		Low for monopile Negligible for pin-pile	Minor adverse		**Minor adverse**	Negligible	Minor adverse		**Minor adverse**
Harbour porpoise – using the behavioural response threshold	SEP	Medium	Negligible for both monopile and pin-pile	Minor adverse	SIP (Section 10.3.4.2 of ES Chapter 10)	**Minor adverse**	Negligible	Minor adverse	None required	**Minor adverse**
	DEP		Negligible for both monopile and	Minor adverse		**Minor adverse**	Negligible	Minor adverse		**Minor adverse**

Species	Location	Sensitivity	Impact assessment as presented in ES Chapter 10 (Table 10-52 and Table 10-53 for SEP or DEP, and Table 10-58 and Table 10-59 for SEP and DEP for harbour porpoise; and Table 10-37 for SEP or DEP; Table 10-46 for SEP and DEP for grey and harbour seal, based on the assessments for TTS as a proxy for disturbance) [APP-096]				Updated Assessment Based on Dose Response			
			pin-pile							
	SEP & DEP		Low for monopile Negligible for pin-pile	Minor adverse		**Minor adverse**	Negligible	Minor adverse		**Minor adverse**
Grey seal	SEP	Medium	Negligible (negligible) for both monopile and pin-pile	Minor (minor) adverse for both monopile and pin-pile	MMMP (**Section 10.3.4 of ES Chapter 10**)	**Minor adverse**	Negligible (Negligible)	Minor adverse	None required	**Minor adverse**
	DEP		Low (negligible) for monopile Negligible (negligible) for pin-pile	Minor (minor) adverse for both monopile and pin-pile		**Minor adverse**	Low (Negligible)	Minor adverse		**Minor adverse**
	SEP & DEP		Low (low) for monopiles and pin-piles	Minor (minor) adverse		**Minor adverse**	Low (Low)	Minor adverse		**Minor adverse**
Harbour seal	SEP	Medium	Negligible (negligible) for both monopile and pin-pile	Minor (minor) adverse for both monopile and pin-pile	MMMP (**Section 10.3.4** of **ES Chapter**	**Minor adverse**	Low	Minor adverse	None required	**Minor adverse**

Species	Location	Sensitivity	Impact assessment as presented in ES Chapter 10 (Table 10-52 and Table 10-53 for SEP or DEP, and Table 10-58 and Table 10-59 for SEP and DEP for harbour porpoise; and Table 10-37 for SEP or DEP; Table 10-46 for SEP and DEP for grey and harbour seal, based on the assessments for TTS as a proxy for disturbance) [APP-096]				Updated Assessment Based on Dose Response			
	DEP		Negligible (negligible) for both monopile and pin-pile	Minor (minor) adverse for both monopile and pin-pile	**10**)	**Minor adverse**	Negligible	Minor adverse		**Minor adverse**
	SEP & DEP		Low (negligible) for monopiles	Minor (minor) adverse		**Minor adverse**	Low	Minor adverse		**Minor adverse**

6.1.2.3 Population Modelling

In response to Natural England's Relevant Representation [RR-063], as stated in Applicant's Response (ID 61, 112) [REP2-051].

102. Population modelling has been undertaken to determine the population level consequences of disturbance due to piling at SEP and DEP. As assessed under the known seal deterrence range approach above (**Section 6.1.2.1**), there is the potential for a significant impact due to disturbance from piling for grey seal and harbour seal (**Table 6-1**). While an assessment under the dose response curve approach is considered to be most realistic for both seal species, population modelling has been undertaken to determine whether the greater number of animals disturbed under the known seal deterrence range approach would cause a population level effect. The results of this modelling for harbour porpoise, grey seal and harbour seal will be used to determine the requirement for any noise reduction measures to be put in place.

6.1.2.3.1 Introduction to Population Modelling

103. **ES Chapter 10** [APP-096], and the updated results for disturbance presented in this report (**Section 6.1.2**), reveal that elevations in subsea noise due to piling could potentially lead to the behavioural disturbance of a large number of individuals of the key species identified within the marine mammal study area.

104. Population modelling has therefore been conducted for harbour porpoise, harbour seal and grey seal. The interim Population Consequences of Disturbance (iPCoD) framework (Harwood *et al.,* 2014, King *et al.*, 2015) has been used to predict the potential medium- and long-term population consequences of the predicted amount of disturbance resulting from piling at SEP and DEP.

105. iPCoD uses a stage-structured model of population dynamics with nine age classes and one stage class (adults 10 years and older). The model is used to run a number of simulations of future population trajectory with and without the predicted level of impact to allow an understanding of the potential future population-level consequences of predicted behavioural responses and auditory injury.

106. There is a lack of empirical data on the way in which changes in behaviour and hearing sensitivity may affect the ability of individual marine mammals to survive and reproduce. Therefore, in the absence of empirical data, the iPCoD framework uses the results of an expert elicitation process described in Donovan *et al.* (2016) to predict the effects of disturbance and Permanent Threshold Shift (PTS) on survival and reproductive rates. The process generates a set of statistical distributions for these effects and then simulations are conducted using values randomly selected from these distributions that represent the opinions of a "virtual" expert. This process is repeated many 100s of times to capture the uncertainty among experts. While the iPCoD model is subject to many assumptions and uncertainties relating to the link between impacts and vital rates, the model presents the best available scientific expert opinion at this time.

107. Another potential limitation of the iPCoD model is that no form of density dependence has been incorporated due to the uncertainties as to how this may

occur. As discussed in Harwood *et al.* (2014), the concept of density-dependence is fundamental to understanding how animal populations respond to a reduction in their size. In population biology, density-dependant factors, such as resource availability or competition for space, can limit population growth. If the population declines, these factors no longer become limiting and therefore, for the remaining individuals in a population, there is likely to be an increase in survival rate and reproduction. This then allows the population to expand back to previous levels at which density-dependent factors become limiting again (i.e. population remains at carrying capacity).

108. The limitations for assuming a simple linear ratio between the maximum net productivity level and carrying capacity have been highlighted by Taylor and Master (1993) as simple models demonstrate that density dependence is likely to involve several biological parameters which themselves have biological limits (e.g. fecundity and survival). For UK populations of harbour porpoise (and other marine mammal species) however, there is no published evidence for density dependence and therefore, density dependence assumptions are not currently included within the iPCoD protocol.

109. Despite these limitations and uncertainties, this assessment has been carried out according to best practice, using the best available scientific information, and the latest expert elicitation results from Booth and Heinis (2018). The information provided is therefore considered to be sufficient to carry out an adequate assessment for harbour porpoise, harbour seal and grey seal.

6.1.2.3.2 Methodology

Piling Parameters

110. The amount of piling required for the Project is dependent on the construction scenario taken forwards: SEP alone, DEP alone, or SEP and DEP (sequentially or concurrently). Each of these construction scenarios has been taken forward for modelling in iPCoD.

111. Whilst there is potential that piling for SEP and DEP could occur simultaneously, thereby reducing the number of days in which disturbance can occur, as a worst case it has been assumed that only 1 monopile and 1 pin pile can be installed in each 24 hour period.

112. At this stage, uncertainty exists around the exact piling schedule that will be used for construction of SEP and DEP, however the periods during which piling is likely to occur are known. Therefore, the required number of piling days for each construction scenario have been distributed randomly within the known piling periods.

113. The piling parameters for each project scenario are detailed in **Table 6-4**, **Table 6-5**, and **Table 6-6**.

Table 6-4 Piling scenarios used for iPCoD modelling for SEP alone and DEP alone

Parameter	SEP	DEP
Number of WTGs	23	30
Number of Offshore Substation Platforms (OSP)	1	1
Number of piles	23 monopiles (WTG) and 8 pin piles (OSP)	30 monopiles (WTG) and 8 pin piles (OSP)
Number of piling days	31 (assumed 1 pile per day)	38 (assumed 1 pile per day)
Piling window	March – June 2027 (WTG monopiles) May 2028 (OSP pin piles)	March – June 2027 (WTG monopiles) May 2028 (OSP pin piles)
Piling schedule	March – June 2027: 23 monopile days (distributed randomly) May 2028 (two blocks of four consecutive pin pile days, at random point within the month)	March – June 2027: 30 monopile days (distributed randomly) May 2028 (two blocks of four consecutive pin pile days, at random point within the month)

Table 6-5 Piling scenario used for iPCoD modelling for SEP, followed by DEP (sequential scenario)

Parameter	SEP	DEP
Number of WTGs	23	30
Number of OSPs	1	1
Number of piles	23 monopiles (WTG) and 8 pin piles (OSP)	30 monopiles (WTG) and 8 pin piles (OSP)
Number of piling days	69 (assumed 1 pile per day)	
Piling window	March – June 2027 (SEP WTG monopiles) May 2028 (SEP OSP pin piles) March – June 2029 (DEP WTG monopiles) May 2030 (DEP OSP pin piles)	
Piling schedule	March – June 2027, SEP: 23 monopile days (distributed randomly) May 2028, SEP: (two blocks of four consecutive pin pile days, at random point within the month) March – June 2029, DEP: 30 monopile days (distributed randomly) May 2030, DEP: (two blocks of four consecutive pin pile days, at random point within the month)	

Table 6-6 Piling scenario used for iPCoD modelling for SEP and DEP constructed concurrently

Parameter	SEP	DEP

Parameter	SEP	DEP
Number of WTGs	23	30
Number of OSPs	1	1
Number of piles	23 monopiles (WTG) and 8 pin piles (OSP)	30 monopiles (WTG) and 8 pin piles (OSP)
Number of piling days	69 (assumed 1 pile per day)	
Piling window	March – August 2027 (WTG monopiles) May 2028 (OSP pin piles)	
Piling schedule	March – June 2027: 53 monopile days (distributed randomly) May – July 2028 (four blocks of four consecutive pin pile days, at random points within the month)	

Model Inputs

114. The iPCoD model v5.2 was set up using the program R v4.2.3 (2023) with RStudio as the user interface. To enable the iPCoD model to be run, the following data were provided:

- Demographic parameters for each key species;
- User specified input parameters
  - Vulnerable subpopulations
  - Residual days of disturbance
- Number of animals predicted to experience PTS and/or disturbance during piling; and
- Estimated piling schedule during the proposed construction programme.

Demographic Parameters

115. Demographic parameters for the key species assessed in the population model are presented in **Table 6-7**. In the case of harbour seal, evidence for demographic parameters for the English populations is lacking (Sinclair *et al.*, 2020). The combined counts for harbour seal in the SE MU in 2019 (3,081) was 27.6% lower than the 2012 to 2018 mean count. Additional surveys in 2020 and 2021 confirmed the decrease (SCOS, 2021). Given that the SE MU appears to be decreasing in recent years, the worst-case demographic parameters for the similarly decreasing population on the Scottish East coast (Sinclair *et al.,* 2019) have been utilised in the modelling.

Table 6-7 Demographic Parameters Recommended for Each Species for the Relevant Management Unit (MU)/SMAs (Sinclair et al., 2019)

Species	MU	Age calf/pup becomes independent	Age of first birth	Calf/Pup Survival	Juvenile Survival	Adult Survival	Fertility	Growth Rate
		age1	age2	Surv[1]	Surv[7]	Surv[13]		

Species	MU	Age calf/pup becomes independent	Age of first birth	Calf/Pup Survival	Juvenile Survival	Adult Survival	Fertility	Growth Rate
Harbour Porpoise	North Sea	1	5	0.6	0.85	0.925	0.479	1.0000
Grey Seal	All	1	5	0.222	0.94	0.94	0.84	1.0100
Harbour Seal	Southern North Sea	1	4	0.5	0.5	0.7701	0.88	0.82
Bottlenose Dolphin	Greater North Sea	2	9	0.86	0.94	0.94	0.25	1.0000

Reference Populations

116. The populations of marine mammal species vulnerable to piling-induced PTS/disturbance were specified in the model as the reference populations against which the effects (i.e. number of animals suffering PTS/disturbed) were assessed in **ES Chapter 10** [APP-096] for harbour porpoise, or in the updated assessments for seals (updated reference populations set out in **Section 5.2**). **Table 6-8** provides the reference populations used in the iPCoD modelling.

Table 6-8 Reference Populations Used in the iPCoD Modelling

Species	Area	Population
Harbour porpoise	North Sea MU	346,601
Grey seal	Reference population (NE England MU + SE England MU)	60,310
Harbour Seal	SE England MU	4,853
Bottlenose Dolphin	Greater North Sea MU	2,022

Residual Days Disturbance

117. Empirical evidence from constructed wind farms (e.g. Graham *et al.,* 2019; Brandt *et al.,* 2011) suggests that the detection of animals returns to baseline levels in the hours following a disturbance from piling and therefore, for the most part, it can be assumed that the disturbance occurs only on the day (24 hours) that piling takes place (at least in the case of harbour porpoise which was the focus of these studies). However, the number of residual days of disturbance has, conservatively, been selected as one, meaning that the model assumes that disturbance occurs on the day of piling and persists for a period of 24 hours after piling has ceased.

Number of Animals with PTS or Disturbed

118. The number of animals predicted to experience PTS and/or disturbance during piling was based on the density values provided as part of the baseline assessment of the **ES Chapter 10** [APP-096] for harbour porpoise, and the

updated baseline assessment set out in this report (**Section 5**) for harbour and grey seal.

119. In the case of disturbance, the estimated number of animals affected are based on effective deterrent ranges. Whilst this report provides alternative estimates of the number of animals disturbed, based on a dose-response analysis (which can be considered more realistic), the estimates resulting from Effective Deterrent Range (EDRs) are greater, and therefore have been used in the iPCoD model as a conservative worst-case.

Table 6-9 Estimated Number of Animals to have PTS or to be Disturbed During Each Piling Event

Species	Number of Animals Affected During Each Piling Event			
	SEP		DEP	
	PTS	Disturbance	PTS	Disturbance
Harbour porpoise	27	1,338	148	5,161
Grey seal	0.63	1,769	1.09	1,532
Harbour Seal	0.22	511	0.11	149
Bottlenose Dolphin	0.003	0.009	0.003	0.012

Piling Schedule

120. The piling schedule was developed from the project design envelope which provided an estimate of the number of days piling for the wind turbine and OSP foundations within a defined piling phase, which is scheduled to take place within an overall offshore piling construction window, as described above.

6.1.2.3.3 Results of the Population Modelling for SEP and DEP Alone

Harbour Porpoise

121. Assuming a worst-case of 1,338 porpoise disturbed and 27 with PTS at SEP, and 5,161 disturbed and 148 with PTS at DEP on every piling day (**Table 6-9**), the iPCoD model estimates there to be only the slightest discernible impact to the harbour porpoise population (**Plate 6-1** and **Table 6-10**) in the worst-case project scenario where both SEP and DEP are constructed sequentially.

122. The mean population size for the impacted population was predicted to be >99.99% of the un-impacted population size at the end of 2027 (after the first year of pile driving has completed). By the end of 2032 (2 years after piling ends) the mean population size for the impacted population was predicted to be 99.97% of the un-impacted population size. The impacted population is expected to maintain the same increasing trajectory as the un-impacted population after the impact period has ceased (as far as 2050 which is the end point of the modelling).

Table 6-10 Results of the iPCoD modelling for the SEP and DEP sequential project scenario, giving the mean population size of the harbour porpoise population (North Sea MU) for years up to 2050 for both impacted and un-impacted populations as well as the mean and median ratio between their populations

Year	Un-impacted population mean	Impacted population mean	Median impacted as % of un-impacted	Mean impacted as % of un-impacted
Start	346,600	346,600	100%	100%
End 2027	346,550	346,498	>99.99%	99.98%
End 2032	346,967	346,875	99.99%	99.97%
End 2038	346,491	346,396	99.99%	99.97%
End 2044	346,648	346,552	99.99%	99.97%
End 2050	347,280	347,184	99.99%	99.97%

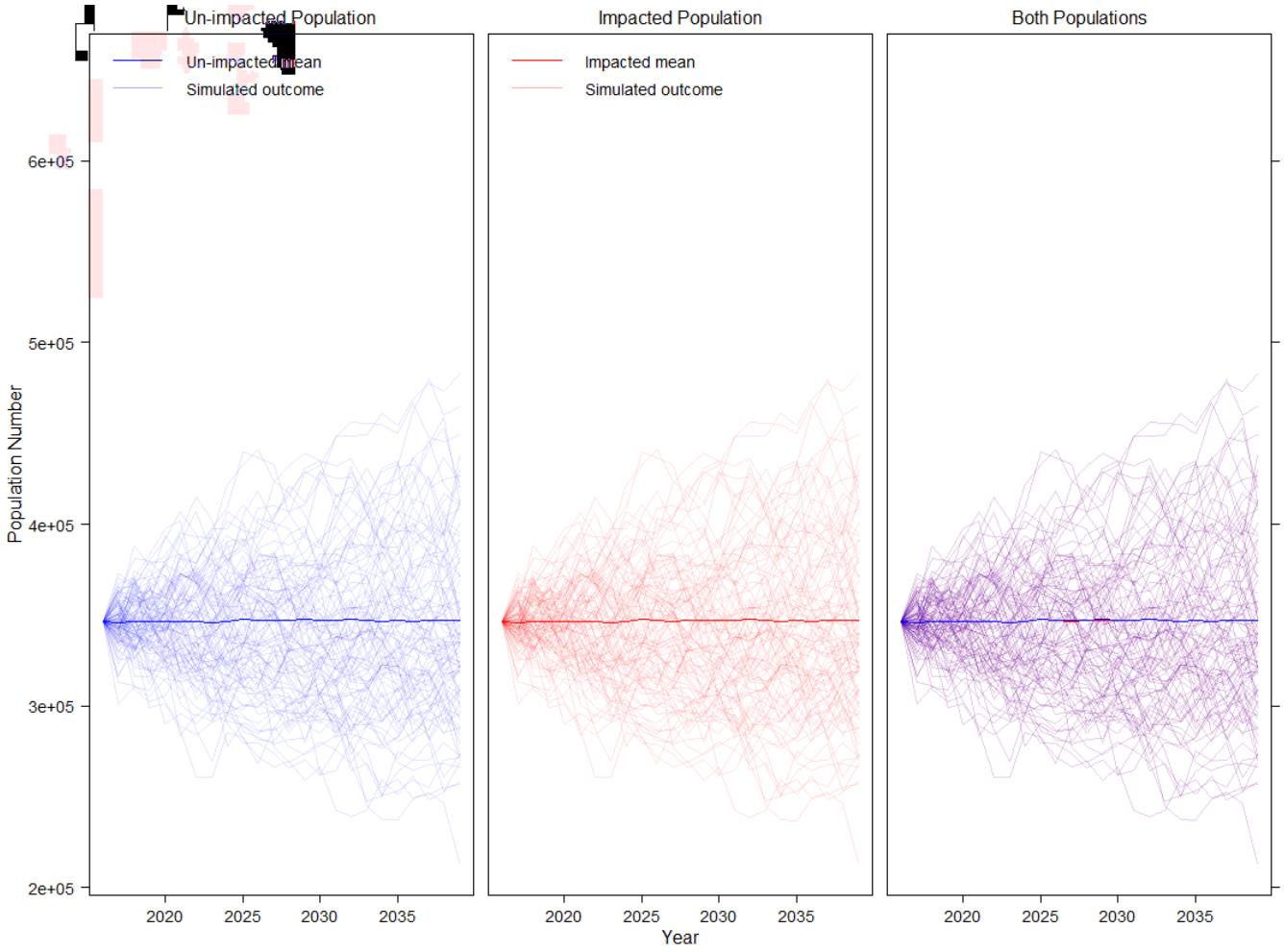

Plate 6-1 Simulated worst-case harbour porpoise population sizes for both the un-impacted and the impacted populations

Grey Seal

123. Assuming a worst-case of 1769 grey seal disturbed and 0.63 with PTS at SEP, and 1532 disturbed and 1.09 with PTS at DEP on every piling day (**Table 6-9**), the iPCoD model estimates there to be no discernible impact to the reference grey seal population (**Plate 6-2** and **Table 6-11**) in the worst-case project scenario where both SEP and DEP are constructed sequentially. The mean population size for the impacted population was predicted to be 100% of the un-impacted population size at the end of 2027 (after the first year of pile driving has completed). By the end of 2032 (2 years after piling ends) the mean population size for the impacted population was predicted to be 100% of the un-impacted population size. The impacted population is expected to maintain the same increasing trajectory as the un-impacted population after the impact period has ceased (as far as 2050 which is the end point of the modelling).

Table 6-11 Results of the iPCoD modelling for the SEP and DEP sequential project scenario, giving the mean population size of the grey seal population (Reference population) for years up to 2050 for both impacted and un-impacted populations as well as the mean and median ratio between their populations

Year	Un-impacted population mean	Impacted population mean*	Median impacted as % of un-impacted	Mean impacted as % of un-impacted
Start	60,308	60,308	100%	100%
End 2027	60,801	60,802	100%	100%
End 2032	63,920	63,923	100%	100%
End 2038	67,817	67,820	100%	100%
End 2044	71,676	71,679	100%	100%
End 2050	75,990	75,993	100%	100%

**Note that the marginal increase in the impacted population in comparison to the un-impacted population is a result of the environmental stochasticity built into the model*

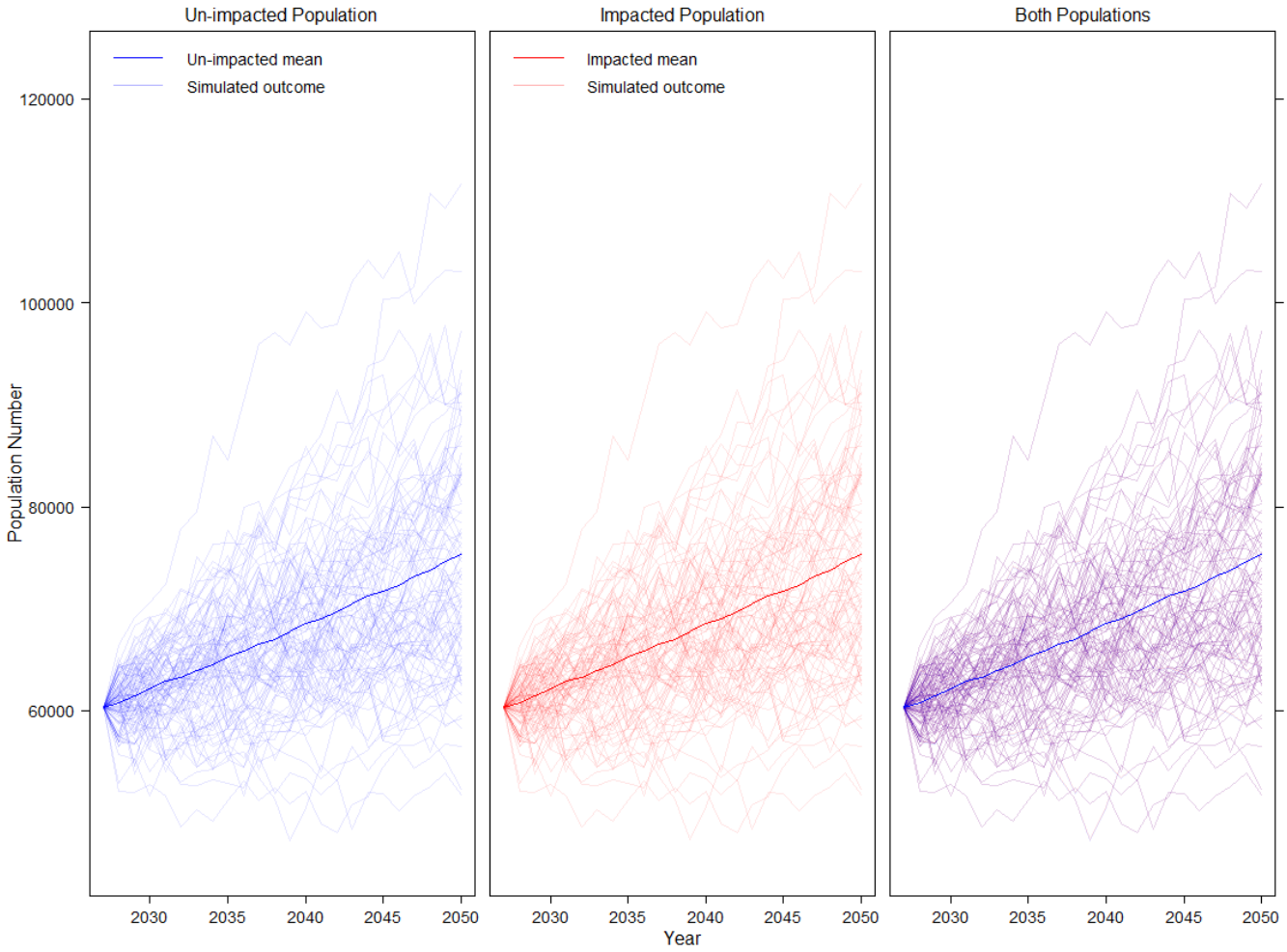

Plate 6-2 Simulated worst-case grey seal reference population sizes for both the un-impacted and the impacted populations

6.1.2.3.3 Harbour Seal

124. Assuming a worst-case of 511 harbour seal disturbed and 0.22 with PTS at SEP, and 149 disturbed and 0.11 with PTS at DEP on every piling day (**Table 6-9**), the iPCoD model estimates there to be no discernible impact to the SE England MU harbour seal population (**Plate 6-3** and **Table 6-11**) in the worst-case project scenario where both SEP and DEP are constructed sequentially. The mean population size for the impacted population was predicted to be 100% of the un-impacted population size at the end of 2027 (after the first year of pile driving has completed). By the end of 2032 (2 years after piling ends) the mean population size for the impacted population was predicted to be 100% of the un-impacted population size. The impacted population is expected to maintain the same decreasing trajectory as the un-impacted population after the impact period has ceased (as far as 2050 which is the end point of the modelling).

Table 6-12 Results of the iPCoD modelling for the SEP and DEP sequential project scenario, giving the mean population size of the harbour seal population (SE England MU) for years up to 2050 for both impacted and un-impacted populations as well as the mean and median ratio between their populations

Year	Un-impacted population mean	Impacted population mean*	Median impacted as % of un-impacted	Mean impacted as % of un-impacted
Start	4,850	4,850	100%	100%
End 2027	3,982	3,982	100%	100%
End 2032	1,483	1,484	100%	100%
End 2038	453	453	100%	100%
End 2044	138	138	100%	100%
End 2050	41	41	100%	100%

**Note that the model assumes that population demographics remain constant over time. This means that the currently declining population is projected to continue its decline regardless of any additional piling activity.*

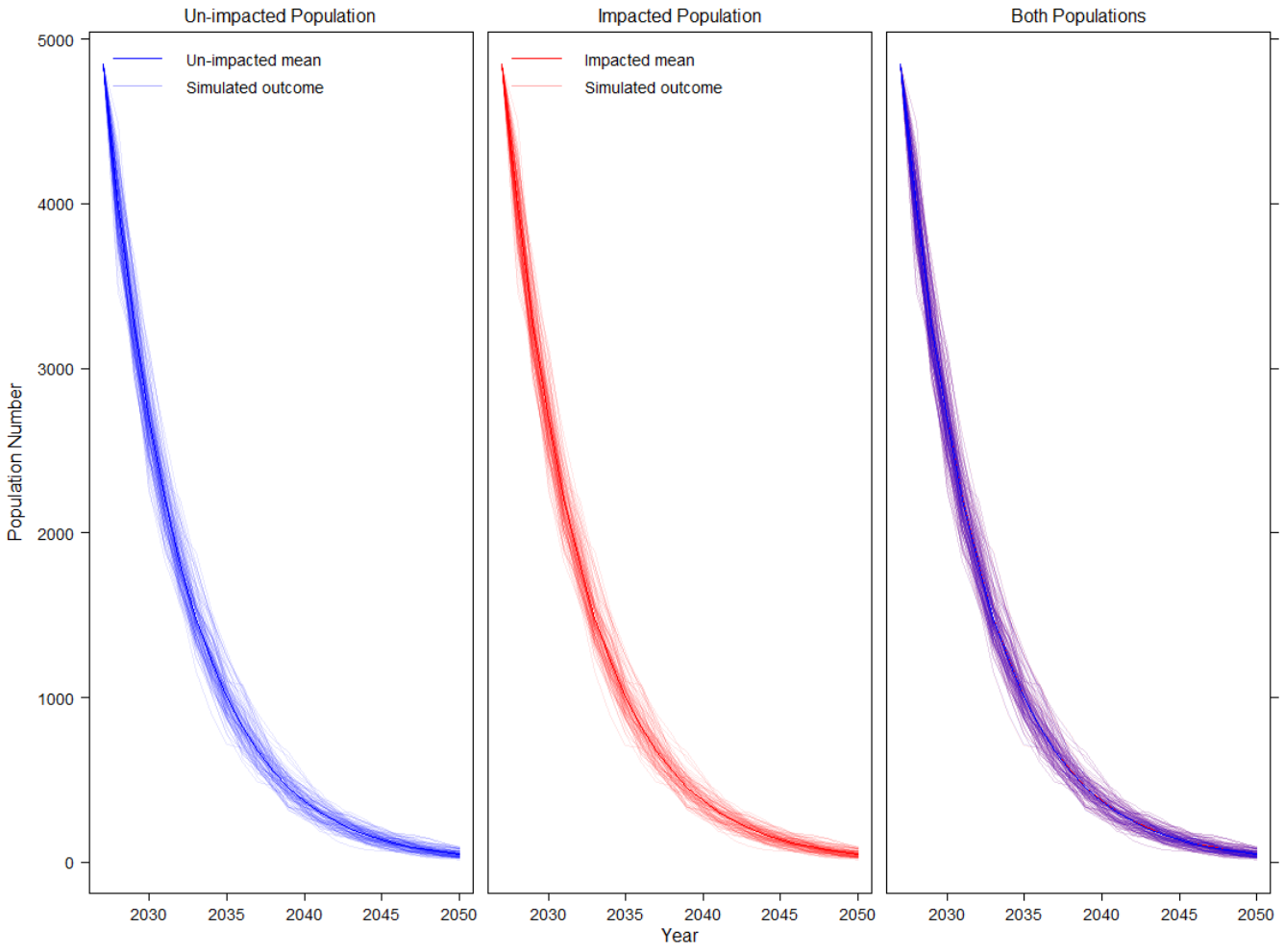

Plate 6-3 Simulated worst-case harbour seal SE England MU population sizes for both the un-impacted and the impacted populations

Bottlenose dolphin

125. Assuming a worst-case of 0.009 bottlenose dolphin disturbed and 0.003 with PTS at SEP, and 0.012 disturbed and 0.003 with PTS at DEP on every piling day (**Table 6-9**), the iPCoD model estimates there to be no discernible impact to the Greater North Sea MU bottlenose dolphin population (**Table 6-13**) in the worst-case project scenario where both SEP and DEP are constructed sequentially. The mean population size for the impacted population was predicted to be 100% of the un-impacted population size at the end of 2027 (after the first year of pile driving has completed). This lack of discernible change in the mean impacted population size is expected to maintain until after the impact period has ceased (as far as 2050 which is the end point of the modelling).

Table 6-13 Results of the iPCoD modelling for the SEP and DEP sequential project scenario, giving the mean population size of the bottlenose dolphin population (Greater North Sea MU) for years up to 2050 for both impacted and un-impacted populations as well as the mean and median ratio between their populations

Year	Un-impacted population mean	Impacted population mean	Median impacted as % of un-impacted	Mean impacted as % of un-impacted
Start	2,024	2,024	100%	100%
End 2027	2,023	2,023	100%	100%
End 2032	2,023	2,023	100%	100%
End 2038	2,026	2,026	100%	100%
End 2044	2,030	2,030	100%	100%
End 2050	2,034	2,034	100%	100%

Plate 6-4 Simulated worst-case bottlenose dolphin Greater North Sea MU population sizes for both the un-impacted and the impacted populations

6.1.2.3.4 Magnitude of Population Level Consequences due to Disturbance at SEP and DEP

126. The results of population modelling for SEP and DEP piling as shown above show no significant difference in the population estimates at the end of the 25 year modelling period for the disturbed or un-disturbed populations.

127. There is the potential for a 0.01% to 0.03% reduction in the harbour porpoise population over the modelled period of 25 years (**Table 6-10**). For bottlenose dolphin, grey seal and harbour seal, the disturbance from piling at SEP and DEP would not cause a population level effect (**Table 6-13, Table 6-12, Table 6-11**). The magnitude of effect is therefore predicted to be negligible for all species (**Table 6-12**).

128. The harbour seal population is currently in decline, and the population modelling has used a declining harbour seal population as the input values to provide a precautionary assessment. The population reduces to 41 (from the starting estimate of 4,850 individuals) over the 25 year modelled period. However, the SEP and DEP piling scenario also predicts a population level of 41 by the end of the modelled period. This indicates that the disturbance associated with offshore wind

farm piling would not worsen the already declining population, even under the most precautionary and worst-case assessments.

6.1.2.4 Requirement for Further Mitigation to Reduce Disturbance due to Piling

129. The results of the population modelling, as provided in **Section 6.1.2.3.3** above, have shown that there would be no effect on the population of any of the modelled species. No mitigation for disturbance is therefore proposed (or required) for piling at SEP and DEP.

130. Additional modelling has been undertaken to determine the potential for population level effects due to cumulative disturbance with other offshore wind farm piling activities (see **Section 6.2.1.5**).

6.1.3 Disturbance from ADD Activation

6.1.3.1 ADD Activation Durations

In response to Natural England's Relevant Representation [RR-063], as stated in Applicant's Response (ID 35, 46) [REP2-051].

131. As stated in **ES Chapter 10 Section 10.6.1.2.2.1** [APP-096], mitigation for piling activities may include the use of Acoustic Deterrent Devices (ADDs) prior to the commencement of piling. While an assessment is provided within **ES Chapter 10 Section 10.6.1.2.2.1** [APP-096] for the potential disturbance to marine mammals due to the use of ADDs, it is based on an indicative ADD activation duration of 10 minutes or 20 minutes. An updated assessment is provided in the following sections for actual expected ADD durations, based on the current worst-case piling design.

132. Note that the following assessment provides an assessment for both single and sequential piling only, based on the maximum predicted PTS impact ranges. In the case of simultaneous piling, the required ADD activation durations (and assessments of such) would be undertaken in the post-consent phase. As noted in **Section 6.1**, it is likely that simultaneous piling would not be undertaken at SEP and DEP, however, if simultaneous piling remains within the piling scenario envelope, an assessment of the disturbance from ADD durations associated with simultaneous piling would be provided as part of the EPS licence application in the pre-construction phase[5].

133. The following information provides an update to **ES Chapter 10 Section 10.6.1.2.2.1** [APP-096].

134. To determine the ADD duration required for each piling scenario, the time required for each marine mammal species to flee to a range of more than the PTS effect range is calculated based on the flee speed of each species. That distance is taken as the disturbance range for which to undertake an assessment.

[5]If simultaneous piling remains as an option for piling at SEP and DEP, the associated ADD activation durations (and resultant assessments on disturbance) would be based on the time required for each species to travel from each piling location to the furthest point within the area of effect associated with each piling location. It is expected that multiple ADDs would be required to ensure marine mammals had sufficient time to flee the full area of effect.

135. For harbour porpoise, bottlenose dolphin, white-beaked dolphin, grey seal and harbour seal, the ADD duration requirements are based a precautionary marine mammal swimming speed of 1.5m/s; Otani *et al.,* 2000), and for minke whale, the ADD durations areas based on a precautionary marine mammal swimming speed of 3.25m/s; Blix and Folkow, 1995). The PTS effect ranges, and ADD durations required, for each piling scenario is provided in **Table 6-14** below.

136. It is anticipated that mitigations would be undertaken prior to each monopile, and therefore the ADD duration requirements are based on the maximum PTS effect ranges for the installation of a single monopile. For pin-piles, it is expected that all four required for the installation of one foundation would be installed in sequence, and that there would be no significant break in the piling of each pin-pile between locations, therefore, the ADD duration requirements are based on the maximum PTS effect ranges for the installation of four pin-piles sequentially.

Table 6-14 ADD Activation Requirements for Piling at SEP or DEP for all Marine Mammal Species (the Largest Required ADD Duration is Highlighted in Bold)

Marine mammal species	Flee speed	Maximum PTS_{cum} range (km)				Required ADD duration (minutes)			
		Sequential SEP monopile (one monopile)	Sequential SEP pin-piles (four pin-piles)	Sequential DEP monopile (one monopile)	Sequential DEP pin-piles (four pin-piles)	Sequential SEP monopile (one monopile)	Sequential SEP pin-piles (four pin-piles)	Sequential DEP monopile (one monopile)	Sequential DEP pin-piles (four pin-piles)
Harbour porpoise	1.5m/s	4.1	1.8	4.9	2.3	46	20	55	26
Bottlenose dolphin and white-beaked dolphin	1.5m/s	0.10	0.10	0.10	0.10	2	2	2	2
Minke whale	3.25m/s	6.2	2.7	8.3	3.8	69	30	93	43
Grey seal and harbour seal	1.5m/s	0.60	0.13	0.70	0.18	7	2	8	2

137. **Table 6-15** below provides the resultant potential disturbance ranges due to the required ADD activation durations.

Table 6-15 ADD Activation Requirements for Piling at SEP or DEP for all Marine Mammal Species (the Largest Required Range is Highlighted in Bold)

Marine mammal species	Flee speed	Potential disturbance range and (area[6])			
		Sequential SEP monopile (one monopile)	Sequential SEP pin-piles (four pin-piles)	Sequential DEP monopile (one monopile)	Sequential DEP pin-piles (four pin-piles)
Harbour porpoise	1.5m/s	6.21km ($121.15km^2$)	2.70km ($121.15km^2$)	8.37km ($22.90km^2$)	3.87km ($47.05km^2$)
Bottlenose dolphin and white-beaked dolphin	1.5m/s	6.21km ($121.15km^2$)	2.70km ($121.15km^2$)	8.37km ($22.90km^2$)	3.87km ($47.05km^2$)
Minke whale	3.25m/s	13.46km ($568.74km^2$)	5.85km ($107.51km^2$)	18.14km ($1,033.20km^2$)	8.39km ($220.88km^2$)
Grey seal and harbour seal	1.5m/s	6.21km ($121.15km^2$)	2.70km ($121.15km^2$)	8.37km ($22.90km^2$)	3.87km ($47.05km^2$)

138. The ADD activation for 69 or 93 minutes for monopiles at SEP and DEP respectively would ensure all species are beyond the maximum impact range for cumulative PTS for the installation of each monopile (**Table 6-14**). The ADD activation for 30 or 43 minutes for pin-piles at SEP and DEP respectively would ensure all species are beyond the maximum impact range for cumulative PTS for the sequential installation of four pin-piles (**Table 6-14**).

6.1.3.2 Magnitude of Potential Disturbance

6.1.3.2.1 SEP or DEP in Isolation

139. The maximum total ADD activation time to install all piles, for SEP or DEP in isolation, based on worst-case scenarios, is as follows:

- SEP:
  - WTGs;
    - 23 monopiles = 26 hours and 27 minutes for 69 minute ADD activation prior to each soft-start; or
    - 92 pin-piles, however, anticipated 4 pin-piles for jacket foundation of each wind turbine to be installed in sequence, therefore ADDs only activated once per foundation (23 foundations) = 11 hours 30 minutes for 30 minute ADD activation; and

[6]Based on the maximum required ADD durations and flee speeds to calculate the disturbance range, and the area of a circle to determine the potential area of disturbance

- OSPs;
  - eight pin-piles for offshore sub-station, anticipated 4 pin-piles would be installed in sequence and ADDs activated prior to each group of 4 pin-piles = 1 hour for 30 minute ADD activation.

- DEP:
  - WTGs;
    - 30 monopiles = 46 hours 30 minutes for 93 minute ADD activation prior to each soft-start; or
    - 120 pin-piles, however, anticipated 4 pin-piles for jacket foundation of each wind turbine to be installed in sequence, therefore ADDs only activated per foundation (30 foundations) = 21 hours 30 minutes for 43 minute ADD activation; and
  - OSPs;
    - Eight pin-piles for offshore sub-station, anticipated 4 pin-piles would be installed in sequence and ADDs activated prior to each group of 4 pin-piles = 1 hour 26 minutes for 43 minute ADD activation.

140. Within **ES Chapter 12 Section 10.6.1.2.2.1** [APP-096], the magnitude of the potential impact due to disturbance from the indicative ADD activation duration was assessed as negligible for harbour porpoise, bottlenose dolphin, white-beaked dolphin, minke whale, grey seal and harbour seal, with 1% or less of the relevant reference populations anticipated to be temporarily disturbed.

141. The updated assessments for the required ADD durations for monopiles or pin-piles at either SEP or DEP result in a magnitude of negligible for all species and piling scenarios, with the exception of bottlenose dolphin under the assessment against the Coastal East Scotland (CES) MU population, which results in a magnitude of low for both SEP and DEP monopiles (**Table 6-16**).

Table 6-16: Maximum Number of Individuals (and % of Reference Population) that could be at Disturbed during ADD Activation at SEP or DEP Prior to Piling of Monopiles (Magnitudes given in brackets are for the secondary MU assessed for CES and for the wider population for seal species)

Species	Location	ES Table 10-47 [APP-096]				Updated assessments			
		Disturbance from 10 minute ADD activation		Disturbance from 20 minute ADD activation		Disturbance from 69 minute ADD activation prior to monopiling at SEP or 93 minute ADD activation prior to monopiling at DEP		Disturbance from 30 minute ADD activation prior to monopiling at SEP or 43 minute ADD activation prior to monopiling at DEP	
		Maximum number of individuals (% of reference population)	Magnitude* (temporary impact)	Maximum number of individuals (% of reference population)	Magnitude* (temporary impact)	Maximum number of individuals (% of reference population)	Magnitude* (temporary impact)	Maximum number of individuals (% of reference population)	Magnitude* (temporary impact)
Harbour porpoise	SEP	1.6 (0.00046% of NS MU)	**Negligible**	6.41 (0.0019% of NS MU)	**Negligible**	76.3 (0.02% of NS MU)	**Negligible**	14.4 (0.004% of NS MU)	**Negligible**
	DEP	6.17 (0.0018% of NS MU)	**Negligible**	24.74 (0.0071% of NS MU)	**Negligible**	534.8 (0.15% of NS MU)	**Negligible**	114.3 (0.03% of NS MU)	**Negligible**
Bottlenose dolphin	SEP	0.08 (0.0037 of GNS MU; 0.034% CES MU)	**Negligible (negligible)**	0.30 (0.015 of GNS MU; 0.27% CES MU)	**Negligible (negligible)**	3.6 (0.18% of Greater North Sea (GNS) MU; 1.6% CES MU)	**Negligible (low)**	0.67 (0.03 of GNS MU; 0.07% CES MU)	**Negligible (negligible)**
	DEP	0.08 (0.0037% of GNS MU; 0.034% CES MU)	**Negligible (negligible)**	0.30 (0.015% of GNS MU; 0.27% CES MU)	**Negligible (negligible)**	6.6 (0.32% of GNS MU; 2.9% CES MU)	**Negligible (low)**	1.40 (0.31% of GNS MU; 0.63% CES MU)	**Negligible (negligible)**
White-beaked dolphin	SEP	0.02 (0.000035% of CGNS MU)	**Negligible**	0.06 (0.00014% of CGNS MU)	**Negligible**	0.73 (0.002% of Celtic and Greater Noise Sea (CGNS)	**Negligible**	0.14 (0.0003% of CGNS MU)	**Negligible**

Species	Location	ES Table 10-47 [APP-096]				Updated assessments			
						MU)			
	DEP	0.02 (0.000035% of CGNS MU)	**Negligible**	0.06 (0.00014% of CGNS MU)	**Negligible**	1.32 (0.003% of CGNS MU)	**Negligible**	0.28 (0.0006% of CGNS MU)	**Negligible**
Minke whale	SEP	0.12 (0.00059% of CGNS MU)	**Negligible**	0.48 (0.0024% of CGNS MU)	**Negligible**	5.7 (0.03% of CGNS MU)	**Negligible**	1.1 (0.005% of CGNS MU)	**Negligible**
	DEP	0.12 (0.00059% of CGNS MU)	**Negligible**	0.48 (0.0024% of CGNS MU)	**Negligible**	10.3 (0.05% of CGNS MU)	**Negligible**	2.2 (0.01% of CGNS MU)	**Negligible**
Grey seal	SEP	2.17 (0.025% of SE MU or 0.009% of wider ref pop)	**Negligible (negligible)**	8.68 (0.10% of SE MU or 0.036% of wider ref pop)	**Negligible (negligible)**	109.2 (0.32% of SE MU or 0.18% of wider ref pop)	**Negligible (negligible)**	20.6 (0.06% of SE MU or 0.03% of wider ref pop)	**Negligible (negligible)**
	DEP	1.88 (0.0022% of SE MU or 0.0078% of wider ref pop)	**Negligible (negligible)**	7.52 (0.087% of SE MU or 0.031% of wider ref pop)	**Negligible (negligible)**	171.7 (0.50% of SE MU or 0.28% of wider ref pop)	**Negligible (negligible)**	36.7 (0.11% of SE MU or 0.06% of wider ref pop)	**Negligible (negligible)**
Harbour seal	SEP	0.70 (0.019% of SE MU or 0.0023% of wider ref pop)	**Negligible (negligible)**	2.79 (0.074% of SE MU or 0.0091% of wider ref pop)	**Negligible (negligible)**	31.5 (0.65% of SE MU)	**Negligible**	6.0 (0.12% of SE MU)	**Negligible**
	DEP	0.20 (0.005% of SE MU or 0.0007% of wider ref pop)	**Negligible (negligible)**	0.81 (0.022% of SE MU or 0.0027% of wider ref pop)	**Negligible (negligible)**	16.7 (0.35% of SE MU)	**Negligible**	3.6 (0.07% of SE MU or 0.0027%)	**Negligible**

6.1.3.2.2 SEP and DEP

142. If SEP and DEP are both constructed, there is the potential for impact ranges from both Projects to occur at the same time, and therefore, as a worst-case, the maximum number of marine mammals from each Project have been assessed to indicate the maximum number of marine mammals that could be impacted from SEP and DEP under a concurrent construction scenario, and ADDs were activated at both sites at the same time. The following assessment updates the assessment as provided in **ES Chapter 10 Section 10.6.1.2.4.1** [APP-096].

143. Based on the updated maximum total ADD activation times required to install all piles, as presented in **Section 6.1.3.1** above, the total ADD activated times for both SEP and DEP together are:

- SEP and DEP:
  - WTGs:
    - 53 monopiles = up to 72 hours and 57 minutes for 69 minute ADD activation prior to each soft-start at SEP, and 93 minute ADD activation at DEP; or
    - 212 pin-piles, however, anticipated 4 pin-piles for jacket foundation of each wind turbine to be installed in sequence, therefore ADDs only activated per foundation (53 foundations) = up to 33 hours for 30 minute ADD activation at SEP and 43 minute ADD activation at DEP; and
  - OSPs:
    - 16 pin-piles for offshore sub-station, anticipated 4 pin-piles would be installed in sequence and ADDs activated prior to each group of 4 pin-piles = 2 hours 56 minutes for 30 minute ADD activation at SEP and 43 minute ADD activation at DEP.

144. Within ES **Chapter 10 Section 10.6.1.2.4.1**, the magnitude of the potential impact was assessed as negligible for harbour porpoise, bottlenose dolphin, white-beaked dolphin, minke whale, grey seal and harbour seal, with 1% or less of the relevant reference populations anticipated to be temporarily disturbed.

145. The updated assessments for the required ADD durations for monopiles or pin-piles at SEP and DEP result in a magnitude of negligible for all species and piling scenarios, with the exception of bottlenose dolphin under the assessment against the CES MU population, which results in a magnitude of low for both SEP and DEP monopiling (**Table 6-17**).

Table 6-17: Maximum Number of Individuals (and % of Reference Population) that Could be at Disturbed during ADD Activation at SEP and DEP Prior to Piling of Monopiles (Magnitudes given in brackets are for the secondary MU assessed for CES and for the wider population for seal species)

		ES Table 10-54 [APP-096]				Updated assessments			
Species	**Location**	**Disturbance from 10 minute ADD activation**		**Disturbance from 20 minute ADD activation**		**Disturbance from 69 minute ADD activation prior to monopiling at SEP and 93 minute ADD activation prior to monopiling at DEP**		**Disturbance from 30 minute ADD activation prior to monopiling at SEP and 43 minute ADD activation prior to monopiling at DEP**	
		Maximum number of individuals (% of reference population)	**Magnitude* (temporary impact)**	**Maximum number of individuals (% of reference population)**	**Magnitude* (temporary impact)**	**Maximum number of individuals (% of reference population)**	**Magnitude* (temporary impact)**	**Maximum number of individuals (% of reference population)**	**Magnitude* (temporary impact)**
Harbour porpoise	SEP & DEP	7.8 (0.0022% of NS MU)	**Negligible**	31.2 (0.009% of NS MU)	**Negligible**	611.2 (0.18% of NS MU)	**Negligible**	128.8 (0.04% of NS MU)	**Negligible**
Bottlenose dolphin	SEP & DEP	0.15 (0.0075% of GNS MU; 0.068% CES MU)	**Negligible (negligible)**	0.6 (0.03% of GNS MU; 0.27% CES MU)	**Negligible (negligible)**	10.2 (0.50% of GNS MU; 4.5% CES MU)	**Negligible (low)**	2.1 (0.10 of GNS MU; 0.93% CES MU)	**Negligible (negligible)**
White-beaked dolphin	SEP & DEP	0.03 (0.000069% of CGNS MU)	**Negligible**	0.12 (0.0003% of CGNS MU)	**Negligible**	2.1 (0.005% of CGNS MU)	**Negligible**	0.42 (0.001% of CGNS MU)	**Negligible**
Minke whale	SEP & DEP	0.24 (0.0012% of CGNS MU)	**Negligible**	0.96 (0.005% of CGNS MU)	**Negligible**	16.0 (0.08% of CGNS MU)	**Negligible**	3.3 (0.02% of CGNS MU)	**Negligible**
Grey seal	SEP & DEP	4.04 (0.047% of SE MU or 0.017% of wider ref pop)	**Negligible (negligible)**	16.21 (0.187% of SE MU or 0.067% of wider ref pop)	**Negligible (negligible)**	280.8 (0.82% of SE MU or 0.47% of wider ref pop)	**Negligible (negligible)**	57.3 (0.17% of SE MU or 0.10% of wider ref pop)	**Negligible (negligible)**
Harbour seal	SEP & DEP	0.90 (0.024% of SE MU or 0.003% of wider ref pop)	**Negligible (negligible)**	3.6 (0.10% of SE MU or 0.012% of wider ref pop)	**Negligible (negligible)**	48.2 (0.99% of SE MU)	**Negligible**	9.5 (0.20% of SE MU)	**Negligible**

6.1.3.3 Impact Significance for Disturbance During ADD Activation

146. The following impact significance assessments updates the assessment provided in **ES Chapter 12 Section 10.6.1.2.3.1** [APP-096].

147. Within **ES Chapter 10 Table 10-51** [APP-096], the results of the assessment of disturbance using indicative ADD durations resulted in impact significances of minor adverse (not significant) for harbour porpoise, bottlenose dolphin, white-beaked dolphin, minke whale, grey seal and harbour seal. The updated assessments to take account of required ADD durations at SEP and DEP also result in an impact significance of minor adverse for all marine mammal species, and for all piling scenarios (**Table 6-18**).

Table 6-18: Assessment of Impact Significance for Disturbance from ADD Activation

Species	Location	Sensitivity	ES Table 10-51 & Table 10-57 [APP-096]		Updated assessments	
			Magnitude	Significance	Magnitude	Significance
Harbour porpoise	SEP	Medium	Negligible	**Minor adverse**	Negligible	**Minor adverse**
	DEP					
	SEP & DEP					
Bottlenose dolphin	SEP	Medium	Negligible	**Minor adverse**	Negligible (negligible to low)	**Minor adverse**
	DEP					
	SEP & DEP					
White-beaked dolphin	SEP	Medium	Negligible	**Minor adverse**	Negligible	**Minor adverse**
	DEP					
	SEP & DEP					
Minke whale	SEP	Medium	Negligible	**Minor adverse**	Negligible	**Minor adverse**
	DEP					
	SEP & DEP					
Grey seal	SEP	Medium	Negligible	**Minor adverse**	Negligible (negligible)	**Minor adverse**
	DEP					
	SEP & DEP					
Harbour seal	SEP	Medium	Negligible	**Minor adverse**	Negligible	**Minor adverse**
	DEP					
	SEP & DEP					

6.1.4 Residual Effects of Piling on Marine Mammals Following Mitigation

In response to Natural England's Relevant Representation [RR-063], as stated in Applicant's Response (ID 44) [REP2-051].

148. The residual effects of piling on marine mammals, following mitigation, will be provided within the EPS Licence Application post-consent. This will take into account final pile design and installation methods, as well the final agreed mitigation (including ADD activation periods).

6.2 Updates to the Cumulative Impact Assessment

In response to Natural England's Relevant Representation [RR-063], as stated in Applicant's Response (ID 7, 11, 59, 60, 61, 63, 67, 70, 71, 104 106, 108, 115) [REP2-051].

6.2.1 Assessment of Disturbance from Underwater Noise

6.2.1.1 Updates to Underwater Noise Impacts during Construction from Offshore Wind Farm Piling

6.2.1.1.1 Offshore Wind Farms Screened In

149. A review of the data available for screened in offshore wind farms has been undertaken, and the resultant assessments updated to take account of project specific data where possible (**Table 6-19**).

150. The same offshore wind farms have been included for assessment as provided in **ES Chapter 10 Section 10.7.1.1** [APP-096], including;

- Berwick Bank (not for grey and harbour seal)
- Dogger Bank South (all species)
- East Anglia ONE North (all species)
- East Anglia TWO (all species)
- Five Estuaries (all species)
- Hornsea Project Four (all species)
- North Falls (all species)
- Outer Dowsing (all species)
- Rampion Extension (harbour porpoise only)

Table 6-19 Available Project Data for Screened in Offshore Wind Farm Projects

Name of Project	Source of information	Piling scenario	Maximum number of Foundations	Maximum hammer energy (kJ)	Number days of piling	Currently expected piling / offshore construction dates
SEP	**SEP & DEP ES chapter 12** [APP-096]	Sequential (2 monopiles in 24 hours)	23 (plus 8 pin-piles for platform)	5500 (3000 for pin-piles)	27 (assuming 1 monopile per day and 2 pin-piles per day)	2028 - 2031
DEP	**SEP & DEP ES chapter 12** [APP-096]	Sequential (1 monopile in 24 hours)	30 (plus 8 pin-piles for platform)	5500 (3000 for pin-piles)	34 (assuming 1 monopile per day and 2 pin-piles per day)	2028 - 2031
SEP & DEP together	**SEP & DEP ES chapter 12** [APP-096]	Sequential (1 monopile at Sep followed by 1 monopile at DEP)	53 (plus 16 pin-piles for platforms)	5500 (3000 for pin-piles)	61 (assuming 1 monopile per day and 2 pin-piles per day)	2028
SEP & DEP together	**SEP & DEP ES chapter 12** [APP-096]	Simultaneous – 2 monopiles (1 at SEP & 1 at DEP) at the same time	53 (plus 16 pin-piles for platforms)	5500 (3000 for pin-piles)	35 (assuming 2 monopiles per day and 2 pin-piles per day)	2028
Berwick Bank	Berwick Bank Wind Farm EIA	Single piling	1,432 (pin-piles only)	4,000	372	2025 – 2033
		Simultaneous (2 piles at the same time, and 5 in the same 24 hour period)	1,432 (pin-piles only)	4,000	372	2025 – 2033
Dogger Bank South (East and West)	Dogger Bank South Offshore Wind Farms EIA Scoping Report[7]	Limited information available – assume 1 pile in each site and generalised approach due to lack of further	300	Unknown	300 (assuming one per day)	No earlier than 2026

[7] https://infrastructure.planninginspectorate.gov.uk/wp-content/ipc/uploads/projects/EN010125/EN010125-000181-DBS%20-%20Environmental%20Impact%20Assessment%20Scoping%20Report.pdf

Name of	Source of information	Piling scenario	Maximum	Maximum	Number days of piling	Currently expected
		information				
East Anglia ONE North	East Anglia ONE North Offshore Windfarm Environmental Statement: Chapter 11 Marine Mammals[8]	One pile per 24 hours	68 (plus 40 pin-piles for platforms)	4000 (2,400 for pin-piles)	88 (assuming 1 monopile per day and 2 pin-piles per day)	2026 - 2028
East Anglia TWO	East Anglia TWO Offshore Windfarm Environmental Statement: Chapter 11 Marine Mammals[9]	One pile per 24 hours	76 (plus 40 pin-piles for platforms)	4000 (2,400 for pin-piles)	96 (assuming 1 monopile per day and 2 pin-piles per day)	2025-2027
Five Estuaries	Five Estuaries Offshore Wind Farm Preliminary Environmental Information Report, Volume 2 Chapter 7: Marine Mammal Ecology	Single (1 pile per 24 hours)	79 (plus 24 for platforms)	7,000 (3,000 for pin-piles)	91 (assuming one per day and 2 pin-piles per day)	2029-2030
		Simultaneous piling (2 monopiles at the same time)	79 (plus 24 for platforms)	7,000 (3,000 for pin-piles)	52 (assuming two per day and 2 pin-piles per day)	2029-2030
Hornsea Project Four	Hornsea Project Four: Environmental Statement, Volume A5, Annex 4.1: Marine Mammal Technical Report (Part 1)[10] Hornsea Project Four: Environmental Statement,	Single (1 pile per 24 hours)	180 (plus up to 208 pin-piles for platforms)	5,000 (3,000 for pin-piles)	216 (plus 39 for pin-piles)	2027 - 2028
		Simultaneous piling (2 monopiles at the	180 (plus up to 208 pin-piles for	5,000 (3,000 for pin-piles)	216 (plus 39 for pin-piles)	2027 - 2028

[8] https://infrastructure.planninginspectorate.gov.uk/wp-content/ipc/uploads/projects/EN010077/EN010077-001158-6.1.11%20EA1N%20Environmental%20Statement%20Chapter%2011%20Marine%20Mammals.pdf
[9] https://infrastructure.planninginspectorate.gov.uk/wp-content/ipc/uploads/projects/EN010078/EN010078-001082-6.1.11%20EA2%20Environmental%20Statement%20Chapter%2011%20Marine%20Mammals.pdf
[10] https://infrastructure.planninginspectorate.gov.uk/wp-content/ipc/uploads/projects/EN010098/EN010098-000760-A5.4.1%20ES%20Volume%20A5%20Annex%204.1%20Marine%20Mammal%20Technical%20Report%20Part%201.pdf

Name of	Source of information	Piling scenario	Maximum	Maximum	Number days of piling	Currently expected
	Volume A4, Annex 4.5: Subsea Noise Technical Report Part 2[11] Hornsea Project Four: Environmental Statement, Volume A2, Chapter 4: Marine Mammals[12]	same time)	platforms)			
North Falls	North Falls Offshore Wind Farm Scoping Report	Limited information available – assume 1 pile and generalised approach due to lack of further information	71 (plus up to 8 pin-piles for platforms)	Unknown	76 (estimated based on 1 monopile a day and 2 pin-piles a day)	2028 - 2030
Outer Dowsing	Outer Dowsing Offshore Wind Scoping Report	Limited information available – assume 1 pile and generalised approach due to lack of further information	100 (plus up to 56 pin-piles for platforms)	5,500 (3,000 for pin-piles)	128 (estimated based on 1 monopile a day and 2 pin-piles a day)	2027 - 2030
Rampion 2	Rampion 2 Wind Farm Preliminary Environmental Information Report, Volume 2, Chapter 11: Marine mammals	Single piling	116 (plus up to 18 pin-piles)	4,400 (2,500 for pins-piles)	125 (estimated based on 1 monopile per day and 2 pin-piles per day)	2027 onwards
		Simultaneous piling	116 (plus up to 18 pin-piles)	4,400 (2,500 for pins-piles)	125 (estimated based on 1 monopile per day and	2027 onwards

[11] https://infrastructure.planninginspectorate.gov.uk/wp-content/ipc/uploads/projects/EN010098/EN010098-000734-A4.4.5%20ES%20Volume%20A4%20Annex%204.5%20Subsea%20Noise%20Technical%20Report%20Part%202.pdf
[12] https://infrastructure.planninginspectorate.gov.uk/wp-content/ipc/uploads/projects/EN010098/EN010098-000706-A2.4%20ES%20Volume%20A2%20Chapter%204%20Marine%20Mammals.pdf

Name of	Source of information	Piling scenario	Maximum	Maximum	Number days of piling	Currently expected
					2 pin-piles per day)	

6.2.1.1.2 Magnitude of Potential Cumulative Disturbance from Other Offshore Wind Farms

151. The following provides an update to the assessment as provided in ES **Chapter 10 Section 10.7.1.1.1.2** [APP-096]. Unless specified otherwise, the approach and methods of the assessment are as previously undertaken.

152. The following assessment of disturbance from other offshore wind farm piling has been updated to take account of project specific data and information where it is known. The currently available data for each screened in project are provided in **Table 6-19** above.

153. Where project specific data is not available, a generalised approach has been used to inform the assessment (following the methods used in **ES Chapter 10 Section 10.7.1.1)** [APP-096].

154. For seals the generalised approach has been updated to cover the reported disturbance range of 25km (Russell *et al*., 2016) as per the updated assessment in **Section 6.1.2.1**. The Carter *et al*. (2022) densities have also been used to inform the assessments where relevant.

155. The following assessments are based on one piling event in SEP and one piling event in DEP simultaneously, as a worst-case. The assessments also provide assessments for single piling at each of the other screened in offshore wind farms, unless the project specific information includes simultaneous piling within their project design envelope. The overall cumulative disturbance for each species is based on either single piling in each of the other included offshore wind farms (as the more realistic case) as well as simultaneous piling for the relevant projects (as the worst-case).

156. For harbour porpoise, the assessment provided in **ES Chapter 10 (Table 10-98)** [APP-096] concluded there was the potential for a low magnitude of impact based on the generalised approach (with up to 16,310 harbour porpoise potentially disturbed (4.71% of the NS MU).

157. The updated assessment as provided in **Table 6-20**, based on project specific data (where available) concludes that under the realistic case of single piling at all other offshore wind farms, there is the potential for 25,040 harbour porpoise (or up to 7.2% of the NS MU) to be disturbed, with a medium magnitude of impact. For the worst-case assessment of simultaneous piling at the relevant projects, there is the potential for 33,808 harbour porpoise to be disturbed (or 9.8% of the NS MU), which also leads to a medium magnitude of impact (**Table 6-20**). This represents a significant increase in the number of harbour porpoise at risk of disturbance from cumulative disturbance at other offshore wind farms when compared to the assessment provided within **ES Chapter 10 (Table 10-98)** [APP-096]. The increase is partly due to the inclusion of simultaneous piling rather than single piling (at Dogger Bank South for example), and partly due to the inclusion of project specific data, rather than utilising a generalised approach.

158. To determine the population level consequences of disturbance, under the worst-case simultaneous piling scenario, population modelling has been undertaken (see **Section 6.2.1.5** for further information and results of the modelling assessment).

Table 6-20 Quantified CIA for the Potential Disturbance of Harbour Porpoise during Piling at the Offshore Wind Farm Projects which Could be Single or Simultaneously Piling at the Same Time as SEP and DEP

Name of Project	Piling scenario	Density source	Harbour porpoise density	Disturbance	
				Impact area (km^2)	Maximum number of individuals potentially disturbed during single piling
SEP	Single piling	Aerial surveys	Based on the dose response curve assessments (Section 6.1.2.2)		582
DEP	Single piling	Aerial surveys			804
SEP & DEP	Sequential or simultaneous piling	Aerial surveys			1,386
Berwick Bank	Single piling	Average density taken as summer peak from site-specific aerial survey data.	0.826	-	1,754 (0.51% of the NS MU)
Berwick Bank	Simultaneous (2 piles at the same time, and 5 in the same 24 hour period)	Average density taken as summer peak from site-specific aerial survey data.	0.826	-	2,822 (0.81% of the NS MU)
Dogger Bank South (East and West)	Generalised approach due to lack of further information	SCANS III block O	0.888	4,247.4	3,771.7
East Anglia ONE North	One pile per 24 hours	SCANS-III survey block L	0.607	2,123.7	1,289 (0.4% of NS MU)
East Anglia TWO	One pile per 24 hours	East Anglia TWO windfarm site specific survey density	0.73	2123.7	1,551 (0.45% of NS MU)

Name of Project	Piling scenario	Density source	Harbour porpoise	Disturbance	
Five Estuaries	Single (1 pile per 24 hours)	Five Estuaries aerial surveys	1.82	-	7,031 (2.03% of the NS MU)
	Simultaneous piling (2 monopiles at the same time)	Five Estuaries aerial surveys	1.82	-	9,498 (2.74% of the NS MU)
Hornsea Project Four	Single (1 pile per 24 hours)	Hornsea Project site specific surveys	1.74	-	6,417 (1.86% of NS MU)
	Simultaneous piling (2 monopiles at the same time)	Hornsea Project site specific surveys	1.74	-	9,686 (2.8% of the NS MU)
North Falls	Generalised approach due to lack of further information	SCANS III block L	0.607	2,123.7	1,289.1
Outer Dowsing	Generalised approach due to lack of further information	SCANS III block O	0.888	2,123.7	1,885.8
Rampion 2	Single piling	SCANS III block C	0.213	-	551 (0.16% MU)
	Simultaneous piling	SCANS III block C	0.213	-	630 (0.18% of the MU)
SEP and DEP together – best case scenario of all projects single piling					
Total number of harbour porpoise *(without SEP and DEP)*					**25,039.6** *(23,653.6)*
Percentage of North Sea MU *(without SEP and DEP)*					**7.22%** *(6.82%)*
Magnitude of cumulative impact *(without SEP and DEP)*					**Medium** *(Medium)*
SEP and DEP together - worst case scenario of all projects simultaneously piling					
Total number of harbour porpoise *(without SEP and DEP)*					**33,808.4** *(32,422.4)*
Percentage of North Sea MU *(without SEP and DEP)*					**9.75%** *(9.35%)*
Magnitude of cumulative impact *(without SEP and DEP)*					**Medium** *(Medium)*

159. For bottlenose dolphin, the assessment provided in **ES Chapter 10 (Table 10-99)** [APP-096] concluded there was the potential for a negligible magnitude of impact based on the generalised approach (with up to 0.08 bottlenose dolphin potentially disturbed (or 0.004% of the GNS MU).

160. The updated assessment as provided in **Table 6-21**, based on project specific data (where available) concludes that under the more realistic case of single piling at all other offshore wind farms, there is the potential for 79.0 bottlenose dolphins (or up to 3.9% of the GNS MU) to be disturbed, with a low magnitude of impact. For the worst-case assessment of simultaneous piling at the relevant projects, there is the potential for 123 individuals to be disturbed (or 6.1% of the GNS MU), which leads to a medium magnitude of effect (**Table 6-21**). This represents a significant increase in the number of bottlenose dolphins at risk of cumulative disturbance at other offshore wind farms when compared to the assessment provided within **ES Chapter 10 (Table 10-99)** [APP-096]. The increase is partly due to the inclusion of simultaneous piling rather than single piling (at Dogger Bank South for example), and partly due to the inclusion of project specific data, rather than utilising a generalised approach.

161. It should be noted that a number of offshore wind farm projects within the cumulative scenario for bottlenose dolphin based the number of individuals at risk of disturbance on 5dB noise contours, with Hornsea Project Four using a dose response curve that was developed for harbour porpoise (Graham *et al*., 2017) which is considered to be highly precautionary and unrealistic. Berwick Bank based their assessment of disturbance on bottlenose dolphin on the 120dB noise contour distance, which is also considered to be highly precautionary and unrealistic. It is therefore expected that a magnitude of low would be more appropriate for this species.

Table 6-21: Quantified CIA for the Potential Disturbance of Bottlenose Dolphin during Piling at Offshore Wind Farm Projects which Could be Single or Simultaneously Piling at the Same Time as SEP and DEP

Name of Project	Piling scenario	Density source	Bottlenose dolphin density	Disturbance	
				Impact area (km^2)	Maximum number of individuals potentially disturbed during single piling
SEP	Sequential (2 monopiles in 24 hours)	SCANS III block R	0.0298	0.33	0.009 (0.00044% of GNS MU; 0.004% CES MU)
DEP	Sequential (1 monopile in 24	SCANS III block R	0.0298	0.38	0.012 (0.00059% of GNS MU;

Name of	Piling scenario	Density source	Bottlenose	Disturbance	
	hours)				0.0063% CES MU)
SEP & DEP together	Sequential (1 monopile at Sep followed by 1 monopile at DEP)	SCANS III block R	0.0298	17.0	0.51
SEP & DEP together	Simultaneous – 2 monopiles (1 at SEP & 1 at DEP) at the same time	SCANS III block R	0.0298	As above	As above
Berwick Bank	*Single piling*	*SCANS III block R OR Average coastal density derived from five -year average from Arso Civil et al. (2021)*	*0.0298 OR 0.197 to 0.294*	-	*4 - 64*
	Simultaneous (2 piles at the same time, and 5 in the same 24 hour period)	SCANS III block R OR Average coastal density derived from five -year average from Arso Civil *et al.* (2021)	0.0298 OR 0.197 to 0.294	-	5 - 102
Dogger Bank South (East and West)	*Generalised approach due to lack of further information*	*SCANS III block R (as worst-case, site is in Block O)*	*0.0298*	*17.0*	*0.51*
East Anglia ONE North	*One pile per 24 hours*	*Not assessed*	*Not assessed*	*Not assessed*	*Not assessed*
East Anglia TWO	*One pile per 24 hours*	*Not assessed*	*Not assessed*	*Not assessed*	*Not assessed*
Five Estuaries	*Single (1 pile per 24 hours)*	*Not assessed*	*Not assessed*	*Not assessed*	*Not assessed*
	Simultaneous piling (2 monopiles at the same time)	Not assessed	Not assessed	Not assessed	Not assessed
Hornsea Project Four	*Single (1 pile per 24 hours)*	*Assuming a uniform density throughout the Greater North Sea MU (2,022 dolphins in 639,886 km^2) = 0.003 dolphins/km^2*	*0.003*	-	*14 (0.63% of CGNS & CES)*
	Simultaneous piling (2 monopiles at the same time)	Assuming a uniform density throughout the Greater North Sea MU (2,022 dolphins in 639,886 km^2) = 0.003 dolphins/km^2	0.003	-	20 (0.9% of CGNS & CES)
North Falls	*Generalised*	*SCANS-III Block R*	*0.0298*	*Not scoped*	*Not scoped in*

Name of	Piling scenario	Density source	Bottlenose	Disturbance	
	approach due to lack of further information	*as worst-case (site is in Block L)*		*in*	
Outer Dowsing	*Generalised approach due to lack of further information*	*SCANS-III Block R as worst-case (site is in Block O)*	*0.0298*	*0.4*	*0.01*
SEP and DEP together – best case scenario of all projects single piling					
Total number of bottlenose dolphin *(without SEP & DEP)*					**79.0** *(78.5)*
Percentage of GNS MU *(without SEP & DEP)*					**3.9%** *(3.9%)*
Magnitude of cumulative impact *(without SEP & DEP)*					**Low** *(Low)*
SEP and DEP together - worst case scenario of all projects simultaneously piling					
Total number of bottlenose dolphin *(without SEP & DEP)*					**123.0** *(122.5)*
Percentage of GNS MU *(without SEP & DEP)*					**6.1%** *(6.1%)*
Magnitude of cumulative impact *(without SEP & DEP)*					**Medium** *(Medium)*

162. For white-beaked dolphin, the assessment provided in **ES Chapter 10 (Table 10-100)** [APP-096] concluded there was the potential for a negligible magnitude of impact based on the generalised approach (with up to 0.11 individuals potentially disturbed (or 0.0003% of the CGNS MU).

163. The updated assessment as provided in **Table 6-22**, based on project specific data (where available) concludes that under the more realistic case of single piling at all other offshore wind farms, there is the potential for 601.1 white-beaked dolphins (or up to 1.4% of the CGNS MU) to be disturbed, with a low magnitude of impact. For the worst-case assessment of simultaneous piling at the relevant projects, there is the potential for 921.1 individuals to be disturbed (or 2.1% of the CGNS MU), which also leads to a low magnitude of effect (**Table 6-22**). This represents a significant increase in the number of white-beaked dolphins at risk of disturbance from cumulative disturbance at other offshore wind farms when compared to the assessment provided within **ES Chapter 10 (Table 10-99)** [APP-096]. The increase is partly due to the inclusion of simultaneous piling rather than single piling (at Dogger Bank South for example), and partly due to the inclusion of project specific data, rather than utilising a generalised approach.

164. As for bottlenose dolphin, a number of offshore wind farm projects within the cumulative scenario for white-beaked dolphin based the number of individuals at risk of disturbance on 5 dB noise contours, with Hornsea Project Four using a dose response curve that was developed for harbour porpoise (Graham *et al.*, 2017) which is considered to be highly precautionary and unrealistic. Berwick Bank based their assessment of disturbance on dolphin species on the 120dB noise contour distance, which is also considered to be highly precautionary and unrealistic. It is therefore expected that a magnitude of low is highly precautionary and an overestimation.

Table 6-22: Quantified CIA for the Potential Disturbance of White-Beaked Dolphin during Piling at Offshore Wind Farm Projects which Could be Single or Simultaneously Piling at the Same Time as SEP and DEP

Name of Project	Piling scenario	Density source	White-beaked dolphin density	Disturbance	
				Impact area (km^2)	Maximum number of individuals potentially disturbed during single piling
SEP	Sequential (2 monopiles in 24 hours)	Waggitt *et al.*, 2019	0.006	0.3	0.0018 (0.000004% of CGNS MU)
DEP	Sequential (1 monopile in 24 hours)	Waggitt *et al.*, 2019	0.006	0.4	0.0024 (0.000005% of CGNS MU)
SEP & DEP together	Sequential (1 monopile at Sep followed by 1 monopile at DEP)	Waggitt *et al.*, 2019	0.006	17	0.1
SEP & DEP together	Simultaneous – 2 monopiles (1 at SEP & 1 at DEP) at the same time	Waggitt *et al.*, 2019	0.006	As above	As above
Berwick Bank	*Single piling*	*Scans III block R*	*0.243*	-	*516 (1.17% of CGNS MU)*
	Simultaneous (2 piles at the same time, and 5 in the same 24 hour period)	Scans III block R	0.243	-	830 (1.89% of CGNS MU)
Dogger Bank South (East and West)	*Generalised approach due to lack of further information*	*Scans III block O*	*0.002*	*17.0*	*0.03*
East Anglia ONE North	*One pile per 24 hours*	*Not assessed*	*Not assessed*	*Not assessed*	*Not assessed*
East Anglia TWO	*One pile per 24 hours*	*Not assessed*	*Not assessed*	*Not assessed*	*Not assessed*
Five Estuaries	*Single (1 pile per 24 hours)*	*Not assessed*	*Not assessed*	*Not assessed*	*Not assessed*
	Simultaneous piling (2 monopiles at the same time)	Not assessed	Not assessed	Not assessed	Not assessed
Hornsea Project Four	*Single (1 pile per 24 hours)*	*Hornsea 4 site specific surveys*	*0.02*	-	*85 (0.19% of CGNS MU)*
	Simultaneous piling (2 monopiles at the same time)	Hornsea 4 site specific surveys	0.02	-	91 (0.21% of CGNS MU)
North Falls	*Generalised approach due to lack of further information*	*SCANS-III Block O as worst-case (in Block L with no BND density estimate)*	*0.002*	*Not scoped in*	*Not scoped in*

Name of	Piling scenario	Density source	White-	Disturbance	
Outer Dowsing	*Generalised approach due to lack of further information*	*SCANS-III Block O*	*0.002*	*0.4*	*0.001*
Rampion 2	*Single piling*	*Not assessed*	*Not assessed*	*Not assessed*	*Not assessed*
Rampion 2	Simultaneous piling	Not assessed	Not assessed	Not assessed	Not assessed
SEP and DEP together – best case scenario of all projects single piling					
Total number of white-beaked dolphin *(without SEP)*					**601.1** *(601.0)*
Percentage of CGNS MU *(without SEP)*					**1.37%** *(1.37%)*
Magnitude of cumulative impact *(without SEP and DEP)*					**Low** *(Low)*
SEP and DEP together - worst case scenario of all projects simultaneously piling					
Total number of white-beaked dolphin *(without SEP)*					**921.1** *(921.0)*
Percentage of CGNS MU *(without SEP)*					**2.10%** *(2.10%)*
Magnitude of cumulative impact *(without SEP and DEP)*					**Low** *(Low)*

165. For minke whale, the assessment provided in **ES Chapter 10 (Table 10-101)** [APP-096] concluded there was the potential for a low magnitude of impact based on the generalised approach (with up to 481 individuals potentially disturbed (or 2.28% of the CGNS MU).

166. The updated assessment as provided in **Table 6-23**, based on project specific data (where available) concludes that under the more realistic case of single piling at all other offshore wind farms, there is the potential for 188 minke whale (or up to 0.93% of the CGNS MU) to be disturbed, with a negligible magnitude of impact. For the worst-case assessment of simultaneous piling at the relevant projects, there is the potential for 252 individuals to be disturbed (or 1.25% of the CGNS MU), which leads to a low magnitude of effect (**Table 6-23**). This represents a decrease in the number of minke whale at risk of disturbance from cumulative disturbance at other offshore wind farms when compared to the assessment provided within **ES Chapter 10 (Table 10-99)** [APP-096].

167. As for bottlenose dolphin, a number of offshore wind farm projects within the cumulative scenario for minke whale have based the number of individuals at risk of disturbance on 5 dB noise contours, with Hornsea Project Four using a dose response curve that was developed for harbour porpoise (Graham *et al.*, 2017) which is considered to be highly precautionary and unrealistic. Berwick Bank based their assessment of disturbance on minke whale on the 120dB noise contour distance, which is also considered to be highly precautionary and unrealistic. It is therefore expected that a magnitude of low is highly precautionary and an overestimation.

Table 6-23: Quantified CIA for the Potential Disturbance of Minke Whale during Piling at Offshore Wind Farm Projects which Could be Single or Simultaneously Piling at the Same Time as SEP and DEP

Name of Project	Piling scenario	Density source	Minke Whale density	Disturbance	
				Impact area (km^2)	Maximum number of individuals potentially disturbed during single piling
SEP	Sequential (2 monopiles in 24 hours)	Scans III block O	0.01	720.0	7.2 (0.04% of CGNS MU)
DEP	Sequential (1 monopile in 24 hours)	Scans III block O	0.01	1,100.0	11 (0.05% of CGNS MU)
SEP & DEP together	Sequential (1 monopile at Sep followed by 1 monopile at DEP)	Scans III block O	0.01	1,200.0	12 (0.006% of CGNS MU)
SEP & DEP together	Simultaneous – 2 monopiles (1 at SEP & 1 at DEP) at the same time	Scans III block O	0.01	1,600.0	16 (0.08 of CGNS MU)
Berwick Bank	*Single piling*	*Scans III block R*	*0.387*	-	*82 (0.41% of CGNSMU)*
	Simultaneous (2 piles at the same time, and 5 in the same 24 hour period)	Scans III block R	0.387	-	132 (0.66% of CGNSMU)
Dogger Bank South (East and West)	*Generalised approach due to lack of further information*	*Scans III block O*	*0.010*	*1,600.0*	*16*
East Anglia ONE North	*One pile per 24 hours*	*Not assessed*	*Not assessed*	*Not assessed*	*Not assessed*
East Anglia TWO	*One pile per 24 hours*	*Not assessed*	*Not assessed*	*Not assessed*	*Not assessed*
Five Estuaries	*Single (1 pile per 24 hours)*	*Not assessed*	*Not assessed*	*Not assessed*	*Not assessed*
	Simultaneous piling (2 monopiles at the same time)	Not assessed	Not assessed	Not assessed	Not assessed
Hornsea Project Four	Single (1 pile per 24 hours)	SCANS-III Block O	0.01	-	*46 (0.23% of CGNS MU)*
	Simultaneous piling (2 monopiles at the same time)	SCANS-III Block O	0.01	-	60 (0.30% of CGNS MU)
North Falls	*Generalised approach due to lack of further information*	*SCANS-III Block O as worst-case (in Block L with no MW density estimate)*	*0.01*	*1,100.0*	*11*
Outer Dowsing	*Generalised approach due to lack of further information*	*Scans III block O*	*0.01*	*1,100.0*	*11*

Name of	Piling scenario	Density	Minke	Disturbance	
Rampion 2	*Single piling*	*Scans III block C*	*0.002*	-	*6*
Rampion 2	Simultaneous piling	Scans III block C	0.002	-	6
SEP and DEP together – best case scenario of all projects single piling					
Total number of minke whale *(without SEP)*					**188.0** *(172.0)*
Percentage of CGNS MU *(without SEP)*					**0.93%** *(0.85%)*
Magnitude of cumulative impact *(without SEP and DEP)*					**Negligible** *(Negligible)*
SEP and DEP together - worst case scenario of all projects simultaneously piling					
Total number of minke whale *(without SEP)*					**252.0** *(236.0)*
Percentage of CGNS MU *(without SEP)*					**1.25%** *(1.17%)*
Magnitude of cumulative impact *(without SEP and DEP)*					**Low** *(Low)*

168. For grey seal, the assessment provided in **ES Chapter 10 (Table 10-102)** [APP-096] concluded there was the potential for a low to negligible magnitude of impact based on the generalised approach, with up to 421 individuals potentially disturbed (1.75% of the SE England MU or 0.29% of the wider reference population).

169. The number of grey seal at risk of disturbance at Hornsea Project Four during simultaneous piling is lower than for single piling, due to the inclusion of piling at the HVAC within the export cable corridor under the single piling scenario (with a much higher presence of grey seal). The scenario of single piling is therefore the worst-case for seal species. The updated assessment as provided in **Table 6-24**, based on project specific data (where available), and updated density and reference population estimate (as summarised in **Section 5**) concludes that under the worst-case of single piling at all other offshore wind farms, there is the potential for 5,061 grey seal (or up to 8.4% of the wider reference population) to be disturbed, with a medium magnitude of impact (**Table 6-24**). This represents a significant increase in the number of grey seal at risk of disturbance from cumulative disturbance at other offshore wind farms when compared to the assessment provided within **ES Chapter 10 (Table 10-98)** [APP-096]. The increase is partly due to the inclusion of simultaneous piling rather than single piling (at Dogger Bank South for example), partly due to the inclusion of project specific data, rather than utilising a generalised approach, and due to the use of the disturbance range of 25km (as reported by Russell *et al*,. 2016) where a generalised approach to the assessment for specific projects is still required.

170. To determine the population level consequences of disturbance, under the worst-case simultaneous piling scenario, population modelling has been undertaken (see **Section 6.2.1.5** for further information and results of the modelling assessment).

Table 6-24: Quantified CIA for the Potential Disturbance of Grey Seal during Single Piling at Offshore Wind Farm Projects which Could be Single or Simultaneously Piling at the Same Time as SEP and DEP

Name of	Piling scenario	Density source	Grey seal	Disturbance

Project			density	Impact area (km^2)	Maximum number of individuals potentially disturbed during single piling
SEP	Single piling	Carter *et al.*, 2022	Based on the dose response curve assessments (Section 6.1.2.2)		338
DEP	Single piling	Carter *et al.*, 2022			374
SEP & DEP	Sequential or simultaneous piling	Carter *et al.*, 2022			712
Dogger Bank South (East and West)	*Generalised approach due to lack of further information*	*Carter 2022*	*0.225*	*3,927*	*883.6*
East Anglia ONE North	*One pile per 24 hours*	*Russell 2017*	*0.001*	*2124*	*2 (0.5% SE MU & 0.2% ref pop)*
East Anglia TWO	*One pile per 24 hours*	*Russell 2017*	*0.02*	*2124*	*42.5 (0.2% ref pop (0.5% SE England MU))*
Five Estuaries	*Single (1 pile per 24 hours)*	*Carter 2020; 2022 (mean)*	*0.106*	-	*112*
	Simultaneous piling (2 monopiles at the same time)	Carter 2020; 2022 (mean)	0.106	-	168
Hornsea Project Four	*Single (1 pile per 24 hours)*	*Carter 2020*	-	-	*1,489*
	Simultaneous piling (2 monopiles at the same time)	Carter 2020	-	-	1,371
North Falls	*Generalised approach due to lack of further information*	*Carter 2022*	*0.111*	*1,963.5*	*217.9*
Outer Dowsing	*Generalised approach due to lack of further information*	*Carter 2022*	*0.816*	1,963.5	1,602.2
SEP and DEP together – worst-case scenario of all projects single piling					
Total number of grey seal *(without SEP and DEP)*					**5,061.2** *(4,349.2)*
Percentage of wider reference population MU *(without SEP and DEP)*					**8.39%** *(7.21%)*
Magnitude of cumulative impact *(without SEP and DEP)*					**Medium** *(Medium)*
SEP and DEP together - best-case scenario of all projects simultaneously piling					
Total number of grey seal *(without SEP and DEP)*					**4,999.2** *(4,287.2)*
Percentage of wider reference population MU *(without SEP and DEP)*					**8.29%** *(7.11%)*
Magnitude of cumulative impact *(without SEP and DEP)*					**Medium** *(Medium)*

171. For harbour seal, the assessment provided in **ES Chapter 10 (Table 10-102)** [APP-096] concluded there was the potential for a negligible magnitude of impact based on the generalised approach (with up to 130 harbour seal potentially disturbed (0.4% of the SE England MU; or 0.2% of the wider reference population).

172. The number of harbour seal at risk of disturbance at Hornsea Project Four during simultaneous piling is lower than for single piling, due to the inclusion of piling at the HVAC within the export cable corridor under the single piling scenario (with a much higher presence of harbour seal). Therefore, the worst-case piling scenario for harbour seal is from single piling at all other included offshore wind farms. The updated assessment as provided in **Table 6-25**, based on project specific data (where available) concludes that under the worst-case of single piling at all other offshore wind farms, there is the potential for 227 harbour seal (or up to 4.7% of the SE England MU) to be disturbed, with a low magnitude of impact (**Table 6-25**). This represents an increase in the number of harbour seal at risk of disturbance from cumulative disturbance at other offshore wind farms when compared to the assessment provided within **ES Chapter 10 (Table 10-98)** [APP-096]. The increase is partly due to the inclusion of simultaneous piling rather than single piling (at Dogger Bank South for example), and partly due to the inclusion of project specific data, rather than utilising a generalised approach, and due to the use of the disturbance range of 25km (as reported by Russell *et al*,. 2016) where a generalised approach to the assessment for specific projects is still required.

173. To determine the population level consequences of disturbance, under the worst-case simultaneous piling scenario, population modelling has been undertaken (see **Section 6.2.1.5** for further information and results of the modelling assessment).

Table 6-25: Quantified CIA for the Potential Disturbance of Harbour Seal during Single Piling at Offshore Wind Farm Projects which Could be Single or Simultaneously Piling at the Same Time as SEP and DEP

Name of Project	Piling scenario	Density source	Harbour seal density	Disturbance	
				Impact area (km^2)	Maximum number of individuals potentially disturbed during single piling
SEP	Single piling	Carter 2022	Based on the dose response curve assessments (**Section 6.1.2.2**)		84
DEP	Single piling	Carter 2022			43
SEP & DEP together	Sequential or simultaneous piling	Carter 2022			127
Dogger Bank South (East and West)	*Generalised approach due to lack of further information*	*Carter 2022*	*0.0013*	*3,927*	*5.3*
East Anglia ONE North	*One pile per 24 hours*	*Russell 2017*	*0.0005*	*2124*	*1 (0.02% SE MU)*
East Anglia TWO	*One pile per 24 hours*	*Russell 2017*	*0.0007*	*2124*	*1.5 (0.03% SE MU & 0.003% ref pop)*
Five Estuaries	*Single (1 pile per 24 hours)*	*Carter 2020; 2022 (mean)*	*0.018*	-	*2*
	Simultaneous piling (2	Carter 2020; 2022 (mean)	0.018	-	3

Name of	Piling scenario	Density source	Harbour	Disturbance	
	monopiles at the same time)				
Hornsea Project Four	*Single (1 pile per 24 hours)*	*Carter 2020*	-	-	*5 (0.10% of SE MU)*
	Simultaneous piling (2 monopiles at the same time)	Carter 2020	-	-	2 (0.04% of SE MU)
North Falls	*Generalised approach due to lack of further information*	*Carter 2022*	*0.0014*	*1,963.5*	*2.7*
Outer Dowsing	*Generalised approach due to lack of further information*	*Carter 2022*	*0.042*	*1,963.5*	*82.7*
SEP and DEP together – worst-case scenario of all projects single piling					
Total number of harbour seal *(without SEP and DEP)*					**227.2** *(100.2)*
Percentage of SE England MU *(without SEP and DEP)*					**4.68%** *(2.06%)*
Magnitude of cumulative impact *(without SEP and DEP)*					**Low** *(Low)*
SEP and DEP together - best-case scenario of all projects simultaneously piling					
Total number of harbour seal *(without SEP and DEP)*					**225.2** *(98.2)*
Percentage of SE England MU *(without SEP and DEP)*					**4.64%** *(2.02%)*
Magnitude of cumulative impact *(without SEP and DEP)*					**Low** *(Low)*

6.2.1.2 Update to Cumulative Disturbance Assessment from other Offshore Wind Farm Construction Activities

In response to Natural England's Relevant Representation [RR-063], as stated in Applicant's Response (ID 7 and 59) [REP2-051].

174. The following provides an update to the assessment as provided in ES **Chapter 10 Section 10.7.1.2.1** [APP-096]. Unless specified otherwise, the approach and methods of the assessment are as previously undertaken.

175. The potential disturbance from offshore wind farms during non-piling construction activities, such as vessel noise, sea bed preparation, rock placement and cable installation, has been updated to take account of project specific information where it is available.

176. For SEP and DEP, the cumulative assessment for all construction activities (other than piling) has been based on the following;

- Harbour porpoise
  - The potential impact area, based on all five activities (3.36km^2) and 25 vessels (0.75km^2) is 4.11km^2 per project

- Bottlenose dolphin, white-beaked dolphin, minke whale, grey and harbour seal
  - The potential impact area, based on all five activities (0.15km^2) and 25 vessels (0.75km^2) is 0.90km^2 per project

177. Where project specific information is not available, a generalised approach has been used to inform the assessment. This uses the above listed total disturbance areas, and for seals has been updated to include the updated Carter *et al*. (2022) densities.

178. The maximum number of harbour porpoise that could potentially be temporarily disturbed is approximately 819 (or 0.24% of the NS MU reference population) (**Table 6-26**). Therefore, the potential magnitude of the temporary effect is assessed as negligible. There is no change to the magnitude of impact as assessed within the **ES Chapter 10 Section 10.7.1.2.1** [APP-096].

Table 6-26: Quantified CIA for the Potential Disturbance of Harbour Porpoise during the Construction (Other than Piling) at Offshore Wind Farm Projects at the Same Time as Construction at SEP and DEP

Name of Project	Area (km^2)	Density source	Harbour porpoise density	ES Table 10-104 [APP-096]	Updated assessment
				Maximum number of individuals potentially disturbed	Maximum number of individuals potentially disturbed
SEP	4.11	Aerial surveys	0.63	3	2.6
DEP	4.11	Aerial surveys	2.43	3	10.0
Norfolk Boreas	0.66	Aerial surveys	1.06	3	0.7[13]
East Anglia ONE North	3.08	L	0.607	2	1.9[14]
East Anglia TWO	3.08	Aerial surveys	0.73	2	2.2[15]
Hornsea Project Four[16]	-	-	-	3	-
Norfolk Vanguard[17]	Total offshore project area	Aerial surveys	-	3	736.5
Berwick Bank	-	-	-	2	50[18]
Dogger Bank South[19]	4.11	O	0.888	3	3.6
Dolphyn Project[20]	4.11	T	0.402	2	1.7
Five Estuaries[21]	-	-	-	2	-

[13] Highest number at risk of TTS / fleeing response or disturbance as reported in the Norfolk Boreas ES Chapter 12 Marine Mammal Ecology
[14] Highest number at risk of TTS / fleeing response or disturbance as reported in the East Anglia ONE North ES Chapter 11 Marine Mammals
[15] Highest number at risk of TTS / fleeing response or disturbance as reported in the East Anglia TWO ES Chapter 11 Marine Mammals
[16] Not quantitively assessed within the ES Volume A2, Chapter 4: Marine Mammals
[17] ES Chapter 12 Marine Mammals
[18] Highest number at risk of disturbance as reported in the Berwick Bank ES Chapter 10 Marine Mammals
[19] Scoping only – generalised approach used
[20] Scoping not yet submitted – generalised approach used
[21] Not quantitively assessed within the PEIR Volume 2, Chapter 7: Marine Mammal Ecology

Name of Project	Area (km^2)	Density source	Harbour porpoise	ES Table 10-104 [APP-096]	Updated assessment
North Falls[22]	4.11	O	0.888	3	3.6
Outer Dowsing[23]	4.11	O	0.888	3	3.6
Rampion Extension[24]	-	-	-	1	-
Salamander[25]	4.11	R	0.599	2	2.5
Total number of harbour porpoise (without SEP & DEP)				**41 (34)**	**819.0 (806.4)**
Percentage of NS MU (346,601 harbour porpoise) (without SEP & DEP)				**0.012% (0.01%)**	**0.24% (0.23%)**
Magnitude (without SEP & DEP)				**Negligible (negligible)**	**Negligible (negligible)**

179. Based on all offshore wind farms with the potential for overlapping construction periods with SEP and DEP, the maximum number of bottlenose dolphin that could potentially be disturbed is 2.1 (0.11% of the reference population) (**Table 6-27**). Therefore, the potential magnitude of the temporary effect is assessed as negligible (less than 1% of the reference population). There is no change to the magnitude of impact as assessed within the **ES Chapter 10 Section 10.7.1.2.1** [APP-096].

Table 6-27: Quantified CIA for the Potential Disturbance of Bottlenose Dolphin during the Construction (Other than Piling) at Offshore Wind Farm Projects at the Same Time as Construction at SEP and DEP

Name of Project	Area (km^2)	Density source	Bottlenose dolphin density	ES Table 10-105 [APP-096]	Updated assessment
				Maximum number of individuals potentially disturbed	Maximum number of individuals potentially disturbed
SEP	0.90	R	0.0298	0.019	0.03
DEP	0.90	R	0.0298	0.019	0.03
Norfolk Boreas	-	-	-	0.019	Not assessed
East Anglia ONE North	-	-	-	0	Not assessed
East Anglia TWO	-	-	-	0	Not assessed
Hornsea Project Four[26]	-	-	-	0.019	-
Norfolk Vanguard	-	-	-	0.019	Not assessed
Berwick Bank	-	-	-	0.019	2[27]
Dogger Bank South[28]	0.90	R	0.0298	0.019	0.03
Dolphyn Project[29]	0.90	S	0.0037	0.002	0.003
Five Estuaries	-	-	-	0	Not assessed

[22] Scoping only – generalised approach used
[23] Scoping only – generalised approach used
[24] Not quantitively assessed within the PEIR Chapter 11 Marine Mammals
[25] Scoping only – generalised approach used
[26] Not quantitively assessed within the ES Volume A2, Chapter 4: Marine Mammals
[27] Highest number at risk of disturbance as reported in the Berwick Bank ES Chapter 10 Marine Mammals
[28] Scoping only – generalised approach used
[29] Scoping not yet submitted – generalised approach used

Name of Project	Area (km^2)	Density source	Bottlenose dolphin	ES Table 10-105 [APP-096]	Updated assessment
North Falls	-	R	-	0.019	Not assessed
Outer Dowsing[30]	0.63	R	0.0298	0.019	0.03
Rampion Extension[31]	-	-	-	0	-
Salamander[32]	0.90	R	0.0298	0.019	0.03
Total number of bottlenose dolphin (without SEP & DEP)				**0.19 (0.15)**	**2.14 (2.1)**
Percentage of GNS MU (2,022 bottlenose dolphin) (without SEP & DEP)				**0.0094% (0.0075%)**	**0.11% (0.10%)**
Magnitude (without SEP & DEP)				**Negligible (negligible)**	**Negligible (negligible)**

180. Based on all offshore wind farms with the potential for overlapping construction periods with SEP and DEP, the maximum number of white-beaked dolphin that could potentially be disturbed is 15.3 (0.03% of the reference population) (**Table 6-28**). Therefore, the potential magnitude of the temporary effect is assessed as negligible (less than 1% of the reference population). There is no change to the magnitude of impact as assessed within the **ES Chapter 10 Section 10.7.1.2.1** [APP-096].

Table 6-28: Quantified CIA for the Potential Disturbance of White-Beaked Dolphin during Construction (Other than Piling) at Offshore Wind Farm Projects at the Same Time as Construction at SEP and DEP

Name of Project	Area (km^2)	Density source	White-beaked dolphin density	ES Table 10-106 [APP-096]	Updated assessment
				Maximum number of individuals potentially disturbed	Maximum number of individuals potentially disturbed
SEP	0.90	Waggitt *et al.*, 2019	0.006	0.0013	0.005
DEP	0.90	Waggitt *et al.*, 2019	0.006	0.0013	0.005
Norfolk Boreas	-	-	-	0.0013	Not assessed
East Anglia ONE North	-	-	-	0	Not assessed
East Anglia TWO	-	-	-	0	Not assessed
Hornsea Project Four[33]	-	-	-	0.0013	-
Norfolk Vanguard	-	-	-	0.0013	Not assessed
Berwick Bank	-	-	-	0.15	15[34]
Dogger Bank South[35]	0.90	O	0.002	0.0013	0.002

[30] Scoping only – generalised approach used
[31] Not quantitively assessed within the PEIR Chapter 11 Marine Mammals
[32] Scoping only – generalised approach used
[33] Not quantitively assessed within the ES Volume A2, Chapter 4: Marine Mammals
[34] Highest number at risk of disturbance as reported in the Berwick Bank ES Chapter 10 Marine Mammals

Name of Project	Area (km^2)	Density source	White-beaked dolphin density	ES Table 10-106 [APP-096]	Updated assessment
Dolphyn Project[36]	0.90	T	0.037	0.023	0.03
Five Estuaries	-	-	-	0	Not assessed
North Falls	-	-	-	0.0013	Not assessed
Outer Dowsing[37]	0.90	O	0.002	0.0013	0.002
Rampion Extension	-	-	-	0	Not assessed
Salamander[38]	0.90	R	0.243	0.15	0.22
Total number of white-beaked dolphin (without SEP & DEP)				**0.34 (0.34)**	**15.3 (15.3)**
Percentage of CGNS MU (43,951 white-beaked dolphin) (without SEP & DEP)				**0.0008% (0.0008%)**	**0.03% (0.03%)**
Magnitude (without SEP & DEP)				**Negligible (negligible)**	**Negligible (negligible)**

181. Based on the offshore wind farms that could be undergoing construction at the same time as SEP and DEP, the maximum number of minke whale that could be potentially temporarily disturbed is 2.4, approximately 0.012% of the reference population (**Table 6-29**). Therefore, the potential magnitude of the temporary effect is assessed as negligible, with less than 1% of the reference population likely to be exposed to the effect. There is no change to the magnitude of impact as assessed within the **ES Chapter 10 Section 10.7.1.2.1** [APP-096].

Table 6-29: Quantified CIA for the Potential Disturbance of Minke Whale during the Construction (Other than Piling) at Offshore Wind Farm Projects at the Same Time as Construction at SEP and DEP

Name of Project	Area (km^2)	Density source	Minke whale density	ES Table 10-107 [APP-096]	Updated assessment
				Maximum number of individuals potentially disturbed	Maximum number of individuals potentially disturbed
SEP	0.90	O	0.01	0.006	0.009
DEP	0.90	O	0.01	0.006	0.009
Norfolk Boreas	-	-	-	0.006	Not assessed
East Anglia ONE North	-	-	-	0	Not assessed
East Anglia TWO	-	-	-	0	Not assessed
Hornsea Project Four[39]	-	-	-	0.006	-
Norfolk Vanguard	-	-	-	0.006	Not assessed

[35]Scoping only – generalised approach used
[36]Scoping not yet submitted – generalised approach used
[37]Scoping only – generalised approach used
[38]Scoping only – generalised approach used
[39]Not quantitively assessed within the ES Volume A2, Chapter 4: Marine Mammals

Name of Project	Area (km^2)	Density source	Minke whale density	ES Table 10-107 [APP-096]	Updated assessment
Berwick Bank	-	-	-	0.24	2[40]
Dogger Bank South[41]	0.90	O	0.01	0.006	0.009
Dolphyn Project[42]	0.90	T	0.0316	0.02	0.03
Five Estuaries	-	-	-	0	Not assessed
North Falls[43]	0.90	O	0.01	0.006	0.009
Outer Dowsing[44]	0.90	O	0.01	0.006	0.009
Rampion Extension[45]	-	-	-	0	-
Salamander[46]	0.90	R	0.387	0.24	0.35
Total number of minke whale (without SEP & DEP)				**0.56 (0.55)**	**2.4 (2.4)**
Percentage of CGNS MU (20,118 minke whale) (without SEP & DEP)				**0.003% (0.003%)**	**0.012% (0.012%)**
Magnitude (without SEP & DEP)				**Negligible (negligible)**	**Negligible (negligible)**

182. Based on the projects that could have construction overlapping with SEP and DEP, the maximum number of grey seal and harbour seal that could potentially be disturbed is 41.6 and 24.3 (or 0.07% and 0.50% of the reference populations respectively) (**Table 6-30**). The potential magnitude for the cumulative impacts is assessed as negligible for both grey seal and harbour seal, with less than 1% of the reference population that could be temporarily disturbed. There is no change to the magnitude of impact as assessed within the **ES Chapter 10 Section 10.7.1.2.1** [APP-096].

[40]Highest number at risk of disturbance as reported in the Berwick Bank ES Chapter 10 Marine Mammals
[41]Scoping only – generalised approach used
[42]Scoping not yet submitted – generalised approach used
[43]Scoping only – generalised approach used
[44]Scoping only – generalised approach used
[45]Not quantitively assessed within the PEIR Chapter 11 Marine Mammals
[46]Scoping only – generalised approach used

Table 6-30: Quantified CIA for the Potential Disturbance of Grey Seal and Harbour Seal during the Construction (Other than Piling) at Offshore Wind Farm Projects at the Same Time as Construction at SEP and DEP

Name of Project	Area (km^2)	Density source	Grey seal density	Harbour seal density	ES Table 10-108 [APP-096]		Updated assessment	
					Maximum number of grey seal potentially disturbed	Maximum number of harbour seal potentially disturbed	Maximum number of grey seal potentially disturbed	Maximum number of harbour seal potentially disturbed
SEP	0.90	Carter *et al.*, (2022)	0.901	0.260	0.54	0.173	0.81	0.23
DEP	0.90	Carter *et al.*, (2022)	0.780	0.076	0.466	0.050	0.70	0.07
Norfolk Boreas	0.03	Russell *et al.*, 2017	0.032	0.019	0.0004	0.00004	0.001[47]	0.0006[47]
East Anglia ONE North	0.03	Russell *et al.*, 2017	0.03	0.007	0.0006	0.00025	0.001[48]	0.0002[48]
East Anglia TWO	0.03	Russell *et al.*, 2017	0.04	0.007	0.003	0.00025	0.001[49]	0.0002[49]
Hornsea Project Four[50]	-	-	-	-	0.088	0.025	-	-
Norfolk Vanguard[51]	Total offshore project area	Russell *et al.*, 2017	-	-	0.001	0.00005	39	24

[47] Highest number at risk of TTS / fleeing response or disturbance as reported in the Norfolk Boreas ES Chapter 12 Marine Mammal Ecology
[48] Highest number at risk of TTS / fleeing response as reported in the East Anglia ONE North ES Chapter 11 Marine Mammals
[49] Highest number at risk of TTS / fleeing response as reported in the East Anglia TWO ES Chapter 11 Marine Mammals
[50] Not quantitively assessed within the ES Volume A2, Chapter 4: Marine Mammals
[51] ES Chapter 12 Marine Mammals

Name of Project	Area (km^2)	Density source	Grey seal density	Harbour seal density	ES Table 10-108 [APP-096]		Updated assessment	
Dogger Bank South[52]	0.90	Carter *et al*., (2022)	0.112	0.004	0.071	0.00025	0.2	0.001
Five Estuaries[53]	-	-	-	-	0.006	0.0004	-	-
North Falls[54]	0.90	Carter *et al*., (2022)	0.016	0.002	0.01	0.001	0.1	0.001
Outer Dowsing[55]	0.90	Carter *et al*., (2022)	0.038	0.191	0.02	0.12	0.73	0.04
Total number of grey and harbour seal (without SEP & DEP)					**1.21 (0.20)**	**0.37 (0.27)**	**41.6 (40.0)**	**24.3 (24.0)**
Percentage of wider reference population (60,310 grey seal; 4,853 harbour seal) (without SEP & DEP)					**0.005% (0.001%)**	**0.0012% (0.0003%)**	**0.07% (0.07%)**	**0.50% (0.50%)**
Magnitude (without SEP & DEP)					**Negligible (negligible)**	**Negligible (negligible)**	**Negligible (negligible)**	**Negligible (negligible)**

[52]Scoping only – generalised approach used
[53]Not quantitively assessed within the [redacted]
[54]Scoping only – generalised approach used
[55]Scoping only – generalised approach used

6.2.1.3 Update to Cumulative Disturbance Assessment from Geophysical and Seismic Surveys at Other OWFs

6.2.1.3.1 Potential for Disturbance from Offshore Wind Farm Geophysical Surveys

In response to Natural England's Relevant Representation [RR-063], as stated in Applicant's Response (ID 7, 71 and 106) [REP2-051].

183. As assessed in **ES Chapter 10 Section 10.7.1.2.2.2** [APP-096], for geophysical surveys, the current guidance for assessing the significance of noise disturbance for harbour porpoise SACs (JNCC *et al.,* 2020) recommends the use of an EDR of 5km (78.54km^2) for geophysical surveys. As a worst-case, it has been assumed that all marine mammals within 5km of the survey source, a total area of 78.54km^2, could be disturbed.

184. However, this assessment has been updated to reflect that geophysical surveys are a moving source, rather than a stationary one (i.e. the distance at which a survey vessel could travel in one day, with a 5km buffer area).

185. It is difficult to determine what the potential area of effect would be when taking into account it is a moving source (as it is difficult to predict how far a vessel may survey in a day). Based on survey vessels travelling at a speed of 4.5 to 5 knots, up to 199km could be surveyed in one day. This however does not take into account the survey downtime for line changes, weather, or other technical reasons.

186. A review of seismic surveys within the UK indicated that surveys were being undertaken for approximately 52% of the time (BEIS, 2020). This data has been applied to geophysical surveys due to their similarity in approach. Taking this into account, up to 103.5km of surveys could be undertaken in one day, resulting in a potential disturbance area of 1,113.5km^2 with the 5km EDR buffer applied. This is highly precautionary as it is unlikely that the whole seismic survey transect area would be cause disturbance to marine mammals.

187. Without knowing the actual location for offshore wind farm geophysical surveys, the density estimates for the wider area have been used to estimate the potential number of individuals that could potentially be disturbed. For all cetacean species, the same density estimates as provided in **ES Chapter 10 Section 10.7.1.2.2.2** [APP-096] have been used.

188. For grey and harbour seal, densities were calculated for the entire area of the English North Sea, approximately covering the SE England and NE England MUs for grey seal, and the SE England MU for harbour seal, based on the grid cells that overlap with the area, and using the most recent grey and harbour seal population estimates to convert the Carter *et al.* (2022) relative densities to absolute densities (as described in **Section 5**). This is 0.307 grey seal per km^2 and 0.066 harbour seal per km^2.

189. Updated assessments have been provided for all marine mammal species (**Table 6-31**).

190. Under the updated assessments to take account of geophysical surveys as a moving source, the magnitude of impact is as assessed within **ES Chapter 10 Section 10.7.1.2.2.2** [APP-096] for white-beaked dolphin and minke whale (with a

magnitude of negligible), and has remained at low for grey seal. The magnitude has increased for bottlenose dolphin, and harbour seal. The magnitude has decreased for harbour porpoise, from low to negligible.

Table 6-31 Quantified CIA for the Potential Disturbance of Marine Mammals for Offshore Wind Farm Geophysical Surveys at the Same Time as Piling at SEP and DEP

		ES Table 10-109 [APP-096]		Updated assessment[56]	
Species	**Activity**	**Area of disturbance**	**Potential number disturbed (% of reference population)**	**Area of disturbance**	**Potential number disturbed (% of reference population)**
Harbour porpoise	Piling at SEP	2,123.7km^2	1,886	-	582
	Piling at DEP	2,123.7km^2	1,886	-	804
	Disturbance from two geophysical surveys in the North Sea area	157.08km^2	82 (0.02%)	2,227.0km^2	1,158.0 (0.33%)
	Cumulative assessment for harbour porpoise		**3,853 (1.11%) Low**	**Cumulative assessment for harbour porpoise**	**2,544.0 (0.73%) Negligible**
Bottlenose dolphin	Piling at SEP	0.44km^2	0.013	0.3km^2	0.01
	Piling at DEP	0.44km^2	0.013	0.4km^2	0.011
	Disturbance from two geophysical surveys in the North Sea area	157.08km^2	5 (0.23%)	2,227.0km^2	66.4 (3.28%)
	Cumulative assessment for bottlenose dolphin		**5 (0.23%) Negligible**	**Cumulative assessment for bottlenose dolphin**	**66.4 (3.28%) Low**
White-beaked dolphin	Piling at SEP	0.44km^2	0.001	0.3km^2	0.002
	Piling at DEP	0.44km^2	0.001	0.4km^2	0.002
	Disturbance from two geophysical surveys in	157.08km^2	0.31 (0.0007%)	2,227.0km^2	4.45 (0.01%)

[56]Based on the dose-response curve assessment (**Section 6.1.2.2**) for harbour porpoise, grey seal and harbour seal

		ES Table 10-109 [APP-096]		Updated assessment[56]	
	the North Sea area				
	Cumulative assessment for white-beaked dolphin		**0.32 (0.0007%) Negligible**	**Cumulative assessment for white-beaked dolphin**	**4.46 (0.01%) Negligible**
Minke whale	Piling at SEP	1,100km^2	11	720km^2	7.2
	Piling at DEP	1,100km^2	11	1,100km^2	11.0
	Disturbance from two geophysical surveys in the North Sea area	157.08km^2	1.57 (0.008%)	2,227.0km^2	22.3 (0.11%)
	Cumulative assessment for minke whale		**23.57 (0.12%) Negligible**	**Cumulative assessment for minke whale**	**40.5 (0.20%) Negligible**
Grey seal	Piling at SEP	220km^2	188	-	338
	Piling at DEP	220km^2	163	-	374
	Disturbance from two geophysical surveys in the North Sea area	157.08km^2	47.3 (0.2%)	2,227.0km^2	683.7 (1.13%)
	Cumulative assessment for grey seal		**397.5 (1.65%) Low**	**Cumulative assessment for grey seal**	**1,395.7 (2.31%) Low**
Harbour seal	Piling at SEP	220km^2	60	-	84
	Piling at DEP	220km^2	18	-	43
	Disturbance from two geophysical surveys in the North Sea area	157.08km^2	6.9 (0.023%)	2,227.0km^2	147.0 (3.0%)
	Cumulative assessment for harbour seal		**84.8 (0.28%) Negligible**	**Cumulative assessment for harbour seal**	**274.0 (5.7%) Medium**

6.2.1.3.2 Potential for Disturbance from Oil and Gas Seismic Surveys

191. As assessed in **ES Chapter 10 Section 10.7.1.2.4.2** [APP-096], for oil and gas seismic surveys, the current guidance for assessing the significance of noise disturbance for harbour porpoise SACs (JNCC *et al.,* 2020) recommends the use of an EDR of 12km (452.4km^2) for seismic surveys. As a worst-case, it has been assumed that all harbour porpoise within 12km of the survey source, could be disturbed.

192. For both dolphin species, a disturbance range of 11km has been applied (based on avoidance behaviours observed of bottlenose dolphin (DECC, 2011d), and for minke whale, a disturbance range of 10km has been used to inform the assessment, based on observed behavioural reactions of baleen whales to seismic surveys (Macdonald *et al*., 1995). For grey and harbour seal, a potential disturbance range of 17km (BEIS, 2020b) has been applied.

193. As for geophysical surveys, this assessment has been updated to reflect that oil and gas seismic surveys are a moving source, rather than a stationary one (i.e. the distance at which a survey vessel could travel in one day, with a buffer area reflecting the potential disturbance range). The same method of determining the potential total survey area in one day has used the same approach as outlined above, with up to 103.5km being surveyed in one day.

194. This results in a potential disturbance area of 2,936.4km^2 with the 12km EDR buffer applied for harbour porpoise. For bottlenose dolphin, the resultant disturbance area is 2,657.1km^2, for minke whale the area is 2,384.1km^2, and for both seal species is 5,334.8km^2. This is highly precautionary as it is unlikely that the whole seismic survey transect area would cause disturbance to marine mammals.

195. Without knowing the actual location for offshore wind farm geophysical surveys, the density estimates for the wider area have been used to estimate the potential number of individuals that could potentially be disturbed. For all cetacean species, the same density estimates as provided in **ES Chapter 10 Section 10.7.1.2.2.2** [APP-096] have been used.

196. For grey and harbour seal, the same densities as used for the assessment for the updated assessment for geophysical surveys as outlined above have been used (0.307 grey seal per km^2 and 0.066 harbour seal per km^2).

197. Updated assessments have been provided for all marine mammal species (**Table 6-32**).

198. Under the updated assessments to take account of seismic surveys as a moving source, the magnitude of impact is as assessed within **ES Chapter 10 Section 10.7.1.2.4.2** [APP-096] for harbour porpoise, white-beaked dolphin, and minke whale (with magnitudes of negligible or low). The magnitude has increased for bottlenose dolphin, grey seal and harbour seal, with the magnitude increasing to medium for bottlenose dolphin and grey seal, and to high for harbour seal.

Table 6-32 Quantified CIA for the Potential Disturbance of Marine Mammals for Offshore Wind Farm Seismic Surveys at the Same Time as Piling at SEP and DEP

		ES Table 10-109 [APP-096]		Updated assessment[57]	
Species	**Activity**	**Area of disturbance**	**Potential number disturbed (% of reference population)**	**Area of disturbance**	**Potential number disturbed (% of reference population)**
Harbour porpoise	Piling at SEP	2,123.7km^2	1,886	-	582
	Piling at DEP	2,123.7km^2	1,886	-	804
	Disturbance from up to two seismic surveys in the North Sea area	904.8km^2	470 (0.14%)	5,872.8km^2	3,053.9 (0.88%)
	Cumulative assessment for harbour porpoise		**4,242 (1.22%) Low**	**Cumulative assessment for harbour porpoise**	**4,439.9 (1.28%) Low**
Bottlenose dolphin	Piling at SEP	0.44km^2	0.013	0.3km^2	0.01
	Piling at DEP	0.44km^2	0.013	0.4km^2	0.01
	Disturbance from up to two seismic surveys in the North Sea area	760.3km^2	5 (0.23%)	5,314.2km^2	158.4 (7.8%)
	Cumulative assessment for bottlenose dolphin		**22.7 (1.1%) Low**	**Cumulative assessment for bottlenose dolphin**	**158.4 (7.8%) Medium**
White-beaked dolphin	Piling at SEP	0.44km^2	0.001	0.3km^2	0.002
	Piling at DEP	0.44km^2	0.001	0.4km^2	0.002
	Disturbance from up to two seismic surveys in the North Sea area	760.3km^2	0.31 (0.0007%)	5,314.2km^2	10.6 (0.02%)

[57]Based on the dose-response curve assessment (**Section 6.1.2.2**) for harbour porpoise, grey seal and harbour seal

		ES Table 10-109 [APP-096]		Updated assessment[57]	
	Cumulative assessment for white-beaked dolphin		**1.5 (0.0003%) Negligible**	**Cumulative assessment for white-beaked dolphin**	**10.6 (0.02%) Negligible**
Minke whale	Piling at SEP	1,100km^2	11	720km^2	7.2
	Piling at DEP	1,100km^2	11	1,100km^2	11.0
	Disturbance from up to two seismic surveys in the North Sea area	628.2km^2	6.28 (0.03%)	4,768.2km^2	47.7 (0.24%)
	Cumulative assessment for minke whale		**28.28 (0.14%) Negligible**	**Cumulative assessment for minke whale**	**69.7 (0.35%) Negligible**
Grey seal	Piling at SEP	220km^2	188	-	338
	Piling at DEP	220km^2	163	-	374
	Disturbance from up to two seismic surveys in the North Sea area	1,815.8km^2	546.6 (2.3%)	10,669.6km^2	3,275.57 (5.4%)
	Cumulative assessment for grey seal		**896.8 (3.72%) Low**	**Cumulative assessment for grey seal**	**3,987.6 (6.6%) Medium**
Harbour seal	Piling at SEP	220km^2	60	-	84
	Piling at DEP	220km^2	18	-	43
	Disturbance from up to two seismic surveys in the North Sea area	1,815.8km^2	79.9 (0.26%)	10,669.6km^2	704.2 (14.5%)
	Cumulative assessment for harbour seal		**157.8 (0.52%) Negligible**	**Cumulative assessment for harbour seal**	**831.2 (17.1%) High**

6.2.1.4 Update to Overall Cumulative Disturbance Assessments

199. **ES Chapter 10 Section 10.7.1.3** [APP-096] provides an overall cumulative impact assessment form all disturbance activities. The following sections provide an update to that assessment, based on the updates as provided in **Sections 6.2.1.1 and 6.2.1.2** above.

200. For harbour porpoise, under the updated assessments, up to 39,959 individuals (11.5% of NS MU) could be disturbed as a result of cumulative underwater noise for SEP and DEP (**Table 6-33**). The magnitude of impact is high, increasing from medium as assessed within **ES Chapter 10 Section 10.7.1.3 (Table 10-114)** [APP-096].

201. For bottlenose dolphin, 248 individuals (or 12.3% of the GNS MU) could be disturbed as a result of cumulative underwater noise (**Table 6-33**). The magnitude of impact is high, increasing from low as assessed within **ES Chapter 10 Section 10.7.1.3 (Table 10-114)** [APP-096].

202. For white-beaked dolphin, up to 952 individuals (2.2% of CGNS MU) could be disturbed as a result of cumulative underwater noise (**Table 6-33**). The magnitude of impact is low, increasing from negligible as assessed within **ES Chapter 10 Section 10.7.1.3 (Table 10-114)** [APP-096].

203. For minke whale, up to 658 individuals (3.3% of CGNS MU) could be disturbed as a result of cumulative underwater noise (**Table 6-33**). The magnitude of impact is low in both the updated assessment and within **ES Chapter 10 Section 10.7.1.3 (Table 10-114)** [APP-096].

204. For grey seal and harbour seal, up to 9,378 and 1,134 individuals (15.5% and 23.9% of the reference populations), respectively, could be disturbed as a result of cumulative underwater noise (**Table 6-33**). The magnitude of impact is high for both seal species, increasing from medium and negligible as assessed within **ES Chapter 10 Section 10.7.1.3 (Table 10-114)** [APP-096].

205. **Table 6-34** provides a summary of the number of each marine mammal species that could be disturbed from all cumulative noise sources, including piling at SEP or DEP, which provides as update to **ES Chapter 10 Section 10.7.1.3 (Table 10-115)** [APP-096].

Table 6-33: Quantified CIA for the Potential Disturbance of Marine Mammals from Cumulative Underwater Noise Sources during Piling at SEP and DEP (Worst-Case)

Cumulative underwater noise	Potential number of harbour porpoise disturbed	Potential number of bottlenose dolphin disturbed	Potential number of white-beaked dolphin disturbed	Potential number of minke whale disturbed	Potential number of grey seal disturbed	Potential number of harbour seal disturbed
Piling at SEP and DEP[58]	1,386.0	0.51	0.10	16.0	712.0	127.0
Piling at other OWFs (**Section 6.2.1.1.2**)[59]	32,422.4	20.5	921.0	236.0	4,287.2	100.2
Construction at other OWFs (**Section 6.2.1.2**)	819	2.14	15.3	2.4	41.6	24.3
Two OWF geophysical surveys (**Section 6.2.1.3.1**)	1,158.0	66.4	4.45	22.3	683.7	147.0
Aggregate extraction and dredging (**Section 10.7.1.2.3 of ES Chapter 10** [APP-096])	6.0	0	0	0	0	0
Two oil and gas seismic surveys (**Section 6.2.1.3.2**)	3,053.9	158.4	10.6	47.7	3,275.57	704.2
Subsea cables and pipelines (**Section 10.7.1.2.5 of ES Chapter 10** [APP-096])	10.0	0	0	0	0	0
One high-order UXO detonation without mitigation (**Section 10.7.1.2.6 of ES Chapter 10** [APP-096])	1,104	0.16	0.011	333.3	378.2	55.3
ES Table 10-114						
Total	**18,016**	**28.1**	**2.3**	**823**	**1,394**	**272**
% of reference population	**5.2**	**1.4**	**0.005**	**4.1**	**5.8**	**0.89**
Magnitude	**Medium**	**Low**	**Negligible**	**Low**	**Medium**	**Negligible**
Updated assessments						

[58]Based on the dose response curve assessments (**Section 6.1.2.2**) for harbour porpoise, grey seal and harbour seal, as the most realistic assessment for SEP and DEP
[59]Under the simultaneous piling scenario as the worst-case

Cumulative underwater noise	Potential number of harbour porpoise disturbed	Potential number of bottlenose dolphin disturbed	Potential number of white-beaked dolphin disturbed	Potential number of minke whale disturbed	Potential number of grey seal disturbed	Potential number of harbour seal disturbed
Total	**39,959.2**	**248.1**	**951.5**	**657.6**	**9,378.2**	**1,134.0**
% of reference population	**11.5**	**12.3**	**2.2**	**3.3**	**15.5**	**23.9**
Magnitude	**High**	**High**	**Low**	**Low**	**High**	**High**

Table 6-34: Quantified CIA for the Potential Disturbance of Marine Mammals from Cumulative Underwater Noise Sources during Piling at SEP or DEP in Isolation

Cumulative underwater noise	Potential number of harbour porpoise disturbed	Potential number of bottlenose dolphin disturbed	Potential number of white-beaked dolphin disturbed	Potential number of minke whale disturbed	Potential number of grey seal disturbed	Potential number of harbour seal disturbed
Piling at SEP or DEP (worst-case)[60]	804.0	0.011	0.0024	11.0	374.0	84.0
Piling at other OWFs (**Section 6.2.1.1.2**)[61]	32,422.4	20.5	921.0	236.0	4,287.2	100.2
Construction at other OWFs (**Section 6.2.1.2**)	819	2.14	15.3	2.4	41.6	24.3
Two OWF geophysical surveys (**Section 6.2.1.3.1**)	1,158.0	66.4	4.45	22.3	683.7	147.0
Aggregate extraction and dredging (**Section 10.7.1.2.3 of ES Chapter 10** [APP-096])	6.0	0	0	0	0	0
Two oil and gas seismic surveys (**Section 6.2.1.3.2**)	3,053.9	158.4	10.6	47.7	3,275.57	704.2
Subsea cables and pipelines (**Section 10.7.1.2.5 of ES Chapter 10** [APP-096])	10.0	0	0	0	0	0

[60]Based on the dose response curve assessments (**Section 6.1.2.2**) for harbour porpoise, grey sela and harbour seal, as the most realistic assessment for SEP and DEP
[61]Under the simultaneous piling scenario as the worst-case

Cumulative underwater noise	Potential number of harbour porpoise disturbed	Potential number of bottlenose dolphin disturbed	Potential number of white-beaked dolphin disturbed	Potential number of minke whale disturbed	Potential number of grey seal disturbed	Potential number of harbour seal disturbed
One high-order UXO detonation without mitigation (**Section 10.7.1.2.6 of ES Chapter 10** [APP-096])	1,104	0.16	0.011	333.3	378.2	55.3
ES Table 10-115						
Total	**16,130**	**28.1**	**2.3**	**812**	**1,168**	**282**
% of reference population	**4.7**	**1.4**	**0.005**	**4.0**	**4.8**	**0.6**
Magnitude	**Low**	**Low**	**Negligible**	**Low**	**Low**	**Negligible**
Updated assessments						
Total	**39,377.2**	**247.6**	**951.4**	**652.6**	**9,040.2**	**1,115.0**
% of reference population	**11.4**	**12.2**	**2.2**	**3.2**	**15.0**	**23.0**
Magnitude	**High**	**High**	**Low**	**Low**	**High**	**High**

206. If all included activities were being undertaken at the same time as piling at SEP and DEP, there is the potential for a low to high magnitude of impact (dependent on species), however, it is highly unlikely that all these activities would be conducted at exactly the same time as piling at SEP and DEP. The inclusion of two geophysical surveys and two oil and gas seismic surveys is highly precautionary, as is assessing all as moving sound sources. This is likely providing an overestimation in the potential disturbance areas assessed as marine mammals are likely to return to an area following the survey taking place, rather than avoiding the full daily disturbance area for a full day. The inclusion of all offshore wind farms undertaking simultaneous piling is precautionary, as it is unlikely that it would be possible for that number of piling events to take place at the same time given current vessel availabilities.

207. In the case of bottlenose dolphin, white-beaked dolphin and minke whale, the inclusion of project specific data has likely further contributed to an over-estimation of the number of individuals at risk due to the methods of assessment utilised by those projects. Further information is provided in **Section 6.2.1.1.2**.

208. In addition, with the implementation of any management measures for the Southern North Sea SAC, the potential impacts could be reduced. Mitigation measures to reduce the disturbance of harbour porpoise in the project specific Site Integrity Plans (SIPs) which reduce noise levels may also reduce the potential disturbance of white-beaked dolphin, minke whale, bottlenose dolphin, as well as grey and harbour seal.

6.2.1.4.1 Overall CIA Impact Significance

209. The following assessment of impact significance for all marine mammal species updates that as presented in **ES Chapter 10 Section 10.7.1.3.2 (Table 10-118)** [APP-096].

210. **Table 6-35** presents the overall significances for the updated cumulative disturbance assessments. Harbour porpoise, grey seal and harbour seal are assessed as having a major adverse impact. While the project specific underwater noise management and mitigation measures to be provided within the Southern North Sea SAC SIP could reduce disturbance to non-significant levels, population modelling has been undertaken for offshore wind farm piling cumulative impacts to determine the potential for population level consequences, and therefore the potential for mitigation for disturbance to be required.

Table 6-35: Overall Cumulative Impact Significance for Disturbance of Marine Mammals from Cumulative Underwater Noise during Piling at both SEP and DEP

Potential Impact	Species	Sensitivity	ES Table 10-118 [APP-096]				Updated assessments			
			Magnitude	Impact Significance	Mitigation	Residual Impact	Magnitude	Impact Significance	Mitigation	Residual Impact
Overall cumulative impact of disturbance to marine mammals during piling at SEP and DEP	Harbour porpoise	Medium	Medium	**Moderate adverse**	Project specific SIP for the SNS SAC would manage and reduce potential for disturbance of harbour porpoise	**Minor adverse**	High	**Major adverse**	Disturbance reduction measures in project specific SIP for the SNS SAC may reduce potential for disturbance for all marine mammal species	**Major adverse**
	Bottlenose dolphin		Low	**Minor adverse**		**Minor adverse**	Low[62]	**Minor adverse**		**Minor adverse**
	White-beaked dolphin		Negligible	**Minor adverse**		**Minor adverse**	Low	**Minor adverse**		**Minor adverse**
	Minke whale		Low	**Minor adverse**		**Minor adverse**	Low	**Minor adverse**		**Minor adverse**
	Grey seal		Medium	**Moderate adverse**		**Minor adverse**	High	**Major adverse**		**Major adverse**
	Harbour seal		Negligible	**Minor adverse**		**Minor adverse**	High	**Major adverse**		**Major adverse**

[62]Likely an over-estimation of impact due to precautionary and worst-case approach taken throughout assessment, and methods utilised by other included projects. A magnitude of low is considered more appropriate for bottlenose dolphin.

Table 6-36: Overall Cumulative Impact Significance for Disturbance of Marine Mammals from Cumulative Underwater Noise during Piling at Either SEP or DEP in isolation

Potential Impact	Species	Sensitivity	ES Table 10-119 [APP-096]				Updated assessment			
			Magnitude	Impact Significance	Mitigation	Residual Impact	Magnitude	Impact Significance	Mitigation	Residual Impact
Overall cumulative impact of disturbance to marine mammals during piling at SEP or DEP	Harbour porpoise	Medium	Low	Minor	Project specific SIP for the SNS SAC would manage and reduce potential for disturbance of harbour porpoise	**Minor adverse**	High	**Major adverse**	Disturbance reduction measures in project specific SIP for the SNS SAC may reduce potential for disturbance for all marine mammal species	**Major adverse**
	Bottlenose dolphin		Low	Minor		**Minor adverse**	Low[63]	**Minor adverse**		**Minor adverse**
	White-beaked dolphin		Negligible	Minor		**Minor adverse**	Low	**Minor adverse**		**Minor adverse**
	Minke whale		Low	Minor		**Minor adverse**	Low	**Minor adverse**		**Minor adverse**
	Grey seal		Low	Minor		**Minor adverse**	High	**Major adverse**		**Major adverse**
	Harbour seal		Negligible	Minor		**Minor adverse**	High	**Major adverse**		**Major adverse**

[63]Likely an over-estimation of impact due to precautionary and worst-case approach taken throughout assessment, and methods utilised by other included projects. A magnitude of low is considered more appropriate for bottlenose dolphin.

6.2.1.5 Population Modelling for Cumulative Disturbance from Offshore Wind Farm Projects

In response to Natural England's Relevant Representation [RR-063], as stated in Applicant's Response (ID 61, 112) [REP2-051].

6.2.1.5.1 Results for Cumulative Offshore Wind Farm Projects

Harbour Porpoise

211. For the cumulative scenario assessed (see **Table 6-19** for details of the projects considered, and their parameters) within the North Sea MU, the iPCoD model predicts a decrease in harbour porpoise population size over time (**Plate 6-5** and **Table 6-37**).

212. The mean population size for the impacted population was predicted to be 99.73% of the un-impacted population size at the end of 2026 (after the first year of pile driving has completed). By the end of 2031 the mean population size for the impacted population was predicted to be 98.22% of the un-impacted population size. By the end of 2037, the mean population size for the impacted population was predicted to be 98.15% of the un-impacted population size. This 1.85% reduction in population size is predicted to remain to the end 2049, which is the end point of the modelling. It should be noted that this modelling did not account for any density dependent effects, which may increase the survival and fecundity rates of the impacted population, due to reduced intra-specific competition.

Table 6-37 Results of the iPCoD modelling for the in-combination scenario, giving the mean population size of the harbour porpoise population (North Sea MU) for years up to 2049 for both impacted and un-impacted populations as well as the mean and median ratio between their populations

Year	Un-impacted population mean	Impacted population mean	Median impacted as % of un-impacted	Mean impacted as % of un-impacted
Start	346,600	346,600	100%	100%
End 2026	346,721	345,814	99.86%	99.73%
End 2031	346,042	339,836	98.81%	98.22%
End 2037	345,819	339,382	98.75%	98.15%
End 2043	346,066	339,605	98.75%	98.15%
End 2049	347,616	341,148	98.75%	98.15%

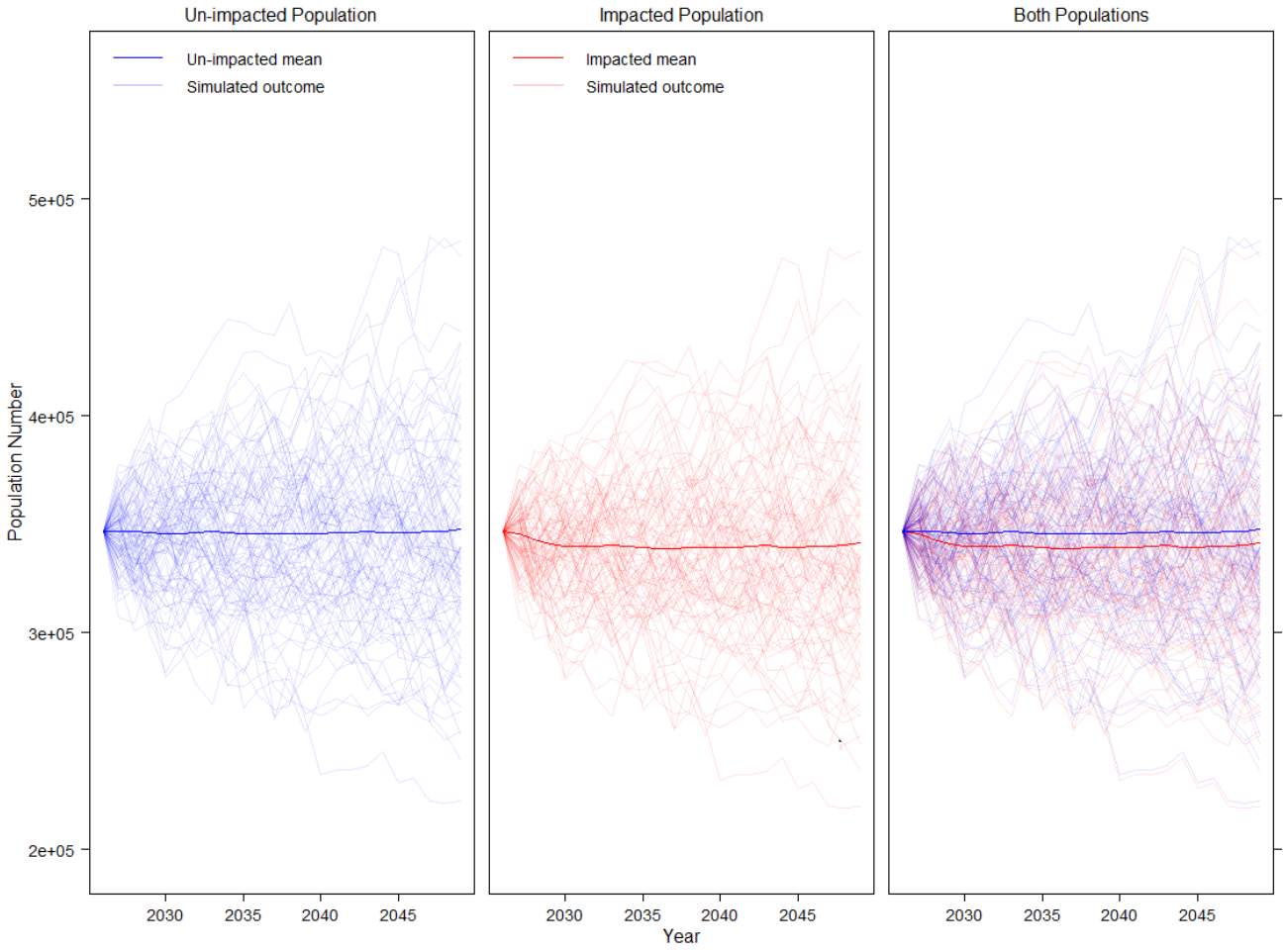

Plate 6-5 Simulated in-combination worst-case harbour porpoise North Sea MU population sizes for both the un-impacted and the impacted populations

Grey Seal

213. For the cumulative scenario assessed (see **Table 6-19** for details of the projects considered, and their parameters) within the reference population, the iPCoD model predicts only a slight discernible decrease in grey seal population size over time (**Plate 6-6** and **Table 6-38**).

214. The mean population size for the impacted population was predicted to be 100% of the un-impacted population size at the end of 2026 (after the first year of pile driving has completed). By the end of 2031 the mean population size for the impacted population was predicted to be 99.97% of the un-impacted population size. This 0.03% reduction in population size is predicted to remain to the end 2049, which is the end point of the modelling. It should be noted that this modelling did not account for any density dependent effects, which may increase the survival and fecundity rates of the impacted population, due to reduced intra-specific competition.

Table 6-38 Results of the iPCoD modelling for the in-combination scenario, giving the mean population size of the grey seal population (reference population) for years up to 2049 for both impacted and un-impacted populations as well as the mean and median ratio between their populations

Year	Un-impacted population mean	Impacted population mean	Median impacted as % of un-impacted	Mean impacted as % of un-impacted
Start	60308	60308	100%	100%
End 2026	60870	60872	100%	100%
End 2031	64115	64095	>99.99%	99.97%
End 2037	68215	68193	>99.99%	99.97%
End 2043	72459	72436	>99.99%	99.97%
End 2049	76737	76712	100%	99.97%

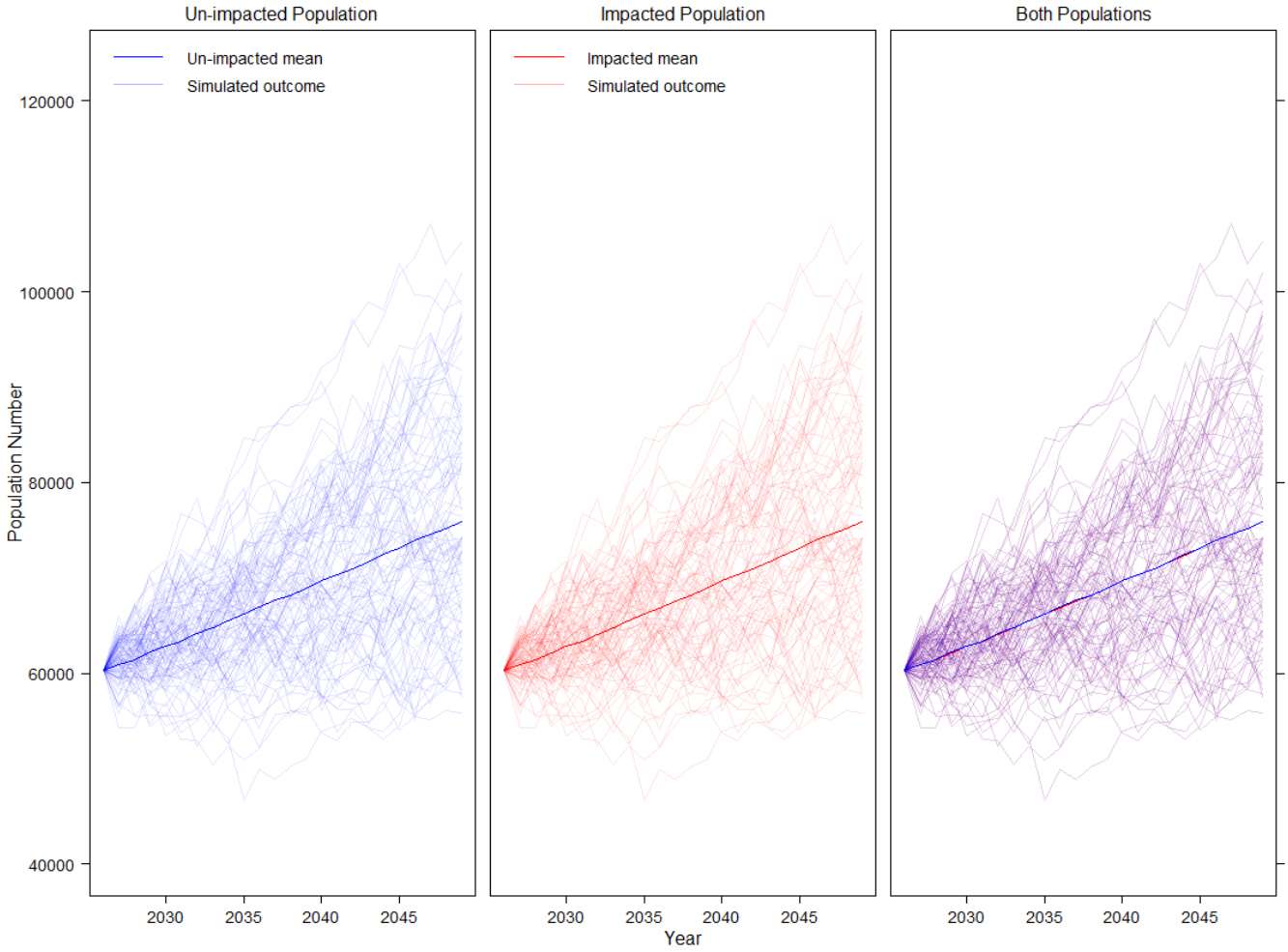

Plate 6-6 Simulated in-combination worst-case grey seal reference population sizes for both the un-impacted and the impacted populations

Harbour Seal

215. For the cumulative scenario assessed (see **Table 6-19** for details of the projects considered, and their parameters) within the SE England MU, the iPCoD model predicts no discernible decrease in harbour seal population size over time (**Plate 6-7** and **Table 6-39**).

216. The mean population size for the impacted population was predicted to be >99.99% of the un-impacted population size at the end of 2026 (after the first year of pile driving has completed). By the end of 2031 the mean population size for the impacted population was predicted to be 100% of the un-impacted population size. The lack of difference in population sizes is predicted to remain to the end 2049, which is the end point of the modelling.

Table 6-39 Results of the iPCoD modelling for the in-combination scenario, giving the mean population size of the harbour seal population (SE England MU population) for years up to 2049 for both impacted and un-impacted populations as well as the mean and median ratio between their populations

Year	Un-impacted population mean	Impacted population mean	Median impacted as % of un-impacted	Mean impacted as % of un-impacted
Start	4850	4850	100%	100%
End 2026	3980	3980	100%	>99.99%
End 2031	1482	1482	100%	100%
End 2037	451	452	100%	100%
End 2043	137	137	100%	100%
End 2049	42	42	100%	100%

**Note that the model assumes that population demographics remain constant over time. This means that the currently declining population is projected to continue its decline regardless of any additional piling activity.*

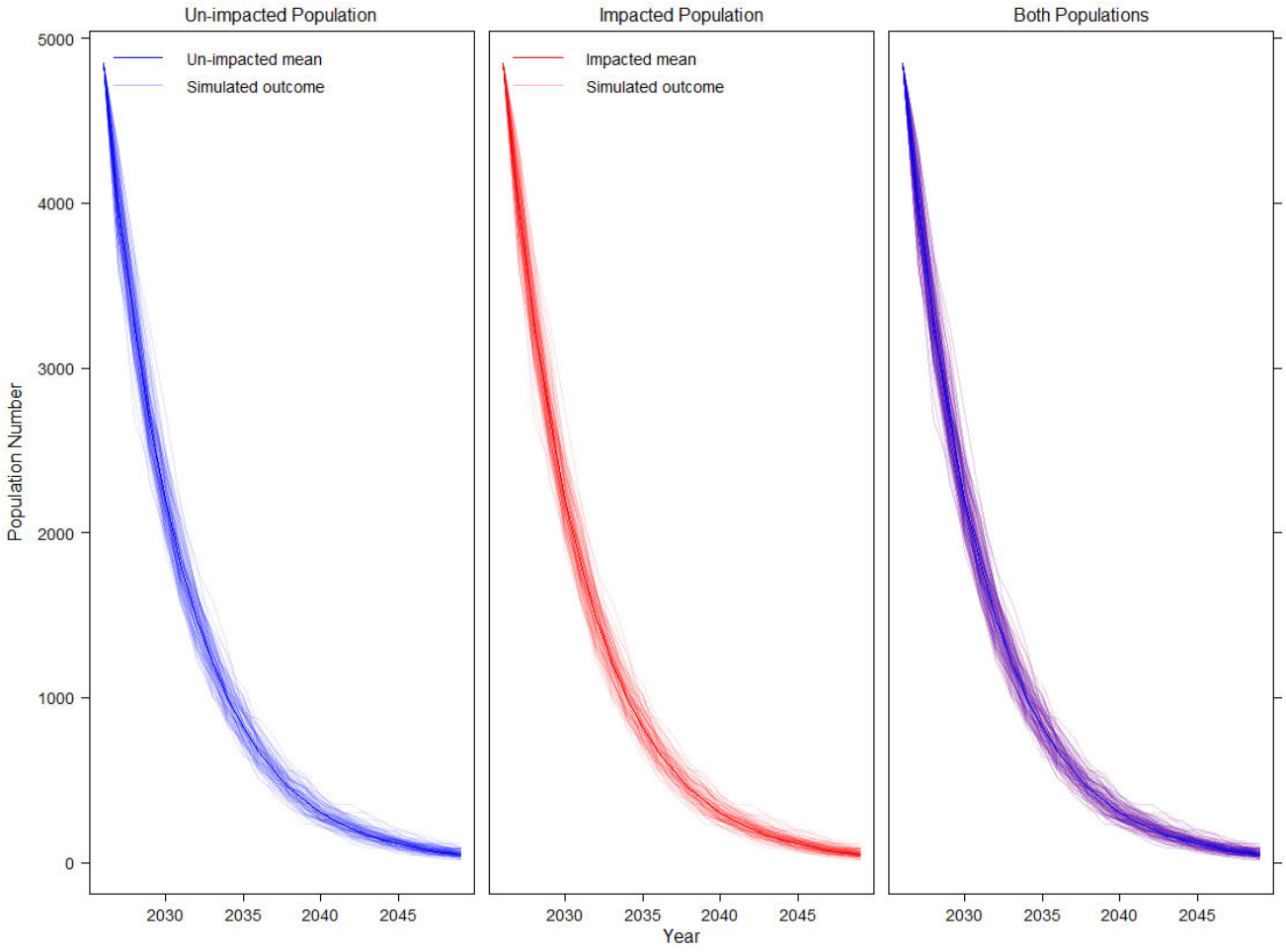

Plate 6-7 Simulated in-combination worst-case harbour seal reference population sizes for both the un-impacted and the impacted populations

Bottlenose dolphin

217. For the cumulative scenario assessed (see **Table 6-19** for details of the projects considered, and their parameters) within the Greater North Sea MU, the iPCoD model predicts a decrease in bottlenose dolphin population size over time (STYLEREF 1 \s Plate 6-8 and **Table 6-40**).

218. The mean population size for the impacted population was predicted to be 99.69% of the un-impacted population size at the end of 2026 (after the first year of pile driving has completed). By the end of 2031 the mean population size for the impacted population was predicted to be 96.33% of the un-impacted population size. By the end of 2037, the mean population size for the impacted population was predicted to be 96.73% of the un-impacted population size. The mean population size of the impacted population then decreases slightly to 96.54% of the un-impacted population size by the end of 2043, and remains relatively stable to the end of 2049 where it stands at 96.56%. It should be noted that this modelling did not account for any density dependent effects, which may increase the survival and fecundity rates of the impacted population, due to reduced intra-specific competition.

Table 6-40 Results of the iPCoD modelling for the in-combination scenario, giving the mean population size of the bottlenose dolphin population (Greater North Sea MU population) for years up to 2049 for both impacted and un-impacted populations as well as the mean and median ratio between their populations

Year	Un-impacted population mean	Impacted population mean	Median impacted as % of un-impacted	Mean impacted as % of un-impacted
Start	2,024	2,024	100%	100%
End 2026	2,028	2,022	100%	99.69%
End 2031	2,026	1,951	100%	96.33%
End 2037	2,014	1,947	100%	96.73%
End 2043	2,016	1,945	100%	96.54%
End 2049	2,016	1,945	100%	96.56%

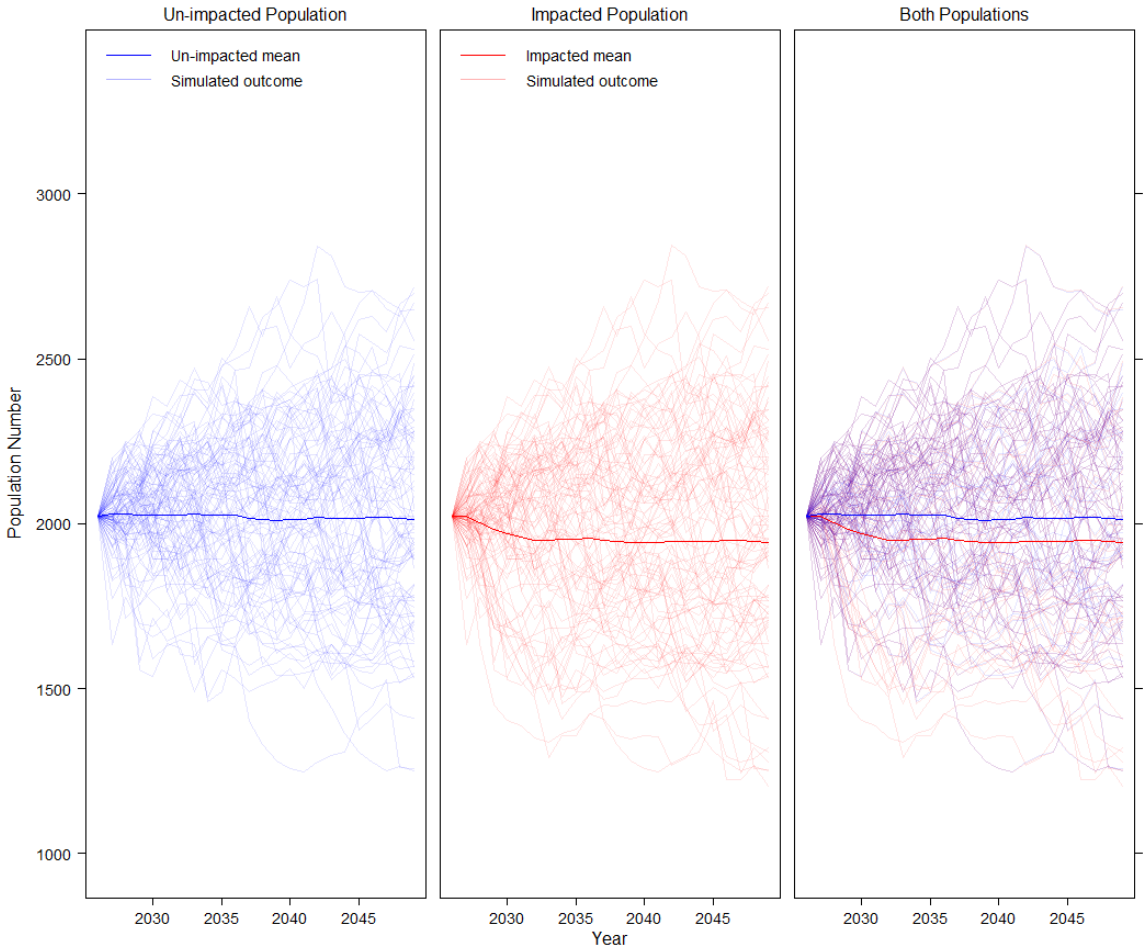

Plate 6-86-9 Simulated in-combination worst-case bottlenose dolphin reference population sizes for both the un-impacted and the impacted populations

6.2.1.5.2 Magnitude of Population Level Consequences of Disturbance from Piling

219. There are no specific potential biological removal limits in place for either the harbour porpoise, grey seal, or harbour seal populations modelled, and therefore there are no specific thresholds to determine whether a population level effect would be significant.

220. As stated in **ES Chapter 10 Section 10.4.3.1** [APP-096], draft EPS guidance defines a level of population that could be lost from a population before a population level effect occurs. The JNCC *et al.* (2010) draft guidance considered 4% as the maximum potential growth rate in harbour porpoise, and the 'default' rate for cetaceans. Therefore, beyond natural mortality, up to 4% of the population could theoretically be permanently removed before population growth could be halted. Therefore, it can be assumed that a population level effect of up to 4% would not cause a population level consequence, and there would not be a significant level of effect. A threshold of 1.7% annual decline of the relevant harbour porpoise population above which a population decline is inevitable has been agreed with Parties to ASCOBANS, with an intermediate precautionary objective of reducing the annual impacts to less than 1% of the population (Defra, 2003; ASCOBANS, 2015).

221. Evans & Arvela (2012) advise that a population annual decline of more than 1% on average over a 12 year period represents unfavourable conservation status. Booth *et al.*, 2016 undertook a study into to use of the Interim IPCoD framework for assessing population level effects of offshore wind farm piling in the North Sea. The study assumed that the harbour porpoise population could already be experiencing an annual decline of 1% (in reference to the Evans and Arvela (2012) threshold noted above), and therefore a threshold of an additional 1% annual decline could be used to determine whether the construction works of offshore wind would result in a disturbed population in comparison to an undisturbed population.

222. There is the potential for a 1.25% to 1.85% reduction in the harbour porpoise population over the modelled period of 25 years (**Table 6-37**). The highest rate of decline is predicted to occur from end 2026 to end 2033, with a 1.05% to 1.51% population decrease, or a 0.2% to 0.3% annual decline. This is well below the high-level population decline limits for harbour porpoise as described above, and therefore it is expected that the expected decline of the harbour porpoise population due to cumulative disturbance would not be significant to the population, and would not cause a population level effect. The magnitude of effect is therefore expected to be low, as a precautionary assessment.

223. There is a potential for a 0% to 3.44% reduction in bottlenose dolphin population over the modelled period of 25 years (**Table 6-40**). The highest rate of decline is predicted to occur from end 2026 to end 2031, with a 0% to 3.36% population decrease, or a 0% to 0.67% annual decline over the five year period. As for harbour porpoise above, this is below the population decline limits of 1% annual decline, and therefore it is expected that the predicted decline of the bottlenose dolphin population due to cumulative disturbance would not cause a population

level effect. The magnitude of effect is therefore expected to be low, as a precautionary assessment.

224. For grey seal, there is the potential for up to a 0.03% reduction in the grey seal population over the modelled period of 25 years (**Table 6-38**). The cumulative disturbance from offshore wind farm piling would not cause a population level effect to harbour seal. The magnitude of effect is therefore expected to be negligible for both seal species (**Table 6-39**).

225. The harbour seal population is currently in decline, and the population modelling has used a declining harbour seal population as the input values to provide a precautionary assessment. The population reduces to 42 (from the starting estimate of 4,850 individuals) over the 25 year modelled period. However, the cumulative offshore wind farm piling scenario also predicts a population level of 42 by the end of the modelled period. This indicates that the disturbance associated with offshore wind farm piling would not worsen the already declining population, even under the most precautionary and worst-case assessments.

6.2.1.6 Need for Further Mitigation

226. The results of the population modelling, as provided in **Section 6.2.1.5** above, have shown that while a potential for a significant effect to harbour porpoise, grey seal and harbour seal was predicted for SEP and DEP (**Table 6-35** and **Table 6-36**), there would be no effect on the population of any of these species (there is no significant difference between the disturbed and undisturbed population estimates at the end of the 25 year period). No mitigation for disturbance is therefore proposed (or required) for piling at SEP and DEP.

6.2.2 Seal Haul-Out Sites

In response to Natural England's Relevant Representation [RR-063], as stated in Applicant's Response (ID 68) [REP2-051].

227. Further information on the screening out of disturbance to seal haul-out sites from the cumulative assessment has been provided below.

228. As assessed for SEP and DEP (**ES Chapter 10 Section 10.6.1.7** [APP-096]), there is the potential for a negligible to minor adverse effect due to disturbance at seal haul-out sites from the Projects alone. This conclusion is drawn from the low sensitivity of seals to disturbance at haul-out sites, with the exception of during the relevant pupping and breeding periods of both species, where they have an increased sensitivity to disturbance. All vessel movements to and from SEP and DEP would utilise already established vessel routes, and are unlikely to transit within 600m of the coastline.

229. It is therefore considered unlikely that there will be significant cumulative effects at seal haul-out sites given the distance of SEP and DEP from the nearest site of Blakeney Point (12km from the landfall / cable corridor), the limited disturbance ranges from vessels (of 300m to 600m), and the vessel safety requirements to avoid near shore waters, as well as the expected habituation of seals to vessels in the area. In addition, good practice measures would be implemented by SEP and DEP (as outlined in the **Outline Project Environmental Management Plan (Revision C)** [document reference 9.10]].

230. It is assumed that all other projects would follow the same good practice measures with regards to avoiding disturbance at haul-out sites. In addition, where seal haul-out sites are near to a vessel corridor, the seals present in that area would be used to vessels transiting past the area. It is therefore considered that there would be limited potential for any cumulative disturbance impact at any seal haul-out site, and the cumulative impact magnitude would be negligible.

6.3 Updated Assessments for Grey and Harbour Seal

In response to Natural England's Relevant Representation [RR-063], as stated in Applicant's Response (ID 28, 29, 48) [REP2-051].

231. **Annex 2** provides an update to all assessments as provided within the **ES Chapter 10** [APP-096] that rely on the grey seal or harbour seal density estimates and reference populations. This includes an update to;

- Construction related impact assessments:
  - Impact 1: Auditory Injury from Underwater Noise Associated with Piling (**ES Chapter 10 Section 10.6.1.1**)
  - Impact 2: Disturbance from Underwater Noise Associated with Piling Activities (**ES Chapter 10 Section 10.6.1.2**)
  - Impact 3: Effects from Underwater Noise Associated with Other Construction Activities (**ES Chapter 10 Section 10.6.1.3**)
  - Impact 4: Impacts from Underwater Noise and Disturbance Associated with Construction Vessels (**ES Chapter 10 Section 10.6.1.4**)
  - Impact 6: Increased Risk of Collision with Vessels during Construction (**ES Chapter 10 Section 10.6.1.6**)
  - Impact 8: Changes to Prey Availability (**ES Chapter 10 Section 10.6.1.8**)
- Operation and maintenance phase related impact assessments:
  - Impact 1: Impacts from Underwater Noise Associated with Operational Wind Turbines (**ES Chapter 10 Section 10.6.2.1**)
  - Impact 2: Impacts from Underwater Noise Associated with Operation and Maintenance Activities (**ES Chapter 10 Section 10.6.2.2**)
  - Impact 3: Impacts from Underwater Noise and Disturbance Associated with Operation and Maintenance Vessels (**ES Chapter 10 Section 10.6.2.3**)
  - Impact 5: Increased Risk of Collision with Vessels during Operation (**ES Chapter 10 Section 10.6.2.5**)

232. An update to the cumulative impact assessment for seal species is provided in **Section 6.2**.

233. A summary of the updates to the assessments is provided in **Table 6-41** and **Table 6-42**.

234. While there are some changes in magnitude levels for both seal species due to the updated density estimates and reference populations, as well as the updated approaches to assessment of disturbance both alone and cumulatively, there are no changes to the residual impacts.

Table 6-41 Summary of Updated Assessments for Grey Seal and Harbour Seal for SEP or DEP in Isolation

Potential impact	Receptor	Sensitivity	ES (Table 10-124)				Updated assessments			
			Magnitude	Pre-mitigation impact	Mitigation measures proposed	Residual impact	Magnitude	Pre-mitigation impact	Mitigation measures proposed	Residual impact
Construction										
Impact 1: Auditory Injury from Underwater Noise Associated with Piling										
PTS from single strike of starting or maximum hammer energy	Grey seal and harbour seal	High	Negligible	Minor adverse	MMMP for piling	**Minor adverse**	Negligible	Minor adverse	MMMP for piling	**Minor adverse**
PTS during piling from cumulative exposure	Grey seal and harbour seal	High	Medium to Negligible	Major to Minor adverse	MMMP for piling	**Minor adverse**	Negligible to low	Minor to moderate adverse		**Minor adverse**
TTS from single strike of maximum hammer energy	Grey seal and harbour seal	Medium	Negligible	Minor adverse	MMMP for piling	**Minor adverse**	Negligible	Minor adverse	None required	**Minor adverse**
TTS during piling from cumulative exposure	Harbour seal	Medium	Negligible	Minor adverse	MMMP for piling	**Minor adverse**	Negligible	Minor adverse		**Minor adverse**
	Grey seal	Medium	Low to Negligible	Minor adverse		**Minor adverse**	Negligible	Minor adverse		**Minor adverse**

Potential impact	Receptor	Sensitivity	ES (Table 10-124)				Updated assessments			
Impact 2: Disturbance from Underwater Noise Associated with Piling Activities										
ADD activation	Grey seal and harbour seal	Medium	Negligible	Minor adverse	Not applicable	**Minor adverse**	Negligible[64]	Minor adverse	Not applicable	**Minor adverse**
Disturbance from piling	Harbour seal	Medium[65]	Negligible	Minor adverse	MMMP for piling	**Minor adverse**	Negligible[66]	Minor adverse	None required	**Minor adverse**
	Grey seal	Medium[67]	Low to Negligible	Minor adverse		**Minor adverse**	Negligible[68]	Minor adverse		**Minor adverse**
Impact 3: Disturbance from Underwater Noise Associated with Other Construction Activities										
TTS from cumulative SEL and disturbance during other construction activities	Grey seal and harbour seal	Medium	Negligible	Minor adverse	No mitigation proposed	**Minor adverse**	Negligible	Minor adverse	None required	**Minor adverse**
Impact 4: Impacts from Underwater Noise and Disturbance Associated with Construction Vessels										
TTS from cumulative SEL and disturbance for construction	Grey seal and harbour seal	Medium	Negligible	Minor adverse	No mitigation proposed	**Minor adverse**	Negligible	Minor adverse	None required	**Minor adverse**

[64] As assessed in **Section 6.1.3**
[65] Using TTS as a proxy for disturbance
[66] As assessed in **Section 6.1.2.3**, using the results of the population modelling as the most realistic indication of the magnitude of potential impact
[67] Using TTS as a proxy for disturbance
[68] As assessed in **Section 6.1.2.3**, using the results of the population modelling as the most realistic indication of the magnitude of potential impact

Potential impact	Receptor	Sensitivity	ES (Table 10-124)				Updated assessments			
vessels										
Impact 5: Barrier Effects from Underwater Noise during Construction										
Barrier effects from underwater noise	Grey seal and harbour seal	Medium	Negligible	Minor adverse	No mitigation proposed. However, measures in SIP will reduce potential significant disturbance of harbour porpoise (and other marine mammals)	**Minor adverse**	No change to assessment.			
Impact 6: Increased Risk of Collision with Vessels during Construction										
Increased collision risk	Grey and harbour seal	High	Medium	Moderate adverse	Good practice as outlined in the PEMP	**Negligible** to **Minor adverse**	Medium	Moderate adverse	Good practice as outlined in the PEMP	**Negligible** to **Minor adverse**
Impact 7: Disturbance at Seal Haul-Out Sites										
Disturbance at seal haul-out sites	Grey and harbour seal	Medium to Low	Negligible	Minor adverse to Negligible	No further mitigation proposed or proposed other than good practice.	**Negligible** to **Minor adverse**	No change to assessment.			
Impact 8: Changes to Prey Availability										
Change in prey availability	Grey and harbour	Low	Low	Minor adverse	No mitigation proposed for	**Negligible** to **Minor**	No change to assessment.			

Potential impact	Receptor	Sensitivity	ES (Table 10-124)				Updated assessments			
during piling	seal				prey. However, measures in MMMP and SIP will also reduce potential impacts of underwater noise on prey.	**adverse**				
Impact 9: Changes to Water Quality										
Changes in water quality	Grey and harbour seal	Negligible	Negligible	Negligible	No further mitigation proposed other than embedded mitigation.	**Negligible**	No change to assessment.			
Operation										
Impact 1: Impacts from Underwater Noise Associated with Operational Wind Turbines										
Underwater noise from operational turbines	Grey and harbour seal	Low to Medium	Negligible	Negligible to Minor adverse	No mitigation proposed	**Negligible** to **Minor adverse**	Negligible	Negligible to Minor adverse	None required	**Negligible** to **Minor adverse**
Impact 2: Impacts from Underwater Noise Associated with Operation and Maintenance Activities										
Underwater noise from maintenance activities	Grey and harbour seal	Medium	Negligible	Minor adverse	No mitigation proposed	**Minor adverse**	Negligible	Minor adverse	None required	**Minor adverse**
Impact 3: Impacts from Underwater Noise and Disturbance Associated with Operation and Maintenance Vessels										

Potential impact	Receptor	Sensitivity	ES (Table 10-124)				Updated assessments			
Underwater noise from operation and maintenance vessels	Grey and harbour seal	Medium	Negligible	Minor adverse	No mitigation proposed	**Minor adverse**	Negligible	Minor adverse	None required	**Minor adverse**
Impact 4: Barrier Effects from Underwater Noise during Operation and Maintenance										
No barrier effects as a result of underwater noise during operation and maintenance.							No change to assessment.			
Impact 5: Increased Risk of Collision with Vessels during Operation and Maintenance										
Less than for construction							No change to assessment.			
Impact 6: Disturbance at Seal Haul-Out Sites										
Disturbance at seal haul-out sites	Grey and harbour seal	Low to medium	Negligible	Negligible to Minor adverse	No further mitigation proposed or proposed other than good practice.	**Negligible** to **Minor adverse**	No change to assessment.			
Impact 7: Changes to Prey Availability										
Change in prey availability during operation and maintenance	Grey and harbour seal	Low	Negligible	Negligible	No mitigation proposed for prey.	**Negligible**	No change to assessment.			
Impact 8: Changes to Water Quality										
Changes in water quality	Grey and harbour seal	Negligible	Negligible	Negligible	No further mitigation proposed other than embedded mitigation.	**Negligible**	No change to assessment.			

Potential impact	Receptor	Sensitivity	ES (Table 10-124)				Updated assessments			
Decommissioning										
Same or less than for construction							No change to assessment.			
Cumulative Impacts										
Overall cumulative impact of disturbance to marine mammals during piling at SEP or DEP	Grey seal	Medium	Low	Minor adverse	Project specific SIP for the SNS SAC would manage and reduce potential for disturbance of harbour porpoise	**Minor adverse**	Negligible[69]	Minor adverse	None required	**Minor adverse**
	Harbour seal		Negligible	Minor adverse		**Minor adverse**	Negligible[70]	Minor adverse		**Minor adverse**

Table 6-42 Summary of Updated Assessments for Grey Seal and Harbour Seal for SEP and DEP Together

Potential impact	Receptor	Sensitivity	ES (Table 10-125)				Updated assessments			
			Magnitude	Pre-mitigation impact	Mitigation measures proposed	Residual impact	Magnitude	Pre-mitigation impact	Mitigation measures proposed	Residual impact
Construction										
Impact 1: Auditory Injury from Underwater Noise Associated with Piling										
PTS from single strike of starting or	Grey seal and harbour	High	Negligible	Minor adverse	MMMP for piling	**Minor adverse**	Negligible	Minor adverse	MMMP for piling	**Minor adverse**

[69] As assessed in **Section 6.2.1.5**, using the results of the population modelling as the most realistic indication of the magnitude of potential impact
[70] As assessed in **Section 6.2.1.5**, using the results of the population modelling as the most realistic indication of the magnitude of potential impact

Potential impact	Receptor	Sensitivity	ES (Table 10-125)				Updated assessments			
maximum hammer energy	seal									
PTS during piling from cumulative exposure	Grey seal	High	Medium to Low	Major to Moderate adverse	MMMP for piling	**Minor adverse**	Negligible to low	Minor to moderate adverse		**Minor adverse**
	Harbour seal	High	Medium to Negligible	Major to Minor adverse		**Minor adverse**	Negligible to low	Minor to moderate adverse		**Minor adverse**
PTS from sequential piling	Grey and harbour seal	High	Medium	Major adverse		**Minor adverse**	Medium	Major adverse		**Minor adverse**
PTS from simultaneous piling	Grey and harbour seal	High	Medium	Major adverse		**Minor adverse**	Medium	Major adverse		**Minor adverse**
TTS from single strike of maximum hammer energy	Grey seal and harbour seal	Medium	Negligible	Minor adverse	MMMP for piling	**Minor adverse**	Negligible	Minor adverse	None required	**Minor adverse**
TTS during piling from cumulative exposure	Grey seal and harbour seal	Medium	Low	Minor adverse	MMMP for piling	**Minor adverse**	Negligible to low	Minor adverse		**Minor adverse**
TTS from sequential piling	Grey seal	Medium	Low	Minor adverse	MMMP for piling	**Minor adverse**	Negligible	Minor adverse		**Minor adverse**
	Harbour seal	Medium	Low	Minor adverse		**Minor adverse**	Negligible	Minor adverse		**Minor adverse**
TTS from simultaneous piling	Grey seal	Medium	Low	Minor adverse	MMMP for piling	**Minor adverse**	Negligible to low	Minor adverse		**Minor adverse**
	Harbour	Medium	Low	Minor		**Minor**	Low	Minor		**Minor**

Potential impact	Receptor	Sensitivity	ES (Table 10-125)				Updated assessments			
	seal			adverse		**adverse**		adverse		**adverse**
Impact 2: Disturbance from Underwater Noise Associated with Piling Activities										
ADD activation	Grey seal and harbour seal	Medium	Negligible	Minor adverse	Not applicable	**Minor adverse**	Negligible[71]	Minor adverse	Not applicable	**Minor adverse**
Disturbance from piling	Harbour seal	Medium[72]	Negligible	Minor adverse	MMMP for piling	**Minor adverse**	Negligible[73]	Minor adverse	None required	**Minor adverse**
	Grey seal	Medium[74]	Low to Negligible	Minor adverse		**Minor adverse**	Negligible[75]	Minor adverse		**Minor adverse**
Impact 3: Disturbance from Underwater Noise Associated with Other Construction Activities										
TTS from cumulative SEL and disturbance during other construction activities	Grey seal and harbour seal	Medium	Negligible	Minor adverse	No mitigation proposed	**Minor adverse**	Negligible	Minor adverse	None required	**Minor adverse**
Impact 4: Impacts from Underwater Noise and Disturbance Associated with Construction Vessels										
TTS from cumulative SEL and disturbance for	Grey seal and harbour seal	Medium	Negligible to Low	Minor adverse	No mitigation proposed	**Minor adverse**	Negligible	Minor adverse	None required	**Minor adverse**

[71] As assessed in **Section 6.1.3**
[72] Using TTS as a proxy for disturbance
[73] As assessed in **Section 6.1.2.3**, using the results of the population modelling as the most realistic indication of the magnitude of potential impact
[74] Using TTS as a proxy for disturbance
[75] As assessed in **Section 6.1.2.3**, using the results of the population modelling as the most realistic indication of the magnitude of potential impact

Potential impact	Receptor	Sensitivity	ES (Table 10-125)				Updated assessments			
construction vessels										
Impact 5: Barrier Effects from Underwater Noise during Construction										
Barrier effects from underwater noise	Grey seal and harbour seal	Medium	Negligible	Minor adverse	No mitigation proposed. However, measures in SIP will reduce potential significant disturbance of harbour porpoise (and other marine mammals)	**Minor adverse**	No change to assessment.			
Impact 6: Increased Risk of Collision with Vessels during Construction										
Increased collision risk	Grey and harbour seal	High	Medium	Major	Good practice as outlined in the PEMP	**Negligible** to **Minor adverse**	Medium	Moderate adverse	Good practice as outlined in the PEMP	**Negligible** to **Minor adverse**
Impact 7: Disturbance at Seal Haul-Out Sites										
Disturbance at seal haul-out sites	Grey and harbour seal	Medium to Low	Negligible	Minor adverse to Negligible	No further mitigation proposed or proposed other than good practice.	**Negligible** to **Minor adverse**	No change to assessment.			
Impact 8: Changes to Prey Availability										
Change in prey	Grey and	Low	Low	Minor	No mitigation	**Negligible** to	No change to assessment.			

Potential impact	Receptor	Sensitivity	ES (Table 10-125)				Updated assessments			
availability during piling	harbour seal			adverse	proposed for prey. However, measures in MMMP and SIP will also reduce potential impacts of underwater noise on prey.	**Minor adverse**				
Impact 9: Changes to Water Quality										
Changes in water quality	Grey and harbour seal	Negligible	Negligible	Negligible	No further mitigation proposed other than embedded mitigation.	**Negligible**	No change to assessment.			
Operation										
Impact 1: Impacts from Underwater Noise Associated with Operational Wind Turbines										
Underwater noise from operational turbines	Grey and harbour seal	Low to Medium	Negligible	Negligible to Minor adverse	No mitigation proposed	**Negligible** to **Minor adverse**	Negligible	Negligible to Minor adverse	None required	**Negligible** to **Minor adverse**
Impact 2: Impacts from Underwater Noise Associated with Operation and Maintenance Activities										
Underwater noise from maintenance activities	Grey and harbour seal	Medium	Negligible	Minor adverse	No mitigation proposed	**Minor adverse**	Negligible	Minor adverse	None required	**Minor adverse**

Potential impact	Receptor	Sensitivity	ES (Table 10-125)				Updated assessments			
Impact 3: Impacts from Underwater Noise and Disturbance Associated with Operation and Maintenance Vessels										
Underwater noise from operation and maintenance vessels	Grey and harbour seal	Medium	Negligible	Minor adverse	No mitigation proposed	**Minor adverse**	Negligible	Minor adverse	None required	**Minor adverse**
Impact 4: Barrier Effects from Underwater Noise during Operation and Maintenance										
No barrier effects as a result of underwater noise during operation and maintenance.							No change to assessment.			
Impact 5: Increased Risk of Collision with Vessels during Operation and Maintenance										
Less than for construction							No change to assessment.			
Impact 6: Disturbance at Seal Haul-Out Sites										
Disturbance at seal haul-out sites	Grey and harbour seal	Low to medium	Negligible	Negligible to Minor adverse	No further mitigation proposed or proposed other than good practice.	**Negligible** to **Minor adverse**	No change to assessment.			
Impact 7: Changes to Prey Availability										
Change in prey availability during operation and maintenance	Grey and harbour seal	Low	Negligible	Negligible	No mitigation proposed for prey.	**Negligible**	No change to assessment.			
Impact 8: Changes to Water Quality										
Changes in water quality	Grey and harbour seal	Negligible	Negligible	Negligible	No further mitigation proposed other than	**Negligible**	No change to assessment.			

Potential impact	Receptor	Sensitivity	ES (Table 10-125)				Updated assessments			
					embedded mitigation.					
Decommissioning										
Same or less than for construction							No change to assessment.			
Cumulative Impacts										
Overall cumulative impact of disturbance to marine mammals during piling at SEP or DEP	Grey seal	Medium	Medium	Moderate adverse	Project specific SIP for the SNS SAC would manage and reduce potential for disturbance of harbour porpoise	**Minor adverse**	Negligible[76]	Minor adverse	None required	**Minor adverse**
	Harbour seal		Negligible	Minor adverse		**Minor adverse**	Negligible[77]	Minor adverse		**Minor adverse**

[76] As assessed in **Section 6.2.1.5**, using the results of the population modelling as the most realistic indication of the magnitude of potential impact
[77] As assessed in **Section 6.2.1.5**, using the results of the population modelling as the most realistic indication of the magnitude of potential impact

7 Updates to the HRA

235. The following sections provide updates to **RIAA Section 8** [APP-059] in line with the Applicants Response to Natural England's Relevant Representations [RR-063]. Each section provides signposting to where the updates would apply within the **RIAA Section 8**.

236. In the case of any changes in the conclusions on the potential for adverse effect to that presented within **RIAA Section 8**, these are highlighted red within each assessment.

237. The updated assessments use the approach to determining the potential for adverse effect as outlined in **RIAA Section 8.4** [APP-059].

7.1 Updates to Assessment of Disturbance from Underwater Noise During Piling Activities at SEP and DEP

In response to Natural England's Relevant Representation [RR-063], as stated in Applicant's Response (ID 8, 11) [REP2-051].

238. Within the **RIAA Section 8** [APP-059] and the **Appendix 10.2 Underwater Noise Modelling Report** [APP-192], a hammer energy of 5,500kJ was assessed as the highest potential to be used for the foundation installation at SEP and DEP. While this remains the worst-case, and all assessments are based on a maximum hammer energy of 5,500kJ, there is potential for the more realistic hammer energy of 4,500kJ (as modelled in addition to the maximum hammer; provided in **Appendix 10.2 Underwater Noise Modelling Report** [APP-192]) to be the maximum required. Therefore, all assessments regarding auditory injury and disturbance are highly precautionary.

239. Within the **RIAA Section 8.3.2** [APP-059], simultaneous piling is included within the worst-case scenario as a potential piling scenario at SEP or DEP alone, or SEP and DEP; specifically, the potential for simultaneous piling at either SEP, DEP, or at SEP and DEP at the same time. It should be noted that while the potential for simultaneous monopiling events cannot currently be ruled out, it is considered to be a highly unlikely piling scenario. It is currently expected that the more realistic worst-case scenario would be that of simultaneous monopiling and pin-piling, although the majority of piling events would not be undertaken simultaneously with any other piling event at SEP or DEP.

240. The final piling scenario will be confirmed post-consent and will be used to inform the final MMMP and SIP, and will likely include the worst-case of monopiling at one site, with pin-piling at another at the same time.

241. The worst-case currently remains as one monopile at SEP at the same time as one monopile at DEP (with the exception of two monopiles at DEP under the Southern North Sea SAC disturbance thresholds), although this is considered to be highly unlikely. Therefore, with the exception of the following updates and

amendments, the assessments for piling as presented within the **RIAA Section 8** remain valid as the current worst-case.

7.1.1 Review of Potential Effects of Underwater Noise from Piling Activities

In response to Natural England's Relevant Representation [RR-063], as stated in Applicant's Response (ID 47) [REP2-051].

7.1.1.1 Behavioural Response of Dolphins to Piling

242. A review of the potential for disturbance effects on bottlenose dolphin, due to offshore wind farm piling, has been provided in **Section 6.1.1.1**. This is used to supplement the assessments as provided in **RIAA Section 8.4.3.1.1** and **8.4.4.1.1** [APP-059].

7.1.1.2 Behavioural Response of Seals to Piling

243. A review of the potential for disturbance effects on both grey seal and harbour seal, due to offshore wind farm piling, has been provided in **Section 6.1.1.3**. This is used to supplement the assessments as provided in **RIAA Section 8.4.3.1.1** and **8.4.4.1.1** [APP-059].

244. As stated in **Section 6.1.1.3,** one study found harbour seal avoidance during pile driving, with significantly reduced levels of seal activity at ranges of up to 25km from piling sites (Russell *et al*., 2016).

7.1.2 Assessments of Significance for Disturbance from Piling

7.1.2.1 Assessments of Disturbance from Simultaneous Piling for the Southern North Sea SAC

In response to Natural England's Relevant Representation [RR-063], as stated in Applicant's Response (ID 95 & 96) [REP2-051].

245. An assessment against the Southern North Sea SAC disturbance thresholds (of 20% on any given day and 10% on average over a season) are provided in **RIAA Section 8.4.1.1.1.1.2** [APP-059].

246. The following assessments provide an update to account for the potential for two simultaneous piling events at DEP as being the worst-case, rather than one simultaneous piling event at SEP and DEP (as has been assessed in **RIAA Section 8.4.1.1.1.1.2**). The approach to assessment is the same as provided in **RIAA Section 8.4.1.1.1.1.2**.

247. The following assessment also provides clarification on the disturbance overlap with the Southern North Sea SAC for one monopile at DEP, and for one monopile at SEP and DEP on the same day.

7.1.2.1.1 Spatial Assessment for Simultaneous Piling

248. **RIAA Section 8.4.1.1.1.2.1** [APP-059] concluded that for piling at either SEP or DEP, disturbance of harbour porpoise would not exceed 20% of the spatial component of the Southern North Sea SAC summer or winter area on any given day during piling at SEP or DEP, based on the worst-case scenario.

249. The following assessment updates the spatial assessment for simultaneous piling (as presented in **RIAA Section 8.4.1.1.2.2.1**). Under the updated assessment of either two monopiles at DEP or two monopiles at SEP, the maximum area of disturbance within the Southern North Sea SAC would be 2.32% of the summer area due to two monopiles at DEP. Therefore, disturbance of harbour porpoise would not exceed 20% of the spatial component of the Southern North Sea SAC summer or winter area on any given day during simultaneous piling at SEP or DEP, or SEP and DEP (**Table 7-1**).

250. Therefore, under the updated assessment, there is no significant disturbance and **no adverse effect on the integrity of the Southern North Sea SAC in relation to the conservation objectives for harbour porpoise due to disturbance from piling during construction, for SEP or DEP, or SEP and DEP**.

Table 7-1: Maximum Potential Overlap with Southern North Sea SAC Summer and Winter Areas Based on 26km EDR at Closest Point for SEP and DEP

Location	Maximum area of overlap with SNS SAC summer area (% of SNS SAC summer area)	Maximum area of overlap with SNS SAC winter area (% of SNS SAC winter area)	Potential adverse effect on site integrity
RIAA Section 8.4.1.1.1.2.2.1 (Table 8-18; Table 8-24) [APP-059]			
One monopile at SEP	0km^2 (0%)	0.15km^2 (0.24%)	No Temporary effect. Displacement of harbour porpoise would not exceed 20% of the seasonal component of the SNS SAC area on any given day during piling at SEP and DEP, based on the worst-case scenario.
One monopile at DEP	356.0km^2 (1.32%)	32.7km^2 (0.26%)	
One monopile at SEP on the same day as one monopile at DEP	356km^2 (1.32%)	30.45km^2 (0.24%)	
Updated assessment			
One monopile at DEP	356.0km^2 (1.32%)	30.33km^2 (0.24%)	No Temporary effect. Displacement of harbour porpoise would not exceed 20% of the seasonal component of the SNS SAC area on any given day
One monopile at SEP on the same day as one monopile at DEP	356km^2 (1.32%)	30.48km^2 (0.24%)	

Location	Maximum area of overlap with SNS SAC summer area (% of SNS SAC summer area)	Maximum area of overlap with SNS SAC winter area (% of SNS SAC winter area)	Potential adverse effect on site integrity
Two monopiles at SEP on the same day	0km^2 (0%)	0.15km^2 (0.24%)[78]	during piling at SEP and DEP, based on the worst-case scenario.
Two monopiles at DEP on the same day	627.59km^2 (2.32%)	30.48km^2 (0.24%)[79]	

7.1.2.1.2 Seasonal Assessment for Simultaneous Piling

251. **RIAA Section 8.4.1.1.1.2.2** concluded that for piling at either SEP or DEP, disturbance of harbour porpoise would not exceed 10% of the seasonal component of the Southern North Sea SAC summer or winter season, based on the worst-case scenario.

252. The following assessment updates the seasonal assessment for simultaneous piling (as presented in **RIAA Section 8.4.1.1.1.2.2.2**). Under the updated assessment of either two monopiles at DEP or two monopiles at SEP, the maximum seasonal disturbance would be 0.22% of the summer area due to two monopiles per day at DEP, or for two monopiles per day at SEP and two per day at DEP within the same summer season. However, the worst-case seasonal overlap is 0.41% as was assessed in **RIAA Section 8.4.1.1.1.2.2.2**. Therefore, disturbance of harbour porpoise would not exceed 10% of the seasonal component of the Southern North Sea SAC summer or winter area during simultaneous piling at SEP or DEP, or SEP and DEP (**Table 7-2**).

253. Therefore, under the updated assessment, there is no significant disturbance and **no adverse effect on the integrity of the Southern North Sea SAC in relation to the conservation objectives for harbour porpoise due to disturbance from piling during construction, for SEP or DEP, or SEP and DEP**.

[78]No change to the assessment for one monopile at SEP in the winter area
[79]No change to the assessment for one monopile at DEP in the winter area

Table 7-2: Estimated Seasonal Average for Southern North Sea SAC Summer and Winter Areas Based on 26km EDR at Closest Point for SEP or DEP

Location	Number of disturbance days per season	Maximum seasonal average for SNS SAC summer area	Maximum seasonal average for SNS SAC winter area	Potential adverse effect on site integrity
RIAA Section 8.4.1.1.1.2.2.2 (Table 8-19; Table 8-25) [APP-059]				
SEP (23 foundation installation plus 2 days recovery)	25 days	No overlap	0.00016%	No Temporary effect. Displacement of harbour porpoise would not exceed 10% of the seasonal component of the SNS SAC over the duration of that season during piling at SEP or DEP, based on the worst-case scenario
DEP (30 foundation installation plus 2 days recovery)	32 days	0.23%	0.04%	
One monopile at SEP on the same day as one monopile at DEP (53 foundation installations plus 4 days recovery)	57 days	0.41%	0.08%	
Updated assessment				
DEP (30 foundation installation plus 2 days recovery)	32 days	0.23%	0.04%	No Temporary effect. Displacement of harbour porpoise would not exceed 10% of the seasonal component of the SNS SAC over the duration of that season during piling at SEP or DEP, based on the worst-case scenario
One monopile at SEP on the same day as one monopile at DEP (53 foundation installations plus 4 days recovery)	57 days	0.41%	0.07%	
Two monopiles per day at SEP for 13 days (plus 2 recovery days)	15 days	No overlap	0.02%	
Two monopiles per day at DEP for 15 days (plus 2 recovery days)	17 days	0.22%	0.02%	
Two monopiles per day at SEP for 13 days (plus 2 recovery days) within the same	32 days	0.22%	0.04%	

Location	Number of disturbance days per season	Maximum seasonal average for SNS SAC summer area	Maximum seasonal average for SNS SAC winter area	Potential adverse effect on site integrity
season as two monopiles per day at DEP for 15 days (plus 2 recovery days)				

7.1.2.1.3 Assessment in Relation to North Sea MU

254. **RIAA Section 8.4.1.1.1.2.3** concluded that for piling at either SEP or DEP, disturbance of harbour porpoise would not exceed 5% of the NS MU population, based on the worst-case scenario.

255. The following assessment updates the assessment against the NS MU for simultaneous piling (as presented in **RIAA Section 8.4.1.1.1.2.2.3**). Under the updated assessment of either two monopiles at DEP or two monopiles at SEP, the maximum number of harbour porpoise at risk of disturbance would be 1,525.0 (or up to 0.44% of the NS MU) (**Table 7-3**).

256. The worst-case assessment is for two monopiles in the wider area, as assessed in the **RIAA Section 8.4.1.1.1.2.2.3**, which indicates that up to 0.95% of the NS MU reference population could be temporarily displaced during piling at SEP and DEP, based on the worst-case scenario (**Table 7-3**).

257. The temporary disturbance of up to 0.95% of the North Sea MU population would not result in any significant population effects or any changes to the favourable conservation status (FCS) of harbour porpoise. Therefore, under these circumstances, there is **no adverse effect on the integrity of the SNC SAC in relation to the conservation objectives for harbour porpoise due to disturbance from piling during construction, for SEP or DEP, or SEP and DEP**.

Table 7-3: Maximum Number of Harbour Porpoise Potentially Disturbed Based on 26km EDR for Piling at SEP and DEP

Species	Location	Season and area in seasonal SNS SAC area	Maximum number of individuals (% of reference population)	Potential adverse effect on site integrity
RIAA Section 8.4.1.1.1.2.2.3 Table 8-26				
Harbour porpoise	Total for SEP and DEP (one monopile at SEP and one monopile at DEP)	Summer (356km^2)	865 (0.25% of NS MU) (SEP&DEP density of 1.46/km^2)	No Temporary effect. Up to 0.95% of the reference population
		Winter (30.45km^2)	26 (0.0075% of NS MU) (SEP&DEP	

Species	Location	Season and area in seasonal SNS SAC area	Maximum number of individuals (% of reference population)	Potential adverse effect on site integrity
			density of 0.65/km^2)	could be temporarily displaced during piling at SEP and DEP, based on the worst-case scenario.
	Two monopiles in the wider area around SEP and DEP (taking into account disturbance area overlaps)	3,719.6km^2	3,303 (0.95% of NS MU) (SCANS-III density of 0.888/km^2)	
Updated assessment				
Harbour porpoise	Two monopiles at SEP	Summer (0km^2)	0	No Temporary effect. Up to 0.44% of the reference population could be temporarily displaced during piling at SEP and DEP, based on the worst-case scenario.
		Winter (0.15km^2)	0.08 (0.00002% of NS MU) (SEP winter density of 0.52/km^2)	
	Two monopiles at DEP	Summer (627.59km^2)	1,525.0 (0.44% of NS MU) (DEP summer density of 2.43/km^2)	
		Winter (30.48km^2)	25.9 (0.007% of NS MU) (DEP winter density of 0.85/km^2)	

7.1.2.2 Assessments of Disturbance from Piling Against Known Seal Deterrence Ranges

In response to Natural England's Relevant Representation [RR-063], as stated in Applicant's Response (ID 117) [REP2-051].

258. The following assessment provides an update to the assessments for disturbance for both grey seal (as a designated feature of the Humber Estuary SAC) and harbour seal (as a designated feature of The Wash and North Norfolk Coast SAC, as presented in **RIAA Sections 8.4.3.1.1** and **8.4.4.1.1** respectively [APP-059]).

259. Regarding both grey and harbour seal, as noted above, a study has shown that harbour seal are present in significantly reduced number up to a distance of 25km during piling (or a disturbance area of 1,963.5km^2) (Russell *et al.*, 2016). This range has been used to determine the number of both grey and harbour seal that may be disturbed during piling at either SEP or DEP, or at SEP and DEP (**Table 7-4**). To inform this assessment, the updated SAC specific density estimates and populations, as provided in **Section 5**, have been used. The following assessment does not differentiate between monopiles and pin-piles, and therefore the assessment for SEP and DEP is highly precautionary given the unlikelihood of two simultaneous monopile events.

260. As stated in **RIAA Section 8.4** [APP-059], any permanent effect that has the potential to affect more than 1% of the SAC population has the potential for an Adverse Effect on Integrity (AEoI), and any temporary effect that has the potential for affect more than 5% of an SACs population has the potential for an AEoI.

7.1.2.2.1 Assessment for the Humber Estuary SAC

261. Within the **RIAA Section 8.4.3.1.1** [APP-059], no AEoI was predicted for grey seal within the Humber Estuary SAC, due to piling at SEP and DEP alone.

262. Under the updated assessments of grey seal associated with the Humber Estuary SAC, assuming a 25km disturbance range for each piling location, there is the potential for more than 5% of the SAC population to be disturbed from either piling at SEP, or from piling at SEP and DEP (for either sequential or simultaneous piling) (**Table 7-4**). To further investigate the potential for AEoI on the Humber Estuary SAC, dose response curve assessments and population modelling have been utilised (see **Sections 7.1.2.3** and **7.1.2.4**).

263. Note that the approach of using a generalised 25km disturbance range for seals is considered highly precautionary, as this assessment assumes that all individuals would react to piling noise in the same manner, at the same noise level, and that all would be disturbed to the same distance of 25km. This does not therefore take account of any individuality in the response of seals to underwater noise, or any variation in the noise levels that an individual may respond at, or to the distance at which they may be deterred. In addition, this assessment approach does not assume any overlap between disturbance areas from the piling events.

Table 7-4 Maximum Number of Grey Seals from the Humber Estuary SAC (and % of SAC Population) that Could be at Disturbed During Piling at SEP and DEP

Species	Location	RIAA Section 8.4.3.1.1	25km Disturbance Range (1,963.5km^2)	
		Potential for Adverse Effect on Integrity	Maximum number of individuals (% of reference population)	Potential for Adverse Effect on Integrity
Grey seal associated with the Humber Estuary SAC	SEP	No Less than 5% of population temporary disturbed	826.6 (5.33% of the Humber Estuary SAC population)	More than 5% of the SAC population temporarily disturbed. Further assessments are undertaken and overall conclusions provided in Section 7.1.2.3 and Section 7.1.2.4.
	DEP	No Less than 5% of population temporary disturbed	712.8 (4.60% of the Humber Estuary SAC population)	No Less than 5% of population temporary disturbed

Species	Location	RIAA Section 8.4.3.1.1	25km Disturbance Range (1,963.5km^2)	
	SEP & DEP	No Less than 5% of population temporary disturbed	1,539.4 (9.93% of the Humber Estuary SAC population)	More than 5% of the SAC population temporarily disturbed. Further assessments are undertaken and overall conclusions provided in Section 7.1.2.3 and Section 7.1.2.4.

264. The above assessment represents a worst-case and precautionary assessment for grey seal, and is therefore presented for information only. The final assessment of the potential for grey seal disturbance due to piling is based on the more realistic dose-response curve assessment and population modelling results, as presented in the following sections.

7.1.2.2.2 Assessment for The Wash and North Norfolk Coast SAC

265. Within the **RIAA Section 8.4.4.1.1** [APP-059], no AEoI was predicted for harbour seal within The Wash and North Norfolk Coast SAC, due to piling at SEP and DEP alone.

266. Under the updated assessments of harbour seal associated with The Wash and North Norfolk Coast SAC, assuming a 25km disturbance range for each piling location, there is the potential for more than 5% of the SAC population to be disturbed from either piling at SEP, or from piling at SEP and DEP at the same time (**Table 7-7**). To further investigate the potential for AEoI on The Wash and North Norfolk Coast SAC, dose response curve assessments and population modelling have been utilised (see **Sections 7.1.2.3** and **7.1.2.4**).

267. Note that the approach of using a generalised 25km disturbance range for seals is considered highly precautionary for the same reasons as set out above for grey seal. This assessment represents a worst-case and precautionary assessment for harbour seal, and is therefore presented for information only. The final assessment of the potential for harbour seal disturbance due to piling is based on the more realistic dose-response curve assessment and population modelling results, as presented in the following sections.

Table 7-5 Maximum Number of Harbour Seals from The Wash and North Norfolk Coast SAC (and % of SAC Population) that Could be at Disturbed During Piling at SEP and DEP

Species	Location	RIAA Section 8.4.4.1.1	25km Disturbance Range (1,963.5km^2)	
		Potential for Adverse Effect on Integrity	Maximum number of individuals (% of reference	Potential for Adverse Effect on

Species	Location	RIAA Section 8.4.4.1.1	25km Disturbance Range (1,963.5km^2)	
			population)	Integrity
Harbour seal associated with The Wash and North Norfolk Coast SAC	SEP	No Less than 5% of population temporary disturbed	396.6 (10.03% of The Wash and North Norfolk Coast SAC population)	More than 5% of the SAC population temporarily disturbed. Further assessments undertaken and overall conclusions are provided in Section 7.1.2.3 and Section 7.1.2.4.
	DEP	No Less than 5% of population temporary disturbed	112.3 (2.84% of The Wash and North Norfolk Coast SAC population)	No Less than 5% of population temporary disturbed
	SEP & DEP	No Less than 5% of population temporary disturbed	508.9 (12.86% of The Wash and North Norfolk Coast SAC population)	More than 5% of the SAC population temporarily disturbed. Further assessments undertaken and overall conclusions are provided in Section 7.1.2.3 and Section 7.1.2.4.

7.1.2.3 Assessments of Disturbance from Piling using a Dose Response Curve Approach

In response to both Natural England's Relevant Representation [RR-063] and the Marine Management Organization (MMO) Relevant Representation [RR-053], as stated in Applicant's Response (ID 42, 47, 112) [REP2-051].

268. The following section is provided as an additional assessment to that as presented in **RIAA Section 8.4.1.1.1** (for harbour porpoise of the Southern North Sea SAC), **Section 8.4.3.1.1** (for grey seal of the Humber Estuary SAC), and **Section 8.4.4.1.1** (for harbour seal of The Wash and North Norfolk Coast SAC) [APP-059], for the potential for disturbance effects due to piling.

7.1.2.3.1 Background to Dose-Response Curves

269. Following current best practice guidance (Southall *et al*., 2021), a behavioural disturbance dose-response analysis has been carried out for harbour seal and

grey seal, in relation to the populations associated with The Wash SAC and Humber Estuary SAC, respectively.

270. The assessment is based on SEL_{ss} for the worst-case of a monopile with maximum diameter of up to 16m and maximum hammer energy of up to 5,500kJ at SEP, DEP and SEP and DEP.

271. A single strike of a pile occurring concurrently in both SEP and DEP will cause overlapping noise in the space between the two Projects. Animals that would have been disturbed in these areas by SEP or DEP alone, will not be disturbed twice. However the assessment of animals disturbed by concurrent piling in SEP and DEP conservatively sums the maximum number of animals disturbed by each project alone.

272. For detailed methods, see **Section 6.1.2.2**.

7.1.2.3.2 Dose Response Assessment of Disturbance for Grey Seal of the Humber Estuary SAC

273. The estimated numbers (and percentage of the Humber Estuary SAC population) of grey seal that could be disturbed as a result of underwater noise during piling are presented in **Table 7-6** (**Figure 7.1** and **Figure 7.2**).

274. For grey seal the current estimate for the Humber Estuary SAC population is 15,495 individuals (see **Section 5.2**). The density data used within this dose response assessment is the Humber Estuary SAC mean grey seal at-sea density data (Carter *et al*., 2022). The densities have been corrected as per the methods described in **Section 5.1**.

275. **Table 7-6** presents the dose response curve assessment for grey seal associated with the Humber Estuary SAC. The results show that for the worst-case scenario, of 323 grey seal being disturbed during piling at SEP and DEP (for either sequential or simultaneous piling), less than 2.1% of the Humber Estuary SAC population would be disturbed. Therefore, there is **no potential adverse effect on the site integrity of the Humber Estuary SAC due to piling-induced behavioural disturbance of grey seal**.

276. It should be noted that this dose-response analysis is carried out in relation to pile driving noise only, and therefore does not account for the use of ADD which may reduce localised grey seal densities prior to piling.

Table 7-6: Number of Grey Seal Associated with the Humber Estuary SAC (and % of SAC Population) that Could be Disturbed During Piling at the SEP and DEP based on the Dose-Response Curve

Species	Location	Number of individuals disturbed (% of SAC population)	Potential for AEoI
Grey seal	SEP	157 grey seal (1.01% of Humber Estuary SAC population)	**No** Less than 5% of SAC population temporarily disturbed

Species	Location	Number of individuals disturbed (% of SAC population)	Potential for AEoI
	DEP	166 grey seal (1.07% of Humber Estuary SAC population)	**No** Less than 5% of SAC population temporarily disturbed
	SEP & DEP	323 grey seal (2.08% of Humber Estuary SAC population)	**No** Less than 5% of SAC population temporarily disturbed

7.1.2.3.3 Dose Response Assessment of Disturbance for Harbour Seal of The Wash and North Norfolk Coast SAC

277. The estimated numbers (and percentage of The Wash and North Norfolk Coast SAC population) of harbour seal that could be disturbed as a result of underwater noise during piling are presented in **Table 7-7** (**Figure 7.3** and **Figure 7.4**).

278. For harbour seal the current estimate for The Wash and North Norfolk Coast SAC population is 3,956 individuals (see **Section 5.2**). The density data used within this dose response assessment is The Wash and North Norfolk Coast SAC mean harbour seal at-sea density data (Carter *et al.*, 2022). The densities have been corrected as per the methods described in **Section 5.1**.

279. **Table 7-7** presents the dose response curve assessment for harbour seal associated with The Wash and North Norfolk Coast SAC. The results show that for the worst-case scenario, of 93 harbour seal being disturbed by piling at SEP and DEP (for either sequential or simultaneous piling), less than 2.4% of The Wash and North Norfolk Coast population would be disturbed. Therefore, there is **no potential adverse effect on the site integrity of The Wash and North Norfolk Coast due to piling-induced behavioural disturbance of harbour seal**.

280. It should be noted that this dose-response analysis is carried out in relation to pile driving noise only, and therefore does not account for the use of ADD which may reduce localised harbour seal densities prior to piling.

Table 7-7 Number of Harbour Seal Associated with The Wash and North Norfolk Coast SAC (and % of SAC Population) that Could be Disturbed During Piling at the SEP and DEP based on the Dose-Response Curve

Species	Location	Number of individuals disturbed (% of reference population)	Potential adverse effect on site integrity
Harbour seal	SEP	62 harbour seal (1.57% of The Wash SAC)	**No** Less than 5% of population temporarily disturbed
	DEP	31 harbour seal (0.78% of The Wash SAC)	**No** Less than 5% of population

Species	Location	Number of individuals disturbed (% of reference population)	Potential adverse effect on site integrity
			temporarily disturbed
	SEP&DEP	93 harbour seal (2.35% of The Wash SAC)	**No** Less than 5% of population temporarily disturbed

Implications to the Blakeney Point Haul-Out Site

281. The Blakeney Point haul-out site for harbour seal, which is part of The Wash and North Norfolk Coast SAC, is location at 20.6km from the Projects (at closest point). Therefore, both the assessments under the generalised 25km disturbance range approach (as presented in **Section 7.1.2.2.2**), and the above assessments under the dose-response curve approach, indicate that there is an overlap with the potential for disturbance and the Blakeney Point site.

282. As noted above, under the approach assuming a 25km disturbance range, seals at the Blakeney Point haul-out site could be at risk of disturbance. However, the Applicant considers the assessment using the 25km disturbance range to be precautionary and based on conservative disturbance ranges. Therefore, the Applicant considers the results of the dose response curve assessments to be more representative and realistic.

283. The dose response curve assessment for harbour seal of The Wash and North Norfolk Coast SAC (**Section 7.1.2.3.3**; **Figures 7.3** & **7.4**) show a potential for overlap of the 5dB contours with the Blakeney Point haul-out site. **Figure 7.4** shows the 5dB contours for the DEP SE modelling location, with no overlap in the 5dB contours with the Blakeney Point haul-out site. **Figure 7.3** shows the 5dB contours for the SEP E modelling location. This shows that the 5dB contours have the potential to overlap with the Blakeney Point haul-out site. The contours for 120dB and 125dB overlap with the Blakeney Point haul-out site, with the contour for 130dB very close to the site. However, as shown by Whyte *et al.,* 2020, the dose response curve for seal species shows no reaction to piling noise at less than 145dB. The 145dB contour is 7-8km from the Blakeney Point site, and the 150dB contour is 10-11km from the site. At 145dB, approximately 36.4% seals are expected to be disturbed, and at 150dB, approximately 47.3% will be (Whyte *et al.,* 2020).

284. The SEP E modelling location is approximately 5.5km from the south-western boundary of the SEP site (**Figure 7.3**) (which is closer to the Blakeney Point haul-out site than the SEP E location), and therefore there is the potential for the 145dB to be closer to the Blakeney Point site, however, based in the noise modelling results for SEP E location, it is not expected that the 145dB contours would reach the Blakeney Point haul-out site, even for a piling location at the closest point to the haul-out site.

285. It is important to note that the underwater noise associated with piling would not cross the water-air boundary, and therefore any noise associated with piling would affect those seals that are underwater only. No seals would be disturbed due to the underwater noise associated with piling if they were be on land.

286. While additional information has been provided above to give context as to the level of noise expected to be present in the vicinity of the Blakeney Point haul-out site, this is only relevant for seals in the water. A full assessment of disturbance effect of seals while foraging in the water column has been provided in **Section 7.1.2.3**, and an assessment for disturbance to seals at the haul-out site itself has been provided in ES Chapter 10 (**APP-096**) (noting that, as above, seals hauled-out would not be at risk of disturbance form the underwater noise associated with piling). Therefore, the assessments as provided within ES Chapter 10 and the Marine Mammals Technical Note / Addendum remain valid for the potential for disturbance to seals hauled-out at Blakeney Point.

7.1.2.4 Population Modelling

In response to Natural England's Relevant Representation [RR-063], as stated in Applicant's Response (ID 61, 112) [REP2-051].

287. Population modelling has been undertaken to determine the population level consequences of disturbance due to piling at SEP and DEP. As assessed under the worst-case scenario above (**Section 7.1.2.2**), there is the potential for a significant impact due to disturbance from piling for grey seal and harbour seal (**Table 7-4** and **Table 7-5**). While an assessment under the dose response curve approach is considered to be most realistic for both seal species, population modelling has been undertaken to determine whether there could be a population level effect for the relevant SACs. The results of this modelling will be used to determine the requirement for any noise reduction measures to be put in place.

7.1.2.4.1 Background to Population Modelling

288. The updated results for disturbance presented in this report for grey seal associated with the Humber Estuary SAC (**Section 7.1.2.2**), reveal that elevations in subsea noise due to piling could potentially lead to the behavioural disturbance of a large number of grey seals within the Humber Estuary SAC, and harbour seals within The Wash and North Norfolk Coast SAC.

289. SAC population estimates are not appropriate to apply to harbour porpoise SACs. The NS MU is the appropriate population for harbour porpoise of the Southern North Sea SAC. Therefore, the population modelling as presented in **Section 6.1.2.3.3** applies. The results of the population modelling for harbour porpoise shows that less than 0.03% of the NS MU population would be lost within the disturbed population in comparison to the undisturbed population, at the end of the 25 year period. This is not considered to be a significant effect to the harbour porpoise NS MU population, and therefore there would be **no adverse effect on**

the integrity of the Southern North Sea SAC due to disturbance to harbour porpoise from piling at SEP and DEP.

290. Population modelling has been conducted for grey seal and harbour seal in relation to the SAC-specific populations. The iPCoD framework (Harwood *et al.,* 2014, King *et al.,* 2015) has been used to predict the potential medium- and long-term population consequences, and therefore potential for adverse effect on site integrity, of the predicted amount of disturbance resulting from piling at SEP and DEP.

291. The details of methods and model parameter inputs are found in **Section 6.1.2.3.2**. The only difference for this SAC-specific analysis is that SAC-specific population sizes (**Table 7-8**), and worst-case disturbance and PTS estimates (**Table 7-9**) were used.

Table 7-8 SAC-specific Populations Used in the iPCoD Modelling

Species	Area	Population
Grey seal	Humber Estuary SAC	15,495
Harbour Seal	The Wash SAC	3,956

Table 7-9 Estimated Number of Animals from Each Relevant SAC Population to have PTS or to be Disturbed During Each Piling Event

Species	Number of Animals Affected During Each Piling Event			
	SEP		DEP	
	PTS	Disturbance	PTS	Disturbance
Grey seal (Humber Estuary SAC)	0.35	826.6	0.51	712.8
Harbour seal (The Wash and North Norfolk Coast SAC)	0.17	396.6	0.08	112.3

7.1.2.4.2 Results of the Population Modelling for the Humber Estuary SAC

292. Assuming a worst-case of 826.6 grey seal disturbed and 0.35 with PTS at SEP, and 712.8 disturbed and 0.51 with PTS at DEP on every piling day (**Table 7-9**), the iPCoD model estimates there to be no discernible impact to the Humber Estuary SAC grey seal population (**Plate 7-1** and **Table 7-10**) in the worst-case project scenario where both SEP and DEP are constructed sequentially.

293. The mean population size for the impacted population was predicted to be 100% of the un-impacted population size at the end of 2027 (after the first year of pile driving has completed). By the end of 2032 (2 years after piling ends) the mean population size for the impacted population was predicted to be 100% of the un-impacted population size. The impacted population is expected to maintain the same increasing trajectory as the un-impacted population after the impact period has ceased (as far as 2050 which is the end point of the modelling). There is

therefore **no adverse effect on the integrity of the Humber Estuary SAC due to disturbance to grey seal from piling at SEP and DEP**.

Table 7-10 Results of the iPCoD modelling for the SEP and DEP sequential project scenario, giving the mean population size of the Humber Estuary SAC grey seal population for years up to 2050 for both impacted and un-impacted populations as well as the mean and median ratio between their populations

Year	Un-impacted population mean	Impacted population mean*	Median impacted as % of un-impacted	Mean impacted as % of un-impacted
Start	15,496	15,496	100%	100%
End 2027	15,669	15,670	100%	100%
End 2032	16,553	16,555	100%	100%
End 2038	17,556	17,558	100%	100%
End 2044	18,656	18,659	100%	100%
End 2050	19,885	19,888	100%	100%

**Note that the marginal increase in the impacted population in comparison to the un-impacted population is a result of the environmental stochasticity built into the model*

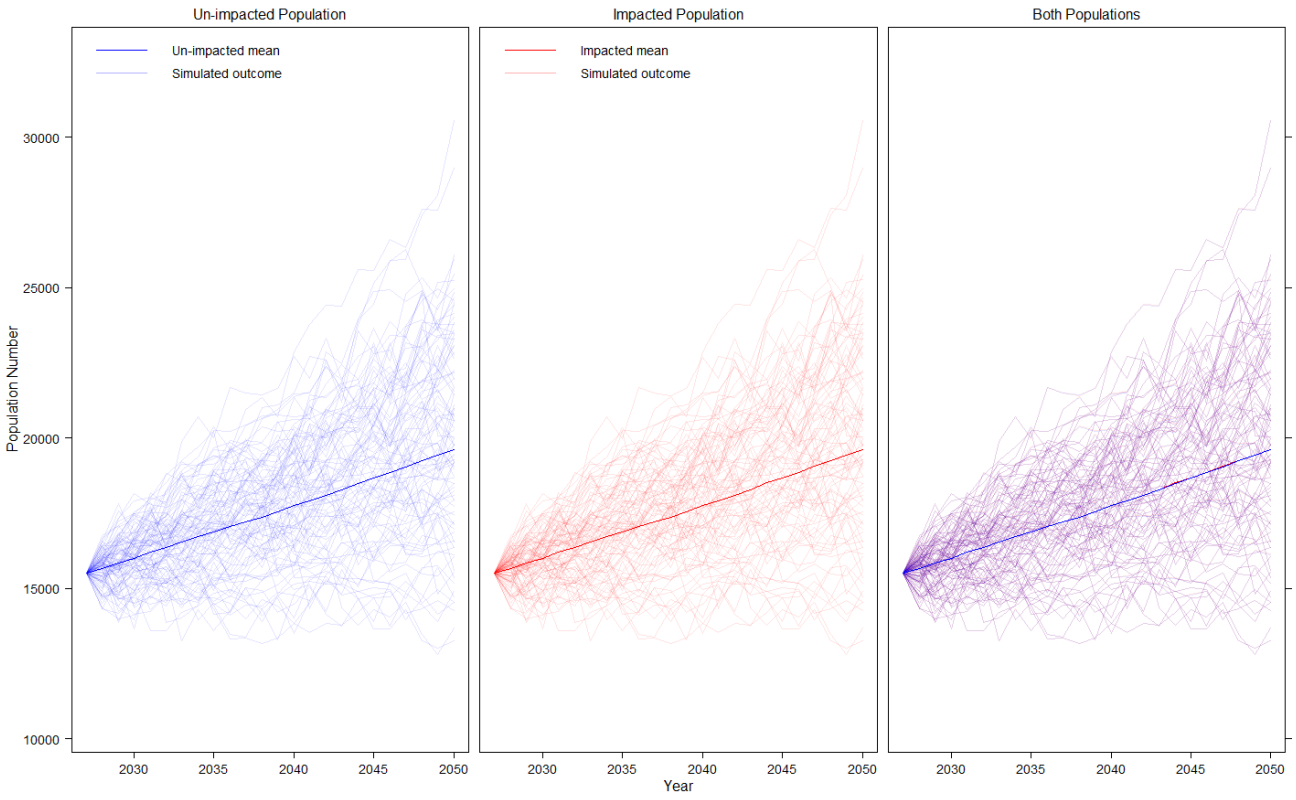

Plate 7-1 Simulated worst-case grey seal Humber Estuary SAC population sizes for both the un-impacted and the impacted populations

7.1.2.4.3 Results of the Population Modelling for The Wash and North Norfolk Coast SAC

294. Assuming a worst-case of 396.6 harbour seal disturbed and 0.17 with PTS at SEP, and 112.3 disturbed and 0.08 with PTS at DEP on every piling day (**Table 7-9**), the iPCoD model estimates there to be no discernible impact to The Wash and North Norfolk Coast SAC harbour seal population (**Plate 7-2** and **Table 7-11**) in the worst-case project scenario where both SEP and DEP are constructed sequentially.

295. The mean population size for the impacted population was predicted to be 100% of the un-impacted population size at the end of 2027 (after the first year of pile driving has completed). By the end of 2032 (2 years after piling ends) the mean population size for the impacted population was predicted to be 100% of the un-impacted population size. The impacted population is expected to maintain the same decreasing trajectory as the un-impacted population after the impact period has ceased (as far as 2050 which is the end point of the modelling). There is therefore **no adverse effect on the integrity of The Wash and North Norfolk Coast SAC due to disturbance to harbour seal from piling at SEP and DEP**.

Table 7-11 Results of the iPCoD modelling for the SEP and DEP sequential project scenario, giving the mean population size of The Wash and North Norfolk Coast SAC harbour seal population for years up to 2050 for both impacted and un-impacted populations as well as the mean and median ratio between their populations

Year	Un-impacted population mean	Impacted population mean*	Median impacted as % of un-impacted	Mean impacted as % of un-impacted
Start	3,954	3,954	100%	100%
End 2027	3,242	3,242	100%	100%
End 2032	1,205	1,207	100%	100%
End 2038	365	366	100%	100%
End 2044	111	111	100%	100%
End 2050	34	34	100%	100%

*Note that the model assumes that population demographics remain constant over time. This means that the currently declining population is projected to continue its decline regardless of any additional piling activity.

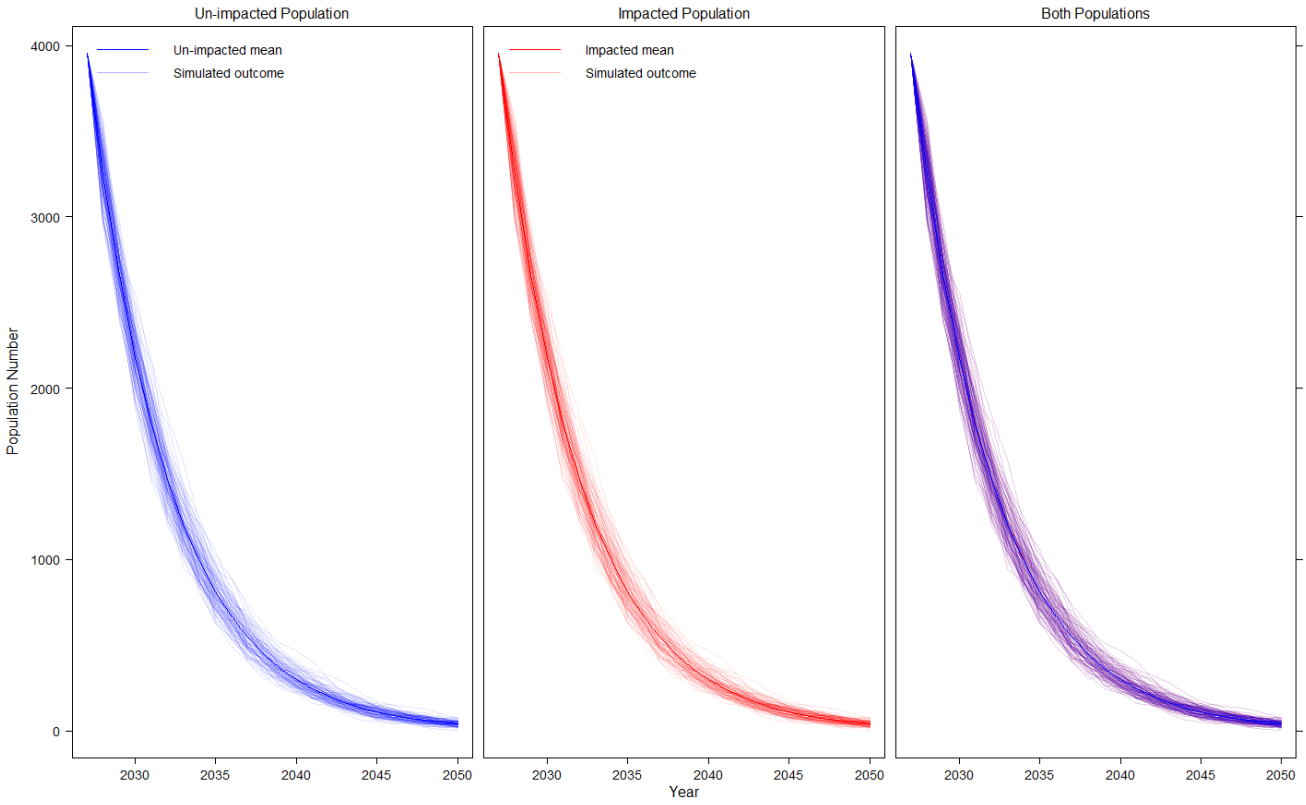

Plate 7-2 Simulated worst-case harbour seal The Wash SAC population sizes for both the un-impacted and the impacted populations

7.1.2.4.4 Population Level Consequences of Disturbance

296. The results of population modelling for SAC populations as shown above show no significant difference in the population estimates at the end of the 25 year modelling period for the disturbed or un-disturbed populations.

297. There is the potential for a 0.01% to 0.03% reduction in the harbour porpoise population over the modelled period of 25 years (**Table 6-10**). For grey seal and harbour seal, the disturbance from piling at SEP and DEP would not cause a SAC population level effect (**Table 7-10** and **Table 7-11**).

298. The harbour seal population of The Wash and North Norfolk Coast SAC is currently in decline, and the population modelling has used a declining harbour seal population as the input value to provide a precautionary assessment. The population reduces to 34 (from the starting estimate of 3,954 individuals) over the 25 year modelled period. However, the cumulative offshore wind farm piling scenario also predicts a population level of 34 by the end of the modelled period. This indicates that the disturbance associated with offshore wind farm piling would not worsen the already declining SAC population, even under the most precautionary and worst-case assessments.

7.1.2.5 Requirement for Further Mitigation to Reduce Disturbance due to Piling

299. The results of the population modelling, as provided in **Section 7.1.2.4** above, have shown that there would be no effect on the SAC populations. No mitigation for disturbance is therefore proposed (or required) for piling at SEP and DEP.

300. Additional modelling has been undertaken to determine the potential for population level effects due to in-combination disturbance with other offshore wind farm piling activities (see **Section 7.4.1.1**).

7.2 Barrier Effects to Seals

In response to Natural England's Relevant Representation [RR-063], as stated in Applicant's Response (ID 10, 49, 113) [REP2-051].

7.2.1 Seal Movements

301. Harbour seals are known to be a predominantly coastal species, particularly on the east coast of Britain, evidence shows that individuals usually stay within 50km of their haul-out site (Bailey *et al*., 2014; Carter *et al*. 2022), however the furthest known foraging ranges were recorded up to 273km (Sharples *et al*., 2012; Carter *et al*. 2022).

302. Tagging studies indicate that harbour seals from the south east coast of England, in particular those individuals hauling out at The Wash and Blakeney Point, are utilising the area where both SEP and DEP will be developed (Sharples *et al*., 2012; Russel *et al*., 2017; Carter *et al*. 2020 (Plate 7-3; **Plate 7-4**). Only a few tagged harbour seals from the Thames estuary have shown connectivity with the Wash region where they spent a significant amount time foraging and hauled out, whilst the majority remained in the Thames (Sharples *et al*., 2012; Barker *et al*., 2014; Carter *et al*. 2020).

303. Site fidelity for particular sandbanks or haul out sites and only minimal interconnectivity between populations is common amongst harbour seals, not only in Britain (Barker *et al*., 2014), but also in other European seal populations bordering the North Sea (Tougaard *et al.,* 2003; Vincent *et al*., 2017).

304. Harbour seal foraging behaviour and movements are influenced by their diet and are assumed to vary seasonally and regionally. In comparison to harbour seals from other regions in the British Isles, seals from the Moray Firth, St. Andrews Bay and the Wash travelled much longer distances (between 86km and 200km) away from the coast to foraging areas (Sharples *et al.,* 2012). These areas are characterised by shallower, soft-sediment habitats which prevent prey species to find refuge, and thus seals may need to travel further offshore to find sufficiently productive foraging areas. Foraging distances were different in winter, spending more time away from haul-out sites than in summer, possibly linked to changes in prey biomass, to which harbour seals are able to adapt (Sharples *et al.,* 2012). Harbour seal exhibit alternate periods of foraging and resting at haul out sites (during which limited, or no feeding occurs).

305. Grey seals exhibit a more wide-ranging distribution than harbour seals, partially migrating between different regions (and countries) for breeding and foraging (Cronin *et al*., 2013; Russel *et al.,* 2013; Brasseur *et al*., 2017; Vincent *et al*., 2017; Peschko *et al*., 2020; Carter *et al*., 2022), but they often return to the same haul-out sites from where they departed (McConnell *et al*., 1991).

306. The site-specific survey and tagging studies indicate that grey seals from the South East coast of England, in particular those individuals hauling out in the Humber and Donna Nook, are utilising the area where SEP and DEP will be developed (Carter *et al*., 2020). Baltic grey seals often concentrate their movements in relatively small areas near haul-out sites (within 120km) (McConnell *et al*., 1991; Oksanen *et al*., 2014), but latest data from the Humber Estuary SAC revealed that density hotspots occur in distances greater than 150km offshore (Carter *et al.,* 2022). This telemetry study also showed that grey seals have foraging ranges of up to 448km, with foraging trips lasting up to 30 days (Cronin *et al*., 2013; SCOS, 2021).

307. Grey seals are capital breeders, meaning that they are able to acquire and store resources prior to offspring production. This provides energy for the males during breeding and it allows the females to fast up to two weeks during lactation (Beck *et al*. 2007). In the summer, there seems to be seasonal differences in foraging behaviour, when grey seals spent more time at sea finding local foraging habitat, which is suggested by rather short trip extents which are possibly linked to increased prey resource in coastal waters (Cronin *et al*., 2013), whereas in winter,

prey are less predictable and occur in deeper water (Breed *et al*., 2005). Prolonged fasting also occurs in these species during annual breeding and moult, when there are marked seasonal changes in body condition (Rosen and Renouf, 1997; Bäcklin *et al*., 2011). Although adult seals may be relatively robust to short term (weeks rather than days when compared to harbour porpoise) changes in prey resources, young and small individuals have a more sensitive energy

balance. This is exhibited through effects of mass dependent survival (Harding *et al.*, 2005).

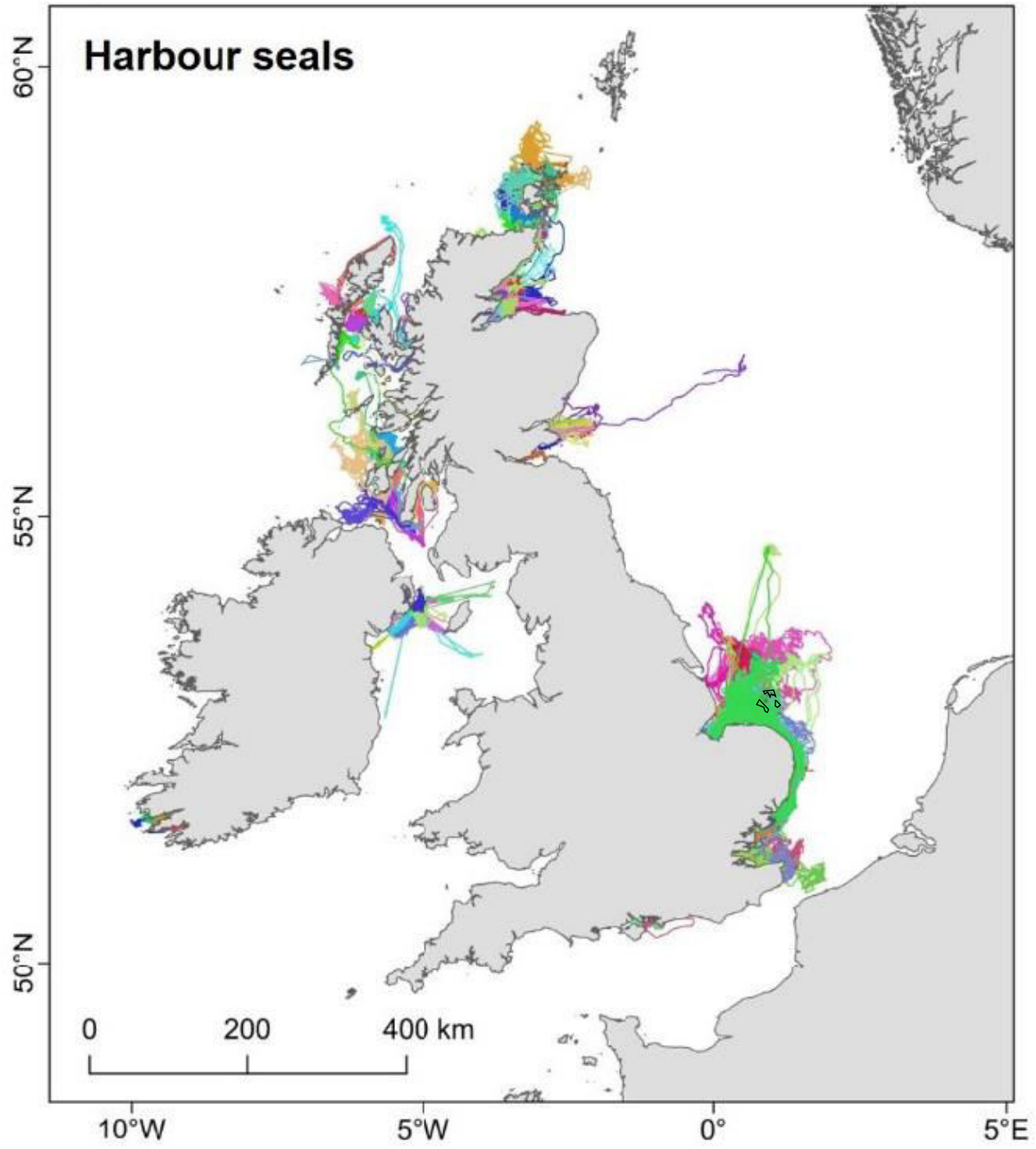

Plate 7-3 GPS tracking data for harbour seals (n = 239 tagged harbour seals). Approximate location of SEP and DEP are shown in black. (Carter et al., 2020).

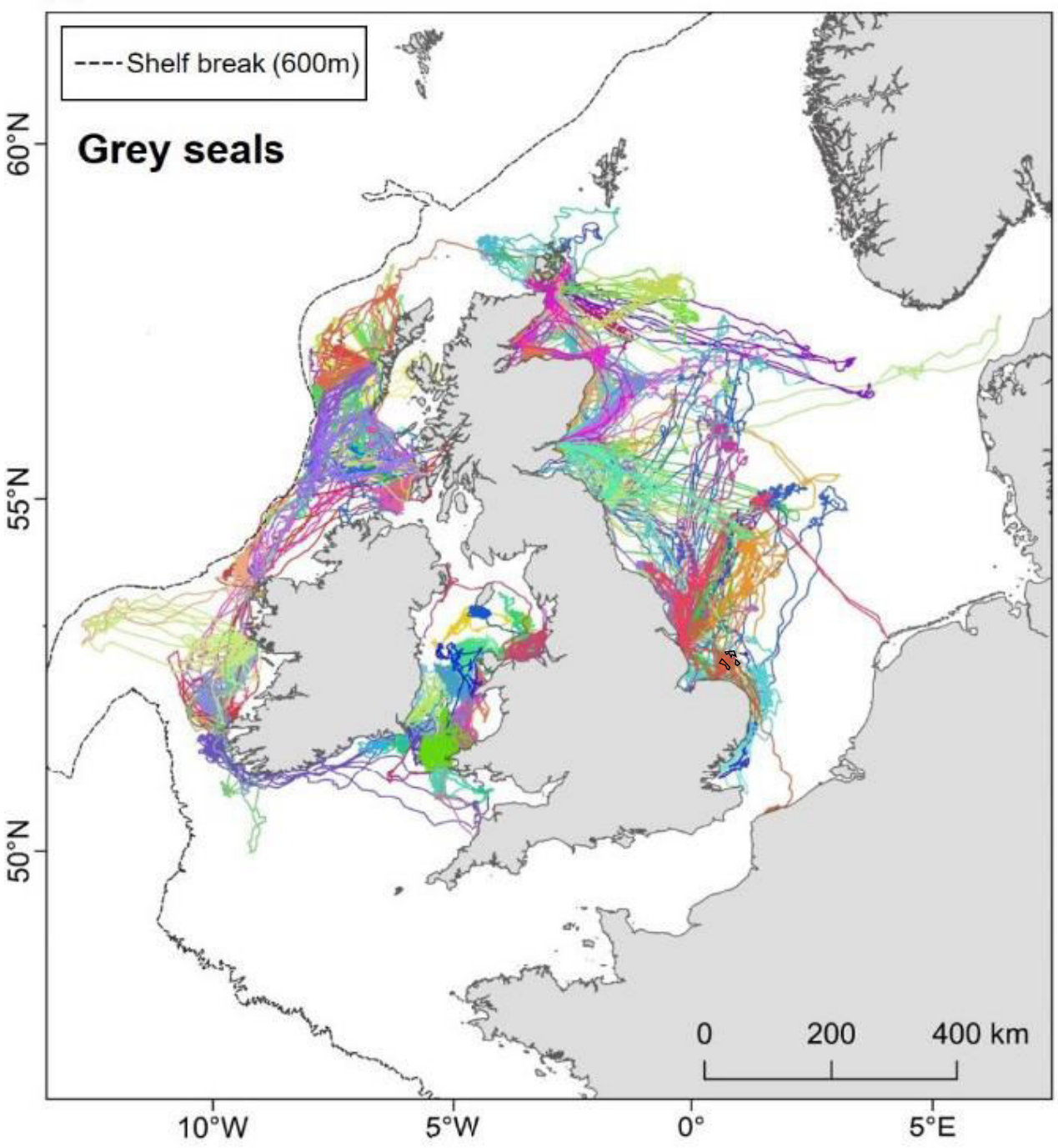

Plate 7-4 GPS tracking data for grey seals (n = 114 grey seals). Approximate location of SEP and DEP are shown in black (Carter et al., 2020)

7.2.2 Updated Assessment of Barrier Effects to Seals

308. The following assessment provides an update to that presented in **RIAA Section 8.4.3.1.4** and **8.4.3.2.4** for grey seal at the Humber Estuary SAC, and **RIAA Section 8.4.4.1.4** and **8.4.4.2.4** for harbour seal of The Wash and North Norfolk Coast SAC [APP-059].

309. Considering the increase in offshore wind farm developments in the North Sea, a possible barrier effect could be present. Various research projects indicate there is no lasting disturbance or exclusion of seals around OWF sites during operation Diederichs *et al*., 2008; Lindeboom *et al*., 2011; Marine Scotland, 2012; McConnell *et al*., 2012; Russell *et al*., 2014; Teilmann *et al*., 2006, Tougaard *et al*., 2009). Data collected suggests that any behavioural responses for harbour seal may only occur up to a few hundred metres away (McConnell *et al*., 2012).

310. Tagged harbour seals in the Wash indicated that seals were not excluded from the vicinity of the Lincs windfarm during the overall construction phase but that there was clear evidence of avoidance during pile driving, with significantly reduced levels of seal activity at ranges of up to 25km from piling sites (Russell *et al*., 2016). However, within two hours of cessation of piling, seal distribution returned to pre-piling levels (Russell *et al*., 2016). Monitoring studies at Nysted and Rødsand have also indicated that operational activities have had no impact on regional seal populations (Teilmann *et al*., 2006; McConnell *et al*., 2012).

311. Tagged grey seal from Donna Nook and Blakeney revealed that of the 19 tagged seals, 17 entered an operational wind farm off the southern North Sea coast (Russell *et al*., 2016). Five of the seals entered a total of three different operational wind farms, and one entered nine operational wind farms as well as a wind farm under construction. The operational sites with the highest number of grey seal within the sites were those closest to their haul-out sites (with Humber Gateway having the most grey seals present (n=12), and Sheringham Shoal having four individual seals present during the tagging study). While this tagging study shows presence of grey seal within operational wind farms, there was no strong evidence to indicate grey seal use of the wind farm structures for foraging (Russell *et al*., 2016). Of the 24 tagged harbour seals, only one was shown to be foraging around the foundations of the Sheringham Shoal wind farm (Russell *et al*., 2016).

312. **Plate 7-5** shows the grey seal tracking from this study, with the (at the time) operational and planned offshore wind farm developments. Of the grey seal tagged in Donna Nook in 2005, there is no indication of an overlap with the SEP and DEP sites, while the grey seal tagged from both Donna Nook and Blakeney Point in 2015 show overlap with SEP and DEP.

313. **Plate 7-6** shows the modelled distribution of grey seal based on the above described tagging study. This shows no predicted presence of grey seal at the SEP and DEP sites.

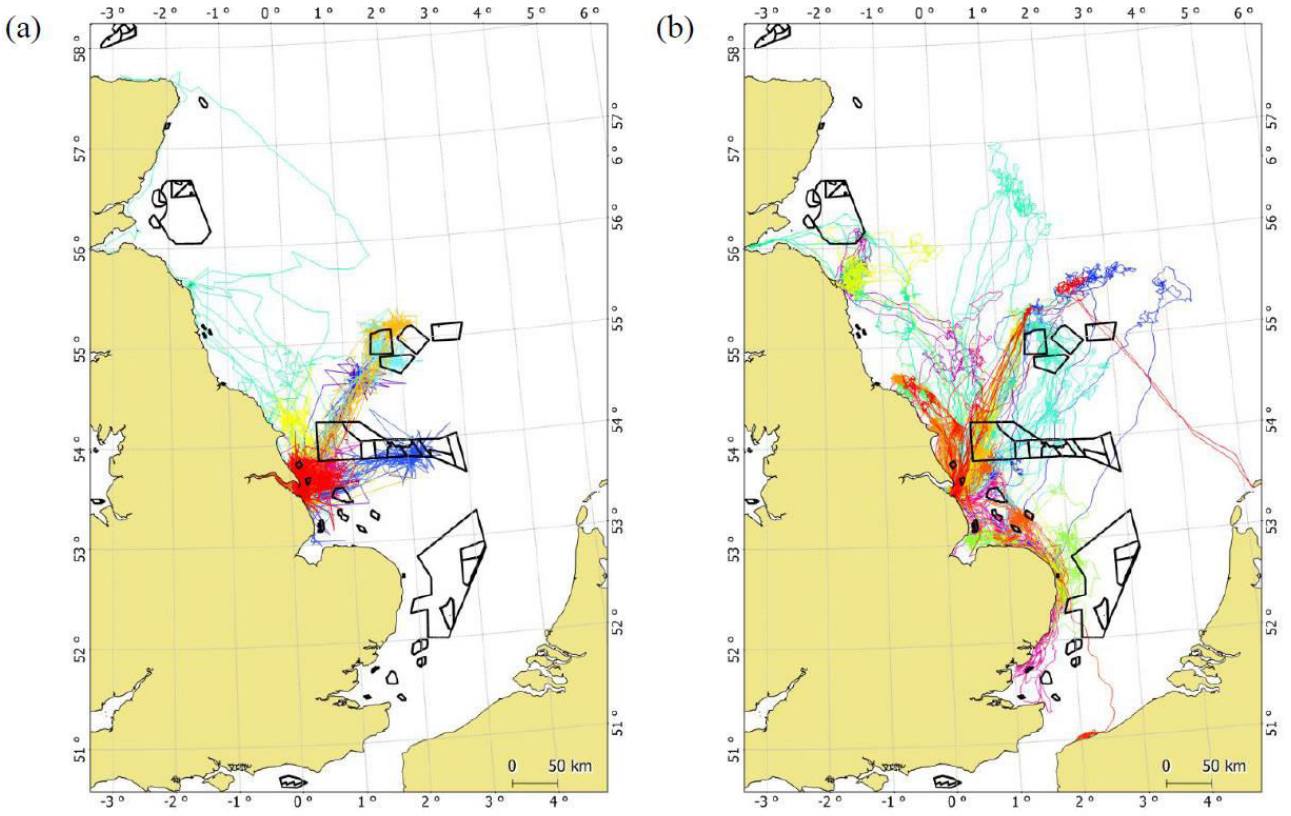

Plate 7-5 Tracks from grey seal tagged in 2005 (a; n=10) and in 2015 (b; n=21) (Russell et al., 2016).

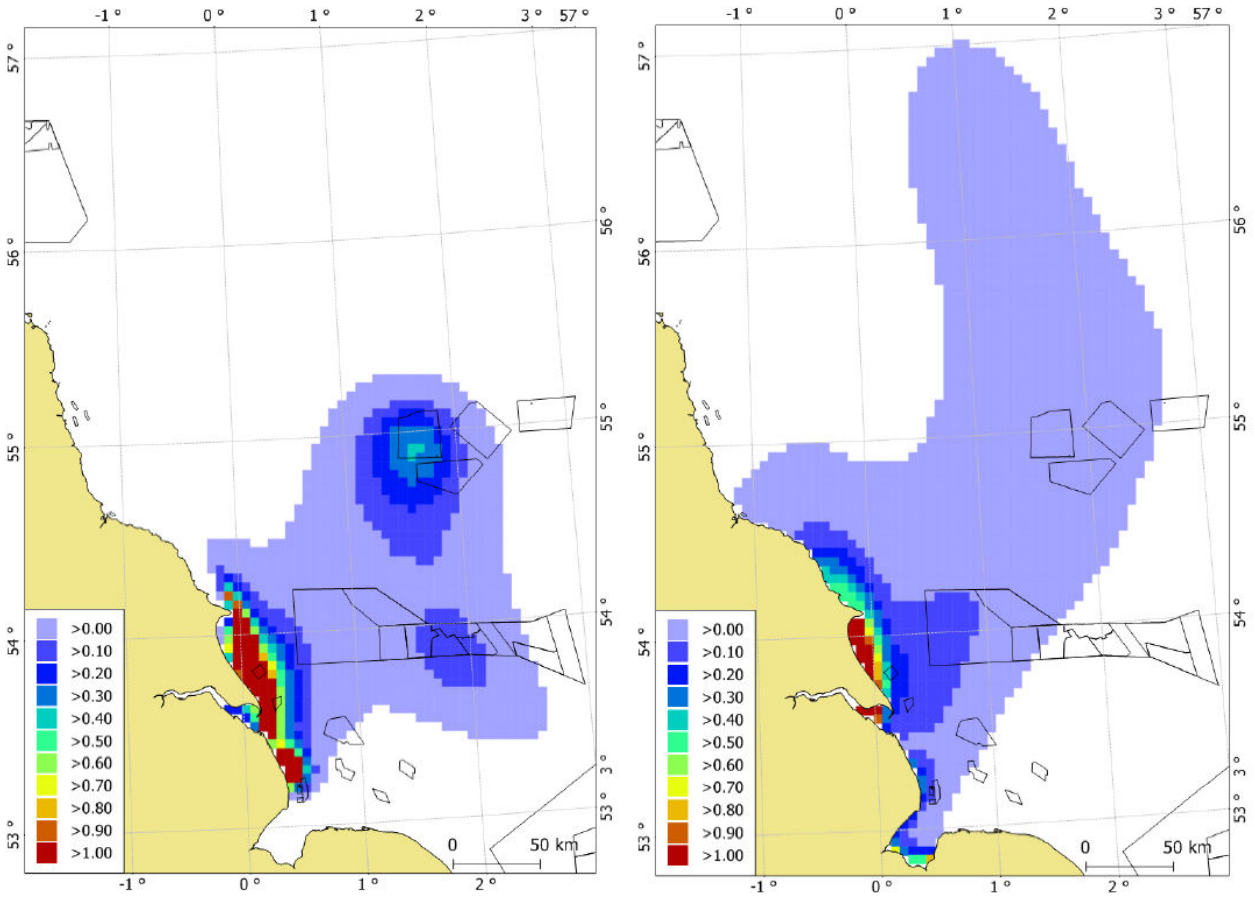

Plate 7-6 Predicted distribution of grey seals on return trips with wind farm sites (on a 5km grid) (showing the upper 95% confidence limit). Left = Grey seals from Donna Nook in 2005; Right = Grey seals from Donna Nook in 2015. (Russell et al., 2016).

314. Russell (2016) analysed the results of tagged seals to determine activity budgets and foraging locations of seals in the southern North Sea. The study found that some offshore wind farm areas are predominantly used for transiting by harbour seals (such as the (at the time) future planned Race Bank site), while the (at the time) proposed Hornsea site is further from the coast and more likely to be used for foraging by harbour seal. Grey seal showed both transiting and foraging within the Hornsea site. **Plate 7-7** shows the results of the study for harbour seal, with foraging locations shown in red. This shows that there is foraging of harbour seal within both the Sheringham Shoal and Dudgeon wind farm sites, and there is likely to be existing foraging activity of harbour seal within the SEP and DEP sites. At the time of harbour seal tagging (2012), Sheringham Shoal was still undergoing construction and was partly operational, while Dudgeon was not yet constructed.

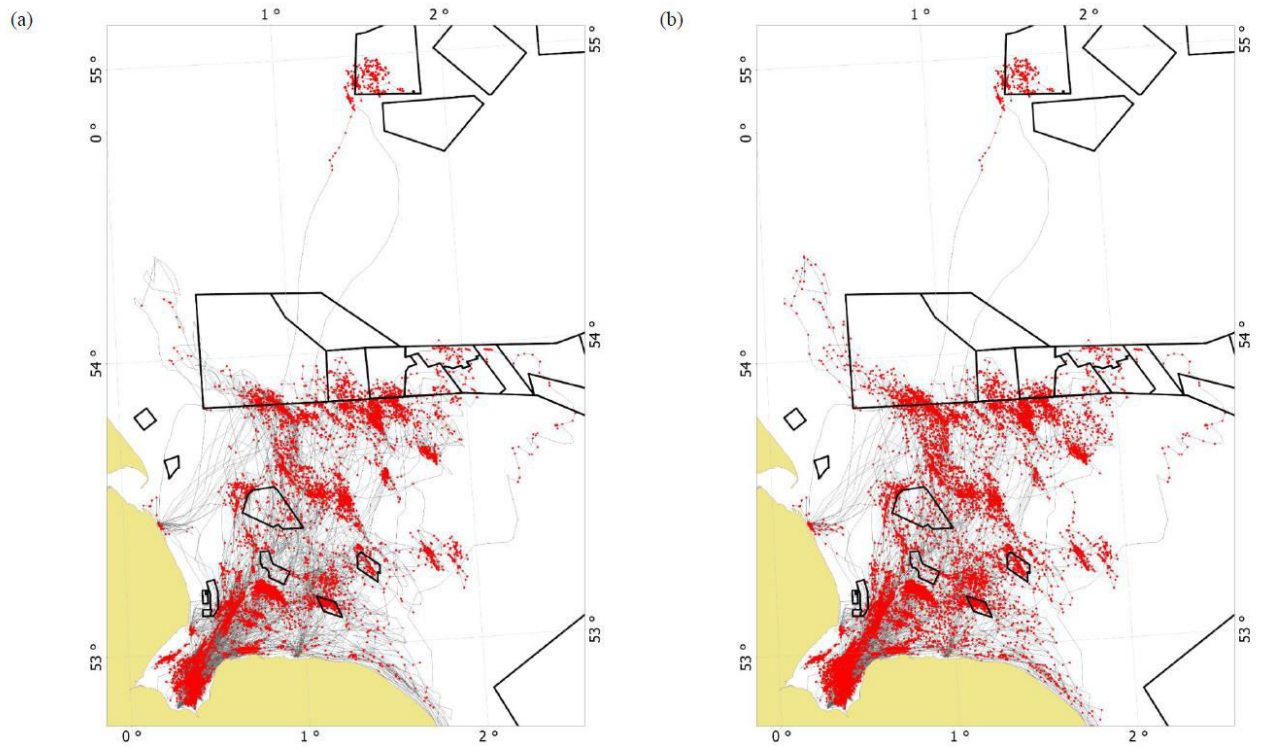

Plate 7-7 The tracks (grey) and estimated foraging locations (red) of tagged harbour seals. The outlines of (at the time) planned and consented windfarms are shown in black (Russell, 2016).

315. The results of the same study for grey seal showed both transiting and foraging within the Hornsea site. **Plate 7-8** shows the results of the study for grey seal, with foraging locations shown in red. This shows that there is limited foraging of individuals within both the Sheringham Shoal and Dudgeon wind farm sites but there is foraging outside of the sites and likely to be at the SEP and DEP sites. At the time of grey seal tagging (2015), Sheringham Shoal was operational, while Dudgeon was not yet under construction.

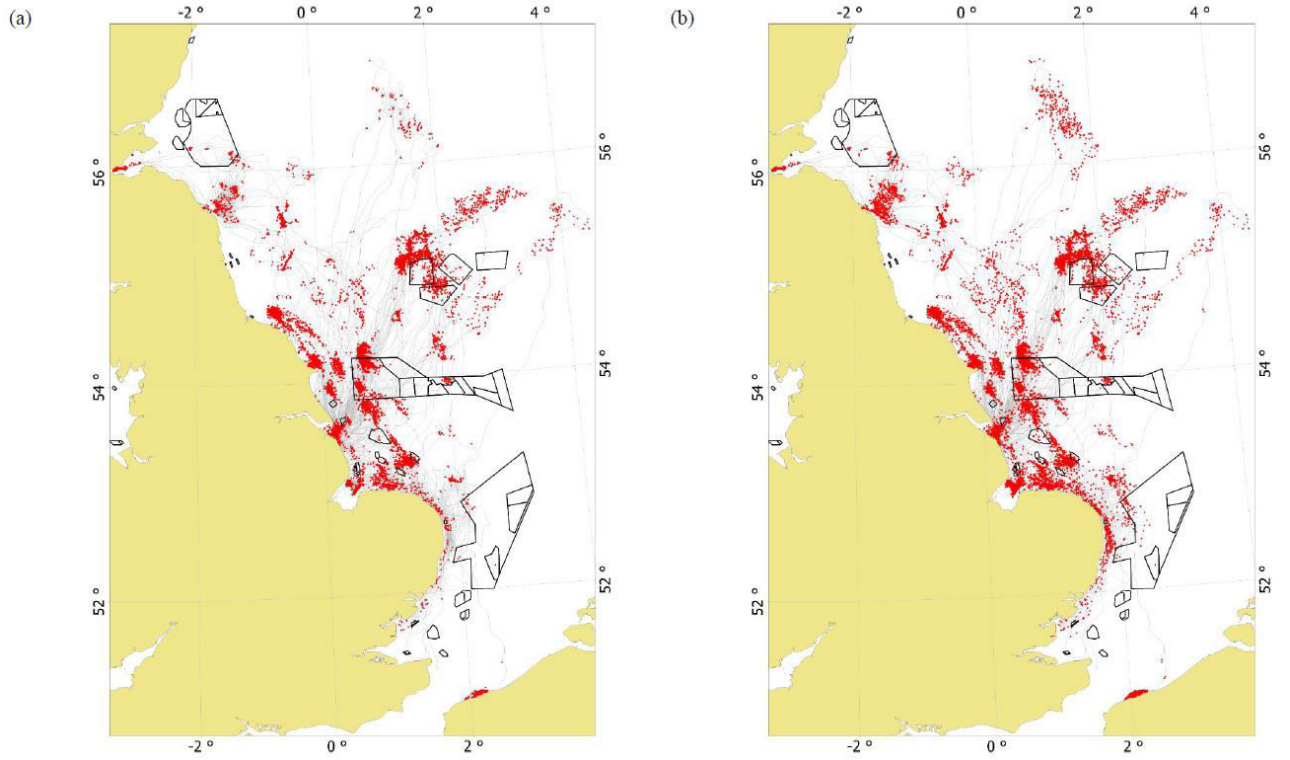

Plate 7-8 The tracks (grey) and estimated foraging locations (red) of tagged grey seals in. The outlines of (at the time) planned and consented windfarms are shown in black.

316. Tagged harbour seals have been recorded within two operational OWF sites (Alpha Ventus in Germany and Sheringham Shoal in UK) with the movement of several of the seals suggesting foraging behaviour around WTGs (Russell *et al*., 2014). Seals have been shown to forage within operational OWFs (e.g. Lindeboom *et al*., 2011; Russell *et al*., 2014), indicating no restriction to movements in operational OWF sites.

317. Seals are wide ranging. For example, grey seals travel over 100km between haul-out sites and with foraging trips lasting up to 30 days (SCOS, 2020). Data from The Wash (from 2003-2005) suggest that harbour seal in this area travel and forage between 75km and 273km offshore (Sharples *et al.,* 2008; Carter *et al*. 2022). Therefore, if there are any potential barrier effects from underwater noise, marine mammals would be able to compensate by travelling to other foraging areas within their range.

318. The tagging studies presented above indicate that there is the potential for seals to be present within the SEP and DEP sites, and to be foraging in the area, however, the results of the studies also indicate that seals are not deterred from using operational wind farm areas. From this, it can be concluded that operational wind farm sites do not pose a barrier to movement for either grey or harbour seal.

319. In addition, the spacing of the wind turbines is such that there would be room for seals to transit between turbine locations, with a minimum spacing of 1.05km, and

a maximum of 3.3km (**ES Chapter 4 (Revision B) Table 4-5** [document reference 6.1.4]).

320. The assessment for the potential for adverse effect are therefore as presented in **RIAA Section 8.4.3.1.4** and **8.4.3.2.4** for grey seal at the Humber Estuary SAC, and **RIAA Section 8.4.4.1.4** and **8.4.4.2.4** for harbour seal of The Wash and North Norfolk Coast SAC [APP-059].

321. There would be no significant disturbance of grey seal and **no adverse effect on the integrity of the Humber Estuary SAC in relation to the conservation objectives for grey seal due to potential barrier effects for SEP and DEP**.

322. There would be no significant disturbance of harbour seal and **no adverse effect on the integrity of The Wash and North Norfolk SAC in relation to the conservation objectives for harbour seal due to potential barrier effects for SEP and DEP**.

7.3 Updated Assessments for Grey and Harbour Seal

In response to Natural England's Relevant Representation [RR-063], as stated in Applicant's Response (ID 77, 85, 86) [REP2-051].

323. **Annex 2** provides an update to all assessments as provided within the **RIAA Section 8** [APP-059] that rely on the grey seal or harbour seal density estimates and reference populations. This includes an update to;

- Construction related impact assessments:
  - Impact 1: auditory injury from underwater noise associated with piling
  - Impact 2: disturbance from underwater noise associated with piling activities
  - Impact 3: effects from underwater noise associated with other construction activities
  - Impact 4: impacts from underwater noise and disturbance associated with construction vessels
  - Impact 6: increased risk of collision with vessels during construction
  - Impact 8: changes to prey availability
- Operation and maintenance phase related impact assessments:
  - Impact 1: impacts from underwater noise associated with operational wind turbines
  - Impact 2: impacts from underwater noise associated with operation and maintenance activities
  - Impact 3: impacts from underwater noise and disturbance associated with operation and maintenance vessels
  - Impact 5: increased risk of collision with vessels during operation

324. An update to the in-combination assessment for grey seal of the Humber Estuary SAC and harbour seal of The Wash and North Norfolk Coast SAC is provided in **Section 7.4**.

7.3.1 Conclusions for the Humber Estuary SAC

325. While there are some changes in the number of grey seal potentially at risk, due to both a change in density estimate and SAC population, there are no changes to the overall assessments of effect. Therefore, as assessed in **RIAA Section 8.4.3**, there is **no potential for adverse effect on the integrity of the grey seal feature of the Humber Estuary SAC**.

7.3.2 Conclusions for The Wash and North Norfolk Coast SAC

326. While there are some changes in the number of harbour seal potentially at risk, due to both a change in density estimate and SAC population, there are no changes to the overall assessments of effect. Therefore, as assessed in **RIAA Section 8.4.4**, there is **no potential for adverse effect on the integrity of the harbour seal feature of The Wash and North Norfolk Coast SAC**.

7.4 Updates to In-Combination Assessment

In response to Natural England's Relevant Representation [RR-063], as stated in Applicant's Response (ID 4, 7, 15, 65, 86, 106, 115) [REP2-051].

7.4.1 Updates to In-Combination Assessment of Disturbance from Underwater Noise

7.4.1.1 Updated In-Combination Assessment for the Southern North Sea SAC

In response to Natural England's Relevant Representation [RR-063], as stated in Applicant's Response (ID 16, 105) [REP2-051].

327. The following section provides an update to the in-combination assessment, due to underwater noise, at the Southern North Sea SAC. Unless stated otherwise, the following assessments follow the same methodology and approach as set out in **RIAA Section 8.4.1.6** [APP-059].

7.4.1.1.1 Updates to the In-combination Assessment for the Potential for In-Combination Disturbance Effects due to Underwater Noise from Piling at Other OWFs

328. The following section provides an update to the in-combination assessment as presented in the **RIAA Section 8.4.1.6.1** [APP-059], for underwater noise due to piling at other offshore wind farms.

329. The assessment has been updated to incorporate project specific data (wherever it is available), to include simultaneous piling where relevant, and to take account of the worst-case piling season (both summer and winter) within the Southern North Sea SAC, according to the currently available information on piling

programmes of other offshore wind farms. The assessments have also been updated to include all piling days of other offshore wind farms.

330. The same projects have been included as those presented in the **RIAA Section 8.4.1.6.1** [APP-059].

331. The project specific data for other offshore wind farms that have been used to update the assessments is summarised in **Table 7-12**. Taking into account the currently anticipated piling windows of each considered project, the worst-case in-combination scenario for the summer season would be for piling in 2028, with all projects expect East Anglia TWO and Five Estuaries potentially piling. The worst-case in-combination scenario for the winter area would be for piling in the 2027 to 2028 winter season, with all projects except Five Estuaries potentially piling.

Table 7-12 Project Specific Data of Other Offshore Wind Farms included in the In-combination Assessment for Disturbance Due to Piling

Project	Piling window	Duration of activity (days)	Assumptions on assessment
SEP	2028-2031	27	Assuming the worst-case spatial of 2 piles a day and the worst-case duration
DEP	2028-2031	34	Assuming the worst-case spatial of 2 piles a day and the worst-case duration
SEP & DEP	2028-2031	61	Assuming the worst-case spatial of 2 piles a day and the worst-case duration
Dogger Bank South (East & West)[80]	2026 onwards	300	Activity could take place over an entire season, and assuming within the three years following the earliest start date of 2026
East Anglia ONE North[81]	2026-2028	88	All 88 days could be undertaken in either the summer or winter seasons
East Anglia TWO[82]	2025-2027	96	All 96 days could be undertaken in either the summer or winter seasons
Five Estuaries[83]	2029-2030	91	All 91 days could be undertaken in either the summer or winter seasons
Hornsea Project Four[84]	2027-2028	235	Activity could take place over an entire season

[80] No HRA available - generalised approach used, assuming one pile at each site
[81] East Anglia ONE North RIAA
[82] East Anglia TWO RIAA
[83] No HRA available - generalised approach used, with the expected worst-case of concurrent piling
[84] Hornsea Project Four RIAA

Project	Piling window	Duration of activity	Assumptions on assessment
North Falls[85]	2028-2030	76	All 76 days could be undertaken in either the summer or winter seasons
Outer Dowsing[86]	2027-2030	128	All 128 days could be undertaken in either the summer or winter seasons

Spatial assessment for the Southern North Sea SAC

332. The estimated maximum and average overlaps with the Southern North SAC summer and winter areas are outlined in **Table 7-13**.

333. The updated assessment shows an increase in the spatial overlap with the summer area, when compared to the assessment presented in **RIAA Section 8.4.1.6.1** [APP-059], while the overlap with the winter area has not significantly changed. The potential for disturbance in the summer area has increased due to the inclusion of simultaneous piling at Dogger Bank South (East & West) and Hornsea Project Four.

Table 7-13: Estimated Maximum Average Overlaps with the Southern North Sea SAC Summer and Winter Areas from Piling at Other Offshore Wind Farms on the Same Day as Piling at SEP and DEP

In-combination assessment scenario	Maximum overlap with seasonal area	Average overlap with seasonal area
Summer area:		
Assessment presented in RIAA Table 8-38 [APP-059] Total for summer area	7,489.96km^2 (27.71% of the summer area)	5,733.75km^2 (21.21% of the summer area)
Updated assessments for the summer area		
SEP	0km^2	0km^2
DEP	355.70km^2	177.85km^2
Dogger Bank South (East & West)	4,247.40km^2	3,148.75km^2
East Anglia ONE North	1,167.90km^2	736.66km^2
Hornsea Project Four	3,683.0km^2	2,806.5km^2
North Falls	0km^2	0km^2
Outer Dowsing	1,718.95km^2	931.39km^2
Total for the summer area	**11,172.95km^2 (41.34% of the summer area)**	**7,801.15km^2 (28.86% of the summer area)**

[85] No HRA available - generalised approach used, assuming single piling
[86] No HRA available - generalised approach used, assuming single piling

In-combination assessment scenario	Maximum overlap with seasonal area	Average overlap with seasonal area
Winter area:		
Assessment presented in RIAA Table 8-38 [APP-059] Total for winter area	6,387.0km^2 (50.3% of the winter area)	5,978.70km^2 (47.09% of the winter area)
Updated assessments for the winter area		
SEP	0.15km^2	0.07km^2
DEP	30.33km^2	15.16km^2
Dogger Bank South (East & West)	0km^2	0km^2
East Anglia ONE North	2,123.71km^2	2,110.50km^2
East Anglia TWO	2,123.71km^2	2,083.00km^2
Hornsea Project Four	0km^2	0km^2
North Falls	2,106.76km^2	1,897.57km^2
Outer Dowsing	0km^2	0km^2
Total for winter area	**6,384.49km^2 (50.29% of the winter area)**	**6,106.23km^2 (48.10% of the winter area)**

334. As for the assessment presented in **RIAA Section 8.4.1.6.1** [APP-059], the updated assessment indicates that more than 20% of the summer area or the winter area could be affected, based on the maximum and average potential overlaps for all offshore wind farms (**Table 7-13**).

335. It should be noted that the contribution of both SEP and DEP to the maximum potential disturbance areas that overlap the summer and winter areas of the SAC are small, with a total of 355.7km^2 potential maximum disturbance area due to piling at DEP in the summer area (3.2% of the total in-combination disturbance area), and a total potential disturbance area of 0.15km^2 and 30.33km^2 at SEP and DEP, respectively in the winter area (0.002% and 0.48% of the total in-combination disturbance area, respectively). There is no overlap of the potential disturbance area from SEP with the summer area.

336. While the area of effect has increased for the summer area, the overall conclusions made within **RIAA Section 8.4.1.6.1** [APP-059] remain valid. Therefore, with the use of appropriate mitigation and management measures defined through the SIP process, and managed by the MMO, there would be **no adverse effect on the integrity of the Southern North Sea SAC in relation to the conservation objectives for harbour porpoise as a result of in-combination disturbance effects from underwater noise during piling at SEP and DEP and other offshore wind farms.**

Seasonal Average Assessment for the Southern North Sea SAC

337. Seasonal averages have been calculated by multiplying the *average* effect on any given day in each season by the proportion of days within the season on which piling could occur (i.e. taking into account the average of effect / area of overlap with the Southern North Sea SAC and number of days piling per season).

338. The assessment as presented in **RIAA Section 8.4.1.6.1** [APP-059] has been updated to reflect the noisy days for all activities throughout the full relevant season.

339. For other offshore wind farms, it has been assumed that all piling days would be in each season assessed, and therefore most have been assessed under both the summer in-combination scenario as well as the winter. As a worst-case, no allowance has been made for downtime as a result of technical issues and no assumptions have been made for reloading of piling vessels with foundations.

340. The average seasonal overlaps with the Southern North SAC summer and winter seasons are outlined in **Table 7-14**.

341. The updated seasonal assessment shows an increase in the overlaps with both the summer and winter seasonal areas when compared to the assessment presented in **RIAA Section 8.4.1.6.1** [APP-059]. The potential for disturbance in the summer area has increased due to the inclusion of full piling programmes, and due to the inclusion of project specific data (including simultaneous piling at Dogger Bank South (East & West) and Hornsea Project Four).

Table 7-14 Estimated Seasonal Averages for the Southern North Sea SAC Summer and Winter Areas from Piling at Other Offshore Wind Farms Which Could be Piling on the Same Day as Piling at SEP and DEP

In-combination assessment scenario	Average overlap with seasonal area	Number of piling days for in-combination effects with SEP & DEP	Estimated seasonal average
RIAA Table 8-39 [APP-059]			
Summer area: Single piling at DBC, EA1N, HP4 and OD, at the same time as piling at DEP	21.21%	33 days for piling at DEP	3.82%
Winter area: Single piling at the EA2, FE and NF, at the same time as SEP	46.97%	26 days for piling at SEP	6.71%
Winter area: Single piling at the EA2, FE and NF, at the same time as DEP	47.09%	33 days for piling at DEP	8.54%
Winter area: Single piling at the EA2, FE and NF, at the same time as SEP and DEP	47.1%	26 days for piling at SEP and DEP	6.73%

In-combination assessment scenario	Average overlap with seasonal area	Number of piling days for in-combination effects with SEP & DEP	Estimated seasonal average
Updated assessments			
Summer area: Piling at other offshore wind farms at the same time as piling at DEP	28.86%	Relevant number of piling days for each project as presented in **Table 7-12**	25.88%
Winter area: Piling at other offshore wind farms at the same time as SEP	47.98%	Relevant number of piling days for each project as presented in **Table 7-12**	15.40%
Winter area: Piling at other offshore wind farms at the same time as DEP	48.10%	Relevant number of piling days for each project as presented in **Table 7-12**	15.41%
Winter area: Piling at other offshore wind farms at the same time as SEP and DEP	48.10%	Relevant number of piling days for each project as presented in **Table 7-12**	15.41%

342. The assessment indicates that based on the worst-case scenarios, the 10% seasonal average threshold would be exceeded for the summer or winter seasons, based on the number of piling days throughout each season across each project (**Table 7-14**).

343. As outlined above, the contribution of SEP and DEP to the average seasonal overlap with the seasonal areas is relatively small, compared to the other OWFs included in the in-combination assessment.

344. With the use of appropriate management measures defined through the SIP process, and managed by the MMO, there would be **no adverse effect on the integrity of the Southern North Sea SAC in relation to the conservation objectives for harbour porpoise as a result of in-combination disturbance effects from underwater noise during piling at SEP and DEP and other OWFs.**

Assessment for the North Sea MU reference population

345. The assessment for the potential for disturbance to harbour porpoise of the wider MU population has been updated based on the project specific data for each included offshore wind farm. The approach to this assessment is as defined in **Section 6.2.1.1** for the CIA. The populations that the CIA (as presented for updates to the EIA), and the assessment presented in **RIAA Section 8.4.1.6.1** [APP-059] for the wider harbour porpoise population, use the same spatial scale and are assessed against the same harbour porpoise population. Therefore, the updated assessment as presented in **Table 6-20** would also update the assessment as provided by **Table 8-40** in **RIAA Section 8.4.1.6.1** [APP-059].

346. For harbour porpoise, the assessment provided in **RIAA Section 8.4.1.6.1** [APP-059] concluded there was no potential for adverse effect on the integrity of the Southern North Sea SAC, as the population level effect was below 5% (with up to 16,310 harbour porpoise potentially disturbed (or 4.71% of the NS MU).

347. The updated assessment as provided in **Table 6-20**, based on project specific data (where available) concludes that under the more realistic case of single piling at all other offshore wind farms, there is the potential for 25,040 harbour porpoise (or up to 7.2% of the NS MU) to be disturbed. For the worst-case assessment of simultaneous piling at the relevant projects, there is the potential for 33,808 harbour porpoise to be disturbed (or 9.8% of the NS MU) (**Table 6-20**). This represents a significant increase in the number of harbour porpoise at risk of in-combination disturbance at other offshore wind farms when compared to the assessment provided within **RIAA Section 8.4.1.6.1** [APP-059].

348. To determine the population level consequences of disturbance, under the worst-case simultaneous piling scenario, and therefore whether there is the potential for adverse effect on the integrity of the Southern North Sea SAC harbour porpoise population, population modelling has been undertaken (see **Section 6.2.1.5** for further information and results of the modelling assessment).

349. The potential effects would be less than those predicted in this assessment as there is likely to be a great deal of variation in timing, duration, and hammer energies used throughout the various offshore wind farm construction periods. In addition, not all individuals would be displaced over the entire potential disturbance ranges used within the assessments. For example, the study of harbour porpoise at Horns Rev (Brandt *et al.* 2011), indicated that at closer distances (2.5 to 4.8km) there was 100% avoidance, however, this proportion decreased significantly moving away from the pile driving activity and at distances of 10km to 18km avoidance was 32% to 49% and at 21km the abundance was reduced by just 2%.

7.4.1.1.2 Updates to the In-Combination Assessment for the Potential for Disturbance Effects due to Underwater Noise Sources, Other than Piling

350. The following section provides an update to the in-combination assessment as presented in the **RIAA Section 8.4.1.6.2** [APP-059], for underwater noise due to all other noise sources.

351. The assessment has been updated to incorporate project specific data for the offshore construction activities of other offshore wind farms, and to take account of the worst-case noisy activity programme for each activity. For each of the included activities, a worst-case assumption has been made that the activity would take place over the entirety of each season.

352. For geophysical and seismic surveys, the assessment has also been updated to assess each as a moving source. The method for calculating the potential area of effect for geophysical and seismic surveys as a moving source is provided in **Section 6.2.1.3**.

353. The same projects have been included as those presented in the **RIAA Section 8.4.1.6.2** [APP-059].

Spatial assessment for the Southern North Sea SAC

354. The estimated maximum overlaps with the Southern North SAC summer and winter areas are outlined in **Table 7-15**.

355. The updated assessment shows an increase in the spatial overlap with both the summer and winter areas for construction activities at other offshore wind farms, geophysical surveys and seismic surveys, when compared to the assessment presented in **RIAA Section 8.4.1.6.1** [APP-059]. This is due to the inclusion of project specific data for other offshore wind farms, and the assessment of both geophysical and seismic surveys as moving sources.

Table 7-15 Estimated Maximum Overlaps with the Southern North Sea SAC Summer and Winter Areas from Piling at Other Offshore Wind Farms on the Same Day as Piling at SEP and DEP

In-combination assessment	RIAA Section 8.4.1.6.2 [APP-059]		Updated assessments	
	Maximum overlap with summer area (% of seasonal area)	Maximum overlap with winter area (% of seasonal area)	Maximum overlap with summer area (% of seasonal area)	Maximum overlap with winter area (% of seasonal area)
Offshore construction (other than piling) at other offshore wind farms	11.52km^2 (0.04%)	0km^2 (0%)	1,783.0km^2 (6.60%)	409.3km^2 (3.22%)
Up to two geophysical surveys within the summer area, and up to one within the winter area	512.0km^2 (1.89%)	256.0km^2 (2.02%)	2,227.0km^2 (8.24%)	1,113.5m^2 (8.77%)
Aggregate extraction and dredging	12.43km^2 (0.05%)	12.43km^2 (0.10%)	12.43km^2 (0.05%)	12.43km^2 (0.10%)
Subsea cables and pipelines	18.84km^2 (0.07%)	18.84km^2 (0.15%)	18.84km^2 (0.07%)	18.84km^2 (0.15%)
Up to two seismic surveys within the summer area, and up to one within the winter area	904.8km^2 (3.35%)	452.4km^2 (3.56%)	5,872.8km^2 (21.73%)	2,936.4km^2 (23.13%)
One UXO clearance (high-order)	2,123.7km^2 (7.86%)	2,123.7km^2 (16.73%)	2,123.7km^2 (7.86%)	2,123.7km^2 (16.73%)

356. Under each of the in-combination scenarios, the **RIAA Section 8.4.1.6.2** [APP-059] concluded that displacement of harbour porpoise would not exceed 20% of the summer seasonal component of the Southern North Sea SAC.

357. The updated assessments show that for the seismic survey assessment, there is potential for the 20% spatial threshold to be breached within both the summer and winter area, without the inclusion of SEP and DEP (**Table 7-15**). However, it should be noted that the potential for seismic surveys to take place at the same time as SEP and DEP constructing is unknown, and this assessment is based on a generic approach only. Prior to piling at SEP and DEP, a project specific SIP would be implemented to ensure that the spatial thresholds are not breached.

358. With the use of appropriate management measures defined through the SIP process, and managed by the MMO, there would be **no adverse effect on the integrity of the Southern North Sea SAC in relation to the conservation objectives for harbour porpoise as a result of in-combination disturbance effects from underwater noise due to construction activities (other than piling) for SEP and DEP in-combination with other plans and projects**.

Seasonal Average Assessment for the Southern North Sea SAC

359. The seasonal averages have been calculated by multiplying the maximum area on any one day by the proportion of days within the season on which other noisy activities could occur within the same season as piling at SEP and DEP.

360. The assessment indicates that the seasonal average would be less than 10% of the summer area of the Southern North Sea SAC for noisy activities except seismic surveys and UXO clearance (**Table 7-16**). For seismic surveys, there is the potential for 10% seasonal threshold to be breached in both the summer and winter season, and for UXO clearance there is the potential for the threshold to be breached in the winter season. No potential for breaching of the 10% threshold was predicted in the assessments as presented in **RIAA Section 8.4.1.6.2** [APP-059]. This is due to the inclusion of project specific data for other offshore wind farms, and the assessment of both geophysical and seismic surveys as moving sources, and the inclusion of both activities over the full season.

361. As above, the potential for seismic surveys to take place within the same season as SEP and DEP constructing is unknown, and this assessment is based on a generic approach only. Prior to piling at SEP and DEP, a project specific SIP would be implemented to ensure that the 10% seasonal thresholds are not breached.

362. Therefore, under these circumstances there would be no significant disturbance and **no adverse effect on the integrity of the Southern North Sea SAC in relation to the conservation objectives for harbour porpoise as a result of disturbance due to underwater noise from construction activities (other than piling) for SEP and DEP in-combination with other plans and projects**.

Table 7-16: Estimated Seasonal Averages with the Southern North Sea SAC Summer Area from Other Noisy Activities Taking Place within the Same Season as Piling at SEP and DEP

In-combination assessment	Assessment for summer season			Assessment for winter season		
	Maximum	Number of	Estimated	Average	Number of	Estimated

In-combination assessment	Assessment for summer season			Assessment for winter season		
	overlap with summer area	noisy activity days in the summer season	seasonal average for summer	overlap with winter area	noisy activity days in the winter season	seasonal average for winter
RIAA Section 8.4.1.6 [APP-059]						
Offshore construction (other than piling) at other offshore wind farms	1.36%	33 days for piling at DEP	0.25%	0%	N/A	0%
Up to two geophysical surveys within the summer area, and up to one within the winter area	3.21%	33 days for piling at DEP	0.58%	2.27%	33 days for piling at DEP	0.41%
Aggregate extraction and dredging	1.36%	33 days for piling at DEP	0.25%	0.36%	33 days for piling at DEP	0.06%
Subsea cables and pipelines	1.39%	33 days for piling at DEP	0.25%	0.41%	33 days for piling at DEP	0.07%
Up to two seismic surveys within the summer area, and up to one within the winter area	4.66%	33 days for piling at DEP	0.84%	3.8%	33 days for piling at DEP	0.69%
One UXO clearance (high-order)	9.17%	33 days for piling at DEP	1.65%	16.98%	26 days	2.42%
Updated assessments						
Offshore construction (other than piling) at other offshore wind farms	6.60%	Over the full summer season (183 days)	6.60%	3.22%	Over the full winter season (182 days)	3.22%
Up to two geophysical surveys within the summer area, and up to one within the winter area	8.24%	Over the full summer season (183 days)	8.24%	8.77%	Over the full winter season (182 days)	8.77%
Aggregate extraction and dredging	0.05%	Over the full summer season (183 days)	0.05%	0.10%	Over the full winter season (182 days)	0.10%
Subsea cables and pipelines	0.07%	Over the full summer season (183 days)	0.07%	0.15%	Over the full winter season (182 days)	0.15%
Up to two seismic surveys within the	21.73%	Over the full summer	21.73%	23.13%	Over the full winter season	23.13%

In-combination assessment	Assessment for summer season			Assessment for winter season		
summer area, and up to one within the winter area		season (183 days)			(182 days)	
One UXO clearance (high-order)	7.86%	Over the full summer season (183 days)	7.86%	16.73%	Over the full winter season (182 days)	16.73%

Assessment for the North Sea MU reference population

363. The assessment for the potential for disturbance to harbour porpoise of the wider MU population has been updated as described above. The approach to this assessment is as defined in **Section 6.2.1.1** for the CIA. The populations that the CIA (as presented for updates to the EIA), and the assessment presented in **RIAA Section 8.4.1.6.2** [APP-059] for the wider harbour porpoise population, use the same spatial scale and are assessed against the same harbour porpoise population. Therefore, the updated assessment as presented in **Table 6-33** and **Table 6-34** would also update the assessment as provided by **Table 8-42** in **RIAA Section 8.4.1.6.2** [APP-059].

364. For harbour porpoise, the assessment provided in **RIAA Section 8.4.1.6.2** [APP-059] concluded that there was no potential for adverse effect on the integrity of the Southern North Sea SAC for any of the included activities, as the population level effect was below 5% for all assessment activities.

365. Under the updated assessments, up to 39,959 individuals (11.5% of NS MU) could be disturbed as a result of in-combination noisy activities for SEP and DEP (or 38,573 harbour porpoise (11.5% of the NS MU) without SEP and DEP (**Table 6-33**). This represents a significant increase in the number of harbour porpoise at risk of disturbance due to noisy activities (other than piling) when compared to the assessment provided within **RIAA Section 8.4.1.6.2** [APP-059]. This is due to the inclusion of project specific data for other offshore wind farms, and the assessment of both geophysical and seismic surveys as moving sources.

366. For the potential temporary effects during construction, including vessels, there is likely to be a great deal of variation in timing and durations, as well as different construction methods, used throughout the various offshore wind farm construction periods. Therefore, this assessment is considered to be an over-precautionary worst-case.

367. To determine the population level consequences of disturbance, and therefore whether there is the potential for adverse effect on the integrity of the Southern North Sea SAC harbour porpoise population, population modelling has been undertaken (see **Section 6.2.1.5** for further information and results of the modelling assessment).

7.4.1.1.3 Updates to the Overall In-Combination Disturbance Effects from All Noise Sources

368. The potential in-combination effects from all potential noise sources during piling at SEP and DEP are summarised in **Table 7-17**.

369. Under the updated assessments, there is the potential for up to 85.9% of the summer area, with a seasonal average of 70.4%, or up to 102.4% of the winter area, with a seasonal average of 71.9%, to be affected. Up to 39,959.2 harbour porpoise (11.5% of the NS MU reference population) could potentially be disturbed (**Table 7-17**).

370. With the development of project specific SIPs to deliver the appropriate mitigation and management measures across projects and management by the MMO, there would be **no significant disturbance and no adverse effect on the integrity of the Southern North Sea SAC in relation to the conservation objectives for harbour porpoise as a result of SEP and DEP in-combination with other plans and projects**.

371. As both SEP and DEP are located outside of the SNS SAC summer and winter areas, there is the potential for several options to reduce the potential contribution to the underwater noise in-combination effects, for example:

- Scheduling of piling based on specific locations within the SEP or DEP wind farm sites to avoid maximum overlap with seasonal areas, for example, piling at a location which could have potential overlap with the winter area during the summer period.

372. In order to further understand the implications of in-combination wind farm piling on the harbour porpoise population, population modelling has been undertaken (**Section 7.1.2.4**).

Table 7-17: Overall In-Combination Assessment for the Potential Disturbance of Harbour Porpoise from All Possible Noise Sources during Piling at SEP and DEP

Potential noise source	Area of disturbance of the SNS SAC summer area	Area of disturbance of the SNS SAC winter area	Seasonal average for summer area	Seasonal average for winter area	Potential number of harbour porpoise disturbed (% of NS MU)
RIAA Table 8-53					
Piling at OWFs including piling at SEP and DEP	5,733.75km^2	5,978.7km^2	3.82%	8.54%	16,310 (4.7% of the NS MU)
Non-piling construction activities and vessels at other OWFs	11.52km^2	0	0.01%	0	14 (0.004% of the NS MU)
Geophysical surveys	512km^2	256km^2	0.34%	0.37%	266 (0.08% of the NS MU)
Aggregate extraction and dredging	12.43km^2	12.43km^2	0.008%	0.018%	6 (0.002% of the NS MU)
Subsea cables and pipelines	18.84km^2	18.84km^2	0.013%	0.027%	10 (0.003% of the NS MU)
Seismic surveys	904.8km^2	452.4km^2	0.60%	0.65%	470 (0.1% of the NS MU)
UXO clearance	2,123.7km^2	2,123.7km^2	1.42%	2.39%	1,104 (0.3% of the NS MU)
Total (seasonal average based on up to 33 days in summer and 26 days in winter for piling at SEP and DEP)	**9,317km^2 (34.5% of the summer area)**	**8,842km^2 (69.6% of the winter area)**	**6.21%**	**12.0%**	**18,181 (5.25% of the NS MU)**

Potential noise source	Area of disturbance of the SNS SAC summer area	Area of disturbance of the SNS SAC winter area	Seasonal average for summer area	Seasonal average for winter area	Potential number of harbour porpoise disturbed (% of NS MU)
Updated assessment					
Piling at OWFs including piling at SEP and DEP	11,172.95km^2	6,384.49km^2	25.88%	15.41%	33,808.4 (9.75% of the NS MU)
Non-piling construction activities and vessels at other OWFs	1,783.0km^2	409.3km^2	6.60%	3.22%	819 (0.24% of the NS MU)
Geophysical surveys	2,227.0km^2	1,113.5m^2	8.24%	8.77%	1,158.0 (0.33% of the NS MU)
Aggregate extraction and dredging	12.43km^2	12.43km^2	0.05%	0.10%	6 (0.002% of the NS MU)
Subsea cables and pipelines	18.84km^2	18.84km^2	0.07%	0.15%	10 (0.003% of the NS MU)
Seismic surveys	5,872.8km^2	2,936.4km^2	21.73%	23.13%	3,053.9 (0.88% of the NS MU)
UXO clearance	2,123.7km^2	2,123.7km^2	7.86%	16.73%	1,104 (0.3% of the NS MU)
Total	**23,210.72km^2 (85.88% of the summer area)**	**12,998.66km^2 (102.38% of the winter area)**	**70.41%**	**71.92%**	**39,959.2 (11.5% of the NS MU)**

7.4.1.2 Updated In-Combination Assessment for the Humber Estuary SAC

In response to Natural England's Relevant Representation [RR-063], as stated in Applicant's Response (ID 7, 11, 59, 60, 61, 63, 67, 70, 71, 104, 106, 108, 115) [REP2-051].

7.4.1.2.1 Assessment of Disturbance from Underwater Noise

Updates to In-Combination Effects due to Underwater Noise during Construction from Offshore Wind Farm Piling

373. A review of the data available for screened in offshore wind farms has been undertaken, and the resultant assessments updated to take account of project specific data where possible (**Table 6-19**).

374. The same offshore wind farms have been included for assessment against grey seal of the Humber Estuary SAC as provided in **RIAA Section 8.4.3.4** [APP-059], including:

- Dogger Bank South
- East Anglia ONE North
- East Anglia TWO
- Five Estuaries
- Hornsea Project Four
- North Falls
- Outer Dowsing

375. The following provides an update to the assessment as provided in **RIAA Section 8.4.3.4** [APP-059]. Unless specified otherwise, the approach and methods of the assessment are as previously undertaken.

376. The following assessment of disturbance from other offshore wind farm piling has been updated to take account of project specific data and information where it is known. The currently available data for each screened in project are provided in **Table 6-19** above.

377. Where project specific data is not available, a generalised approach has been used to inform the assessment (following the methods used in **RIAA Section 8.4.3.4** [APP-059]. For seals, the generalised approach has been updated to cover the reported disturbance range of 25km (Russell *et al*., 2016) as per the updated assessment in **Section 7.1.2.2**. The Carter *et al*. (2022) densities have also been used to inform the assessments where relevant.

378. The following assessments are based on one piling event in SEP and one piling event in DEP (for simultaneous or sequential piling), as a worst-case. The assessments also provide assessments for single piling at each of the other screened in offshore wind farms, unless the project specific information includes simultaneous piling within their project design envelope. The overall in-combination disturbance for each species is based on either single piling in each

of the other included offshore wind farms (as the more realistic case) as well as simultaneous piling for the relevant projects (as the worst-case).

379. For grey seal, the assessment provided in **RIAA Section 8.4.3.4 (Table 8-74)** [APP-059] shows the potential for up to 683.7 individuals to potentially be disturbed.

380. The updated assessment as provided in **Table 7-18**, based on project specific data (where available), and updated density and SAC population estimate (as summarised in **Section 5**) concludes that under the in-combination scenario of single piling at all other offshore wind farms, there is the potential for 2,110.6 grey seal (or up to 13.62% of the Humber Estuary SAC population) to be disturbed. For the worst-case in-combination scenario of simultaneous piling at the relevant projects, there is the potential for 2,701.1 individuals to be disturbed (or 17.4% of the Humber Estuary SAC population). This represents a significant increase in the number of grey seal at risk of disturbance from disturbance at other offshore wind farms when compared to the assessment provided within **RIAA Section 8.4.3.4** [APP-059]. This is due to the inclusion of project specific data where information was available, and the inclusion of simultaneous piling for the relevant projects (i.e. Dogger Bank South (East & West) and Hornsea Project Four). In addition, for the projects where a generalised assessment was required due to a lack of project specific information, the assessment uses the worst-case recorded disturbance ranges of seals (of 25km as reported by Russell *et al.,* 2016).

381. To determine the population level consequences of disturbance for grey seal at the Humber Estuary SAC, under the worst-case simultaneous piling scenario, population modelling has been undertaken (see **Section 7.4.1.4** for further information and results of the modelling assessment).

Table 7-18 Quantified In-Combination Assessment for the Potential Disturbance of Grey Seal Associated with the Humber Estuary SAC during Piling at Offshore Wind Farm Projects which Could be Piling at the Same Time as SEP and DEP

Name of Project	Piling scenario	Density source	Grey seal density	Disturbance	
				Impact area (km^2)	Maximum number of individuals potentially disturbed during piling
SEP	Single piling	Carter *et al.,* 2022 for Humber Estuary SAC	Based on the dose response curve assessments (**Section 7.1.2.3**)		157
DEP	Single piling	Carter *et al.,* 2022 for Humber Estuary SAC			166
SEP & DEP	Sequential or simultaneous piling	Carter *et al.,* 2022 for Humber Estuary SAC			323
Dogger Bank South	*Generalised approach due*	*Carter et al., 2022 for Humber Estuary*	*0.08*	*3,927*	*314.2*

Name of Project	Piling scenario	Density source	Grey seal density	Disturbance	
(East and West)	*to lack of further information*	*SAC*			
East Anglia ONE North	*One pile per 24 hours*	*Russell 2017*	*0.001*	*2124*	*2 (0.5% SE MU & 0.2% ref pop)*
East Anglia TWO	*One pile per 24 hours*	*Russell 2017*	*0.02*	*2124*	*42.5 (0.2% ref pop (0.5% SE England MU))*
Five Estuaries	*Single (1 pile per 24 hours)*	*Carter et al., 2022 for Humber Estuary SAC*	*0.005*	-	*9.8*
	Concurrent piling (2 monopiles at the same time)	Carter *et al.*, 2022 for Humber Estuary SAC	0.005	-	19.6
Hornsea Project Four	*Single (1 pile per 24 hours)*	*Carter 2020*	-	-	*580.7*
	Concurrent piling (2 monopiles at the same time)	Carter 2020	-	-	1,161.4[87]
North Falls	*Generalised approach due to lack of further information*	*Carter et al., 2022 for Humber Estuary SAC*	*0.018*	*1,963.5*	*35.3*
Outer Dowsing	*Generalised approach due to lack of further information*	*Carter et al., 2022 for Humber Estuary SAC*	*0.409*	1,963.5	803.1
SEP and DEP together – best case scenario of all projects single piling					
Total number of grey seal *(without SEP and DEP)*					2,110.6 *1,787.6*
Percentage of the Humber Estuary SAC population *(without SEP and DEP)*					13.62% *11.54%*
SEP and DEP together - worst case scenario of all projects simultaneously piling					
Total number of grey seal *(without SEP and DEP)*					2,701.1 *2,378.1*
Percentage of the Humber Estuary SAC population					17.43%

[87]Simultaneous piling was not assessed within the Hornsea Project Four RIAA, therefore as a worst-case, the number at risk of disturbance from single piling was doubled

Name of Project	Piling scenario	Density source	Grey seal density	Disturbance
(without SEP and DEP)				*15.35%*

Update to Cumulative Disturbance Assessment from other Offshore Wind Farm Construction Activities

In response to Natural England's Relevant Representation [RR-063], as stated in Applicant's Response (ID 7 and 59) [REP2-051].

382. The following provides an update to the assessment as provided in the **RIAA Section 8.4.3.4** [APP-059]. Unless specified otherwise, the approach and methods of the assessment are as previously undertaken.

383. The potential disturbance from offshore wind farms during non-piling construction activities, such as vessel noise, sea bed preparation, rock placement and cable installation, has been updated to take account of project specific information where it is available.

384. For SEP and DEP, the in-combination assessment for all construction activities (other than piling) has been based on the potential impact area, which is based on all five activities (0.15km^2) and 25 vessels (0.75km^2) and so is 0.90km^2 per project.

385. Where project specific information is not available, a generalised approach has been used to inform the assessment. This uses the above listed total disturbance areas, and for seals has been updated to include the updated Carter *et al*. (2022) densities.

386. Based on the projects that could have construction overlapping with SEP and DEP, the maximum number of grey seal that could potentially be disturbed is 75.9 (or 0.49% of the Humber Estuary SAC population) (**Table 7-19**). As less than 5% of the population are at risk of disturbance, there is no potential for a significant effect.

387. The assessment provided in **RIAA Section 8.4.3.4 (Table 8-74)** [APP-059] concluded that 0.2 grey seal may be at risk of disturbance from construction activities at other offshore wind farms. While the number of seals at risk of disturbance has increased under the updated assessments, there is no change to the overall assessment conclusions as assessed within **RIAA Section 8.4.3.4** [APP-059].

Table 7-19 Quantified In-Combination Assessment for the Potential Disturbance of Grey Seal Associated with the Humber Estuary SAC during the Construction (Other than Piling) at Offshore Wind Farm Projects at the Same Time as Construction at SEP and DEP

Name of Project	Area (km^2)	Density source	Grey seal density	Maximum number of grey seal potentially disturbed
SEP	0.90	Carter et al., 2022 for Humber Estuary SAC	0.344	0.31

Name of Project	Area (km^2)	Density source	Grey seal density	Maximum number of grey seal potentially disturbed
DEP	0.90	Carter et al., 2022 for Humber Estuary SAC	0.365	0.33
Norfolk Boreas[88]	0.03	Russell *et al.*, 2017	0.08	36.2
Norfolk Vanguard[89]	Total offshore project area	Russell *et al.*, 2017	-	39.0
Total number of grey seal *(without SEP and DEP)*				**75.9 (75.2)**
Percentage of the Humber Estuary SAC population *(without SEP and DEP)*				**0.49% (0.49%)**

Update to Cumulative Disturbance Assessment from Geophysical and Seismic Surveys at Other OWFs

Potential for Disturbance from Offshore Wind Farm Geophysical Surveys

In response to Natural England's Relevant Representation [RR-063], as stated in Applicant's Response (ID 7, 71 and 106) [REP2-051].

388. As assessed in **RIAA Section 8.4.3.4** [APP-059], as a worst-case for geophysical surveys, it has been assumed that grey seal within 1km (a total area of 3.1km^2), could be disturbed for each geophysical survey.

389. However, this assessment has been updated to reflect that geophysical surveys are a moving source, rather than a stationary one (i.e. the distance at which a survey vessel could travel in one day, with a 1km buffer area).

390. It is difficult to determine what the potential area of effect would be when taking into account it is a moving source (as it is difficult to predict how far a vessel may survey in a day). Based on survey vessels travelling at a speed of 4.5 to 5 knots, up to 199km could be surveyed in one day. This however does not take into account the survey downtime for line changes, weather, or other technical reason.

391. A review of seismic surveys within the UK indicated that surveys were being undertaken for approximately 52% of the time (BEIS, 2020). This data has been applied to geophysical surveys due to their similarity in approach. Taking this into account, up to 103.5km of surveys could be undertaken in one day, resulting in a potential disturbance area of 210.1km^2 with the 1km disturbance buffer applied. This is highly precautionary as it is unlikely that the whole geophysical survey transect area would cause disturbance to seal species.

[88] Norfolk Boreas Information to Support Appropriate Assessment
[89] Norfolk Vanguard Information to Support Appropriate Assessment

392. For grey seal, densities were calculated for the entire area where individuals may have connectivity with the Humber Estuary SAC (i.e. an average density across all grid cells included within the Carter *et al*., 2022 data for the Humber Estuary SAC). This assumes that the activity may take place in any area where grey seals are shown to have connectivity with the Humber Estuary SAC. This is 0.053 grey seal per km^2.

393. The updated assessments for an in-combination effect from geophysical surveys is shown in **Table 7-20**. The maximum number of grey seal that could potentially be disturbed is 345.3 (or 2.2% of the Humber Estuary SAC population). As less than 5% of the population are at risk of disturbance, there is no potential for a significant effect.

394. The assessment provided in **RIAA Section 8.4.3.4 (Table 8-74)** [APP-059] concluded that 1.9 grey seal may be at risk of disturbance from geophysical surveys. While the number of seals at risk of disturbance has increased under the updated assessments, there is no change to the overall assessment of effect as assessed within **RIAA Section 8.4.3.4** [APP-059]. Therefore, as assessed in **RIAA Section 8.4.3.4**, there is **no potential for adverse effect on the integrity of the grey seal feature of the Humber Estuary SAC**.

Table 7-20 Quantified In-Combination Assessment for the Potential Disturbance of Grey Seal Associated with the Humber Estuary SAC for Offshore Wind Farm Geophysical Surveys at the Same Time as Piling at SEP and DEP

Species	Activity	Updated assessment[90]	
		Area of disturbance	Potential number disturbed (% of reference population)
Grey seal	Piling at SEP	-	157
	Piling at DEP	-	166
	Disturbance from two geophysical surveys	420.2km^2	22.3 (0.14%)
	In-combination assessment for grey seal (% of SAC population)		**345.3 (2.2%)**

Potential for Disturbance from Oil and Gas Seismic Surveys

395. As assessed in **RIAA Section 8.4.3.4** [APP-059], a potential disturbance range of 17.0km (disturbance area of 907.9km^2) has been used in the in-combination assessment for grey seal.

[90]Based on the dose response curve assessments (**Section 7.1.2.3**)

396. As for geophysical surveys, this assessment has been updated to reflect that oil and gas seismic surveys are a moving source, rather than a stationary one (i.e. the distance at which a survey vessel could travel in one day, with a buffer area reflecting the potential disturbance range). The method of determining the potential total survey area in one day has used the same approach as outlined above, with up to 103.5km being surveyed in one day.

397. This results in a potential disturbance area of 5,334.8km^2 per seismic survey. This is highly precautionary as it is unlikely that the whole seismic survey transect area would cause disturbance to grey seal.

398. For grey seal associated with the Humber Estuary SAC, the same density as used for the assessment for the updated assessment for geophysical surveys as outlined above has been used (0.053 grey seal per km^2).

399. The updated assessments for an in-combination effect from seismic surveys is shown in **Table 7-21**. The maximum number of grey seal that could potentially be disturbed is 888.5 (or 5.7% of the Humber Estuary SAC population).

400. The assessment provided in **RIAA Section 8.4.3.4 (Table 8-74)** [APP-059] concluded that 546.6 grey seal may at risk of disturbance from seismic surveys. While the number of seals at risk of disturbance has increased under the updated assessments, there is no change to the overall assessment of effect as assessed within **RIAA Section 8.4.3.4** [APP-059]. Therefore, as assessed in **RIAA Section 8.4.3.4**, there is **no potential for adverse effect on the integrity of the grey seal feature of the Humber Estuary SAC**.

Table 7-21 Quantified In-Combination Assessment for the Potential Disturbance of Grey Seal Associated with the Humber Estuary SAC for Seismic Surveys at the Same Time as Piling at SEP and DEP

Species	Activity	Updated assessment[91]	
		Area of disturbance	Potential number disturbed (% of reference population)
Grey seal	Piling at SEP	-	157
	Piling at DEP	-	166
	Disturbance from two seismic surveys	10,669.6km2	565.5 (3.7%)
	In-combination assessment for grey seal (% of SAC population)		**888.5 (5.7%)**

[91] Based on the dose response curve assessments (**Section 7.1.2.3**)

Update to Overall Cumulative Disturbance Assessments

401. **RIAA Section 8.4.3.4** [APP-059] provides an overall in-combination assessment from all disturbance activities. The following sections provide an update to that assessment, based on the updates as provided above.

402. For grey seal associated with the Humber Estuary SAC, the same density as used for the assessment for the updated assessment for geophysical surveys as outlined above has been used across all noisy activities where the location is currently unknown (0.053 grey seal per km^2). The assessments for geophysical and seismic surveys have been updated using this density estimate (as outlined above), and the assessments for aggregate and dredging projects, cables and pipelines, and UXO clearance have also been updated with this density estimate.

403. For grey seal associated with the Humber Estuary SAC, up to 3,465.8 individuals (or 22.4% of the SAC population) could be disturbed as a result of disturbance from underwater noise in-combination with other projects (**Table 7-22**Table 6-33). This is an increase in the number of grey seal at risk of disturbance in comparison to **RIAA Section 8.4.3.4 (Table 8-74)** [APP-059], and a decrease in the proportion of the SAC population at risk of disturbance.

404. If all included activities were being undertaken at the same time as piling at SEP and DEP, there is the potential for an adverse effect on the SAC population, however, it is highly unlikely that all these activities would be conducted at exactly the same time as piling at SEP and DEP. The inclusion of two geophysical surveys and two oil and gas seismic surveys is highly precautionary, as is assessing all as moving sound sources. This is likely providing an overestimation in the potential disturbance areas assessed as grey seal are likely to return to an area following the survey taking place, rather than avoiding the full daily disturbance area for a full day. The inclusion of all offshore wind farms undertaking simultaneous piling is precautionary, as it is unlikely that it would be possible for that number of piling events to take place at the same time given current piling vessel availabilities.

405. In addition, with the implementation of any management measures for the Southern North Sea SAC, the potential impacts could be reduced. Any mitigation measures to reduce the disturbance of harbour porpoise in the project specific SIPs may also reduce the potential disturbance of grey seal.

406. In order to further understand the implications of in-combination disturbance on the grey seal Humber Estuary SAC population, population modelling has been undertaken (**Section 7.1.2.4**).

Table 7-22: Quantified In-Combination Assessment for the Potential Disturbance of Grey Seal Associated with the Humber Estuary SAC from All Underwater Noise Sources during Piling at SEP and DEP (Worst-Case)

In-combination underwater noise	Potential number of grey seal associated with the Humber Estuary SAC disturbed

In-combination underwater noise	Potential number of grey seal associated with the Humber Estuary SAC disturbed
Piling at SEP and DEP[92]	323
Piling at other OWFs[93]	2,378.1
Construction at other OWFs	75.2
Two OWF geophysical surveys	11.4
Two oil and gas seismic surveys	565.5
One high-order UXO detonation without mitigation	112.6
RIAA Table 8-74	
Total	1,610.6
% of reference population (% SAC count)	6.68% (41.3%)
Updated assessments	
Total	3,465.8
% of the Humber Estuary SAC population (15,495 grey seal)	22.37%

7.4.1.3 Updated In-Combination Assessment for The Wash and North Norfolk Coast SAC

In response to Natural England's Relevant Representation [RR-063], as stated in Applicant's Response (ID 7, 11, 59, 60, 61, 63, 67, 70, 71, 104, 106, 108, 115) [REP2-051].

7.4.1.3.1 Assessment of Disturbance from Underwater Noise

Updates to Underwater Noise Impacts during Construction from Offshore Wind Farm Piling

407. A review of the data available for screened in offshore wind farms has been undertaken, and the resultant assessments updated to take account of project specific data where possible (**Table 6-19**).

408. The same offshore wind farms have been included for assessment against harbour seal of The Wash and North Norfolk Coast SAC as provided in **RIAA Section 8.4.3.4** [APP-059], including;

- Dogger Bank South
- East Anglia ONE North
- East Anglia TWO
- Five Estuaries
- Hornsea Project Four

[92]Based on the dose response curve assessments (**Section 7.1.2.3**)
[93]Under the simultaneous piling scenario as the worst-case

- North Falls
- Outer Dowsing

409. The following provides an update to the assessment as provided in **RIAA Section 8.4.4.4** [APP-059]. Unless specified otherwise, the approach and methods of the assessment are as previously undertaken.

410. The following assessment of disturbance from other offshore wind farm piling has been updated to take account of project specific data and information where it is known. The currently available data for each screened in project are provided in **Table 6-19** above.

411. Where project specific data is not available, a generalised approach has been used to inform the assessment (following the methods used in **RIAA Section 8.4.4.4** [APP-059]. For seals, the generalised approach has been updated to cover the reported disturbance range of 25km (Russell *et al*., 2016) as per the updated assessment in **Section 7.1.2.2**. The Carter *et al*. (2022) densities have also been used to inform the assessments where relevant.

412. The following assessments are based on one piling event in SEP and one piling event in DEP (for simultaneous or sequential piling), as a worst-case. The assessments also provide assessments for single piling at each of the other screened in offshore wind farms, unless the project specific information includes simultaneous piling within their project design envelope. The overall in-combination disturbance for each species is based on either single piling in each of the other included offshore wind farms (as the more realistic case) as well as simultaneous piling for the relevant projects (as the worst-case).

413. For harbour seal, the assessment provided in **RIAA Section 8.4.4.4 (Table 8-84)** [APP-059] shows the potential for 88.9 individuals to be disturbed.

414. The updated assessment as provided in **Table 7-23**, based on project specific data (where available), and updated density and SAC population estimates (as summarised in **Section 5**) concludes that under the scenario of single piling at all other offshore wind farms, there is the potential for 163.3 harbour seal associated with The Wash and North Norfolk Coast SAC (or up to 4.1% of the SAC population) to be disturbed. For the in-combination scenario of simultaneous piling at the relevant projects, there is the potential for 160.3 harbour seal to be disturbed (or 4.1% of the SAC population). The number of harbour seal at risk of disturbance at Hornsea Project Four during simultaneous piling is lower than for single piling, due to the inclusion of piling at the HVAC under the single piling scenario (with a much higher presence of harbour seal). This represents an increase in the number of harbour seal at risk of disturbance from in-combination disturbance at other offshore wind farms when compared to the assessment provided within **RIAA Section 8.4.4.4 (Table 8-84)** [APP-059]. This is due to the inclusion of project specific data where information was available, and the inclusion of simultaneous piling for the relevant projects (i.e. Dogger Bank South (East & West) and Hornsea Project Four). In addition, for the projects where are generalised assessment was required due to a lack of project specific information,

the assessment uses the worst-case recorded disturbance ranges of seals (of 25km as reported by Russell *et al.,* 2016).

415. To determine the population level consequences of disturbance to harbour seal of The Wash and North Norfolk Coast SAC, population modelling has been undertaken (see **Section 7.4.1.4** for further information and results of the modelling assessment).

Table 7-23: Quantified In-Combination Assessment for the Potential Disturbance of Harbour Seal Associated with The Wash and North Norfolk Coast SAC during Piling at Offshore Wind Farm Projects which Could be Piling at the Same Time as SEP and DEP

Name of Project	Piling scenario	Density source	Harbour seal density	Disturbance	
				Impact area (km^2)	Maximum number of individuals potentially disturbed during single piling
SEP	Single piling	Carter *et al.* (2022) for The Wash and North Norfolk Coast SAC	Based on the dose response curve assessments (**Section 7.1.2.3**)		62
DEP	Single piling	Carter *et al.* (2022) for The Wash and North Norfolk Coast SAC			31
SEP & DEP together	Sequential or simultaneous piling	Carter *et al.* (2022) for The Wash and North Norfolk Coast SAC			93
Dogger Bank South (East and West)	*Generalised approach due to lack of further information*	Carter *et al.* (2022) for The Wash and North Norfolk Coast SAC	*0.0013*	*3,927*	*3.7*
East Anglia ONE North	*One pile per 24 hours*	*Russell 2017*	*0.0005*	*2124*	*1 (0.02% SE MU)*
East Anglia TWO	*One pile per 24 hours*	*Russell 2017*	*0.0007*	*2124*	*1.5 (0.03% SE MU & 0.003% ref pop)*
Five Estuaries	*Single (1 pile per 24 hours)*	Carter *et al.* (2022) for The Wash and North Norfolk Coast SAC	*0.00001*	-	*0.02*
	Concurrent piling (2 monopiles at the same time)	Carter *et al.* (2022) for The Wash and North Norfolk Coast SAC	*0.00001*	-	0.04
Hornsea Project Four	*Single (1 pile per 24 hours)*	*Carter 2020*	-	-	*5 (0.10% of SE MU)*
	Concurrent piling (2 monopiles at	Carter 2020	-	-	2 (0.04% of SE MU)

Name of Project	Piling scenario	Density source	Harbour seal	Disturbance	
	the same time)				
North Falls	*Generalised approach due to lack of further information*	Carter *et al.* (2022) for The Wash and North Norfolk Coast SAC	*0.001*	*1,963.5*	*0.2*
Outer Dowsing	*Generalised approach due to lack of further information*	Carter *et al.* (2022) for The Wash and North Norfolk Coast SAC	*0.03*	*1,963.5*	*58.9*
SEP and DEP together – worst-case scenario of all projects single piling					
Total number of harbour seal *(without SEP and DEP)*					163.3 *(70.3)*
Percentage of The Wash and North Norfolk Coast SAC population *(without SEP and DEP)*					4.14% *(1.78%)*
SEP and DEP together – best-case scenario of all projects simultaneously piling					
Total number of harbour seal *(without SEP and DEP)*					160.3 *(67.3)*
Percentage of The Wash and North Norfolk Coast SAC population *(without SEP and DEP)*					4.06% *(1.78%)*

Update to Cumulative Disturbance Assessment from other Offshore Wind Farm Construction Activities

In response to Natural England's Relevant Representation [RR-063], as stated in Applicant's Response (ID 7 and 59) [REP2-051].

416. The following provides an update to the assessment as provided in **RIAA Section 8.4.3.4** [APP-059]. Unless specified otherwise, the approach and methods of the assessment are as previously undertaken.

417. The potential disturbance from offshore wind farms during non-piling construction activities, such as vessel noise, sea bed preparation, rock placement and cable installation, has been updated to take account of project specific information where it is available.

418. For SEP and DEP, the cumulative assessment for all construction activities (other than piling) has been based on all five activities (0.15km^2) and 25 vessels (0.75km^2) which equals 0.90km^2 per project.

419. Where project specific information is not available, a generalised approach has been used to inform the assessment. This uses the above listed total disturbance areas, and for seals has been updated to include the updated Carter *et al*. (2022) densities.

420. Based on the projects that could have construction overlapping with SEP and DEP, the maximum number of harbour seal associated with The Wash and North Norfolk Coast SAC that could potentially be disturbed is 33.3 (0.84% of the SAC population) (**Table 7-24**). As less than 5% of the population are at risk of disturbance, there is no potential for a significant effect.

421. The assessment provided in **RIAA Section 8.4.4.4 (Table 8-84)** [APP-059] concluded that 0.006 harbour seal may be at risk of disturbance from construction activities at other offshore wind farms. While the number of seals at risk of disturbance has increased under the updated assessments, there is no change to the overall assessment of effect as assessed within **RIAA Section 8.4.4.4** [APP-059]. Therefore, as assessed in **RIAA Section 8.4.4.4**, there is **no potential for adverse effect on the integrity of the harbour seal feature of The Wash and North Norfolk Coast SAC**.

Table 7-24: Quantified In-Combination Assessment for the Potential Disturbance of Harbour Seal during the Construction (Other than Piling) at Offshore Wind Farm Projects at the Same Time as Construction at SEP and DEP

Name of Project	Area (km^2)	Density source	Harbour seal density	Updated assessment
				Maximum number of harbour seal potentially disturbed
SEP	0.90	Carter *et al.* (2022) for The Wash and North Norfolk Coast SAC	0.057	0.051
DEP	0.90	Carter *et al.* (2022) for The Wash and North Norfolk Coast SAC	0.072	0.065
Norfolk Boreas	453	Russell *et al.*, 2017	0.02	9.1[47]
Norfolk Vanguard[94]	829	Russell *et al.*, 2017	-	24.1
Total number of harbour seal *(without SEP and DEP)*				**33.3 (33.2)**
Percentage of The Wash and North Norfolk Coast SAC population *(without SEP and DEP)*				**0.84% (0.84%)**

Update to Cumulative Disturbance Assessment from Geophysical and Seismic Surveys at Other OWFs

Potential for Disturbance from Offshore Wind Farm Geophysical Surveys

In response to Natural England's Relevant Representation [RR-063], as stated in Applicant's Response (ID 7, 71 and 106) [REP2-051].

[94] ES Chapter 12 Marine Mammals

422. As assessed in **RIAA Section 8.4.4.4** [APP-059], as a worst-case for geophysical surveys, it has been assumed that grey seal within 1km (a total area of 3.1km^2), could be disturbed for each geophysical survey.

423. However, this assessment has been updated to reflect that geophysical surveys are a moving source, rather than a stationary one (i.e. the distance at which a survey vessel could travel in one day, with a 5km buffer area).

424. It is difficult to determine what the potential area of effect would be when taking into account it is a moving source (as it is difficult to predict how far a vessel may survey in a day). Based on survey vessels travelling at a speed of 4.5 to 5 knots, up to 199km could be surveyed in one day. This however does not take into account the survey downtime for line changes, weather, or other technical reason.

425. A review of seismic surveys within the UK indicated that surveys were being undertaken for approximately 52% of the time (BEIS, 2020). This data has been applied to geophysical surveys due to their similarity in approach. Taking this into account, up to 103.5km of surveys could be undertaken in one day, resulting in a potential disturbance area of 210.1km^2 with the 1km disturbance buffer applied. This is highly precautionary as it is unlikely that the whole seismic survey transect area would be cause disturbance to harbour seals.

426. For harbour seal, densities were calculated for the entire area where individuals may have connectivity with The Wash and North Norfolk Coast SAC (i.e. an average density across all grid cells included within the Carter *et al*., 2022 data for The Wash and North Norfolk Coast SAC). This assumes that the activity may take place in any area where harbour seals are shown to have connectivity with the site. This is 0.027 harbour seal per km^2.

427. The updated assessments for an in-combination effect from geophysical surveys is shown in **Table 7-20**. The maximum number of harbour seal that could potentially be disturbed is 104.3 (or 2.6% of The Wash and North Norfolk Coast SAC population). As less than 5% of the population are at risk of disturbance, there is no potential for a significant effect.

428. The assessment provided in **RIAA Section 8.4.4.4 (Table 8-84)** [APP-059] concluded that 1.9 harbour seal may at risk of disturbance from geophysical surveys. While the number of seals at risk of disturbance has increased under the updated assessments, there is no change to the overall assessment of effect as assessed within **RIAA Section 8.4.3.4** [APP-059].

Table 7-25 Quantified In-Combination Assessment for the Potential Disturbance of Harbour Seal Associated with The Wash and North Norfolk Coast SAC for Offshore Wind Farm Geophysical Surveys at the Same Time as Piling at SEP and DEP

Species	Activity	Updated assessment[95]	
		Area of disturbance	Potential number disturbed (% of reference population)

[95]Based on the dose response curve assessments (**Section 7.1.2.3**)

Species	Activity	Updated assessment[95]	
Harbour seal	Piling at SEP	-	62
	Piling at DEP	-	31
	Disturbance from two geophysical surveys	420.2km2	11.4 (0.3%)
	In-combination assessment for harbour seal (% of SAC population)		**104.3 (2.6%)**

Potential for Disturbance from Oil and Gas Seismic Surveys

429. As assessed in **RIAA Section 8.4.4.4** [APP-059], a potential disturbance range of 17.0km (disturbance area of 907.9km^2) has been used in the in-combination assessment for harbour seal.

430. As for geophysical surveys, this assessment has been updated to reflect that oil and gas seismic surveys are a moving source, rather than a stationary one (i.e. the distance at which a survey vessel could travel in one day, with a buffer area reflecting the potential disturbance range). The same method of determining the potential total survey area in one day has used the same approach as outlined above, with up to 103.5km being surveyed in one day.

431. This results in a potential disturbance area of 5,334.8km^2 per seismic survey. This is highly precautionary as it is unlikely that the whole seismic survey transect area would cause disturbance to grey seal.

432. For harbour seal associated with The Wash and North Norfolk Coast SAC, the same density as used for the updated assessment for geophysical surveys as outlined above has been used (0.027 harbour seal per km^2).

433. The updated assessments for an in-combination effect from seismic surveys is shown in **Table 7-26**. The maximum number of harbour seal that could potentially be disturbed is 381.1 (or 9.7% of The Wash and North Norfolk Coast SAC population).

434. The assessment provided in **RIAA Section 8.4.4.4 (Table 8-84)** [APP-059] concluded that 79.9 harbour seal may be at risk of disturbance from seismic surveys. The updated assessment indicates a significant number of harbour seal associated with The Wash and North Norfolk Coast SAC could be disturbed due to seismic surveys taking place at the same time as piling at SEP and DEP. Population modelling has been undertaken for in-combination disturbance within the SAC, to determine whether there could be a population level consequence due to in-combination disturbance (see **Section 7.4.1.4**).

Table 7-26 Quantified In-Combination Assessment for the Potential Disturbance of Harbour Seal Associated with The Wash and North Norfolk Coast SAC for Offshore Wind Farm Seismic Surveys at the Same Time as Piling at SEP and DEP

Species	Activity	Updated assessment[96]	
		Area of disturbance	Potential number disturbed (% of reference population)
Harbour seal	Piling at SEP	-	62
	Piling at DEP	-	31
	Disturbance from up to two seismic surveys	10,669.6km2	288.1 (7.3%)
	In-combination assessment for harbour seal (% of the SAC population)		**381.1 (9.7%)**

Update to Overall Cumulative Disturbance Assessments

435. **RIAA Section 8.4.4.4** [APP-059] provides an overall in-combination assessment from all disturbance activities. The following sections provide an update to that assessment, based on the updates as provided above.

436. For harbour seal associated with The Wash and North Norfolk Coast SAC, the same density as used for the updated assessment for geophysical surveys as outlined above has been used across all noisy activities where the location is currently unknown (0.027 harbour seal per km^2). The assessments for geophysical and seismic surveys have been updated using this density estimate (as outlined above), and the assessments for aggregate and dredging projects, cables and pipelines, and UXO clearance have also been updated with this density estimate.

437. For harbour seal associated with The Wash and North Norfolk Coast SAC, up to 553.4 individuals (14.0% of the SAC population) could be disturbed as a result of in-combination disturbance (**Table 7-27**). This is an increase in the number of harbour seal at risk of disturbance in comparison to **RIAA Section 8.4.4.4 (Table 8-84)** [APP-059].

[96]Based on the dose response curve assessments (**Section 7.1.2.3**) l

438. If all included activities were being undertaken at the same time as piling at SEP and DEP, there is the potential for an adverse effect on the SAC population, however, it is highly unlikely that all these activities would be conducted at exactly the same time as piling at SEP and DEP. The inclusion of two geophysical surveys and two oil and gas seismic surveys is highly precautionary, as is assessing all as moving sound sources. This is likely providing an overestimation in the potential disturbance areas assessed as harbour seal are likely to return to an area following the survey taking place, rather than avoiding the full daily disturbance area for a full day. The inclusion of all offshore wind farms undertaking simultaneous piling is precautionary, as it is unlikely that it would be possible for that number of piling events to take place at the same time given current piling vessel availabilities.

439. In addition, with the implementation of any management measures for the Southern North Sea SAC, the potential impacts could be reduced. Any mitigation measures to reduce the disturbance of harbour porpoise in the project specific SIPs may also reduce the potential disturbance of harbour seal.

440. In order to further understand the implications of in-combination disturbance on the harbour seal feature of The Wash and North Norfolk Coast SAC population, population modelling has been undertaken (**Section 7.1.2.4**).

Table 7-27: Quantified In-Combination Assessment for the Potential Disturbance of Harbour Seal Associated with The Wash and North Norfolk Coast SAC from Cumulative Underwater Noise Sources during Piling at SEP and DEP (Worst-Case)

Cumulative underwater noise	Potential number of harbour seal disturbed
Piling at SEP and DEP[97]	93
Piling at other OWFs[98]	70.3
Construction at other OWFs	33.3
Two OWF geophysical surveys	11.4
Two oil and gas seismic surveys	288.1
One high-order UXO detonation without mitigation	57.3
RIAA Table 8-84	
Total	224.3
% of reference population (% of SAC population)	0.73% (5.98%)
Updated assessments	
Total	553.4
% of The Wash and North Norfolk Coast SAC population	14.02%

[97]Based on the dose response curve assessments (**Section 7.1.2.3**)
[98]Under the simultaneous piling scenario as the worst-case

7.4.1.4 Population Modelling for In-Combination Disturbance from Offshore Wind Farm Projects

In response to Natural England's Relevant Representation [RR-063], as stated in Applicant's Response (ID 61, 112) [REP2-051].

441. Population modelling of the in-combination disturbance of offshore wind farms for harbour porpoise has been undertaken in **Section 6.2.1.5.** As the overall population for the Southern North Sea SAC is the NS MU population, the population modelling undertaken in **Section 6.2.1.5** would also apply to the Southern North Sea SAC.

442. The results of the modelling show a 1.25 to 1.85% reduction in the NS harbour porpoise population at the end of the 25 year modelling period.

443. **Section 6.2.1.5** discusses the implications of a 1.25% to 1.85% reduction in the harbour porpoise population over 25 years, and concludes that the reduction would not cause a population level consequence. Therefore, for the in-combination assessment for disturbance, there would be **no adverse effect on the integrity of the Southern North Sea SAC due to in-combination disturbance to harbour porpoise**.

7.4.1.4.1 In-Combination Disturbance of Grey Seal Associated with Humber Estuary SAC

444. For the in-combination scenario assessed (see **Table 6-19** for details of the projects considered, and their parameters) within the Humber Estuary SAC population, the iPCoD model predicts only a slight discernible decrease in grey seal population size over time (**Plate 7-9** and **Table 7-28**). The mean population size for the impacted population was predicted to be 100% of the un-impacted population size at the end of 2026 (after the first year of pile driving has completed). By the end of 2031, the mean population size for the impacted population was predicted to be 99.92% of the un-impacted population size, then reducing further to 99.91% by the end of 2037. This 0.09% reduction in population size is predicted to remain to the end 2049, which is the end point of the modelling. It should be noted that this modelling did not account for any density dependent effects, which may increase the survival and fecundity rates of the impacted population, due to reduced intra-specific competition. There is therefore **no potential for adverse effect on the integrity of the Humber Estuary SAC due to in-combination disturbance to grey seal**.

Table 7-28 Results of the iPCoD modelling for the in-combination scenario, giving the mean population size of the Humber Estuary SAC grey seal population for years up to 2049 for both impacted and un-impacted populations as well as the mean and median ratio between their populations

Year	Un-impacted population mean	Impacted population mean	Median impacted as % of un-impacted	Mean impacted as % of un-impacted
Start	15,496	15,496	100%	100%

Year	Un-impacted population mean	Impacted population mean	Median impacted as % of un-impacted	Mean impacted as % of un-impacted
End 2026	15,641	15,642	100%	100%
End 2031	16,415	16,401	99.97%	99.92%
End 2037	17,454	17,439	99.98%	99.91%
End 2043	18,542	18,525	99.98%	99.91%
End 2049	19,761	19,744	99.98%	99.91%

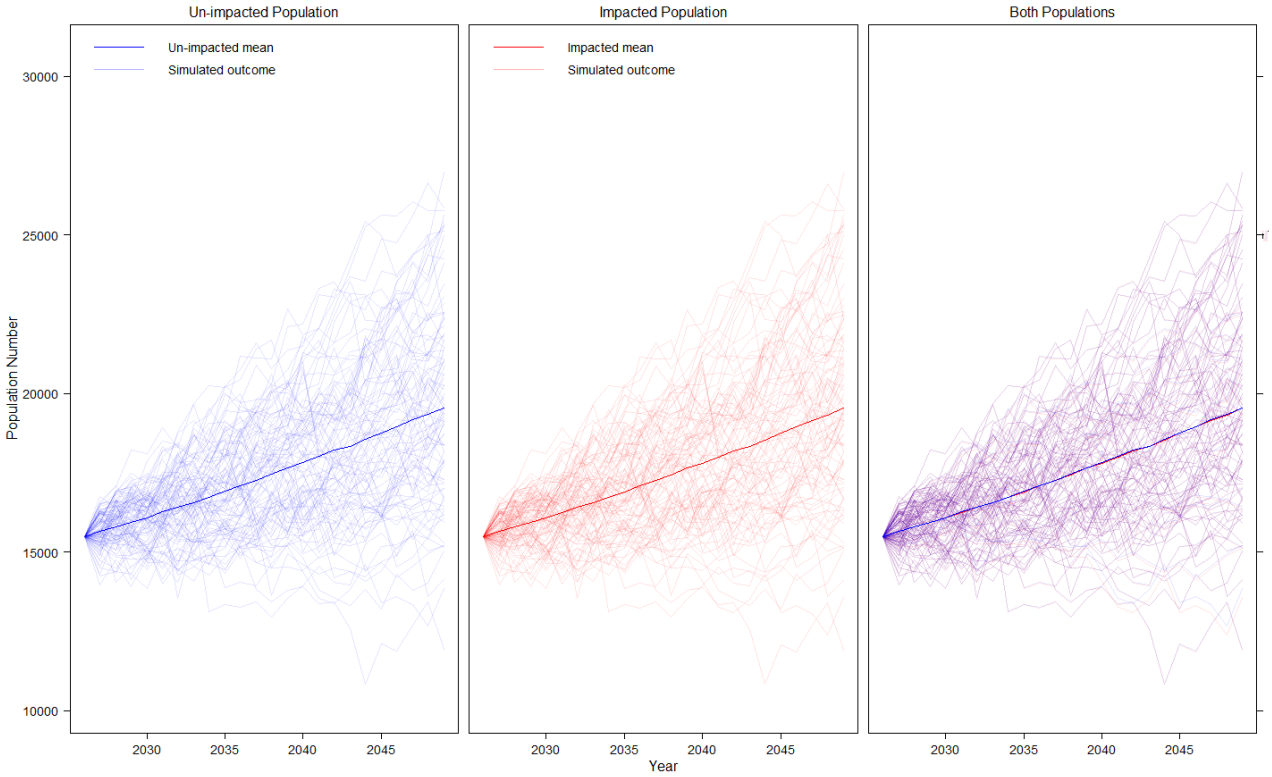

Plate 7-9 Simulated in-combination worst-case Humber Estuary SAC grey seal reference population sizes for both the un-impacted and the impacted populations

7.4.1.4.2 In-Combination Disturbance of Harbour Seal Associated with The Wash and North Norfolk Coast SAC

445. For the in-combination scenario assessed (see **Table 6-19** for details of the projects considered, and their parameters) within The Wash and North Norfolk Coast SAC, the iPCoD model predicts no discernible decrease in harbour seal population size over time (**Plate 7-10** and **Table 7-29**). The mean population size for the impacted population was predicted to be >99.99% of the un-impacted population size at the end of 2026 (after the first year of pile driving has completed). By the end of 2031 the mean population size for the impacted population was predicted to be 100% of the un-impacted population size. The lack

of difference in population sizes is predicted to remain to the end of 2049, which is the end point of the modelling. Therefore, there is **no potential for adverse effect on the integrity of The Wash and North Norfolk Coast SAC due to in-combination disturbance to harbour seal**.

Table 7-29 Results of the iPCoD modelling for the in-combination scenario, giving the mean population size of The Wash SAC harbour seal population for years up to 2049 for both impacted and un-impacted populations as well as the mean and median ratio between their populations

Year	Un-impacted population mean	Impacted population mean	Median impacted as % of un-impacted	Mean impacted as % of un-impacted
Start	3954	3954	100%	100%
End 2026	3247	3247	100%	>99.99%
End 2031	1201	1203	100%	100%
End 2037	367	368	100%	100%
End 2043	113	113	100%	100%
End 2049	35	35	100%	100%

**Note that the model assumes that population demographics remain constant over time. This means that the currently declining population is projected to continue its decline regardless of any additional piling activity.*

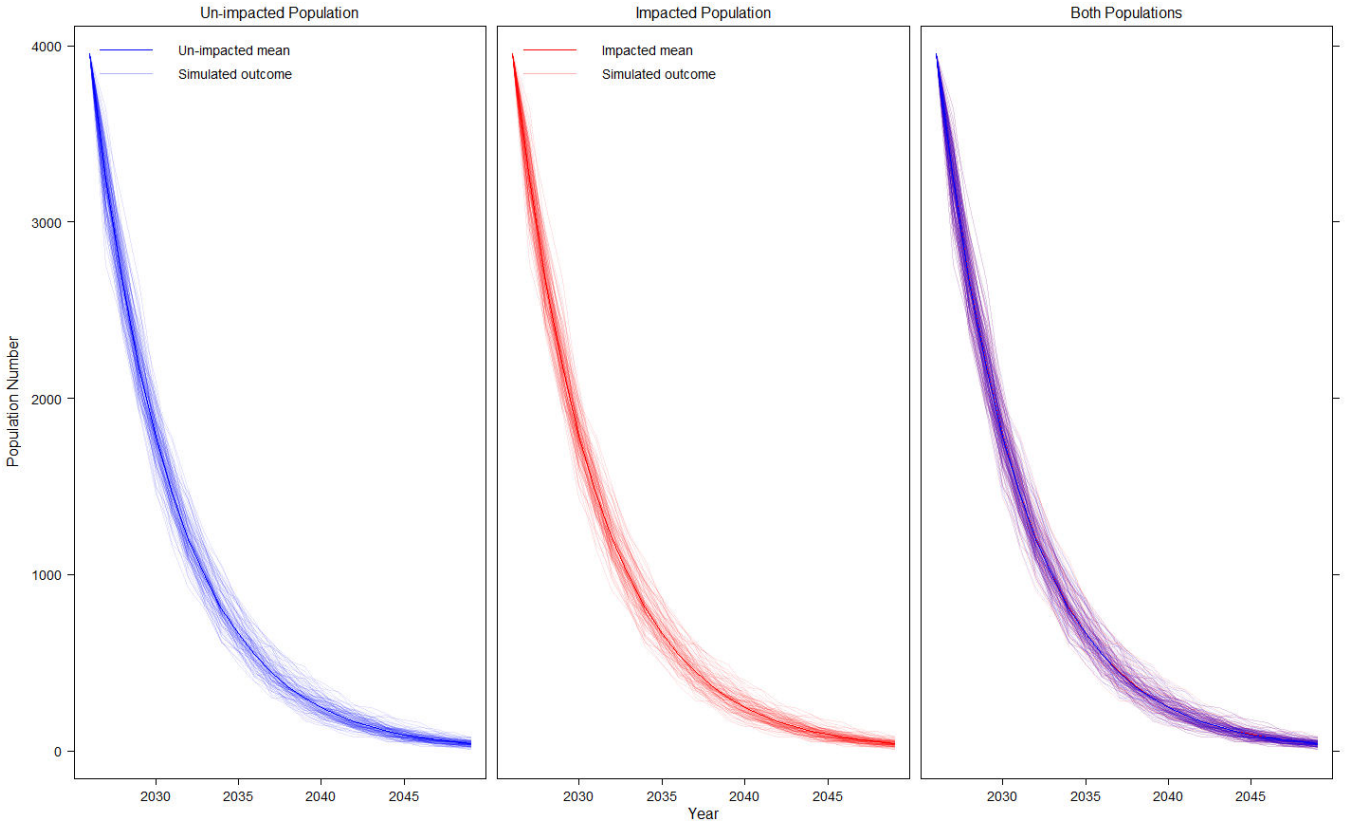

Plate 7-10 Simulated in-combination worst-case The Wash and North Norfolk Coast SAC harbour seal population sizes for both the un-impacted and the impacted populations

7.4.1.5 Need for Further Mitigation

446. The results of the population modelling, as provided in **Section 7.4.1.4** above, have shown that while a potential for an adverse effect to harbour porpoise, grey seal and harbour seal was predicted for SEP and DEP, there would be no effect on the population of any of these species (i.e. there is no significant difference between the disturbed and undisturbed population estimates at the end of the 25 year period), and there would therefore be no potential for adverse effect. No mitigation for disturbance is therefore proposed (or required) for piling at SEP and DEP.

7.4.2 Seal Haul-Out Sites

In response to Natural England's Relevant Representation [RR-063], as stated in Applicant's Response (ID 68) [REP2-051].

447. Further information on the screening out of disturbance to seal haul-out sites from the in-combination assessment has been provided below.

448. As assessed for SEP and DEP (**RIAA Section 8.4.3** and **8.4.4** [APP-059]), there is no potential for adverse effect to either of the included seal SACs due to disturbance at seal haul-out sites from the Projects alone. This conclusion is drawn from the low sensitivity of seals to disturbance at haul-out sites, with the exception of during the relevant pupping and breeding periods of both species,

where they have an increased sensitivity to disturbance. All vessel movements to and from SEP and DEP would utilise already established vessel routes, and, as stated in the **Outline Project Environmental Management Plan (PEMP) (Revision C)** [document reference 9.10] where possible and safe to do so, transiting vessels will maintain distances of 600m or more off the coast, particularly in areas near known seal haul-out sites during sensitive periods.

449. It is therefore considered unlikely that there will be significant in-combination effects at seal haul-out sites given the distance of SEP and DEP from the nearest site of Blakeney Point (12km from the landfall / cable corridor), the limited disturbance ranges from vessels (of 300m to 600m), and the vessel safety requirements to avoid near shore waters, as well as the expected habituation of seals to vessels in the area. In addition, good practice measures would be implemented by SEP and DEP (as outlined in the **Outline PEMP (Revision C)** [document reference 9.10].

450. It is assumed that all other projects would follow the same good practice measures with regards to avoiding disturbance at haul-out sites. In addition, where seal haul-out sites are near to a vessel corridor, the seals present in that area would be used to vessels transiting past the area. Therefore, there would be **no adverse effect on the integrity of either the Humber Estuary SAC or The Wash and North Norfolk Coast SAC in relation to the conservation objectives for grey seal and harbour seal respectively due to disturbance at seal haul-out sites during construction for SEP and DEP**.

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Annex 1

Potential for Impact due to Underwater Noise Associated with Horizontal Directional Drilling

In response to the Examining Authority's Second Written Questions [PD-012] Question 2.12.2.2.

451. Horizontal Directional Drilling (HDD) is a minimal impact trenchless method of installing underground utilities such as pipe, conduit, or cables along an underground path, using a surface-launched drilling rig. Directional boring offers significant environmental advantages over traditional cut and cover pipeline/utility installations. The technique is routinely used when conventional trenching or excavating is not practical or when minimal surface disturbance is required.

452. HDD is generally accomplished in three principal phases;

- A small diameter pilot hole is drilled along a directional path from one surface point to another (onshore).
- The bore created during pilot hole drilling is enlarged to a diameter that will facilitate installation of the desired pipeline.
- The pipeline is pulled into the enlarged hole, thus creating a continuous segment of pipe underground exposed only at the two initial endpoints.

453. The majority of noise from the HDD process will be generated onshore, by the drilling rig itself, and therefore is not considered likely to disturb marine mammals. As the drilling activity progresses beneath the seabed, there is a potential for underwater noise to be generated due to contact between the drill head and hard ground beneath the seabed. However, the majority of drilling activity will be undertaken at a depth of greater than 10 m under the seabed and it is therefore not considered that this will be audible through this thickness of seabed. There is the potential for some noise to become audible as the drill nears the seabed surface.

454. It would be expected that drilling activity required would result in similarly low levels of underwater noise for a period of approximately five days per drill during the breakthrough to the seabed surface. There would then be a gap of up to five days before the next drilling process would begin.

455. Noise levels generated by HDD works would vary depending on ground and sea conditions, and little information is available on underwater noise levels generated from HDD. However, it is not expected that HDD operations will produce any significant noise since the noise generating equipment will all be located onshore with the exception of the drill bit and string which will be under the sea floor.

456. Drilling noise, when audible, would be a continuous noise rather than impulsive noise, and there would be some masking of drilling noise by vessels in the vicinity of the works. Due to the low level of associated noise, and continuous nature of

the noise, it would be expected the noise generated by the HDD drill would be partially masked by natural noise emitted by waves and weather in shallow water.

457. Underwater noise modelling undertaken for an application to National Oceanic and Atmospheric Administration (NOAA) in relation to the Port Dolphin Energy LLC Deepwater port (2011), considered HDD activities and estimated a maximum SEL of 154 dB @ 250 Hz, and predicted a disturbance impact radius of 250 m.

458. Measurements of a generic HDD operation have been taken by Subacoustech Environmental Ltd in shallow riverine conditions while drilling was being undertaken directly below the riverbed (Beatrice Offshore Wind Limited, 2012). Measurements with HDD operations occurring 39m below the river bed gave maximum unweighted SPLs of 129.5 dB re. 1µPa on the riverbed, which equates to measured dB_{ht} levels of between 25 and 41 dB_{ht} for harbour seal and between 26 and 47 dB_{ht} for harbour porpoise.

459. Southall *et al.,* 2007 completed a literature review looking at impacts of noise on marine mammals. There is very little documented on disturbance ranges for marine mammals, however their findings were for pinnipeds; disturbance from continuous noise exposure in the water suggested that exposures between ~90 and 140 dB re: 1 µPa generally do not appear to induce strong behavioural responses in pinnipeds.

460. Very high frequency cetaceans such as harbour porpoises are quite sensitive to a wide range of anthropogenic sounds at very low exposure received levels (~90 to 120 dB re: 1 µPa), at least for initial exposures.

461. High frequency cetaceans, such as dolphin species, when exposed to received levels 110- 150 dB SPL; have shown a varied response, such as no response, change of orientation, modified or cessation of vocal activity, showing signs of alertness, changes in respiration rate.

462. For baleen whales, exposure received levels of 100-140 dB SPL have shown a varied response, such as no response, change of orientation, modified or cessation of vocal activity, showing signs of alertness, changes in respiration rate, changes in locomotion speed, diving activity along with minor or moderate individual and/or group avoidance of sound source. In contrast, early observations of bowhead and grey whales exposed to continuous industrial sounds, such as those associated with drilling operations, suggested 120 dB re: 1 µPa as the approximate threshold for behavioural disturbance of these baleen whales (Malme *et al*., 1984; Richardson *et al.,* 1990a, 1995).

463. The above review of underwater noise associated with HDD activities suggests that there would be no potential for auditory injury due to the very low noise levels associated with the works, however, there is the potential for localised disturbance to occur. If any marine mammal was going to suffer disturbance from HDD, they would have to be in extremely close proximity to the source which is very unlikely, and they would be more likely to react to the vessels associated with the works than for the HDD works themselves.

464. The focus of standard mitigation protocols on mammals is around the prevention of auditory injury through percussive noise, and as noted above, there is no

potential for auditory injury due to HDD activities. The HDD works would also generate continuous rather than impulsive noise, which marine mammals are less sensitive to.

465. There are no guidelines for mitigation for disturbance for continuous noise sources, and therefore no requirement to mitigation for these works.

Annex 2

Update to all assessments as provided within the ES Chapter 10 [APP-096] that rely on grey seal or harbour seal density estimates and reference populations

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1 Introduction

1. This Annex provides an update to all assessments as provided within the **ES Chapter 10** [APP-096] that rely on the grey seal and harbour seal density and population estimates. For both seal species, the density estimate and population numbers have been updated in line with the Natural England Relevant Representations [RR-063], and as described in **Section 3** of the Marine Mammal Technical Note and Addendum.
2. In the case of any changes in magnitude or significance levels to those as presented within ES Chapter 12, these are highlighted red within each assessment.

2 Updated Assessments for Grey and Harbour Seal within the Environmental Statement

In response to Natural England's Relevant Representation (RR-063), as stated in Applicant's Response (ID 28, 29, 48) [REP2-051].

2.1 Potential Impacts during Construction

2.1.1 Updates to Assessments for Auditory Injury from Underwater Noise Associated with Piling (ES Section 10.6.1.1; Impact 1 [APP-096])

2.1.1.1 SEP or DEP in Isolation

2.1.1.1.1 Magnitudes for PTS from SEP or DEP in Isolation (Section 10.6.1.1.3.1)

PTS from First Strike of Soft-Start

3. **Table 2-1** presents updates for a single strike of the starting hammer energy for monopiles, with a hammer energy of 1,000kJ. There were no changes in magnitude for grey and harbour seal in the updated assessment for SEP or DEP.

Table 2-1 Maximum Number of Individuals (and % of Reference Population) that Could be at Risk of PTS from First Strike of Soft-Start for Monopile without Mitigation, based on Worst-Case at SEP and DEP

Species	Location	ES (Table 10-29)		Updated Assessment	
		Monopile with starting hammer energy of 1,000kJ		Monopile with starting hammer energy of 1,000kJ	
		Maximum number of individuals (% of reference population)	Magnitude* (permanent impact)	Maximum number of individuals (% of reference population)	Magnitude* (permanent impact)
Grey seal (PW)	SEP	0.009 (0.000098% of SE MU; or 0.000035% of wider ref pop)	**Negligible (negligible)**	0.009 (0.00006% of SE MU; or 0.00002% of wider ref pop)	**Negligible (negligible)**
	DEP	0.0074 (0.000085% of SE MU; or	**Negligible (negligible)**	0.008 (0.00002% of SE MU; or	**Negligible (negligible)**

Species	Location	ES (Table 10-29)		Updated Assessment	
		Monopile with starting hammer energy of 1,000kJ		Monopile with starting hammer energy of 1,000kJ	
		Maximum number of individuals (% of reference population)	Magnitude* (permanent impact)	Maximum number of individuals (% of reference population)	Magnitude* (permanent impact)
		0.000031% of wider ref pop)		0.00001% of wider ref pop)	
Harbour seal (PW)	SEP	0.0027 (0.000073% of SE MU; or 0.0000090% of wider ref pop)	**Negligible (negligible)**	0.003 (0.00005% of SE MU)	**Negligible**
	DEP	0.0008 (0.000021% of SE MU; or 0.0000026% of wider ref pop)	**Negligible (negligible)**	0.0008 (0.00002% of SE MU)	**Negligible**

4. **Table 2-2** presents updates for a single strike of the starting hammer energy for pin-piles, with a hammer energy of 400kJ. There were no changes in magnitude for grey and harbour seal in the updated assessment for SEP or DEP.

Table 2-2 Maximum Number of Individuals (and % of Reference Population) that Could be at Risk of PTS from First Strike of Soft-Start for Pin-Pile without Mitigation, based on Worst-Case at SEP and DEP

Species	Location	ES (Table 10-29)		Updated Assessment	
		Pin-pile with starting hammer energy of 400kJ		Pin-pile with starting hammer energy of 400kJ	
		Maximum number of individuals (% of reference population)	Magnitude* (permanent impact)	Maximum number of individuals (% of reference population)	Magnitude* (permanent impact)
Grey seal (PW)	SEP	0.005 (0.000098% of SE MU; or 0.000035% of wider ref pop)	**Negligible (negligible)**	0.009 (0.00003% of SE MU; or 0.00002% of wider ref pop)	**Negligible (negligible)**
	DEP	0.0009 (0.000085% of SE MU; or 0.000031% of wider ref pop)	**Negligible (negligible)**	0.008 (0.00002% of SE MU; or 0.00001% of wider ref pop)	**Negligible (negligible)**
Harbour seal (PW)	SEP	0.0021 (0.000073% of SE MU; or 0.0000090% of wider ref pop)	**Negligible (negligible)**	0.003 (0.00005% of SE MU)	**Negligible**
	DEP	0.0024 (0.000021% of SE MU; or 0.0000026% of wider ref pop)	**Negligible (negligible)**	0.001 (0.00001% of SE MU)	**Negligible**

PTS from Single Strike at Maximum Hammer Energy

5. **Table 2-3** presents updates for a single strike of the maximum hammer energy for monopiles, with a hammer energy of 5,500kJ. There were no changes in magnitude for grey and harbour seal in the updated assessment for SEP or DEP.

Table 2-3 Maximum Number of Individuals (and % of Reference Population) that Could be at Risk of PTS from Single Strike of Monopile at Maximum Hammer Energy without Mitigation, based on Worst-Case at SEP and DEP

Species	Location	ES (Table 10-30)		Updated Assessment	
		Monopile with maximum hammer energy of 5,500kJ		Monopile with maximum hammer energy of 5,500kJ	
		Maximum number of individuals (% of reference population)	Magnitude* (permanent impact)	Maximum number of individuals (% of reference population)	Magnitude* (permanent impact)
Grey seal (PW)	SEP	0.009 (0.000098% of SE MU; or 0.000035% of wider ref pop)	**Negligible (negligible)**	0.009 (0.00003% of SE MU; or 0.00002% of wider ref pop)	**Negligible (negligible)**
	DEP	0.0074 (0.000085% of SE MU; or 0.000031% of wider ref pop)	**Negligible (negligible)**	0.008 (0.00002% of SE MU; or 0.00001% of wider ref pop)	**Negligible (negligible)**
Harbour seal (PW)	SEP	0.0027 (0.000073% of SE MU; or 0.000009% of wider ref pop)	**Negligible (negligible)**	0.003 (0.00005% of SE MU)	**Negligible**
	DEP	0.0008 (0.000021% of SE MU; or 0.0000026% of wider ref pop)	**Negligible (negligible)**	0.0008 (0.00002% of SE MU)	**Negligible**

6. **Table 2-4** presents updates for a single strike of the maximum hammer energy for pin-piles, with a hammer energy of 3,000kJ. There were no changes in magnitude for grey and harbour seal in the updated assessment for SEP or DEP.

Table 2-4 Maximum Number of Individuals (and % of Reference Population) that Could be at Risk of PTS from Single Strike of Pin-pile at Maximum Hammer Energy without Mitigation, based on Worst-Case at SEP and DEP

Species	Location	ES (Table 10-30)		Updated Assessment	
		Pin-pile with maximum hammer energy of 3,000kJ		Pin-pile with maximum hammer energy of 3,000kJ	
		Maximum number of individuals (% of reference population)	Magnitude* (permanent impact)	Maximum number of individuals (% of reference population)	Magnitude* (permanent impact)
Grey seal (PW)	SEP	0.009 (0.000098% of SE MU; or 0.000035% of wider ref pop)	**Negligible (negligible)**	0.009 (0.00003% of SE MU; or 0.00002% of wider ref pop)	**Negligible (negligible)**

Species	Location	ES (Table 10-30)		Updated Assessment	
		Pin-pile with maximum hammer energy of 3,000kJ		Pin-pile with maximum hammer energy of 3,000kJ	
		Maximum number of individuals (% of reference population)	Magnitude* (permanent impact)	Maximum number of individuals (% of reference population)	Magnitude* (permanent impact)
	DEP	0.0074 (0.000085% of SE MU; or 0.000031% of wider ref pop)	**Negligible (negligible)**	0.008 (0.00002% of SE MU; or 0.00001% of wider ref pop)	**Negligible (negligible)**
Harbour seal (PW)	SEP	0.0027 (0.000073% of SE MU; or 0.000009% of wider ref pop)	**Negligible (negligible)**	0.003 (0.00005% of SE MU)	**Negligible**
	DEP	0.0008 (0.000021% of SE MU; or 0.0000026% of wider ref pop)	**Negligible (negligible)**	0.0008 (0.00002% of SE MU)	**Negligible**

**Magnitudes and significance given in brackets are for the wider population for seal species*

PTS from Cumulative Exposure of a Single Pile

7. **Table 2-5** presents updates for the cumulative exposure of one monopile installation. The magnitude for grey seal changed from a medium to low magnitude in the updated assessment at DEP. There were no changes in magnitude for grey seal at DEP and for harbour seal at SEP or DEP.

Table 2-5: Maximum Number of Individuals (and % of Reference Population) that Could be at Risk of PTS from Cumulative Exposure (SEL_{cum}) During Installation of Monopile without Mitigation, Based on Worst-Case at SEP or DEP

Species	Location	ES (Table 10-31)		Updated Assessment	
		Monopile with maximum hammer energy of 5,500kJ		Monopile with maximum hammer energy of 5,500kJ	
		Maximum number of individuals (% of reference population)	Magnitude* (permanent impact)	Maximum number of individuals (% of reference population)	Magnitude* (permanent impact)
Grey seal (PW)	SEP	0.72 (0.008% of SE MU; or 0.003% of wider ref pop)	**Low (low)**	0.63 (0.002% of SE MU; or 0.0013% of wider ref pop)	**Low (low)**
	DEP	1.03 (0.0012% of SE MU; or 0.0043% of wider ref pop)	**Medium (low)**	1.09 (0.003% of SE MU; or 0.002% of wider ref pop)	**Low (low)**
Harbour seal (PW)	SEP	0.23 (0.006% of SE MU; or 0.0008% of wider ref pop)	**Low (negligible)**	0.22 (0.005% of SE MU)	**Low**
	DEP	0.11 (0.003% of SE MU; or 0.0004% of wider ref pop)	**Low (negligible)**	0.11 (0.002% of SE MU)	**Low**

**Magnitudes given in brackets are for the wider population for seal species*

8. **Table 2-6** presents updates for the cumulative exposure of one pin-pile installation. The magnitude for grey seal changed from a low to negligible magnitude in the updated assessment at SEP. There were no changes in magnitude for grey seal at DEP and for harbour seal at SEP or DEP.

Table 2-6: Maximum Number of Individuals (and % of Reference Population) that Could be at Risk of PTS from Cumulative Exposure (SEL_{cum}) During Installation of Pin-Pile without Mitigation, Based on Worst-Case at SEP or DEP

Species	Location	ES (Table 10-31)		Updated Assessment	
		Pin-pile with maximum hammer energy of 3,000kJ		Pin-pile with maximum hammer energy of 3,000kJ	
		Maximum number of individuals (% of reference population)	Magnitude* (permanent impact)	Maximum number of individuals (% of reference population)	Magnitude* (permanent impact)
Grey seal (PW)	SEP	0.09 (0.001% of SE MU; or 0.0004% of SE MU)	**Low (negligible)**	0.09 (0.0003% of SE MU or 0.0001% of wider ref pop)	**Negligible (negligible)**
	DEP	0.074 (0.0009% of SE MU; or 0.00031% of wider ref pop)	**Negligible (negligible)**	0.08 (0.0002% of SE MU or 0.0001% of wider ref pop)	**Negligible (negligible)**

Species	Location	ES (Table 10-31)		Updated Assessment	
		Pin-pile with maximum hammer energy of 3,000kJ		Pin-pile with maximum hammer energy of 3,000kJ	
		Maximum number of individuals (% of reference population)	Magnitude* (permanent impact)	Maximum number of individuals (% of reference population)	Magnitude* (permanent impact)
Harbour seal (PW)	SEP	0.027 (0.0007% of SE MU; or 0.00009% of wider ref pop)	**Negligible (negligible)**	0.03 (0.0005% of SE MU)	**Negligible**
	DEP	0.008 (0.0002% of SE MU; or 0.00003% of wider ref pop)	**Negligible (negligible)**	0.008 (0.0002% of SE MU)	**Negligible**

**Magnitudes given in brackets are for the wider population for seal species*

PTS from Cumulative Exposure of Sequential Piling

9. **Table 2-7** presents updates for the cumulative exposure of one monopile installation. The magnitude for grey seal changed from medium to low magnitude in the updated assessment at DEP. There were no changes in magnitude for grey seal at SEP and harbour seal at SEP or DEP.

Table 2-7: Maximum Number of Individuals (and % of Reference Population) that Could be at Risk of PTS from Cumulative Exposure (SEL_{cum}) During Sequential Piling, Based on Worst-Case at SEP or DEP

Species	Location	ES (Table 10-32)		Updated Assessment	
		Two monopiles (16m diameter; 5,500kJ)		Two monopiles (16m diameter; 5,500kJ)	
		Maximum number of individuals (% of reference population)	Magnitude* (permanent impact)	Maximum number of individuals (% of reference population)	Magnitude* (permanent impact)
Grey seal (PW)	SEP	0.72 (0.008% of SE MU; or 0.003% of wider ref pop)	**Low (low)**	0.63 (0.002% of SE MU; or 0.0011% of wider ref pop)	**Low (low)**
	DEP	1.03 (0.012% of SE MU; or 0.0043% of wider ref pop)	**Medium (low)**	1.0 (0.003% of SE MU; or 0.002% of wider ref pop)	**Low (low)**
Harbour seal (PW)	SEP	0.15 (0.004% of SE MU; or 0.0003% of wider ref pop)	**Low (negligible)**	0.18 (0.004% of SE MU)	**Low**
	DEP	0.31 (0.008% of SE MU; or 0.0007% of wider ref pop)	**Low (negligible)**	0.10 (0.002% of SE MU)	**Low**

**Magnitudes given in brackets are for the wider population for seal species.*

10. **Table 2-8** presents updates for the cumulative exposure of one pin-pile installation. The magnitude for grey seal changed from a low to negligible magnitude in the updated assessment at SEP. There were no changes in magnitude for grey seal at DEP and for harbour seal at SEP or DEP.

Table 2-8: Maximum Number of Individuals (and % of Reference Population) that Could be at Risk of PTS from Cumulative Exposure (SEL_{cum}) During Sequential Piling, Based on Worst-Case at SEP or DEP

Species	Location	ES (Table 10-32)		Updated Assessment	
		Four pin-pile (4m diameter; 3,000kJ)		Four pin-pile (4m diameter; 3,000kJ)	
		Maximum number of individuals (% of reference population)	Magnitude* (permanent impact)	Maximum number of individuals (% of reference population)	Magnitude* (permanent impact)
Grey seal (PW)	SEP	0.09 (0.001% of ref pop (or 0.0004% of SE MU)	**Low (negligible)**	0.09 (0.0003% of SE MU; or 0.0001% of wider ref pop)	**Negligible (negligible)**
	DEP	0.074 (0.0009% of SE MU; or 0.00031% of wider ref pop)	**Negligible (negligible)**	0.08 (0.0002% of SE MU; or 0.0001% of wider ref pop)	**Negligible (negligible)**
Harbour seal (PW)	SEP	0.021 (0.0006% of SE MU; or 0.00005% of wider ref pop)	**Negligible (negligible)**	0.03 (0.0005% of SE MU)	**Negligible**
	DEP	0.024 (0.0006% of SE MU; or 0.00005% of wider ref pop)	**Negligible (negligible)**	0.008 (0.0002% of SE MU)	**Negligible**

**Magnitudes given in brackets are for the wider population for seal species*

2.1.1.1.2 Magnitudes for TTS from SEP or DEP in Isolation (Section 10.6.1.1.3.2)

TTS from Single Strike at Maximum Hammer Energy

11. **Table 2-9** presents updates for single strike of maximum hammer energy for monopiles, with a hammer energy of 5,500kJ. There were no changes in magnitude in the updated assessment for grey or harbour seal at SEP or DEP.

Table 2-9: Maximum Number of Individuals (and % of Reference Population) that Could be at Risk of TTS from Single Strike of Monopile at Maximum Hammer Energy without Mitigation, Based on Worst-Case at SEP or DEP

			ES (Table 10-33)		Updated	
Species	**Criteria and threshold (Southall *et al*., 2019)**	**Location**	**Monopile with maximum hammer energy of 5,500kJ**		**Monopile with maximum hammer energy of 5,500kJ**	
			Maximum number of individuals (% of reference population)	**Magnitude* (temporary impact)**	**Maximum number of individuals (% of reference population)**	**Magnitude* (temporary impact)**
Grey seal (PW)	SEL_{ss} Weighted (170 dB re 1µPa^{2}s) Impulsive	SEP	0.09 (0.0011% of SE MU; or 0.00039% of wider ref pop)	**Negligible (negligible)**	0.099 (0.00029% of SE MU; or 0.00016% of wider ref pop)	**Negligible (negligible)**
		DEP	0.096 (0.0011% of SE MU; or 0.00040% of wider ref pop)	**Negligible (negligible)**	0.101 (0.00029% of SE MU; or 0.00017% of wider ref pop)	**Negligible (negligible)**
Harbour seal (PW)	SEL_{ss} Weighted (170 dB re 1µPa^{2}s) Impulsive	SEP	0.03 (0.0008% of SE MU; or 0.000099% of wider ref pop)	**Negligible (negligible)**	0.03 (0.00059% of SE MU)	**Negligible**
		DEP	0.01 (0.00028% of SE MU; or 0.000034% of wider ref pop)	**Negligible (negligible)**	0.01 (0.00020% of SE MU)	**Negligible**

**Magnitudes given in brackets are for the wider population for seal species*

12. **Table 2-10** presents updates for single strike of maximum hammer energy for pin-piles, with a hammer energy of 3,000kJ. There were no changes in magnitude in the updated assessment for grey or harbour seal at SEP or DEP.

Table 2-10: Maximum Number of Individuals (and % of Reference Population) that Could be at Risk of TTS from Single Strike of Pin-Pile at Maximum Hammer Energy without Mitigation, Based on Worst-Case at SEP or DEP

			ES (Table 10-33)		Updated	
Species	**Criteria and threshold (Southall *et al*., 2019)**	**Location**	**Pin-pile with maximum hammer energy of 3,000kJ**		**Pin-pile with maximum hammer energy of 3,000kJ**	
			Maximum number of individuals (% of reference population)	**Magnitude* (temporary impact)**	**Maximum number of individuals (% of reference population)**	**Magnitude* (temporary impact)**
Grey seal (PW)	SEL_{ss} Weighted (170 dB re 1µPa^{2}s) Impulsive	SEP	0.05 (0.0011% of SE MU; or 0.00039% of wider ref pop)	**Negligible (negligible)**	0.099 (0.00029% of SE MU; or 0.00016% of wider ref pop)	**Negligible (negligible)**
		DEP	0.0089 (0.00102% of SE MU; or 0.00037% of wider ref pop)	**Negligible (negligible)**	0.094 (0.00027% of SE MU; or 0.00016% of wider ref pop)	**Negligible (negligible)**
Harbour seal (PW)	SEL_{ss} Weighted (170 dB re 1µPa^{2}s) Impulsive	SEP	0.03 (0.0008% of SE MU; or 0.000099% of wider ref pop)	**Negligible (negligible)**	0.03 (0.00059% of SE MU)	**Negligible**
		DEP	0.01 (0.00026% of SE MU; or 0.000031% of wider ref pop)	**Negligible (negligible)**	0.01 (0.00019% of SE MU)	**Negligible**

**Magnitudes given in brackets are for the wider population for seal species*

TTS from Cumulative Exposure of a Single Pile

13. **Table 2-11** presents updates for the cumulative exposure of one monopile installation. The magnitude for grey seal changed from a low to negligible in the updated assessment at SEP and DEP. For harbour seal, the magnitude changed from low to negligible at SEP, but there were no changes at DEP.

Table 2-11: Maximum Number of Individuals (and % of Reference Population) that Could be at Risk of TTS from Cumulative Exposure (SEL_{cum}) During Installation of Monopile without Mitigation, Based on Worst-Case at SEP or DEP

			ES (Table 10-34)		Updated	
Species	**Criteria and threshold (Southall *et al.*, 2019)**	**Location**	**Monopile with maximum hammer energy of 5,500kJ**		**Monopile with maximum hammer energy of 5,500kJ**	
			Maximum number of individuals (% of reference population)	**Magnitude* (temporary impact)**	**Maximum number of individuals (% of reference population)**	**Magnitude* (temporary impact)**
Grey seal (PW)	SEL_{cum} Weighted (170 dB re 1µPa^{2}s) Impulsive	SEP	119.4 (1.4% of SE MU; or 0.5% of wider ref pop)	**Low (negligible)**	126.1 (0.37% of SE MU; or 0.21% of wider ref pop)	**Negligible (negligible)**
		DEP	162.6 (1.9% of SE MU; or 0.7% of wider ref pop)	**Low (negligible)**	171.6 (0.50% of SE MU; 0.28% of wider ref pop)	**Negligible (negligible)**
Harbour seal (PW)	SEL_{cum} Weighted (170 dB re 1µPa^{2}s) Impulsive	SEP	38.4 (1.0% of SE MU; or 0.1% of wider ref pop)	**Low (negligible)**	36.4 (0.75% of SE MU)	**Negligible**
		DEP	17.6 (0.5% of SE MU; or 0.1% of wider ref pop)	**Negligible (negligible)**	16.7 (0.34% of SE MU)	**Negligible**

**Magnitudes given in brackets are for the wider population for seal species*

14. **Table 2-12** presents updates for the cumulative exposure of one pin-pile installation. There were no changes in magnitude for grey and harbour seal in the updated assessment for SEP or DEP.

Table 2-12: Maximum Number of Individuals (and % of Reference Population) that Could be at Risk of TTS from Cumulative Exposure (SEL_{cum}) During Installation of Pin-Pile without Mitigation, Based on Worst-Case at SEP or DEP

			ES (Table 10-34)		Updated	
Species	**Criteria and threshold (Southall *et al.*, 2019)**	**Location**	**Pin-pile with maximum hammer energy of 3,000kJ**		**Pin-pile with maximum hammer energy of 3,000kJ**	
			Maximum number of individuals (% of reference population)	**Magnitude* (temporary impact)**	**Maximum number of individuals (% of reference population)**	**Magnitude* (temporary impact)**
Grey seal (PW)	SEL_{cum} Weighted (170 dB re 1µPa^{2}s) Impulsive	SEP	47.8 (0.6% of SE MU; or 0.2% of wider ref pop)	**Negligible (negligible)**	50.5 (0.15% of SE MU; or 0.08% of wider ref pop)	**Negligible (negligible)**
		DEP	66.5 (0.8% of SE MU; or 0.28% of wider ref pop)	**Negligible (negligible)**	70.2 (0.20% of SE MU; or 0.12% of wider ref pop)	**Negligible (negligible)**
Harbour seal (PW)	SEL_{cum} Weighted (170 dB re 1µPa^{2}s) Impulsive	SEP	15.3 (0.4% of SE MU; or 0.05% of wider ref pop)	**Negligible (negligible)**	14.6 (0.30% of SE MU)	**Negligible**
		DEP	7.2 (0.2% of SE MU; or 0.02% of wider ref pop)	**Negligible (negligible)**	6.8 (0.14% of SE MU)	**Negligible**

**Magnitudes given in brackets are for the wider population for seal species*

TTS from Cumulative Exposure of Sequential Piling

15. **Table 2-13** presents updates for the cumulative exposure of two monopiles installation. The magnitude for grey seal changed from a low to negligible in the updated assessment at DEP, but not at SEP. There were no changes in magnitude for harbour seal at SEP or DEP.

Table 2-13: Maximum Number of Individuals (and % of Reference Population) that Could be at Risk of TTS from Cumulative Exposure (SEL_{cum}) During Sequential Piling, Based on Worst-Case at SEP or DEP

			ES (Table 10-35)		Update	
Species	**Criteria and threshold (Southall *et al.*, 2019)**	**Location**	**Two monopiles (16m diameter; 5,500kJ)**		**Two monopiles (16m diameter; 5,500kJ)**	
			Maximum number of individuals (% of reference population)	**Magnitude* (temporary impact)**	**Maximum number of individuals (% of reference population)**	**Magnitude* (temporary impact)**
Grey seal (PW)	SEL_{cum} Weighted (170 dB re 1µPa²s) Impulsive	SEP	4.8 (0.06% of SE MU; or 0.02% of wider ref pop)	**Negligible (negligible)**	5.0 (0.01% of SE MU; or 0.01% of wider ref pop)	**Negligible (negligible)**
		DEP	162.6 (1.88% of SE MU; or 0.67% of wider ref pop)	**Low (negligible)**	171.6 (0.50% of SE MU; or 0.28% of wider ref pop)	**Negligible (negligible)**
Harbour seal (PW)	SEL_{cum} Weighted (170 dB re 1µPa²s) Impulsive	SEP	1.5 (0.04% of SE MU; or 0.0053% of wider ref pop)	**Negligible (negligible)**	1.5 (0.03% of SE MU)	**Negligible**
		DEP	17.6 (0.471% of SE MU; or 0.06% of wider ref pop)	**Negligible (negligible)**	16.7 (0.34% of SE MU)	**Negligible**

**Magnitudes given in brackets are for the wider population for seal species*

16. **Table 2-14** presents updates for the cumulative exposure of four pin-piles installation. There were no changes in magnitude in the updated assessment for harbour seal at SEP or DEP.

Table 2-14: Maximum Number of Individuals (and % of Reference Population) that Could be at Risk of TTS from Cumulative Exposure (SEL_{cum}) During Sequential Piling, Based on Worst-Case at SEP or DEP

			ES (Table 10-35)		Update	
Species	**Criteria and threshold (Southall *et al.*, 2019)**	**Location**	**Four pin-pile (4m diameter; 3,000kJ)**		**Four pin-pile (4m diameter; 3,000kJ)**	
			Maximum number of individuals (% of reference population)	**Magnitude* (temporary impact)**	**Maximum number of individuals (% of reference population)**	**Magnitude* (temporary impact)**
Grey seal (PW)	SEL_{cum} Weighted (170 dB re 1µPa^2s) Impulsive	SEP	47.8 (0.55% of SE MU; or 0.2% of wider ref pop)	**Negligible (negligible)**	50.5 (0.15% of SE MU; or 0.08% of wider ref pop)	**Negligible (negligible)**
		DEP	8.3 (0.1% of SE MU; or 0.03% of wider ref pop)	**Negligible (negligible)**	71.8 (0.21% of SE MU; or 0.12% of wider ref pop)	**Negligible (negligible)**
Harbour seal (PW)	SEL_{cum} Weighted (170 dB re 1µPa^2s) Impulsive	SEP	15.3 (0.41% of SE MU; or 0.05% of wider ref pop)	**Negligible (negligible)**	14.6 (0.30% of SE MU)	**Negligible**
		DEP	7.4 (0. 2% of SE MU; or 0.02% of wider ref pop)	**Negligible (negligible)**	7.0 (0.14% of SE MU)	**Negligible**

**Magnitudes given in brackets are for the wider population for seal species*

2.1.1.1.3 Impact Significance for Auditory Injury from Underwater Noise Associated with Piling (Section 10.6.1.1.4) from SEP or DEP in Isolation

17. **Table 2-15** presents the updated assessment of impact significance. Taking into consideration the updates in magnitude for PTS during piling from cumulative exposure for single or sequential piling at SEP or DEP for grey seals, the significance of effect remains the same as in the original assessment (**ES Chapter 10**).

18. The mitigation outlined in the MMMP (**ES Chapter 10 Section 10.3.4**) reduces the residual impact for PTS to minor adverse for both grey and harbour seals.

Table 2-15: Assessment of Impact Significance for PTS in Marine Mammals from Underwater Noise During Piling of Monopile or Pin-Pile at Either SEP or DEP

Species	Impact	Location	Sensitivity	Magnitude*	Significance*	Mitigation	Residual Impact
Grey seal	PTS from single strike of starting hammer energy	SEP	High	Negligible (negligible) for both monopile and pin-pile	Minor (minor) adverse for both monopile and pin-pile	MMMP (ES Chapter 10 Section 10.3.4)	Minor adverse
		DEP					
	PTS from single strike of maximum hammer energy	SEP		Negligible (negligible) for both monopile and pin-pile	Minor (minor) adverse for both monopile and pin-pile		Minor adverse
		DEP					
	PTS during piling from cumulative exposure for single or sequential piling	SEP		Low (low) for monopile and Negligible (negligible) for pin-pile	Moderate (moderate) adverse for monopile and Minor (minor) adverse for pin-pile		Minor adverse
		DEP		Low (low) for monopile and Negligible (negligible) for pin-pile	Moderate (moderate) adverse for monopile and Minor (minor) adverse for pin-pile		Minor adverse
Harbour seal	PTS from single strike of starting hammer energy	SEP	High	Negligible for both monopile and pin-pile	Minor adverse for both monopile and pin-pile	MMMP (ES Chapter 10 Section 10.3.4)	Minor adverse
		DEP					
	PTS from single strike of maximum hammer energy	SEP		Negligible for both monopile and pin-pile	Minor adverse for both monopile and pin-pile		Minor adverse
		DEP					
	PTS during piling from cumulative exposure for single or sequential piling	SEP		Low for monopile and Negligible for pin-pile	Moderate adverse for monopile Minor adverse for pin-pile		Minor adverse
		DEP					

* Magnitudes and significance given in brackets are for the wider population for seal species

19. **Table 2-16** presents the updated assessment of impact significance. Taking into consideration the updates in magnitude for TTS during piling from cumulative exposure for single or sequential piling at SEP or DEP, the significance of effect for monopiles changes from moderate (moderate) to minor (minor) and for pin-piles from moderate (minor) to minor (minor) at SEP. At DEP, the significance of effect changes from major (moderate) adverse for monopile and minor (minor) adverse for pin-pile to minor (minor) adverse for both monopile and pin-pile.

20. Taking into consideration the updates in magnitude for TTS during piling from cumulative exposure for single or sequential piling at SEP or DEP for harbour seals, the significance of effect remains the same as in the original assessment.

21. The mitigation outlined in the MMMP (**ES Chapter 10 Section 10.3.4**) reduces the residual impact for TTS to minor adverse for both grey and harbour seals.

Table 2-16: Assessment of Impact Significance for TTS in Marine Mammals from Underwater Noise During Piling of Monopile or Pin-Pile at Either SEP or DEP

Species	Impact	Location	Sensitivity	Magnitude*	Significance*	Mitigation	Residual Impact
Grey seal	TTS from single strike of maximum hammer energy	SEP	Medium	Negligible (negligible) for both monopile and pin-pile	Minor (minor) adverse for both monopile and pin-pile	MMMP (**ES Chapter 10 Section 10.3.4**)	**Minor adverse**
		DEP					
	TTS during piling from cumulative exposure for single or sequential piling	SEP		Negligible (negligible) for both monopile and pin-pile	Minor (minor) adverse for both monopile and pin-pile		**Minor adverse**
		DEP		Negligible (negligible) for both monopile and pin-pile	Minor (minor) adverse for both monopile and pin-pile		**Minor adverse**
Harbour seal	TTS from single strike of maximum hammer energy	SEP	Medium	Negligible for monopile and Negligible for pin-pile	Minor adverse for both monopile and pin-pile	MMMP (**ES Chapter 10 Section 10.3.4**)	**Minor adverse**
		DEP		Negligible for both monopile and pin-pile	Minor adverse for both monopile and pin-pile		**Minor adverse**
	TTS during piling from cumulative exposure for single or sequential piling	SEP		Negligible for both monopile and pin-pile	Minor adverse for both monopile and pin-pile		**Minor adverse**
		DEP					

2.1.1.2 SEP and DEP Together

2.1.1.2.1 Magnitudes for PTS from SEP and DEP Together (Section 10.6.1.1.7)

PTS from First Strike of Soft-Start

22. **Table 2-17** presents updates for a single strike of starting hammer energy for monopiles, with a hammer energy of 1,000kJ. There were no changes in magnitude for grey and harbour seal in the updated assessment for SEP and DEP.

Table 2-17: Maximum Number of Individuals (and % of Reference Population) that Could be at Risk of PTS from First Strike of Soft-Start for Monopile without Mitigation, Based on Worst-Case for SEP and DEP

Species	Location	ES (Table 10-38)		Updated Assessment	
		Monopile with starting hammer energy of 1,000kJ		Monopile with starting hammer energy of 1,000kJ	
		Maximum number of individuals (% of reference population)	Magnitude* (permanent impact)	Maximum number of individuals (% of reference population)	Magnitude* (permanent impact)
Grey seal (PW)	SEP & DEP	0.016 (0.00018% of SE MU; or 0.000066 % of wider ref pop)	**Negligible (negligible)**	0.017 (0.00005% of SE MU; or 0.00003% of wider ref pop)	**Negligible (negligible)**
Harbour seal (PW)	SEP & DEP	0.004 (0.00009% of SE MU; or 0.00001% of wider ref pop)	**Negligible (negligible)**	0.003 (0.00007% of SE MU)	**Negligible**

**Magnitudes given in brackets are for the wider population for seal species*

23. **Table 2-18** presents updates for a single strike of the starting hammer energy for pin-piles, with a hammer energy of 400kJ. There were no changes in magnitude for grey and harbour seal in the updated assessment for SEP and DEP.

Table 2-18: Maximum Number of Individuals (and % of Reference Population) that Could be at Risk of PTS from First Strike of Soft-Start for Pin-Pile without Mitigation, Based on Worst-Case for SEP and DEP

Species	Location	ES (Table 10-38)		Updated Assessment	
		Pin-pile with starting hammer energy of 400kJ		Pin-pile with starting hammer energy of 400kJ	
		Maximum number of individuals (% of reference population)	Magnitude* (permanent impact)	Maximum number of individuals (% of reference population)	Magnitude* (permanent impact)
Grey seal (PW)	SEP & DEP	0.016 (0.00018% of SE MU; or 0.000066 % of wider ref pop)	**Negligible (negligible)**	0.017 (0.00005% of SE MU; or 0.00003% of wider ref pop)	**Negligible (negligible)**

Species	Location	ES (Table 10-38)		Updated Assessment	
		Pin-pile with starting hammer energy of 400kJ		Pin-pile with starting hammer energy of 400kJ	
		Maximum number of individuals (% of reference population)	Magnitude* (permanent impact)	Maximum number of individuals (% of reference population)	Magnitude* (permanent impact)
Harbour seal (PW)	SEP & DEP	0.004 (0.00009% of SE MU; or 0.00001% of wider ref pop)	**Negligible (negligible)**	0.003 (0.00007% of SE MU)	**Negligible**

**Magnitudes given in brackets are for the wider population for seal species*

PTS from Single Strike at Maximum Hammer Energy

24. **Table 2-19** presents updates for a single strike of the maximum hammer energy for monopiles, with a hammer energy of 5,500kJ. There were no changes in magnitude for grey and harbour seal in the updated assessment for SEP and DEP.

Table 2-19: Maximum Number of Individuals (and % of Reference Population) that Could be at Risk of PTS from Single Strike of Monopile or Pin-Pile at Maximum Hammer Energy without Mitigation, Based on Worst-Case for SEP and DEP

Species	Location	ES (Table 10-39)		Updated Assessment	
		Monopile with maximum hammer energy of 5,500kJ		Monopile with maximum hammer energy of 5,500kJ	
		Maximum number of individuals (% of reference population)	Magnitude* (permanent impact)	Maximum number of individuals (% of reference population)	Magnitude* (permanent impact)
Grey seal (PW)	SEP & DEP	0.016 (0.00018% of SE MU or 0.000066% of wider ref pop)	**Negligible (negligible)**	0.017 (0.00005% of SE MU or 0.00003% of wider ref pop)	**Negligible (negligible)**
Harbour seal (PW)	SEP & DEP	0.004 (0.00009% of SE MU or 0.00001% of wider ref pop)	**Negligible (negligible)**	0.003 (0.00007% of SE MU)	**Negligible**

**Magnitudes given in brackets are for the wider population for seal species*

25. **Table 2-20** presents updates for a single strike of the maximum hammer energy for pin-piles, with a hammer energy of 3,000kJ. There were no changes in magnitude for grey and harbour seal in the updated assessment for SEP and DEP.

Table 2-20: Maximum Number of Individuals (and % of Reference Population) that Could be at Risk of PTS from Single Strike of Monopile or Pin-Pile at Maximum Hammer Energy without Mitigation, Based on Worst-Case for SEP and DEP

Species	Location	ES (Table 10-39)		Updated Assessment	
		Pin-pile with maximum hammer energy of 3,000kJ		Pin-pile with maximum hammer energy of 3,000kJ	
		Maximum number of individuals (% of reference population)	Magnitude* (permanent impact)	Maximum number of individuals (% of reference population)	Magnitude* (permanent impact)
Grey seal (PW)	SEP & DEP	0.016 (0.00018% of SE MU; or 0.000066% of wider ref pop)	**Negligible (negligible)**	0.017 (0.00005% of SE MU; or 0.00003% of wider ref pop)	**Negligible (negligible)**
Harbour seal (PW)	SEP & DEP	0.004 (0.00009% of SE MU; or 0.00001% of wider ref pop)	**Negligible (negligible)**	0.003 (0.00007% of SE MU)	**Negligible**

**Magnitudes given in brackets are for the wider population for seal species*

PTS from Cumulative Exposure of a Single Pile

26. **Table 2-21** presents updates for the cumulative exposure of one monopile installation. The magnitude for grey seal changed from medium to low, in the updated assessment at SEP and DEP. For harbour seal, the magnitude changed from negligible to low.

Table 2-21: Maximum Number of Individuals (and % of Reference Population) that Could be at Risk of PTS from Cumulative Exposure (SEL_{cum}) During Installation of Monopile without Mitigation, Based on Worst-Case for SEP and DEP

Species	Location	ES (Table 10-40)		Updated Assessment	
		Monopile with maximum hammer energy of 5,500kJ		Monopile with maximum hammer energy of 5,500kJ	
		Maximum number of individuals (% of reference population)	Magnitude* (permanent impact)	Maximum number of individuals (% of reference population)	Magnitude* (permanent impact)
Grey seal (PW)	SEP & DEP	0.52 (0.006% of SE MU; or 0.007% of wider ref pop)	**Medium (low)**	1.9 (0.005% of SE MU; or 0.003% of wider ref pop)	**Low (low)**
Harbour seal (PW)	SEP & DEP	0.3 (0.0009% of SE MU; or 0.001% of wider ref pop)	**Negligible (low)**	0.3 (0.007% of SE MU)	**Low**

**Magnitudes given in brackets are for the wider population for seal species*

27. **Table 2-22** presents updates for the cumulative exposure of one pin-pile installation. The magnitude for grey seal changed from low to negligible in the updated assessment at SEP and DEP. There were no changes in magnitude for harbour seal.

Table 2-22: Maximum Number of Individuals (and % of Reference Population) that Could be at Risk of PTS from Cumulative Exposure (SEL_{cum}) During Installation of Pin-Pile without Mitigation, Based on Worst-Case for SEP and DEP

Species	Location	ES (Table 10-40)		Updated Assessment	
		Pin-pile with maximum hammer energy of 3,000kJ		Pin-pile with maximum hammer energy of 3,000kJ	
		Maximum number of individuals (% of reference population)	Magnitude* (permanent impact)	Maximum number of individuals (% of reference population)	Magnitude* (permanent impact)
Grey seal (PW)	SEP & DEP	0.16 (0.0018% of SE MU; or 0.0007% of wider ref pop)	**Low (negligible)**	0.17 (0.0005% of SE MU; or 0.0003% of wider ref pop)	**Negligible (negligible)**
Harbour seal (PW)	SEP & DEP	0.035 (0.0009% of SE MU; or 0.0001% of wider ref pop)	**Negligible (negligible)**	0.03 (0.0007% of SE MU)	**Negligible**

**Magnitudes given in brackets are for the wider population for seal species*

PTS from Cumulative Exposure of Sequential Piling

28. **Table 2-23** presents updates for the cumulative exposure of one monopile installation at DEP followed by one monopile at SEP in the same 24 hours, as the worst-case. There were no changes in magnitude for grey and harbour seal in the updated assessment for SEP and DEP.

Table 2-23: Maximum Number of Individuals (and % of Reference Population) that Could be at Risk of PTS from Cumulative Exposure (SEL_{cum}) During Sequential Installation of Monopile at DEP Followed by Monopile at SEP, without Mitigation, Based on Worst-Case for SEP and DEP

Species	Impact	Location	ES (Table 10-43)		Updated Assessment	
			Monopiles (16m diameter; 5,500kJ)		Monopiles (16m diameter; 5,500kJ)	
			Maximum number of individuals (% of reference population)	Magnitude*	Maximum number of individuals (% of reference population)	Magnitude*
Grey seal (PW)	PTS from cumulative SEL during sequential piling at SEP and DEP in	SEP & DEP	13.23 (0.15% of SE MU; or 0.056% of wider ref pop)	**Medium (medium)**	14.0 (0.04% of SE MU; or 0.02% of wider ref pop)	**Medium (medium)**

Species	Impact	Location	ES (Table 10-43)		Updated Assessment	
			Monopiles (16m diameter; 5,500kJ)		Monopiles (16m diameter; 5,500kJ)	
			Maximum number of individuals (% of reference population)	Magnitude*	Maximum number of individuals (% of reference population)	Magnitude*
	same 24 hour period					
Harbour seal (PW)	PTS from cumulative SEL during sequential piling at SEP and DEP in same 24 hour period	SEP & DEP	3.4 (0.09% of SE MU; or 0.011% of wider ref pop)	**Medium (medium)**	3.2 (0.07% of SE MU)	**Medium**

**Magnitudes given in brackets are for the wider population for seal species*

PTS from Simultaneous Piling at SEP and DEP

29. **Table 2-24** presents updates for the cumulative exposure of one pile installation at DEP at the exact same time as one pile at SEP. There were no changes in magnitude for grey and harbour seal in the updated assessment for SEP and DEP.

Table 2-24: Maximum Number of Individuals (and % of Reference Population) that Could be at Risk of PTS from Cumulative Exposure (SEL_{cum}) During Simultaneous Piling at SEP and DEP, without Mitigation and Based on Worst-Case Scenarios

Species	Impact	Location	ES (Table 10-44)				Updated Assessments			
			Monopile (16m diameter; 5,500kJ) at each site	Pin-pile (4m diameter; 3,000kJ) at each site	Pin-pile at SEP and monopile at DEP	Monopile at SEP and pin-pile at DEP	Monopile (16m diameter; 5,500kJ) at each site	Pin-pile (4m diameter; 3,000kJ) at each site	Pin-pile at SEP and monopile at DEP	Monopile at SEP and pin-pile at DEP
			Maximum number of individuals (% of reference population) and Magnitude*				Maximum number of individuals (% of reference population) and Magnitude*			
Grey seal (PW)	PTS from cumulative SEL during simultaneous piling	SEP & DEP	24.3 (0.28% of SE MU or 0.10% of wider ref pop) Medium (medium)	impact areas do not overlap	19.8 (0.23% of SE MU or 0.08% of wider ref pop) Medium (medium)	16.9 (0.20% of SE MU or 0.07% of wider ref pop) Medium (medium)	25.6 (0.07% of SE MU or 0.04% of wider ref pop) Medium (medium)	Impact areas do not overlap	21.0 (0.06% of SE MU or 0.03% of wider ref pop) Medium (medium)	17.9 (0.05% of SE MU or 0.03% of wider ref pop) Medium (medium)
Harbour seal (PW)	PTS from cumulative SEL during simultaneous piling	SEP & DEP	6.2 (0.17% of SE MU or 0.02% of wider ref pop) Medium (medium)	impact areas do not overlap	5.1 (0.14% of SE MU or 0.02% of wider ref pop) Medium (medium)	4.3 (0.12% of SE MU or 0.01% of wider ref pop) Medium (medium)	5.9 (0.12% of SE MU) Medium	Impact areas do not overlap	4.9 (0.10% of SE MU) Medium	4.1 (0.09% of SE MU) Medium

**Magnitudes given in brackets are for the wider population for seal species*

2.1.1.2.2 Magnitudes for TTS from SEP or DEP in Isolation (Section 10.6.1.1.3.2)

TTS from Single Strike at Maximum Hammer Energy

30. **Table 2-25** presents updates for single strike of maximum hammer energy for monopiles, with a hammer energy of 5,500kJ. There were no changes in magnitude for grey and harbour seal in the updated assessment for SEP and DEP.

Table 2-25: Maximum Number of Individuals (and % of Reference Population) that Could be at Risk of TTS from Single Strike of Monopile or Pin-Pile at Maximum Hammer Energy without Mitigation, based on Worst-Case for SEP and DEP

			ES (Table 10-41)		Update	
Species	**Criteria and threshold (Southall *et al.*, 2019)**	**Location**	**Monopile with maximum hammer energy of 5,500kJ**		**Monopile with maximum hammer energy of 5,500kJ**	
			Maximum number of individuals (% of reference population)	**Magnitude* (temporary impact)**	**Maximum number of individuals (% of reference population)**	**Magnitude* (temporary impact)**
Grey seal (PW)	SEL_{ss} Weighted (170 dB re 1µPa^{2}s) Impulsive	SEP & DEP	0.19 (0.0022% of SE MU; or 0.00079% of wider ref pop)	**Negligible (negligible)**	0.20 (0.00058% of SE MU; or 0.00033% of wider ref pop)	**Negligible (negligible)**
Harbour seal (PW)	SEL_{ss} Weighted (170 dB re 1µPa^{2}s) Impulsive	SEP & DEP	0.04 (0.0011 % of SE MU; or 0.0001% of wider ref pop)	**Negligible (negligible)**	0.04 (0.0008% of SE MU pop	**Negligible**

**Magnitudes given in brackets are for the wider population for seal species*

31. **Table 2-26** presents updates for single strike of maximum hammer energy for pin-piles, with a hammer energy of 3,000kJ. There were no changes in magnitude for grey and harbour seal in the updated assessment for SEP and DEP.

Table 2-26: Maximum Number of Individuals (and % of Reference Population) that Could be at Risk of TTS from Single Strike of Pin-Pile at Maximum Hammer Energy without Mitigation, based on Worst-Case for SEP and DEP

			ES (Table 10-41)		Update	
Species	**Criteria and threshold (Southall *et al.*, 2019)**	**Location**	**Pin-pile with maximum hammer energy of 3,000kJ**		**Pin-pile with maximum hammer energy of 3,000kJ**	
			Maximum number of individuals (% of reference population)	**Magnitude* (temporary impact)**	**Maximum number of individuals (% of reference population)**	**Magnitude* (temporary impact)**
Grey seal (PW)	SEL_{ss} Weighted (170 dB re 1µPa^{2}s) Impulsive	SEP & DEP	0.18 (0.0021 % of SE MU or 0.00076% of wider ref pop)	**Negligible (negligible)**	0.19 (0.00056% of SE MU; 0.00032% of wider ref pop)	**Negligible (negligible)**
Harbour seal (PW)	SEL_{ss} Weighted (170 dB re 1µPa^{2}s) Impulsive	SEP & DEP	0.04 (0.0011% of SE MU or 0.00013% of wider ref pop)	**Negligible (negligible)**	0.04 (0.0008% of SE MU)	**Negligible**

**Magnitudes given in brackets are for the wider population for seal species*

TTS from Cumulative Exposure of a Single Pile

32. **Table 2-27** presents updates for the cumulative exposure of one monopile installation. There were no changes in magnitude for grey and harbour seal in the updated assessment for SEP and DEP.

Table 2-27: Maximum Number of Individuals (and % of Reference Population) that Could be at Risk of TTS from Cumulative Exposure (SEL_{cum}) during Installation of Monopile without Mitigation, Based on Worst-Case for SEP and DEP

			ES (Table 10-42)		Update	
Species	**Criteria and threshold (Southall *et al.*, 2019)**	**Location**	**Monopile with maximum hammer energy of 5,500kJ**		**Monopile with maximum hammer energy of 5,500kJ**	
			Maximum number of individuals (% of reference population)	**Magnitude* (temporary impact)**	**Maximum number of individuals (% of reference population)**	**Magnitude* (temporary impact)**
Grey seal (PW)	SEL_{cum} Weighted (170 dB re 1µPa^{2}s) Impulsive	SEP & DEP	282.0 (3.25% of SE MU or 1.17% of wider ref pop)	**Low (low)**	297.7 (0.86% of SE MU or 0.49% of wider ref pop)	**Low (low)**
Harbour seal (PW)	SEL_{cum} Weighted (170 dB re 1µPa^{2}s) Impulsive	SEP & DEP	56.0 (1.49% of SE MU or 0.18% of wider ref pop)	**Low (negligible)**	53.1 (1.09% of SE MU)	**Low**

**Magnitudes given in brackets are for the wider population for seal species*

33. **Table 2-28** presents updates for the cumulative exposure of one pin-pile installation. The magnitude for grey seal changed from a low to negligible in the updated assessment at SEP and DEP. There were no changes in magnitude for harbour seal at SEP and DEP.

Table 2-28: Maximum Number of Individuals (and % of Reference Population) that Could be at Risk of TTS from Cumulative Exposure (SEL_{cum}) during Installation of Pin-Pile without Mitigation, Based on Worst-Case for SEP and DEP

			ES (Table 10-42)		Update	
Species	**Criteria and threshold (Southall *et al.*, 2019)**	**Location**	**Pin-pile with maximum hammer energy of 3,000kJ**		**Pin-pile with maximum hammer energy of 3,000kJ**	
			Maximum number of individuals (% of reference population)	**Magnitude* (temporary impact)**	**Maximum number of individuals (% of reference population)**	**Magnitude* (temporary impact)**
Grey seal (PW)	SEL_{cum} Weighted (170 dB re 1µPa^{2}s)	SEP & DEP	114.3 (1.324% of SE MU or 0.74% of	**Low (negligible)**	120.7 (0.35% of SE MU or 0.20% of	**Negligible (negligible)**

Species	Criteria and threshold (Southall *et al.*, 2019)	Location	ES (Table 10-42) Pin-pile with maximum hammer energy of 3,000kJ		Update Pin-pile with maximum hammer energy of 3,000kJ	
			Maximum number of individuals (% of reference population)	Magnitude* (temporary impact)	Maximum number of individuals (% of reference population)	Magnitude* (temporary impact)
	Impulsive		wider ref pop)		wider ref pop)	
Harbour seal (PW)	SEL_{cum} Weighted (170 dB re 1µPa^{2}s) Impulsive	SEP & DEP	22.5 (0.60% of SE MU or 0.07% of wider ref pop)	**Negligible (negligible)**	21.4 (0.44% of SE MU)	**Negligible**

**Magnitudes given in brackets are for the wider population for seal species*

TTS from Cumulative Exposure of Sequential Piling

34. **Table 2-29** presents updates for the cumulative exposure of one monopile installation at DEP followed by one monopile at SEP in the same 24 hours, as the worst-case. The magnitude for grey seal changed from a low to negligible in the updated assessment at SEP and DEP. For harbour seal there were no changes.

Table 2-29: Maximum Number of Individuals (and % of Reference Population) that Could be at Risk of TTS from Cumulative Exposure (SEL_{cum}) During Sequential Installation of Monopile at DEP Followed by Monopile at SEP, without Mitigation, Based on Worst-Case for SEP and DEP

				ES (Table 10-43)		Update	
				Monopiles (16m diameter; 5,500kJ)			
				Maximum number of individuals (% of reference population)	Magnitude*		
Grey seal (PW)	TTS from cumulative SEL during sequential piling at SEP and DEP in same 24 hour period	SEL_{cum} Weighted (170 dB re 1µPa^{2}s) Impulsive	SEP & DEP	272.0 (3.14% of SE MU; or 1.13% of wider ref pop)	Low (low)	287.5 (0.83% of SE MU; or 0.48% of wider ref pop)	Negligible (negligible)

				ES (Table 10-43)		Update	
Harbour seal (PW)	TTS from cumulative SEL during sequential piling at SEP and DEP in same 24 hour period	SEL_{cum} Weighted (170 dB re 1µPa^{2}s) Impulsive	SEP & DEP	69.9 (1.86% of SE MU; or 0.23% of wider ref pop)	Low (negligible)	66.6 (1.37% of SE MU)	Low

**Magnitudes given in brackets are for the wider population for seal species*

TTS from Simultaneous Piling at SEP and DEP

35. **Table 2-30** presents updates for the cumulative exposure of one pile installation at DEP at the exact same time as one pile at SEP. In the updated assessment for grey seals, the magnitude for a monopile installation at SEP and DEP, or a pin-pile at SEP and monopile at DEP, changed from low (low) to low (negligible). For both pin-pile installations, and the installation of a monopile at SEP and pin-pile at DEP, the magnitude changed from low (low) to negligible (negligible) for grey seals. There were no changes in magnitude for harbour seal in the updated assessment for SEP and DEP.

Table 2-30: Maximum Number of Individuals (and % of Reference Population) that Could be at Risk of TTS from Cumulative Exposure (SEL_{cum}) During Simultaneous Piling at SEP and DEP, without Mitigation and Based on Worst-Case Scenarios

				ES (Table 10-44)				Update			
Species	**Impact**	**Criteria and threshold (Southall *et al.*, 2019)**	**Location**	**Monopile (16m diameter; 5,500kJ) at each site**	**Pin-pile (4m diameter; 3,000kJ) at each site**	**Pin-pile at SEP and monopile at DEP**	**Monopile at SEP and pin-pile at DEP**	**Monopile (16m diameter; 5,500kJ) at each site**	**Pin-pile (4m diameter; 3,000kJ) at each site**	**Pin-pile at SEP and monopile at DEP**	**Monopile at SEP and pin-pile at DEP**
				Maximum number of individuals (% of reference population) and Magnitude*				**Maximum number of individuals (% of reference population) and Magnitude***			
Grey seal (PW)	TTS from cumulative SEL during simultaneous piling	SEL_{cum} Weighted (170 dB re 1µPa^{2}s) Impulsive	SEP & DEP	382 (4.41% of SE MU or 1.58% of wider ref pop) Low (low)	242.6 (2.80% of SE MU or 1.01% of wider ref pop) Low (low)	330.8 (3.82% of SE MU or 1.37% of wider ref pop) Low (low)	301.4 (3.48% of SE MU or 1.25% of wider ref pop) Low (low)	404 (1.17% of SE MU or 0.67% of wider ref pop) Low (negligible)	256.4(0.74% of SE MU or 0.43% of wider ref pop) Negligible (negligible)	349.7 (1.01% of SE MU or 0.58% of wider ref pop) Low (negligible)	318.6 (0.92 % of SE MU or 0.53 % of wider ref pop) Negligible (negligible)
Harbour seal (PW)	TTS from cumulative SEL during simultaneous piling	SEL_{cum} Weighted (170 dB re 1µPa^{2}s) Impulsive	SEP & DEP	98.3 (2.62% of SE MU or 0.32% of wider ref pop) Low (negligible)	62.4 (1.66% of SE MU or 0.20% of wider ref pop) Low (negligible)	85.1 (2.27% of SE MU or 0.28% of wider ref pop) Low (negligible)	77.5 (2.07% of SE MU or 0.25% of wider ref pop) Low (negligible)	93.6 (1.93% of SE MU Low	59.4 (1.22% of SE MU Low	81.0 (1.67% of SE MU) Low	73.8 (1.52% of SE MU) Low

**Magnitudes given in brackets are for the wider population for seal species*

2.1.1.2.3 Impact Significance for Auditory Injury from Underwater Noise Associated with Piling for SEP and DEP Together (Section 10.6.1.1.7.5)

36. **Table 2-31** presents the updated assessment of impact significance. Taking into consideration the updates in magnitude for PTS during piling from cumulative exposure at SEP and DEP for grey seals, the significance of effect for monopiles changes from major (moderate) to moderate (moderate) and for pin-piles from moderate (minor) to minor (minor).

37. Taking into consideration the updates in magnitude for PTS during piling from cumulative exposure at SEP and DEP for harbour seals, the significance of effect for monopiles changes from major (minor) to minor adverse.

38. The mitigation outlined in the MMMP (**Section 10.3.4**) reduces the residual impact for PTS to minor adverse for both grey and harbour seals.

Table 2-31: Assessment of Impact Significance for PTS in Marine Mammals from Underwater Noise during Piling for SEP and DEP

Species	Impact	Location	Sensitivity	Magnitude*	Significance*	Mitigation	Residual Impact
Grey seal	PTS from single strike of starting hammer energy	SEP & DEP	High	Negligible (negligible) for monopile and pin-pile	Minor (minor) adverse	MMMP (Section 10.3.4)	Minor adverse
	PTS from single strike of maximum hammer energy	SEP & DEP		Negligible (negligible) for monopile and pin-pile	Minor (minor) adverse		Minor adverse
	PTS during piling from cumulative exposure	SEP & DEP		Low (low) for monopile Negligible (negligible) for pin-pile	Moderate (moderate) adverse for monopile Minor (minor) adverse for pin-pile		Minor adverse
	PTS from sequential piling	SEP & DEP		Medium (medium) for monopiles	Major (major) adverse		Minor adverse
	PTS from simultaneous piling	SEP & DEP		Medium (medium) for monopiles and pin-piles	Major (major) adverse		Minor adverse
Harbour seal	PTS from single strike of starting hammer energy	SEP & DEP	High	Negligible for monopile and pin-pile	Minor adverse	MMMP (Section 10.3.4)	Minor adverse
	PTS from single strike of maximum hammer energy	SEP & DEP		Negligible for monopile and pin-pile	Minor adverse		Minor adverse
	PTS during piling from cumulative exposure	SEP & DEP		Low for monopile Negligible for pin-pile	Minor adverse for monopile and pin-pile		Minor adverse

Species	Impact	Location	Sensitivity	Magnitude*	Significance*	Mitigation	Residual Impact
	PTS from sequential piling	SEP & DEP		Medium for monopiles	Major adverse		Minor adverse
	PTS from simultaneous piling	SEP & DEP		Medium for monopiles and pin-piles	Major adverse		Minor adverse

**Magnitudes and significance given in brackets are for the wider population for seal species*

39. **Table 2-32** presents the updated assessment of impact significance. Taking into consideration the updates in magnitude for TTS during piling from cumulative exposure, from sequential, and simultaneous piling at SEP and DEP for grey seals, the significance of effect changes remain the same as in the original assessment.

40. The mitigation outlined in the MMMP (**Section 10.3.4**) reduces the residual impact for TTS to minor adverse for both grey and harbour seals.

Table 2-32: Assessment of Impact Significance for TTS in Marine Mammals from Underwater Noise During Piling for SEP and DEP

Species	Impact	Location	Sensitivity	Magnitude*	Significance*	Mitigation	Residual Impact
Grey seal	TTS from single strike of maximum hammer energy	SEP & DEP	Medium	Negligible (negligible) for monopile and pin-pile	Minor (minor) adverse	MMMP (**Section 10.3.4**)	**Minor adverse**
	TTS during piling from cumulative exposure	SEP & DEP		Low (low) for monopile and Negligible (negligible) for pin-pile	Minor (minor) adverse		**Minor adverse**
	TTS from sequential piling	SEP & DEP		Negligible (negligible)	Minor (minor) adverse		**Minor adverse**
	TTS from simultaneous piling	SEP & DEP		Low (negligible) for monopiles and Negligible (negligible) for pin-piles Low (negligible) for Pin-pile at SEP and monopile at DEP Negligible (negligible) for Monopile at SEP and pin-pile at DEP	Minor (minor) adverse		**Minor adverse**
Harbour seal	TTS from single strike of maximum hammer energy	SEP & DEP	Medium	Negligible for monopile and pin-pile	Minor adverse	MMMP (**Section 10.3.4**)	**Minor adverse**
	TTS during piling from cumulative exposure	SEP & DEP		Low for monopile and Negligible pin-pile	Minor adverse		**Minor adverse**

Species	Impact	Location	Sensitivity	Magnitude*	Significance*	Mitigation	Residual Impact
	TTS from sequential piling	SEP & DEP		Low for monopiles	Minor adverse		**Minor adverse**
	TTS from simultaneous piling	SEP & DEP		Low for monopiles and pin-piles	Minor adverse		**Minor adverse**

**Magnitudes and significance given in brackets are for the wider population for seal species*

2.1.2 Updates to Assessments for Disturbance from Underwater Noise Associated with Piling (ES Section 10.6.1.2; Impact 2)

2.1.2.1 Disturbance During ADD Activation

41. Duration of ADDs has been re-assessed for a more realistic ADD activation period. See **Marine Mammals Technical Note and Addendum Section 4.1.3** for an updated assessment, using the updated seal data, and all other marine mammal species.

2.1.2.2 Disturbance During Piling

42. An assessment of disturbance from piling is provided in **Marine Mammals Technical Note and Addendum Section 4.1.2**.

2.1.3 Updates to Assessments for Effects from Underwater Noise Associated with Other Construction Activities (ES Section 10.6.1.3; Impact 3)

2.1.3.1 SEP or DEP in Isolation

43. **Table 2-33** presents updates for the potential impact for any TTS as a result of non-piling construction noise. There were no changes in magnitude for grey and harbour seal in the updated assessment for SEP and/or DEP.

Table 2-33: Maximum Number of Individuals (and % of Reference Population) that Could be Impacted as a Result of Underwater Noise Associated with Non-Piling Construction Activities Based on Underwater Noise Modelling for Each Individual Activity and for All Activities at the Same Time at SEP and DEP

			ES (Table 10-61)				Update			
Species	**Potential Impact**	**Location**	**Maximum number of individuals (% of reference population) for TTS for each individual activity**	**Magnitude* (temporary impact)**	**Maximum number of individuals (% of reference population) for TTS for all activities at the same time**	**Magnitude* (temporary impact)**	**Maximum number of individuals (% of reference population) for TTS for each individual activity**	**Magnitude* (temporary impact)**	**Maximum number of individuals (% of reference population) for TTS for all activities at the same time**	**Magnitude* (temporary impact)**
Grey seal (PW)	TTS from cumulative SEL, based on 24 hour exposure, for: - Cable laying - Trenching - Rock placement - Drilling - Dredging	SEP	0.026 (0.0003% of SE MU or 0.00011% of wider ref pop)	**Negligible (negligible)**	0.071 (0.00081% of SE MU or 0.00029% of wider ref pop)	**Negligible (negligible)**	0.027 (0.00008% of SE MU or 0.000045% of wider ref pop)	**Negligible (negligible)**	0.135 (0.00039% of SE MU; or 0.00022% of wider ref pop)	**Negligible (negligible)**
		DEP	0.0022 (0.00026% of SE MU or 0.000092% of wider ref pop)	**Negligible (negligible)**			0.0234 (0.000068% of SE MU or 0.000039% of wider ref pop)	**Negligible (negligible)**	0.117 (0.00034% of SE MU; or 0.000194% of wider ref pop)	**Negligible (negligible)**
		SEP, DEP & cable	0.022 (0.00025% of SE MU	**Negligible (negligible)**			0.023 (0.00007% of SE MU	**Negligible (negligible)**	0.117 (0.00034% of SE MU;	**Negligible (negligible)**

			ES (Table 10-61)				Update			
Species	**Potential Impact**	**Location**	**Maximum number of individuals (% of reference population) for TTS for each individual activity**	**Magnitude* (temporary impact)**	**Maximum number of individuals (% of reference population) for TTS for all activities at the same time**	**Magnitude* (temporary impact)**	**Maximum number of individuals (% of reference population) for TTS for each individual activity**	**Magnitude* (temporary impact)**	**Maximum number of individuals (% of reference population) for TTS for all activities at the same time**	**Magnitude* (temporary impact)**
		export area	or 0.000091% of wider ref pop)				or 0.000039% of wider ref pop)		or 0.00019% of wider ref pop)	
Harbour seal (PW)		SEP	0.0082 (0.00022% of SE MU or 0.000027% of wider ref pop)	**Negligible (negligible)**	0.036 (0.00096% of SE MU or 0.000079% of wider ref pop)	**Negligible (negligible)**	0.0078 (0.00016% of SE MU)	**Negligible**	0.039 (0.00080% of SE MU)	**Negligible**
		DEP	0.0024 (0.00006% of SE MU or 0.000008% of wider ref pop)	**Negligible (negligible)**			0.0023 (0.00005% of SE MU)	**Negligible**	0.011 (0.00023% of SE MU)	**Negligible**
		SEP, DEP & cable	0.0057 (0.00015% of SE MU	**Negligible (negligible)**			0.0054 (0.00011% of SE MU)	**Negligible**	0.027 (0.00056% of SE MU)	**Negligible**

			ES (Table 10-61)				Update			
Species	**Potential Impact**	**Location**	**Maximum number of individuals (% of reference population) for TTS for each individual activity**	**Magnitude* (temporary impact)**	**Maximum number of individuals (% of reference population) for TTS for all activities at the same time**	**Magnitude* (temporary impact)**	**Maximum number of individuals (% of reference population) for TTS for each individual activity**	**Magnitude* (temporary impact)**	**Maximum number of individuals (% of reference population) for TTS for all activities at the same time**	**Magnitude* (temporary impact)**
		export area	or 0.000013% of wider ref pop)							

**Magnitudes given in brackets are for the wider population for seal species*

44. Error! Not a valid bookmark self-reference. presents the updated assessment of impact significance. Taking into consideration the updates in magnitude for TTS during other construction activities at SEP or DEP, the significance of effect changes remain the same as in the original assessment.

Table 2-34: Assessment of Impact Significance for Underwater Noise from Construction Activities Other than Piling

Potential Impact	Species	Sensitivity	Magnitude	Significance	Mitigation	Residual Impact
TTS from cumulative SEL during other construction activities	Grey seal and harbour seal	Medium	Negligible	**Minor adverse**	None required	Minor adverse

2.1.3.2 SEP and DEP Together

Table 2-35 presents updates for the potential impact for any TTS as a result of non-piling construction noise. There were no changes in magnitude for grey and harbour seal in the updated assessment for SEP and DEP.

Table 2-35: Maximum Number of Individuals (and % of Reference Population) that Could be Impacted as a Result of Underwater Noise Associated with Non-Piling Construction Activities Based on Underwater Noise Modelling for all Activities at the Same Time at SEP and DEP

			ES (Table 10-63)		Update	
Potential Impact	**Species**	**Location**	**Maximum number of individuals (% of reference population) for TTS for all activities at the same time**	**Magnitude* (temporary impact)**	**Maximum number of individuals (% of reference population) for TTS for all activities at the same time**	**Magnitude* (temporary impact)**
TTS from cumulative SEL, based on 12 hour exposure, for: - Cable laying - Trenching - Rock placement - Drilling - Dredging	Grey seal (PW)	SEP & DEP including export cable	0.084 (0.001% of SE MU or 0.00035% of wider ref pop)	**Negligible (negligible)**	0.252 (0.00073% of SE MU; or 0.00042 of wider ref pop)	**Negligible (negligible)**
	Harbour seal (PW)	SEP & DEP including export cable	0.068 (0.0018% of SE MU or 0.00015% of wider ref pop)	**Negligible (negligible)**	0.050 (0.0010% of SE MU)	**Negligible**

**Magnitudes given in brackets are for the wider population for seal species*

45. **Table 2-36** presents the updated assessment of impact significance. Taking into consideration the updates in magnitude for TTS during other construction activities at SEP and DEP, the significance of effect changes remain the same as in the original assessment.

Table 2-36: Assessment of Impact Significance for TTS from Construction Activities Other than Piling at SEP and DEP

Potential Impact	Species	Sensitivity	Magnitude	Significance	Mitigation	Residual Impact
TTS from cumulative SEL during other construction activities	Grey seal and harbour seal	Medium	Negligible	**Minor adverse**	No mitigation proposed	**Minor adverse**

2.1.4 Updates to Assessments for Effects from Underwater Noise Associated with Construction Vessels (ES Section 10.6.1.4; Impact 4)

2.1.4.1 SEP or DEP in Isolation

46. **Table 2-37** presents updates for the potential impact for any PTS or TTS as a result of underwater noise associated with construction vessels. There were no changes in magnitude for any marine mammal species in the updated assessment for SEP or DEP.

Table 2-37: Maximum Number of Individuals (and % of Reference Population) that Could be Impacted as a Result of Underwater Noise Associated with All Construction Vessels at SEP or DEP

			ES (Table 10-66)		Update	
Potential Impact	**Species**	**Location**	**Maximum number of individuals (% of reference population) for all vessels**	**Magnitude* (temporary impact)**	**Maximum number of individuals (% of reference population) for all vessels**	**Magnitude* (temporary impact)**
PTS and TTS from cumulative SEL, based on	Grey seal (PW)	SEP including export cable	0.41 (0.0047% of SE MU or 0.0017%	**Negligible (negligible)**	0.36 (0.0011% of SE MU; or 0.00060% of wider ref. pop)	**Negligible (negligible)**

			ES (Table 10-66)		Update	
Potential Impact	**Species**	**Location**	**Maximum number of individuals (% of reference population) for all vessels**	**Magnitude* (temporary impact)**	**Maximum number of individuals (% of reference population) for all vessels**	**Magnitude* (temporary impact)**
24 hour exposure for large or medium vessels		DEP including export cable	of wider ref. pop.)		0.379 (0.00110% of SE MU; or 0.00063 % of wider ref. pop)	
	Harbour seal (PW)	SEP including export cable	0.13 (0.0035% of SE MU or 0.00043% of wider ref. pop.)	**Negligible (negligible)**	0.12 (0.0026% of SE MU)	**Negligible**
		DEP including export cable			0.04 (0.0008% of SE MU)	

**Magnitudes given in brackets are for the wider population for seal species*

47. **Table 2-38**Table 2-36 presents the updated assessment of impact significance. Taking into consideration the updates in magnitude for PTS and TTS due to construction vessels at SEP or DEP, the significance of effect changes remain the same as in the original assessment.

Table 2-38: Assessment of Impact Significance for Underwater Noise from Construction Vessels at SEP or DEP

Potential Impact	Species	Location	Sensitivity	Magnitude	Significance	Mitigation	Residual Impact
PTS and TTS from cumulative SEL for construction vessels	All marine mammal species	SEP or DEP including export cable	Medium	Negligible	**Minor adverse**	No additional mitigation proposed. It is assumed best practice measures will be applied.	**Minor adverse**

2.1.4.2 SEP and DEP Together

48. **Table 2-39** presents updates for the potential impact for any TTS as a result of underwater noise associated with construction vessels. There were no changes in

magnitude for any marine mammal species in the updated assessment for SEP and DEP.

Table 2-39: Maximum Number of Individuals (and % of Reference Population) that Could be Impacted as a Result of Underwater Noise Associated with All Construction Vessels at SEP and DEP

			ES (Table 10-68)		Update	
Potential Impact	**Species**	**Location**	**Maximum number of individuals (% of reference population) for all vessels**	**Magnitude* (temporary impact)**	**Maximum number of individuals (% of reference population) for all vessels**	**Magnitude* (temporary impact)**
TTS from cumulative SEL, based on 24 hour exposure, for large or medium vessels	Grey seal (PW)	SEP & DEP including export cable corridor area	0.64 (0.0074% of SE MU or 0.0027% of wider ref pop)	**Negligible (negligible)**	0.37 (0.0011% of SE MU or 0.00062% of wider ref pop)	**Negligible (negligible)**
	Harbour seal (PW)		0.06 (0.0016% of SE MU or 0.0002% of wider ref pop)	**Negligible (negligible)**	0.086 (0.00178% of SE MU)	**Negligible**

**Magnitudes given in brackets are for the wider population for seal species*

49. **Table 2-40** presents the updated assessment of impact significance. Taking into consideration the updates in magnitude for TTS due to construction vessels at SEP and DEP, the significance of effect changes remain the same as in the original assessment.

Table 2-40: Assessment of Impact Significance for Underwater Noise from Construction Vessels at SEP and DEP

Potential Impact	Species	Sensitivity	Magnitude	Significance	Mitigation	Residual Impact
TTS from cumulative SEL for construction vessels	Grey seal and harbour seal	Medium	Negligible	**Minor adverse**	No additional mitigation proposed. It is assumed best practice measures will be applied.	**Minor adverse**

2.1.5 Updates to Assessment for Increased Risk of Collision with Vessels during Construction (ES Section 10.6.1.6; Impact 6)

2.1.5.1 SEP or DEP in Isolation

50. **Table 2-41** presents updates for the increased vessel collision risk with construction vessels. There were no changes in magnitude for grey and harbour seal in the updated assessment for SEP or DEP.

Table 2-41: Estimated Number of Individuals (and % of Reference Population) that Could be at Increased Collision Risk with Construction Vessels, based on 5% of Individuals Present in SEP or DEP and Offshore Export Cable Corridors

Species	Location	ES (Table 10-73)		Updated Assessment	
		5% Vessel Collision Risk		5% Vessel Collision Risk	
		Maximum number of individuals (% of reference population)	Magnitude* (permanent impact)	Maximum number of individuals (% of reference population)	Magnitude* (permanent impact)
Grey seal	SEP and export cable corridor (160.8km^2)	6.9 (0.08% of SE MU or 0.03% of wider ref pop)	**Medium (medium)**	6.1 (0.018% of SE MU or 0.0101% of wider ref pop)	**Medium (medium)**
	DEP and export cable corridor (211.6km^2)	7.8 (0.09% of SE MU or 0.03% of wider ref pop)	**Medium (medium)**	8.4 (0.024% of SE MU or 0.014% of wider ref pop)	**Medium (medium)**
Harbour seal	SEP and export cable corridor (160.8km^2)	2.2 (0.06% of SE MU or 0.007% of wider ref pop)	**Medium (low)**	2.2 (0.05% of SE MU)	**Medium**
	DEP and export cable corridor (211.6km^2)	0.9 (0.02% of SE MU or 0.003% of wider ref pop)	**Medium (low)**	1.0 (0.02% of SE MU)	**Medium**

**Magnitudes given in brackets are for the wider population for seal species*

51. **Table 2-42** presents the updated assessment of impact significance. Taking into consideration the updates in magnitude for vessel collision risk at SEP or DEP, the significance of effect changes remain the same as in the original assessment.

Table 2-42: Assessment of Impact Significance for Any Increased Collision Risk with Vessels during Construction at SEP or DEP

Potential Impact	Species	Location	Sensitivity	Magnitude*	Significance*	Mitigation	Residual Impact
Increased Collision Risk with Vessels	Grey seal	SEP including export cable	High	Medium (medium)	Major (major)		Minor adverse
		DEP including export cable		Medium (medium)	Moderate (moderate)		Minor adverse
	Harbour seal	SEP including export cable	High	Medium	Major		Minor adverse
		DEP including export cable		Medium	Major		Minor adverse

**Magnitudes and significance given in brackets are for the wider population for seal species*

2.1.5.2 SEP and DEP Together

52. **Table 2-43** presents updates for the increased vessel collision risk with construction vessels. There were no changes in magnitude for grey and harbour seal in the updated assessment for SEP and DEP.

Table 2-43: Estimated Number of Individuals (and % of Reference Population) that Could be at Increased Collision Risk with Construction Vessels, based on 5% of Individuals Present in SEP and DEP Wind Farm Sites and Export Cable Corridor

		ES (Table 10-75)		Updated Assessment	
Species	Location	5% Vessel Collision Risk		5% Vessel Collision Risk	
		Maximum number of individuals (% of reference population)	Magnitude* (permanent impact)	Maximum number of individuals (% of reference population)	Magnitude* (permanent impact)
Grey seal	SEP & DEP and export cable corridor areas (372.4km^2)	14.7 (0.17% of SE MU or 0.06% of wider ref pop)	**Medium (medium)**	14.5 (0.04% of SE MU or 0.02% of wider ref pop)	**Medium (medium)**
Harbour seal	SEP & DEP and export cable corridor areas (372.4km^2)	3.1 (0.08% of SE MU or 0.01% of wider ref pop)	**Medium (medium)**	3.2 (0.07% of SE MU)	**Medium**

**Magnitudes and significance given in brackets are for the wider population for seal species*

53. **Table 2-44** presents the updated assessment of impact significance. Taking into consideration the updates in magnitude for vessel collision risk at SEP and DEP, the significance of effect changes remain the same as in the original assessment.

Table 2-44: Assessment of Impact Significance for any Increased Collision Risk with Vessels during Construction at SEP and DEP

Potential Impact	Species	Location	Sensitivity	Magnitude*	Significance*	Mitigation	Residual Impact
Increased collision risk	Grey seal	SEP & DEP including export cable	High	Medium (medium)	Major (major)	Recommended good practice as Outline PEMP (Revision B) [REP1-017].	Negligible to Minor adverse
	Harbour seal			Medium	Major		Minor adverse

**Magnitudes and significance given in brackets are for the wider population for seal species*

2.2 Potential Impacts during Operation

2.2.1 Updates to Assessment for Impacts from Underwater Noise Associated with Operational Wind Turbines (ES Section 10.6.2.1; Impact 1)

2.2.1.1 SEP or DEP in Isolation

54. **Table 2-45** presents updates for the cumulative exposure of operational turbines. There were no changes in magnitude for grey and harbour seal in the updated assessment for SEP or DEP.

Table 2-45: Maximum Number of Individuals (and % of Reference Population) that Could be at Risk of TTS / Fleeing Response from Cumulative Exposure for all Operational Turbines at SEP or DEP

Species	Location	ES (Table 10-87)		Update	
		Operational Turbines		Operational Turbines	
		Maximum number of individuals (% of reference population)	Magnitude* (long-term impact)	Maximum number of individuals (% of reference population)	Magnitude* (long-term impact)
Grey seal	SEP (up to 23 wind turbines)	0.59 (0.0068% of SE MU or 0.0013% of wider ref pop)	**Negligible (negligible)**	0.62 (0.0018% of SE MU or 0.0010% of wider ref pop)	**Negligible (negligible)**
	DEP (up to 30 wind turbines)	0.67 (0.0077% of SE MU or 0.0028% of wider ref pop)	**Negligible (negligible)**	0.70 (0.0020% of SE MU or 0.0012% of wider ref pop)	**Negligible (negligible)**
Harbour seal	SEP (up to 23	0.19 (0.005% of SE MU or	**Negligible (negligible)**	0.18 (0.0037% of SE MU)	**Negligible**

Species	Location	ES (Table 10-87)		Update	
		Operational Turbines		Operational Turbines	
		Maximum number of individuals (% of reference population)	Magnitude* (long-term impact)	Maximum number of individuals (% of reference population)	Magnitude* (long-term impact)
	wind turbines)	0.0003% of wider ref pop)			
	DEP (up to 30 wind turbines)	0.07 (0.0019% of SE MU or 0.0002% of wider ref pop)	**Negligible (negligible)**	0.07 (0.0014% of SE MU)	**Negligible**

**Magnitudes and significance given in brackets are for the wider population for seal species*

55. **Table 2-46** presents the updated assessment of impact significance. There were no changes in impact significance for grey and harbour seal in the updated assessment for SEP or DEP.

Table 2-46 Assessment of Impact Significance for Underwater Noise from Operational Turbines at SEP or DEP

Potential Impact	Species	Location	Sensitivity	Magnitude*	Significance*	Mitigation	Residual Impact
Underwater noise from operational turbines	Grey seal	SEP	Low	Negligible	**Negligible**	No mitigation proposed	**Negligible**
		DEP		Negligible	**Negligible**		**Negligible**
	Harbour seal	SEP	Low	Negligible	**Negligible**		**Negligible**
		DEP		Negligible	**Negligible**		**Negligible**

*Magnitudes and significance given in brackets are for the wider population for seal species

2.2.1.2 SEP and DEP Together

56. **Table 2-47** presents updates for the cumulative exposure of operational turbines. There were no changes in magnitude for grey and harbour seal in the updated assessment for SEP and DEP.

Table 2-47: Maximum Number of Individuals (and % of Reference Population) that Could be at Risk of TTS / Fleeing Response from Cumulative Exposure for all Operational Turbines at SEP and DEP

		ES (Table 10-89)		Update	
		Operational Turbines		Operational Turbines	
Species	Location	Maximum number of individuals (% of reference population)	Magnitude (long-term impact)	Maximum number of individuals (% of reference population)	Magnitude (long-term impact)
Grey seal	SEP & DEP (up to 53 wind turbines)	1.25 (0.0145% of SE MU or 0.0052% of wider ref pop)	**Negligible (negligible)**	1.32 (0.0038% of SE MU or 0.0022% of wider ref pop)	**Negligible (negligible)**
Harbour seal	SEP & DEP (up to 53 wind turbines)	0.26 (0.007% of SE MU or 0.0009% of wider ref pop)	**Negligible (negligible)**	0.25 (0.0037% of SE MU	**Negligible**

**Magnitudes and significance given in brackets are for the wider population for seal species*

57. **Table 2-48** presents the updated assessment of impact significance. There were no changes in impact significance for grey and harbour seal in the updated assessment for SEP and DEP.

Table 2-48: Assessment of Impact Significance for Underwater Noise from Operational Turbines at SEP and DEP

Potential Impact	Species	Location	Sensitivity	Magnitude*	Significance	Mitigation	Residual Impact
Underwater noise from operational turbines	Grey seal	SEP & DEP	Low	Negligible (negligible)	**Negligible**	No mitigation proposed	**Negligible (negligible)**
	Harbour seal			Negligible	**Negligible**		**Negligible**

**Magnitudes and significance given in brackets are for the wider population for seal species*

2.2.2 Updates to Assessment for Impacts from Underwater Noise Associated with Operation and Maintenance Activities (ES Section 10.6.2.2; Impact 2)

58. As assessment for construction (see **Section 2.1.3**).

2.2.3 Updates to Assessment for Impacts from Underwater Noise and Disturbance Associated with Operation and Maintenance Vessels (ES Section 10.6.2.3; Impact 3)

59. As assessment for construction (see **Section 2.1.4**).

2.2.4 Updates to Assessment for Increased Risk of Collision with Vessels during Operation (ES Section 10.6.2.5; Impact 5)

60. As assessment for construction (see **Section 2.1.5**).

3 Updated Assessments for Grey Seal and Harbour Seal within the Report to Inform Appropriate Assessment

In response to Natural England's Relevant Representation (RR-063), as stated in Applicant's Response (comment 77, 85, 86) [RR-063].

3.1 Humber Estuary SAC

3.1.1 Updates to Assessment for Potential Effects during Construction

3.1.1.1 Updates to Assessment for Potential Effects of Underwater Noise during Piling

61.

62. **Table** 3-1 presents updates for a single strike of the maximum hammer energy for monopiles, with a hammer energy of 5,500kJ, for SEP or DEP in isolation. There were no changes in potential adverse effects on site integrity for grey seal in the updated assessment for SEP or DEP.

Table 3-1: Maximum Number of Grey Seal Potentially at Risk of PTS or TTS during Piling at SEP or DEP

Species	Maximum area	RIAA Table 8-66		Updated Assessment	
		Monopile with maximum hammer energy of 5,500kJ		Monopile with maximum hammer energy of 5,500kJ	
		Maximum number of individuals (% of reference population)	Potential adverse effect on site integrity	Maximum number of individuals (% of reference population)	Potential adverse effect on site integrity
Grey seal	PTS at SEP = 0.84km^2	0.72 (SEP density of 0.853/km^2) (0.018% of SAC count; 0.008% of SE MU)	No MMMP would reduce risk of PTS	0.35 (SEP density of 0.421/km^2) (0.002% of SAC)	No MMMP would reduce risk of PTS
	PTS at DEP = 1.44km^2	1.03 (DEP density of 0.739/km^2) (0.03% of SAC count; 0.012% of SE MU)		0.51 (DEP density of 0.363/km^2) (0.0033% of SAC)	

Species	Maximum area	RIAA Table 8-66		Updated Assessment	
		Monopile with maximum hammer energy of 5,500kJ		Monopile with maximum hammer energy of 5,500kJ	
		Maximum number of individuals (% of reference population)	Potential adverse effect on site integrity	Maximum number of individuals (% of reference population)	Potential adverse effect on site integrity
	TTS at SEP = 140km^2	119.4 (SEP density of 0.853/km^2) (3.1% of SAC count; 1.4% of SE MU)	No Less than 5% of population temporary disturbed MMMP would reduce risk of TTS	58.9 (SEP density of 0.421/km^2) (0.38% of SAC)	No Less than 5% of population temporary disturbed MMMP would reduce risk of TTS
	TTS at DEP = 220km^2	162.6 (DEP density of 0.739/km^2) (4.2% of SAC count; 1.9% of SE MU)		79.9 (DEP density of 0.363/km^2) (0.52% of SAC)	

63. **Table 3-2**

64. Table 3-1 presents updates for a single strike of the maximum hammer energy for monopiles, with a hammer energy of 5,500kJ, for SEP and DEP. There were no changes in potential adverse effects on site integrity for grey seal in the updated assessment for SEP and DEP.

Table 3-2: Maximum Number of Grey Seal Potentially at Risk of PTS or TTS during Piling at SEP and DEP

Species	Maximum area	RIAA Table 8-67		Updated Assessment	
		Monopile at SEP & DEP		Monopile at SEP & DEP	
		Maximum number of individuals (% of reference population)	Potential adverse effect on site integrity	Maximum number of individuals (% of reference population)	Potential adverse effect on site integrity
Grey seal	PTS from sequential piling at SEP & DEP = 18km^2	13.23 (density of 0.735/km^2) (0.34% of SAC count; 0.15% of SE MU)	No MMMP would reduce risk of PTS	7.0 (density of 0.389/km^2) (0.045% of SAC)	No MMMP would reduce risk of PTS

Species	Maximum area	RIAA Table 8-67		Updated Assessment	
		Monopile at SEP & DEP		Monopile at SEP & DEP	
		Maximum number of individuals (% of reference population)	Potential adverse effect on site integrity	Maximum number of individuals (% of reference population)	Potential adverse effect on site integrity
	PTS from simultaneous piling at SEP & DEP = 33km^2	24.3 (density of 0.735/km^2) (0.62% of SAC count; 0.28% of SE MU)		12.8 (density of 0.389/km^2) (0.08% of SAC)	
	TTS from sequential piling at SEP & DEP = 370km^2	272 (density of 0.735/km^2) (7% of SAC count; 3.14% of SE MU)	No Temporary effect MMMP would reduce risk of TTS	143.9 (density of 0.389/km^2) (0.93% of SAC)	No Temporary effect MMMP would reduce risk of TTS

3.1.1.2 Updates to Assessment for Potential Effects of Underwater Noise during Other Construction Activities

65. **Table 3-3**

66. Table 3-1 presents updates for underwater noise impacts from other construction activities, and for SEP or DEP in isolation. There were no changes in potential adverse effects on site integrity for grey and harbour seal in the updated assessment for SEP or DEP.

Table 3-3: Maximum Number of Grey Seal (and % of Reference Population) that Could be Impacted as a Result of Underwater Noise Associated with All Non-Piling Construction Activities at the Same Time at SEP or DEP

Potential Impact	Species	Location	RIAA Table 8-68		Updated Assessment	
			Maximum number of individuals (% of SAC count and SE MU) for TTS for all activities at the same time	Potential adverse effect on site integrity	Maximum number of individuals (% of SAC count and SE MU) for TTS for all activities at the same time	Potential adverse effect on site integrity
TTS from cumulative SEL, based on 24 hour exposure, for: - Cable laying - Trenching - Rock placement - Drilling - Dredging (0.15km^2)	Grey seal	SEP	0.11 (density of 0.735/km^2) (0.0028% of SAC count; 0.0013% of SE MU)	**No**	0.052 (density of 0.344/km^2) (0.00033% of SAC)	**No**
		DEP			0.0547 (density of 0.365/km^2) 0.000353% of SAC)	

67. **Table 3-4**

68. Table 3-1 presents updates for underwater noise impacts from other construction activities, and for SEP and DEP. There were no changes in potential adverse effects on site integrity for grey and harbour seal in the updated assessment for SEP and DEP.

Table 3-4: Maximum Number of Grey Seal (and % of Reference Population) that Could be Impacted as a Result of Underwater Noise Associated with all Non-Piling Construction Activities at the Same Time at SEP and DEP

Potential Impact	Species	Location	RIAA Table 8-69		Updated Assessment	
			Maximum number of individuals (% of SAC count and SE MU) for TTS for all activities at the same time	Potential adverse effect on site integrity	Maximum number of individuals (% of SAC count and SE MU) for TTS for all activities at the same time	Potential adverse effect on site integrity
TTS from cumulative SEL, based on 24 hour exposure, for: - Cable laying - Trenching - Rock placement - Drilling - Dredging (0.3km^2)	Grey seal	SEP & DEP	0.22 (0.006% of SAC count; 0.003% of SE MU)	**No**	0.106 (0.00069% of SAC)	**No**

3.1.1.3 Updates to Assessment for Potential Effects of Underwater Noise and Disturbance from Construction Vessels

69. **Table 3-5**

70. Table 3-1 presents updates for underwater noise impacts from construction vessels at SEP or DEP. There were no changes in potential adverse effects on site integrity for grey seal in the updated assessment for SEP or DEP.

Table 3-5: Maximum Number of Grey Seal (and % of Reference Population) that Could be Impacted as a Result of Underwater Noise Associated with All Construction Vessels at SEP or DEP

Potential Impact	Species	Location	RIAA Table 8-70		Updated Assessment	
			Maximum number of individuals (% of SAC and SE MU) for all vessels	Potential adverse effect on site integrity	Maximum number of individuals (% of SAC and SE MU) for all vessels	Potential adverse effect on site integrity
TTS from cumulative SEL, based on 24 hour exposure for 16 vessels (0.48km^2)	Grey seal	SEP	0.35 (density of 0.735/km^2) (0.009% of SAC count; 0.004% of SE MU)	**No**	0.17 (density of 0.344/km^2) (0.0011% of SAC)	**No**
		DEP			0.175 (density of 0.365/km^2) (0.00113% of SAC)	

71. **Table 3-6**

72. Table 3-1 presents updates for underwater noise impacts from construction vessels at SEP and DEP. There were no changes in potential adverse effects on site integrity for grey seal in the updated assessment for SEP and DEP.

Table 3-6: Maximum Number of Grey Seal (and % of Reference Population) that Could be Impacted as a Result of Underwater Noise Associated with All Construction Vessels at SEP and DEP

Potential Impact	Species	Location	RIAA Table 8-71		Updated Assessment	
			Maximum number of individuals (% of SAC and SE MU) for all vessels	Potential adverse effect on site integrity	Maximum number of individuals (% of SAC and SE MU) for all vessels	Potential adverse effect on site integrity
TTS response from cumulative SEL, based on 24 hour exposure, for 25 vessels (0.75km^2)	Grey seal	SEP & DEP	0.55 (density of 0.735/km^2) (0.014% of SAC count; 0.0064% of SE MU)	**No**	0.340 (0.0022% of SAC)	**No**

3.1.1.4 Updates to Assessment for Potential Effects of Any Increased Collision Risk with Construction Vessels

73. **Table 3-7** presents updates for vessel collision risk at SEP or DEP, and for SEP and DEP. There were no changes in potential adverse effects on site integrity for grey seal in the updated assessment for SEP and/or DEP.

Table 3-7: Estimated Number of Grey Seal (and % of Reference Population) that Could be at Increased Collision Risk with Construction Vessels, Based on 5% of Individuals Present in SEP and / or DEP and Export Cable Corridor

Species	Location (impact area)	RIAA (Table 8-72)		Updated Assessment	
		5% Vessel Collision Risk		5% Vessel Collision Risk	
		5% Vessel Collision Risk Maximum number of individuals (% of SAC count and SE MU)	Potential adverse effect on site integrity	5% Vessel Collision Risk Maximum number of individuals (% of SAC count and SE MU)	Potential adverse effect on site integrity
Grey seal	SEP wind farm site and export cable corridor (160.8km^2)	6.9 (SEP wind farm site & export cable corridor density of 0.835/km^2) (0.18% of SAC count; 0.08% of SE MU)	**No** vessel movements will be kept to the minimum number and vessel operators will use good practice to reduce any risk of collisions with marine mammals	2.76 (density of 0.344/km^2) (0.018% of SAC)	**No** vessel movements will be kept to the minimum number and vessel operators will use good practice to reduce any risk of collisions with marine mammals
	DEP wind farm site and export cable corridor (211.6km^2)	7.8 (DEP & export cable corridor density of 0.739/km^2) (0.20% of SAC count; 0.09% of SE MU)		3.86 (density of 0.365/km^2) (0.0249% of SAC)	
	SEP & DEP wind farm sites and export cable corridor areas (372.4km^2)	14.7 (SEP, DEP & export cable corridor density of 0.735/km^2) (0.38% of SAC count; 0.17% of SE MU)		131.83 (density of 0.354/km^2) (0.851% of SAC)	

3.1.1.5 Updates to Assessment for Potential for Disturbance of Foraging Grey Seals at Sea

74. **Table 3-8** presents updates for the potential for disturbance of foraging grey seals at sea. There were no changes in potential adverse effects on site integrity for grey seal in the updated assessment for SEP and DEP.

Table 3-8 Disturbance of foraging grey seal for simultaneous piling at SEP and DEP (based on maximum TTS impact area)

			RIAA (Section 8.4.3.1.7)		Updated Assessment	
Potential Impact	**Species**	**Location**	**Maximum number of individuals (% of SAC and SE MU) for all vessels**	**Potential adverse effect on site integrity**	**Maximum number of individuals (% of SAC and SE MU) for all vessels**	**Potential adverse effect on site integrity**
Any disturbance of foraging grey (520km^2)	Grey seal	SEP & DEP	1-382 (density of 0.735/km^2) (0.006-9.8% of SAC count; 0.003-4.4% of SE MU)	**No**	202 (density of 0.389/ km^2) (1.31% of SAC)	**No**

3.1.1.6 Updates to Assessment for Potential for Any Changes in Prey Availability

75. **Table 3-9** presents updates for the potential for changes in prey availability. There were no changes in potential adverse effects on site integrity for grey seal in the updated assessment for SEP and DEP.

Table 3-9 Changes in prey availability during piling as a result of underwater noise, based on the worst-case for TTS SEL$_{cum}$ for fish species with a swim bladder involved in hearing

			RIAA (Section 8.4.3.1.9)		Updated Assessment	
Potential Impact	**Species**	**Location**	**Maximum number of individuals (% of SAC and SE MU) for all vessels**	**Potential adverse effect on site integrity**	**Maximum number of individuals (% of SAC and SE MU) for all vessels**	**Potential adverse effect on site integrity**
Any changes in prey availability based on TTS SEL$_{cum}$ for fish species with a swim bladder involved in hearing (max. fleeing area at DEP (330km^2) and SEP (210km^2)	Grey seal	SEP & DEP	423 (10.85% of SAC count; 4.88% of SE MU)	**No**	208.2 (1.34% of SAC)	**No**

3.1.2 Updates to Assessment for Potential Effects during Operation and Maintenance

3.1.2.1 Updates to Assessment for Potential Effects of Underwater Noise from Operational Turbines

76. **Table 3-10** presents updates for potential effects due to underwater noise from operational turbines. There were no changes in potential adverse effects on site integrity for grey seal in the updated assessment for SEP and DEP.

Table 3-10: Maximum Number of Grey Seal (and % of Reference Population) that Could be at Risk of TTS from Cumulative Exposure for All Operational Turbines at SEP and / or DEP

		RIAA (Table 8-73)		Updated Assessment	
Species	**Location**	**Operational Turbines Maximum number of individuals (% of SAC count and SE MU)**	**Potential adverse effect on site integrity**	**Operational Turbines Maximum number of individuals (% of SAC count and SE MU)**	**Potential adverse effect on site integrity**
Grey seal	SEP (up to 23 wind turbines; 0.69km^2)	0.59 (SEP density of 0.853/km^2) (0.015% of SAC count; 0.007% of SE MU)	**No**	0.29 (density of 0.421/km^2) 0.0019% of SAC)	**No**
	DEP (up to 30 wind turbines; 0.90km^2)	0.67 (DEP density of 0.739/km^2) (0.017% of SAC count; 0.008% of SE MU)		0.33 (density of 0.363/km^2) 0.0021% of SAC)	
	SEP & DEP (up to 53 wind turbines; 1.59km^2)	1.25 (0.032% of SAC count; 0.015% of SE MU)		0.62 (density of 0.389/km^2) 0.0040% of SAC)	

3.1.2.2 Updates to Assessment for Impacts from Underwater Noise Associated with Operation and Maintenance Activities

77. As assessment for construction.

3.1.2.3 Updates to Assessment for Impacts from Underwater Noise and Disturbance Associated with Operation and Maintenance Vessels

78. As assessment for construction.

3.1.2.4 Updates to Assessment for Increased Risk of Collision with Vessels during Operation

79. As assessment for construction.

3.2 The Wash and North Norfolk Coast SAC

3.2.1 Updates to Assessment for Potential Effects during Construction

3.2.1.1 Updates to Assessment for Potential Effects of Underwater Noise during Piling

80. **Table 3-11** presents updates for single strike of maximum hammer energy for monopiles, with a hammer energy of 5,500kJ, at either SEP or DEP. There were no changes in potential adverse effects on site integrity for harbour seal in the updated assessment for SEP or DEP.

Table 3-11: Maximum Number of Harbour Seal (and % of Reference Population) that Could be at Risk of PTS or TTS during Piling at SEP or DEP

Species	Maximum area	RIAA (Table 8-76)		Updated Assessment	
		Monopile max single strike 5,500kJ		Monopile max single strike 5,500kJ	
		Maximum number of individuals (% of reference population)	Potential adverse effect on site integrity	Maximum number of individuals (% of reference population)	Potential adverse effect on site integrity
Harbour seal	PTS at SEP = 0.84km^2	0.23 (SEP density of 0.274/km^2) (0.008% of SAC count; 0.006% of SE MU)	**No** MMMP would reduce risk of PTS	0.17 (density of 0.202/km^2) (0.004% of SAC)	**No** MMMP would reduce risk of PTS
	PTS at DEP = 1.44km^2	0.11 (DEP density of 0.080/km^2) (0.004% of SAC count; 0.003% of SE MU)		0.08 (density of 0.057/km^2) (0.002% of SAC)	
	TTS at SEP = 140km^2	38.4 (SEP density of 0.274/km^2) (1.3% of SAC count; 1.0% of SE MU)	**No** Less than 5% of population temporary disturbed; MMMP would reduce risk of TTS	28.3 (density of 0.202/km^2) (0.71% of SAC)	**No** Less than 1% of population temporary disturbed; MMMP would reduce risk of TTS
	TTS at DEP = 220km^2	17.6 (DEP density of 0.080/km^2) (0.6% of SAC count; 0.5% of SE MU)		12.6 (density of 0.057/km^2) (0.32% of SAC)	

81. **Table 3-12** presents updates for single strike of maximum hammer energy for monopiles, with a hammer energy of 5,500kJ, at SEP and DEP. There were no changes in potential adverse effects on site integrity for harbour seal in the updated assessment for SEP or DEP.

Table 3-12: Maximum Number of Harbour Seal (and % of Reference Population) that Could be at Risk of PTS or TTS during Piling at SEP and DEP

Species	Maximum area	RIAA (Table 8-77) Monopile at SEP & DEP		Updated Assessment Monopile at SEP & DEP	
		Maximum number of individuals (% of reference population)	Potential adverse effect on site integrity	Maximum number of individuals (% of reference population)	Potential adverse effect on site integrity
Harbour seal	PTS from sequential piling at SEP & DEP = 18km^2	3.4 (density of 0.189/km^2) (0.12% of SAC count; 0.09% of SE MU)	**No** MMMP would reduce risk of PTS	0.57 (density of 0.032/km^2) 0.01% of SAC)	**No** MMMP would reduce risk of PTS
	PTS from simultaneous piling at SEP & DEP = 33km^2	6.2 (density of 0.189/km^2) (0.22% of SAC count; 0.17% of SE MU)		1.0 (density of 0.032/km^2) 0.03% of SAC)	
	TTS from sequential piling at SEP & DEP = 370km^2	70 (density of 0.189/km^2) (2.46% of SAC count; 1.86% of SE MU)	**No** Less than 5% of population temporary disturbed MMMP would reduce risk of TTS	11.8 (density of 0.0318/km^2) (0.30% of SAC)	**No** Less than 1% of population temporary disturbed MMMP would reduce risk of TTS
	TTS from simultaneous piling at SEP & DEP = 520km^2	98.3 (density of 0.189/km^2) (3.45% of SAC count; 2.62% of SE MU)		16.5 (density of 0.0318/km^2) (0.42% of SAC)	

3.2.1.2 Updates to Assessment for Potential Effects of Underwater Noise during Other Construction Activities

82. There were no changes in potential adverse effects on site integrity for harbour seal in the updated assessment for SEP or DEP.

Table 3-13: Maximum Number of Harbour Seal (and % of Reference Population) that Could be Impacted as a Result of Underwater Noise Associated with All Non-Piling Construction Activities at the Same Time at SEP or DEP

			RIAA (Table 8-78)		Updated Assessment	
Potential Impact	**Species**	**Location**	**Maximum number of individuals (% of SAC count and SE MU) for TTS for all activities at the same time**	**Potential adverse effect on site integrity**	**Maximum number of individuals (% of SAC count and SE MU) for TTS for all activities at the same time**	**Potential adverse effect on site integrity**
TTS from cumulative SEL, based on 24 hour exposure, for: - Cable laying - Trenching - Rock placement - Drilling - Dredging (0.15km^2)	Harbour seal	SEP	0.028 (SEP, DEP & cable export area density of 0.189/km^2) (0.001% of SAC count; 0.0008% of SE MU)	**No**	0.032 (density of 0.213/km^2) (0.00081% of SAC)	**No**
		DEP			0.011 (density of 0.0719/km^2) (0.00027% of SAC)	

83. There were no changes in potential adverse effects on site integrity for harbour seal in the updated assessment for SEP and DEP.

Table 3-14: Maximum Number of Harbour Seal (and % of Reference Population) that Could be Impacted as a Result of Underwater Noise Associated with All Non-Piling Construction Activities at the Same Time at SEP and DEP

			RIAA (Table 8-79)		Updated Assessment	
Potential Impact	**Species**	**Location**	**Maximum number of individuals (% of SAC count and SE MU) for TTS for all activities at the same time**	**Potential adverse effect on site integrity**	**Maximum number of individuals (% of SAC count and SE MU) for TTS for all activities at the same time**	**Potential adverse effect on site integrity**
TTS from cumulative SEL, based on 24 hour exposure, for: - Cable laying - Trenching - Rock placement - Drilling - Dredging (0.3km^2)	Harbour seal	SEP & DEP	0.06 (SEP, DEP & cable export area density of 0.189/km^2) (0.002% of SAC count; 0.0015% of SE MU)	**No**	0.043 (density 0.0318/km^2) (0.0011% of SAC)	**No**

3.2.1.3 Updates to Assessment for Potential Effects of Underwater Noise and Disturbance from Construction Vessels

84. There were no changes in potential adverse effects on site integrity for harbour seal in the updated assessment for SEP or DEP.

Table 3-15: Maximum Number of Harbour Seal (and % of Reference Population) that Could be Impacted as a Result of Underwater Noise Associated with All Construction Vessels at SEP or DEP

			RIAA (Table 8-80)		Updated Assessment	
Potential Impact	**Species**	**Location**	**Maximum number of individuals (% of SAC count and SE MU) for all vessels**	**Potential adverse effect on site integrity**	**Maximum number of individuals (% of SAC count and SE MU) for all vessels**	**Potential adverse effect on site integrity**
TTS response from cumulative SEL, based on	Harbour seal	SEP	0.09 (SEP, DEP & cable export area	**No**	0.10 density (0.202/km^2) (0.0025% of SAC)	**No**

			RIAA (Table 8-80)		Updated Assessment	
Potential Impact	**Species**	**Location**	**Maximum number of individuals (% of SAC count and SE MU) for all vessels**	**Potential adverse effect on site integrity**	**Maximum number of individuals (% of SAC count and SE MU) for all vessels**	**Potential adverse effect on site integrity**
24 hour exposure for 16 vessels (0.48km^2)		DEP	density of 0.189/km^2) (0.003% of SAC count; 0.002% of SE MU)		0.03 density (0.057/km^2) (0.0007% of SAC)	

85. There were no changes in potential adverse effects on site integrity for harbour seal in the updated assessment for SEP and DEP.

Table 3-16: Maximum Number of Harbour Seal (and % of Reference Population) that Could be Impacted as a Result of Underwater Noise Associated with All Construction Vessels at SEP and DEP

			RIAA (Table 8-81)		Updated Assessment	
Potential Impact	**Species**	**Location**	**Maximum number of individuals (% of SAC count and SE MU) for all vessels**	**Potential adverse effect on site integrity**	**Maximum number of individuals (% of SAC count and SE MU) for all vessels**	**Potential adverse effect on site integrity**
TTS from cumulative SEL, based on 24 hour exposure, for 25 vessels (0.75km^2)	Harbour seal	SEP & DEP	0.14 (SEP, DEP & cable export area density of 0.189/km^2) (0.005% of SAC count; 0.004% of SE MU)	**No**	0.02 (density 0.0318/km^2) (0.0006% of SAC)	**No**

3.2.1.4 Updates to Assessment for Potential Effects of Any Increased Collision Risk with Construction Vessels

86. There were no changes in potential adverse effects on site integrity for harbour seal in the updated assessment for SEP or DEP.

Table 3-17: Estimated Number of Harbour Seal (and % of Reference Population) that Could be at Increased Collision Risk with Construction Vessels Based on 5% of Individuals Present in the SEP Wind Farm Site, DEP Wind Farm Site and Export Cable Corridor

		RIAA (Table 8-82)		Updated Assessment	
Species	**Location (impact area)**	**5% Vessel Collision Risk Maximum number of individuals (% of SAC count or SE MU)**	**Potential adverse effect on site integrity**	**5% Vessel Collision Risk Maximum number of individuals (% of SAC count or SE MU)**	**Potential adverse effect on site integrity**
Harbour seal	SEP and export cable corridor (160.8km^2)	2.2 (density of 0.189/km^2) (0.08% of SAC count; 0.06% of SE MU)	**No** vessel movements will be kept to the minimum number and vessel operators will use good practice to reduce any risk of collisions with marine mammals	1.71 (density 0.213/km^2) (0.043% of SAC)	**No** vessel movements will be kept to the minimum number and vessel operators will use good practice to reduce any risk of collisions with marine mammals
	DEP and export cable corridor (211.6km^2)	0.9 (density of 0.189/km^2) (0.03% of SAC count; 0.02% of SE MU)		0.76 (density 0.0719/km^2) (0.019% of SAC)	
	SEP & DEP and export cable corridor (372.4km^2)	3.1 (0.11% of SAC count; 0.0.08% of SE MU)		2.55 (density 0.137/km^2) 0.064% of SAC)	

3.2.1.5 Updates to Assessment for Potential for Disturbance of Foraging Grey Seals at Sea

87. Therefore, between one and 98 harbour seal[1] (0.002-3.45% of SAC count; 0.0015-2.62%), could be temporarily disturbed from foraging at SEP and DEP, due to construction.

3.2.1.6 Updates to Assessment for Potential for Any Changes in Prey Availability

88. There were no changes in potential adverse effects on site integrity for harbour seal in the updated assessment for SEP and DEP.

[1] Calculated from the density of harbour seal, and the total piling disturbance areas. If a total of 98 harbour seal could be disturbed from the area due to piling, then they could also be disturbed from foraging within that area. This is highly precautionary, as it is unlikely that all grey seal present within those piling disturbance areas would be actively foraging at the time that the disturbing activity (i.e. piling) takes place.

Table 3-18 Changes in prey availability during piling as a result of underwater noise, based on the worst-case for TTS SEL_{cum} for fish species with a swim bladder involved in hearing

			RIAA (Section 8.4.4.1.9)		Updated Assessment	
Potential Impact	**Species**	**Location**	**Maximum number of individuals (% of SAC and SE MU) for all vessels**	**Potential adverse effect on site integrity**	**Maximum number of individuals (% of SAC and SE MU)**	**Potential adverse effect on site integrity**
Any changes in prey availability based on **TTS SEL_{cum} for fish species with a swim bladder involved in hearing (max. fleeing area at DEP (330km^2) and SEP (210km^2)**	Harbour seal	SEP & DEP	84 (2.95% of SAC count; 2.24% of SE MU)	**No**	61.3 (1.55% of SAC)	**No**

3.2.2 Updates to Assessment for Potential Effects during Operation and Maintenance

3.2.2.1 Updates to Assessment for Potential Effects of Underwater Noise from Operational Turbines

89. There were no changes in potential adverse effects on site integrity for harbour seal in the updated assessment for SEP or DEP.

Table 3-19: Maximum Number of Harbour Seal (and % of Reference Population) that Could be at Risk of TTS from Cumulative Exposure for All Operational Turbines at SEP and / or DEP

		RIAA (Table 8-83)		Updated Assessment	
Species	**Location**	**Operational Turbines Maximum number of individuals (% of SAC count and SE MU)**	**Potential adverse effect on site integrity**	**Operational Turbines Maximum number of individuals (% of SAC)**	**Potential adverse effect on site integrity**
Harbour seal	SEP (up to 23 wind turbines; 0.69km^2)	0.19 (SEP density of 0.274/km^2) (0.0066% of SAC count; 0.005% of SE MU)	**No**	0.14 (density of 0.202/km^2) (0.0035% of SAC)	**No**
	DEP (up to 30 wind turbines; 0.90km^2)	0.07 (DEP density of 0.080/km^2) (0.0025% of SAC count; 0.002% of SE MU)		0.05 (density of 0.057/km^2) (0.0013% of SAC)	
	SEP & DEP (up to 53 wind turbines; 1.59km^2)	0.26 (0.009% of SAC count; 0.0097% of SE MU)		0.19 (density of 0.0318/km^2) (0.0048% of SAC)	

3.2.2.2 Updates to Assessment for Impacts from Underwater Noise Associated with Operation and Maintenance Activities

90. As assessment for construction.

3.2.2.3 Updates to Assessment for Impacts from Underwater Noise and Disturbance Associated with Operation and Maintenance Vessels

91. As assessment for construction.

3.2.2.4 Updates to Assessment for Increased Risk of Collision with Vessels during Operation

92. As assessment for construction.

Annex 3

Figures

Sheringham Shoal and Dudgeon Extension Projects

Title:

Figure 5.1 - Grey seal at-sea mean densities

Document:

Marine Mammal Technical Note and Addendum

Legend:

- Dudgeon Offshore Wind Farm Extension Project Wind Farm Site
- Sheringham Shoal Offshore Wind Farm Extension Project Wind Farm Site
- Offshore Cable Corridors

Proportion of the population per 25km2 (as a %)

- 0.000000 - 0.002089
- 0.002090 - 0.006724
- 0.006725 - 0.014002
- 0.014003 - 0.025214
- 0.025215 - 0.041589
- 0.041590 - 0.067367
- 0.067368 - 0.101752

Data Source: © Carter et al., 2022.

Coordinate Reference System: WGS 1984 UTM Zone 31N
Transformation WGS84: OSGB_1936_To_WGS_1984_7

0 10 20 30 km
0 10 20 Miles

Scale: 1:500,000 Scale at size: A3

RHDHV Doc. no.: PB8164_RHD_ZZ_OF_DR_Z_0286

REV	DATE	STATUS	DRW	CHK	APR
A	27/04/2023	First Issue	AZ	GS	PM

Data Sources: Russell et al., 2017
Base Map: © OpenStreetMap (and) contributors, CC-BY-SA

Sheringham Shoal and Dudgeon Extension Projects

Title:

Figure 5.2 Grey seal at-sea mean densities for those individuals associated with the Humber Estuary SAC

Document:

Marine Mammal Technical Note and Addendum

Legend:

- Dudgeon Offshore Wind Farm Extension Project Wind Farm Site
- Sheringham Shoal Offshore Wind Farm Extension Project Wind Farm Site
- Offshore Cable Corridors
- Humber Estury SAC

Proportion of the population per 25km2 (as a %)

- 0.000000 - 0.011609
- 0.011610 - 0.037326
- 0.037327 - 0.073490
- 0.073491 - 0.123481
- 0.123482 - 0.205298
- 0.205299 - 0.356598
- 0.356599 - 0.627200

Data Source: © Carter et al., 2022.

Coordinate Reference System: WGS 1984 UTM Zone 31N
Transformation WGS84: OSGB_1936_To_WGS_1984_7

0 10 20 30 40 km
0 10 20 Miles

Scale: 1:650,000 Scale at size: A3

RHDHV Doc. no.: PB8164_RHD_ZZ_OF_DR_Z_0287

REV	DATE	STATUS	DRW	CHK	APR
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Data Sources: Russell et al., 2017
Base Map: © OpenStreetMap (and) contributors, CC-BY-SA

Sheringham Shoal and Dudgeon Extension Projects

Title:

Figure 5.3 Harbour seal at-sea mean densities

Document:

Marine Mammal Technical Note and Addendum

Legend:

- Dudgeon Offshore Wind Farm Extension Project Wind Farm Site
- Sheringham Shoal Offshore Wind Farm Extension Project Wind Farm Site
- Offshore Cable Corridors

Proportion of the population per 25km2 (as a %)

- 0.000000 - 0.005730
- 0.005731 - 0.018986
- 0.018987 - 0.038266
- 0.038267 - 0.066923
- 0.066924 - 0.115476
- 0.115477 - 0.203523
- 0.203524 - 0.421905

Data Source: © Carter et al., 2022.

Coordinate Reference System: WGS 1984 UTM Zone 31N
Transformation WGS84: OSGB_1936_To_WGS_1984_7

0 10 20 30 km
0 10 20 Miles

Scale: 1:500,000 Scale at size: A3

Equinor Doc. no.: C282-RH-Z-GA-00053
RHDHV Doc. no.: PB8164_RHD_ZZ_OF_DR_Z_0288

REV	DATE	STATUS	DRW	CHK	APR
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Data Sources: Russell et al., 2017
Base Map: © OpenStreetMap (and) contributors, CC-BY-SA

Sheringham Shoal and Dudgeon Extension Projects

Title:

Figure 5.4 Harbour seal at-sea mean densities for those individuals associated with The Wash and North Norfolk Coast SAC

Document:

Marine Mammal Technical Note and Addendum

Legend:

- Dudgeon Offshore Wind Farm Extension Project Wind Farm Site
- Sheringham Shoal Offshore Wind Farm Extension Project Wind Farm Site
- Offshore Cable Corridors
- The Wash and North Norfolk Coast SAC

Proportion of the population per 25km2 (as a %)

- 0.000000 - 0.042584
- 0.042585 - 0.156184
- 0.156185 - 0.333281
- 0.333282 - 0.580076
- 0.580077 - 0.843514
- 0.843515 - 1.197262
- 1.197263 - 2.248108

Data Source: © Carter et al., 2022.

Coordinate Reference System: WGS 1984 UTM Zone 31N
Transformation WGS84: OSGB_1936_To_WGS_1984_7

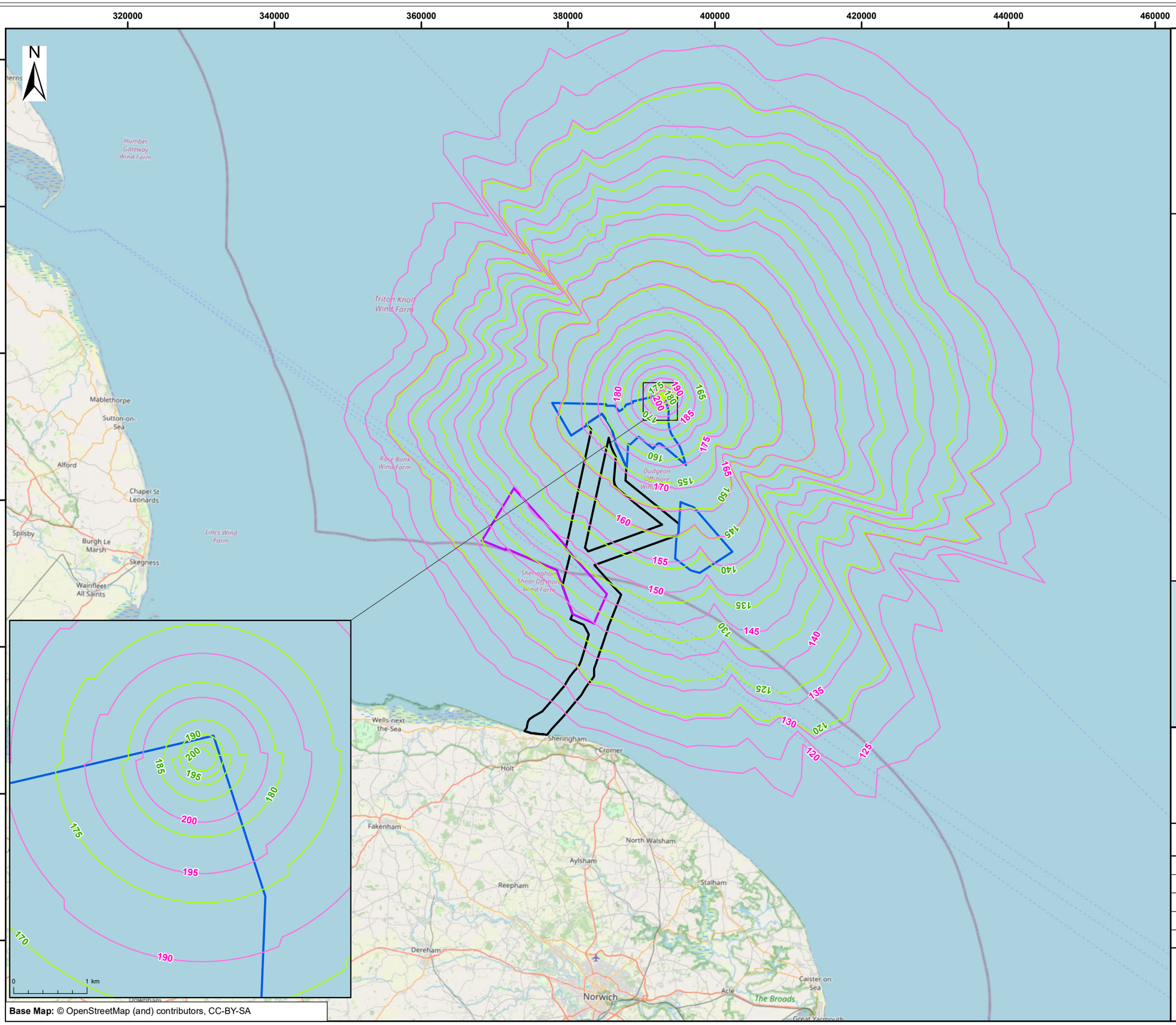
0 10 20 30 km
0 10 20 Miles

Scale: 1:500,000 Scale at size: A3

RHDHV Doc. no.: PB8164_RHD_ZZ_OF_DR_Z_0289

REV	DATE	STATUS	DRW	CHK	APR
A	27/04/2023	First Issue	AZ	GS	PM

Data Sources: Russell et al., 2017
Base Map: © OpenStreetMap (and) contributors, CC-BY-SA



Sheringham Shoal and Dudgeon Extension Projects

Title:

Figure 6.1 DEP NE Location - Monopile 5dB Contours

Document:

Marine Mammal Technical Note and Addendum

Legend:

- Dudgeon Offshore Wind Farm Extension Project Wind Farm Site
- Sheringham Shoal Offshore Wind Farm Extension Project Wind Farm Site
- Offshore Cable Corridors
- DEP NE Mono WC Unwtd SPLpeak (5dB)
- DEP NE Mono WC Unwtd SELss (5dB)

Data Source: © Subacoustech 2021

Coordinate Reference System: WGS 1984 UTM Zone 31N
Transformation WGS84: OSGB_1936_To_WGS_1984_7

0 10 20 30 km
0 10 20 Miles

Scale: 1:500,000 Scale at size: A3

RHDHV Doc. no.: PB8164_RHD_ZZ_OF_DR_Z_0306

REV	DATE	STATUS	DRW	CHK	APR
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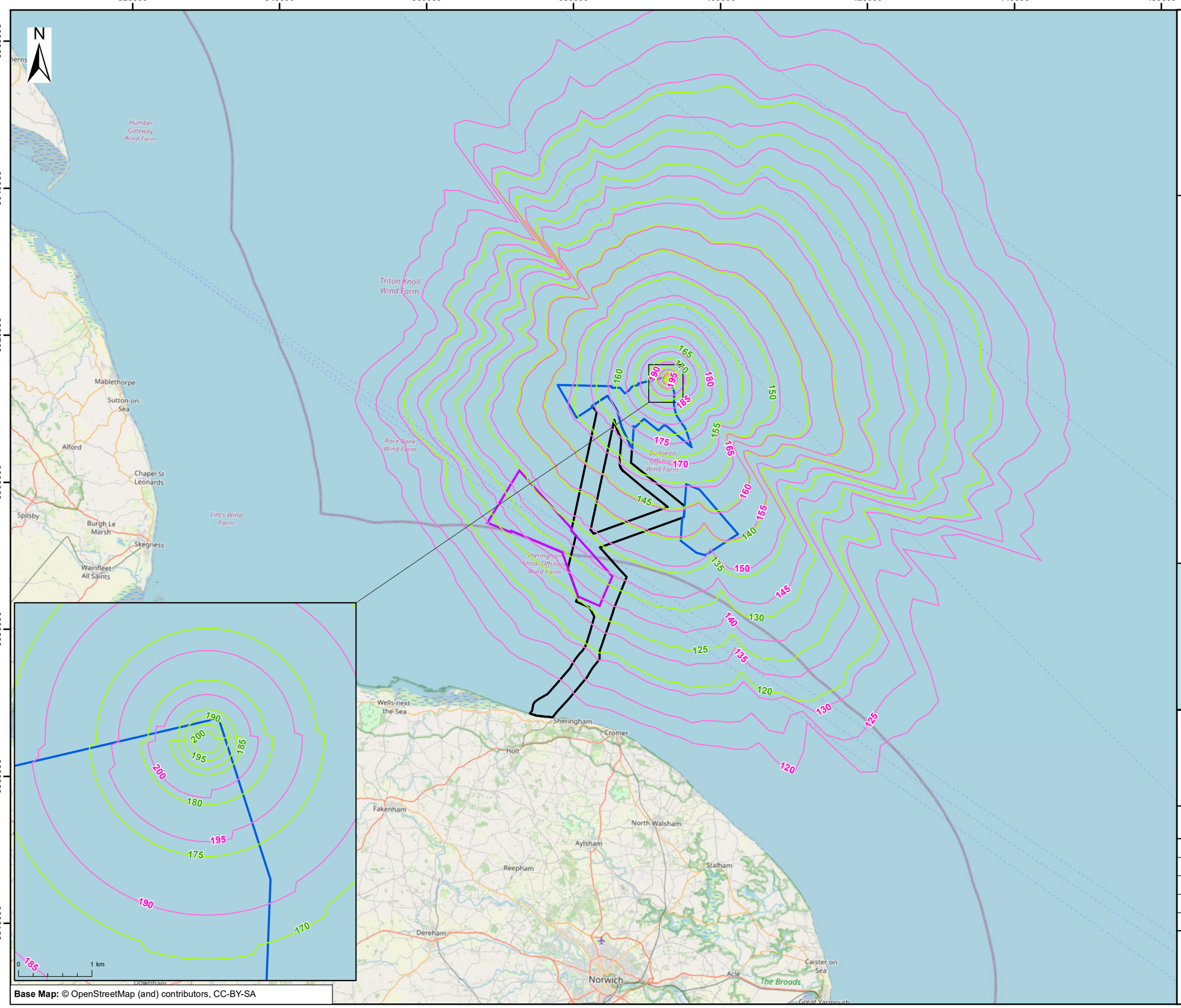

Base Map: © OpenStreetMap (and) contributors, CC-BY-SA

Sheringham Shoal and Dudgeon Extension Projects

Title:

Figure 6.2 DEP NE Location - Pin Pile 5dB Contours

Document:

Marine Mammal Technical Note and Addendum

Legend:

- Dudgeon Offshore Wind Farm Extension Project Wind Farm Site
- Sheringham Shoal Offshore Wind Farm Extension Project Wind Farm Site
- Offshore Cable Corridors
- DEP NE Pin WC4m Unwtd SPLpeak (5dB)
- DEP NE Pin WC4m Unwtd SELss (5dB)

Data Source: © Subacoustech 2021

Coordinate Reference System: WGS 1984 UTM Zone 31N
Transformation WGS84: OSGB_1936_To_WGS_1984_7

0 10 20 30 km
0 10 20 Miles

Scale: 1:500,000 Scale at size: A3

RHDHV Doc. no.: PB8164_RHD_ZZ_OF_DR_Z_0307

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Sheringham Shoal and Dudgeon Extension Projects

Title:

Figure 6.3 DEP SE Location - Monopile 5dB Contours

Document:

Marine Mammal Technical Note and Addendum

Legend:

- Dudgeon Offshore Wind Farm Extension Project Wind Farm Site
- Sheringham Shoal Offshore Wind Farm Extension Project Wind Farm Site
- Offshore Cable Corridors
- DEP SE Mono WC Unwtd SPLpeak (5dB)
- DEP SE Mono WC Unwtd SELss (5dB)

Data Source: © Subacoustech 2021

Coordinate Reference System: WGS 1984 UTM Zone 31N
Transformation WGS84: OSGB_1936_To_WGS_1984_7

0 10 20 30 km
0 10 20 Miles

Scale: 1:500,000 Scale at size: A3

RHDHV Doc. no.: PB8164_RHD_ZZ_OF_DR_Z_0308

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Sheringham Shoal and Dudgeon Extension Projects

Title:

Figure 6.4 DEP SE Location - Pin Pile 5dB Contours

Document:

Marine Mammal Technical Note and Addendum

Legend:

- Dudgeon Offshore Wind Farm Extension Project Wind Farm Site
- Sheringham Shoal Offshore Wind Farm Extension Project Wind Farm Site
- Offshore Cable Corridors
- DEP SE Pin WC4m Unwtd SPLpeak (5dB)
- DEP SE Pin WC4m Unwtd SELss (5dB)

Data Source: © Subacoustech 2021

Coordinate Reference System: WGS 1984 UTM Zone 31N
Transformation WGS84: OSGB_1936_To_WGS_1984_7

0 10 20 30 km
0 10 20 Miles

Scale: 1:500,000 Scale at size: A3

RHDHV Doc. no.: PB8164_RHD_ZZ_OF_DR_Z_0309

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Sheringham Shoal and Dudgeon Extension Projects

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Figure 6.5 DEP NE Location - Monopile 5dB Contours

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Marine Mammal Technical Note and Addendum

Legend:

- Dudgeon Offshore Wind Farm Extension Project Wind Farm Site
- Sheringham Shoal Offshore Wind Farm Extension Project Wind Farm Site
- Offshore Cable Corridors
- SEP E Mono WC Unwtd SPLpeak (5dB)
- SEP E Mono WC Unwtd SELss (5dB)

Data Source: © Subacoustech 2021

Coordinate Reference System: WGS 1984 UTM Zone 31N
Transformation WGS84: OSGB_1936_To_WGS_1984_7

0 10 20 30 km
0 10 20 Miles

Scale: 1:500,000 Scale at size: A3

RHDHV Doc. no.: PB8164_RHD_ZZ_OF_DR_Z_0310

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Sheringham Shoal and Dudgeon Extension Projects

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Figure 6.6 SEP E Location - Pin Pile 5dB Contours

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Marine Mammal Technical Note and Addendum

Legend:

- Sheringham Shoal Offshore Wind Farm Extension Project Wind Farm Site
- Offshore Cable Corridors
- Dudgeon Offshore Wind Farm Extension Project Wind Farm Site
- SEP E Pin WC4m Unwtd SPLpeak (5dB)
- SEP E Pin WC4m Unwtd SELss (5dB)

Data Source: © Subacoustech 2021

Coordinate Reference System: WGS 1984 UTM Zone 31N
Transformation WGS84: OSGB_1936_To_WGS_1984_7

0 10 20 30 km
0 10 20 Miles

Scale: 1:500,000 Scale at size: A3

RHDHV Doc. no.: PB8164_RHD_ZZ_OF_DR_Z_0311

A	07/07/2023	First Issue	FC	GS	PM
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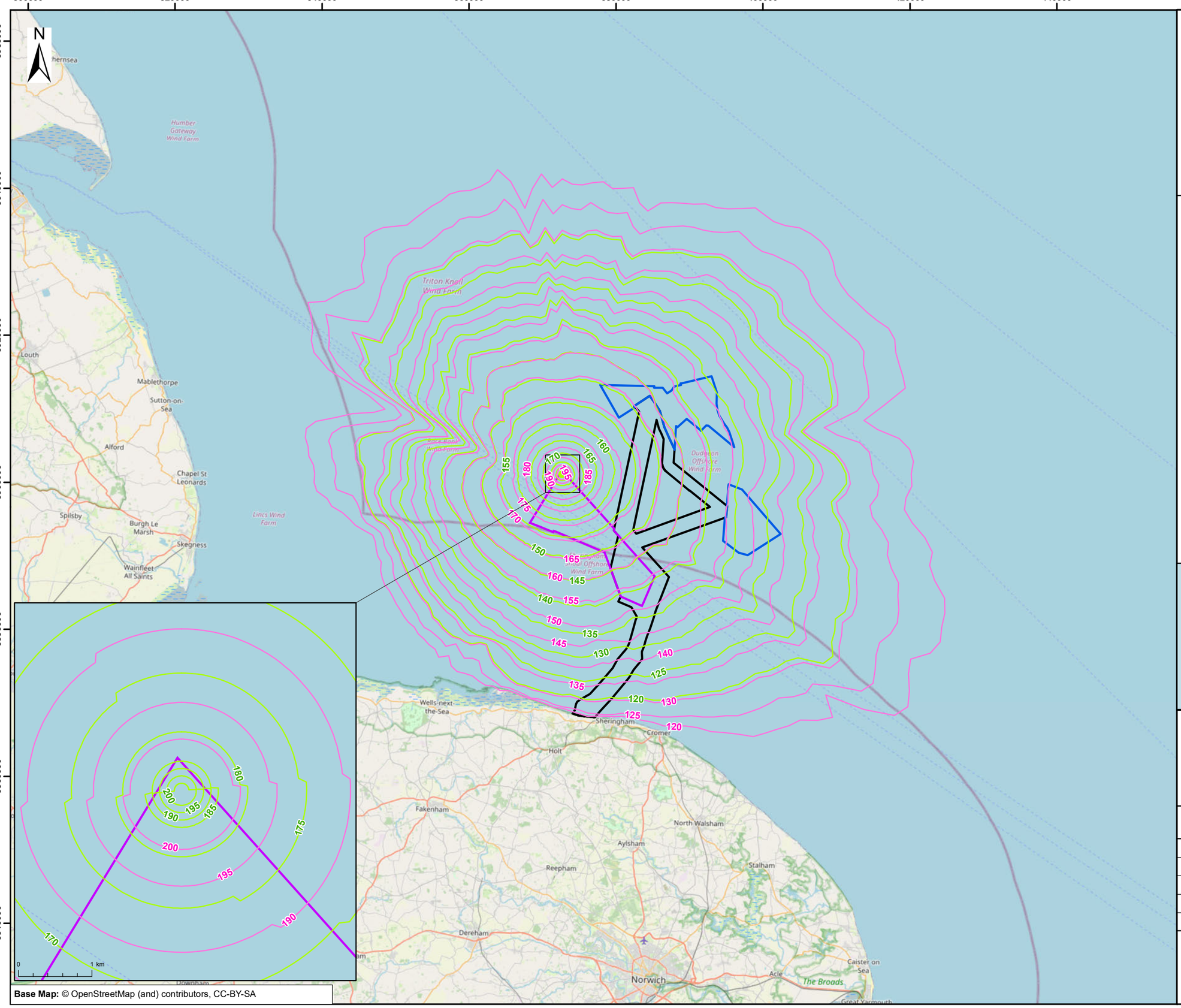

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Sheringham Shoal and Dudgeon Extension Projects

Title:

Figure 6.7 SEP N Location - Monopile 5dB Contours

Document:

Marine Mammal Technical Note and Addendum

Legend:

- Dudgeon Offshore Wind Farm Extension Project Wind Farm Site
- Sheringham Shoal Offshore Wind Farm Extension Project Wind Farm Site
- Offshore Cable Corridors
- SEP N Mono WC Unwtd SPLpeak (5dB)
- SEP N Mono WC Unwtd SELss (5dB)

Data Source: © Subacoustech 2021

Coordinate Reference System: WGS 1984 UTM Zone 31N
Transformation WGS84: OSGB_1936_To_WGS_1984_7

0 10 20 30 km
0 10 20 Miles

Scale: 1:500,000 Scale at size: A3

RHDHV Doc. no.: PB8164_RHD_ZZ_OF_DR_Z_0312

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Sheringham Shoal and Dudgeon Extension Projects

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Figure 6.8 SEP N Location
- Pin Pile 5dB Contours

Document:

Marine Mammal Technical Note and Addendum

Legend:

- Dudgeon Offshore Wind Farm Extension Project Wind Farm Site
- Sheringham Shoal Offshore Wind Farm Extension Project Wind Farm Site
- Offshore Cable Corridors
- SEP N Pin WC4m_Unwtd SPLpeak (5dB)
- SEP N Pin WC4m_Unwtd SELss (5dB)

Data Source: © Subacoustech 2021

Coordinate Reference System: WGS 1984 UTM Zone 31N
Transformation WGS84: OSGB_1936_To_WGS_1984_7

0 10 20 30 km
0 10 20 Miles

Scale: 1:500,000 Scale at size: A3

RHDHV Doc. no.: PB8164_RHD_ZZ_OF_DR_Z_0313

REV	DATE	STATUS	DRW	CHK	APR
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Sheringham Shoal and Dudgeon Extension Projects

Title:

Figure 6.9 Dose response curve assessment or harbour porpoise (monopile at SEP)

Document:

Marine Mammal Technical Note and Addendum

Legend:

- Dudgeon Offshore Wind Farm Extension Project Wind Farm Site
- Sheringham Shoal Offshore Wind Farm Extension Project Wind Farm
- Offshore Cable Corridors

Hartbour Porpoise Density per km2

- 0.000008938 - 0.084565397
- 0.084565397 - 0.238972842
- 0.238972842 - 0.371322081
- 0.371322081 - 0.488965849
- 0.488965849 - 0.624991456
- 0.624991456 - 0.772046166
- 0.772046166 - 0.937482715

dB Level for monopiles at SEP N

120, 125, 130, 135, 140, 145, 150, 155, 160, 165, 170, 175, 180, 185, 190, 195, 200

Data Source: © Waggitt et al., 2019

Coordinate Reference System: WGS 1984 UTM Zone 31N
Transformation WGS84: OSGB_1936_To_WGS_1984_7

0 10 20 30 km
0 10 20 Miles

Scale: 1:500,000 Scale at size: A3

RHDHV Doc. no.: PB8164_RHD_ZZ_OF_DR_Z_0290

REV	DATE	STATUS	DRW	CHK	APR
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Sheringham Shoal and Dudgeon Extension Projects

Title:

Figure 6.10 Dose response curve assessment for harbour porpoise (monopile at DEP)

Document:

Marine Mammal Technical Note and Addendum

Legend:

- Dudgeon Offshore Wind Farm Extension Project Wind Farm Site
- Sheringham Shoal Offshore Wind Farm Extension Project Wind Farm Site
- Offshore Cable Corridors

Harbour Porpoise Density per km2

- 0.000008938 - 0.084565397
- 0.084565397 - 0.238972842
- 0.238972842 - 0.371322081
- 0.371322081 - 0.488965849
- 0.488965849 - 0.624991456
- 0.624991456 - 0.772046166
- 0.772046166 - 0.937482715

dB level for monopiles at DEP SE

- 120
- 125
- 130
- 135
- 140
- 145
- 150
- 155
- 160
- 165
- 170
- 175
- 180
- 185
- 190
- 195
- 200

Data Source: © Waggitt et al., 2019

Coordinate Reference System: WGS 1984 UTM Zone 31N
Transformation WGS84: OSGB_1936_To_WGS_1984_7

0 10 20 30 km
0 10 20 Miles

Scale: 1:500,000 Scale at size: A3

RHDHV Doc. no.: PB8164_RHD_ZZ_OF_DR_Z_0291

REV	DATE	STATUS	DRW	CHK	APR
A	02/05/2023	First Issue	AZ	GS	PM

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Sheringham Shoal and Dudgeon Extension Projects

Title:

Figure 6.11 Dose response curve assessment for grey seal (monopile at SEP)

Document:

Marine Mammal Technical Note and Addendum

Legend:

- Dudgeon Offshore Wind Farm Extension Project Wind Farm Site
- Sheringham Shoal Offshore Wind Farm Extension Project Wind Farm Site
- Offshore Cable Corridors

Proportion of the population per 25km2 (as a %)

- 0.000000 - 0.002089
- 0.002090 - 0.006724
- 0.006725 - 0.014002
- 0.014003 - 0.025214
- 0.025215 - 0.041589
- 0.041590 - 0.067367
- 0.067368 - 0.101752

dB level

- 120
- 125
- 130
- 135
- 140
- 145
- 150
- 155
- 160
- 165
- 170
- 175
- 180
- 185
- 190
- 195
- 200

Data Source: © Carter 2022

Coordinate Reference System: WGS 1984 UTM Zone 31N
Transformation WGS84: OSGB_1936_To_WGS_1984_7

0 10 20 30 km

0 10 20 Miles

Scale: 1:500,000 Scale at size: A3

RHDHV Doc. no.: PB8164_RHD_ZZ_OF_DR_Z_0292

REV	DATE	STATUS	DRW	CHK	APR
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Data Sources: Russell et al., 2017
Base Map: © OpenStreetMap (and) contributors, CC-BY-SA

Sheringham Shoal and Dudgeon Extension Projects

Title:

Figure 6.12 Dose response curve assessment for grey seal (monopile at DEP)

Document:

Marine Mammal Technical Note and Addendum

Legend:

- Dudgeon Offshore Wind Farm Extension Project Wind Farm Site
- Sheringham Shoal Offshore Wind Farm Extension Project Wind Farm Site
- Offshore Cable Corridors

Proportion of the population per 25km2 (as a %)

- 0.000000 - 0.002089
- 0.002090 - 0.006724
- 0.006725 - 0.014002
- 0.014003 - 0.025214
- 0.025215 - 0.041589
- 0.041590 - 0.067367
- 0.067368 - 0.101752

dB level for monopiles at DEP SE

- 120
- 125
- 130
- 135
- 140
- 145
- 150
- 155
- 160
- 165
- 170
- 175
- 180
- 185
- 190
- 195
- 200

Data Source: © Carter 2022

Coordinate Reference System: WGS 1984 UTM Zone 31N
Transformation WGS84: OSGB_1936_To_WGS_1984_7

0 10 20 30 km
0 10 20 Miles

Scale: 1:500,000 Scale at size: A3

RHDHV Doc. no.: PB8164_RHD_ZZ_OF_DR_Z_0293

REV	DATE	STATUS	DRW	CHK	APR
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320000 340000 360000 380000 400000 420000 440000 460000

5940000 5920000 5900000 5880000 5860000 5840000 5820000

N

Triton Knoll Wind Farm
Race Bank Wind Farm
Dudgeon Offshore Wind Farm
Sheringham Shoal Offshore Wind Farm
Lincs Wind Farm
Mablethorpe
Sutton-on-Sea
Chapel St Leonards
Skegness
The Wash
Hunstanton
Wells-next-the-Sea
Sheringham
Cromer
Holt
The Wash National Nature Reserve
Norfolk Coast AONB
Fakenham
North Walsham
Aylsham
King's Lynn
Reepham
Stalham
Dereham
Swaffham
Downham Market
Norwich
Acle
The Broads
Caister on Sea
Great Yarmouth
Gorleston-on-Sea
Watton
Hingham
Wymondham
Stanford Training
Attleborough
Loddon

Base Map: © OpenStreetMap (and) contributors, CC-BY-SA

Sheringham Shoal and Dudgeon Extension Projects

Title:

Figure 6.13 Dose response curve assessment for harbour seal (monopile at SEP)

Document:

Marine Mammal Technical Note and Addendum

Legend:

- Dudgeon Offshore Wind Farm Extension Project Wind Farm Site
- Sheringham Shoal Offshore Wind Farm Extension Project Wind Farm Site
- Offshore Cable Corridors

Proportion of the population per 25km2 (as a %)

- 0.000000 - 0.005730
- 0.005731 - 0.018986
- 0.018987 - 0.038266
- 0.038267 - 0.066923
- 0.066924 - 0.115476
- 0.115477 - 0.203523
- 0.203524 - 0.421905

dB level for monopiles at SEP E

- 120
- 125
- 130
- 135
- 140
- 145
- 150
- 155
- 160
- 165
- 170
- 175
- 180
- 185
- 190
- 195
- 200

Data Source: © Carter 2022

Coordinate Reference System: WGS 1984 UTM Zone 31N
Transformation WGS84: OSGB_1936_To_WGS_1984_7

0 10 20 30 km
0 10 20 Miles

Scale: 1:500,000 Scale at size: A3

RHDHV Doc. no.: PB8164_RHD_ZZ_OF_DR_Z_0294

REV	DATE	STATUS	DRW	CHK	APR
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Sheringham Shoal and Dudgeon Extension Projects

Title:

Figure 6.14 Dose response curve assessment for harbour seal (monopile at DEP)

Document:

Marine Mammal Technical Note and Addendum

Legend:

- Dudgeon Offshore Wind Farm Extension Project Wind Farm Site
- Sheringham Shoal Offshore Wind Farm Extension Project Wind Farm Site
- Offshore Cable Corridors

Proportion of the population per 25km2 (as a %)

- 0.000000 - 0.005730
- 0.005731 - 0.018986
- 0.018987 - 0.038266
- 0.038267 - 0.066923
- 0.066924 - 0.115476
- 0.115477 - 0.203523
- 0.203524 - 0.421905

dB level for monopiles at DEP SE

- 120
- 125
- 130
- 135
- 140
- 145
- 150
- 155
- 160
- 165
- 170
- 175
- 180
- 185
- 190
- 195
- 200

Data Source: © Carter 2022

Coordinate Reference System: WGS 1984 UTM Zone 31N
Transformation WGS84: OSGB_1936_To_WGS_1984_7

0 10 20 30 km
0 10 20 Miles

Scale: 1:500,000 Scale at size: A3

RHDHV Doc. no.: PB8164_RHD_ZZ_OF_DR_Z_0295

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Sheringham Shoal and Dudgeon Extension Projects

Title:

Figure 7.1 Dose response curve assessment for grey seal associated with the Humber Estuary SAC (monopile at SEP)

Document:

Marine Mammal Technical Note and Addendum

Legend:

- Dudgeon Offshore Wind Farm Extension Project Wind Farm Site
- Sheringham Shoal Offshore Wind Farm Extension Project Wind Farm Site
- Offshore Cable Corridors

Proportion of the population per 25km2 (as a %)

- 0.000000 - 0.011609
- 0.011610 - 0.037326
- 0.037327 - 0.073490
- 0.073491 - 0.123481
- 0.123482 - 0.205298
- 0.205299 - 0.356598
- 0.356599 - 0.627200

dB level for monopiles at SEP N

- 120
- 125
- 130
- 135
- 140
- 145
- 150
- 155
- 160
- 165
- 170
- 175
- 180
- 185
- 190
- 195
- 200

Data Source: © Carter 2022

Coordinate Reference System: WGS 1984 UTM Zone 31N
Transformation WGS84: OSGB_1936_To_WGS_1984_7

0 10 20 30 km

0 10 20 Miles

Scale: 1:500,000 Scale at size: A3

RHDHV Doc. no.: PB8164_RHD_ZZ_OF_DR_Z_0296

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320000 340000 360000 380000 400000 420000 440000 460000

5960000 5940000 5920000 5900000 5880000 5860000

N

Hornsea 2 Offshore Wind Farm
Hornsea 1 Offshore Wind Farm
Humber Gateway Wind Farm
Triton Knoll Wind Farm
Race Bank Wind Farm
Dudgeon Offshore Wind Farm
Lincs Wind Farm
Sheringham Shoal Offshore Wind Farm
Mablethorpe
Sutton-on-Sea
Chapel St Leonards
Skegness
The Wash
Hunstanton
Wells-next-the-Sea
Sheringham
Cromer
Holt
Fakenham
North Walsham
Aylsham
Reepham
Stalham
King's Lynn
The Wash National Nature Reserve
Norfolk Coast AONB

Base Map: © OpenStreetMap (and) contributors, CC-BY-SA

Sheringham Shoal and Dudgeon Extension Projects

Title:

Figure 7.2 Dose response curve assessment for grey seal associated with the Humber Estuary SAC (monopile at DEP)

Document:

Marine Mammal Technical Note and Addendum

Legend:

- Dudgeon Offshore Wind Farm Extension Project Wind Farm Site
- Sheringham Shoal Offshore Wind Farm Extension Project Wind Farm Site
- Offshore Cable Corridors

Proportion of the population per 25km2 (as a %)

- 0.000000 - 0.011609
- 0.011610 - 0.037326
- 0.037327 - 0.073490
- 0.073491 - 0.123481
- 0.123482 - 0.205298
- 0.205299 - 0.356598
- 0.356599 - 0.627200

dB level for monopiles at DEP NE

- 120
- 125
- 130
- 135
- 140
- 145
- 150
- 155
- 160
- 165
- 170
- 175
- 180
- 185
- 190
- 195
- 200

Data Source: © Carter 2022

Coordinate Reference System: WGS 1984 UTM Zone 31N
Transformation WGS84: OSGB_1936_To_WGS_1984_7

0 10 20 30 km
0 10 20 Miles

Scale: 1:500,000 Scale at size: A3

RHDHV Doc. no.: PB8164_RHD_ZZ_OF_DR_Z_0297

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Sheringham Shoal and Dudgeon Extension Projects

Title:

Figure 7.3 Dose response curve assessment for harbour seal associated with The Wash and North Norfolk Coast SAC (monopile at SEP)

Document:

Marine Mammal Technical Note and Addendum

Legend:

- Dudgeon Offshore Wind Farm Extension Project Wind Farm Site
- Sheringham Shoal Offshore Wind Farm Extension Project Wind Farm Site
- Offshore Cable Corridors

Proportion of the population per 25km2 (as a %)

- 0.000000 - 0.042584
- 0.042585 - 0.156184
- 0.156185 - 0.333281
- 0.333282 - 0.580076
- 0.580077 - 0.843514
- 0.843515 - 1.197262
- 1.197263 - 2.248108

dB level for monopiles at SEP E

- 120
- 125
- 130
- 135
- 140
- 145
- 150
- 155
- 160
- 165
- 170
- 175
- 180
- 185
- 190
- 195
- 200

Data Source: © Carter 2022

Coordinate Reference System: WGS 1984 UTM Zone 31N
Transformation WGS84: OSGB_1936_To_WGS_1984_7

0 10 20 30 km
0 10 20 Miles

Scale: 1:500,000 Scale at size: A3

RHDHV Doc. no.: PB8164_RHD_ZZ_OF_DR_Z_0298

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Sheringham Shoal and Dudgeon Extension Projects

Title:

Figure 7.4 Dose response curve assessment for harbour seal associated with The Wash and North Norfolk Coast SAC (monopile at DEP)

Document:

Marine Mammal Technical Note and Addendum

Legend:

- Dudgeon Offshore Wind Farm Extension Project Wind Farm Site
- Sheringham Shoal Offshore Wind Farm Extension Project Wind Farm Site
- Offshore Cable Corridors

Proportion of the population per 25km2 (as a %)

- 0.000000 - 0.042584
- 0.042585 - 0.156184
- 0.156185 - 0.333281
- 0.333282 - 0.580076
- 0.580077 - 0.843514
- 0.843515 - 1.197262
- 1.197263 - 2.248108

dB level for monopiles at DEP SE

- 120
- 125
- 130
- 135
- 140
- 145
- 150
- 155
- 160
- 165
- 170
- 175
- 180
- 185
- 190
- 195
- 200

Data Source: © Carter 2022

Coordinate Reference System: WGS 1984 UTM Zone 31N
Transformation WGS84: OSGB_1936_To_WGS_1984_7

0 10 20 30 km
0 10 20 Miles

Scale: 1:500,000 Scale at size: A3

RHDHV Doc. no.: PB8164_RHD_ZZ_OF_DR_Z_0299

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