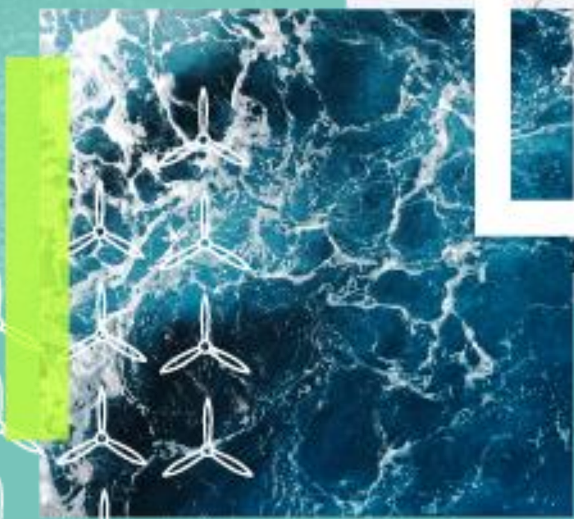

Berwick Bank Wind Farm

Additional Environmental Information (AEI) Submission

AEI01: Addendum to the EIA and HRA

Section 2 Marine Mammal Response

sse Renewables

BERWICK BANK WIND FARM
ENVIRONMENTAL IMPACT ASSESSMENT REPORT

Marine Mammals Additional Information Report to Volume 2, Chapter 10

EOR0825
EIA Report – Chapter 10 Additional Information Report
FINAL

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ACRONYMS

Acronym	Description
ADD	Acoustic Deterrent Device
BBWFL	Berwick Bank Wind Farm Limited
CI	Confidence Interval
EIA	Environmental Impact Assessment
GIS	Geographical Information System
GTI	Global Tech I
iPCoD	interim Population of Consequences of Displacement
LF	Low Frequency
MD-LOT	Marine Directorate - Licensing Operations Team
MU	Management Unit
N/A	Not Applicable
NEQ	Net Explosive Quantity
OSP	Offshore Substation Platform
PTS	Permanent Threshold Shift
SAC	Special Area of Conservation
ScotMER	Scottish Marine Energy Research
SEL	Sound Exposure Level
SELss	Sound Exposure Level Single Strike
SPEN	Scottish Power Energy Networks
TTS	Temporary Threshold Shift
UXO	Unexploded Ordnance
VHF	Very High Frequency

UNITS

Unit	Description
%	Percentage
μPa	Micropascal
$\mu Pa^2 s$	Micropascal Squared Second
dB	Decibel
kg	Kilogram
kJ	Kilojoule
km	Kilometre
km^2	Square Kilometre
m	Metre
mm	Millimetre
t	Tonne

1. INTRODUCTION

1. Berwick Bank Wind Farm Limited (BBWFL), a wholly owned subsidiary of SSE Renewables Limited (hereafter be referred to as 'the Applicant'), is proposing the development of the Berwick Bank Wind Farm (offshore infrastructure is hereafter referred to as "the Proposed Development"), an offshore wind farm off the east coast of Scotland. The Proposed Development array area is located in the outer Firth of Forth and Forth of Tay, approximately 37.8 km east of the Scottish Borders coastline (St Abb's Head) and 47.6 km from the East Lothian coastline. The Proposed Development array area will be connected to a Scottish Power Energy Networks (SPEN) substation at Branxton via a Proposed Development export cable corridor.

2. The application for consent under Section 36 of the Electricity Act 1898 and Marine Licence under Part 4 of the Marine (Scotland) Act has been submitted on 9 December 2022. The application included an Environmental Impact Assessment (EIA) which was carried out to assess the potential effects of the Proposed Development on various sensitive receptors, including marine mammals, from a range of impacts. The assessment of the likely significant effects (as per the "EIA Regulations") of the Proposed Development on marine mammals was provided in volume 2, chapter 10 of the Offshore EIA Report.

3. NatureScot (a statutory consultee to the Marine Directorate Licencing and Operations Team (MD-LOT)) provided their post-submission advice in relation to the marine mammal impact assessment provided as part of the application, on 21 February 2023. In their response, NatureScot provided feedback on a number of aspects of the marine mammal assessment, and identified that additional information as required in order to provide their final advice in relation to potential marine mammal impacts. NatureScot provided their marine mammal advice with regard to the Offshore EIA Report and the Report to Inform the Appropriate Assessment (RIAA) in Appendix E and Appendix G, respectively.

4. Following the review of the Proposed Development supporting documents, presented as a part of the application, and the consultation representations, MD-LOT requested supplementary information to be submitted in their response on 26 May 2023. The information requested by MD-LOT is consistent with advice provided by NatureScot on 21 February 2023.

5. In their responses, NatureScot and MD-LOT identified three main areas where they requested additional information with respect to marine mammals:

- assessment of behavioural disturbance due to the underwater noise during piling for harbour seal *Phoca vitulina*, specifically the use of appropriate dose-response[1];
- the cumulative interim Population of Consequences of Displacement (iPCoD) modelling approach and using more precautionary conversion factor (10% reducing to 1%)[1]; and
- Temporary Threshold Shift (TTS) impact ranges (weighted Sound Exposure Level (SEL)) as a result of underwater noise during Unexploded Ordnance (UXO) detonation.

6. This report presents additional information requested by Nature Scot and MD-LOT:

- Section 2 – an overview of the main points raised by NatureScot and MD-LOT.
- Section 3 – assessment of behavioural disturbance as a result of underwater noise during piling on harbour seal using two different dose-response approaches.
- Section 4 – cumulative iPCoD modelling approach using 10% reducing to 1% conversion factor.
- Section 5 – a summary of information presented in appendix A regarding TTS weighted SEL impact ranges as a result of underwater noise during UXO detonation. The TTS impact ranges were originally presented in volume 3, appendix 10.1 of the Offshore EIA Report and detailed description of these is provided in appendix A of this Additional Information Report, which also provides further evidence with respect to the choice of the conversion factor.
- Section 6 – the implications of findings presented in this Additional Information Report on the RIAA submitted as a part of the consent application.
- Section 7 – a summary of findings.

7. This Additional Information Report should be read alongside the following documents, previously submitted as part of the Offshore EIA Report:

- volume 2, chapter 10: Marine Mammals;
- volume 3, appendix 10.1: Subsea Noise Technical Report;
- volume 3, appendix 10.2: Marine Mammals Technical Report;
- volume 3, appendix 10.3: Marine Mammals Road Map;
- volume 3, appendix 10.4: Marine Mammals iPCoD Modelling Report; and
- volume 3, appendix 10.5: Marine Mammals Conversion Factor Supporting Information.

2. OVERVIEW OF APPLICATION RESPONSES IN RELATION TO MARINE MAMMALS

8. In their response to the Offshore EIA Report and the RIAA (21 February 2023), NatureScot provided feedback on the volume 2, chapter 10 of the Offshore EIA Report (Appendix E) and the Annex II marine mammals section of the RIAA (Appendix G). All responses have been considered and, where appropriate, additional information has been provided below (sections 3 to 5). Subsequently, on the basis of the NatureScot representation, MD-LOT requested additional information to be provided with regard to marine mammal assessment (26 May 2023).

9. A summary of the key points raised by NatureScot and MD-LOT in relation to marine mammals is presented in Table 2.1, together with how these issues have been considered in the production of this marine mammals Additional Information Report.

[1] In Appendix G, NatureScot highlighted that additional information on these queries is required in order to receive final advice in relation to the European sites and further information is provided in section 6.

Table 2.1: Summary of NatureScot and MD-LOT Post-Submission Responses Relevant to Marine Mammals

Overarching Theme	Point Raised	Response to Point Raised and/or where Considered in This Report
Assessment approach/Disturbance risk	NatureScot and MD-LOT requested that: • the harbour seal assessment should be revised to include the updated Whyte *et al*. (2020) dose response information; or • evidence is provided to support the Russell *et al*. (2016) information being more precautionary. NatureScot have highlighted this is required in order to provide their final advice to the volume 2, chapter 10 of the Offshore EIA Report and on the Firth of Tay and Eden Estuary Special Area of Conservation (SAC) where harbour seal is a qualifying feature.	The assessment of behavioural disturbance as a result of underwater noise during piling on harbour seal presented in the volume 2, chapter 10 of the Offshore EIA Report was based on Russell *et al.* (2016). Section 3 of this Additional Information Report provides background information about dose-response applications (Russell *et al*., 2016; Whyte *et al*., 2020) as well as results of assessment of impacts (behavioural disturbance) as a result of underwater noise during piling on harbour seal using both approaches, indicating which approach is most precautionary.
Underwater noise impact assessment/Population level effects	NatureScot advised that due to the high uncertainty around the choice of conversion factor for underwater noise, it has previously been suggested during the Marine Mammal Road Map process that the 10% reducing to 1% conversion factor scenario should be applied in the cumulative assessment. NatureScot and MD-LOT have requested that the 10% reducing to 1% conversion factor scenario is used in the iPCoD cumulative scenario. NatureScot have highlighted that this is required in order to provide their final marine mammal advice on volume 2, chapter 10 of the Offshore EIA Report and the Annex II marine mammals section of the RIAA.	Section 4 presents results of the cumulative iPCoD modelling using the requested scenario of 10% reducing to 1% conversion factor. Other scenarios are presented in volume 3, appendix 10.4 and subsequently in volume 2, chapter 10 of the Offshore EIA Report. Additionally, appendix A provides an overview of further evidence regarding the choice of most appropriate conversion factor, based on scientific literature which has been published since the submission of the application on 9 December 2022.
Underwater noise impact assessment/UXO detonation	NatureScot highlighted that the underwater noise modelling results presented for the low order clearance of the 0.5 kg charge size (volume 3, appendix 10.1 of the Offshore EIA Report) suggest that the Very High Frequency (VHF) hearing group has the largest TTS SEL weighted range amongst all the hearing groups. It was NatureScot's expectation that the Low Frequency (LF) hearing group would have the largest impact range based on the SEL weighted metric. As such, NatureScot and MD-LOT have requested clarification on TTS injury ranges as a result of underwater noise during UXO detonation.	Detailed clarification on TTS injury ranges as a result of underwater noise during UXO detonation is provided in appendix A. A summary of findings presented in this appendix is included in section 4.4.

3. ASSESSMENT OF BEHAVIOURAL DISTURBANCE AS A RESULT OF UNDERWATER NOISE DURING PILING ON HARBOUR SEAL USING TWO DIFFERENT DOSE-RESPONSE APPROACHES

3.1. BACKGROUND

10. Empirical evidence from monitoring at offshore wind farms during construction suggests that pile driving is unlikely to lead to 100% avoidance of all individuals exposed, and that there will be a proportional decrease in avoidance at greater distances from the pile driving source (Brandt *et al*., 2011). The assessment of behavioural disturbance as a result of underwater noise during piling on harbour seal presented in volume 2, chapter 10 of the Offshore EIA Report was based on Russell *et al.* (2016).

11. A telemetry study undertaken by Russell *et al*. (2016) investigating the behaviour of 23 tagged harbour seals during pile driving at the Lincs Offshore Wind Farm in the Wash found that there was a proportional response at different received noise levels. Dividing the study area into a 5 km x 5 km grid, the authors modelled unweighted Sound Exposure Single Strike Levels (SELss) and matched these to corresponding densities of harbour seals in the same grids during non-piling versus piling periods to illustrate change in usage. The study illustrated how seal density changes in relation to predicted SELss (Figure 3.1). More recently, a study by Whyte *et al*. (2020) updated the Russell *et al.* (2016) study to compare how the change in predicted seal density (between piling and non-piling periods) related to both the distance from the centre of the piling operation (e.g. the centre of the Lincs wind farm) and the predicted received SELss at each cell location (Figure 3.2).

12. The authors of Whyte *et al*. (2020) highlighted the main differences between both studies (Russell *et al*., 2016; Whyte *et al.,* 2020) and noted that each applied a different sound propagation modelling approach. The approaches also differed in how the estimates are calculated. The cumulative approach was adopted in Russell *et al.* (2016), where the proportion of seals affected at each isopleth included all seals affected up to that point (i.e. at lower SELss). In contrast, in addition to a cumulative approach, the annulus approach was explored in Whyte *et al.* (2020), which looked at predicted change in seal density separately for each SELss increment (e.g. 135 dB re 1 μPa^2 to 140 dB re 1 μPa^2).

13. In order to identify whether application of Russell *et al.* (2016) or Whyte *et al.* (2020) will result in more precautionary conclusions, as requested by NatureScot (21 February 2023), the assessment was carried out using dose-response values assessed in both studies (see section 3.3).

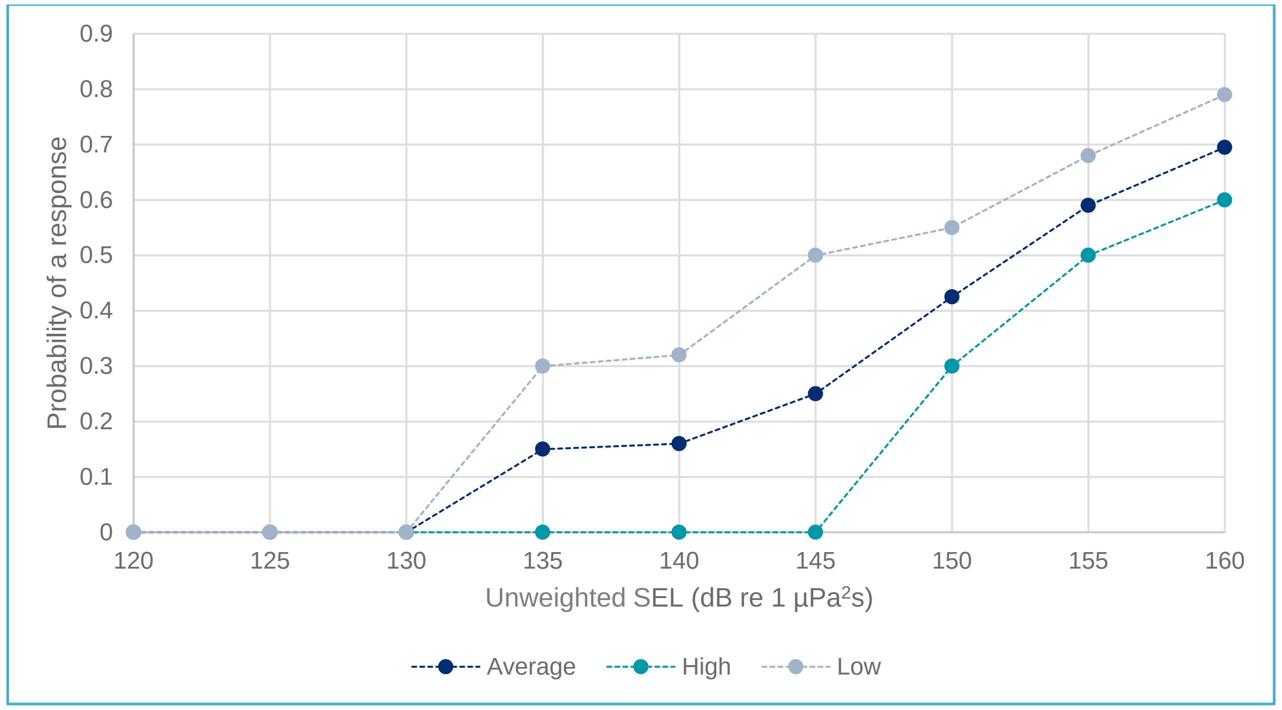

Figure 3.1: The Predicted Percentage Change in Seal Usage During Piling (Compared to Non-piling Periods) in Relation to Unweighted SEL at 5 dB Increments. Source: Russell *et al*. (2016)

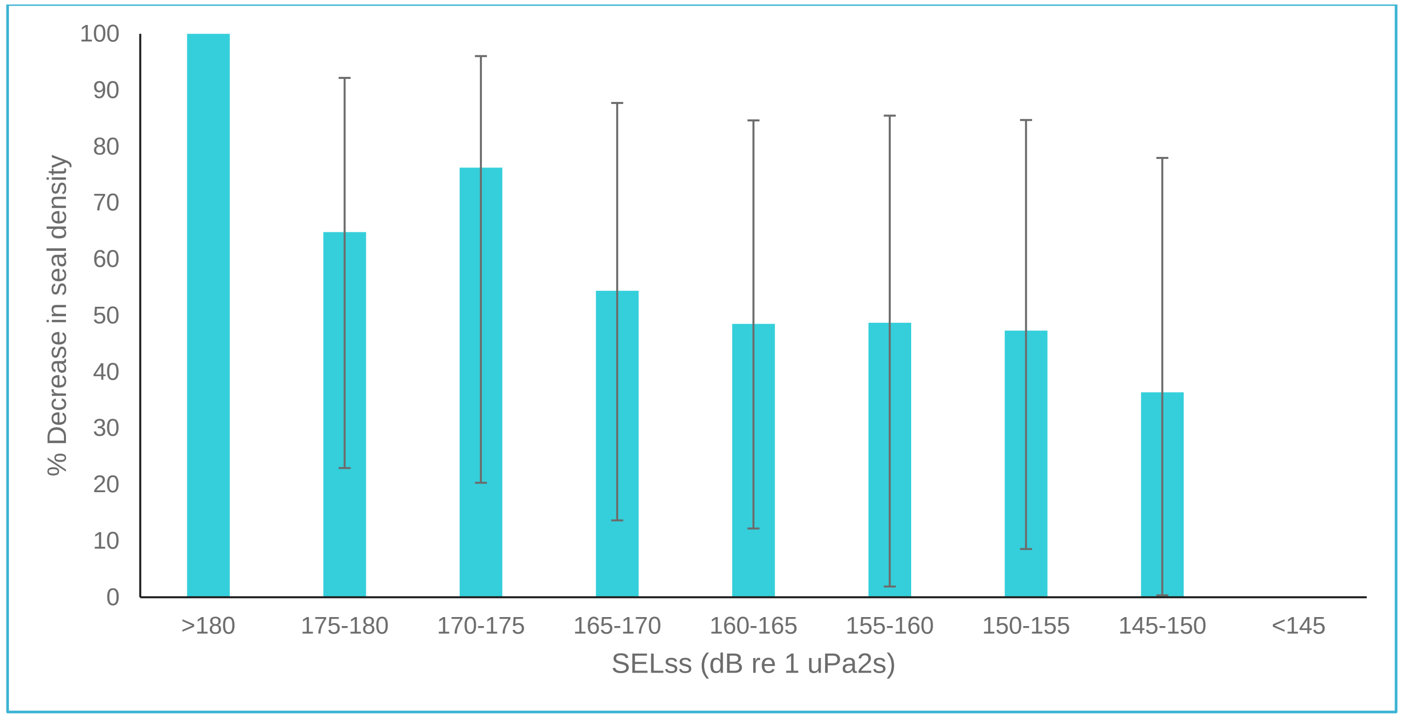

Figure 3.2: Predicted Decrease in Seal Density as a Function of Estimated SEL, Error Bars Show 95% Confidence Interval (CI). Source: Whyte *et al*. (2020)

3.2. METHODS

14. In line with the approach presented in the volume 2, chapter 10 of the Offshore EIA Report, unweighted SELss contours were plotted in 5 dB isopleths in increasing increments from 120 dB re 1 µPa²s using the highest modelled received noise level for 1% constant conversion factor. The contours were plotted in Geographical Information System (GIS) for all modelled locations and the location selected for assessment was the one whereby the contours covered the greatest spatial area, thereby representing the maximum design scenario. The areas within each 5 dB isopleth were calculated from the spatial GIS map and a proportional expected response, derived from the dose-response curve for each isopleth area, was used to calculate the number of animals potentially disturbed. These numbers were subsequently summed across all isopleths to estimate the total number of animals disturbed during piling. The number of animals predicted to respond was based on harbour seal densities as agreed with statutory consultees (Table 3.1).

Table 3.1: Harbour Seal Density Estimates and Reference Population

Species	Density (Animals per km²)	Management Unit	Population in MU	SCANS-III Block R (Hammond *et al*., 2021)
Harbour seal	0.0001 to 0.002[1]	East Scotland plus North-east England	476 + 110 = 586 (Sinclair, 2022; Special Committee on Seals (SCOS), 2020)	Not Applicable (N/A)

[1] Mean and maximum across the Proposed Development marine mammal study area (for more details regarding study areas see volume 3, appendix 10.2 of the Offshore EIA Report) based on at-sea mean density maps (Carter *et al*., 2020).

3.3. RESULTS

15. As previously presented in volume 2, chapter 10 of the Offshore EIA Report, up to three harbour seals were predicted to experience potential disturbance from concurrent piling at a maximum hammer energy of 4,000 kJ using dose-response values from Russell *et al.* (2016) (Table 3.2). For comparison, the number of animals that could be potentially disturbed during the same piling scenario and conversion factor but using dose-response values from Whyte *et al.* (2020) has been assessed as up to one harbour seal (Table 3.2).

Table 3.2: Number of Harbour Seals Predicted to be Disturbed within Unweighted SELss Noise Contours as a Result of Different Piling Scenarios Using 1% Constant Conversion Factor

Scenario (4,000 kJ)	Russell *et al.* (2016)		Whyte *et al.* (2020)	
	Mean	Maximum	Mean	Maximum
Concurrent piling (wind turbine)	<1	<3	<1	<1
Single piling (wind turbine/Offshore Substation Platforms (OSPs)/Offshore convertor station platform)	<1	<2	<1	<1

< = less than

16. A difference in the threshold of the onset of a behavioural response presented in Russell *et al*. (2016) compared to Whyte *et al*. (2020) may be the cause of the difference in the results. Russell *et al.* (2016) predicted that at received levels of 130 dB SELss and below, there would be no detectable response (Figure 3.1). Whyte *et al.* (2020) demonstrated that behavioural response of animals would not occur below a received level of 145 dB re 1 µPa^2 (Figure 3.2). As a result, the number of harbour seal individuals that could be potentially disturbed during concurrent piling at 4,000 kJ is more precautionary using the dose-response from Russell *et al*. (2016).

17. Given that the assessment in volume 2, chapter 10 of the Offshore EIA Report is based on the more precautionary dose-response values from Russell *et al*. (2016), it is concluded that no changes to the original assessment are required.

4. CUMULATIVE IPCOD MODELLING APPROACH USING 10% REDUCING TO 1% CONVERSION FACTOR

4.1. BACKGROUND

18. To understand the potential for long-term population level effects on marine mammal species resulting from piling activities at the Proposed Development, population modelling using the iPCoD model was undertaken. The iPCoD model simulates the changes in a population over time, for both a disturbed and an undisturbed population. This provides a comparison of the type of changes that could occur resulting from natural environmental variation, demographic stochasticity (i.e. variability in population growth rates) and disturbance (Harwood *et al*., 2014; King *et al.,* 2015). For more background about the iPCoD model please refer to volume 2, chapter 10 and volume 3, appendix 10.4 of the Offshore EIA Report.

19. For the purposes of population analysis, the iPCoD modelling (as presented in volume 3, appendix 10.4 of the Offshore EIA Report) focussed only on the absolute maximum of 4,000 kJ as this represented the maximum design scenario (based on concurrent piling at wind turbine foundations with the largest separation between piling locations).

20. The iPCoD modelling for the Proposed Development alone was provided for three conversion factors:

- 10% reducing to 1% conversion factor;
- 1% constant conversion factor throughout the piling period; and
- 4% reducing to 0.5% conversion factor.

21. The choice of an appropriate conversion factor was based on findings of the study presented in volume 3, appendix 10.1, Annex A of the Offshore EIA Report. The study found that a conversion factor of 10% was very likely to be over precautionary and therefore likely to lead to an overestimate of potential range of effect, particularly considering the transition from impulsive to continuous noise over distance from the source.

22. In terms of behavioural effects, the 1% constant conversion factor was found to result in the highest SELss at any point over the piling sequence compared to the 4% reducing to 0.5% conversion factor and therefore resulted in the largest potential effect area (see volume 2, chapter 10 of the Offshore EIA Report for more information). As such, 1% constant conversion factor was used in the iPCoD modelling for the cumulative effects assessment associated with underwater noise during piling. This assessment is presented in volume 3, appendix 10.4 and subsequently in volume 2, chapter 10 of the Offshore EIA Report. The iPCoD modelling was carried out for harbour porpoise *Phocoena phocoena*, bottlenose dolphin *Tursiops truncatus*, minke whale *Balaenoptera acutorostrata*, harbour seal, and grey seal *Halichoerus grypus*.

23. The iPCoD modelling using 1% constant conversion factor demonstrated that for all species there was predicted to be no long-term decline in the population with negligible to very small differences between the unimpacted to impacted population size.

24. Although initially the conversion factor of 10% reducing to 1% was not used in the cumulative scenario as this was deemed to be over precautionary, cumulative population modelling using iPCoD was carried out for all species using 10% reducing to 1% conversion factor, as requested by NatureScot (21 February 2023), and the methods and results for this model are presented in sections 4.2 and 4.3, respectively.

4.2. METHODS

25. The cumulative population modelling presented in this report follows the methodology described in volume 3, appendix 10.4 of the Offshore EIA Report and has not been reiterated here. The summary of model inputs is provided in section 4.2.2.

4.2.2. MODEL INPUTS

26. The iPCoD model v5.2[2] was set up using the program R v4.3.0 (R Core Team, 2023) with RStudio as the user interface. To enable the iPCoD model to be run, the following data were provided:

[2] https://smruconsulting.com/?page_id=13194

- demographic parameters for the key species;
- user specified input parameters, such as residual days of disturbance;
- number of animals predicted to experience Permanent Threshold Shift (PTS) and/or disturbance during piling; and
- estimated piling schedule during the proposed construction programmes.

Demographic parameters

27. Demographic parameters for the key species assessed in the population model are based on Sinclair *et al.* (2020) as agreed in the Marine Mammal Road Map (volume 3, appendix 10.3 of the Offshore EIA Report) and used in the iPCoD modelling presented in volume 3, appendix 10.4 of the Offshore EIA Report.

Residual days disturbance

28. 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 as presented in the Marine Mammal Road Map (volume 3, appendix 10.3 of the Offshore EIA Report) and used in the iPCoD modelling presented in volume 3, appendix 10.4 of the Offshore EIA Report.

Piling schedule

29. The piling schedule for the Proposed Development was developed from the project design envelope which provided an estimate of the number of days piling for the wind turbine and OSP/Offshore convertor station platform foundations. A total of 287 days (24-hour periods) on which piling could occur (based on the maximum design scenario) was estimated for concurrent piling at the wind turbines. A total of 85 days of piling (24-hour periods) was estimated for single piling at the OSPs/Offshore convertor station platforms. The number of piling days was allocated evenly across months.

30. Population modelling was run for cumulative scenarios based on the scheduling of offshore construction for projects within the relevant study areas for each species as per the iPCoD modelling presented in volume 3, appendix 10.4 of the Offshore EIA Report. As piling schedules are not finalised, the piling days were spread evenly throughout the offshore construction phases (Table 2.7 in volume 3, appendix 10.4 of the Offshore EIA Report)[3]. The assessment of cumulative effects presented in volume 3, appendix 10.4 of the Offshore EIA Report focussed on the most up to date information about relevant projects available in the public domain at the time of writing. The same scenarios have subsequently been re-run in this Additional Information Report to allow direct comparison of the results of the 10% reducing to 1% conversion factor model with the results of the 1% constant conversion factor model presented in the cumulative assessment.

Time points

31. Time points in the model were selected, as per the iPCoD modelling presented in volume 3, appendix 10.4 of the Offshore EIA Report, to coincide with the following periods:

- time point 2: start of 2023, construction continues at four projects and commences at four projects;
- time point 3: start of 2024, construction continues with a total of seven projects potentially piling;
- time point 4: start of 2025, construction continues with a total of seven projects potentially piling;
- time point 5: start of 2026, construction continues at four projects plus start of offshore construction phase at the Proposed Development (just prior to start of piling at the Proposed Development);
- time point 7: start of year 2028, construction continues at two cumulative projects and the first two piling campaigns at the Proposed Development are completed;
- time point 11: start of year 2032, construction of cumulative projects is completed and piling is completed after the third piling campaign at the Proposed Development;
- time point 19: start of year 2040, eight years after completion of construction/piling at all projects; and
- time point 25: start of year 2046, fourteen years after completion of construction/piling at all projects.

[3] In the post-application response, NatureScot expressed that they are content with the spatial range and timescales of the other projects included in the cumulative assessment.

Reference populations

32. Management Unit (MU) populations were specified in the model as reference populations against which the effects (i.e. the number of animals that could be exposed to PTS/disturbed) have been assessed as per the iPCoD modelling presented in volume 3, appendix 10.4 of the Offshore EIA Report (Table 4.1).

Table 4.1: Reference Populations Used in the iPCoD Model

Species	MU Population	
	MU	**Population**
Harbour porpoise	North Sea	346,601
Bottlenose dolphin	Coastal East Scotland	224
Minke whale	Celtic and Greater North Seas	20,118
Grey seal	East Scotland plus Northeast England	42,600
Harbour seal	East Scotland[1]	476

[1]The volume 2, chapter 10 of the Offshore EIA Report considers the reference population as East Scotland plus Northeast England MU, however, further to discussions with NatureScot and MS-LOT during the Marine Mammal Road Map consultation (for more details see volume 3, appendix 10.3 of the Offshore EIA Report), it was requested that the iPCoD model was run against the East Scotland population only.

Number of animals (PTS/Disturbance)

33. The number of animals predicted to have the potential to experience PTS and/or disturbance during piling at the Proposed Development was based on the density values provided as part of the baseline assessment (see volume 3, appendix 10.2 of the Offshore EIA Report). For each species studied, the density values – including a mean and a maximum - were provided and these were used to quantify the number of animals potentially affected, based on the modelled noise contours. The number of animals

predicted to be injured or disturbed were calculated using these maximum densities and were estimated from the piling locations that gave rise to the largest potential impact ranges. For the purposes of this population modelling, the number of animals with potential to experience PTS/disturbance is based on information provided for 10% reducing to 1% conversion factor in volume 3, appendix 10.5 of the Offshore EIA Report (Table 4.2).

Table 4.2: Estimated Number of Animals Predicted to be Disturbed at any one Time During Piling at the Proposed Development Using 10% Reducing to 1% Conversion Factor

Species	Number of Animals Affected: Concurrent Piling Wind Turbine	Number of Animals Affected: Single Piling OSP/Offshore Convertor Station Platform
	10% to 1%	10% to 1%
Harbour porpoise	3,575	2,298
Bottlenose dolphin (coastal population)	7	5
Minke whale	167 (1[1])	107
Grey seal	1,867	988
Harbour seal	3	2

[1]There is a risk that a residual number of one minke whale may experience PTS as a result of concurrent piling at the Proposed Development. This value reflects the risk of injury following the application of secondary mitigation measures (use of an Acoustic Deterrent Device (ADD) for a duration of 30 minutes before the piling commences).

34. The number of animals potentially affected during piling at projects considered in the cumulative assessment for each of the key species and number of days on which piling occurred was taken from the maximum design scenario for each of the projects and is presented in detail in volume 3, appendix 10.4 of the Offshore EIA Report. The cumulative iPCoD modelling presented below includes projects as per the cumulative assessment presented in volume 2, chapter 10 of the Offshore EIA Report. The assessment provided in this document considers potential connectivity on a species-by-species basis (Table 4.3).

Table 4.3: Summary of Numbers of Animals Potentially Disturbed By Piling for Cumulative Projects Included in iPCoD Modelling

Project	Source	Number of Animals Disturbed				
		Harbour Porpoise	Bottlenose Dolphin	Minke Whale	Grey Seal	Harbour Seal
Seagreen 1A	Seagreen Wind Energy Ltd (2020)	1,882	4	297[1]	465[1]	51[1]
Inch Cape	Inch Cape Offshore Limited (2018)	302	8	444	1,236	20
Moray West	Moray West (2018)	1,609	15	1,056	-	-
Dogger Creyke Beck A	Forewind (2013)	3,119	-	4,858	-	-
Dogger Creyke Beck B	Forewind (2013)	4,394	-	4,858	-	-
Dogger Bank Teesside A	Royal Haskoning DHV (2020)	2,148	-	420	-	-
Sofia	Innogy (2020)	2,263	-	1,100	-	-
Hornsea Project Three	GoBe (2018)	7,330	-	1,276	-	-
Hornsea Project Four	SMRU Consulting (2021)	9,686	-	792	-	-

[1] The number of minke whale, grey seal and harbour seal potentially disturbed at any one time is based on impacts of piling at Seagreen Bravo presented in the original EIA (Seagreen Wind Energy Ltd, 2012), as it represents maximum scenario number when compared with numbers presented in later documents.

4.2.3. SUMMARY OF SCENARIOS MODELLED

35. Table 4.4 presents a summary of the scenarios modelled through iPCoD for each species for the purpose of this Additional Information Report.

Table 4.4: Summary of Scenarios Modelled

Number	Scenario	Hammer Energy	Conversion Factor	Population Size
Harbour Porpoise				
1	Cumulative projects	4,000 kJ	10% reducing to 1%	346,601
Bottlenose Dolphin				
2	Cumulative projects	4,000 kJ	10% reducing to 1%	224
Minke Whale				
3	Cumulative projects	4,000 kJ	10% reducing to 1%	20,118
Grey Seal				
4	Cumulative projects	4,000 kJ	10% reducing to 1%	42,600
Harbour Seal				
5	Cumulative projects	4,000 kJ	10% reducing to 1%	476

4.3. RESULTS

36. The results in Table 4.5 to Table 4.9 are expressed as the predicted difference in the mean population size of an undisturbed population versus a disturbed population and is provided as the median of the ratio of impacted to unimpacted population size (also referred to as the 'median counterfactual of population size';

Sinclair *et al*., 2020). Thus, for a ratio of one there is no difference between the trajectories of disturbed versus undisturbed populations. Conversely, for a ratio of <1 the median impacted population size is smaller than the median unimpacted population size.

4.3.2. HARBOUR PORPOISE

37. Results of the iPCoD modelling for harbour porpoise using the maximum design scenario and the 10% reducing to 1% conversion factor are presented in Table 4.5 and Figure 4.1.

38. For the cumulative scenario assessed against the North Sea MU population, where multiple projects may be piling either sequentially or concurrently, the population modelling suggested a slight decrease in the median counterfactual of population size (a difference of 588 animals) with a median ratio 0.999 at a time point 3. For comparison, using a 1% constant conversion factor the difference in the population was 552 animals at time point 3, with a median ratio of 0.999. A median ratio of 0.992 is predicted at a time point 7 (after the first two piling campaigns at the Proposed Development) using the 10% to 1% conversion factor where the difference between the impacted and unimpacted population is 4,592 animals. As expected, using the 10 reducing to 1%% conversion factor predicted a larger difference between impacted and unimpacted population but only marginally, as the difference for the 1% constant conversion factor model was 4,321 animals compared to 4,592 animals for the 10% reducing to 1% conversion factor model.

39. The median counterfactual of population size increases to 0.994 at the time point 11 (after the final piling campaign at the Proposed Development), suggesting population recovery, and remains at this ratio up to time point 25. This is analogous to the results for cumulative scenario and 1% constant conversion factor presented in volume 3, appendix 10.4 of the Offshore EIA Report, where the median counterfactual of population size at the 25-year time point was 0.992.

40. When applying the most precautionary 10% reducing to 1% conversion factor, the differences in disturbed to undisturbed populations approaches a ratio of one. As such, it can be concluded there is not considered to be a potential for a long-term effect on this species.

Table 4.5: Population Trajectory of Harbour Porpoise Showing the Mean and Upper and Lower Confidence Limits at Different Time Points Using 10% Reducing to 1% Conversion Factor

Time Point	Unimpacted Population			Impacted Population			Median Ratio of Population Size
	Mean	Lower 2.5%	Upper 97.5%	Mean	Lower 2.5%	Upper 97.5%	
10% to 1% Conversion Factor (no Vulnerable Subpopulation)							
2	346752	318470	371294	346752	318470	371294	1
3	346893	310094	381888	346305	309502	381463	0.9994946
4	347223	303204	386935	345534	301631	386181	0.9978692
5	347776	302553	394405	346328	300596	391133	0.9981807
7	348133	293108	406832	343541	288809	402123	0.9922571
11	348509	281539	428522	344798	278511	423625	0.9944727
19	348281	269290	449508	344338	266968	445066	0.9942033
25	349019	256595	463630	345073	251728	458842	0.9941917

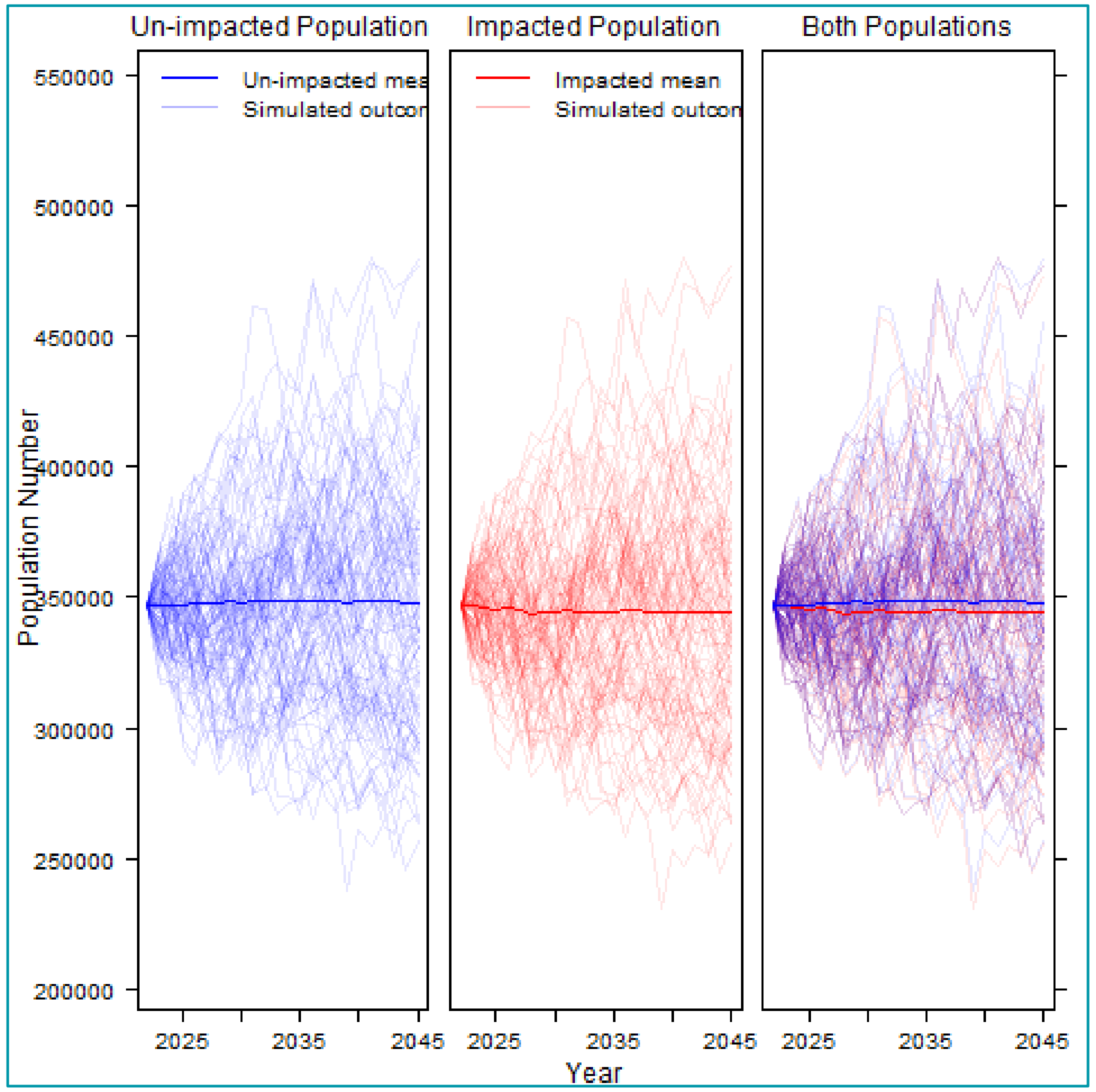

Figure 4.1: Harbour Porpoise Cumulative Scenario Using 10% Reducing to 1% Conversion Factor

4.3.3. BOTTLENOSE DOLPHIN

41. Results of the iPCoD modelling for bottlenose dolphin using the maximum design scenario and the 10% reducing to 1% conversion factor are presented in Table 4.6 and Figure 4.2.

42. For the cumulative scenario assessed against the Coastal East Scotland MU population, where multiple projects may be piling either sequentially or concurrently within the north-east of Scotland, the population modelling suggested a slight difference in the population size from time point 2 onwards. For example, at time point 5 (just prior to the start of piling at the Proposed Development) the predicted mean population size was 413 animals for the impacted population compared to 428 for the unimpacted population (a difference of 15 animals). For comparison, at the same time point using the 1% constant conversion factor model the difference between impacted and unimpacted populations was six animals.

43. At time point 25, the difference between the impacted and unimpacted population is 12 animals but at all time points the median counterfactual of population size provided a ratio of one. This is analogous to the results for cumulative scenario using the 1% constant conversion factor presented in volume 3, appendix 10.4 of the Offshore EIA Report, where slight differences in the size of the unimpacted vs impacted population size were reported at 25-year time point (19 animals) but at all time points the median counterfactual of population size provided a ratio of one.

44. When applying the most precautionary 10% reducing to 1% conversion factor, the differences in disturbed to undisturbed populations is equal to a ratio of one. As such, there is not considered to be a potential for a long-term effect on this species even considering the more precautionary conversion factor.

Table 4.6: Population Trajectory of Bottlenose Dolphin Showing the Mean and Upper and Lower Confidence Limits at Different Time Points Using 10% Reducing to 1% Conversion Factor

Time Point	Unimpacted Population			Impacted Population			Median Ratio of Population Size
	Mean	Lower 2.5%	Upper 97.5%	Mean	Lower 2.5%	Upper 97.5%	
10% to 1% Conversion Factor							
2	249	212	282	244	196	282	1
3	289	234	342	279	198	342	1
4	346	260	428	334	218	424	1
5	428	306	556	413	262	550	1
7	529	366	710	510	308	704	1
11	249	212	282	244	196	282	1
19	289	234	342	279	198	342	1
25	346	260	428	334	218	424	1

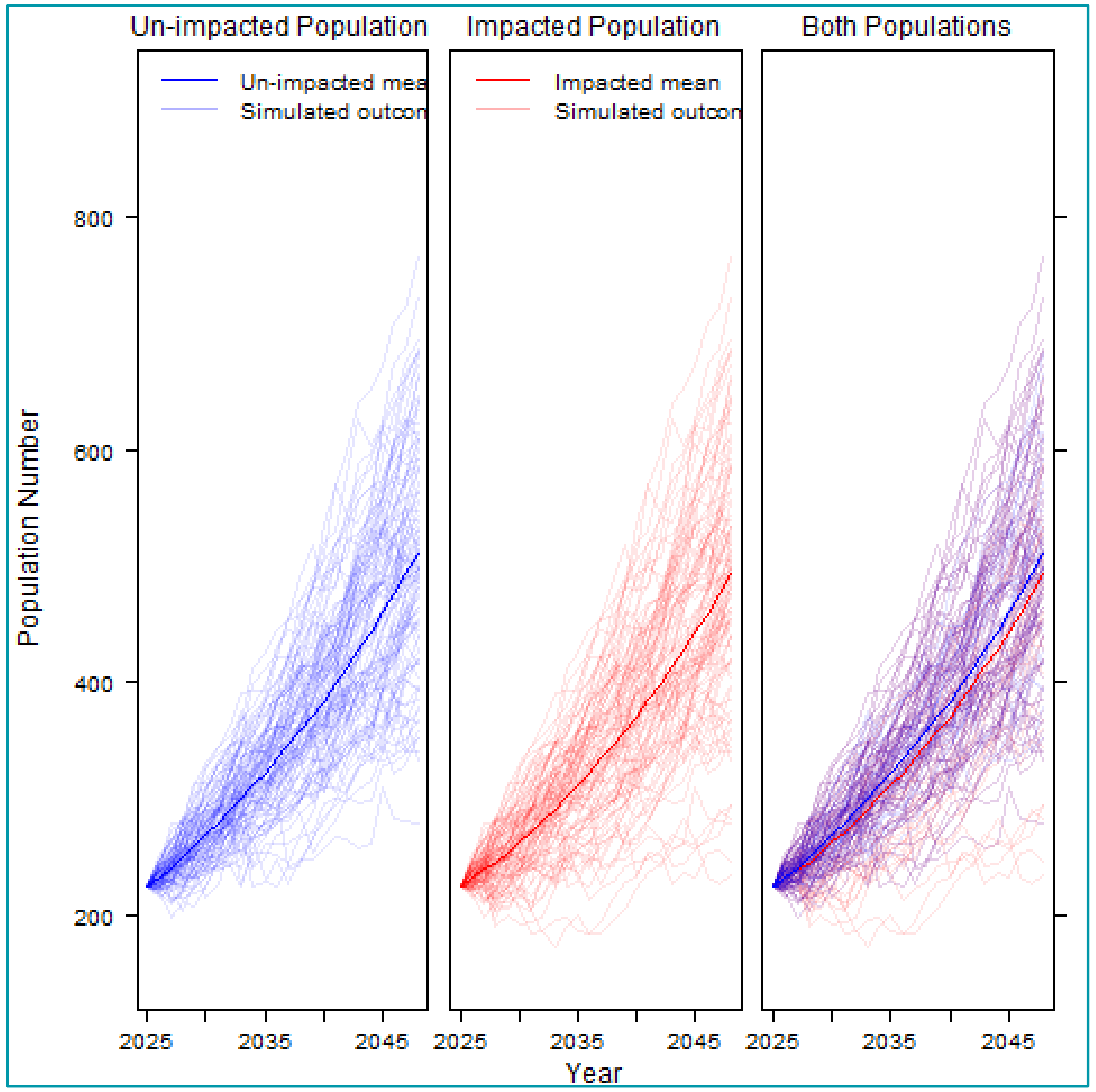

Figure 4.2: Bottlenose Dolphin Cumulative Scenario Using 10% Reducing to 1% Conversion Factor

4.3.4. MINKE WHALE

45. Results of the iPCoD modelling for minke whale using the maximum design scenario and the 10% reducing to 1% conversion factor are presented in Table 4.7 and Figure 4.3.

46. For the cumulative scenario assessed against the Celtic and Greater North Seas MU population, where multiple projects may be piling either sequentially or concurrently within the regional marine mammal study area, the population modelling suggested a slight decrease in the population at time point 7 (after the first two piling campaigns at the Proposed Development) with a difference of 25 animals between the impacted vs unimpacted population and a median ratio of 0.999. For comparison, at time point 7, the population modelling using the 1% constant conversion factor predicted a difference of four animals between the impacted and unimpacted population and the median ratio was one. At time point 25, for 10% reducing to 1% conversion factor, the median counterfactual of population size provided a ratio of 0.989.

47. Based on the results presented in volume 3, appendix 10.4 of the Offshore EIA Report for cumulative scenario and 1% constant conversion factor, at all time points, the median counterfactual of population size provided a ratio of one. Noting that there is a slight difference in the median counterfactual of population size between both conversion factors, there is not considered to be a potential for long term effects on this species as the difference falls within the natural stochasticity of the modelled population.

48. When applying the most precautionary 10% reducing to 1% conversion factor, the differences in disturbed to undisturbed populations approaches a ratio of one. As such, there is not considered to be a potential for a long-term effect on this species.

Table 4.7: Population Trajectory of Minke Whale Showing the Mean and Upper and Lower Confidence Limits at Different Time Points Using 10% Reducing to 1% Conversion Factor

Time Point	Unimpacted Population			Impacted Population			Median Ratio of Population Size
	Mean	Lower 2.5%	Upper 97.5%	Mean	Lower 2.5%	Upper 97.5%	
10% to 1% Conversion Factor							
2	20110	17657	21974	20110	17657	21974	1
3	20079	17460	22531	20079	17460	22531	1
4	20130	17301	22862	20130	17301	22862	1
5	20100	17132	23380	20100	17132	23380	1
7	20110	16698	23945	20085	16654	23929	0.99926033
11	20018	16028	24595	19913	15962	24442	0.99587188
19	19927	15118	26100	19708	14973	25844	0.99046954
25	19867	14339	26941	19625	14248	26524	0.98953810

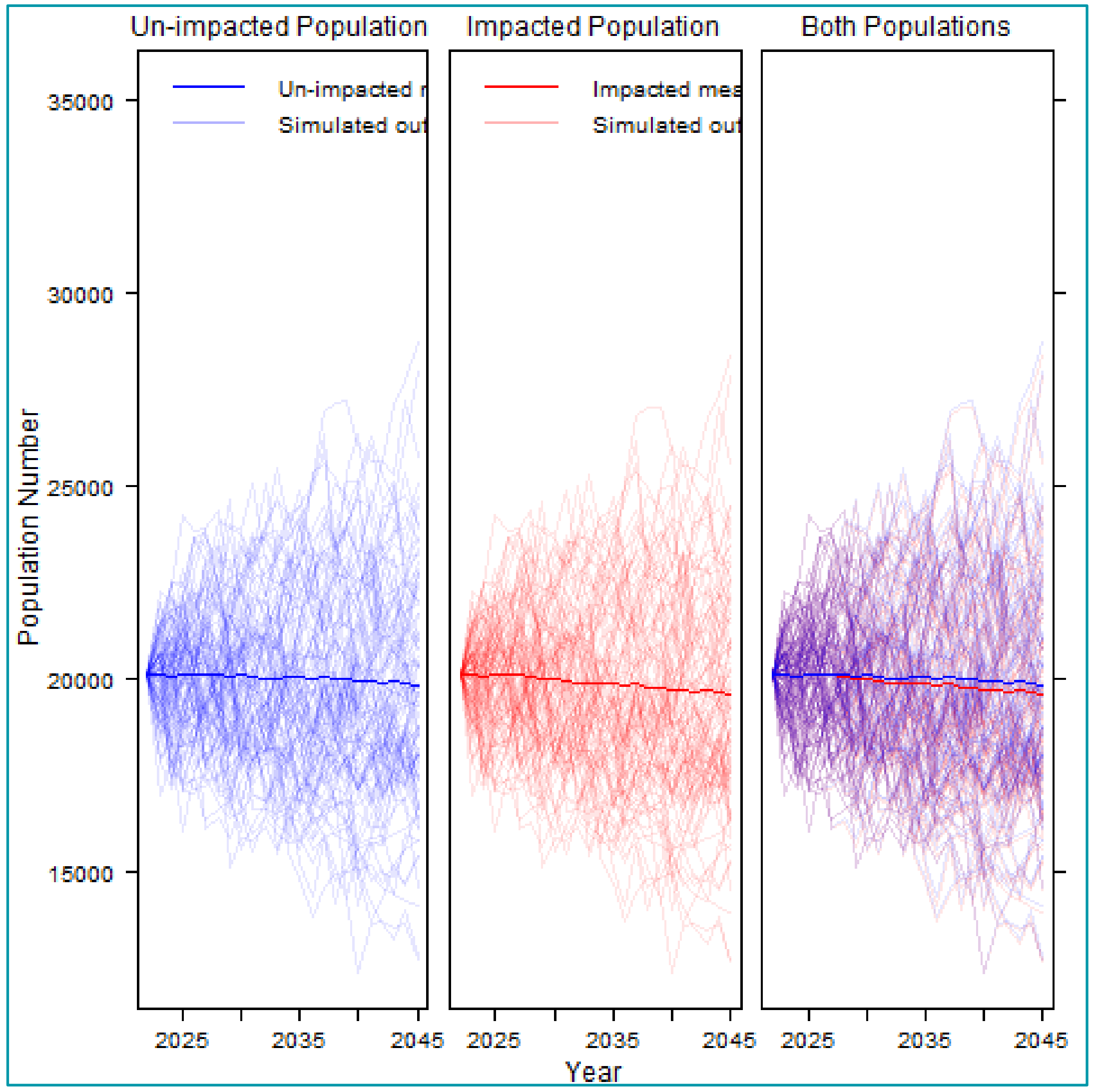

Figure 4.3: Minke Whale Cumulative Scenario Using 10% Reducing to 1% Conversion Factor

4.3.5. GREY SEAL

49. Results of the iPCoD modelling for grey seal using the maximum design scenario and the 10% reducing to 1% conversion factor for the MU population are presented in Table 4.8 and Figure 4.4.

50. For the cumulative scenario assessed against the East Scotland plus Northeast England MU population, where multiple projects may be piling either sequentially or concurrently, the population modelling suggested a slight differences in the population size from time point 7 onwards. For example, at time point 11 (after the final piling campaign at the Proposed Development) the predicted mean population size was 45,638 animals for the impacted population compared to 45,639 for the unimpacted population (a difference of one animal). At time point 25 the difference between the impacted and unimpacted population is two animals but at all time points the median counterfactual of population size provided a ratio of one. For comparison, the population modelling using the 1% constant conversion factor at time point 25

predicted that there will be no difference in number of animals between the impacted and unimpacted population and the median ratio was one.

51. This is analogous to the results for cumulative scenario and 1% constant conversion factor presented in volume 3, appendix 10.4 of the Offshore EIA Report, where at all time points the median counterfactual of population size provided a ratio of one.

52. When applying the most precautionary 10% reducing to 1% conversion factor, the differences in disturbed to undisturbed populations is equal to a ratio of one. As such, there is not considered to be a potential for a long-term effect on this species.

Table 4.8: Population Trajectory of Grey Seal Showing the Mean and Upper and Lower Confidence Limits at Different Time Points Using 10% Reducing to 1% Conversion Factor

Time Point	Unimpacted Population			Impacted Population			Median Ratio of Population Size
	Mean	Lower 2.5%	Upper 97.5%	Mean	Lower 2.5%	Upper 97.5%	
10% to 1% Conversion Factor							
2	42810	39189	45429	42810	39189	45429	1
3	43155	38735	46824	43155	38735	46824	1
4	43449	38666	47742	43449	38666	47742	1
5	43831	38142	48871	43831	38142	48871	1
7	44416	37544	51026	44415	37544	51026	1
11	45639	36528	54602	45638	36528	54602	1
19	48017	35919	61385	48015	35919	61385	1
25	49945	35423	66501	49943	35423	66501	1

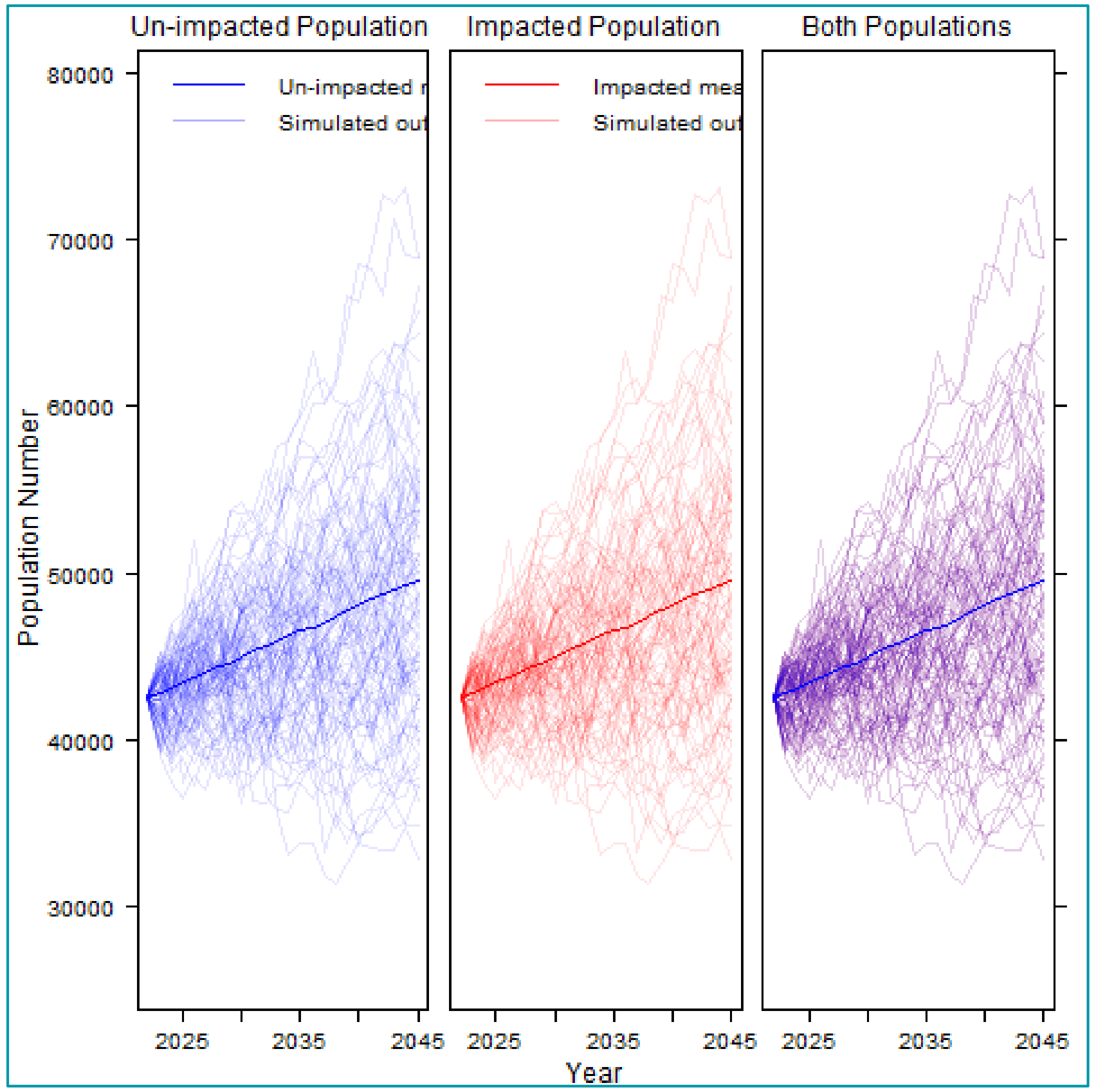

Figure 4.4: Grey Seal Cumulative Scenario Using 10% Reducing to 1% Conversion Factor

4.3.6. HARBOUR SEAL

53. Results of the iPCoD modelling for harbour seal using the maximum design scenario and the 10% reducing to 1% conversion factor for the MU population are presented in Table 4.9 and Figure 4.5.

54. For the cumulative scenario assessed against the East Scotland MU population and projects within the north-east of Scotland, no impacts were predicted on the population of harbour seals, resulting from disturbance and as such, would not lead to a larger number of animals affected at any one time.

55. This is analogous to the results for cumulative scenario and 1% constant conversion factor presented in volume 3, appendix 10.4 of the Offshore EIA Report, where at all time points the median counterfactual of population size provided a ratio of one and no impacts were predicted on the population size.

56. When applying the most precautionary 10% reducing to 1% conversion factor, the differences in disturbed to undisturbed populations is equal to a ratio of one. As such, there is not considered to be a potential for a long-term effect on this species.

Table 4.9: Population Trajectory of Harbour Seal Showing the Mean and Upper and Lower Confidence Limits at Different Time Points Using 10% Reducing to 1% Conversion Factor

Time Point	Unimpacted Population			Impacted Population			Median Ratio of Population Size
	Mean	Lower 2.5%	Upper 97.5%	Mean	Lower 2.5%	Upper 97.5%	
10% to 1% Conversion Factor							
2	472	426	518	472	426	518	1
3	472	414	538	472	414	538	1
4	472	402	546	472	402	546	1
5	474	398	554	474	398	554	1
7	472	382	576	472	382	576	1
11	475	362	610	475	362	610	1
19	478	330	652	478	330	652	1
25	479	316	684	479	316	684	1

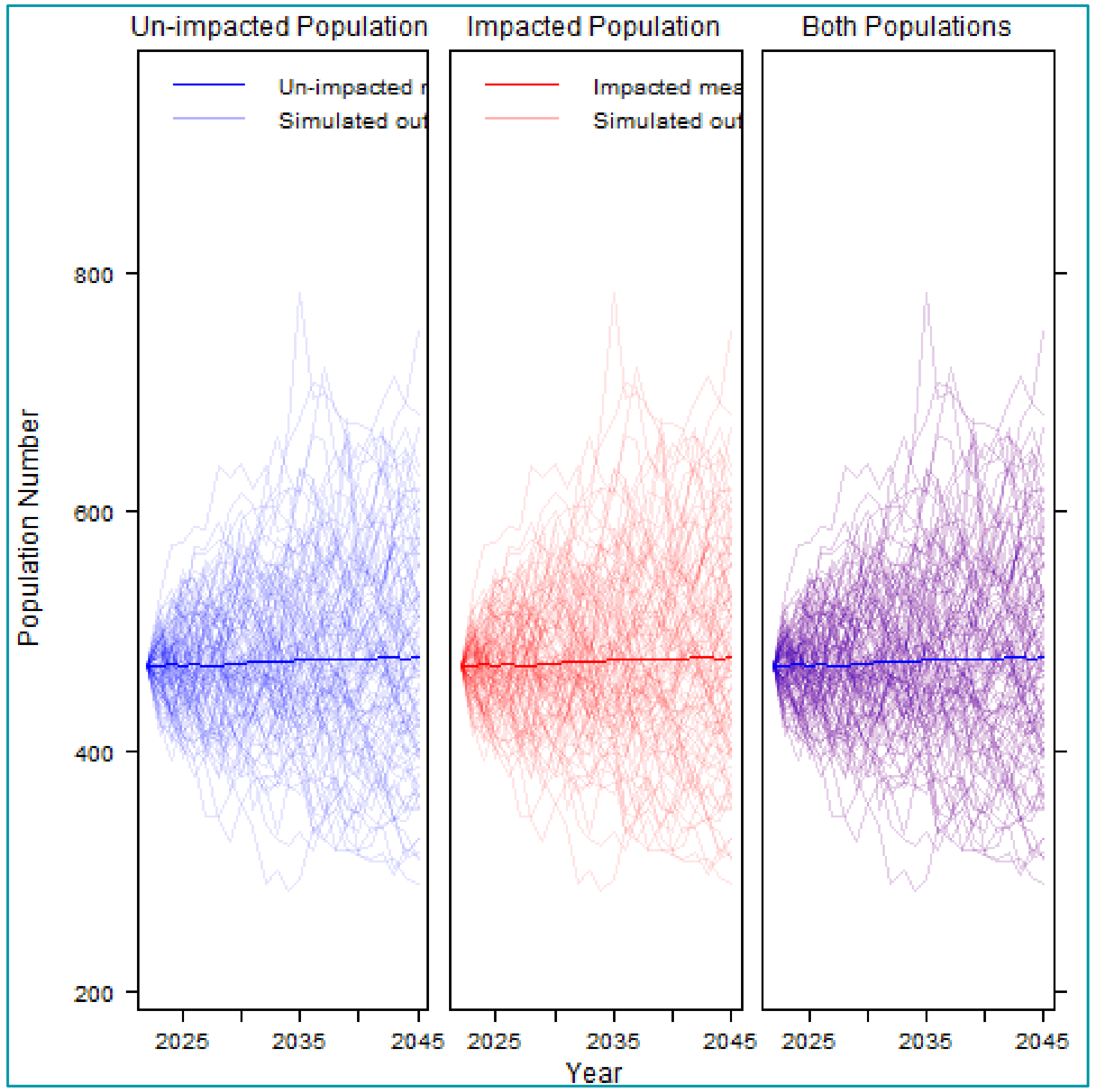

Figure 4.5: Harbour Seal Cumulative Scenario Using 10% Reducing to 1% Conversion Factor

4.4. CONCLUSIONS

57. The assessment in volume 2, chapter 10 of the Offshore EIA Report, based on the 1% constant conversion factor, found similar results for all species when compared to the results when using the most conservative conversion factor of 10% reducing to 1%. Therefore, even when using the most precautionary conversion factor, the assessment showed that populations of all species are not predicted to be adversely affected by piling at the Proposed Development cumulatively with other projects in the long term and are likely to recover following cessation of piling. It is concluded that no changes to the original assessment are required.

58. Subsequently, given that the results of the cumulative population modelling using 10% reducing to 1% conversion factor showed that the median ratio of the impacted to unimpacted population size falls within

the natural variance of the population trajectory and no significant effects are predicted on populations of all species in the long-term, no additional consideration of noise abatement systems is deemed necessary.

5. SUMMARY OF APPENDIX A: TTS WEIGHTED SEL IMPACT RANGES AS A RESULT OF UNDERWATER NOISE DURING UXO DETONATION

59. As requested by NatureScot and MD-LOT, appendix A provides additional information about TTS impact ranges for low order UXO charges for Low Frequency (LF) and Very High Frequency (VHF) cetaceans.

60. Based on information presented in volume 3, appendix 10.1 and subsequently in volume 2, chapter 10 of the Offshore EIA Report, as a result of the low order detonation of 0.5 kg charge size and using the weighted SEL metric, VHF cetaceans could experience TTS within a maximum range of 3,110 m. The maximum TTS range as a result of the same scenario for LF cetaceans was reported as 2,645 m. It was NatureScot's expectation that the LF cetaceans would have the largest impact range based on the SEL weighted metric across all hearing groups.

61. Supplementary information presented in appendix A is based on the auditory weighting functions designed to represent the bandwidth for each group within which acoustic exposures can have auditory effects. The assessment used calculated hearing-weighted SEL for 0.5 kg and 300 kg UXO charges (results for high order detonation of 300 kg were presented for comparison with the smaller charge size) for both hearing groups. The results demonstrated that for very small charge sizes, the TTS impact ranges for VHF cetaceans may be larger than for LF cetaceans when using the hearing weighted SEL metric, due to differences in the slope of the hearing-weighted SEL curves. For more details see section 2 of the appendix A.

6. IMPLICATIONS ON THE RIAA

62. In Appendix G of the post-submission advice letter provided on 21 February 2023 by NatureScot, additional information was required in order to provide the final advice in relation to European sites included in the RIAA for Annex II marine mammals.

63. As presented in paragraph 5 in their response, NatureScot identified two main areas where they requested additional information with respect to marine mammals and the RIAA:

- assessment of behavioural disturbance due to the underwater noise during piling for harbour seal, specifically the use of appropriate dose-response; and
- the cumulative iPCoD modelling approach and using more precautionary conversion factor (10% reducing to 1%).

64. The implications of findings presented in this Additional Information Report on RIAA are presented in sections 6.2 and 6.3.

6.2. ASSESSMENT OF IMPACTS ON HARBOUR SEAL AND USE OF APPROPRIATE DOSE-RESPONSE

65. The assessment of impacts of behavioural disturbance on harbour seal using both dose-responses (Russell *et al.,* 2016; Whyte *et al.,* 2020) is presented in section 3. The results show that the approach applied in the volume 2, chapter 10 of the Offshore EIA Report is based on the more precautionary dose-response values from Russell *et al*. (2016) and therefore no changes to the original assessment are required.

66. The assessment of Adverse Effects on Integrity of the Firth of Tay and Eden Estuary SAC in respect of the harbour seal qualifying interest and conservation objectives carried out in the RIAA was informed by the findings presented in the volume 2, chapter 10 of the Offshore RIA Report. Given that the quantitative results presented in the volume 2, chapter 10 of the Offshore RIA Report are based on the most precautionary approach, it can be concluded that the assessment presented in the RIAA is conservative and no changes are required.

67. Therefore, in line with findings presented in the RIAA submitted as a part of the consent application, it is concluded beyond all reasonable scientific doubt that there will be no Adverse Effect on integrity of the Firth of Tay and Eden Estuary SAC with respect to the conservation objectives set for the harbour seal qualifying interest.

6.3. CUMULATIVE IPCOD MODELLING USING 10% REDUCING TO 1% CONVERSION FACTOR

68. The cumulative population modelling using iPCoD was carried out for all species using 10% reducing to 1% conversion factor and is presented in section 4. The results show that even when using the most precautionary conversion factor of 10% reducing to 1%, populations of all species are not predicted to be adversely affected by piling at the Proposed Development cumulatively with other projects in the long term and are likely to recover following cessation of piling. It is concluded that no changes to the original assessment presented in volume 2, chapter 10 of the Offshore EIA Report are required.

69. The in-combination assessment of Adverse Effects on Integrity of European sites in respect of the Annex II marine mammal qualifying interests and conservation objectives carried out in the RIAA was informed by the findings presented in the volume 2, chapter 10 of the Offshore RIA Report. Given that the assessment in volume 2, chapter 10 of the Offshore EIA Report, based on the 1% constant conversion factor, found similar results for all species when compared to the results using the most conservative conversion factor of 10% reducing to 1%, it is concluded that the assessment presented in the RIAA is conservative and no changes are required.

70. Therefore, in line with findings presented in the RIAA submitted as a part of the consent application, it can be concluded beyond all reasonable scientific doubt that there will be no Adverse Effects on Integrity for any European sites with Annex II marine mammals as a qualifying feature from in-combination effects.

7. SUMMARY

71. In their response to the Offshore Berwick Bank Wind Farm consent application, NatureScot and MD-LOT identified three areas where they requested additional information with respect to marine mammals:

- assessment of behavioural disturbance due to the underwater noise during piling for harbour seals, specifically the use of appropriate dose-response;
- the cumulative iPCoD modelling approach and using more precautionary conversion factor (10% reducing to 1%); and
- TTS impact ranges (weighted SEL) as a result of underwater noise during UXO detonation.

72. This Additional Information Report provides the additional information requested by NatureScot and MD-LOT to allow for provision of their final marine mammal advice on volume 2, chapter 10 of the Offshore EIA Report as well as the Annex II marine mammals section of the RIAA.

73. The assessment of behavioural disturbance as a result of underwater noise during piling on harbour seal presented in the volume 2, chapter 10 of the Offshore EIA Report was based on Russell *et al.* (2016). To identify the most precautionary approach to the assessment of behavioural disturbance on harbour seals, quantitative results using two dose-responses based on Russell *et al.* (2016) and Whyte *et al.* (2020) are presented in section 3. The comparison of two dose-responses demonstrated that application of Russell *et al.* (2016) is the most precautionary and as such it can be concluded that the assessment of effects presented in volume 2, chapter 10 of the Offshore EIA Report predicted the greatest impacts on harbour seal as a result of behavioural disturbance due to underwater noise during piling.

74. The iPCoD modelling for the cumulative scenario of impacts associated with underwater noise during piling (presented in volume 3, appendix 10.4 and subsequently in volume 2, chapter 10 of the Offshore EIA Report) was carried out using 1% conversion factor and demonstrated that for all species there was predicted to be no long-term decline in the population with negligible to very small differences between the unimpacted to impacted population size. The cumulative population modelling using iPCoD using 10% reducing to 1% conversion factor, as requested by NatureScot (21 February 2023) and MD-LOT (26 May 2023), was carried out for all species and results are presented in section 4. The results for all species were similar to those presented for cumulative scenario using 1% constant conversion factor, suggesting that even using the most conservative conversion factor of 10% reducing to 1%, the populations of all species are not predicted to be adversely affected by piling at the Proposed Development cumulatively with other projects in the long term and are therefore likely to recover following cessation of piling. As such, no significant adverse effects (on population trajectory) of all species are predicted in the long-term using both, 1% constant and 10% reducing to 1% conversion factors.

75. The TTS impact ranges as a result of detonation of 0.5 kg clearance shot presented in volume 3, appendix 10.1 and subsequently in volume 2, chapter 10 of the Offshore EIA Report, were larger for VHF cetaceans when compared to LF cetaceans. Analysis presented in appendix A demonstrates that when using the hearing weighted SEL metric and for very small charge sizes, it is possible that the TTS range for VHF cetaceans can be larger compared to LF cetaceans. However, when detonating large UXO that result in impact ranges greater than a few kilometres, the LF cetacean TTS range is expected to be greater compared to VHF cetaceans.

76. Additionally, due to further research being published in the field of underwater noise since the submission of the Berwick Bank Offshore EIA Report, appendix A provides a supplementary comparison using findings of peer-reviewed paper (von Pein *et al.,* 2022a) for the purposes of scaling using the parameters of the Proposed Development. The results corroborated findings originally presented in volume 3, appendix 10.1, annex A and annex B of the Offshore EIA Report and suggest that the 10% reducing to 1% conversion factor is likely to be over-precautionary and may therefore result in an overestimate of the potential effects on marine life due to underwater noise.

77. The assessment presented in this Additional Information Report was prepared to satisfy the advice provided in Appendix E and Appendix G of the letter from NatureScot as well as the request from MD-LOT. The results of this assessment do not change the conclusions on the significance of the effects on marine mammals of the Proposed Development alone or cumulatively with other projects determined in volume 2, chapter 10 of the Offshore EIA Report. Subsequently, the findings of this Additional Information Report do not change the conclusions for SACs with Annex II marine mammals as qualifying features presented in the RIAA.

8. APPENDIX A: UXO INJURY RANGES AND UNDERWATER NOISE CONVERSION FACTORS ADDITIONAL INFORMATION REPORT

8.1. INTRODUCTION

78. This appendix to the Marine Mammals Additional Information Report to volume 2, chapter 10 provides additional information on the subject of underwater noise for the Berwick Bank Wind Farm (hereafter referred to as "the Proposed Development"), in light of comments made by NatureScot in their response to the offshore EIA, entitled "Berwick Bank Offshore Wind Farm - Application for Consent under Section 36 of the Electricity Act 1989 and Marine Licence Under Part 4 Of the Marine (Scotland) Act 2010", received on 21 February 2023.

79. The NatureScot response in relation to underwater noise was as follows:

The modelling approach taken is comprehensive, and we are content that our advice has been followed as discussed during the roadmap process. The underwater noise assessment has also been reviewed by a third party, included as Appendix 10.1 Annex H. This review concludes that the approach taken is appropriate and logical based on the information presented. Whilst we agree the approach is thorough, we consider that this third party review does not add independent support, particularly as to the level of conversion factor that is realistic in the field.

The impact predictions taken through to the assessment are based on the 4% reducing to 0.5% conversion factor. However, we welcome the inclusion of a range of conversion factors as presented in volume 3, appendix 10.5: Conversion Factors – Marine Mammals Supporting Information.

Notwithstanding the information provided, we remain of the view that there is considerable uncertainty relating to the choice of appropriate conversion factor. We highlight that there is currently a Scottish Marine Energy Research (ScotMER) programme of work reviewing the conversion factor methodology used in underwater noise models. The recommendations from this particular work may inform our future advice in terms of noise modelling approaches.

80. Appendix E (Marine Mammal Interests) of the NatureScot response requests additional information relevant to underwater noise as follows:

"Marine mammals – additional information required…

We welcome the detailed marine mammal impact assessment, however, we have identified key concerns regarding the assessment where we require additional information, including:

…We request that the 10% reducing to 1% conversion factor scenario is included in the iPCoD cumulative assessment…

…We also request the following clarification around UXO detonation impact ranges, noting however that this would not change the outcome of our advice:

For the low order 0.5 kg charge (Table 10.46, Chapter 10), the VHF hearing group has the largest TTS SEL weighted range of 3.1 km of all the hearing groups. We query whether this is correct as we might expect the LF hearing group to have the larger impact range."

81. The MD-LOT response, received on 26 May 2023, requests the following additional information in relation to underwater noise:

"Marine Mammals

MD-LOT advises that the following must be submitted as additional information on the basis of the NatureScot representation:

…The 10% reducing to 1% conversion factor scenario must be included in the iPCoD cumulative assessment.

MD-LOT advises the following should be clarified on the basis of the NatureScot representation:

- *In relation to UXO detonation impact ranges, for the low order 0.5 kg charge (Table 10.46, Chapter 10), the VHF hearing group has the largest TTS $SEL_{weighted}$ range of 3.1 km of all the hearing groups. Berwick Bank should clarify whether this is correct, in light of NatureScot's expectation of the LF hearing group having the larger impact range."*

82. The purpose of this appendix is to provide additional information, as requested by NatureScot (paragraph 80) and MD-LOT (paragraph 81), on the TTS ranges for low order charges originally presented in volume 3, appendix 10.1 of the Offshore EIA Report. In addition, in response to NatureScot's comments with respect to conversion factors, this appendix provides some useful context with respect to the use of the conversion factor scenarios used for underwater noise due to impact piling in light of new peer reviewed evidence which has come to light following preparation of the original Subsea Noise Technical Report (volume 3, appendix 10.1 of the Offshore EIA Report).

83. The methods and results of the iPCoD model using the 10% reducing to 1% conversion factor scenario, as requested by NatureScot (paragraph 80), are presented in the Marine Mammals Additional Information Report to volume 2, chapter 10.

84. This appendix has been prepared by Seiche Ltd who undertook the underwater noise modelling for the Proposed Development EIA (volume 3, appendix 10.1 of the Offshore EIA Report).

8.2. UXO INJURY RANGES

85. The TTS injury ranges presented in the Subsea Noise Technical Report (volume 3, appendix 10.1 of the Offshore EIA Report) show that VHF cetaceans will have a larger TTS range based on the hearing weighted SEL) metric than LF cetaceans for a 0.5 kg clearance shot. The PTS and TTS ranges presented in the technical report are reproduced in Table 8.1 below for LF and VHF cetaceans.

Table 8.1: Potential Injury Ranges for Marine Mammals due to Detonation of 0.5 kg Clearance Shot (Based on SEL)

Hearing Group	PTS Range		TTS Range	
	SEL (Weighted) Threshold (dB re 1 μPa²s)	Range (m)	SEL (Weighted) Threshold (dB re 1 μPa²s)	Range (m)
LF	183	195	168	2,645
VHF	155	650	140	3,110

86. These same results are represented in Figure 8.1 which shows the calculated hearing-weighted SEL for a 0.5 kg donor charge (denoted by the solid red line in the case of VHF cetaceans and solid blue line for LF cetaceans) alongside the corresponding threshold levels (dashed for PTS, dotted for TTS and using red for VHF and blue for LF). These calculations are based on two clearance events per day.

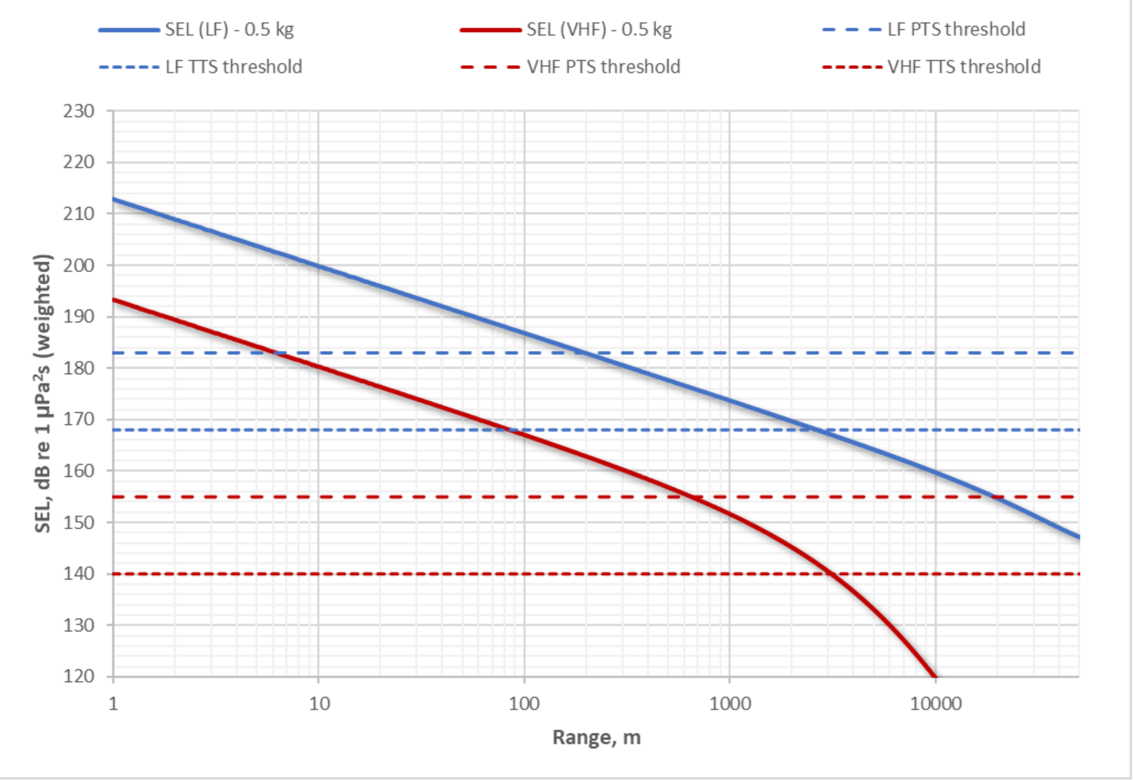

Figure 8.1: Calculated Hearing Weighted SEL (Solid Lines) vs PTS and TTS Thresholds (0.5 kg Net Explosive Quantity (NEQ))

87. It can be seen that the slope of the LF and VHF SEL curves differ from each other, with the VHF weighted SEL having a similar slope (but lower level) to the LF curve at closer ranges, but falling off more quickly at more distant ranges. This is caused by molecular absorption of sound energy at higher frequencies, which is absorbed much more quickly than at lower frequencies.

88. Figure 8.2 shows the same parameters presented above but for a 300 kg charge.

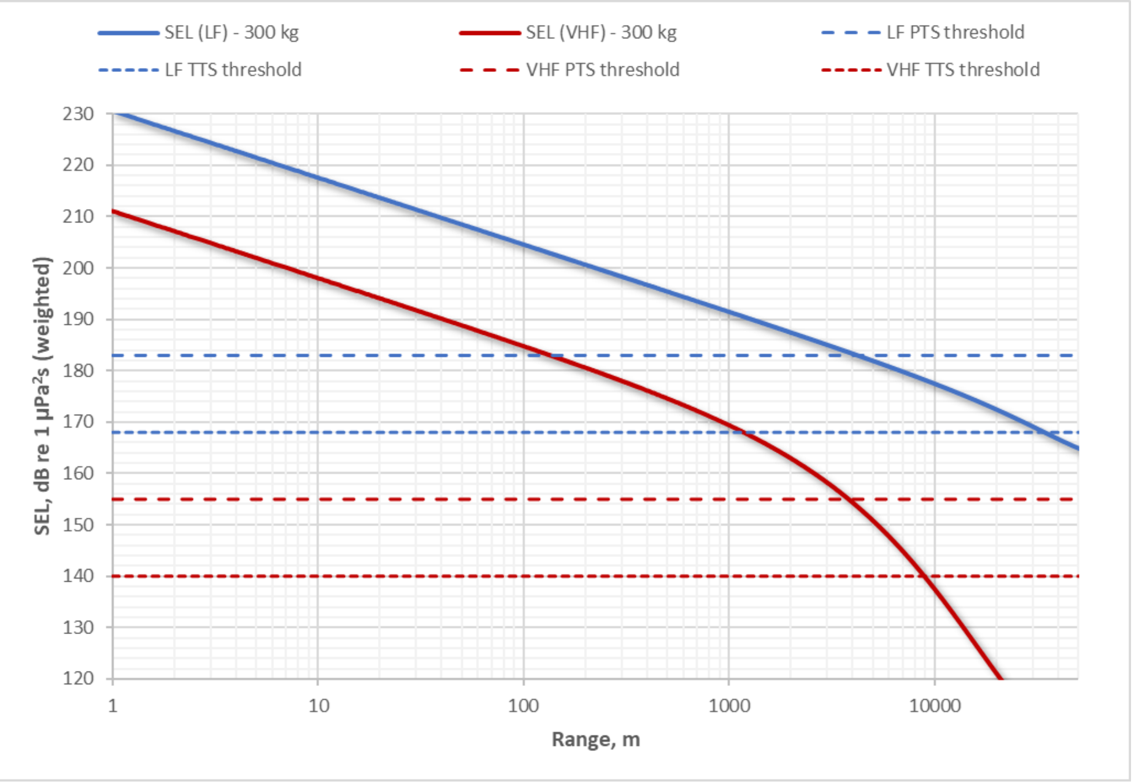

Figure 8.2: Calculated Hearing Weighted SEL (Solid Lines) vs PTS and TTS Thresholds (300 kg NEQ)

89. Comparing the two graphs, it can easily be seen why the TTS range for VHF cetaceans is higher than for LF cetaceans for the smaller charge size. Since the smaller charge size results in significantly lower injury ranges, the slope of the VHF curve at these closer ranges is similar to that of the LF curve slope. It is only at ranges of greater than a few kilometres that the VHF and LF curves diverge significantly and where, as a result, the LF cetacean TTS range exceeds the VHF cetacean TTS range.

90. Therefore, for very small charge sizes, it is possible that the TTS range for VHF cetaceans can be (and in this case is) larger than that for LF cetaceans when using the hearing weighted SEL metric.

8.3. CONVERSION FACTORS

91. The Subsea Noise Technical Report (volume 3, appendix 10.1 of the Offshore EIA Report) and supporting annexes used an approach to calculating the equivalent monopole sound level (i.e. "source level") for impact piling based on an estimate of the percentage of the total hammer energy that is likely to be emitted into the water column, where the percentage of the hammer energy emitted as sound is referred to as a conversion factor (denoted as β). This approach was based on the best available evidence and Project Design information at the time the assessment was carried out (as discussed in detail in annex A of volume 3, appendix 10.1 of the Offshore EIA Report). Based on this review, the assumption that piling is likely to use a submersible hammer, best available scientific evidence, professional judgement, and taking into account the advice of Marine Scotland Science and NatureScot, it was proposed to utilise a varying energy conversion factor of β = 4% at the start of piling to 0.5% at the end of piling for noise modelling at the Proposed Development. However, in light of potential uncertainties in the derivation of source level it is also proposed to carry out a sensitivity analysis using a conversion factor of β = 10% at the start of piling

to 1% at the end of piling as well as a scenario utilising a conversion factor of 1% throughout the piling sequence for comparison purposes. The latter conversion factor of 1% throughout is considered representative of a scenario where above-water hammers are used, although it is considered unlikely to be the case at the Proposed Development.

92. The subject of sound generation due to impact piling is an active area of research and the evidence base is constantly being updated by new measurements, research and published papers. A recent peer-reviewed paper (von Pein *et al.*, 2022a; 2022b; 2022c) presents a methodology for the dependencies of the SEL on strike energy, diameter, ram weight, and water depth that can be used for scaling measured or computed SELs from one project to another. This method allows to apply multiple project parameters (see paragraph 97) for deriving the sound source level. Method proposed by von Pein *et al.* (2022) is different to the conversion factor method, which assumes that a percentage of the hammer energy is converted into sound irrespective of parameters such as pile size, water depth and hammer specifications.

93. The purpose of the von Pein *et al.* (2022a) methodology is to provide a method to determine the SEL of a hammer strike on a pile that is relatively easy to apply and can be used for scaling measured or computed SELs from one project to the other. The method has been shown to be usable within practical ranges of accuracy, especially if the measurement uncertainties are taken into account. The paper suggests that scaling should be performed over either a small number of very similar piling situations or over a larger data set with according averaging.

94. Using the equation below (von Pein *et al.*, 2022a; 2022b), a broadband source level value is evaluated for the noise emitted during impact pile driving operations.

$$SEL_1 = SEL_0 + 10log_{10}\left(\frac{E_1}{E_0}\right) + 16.7log_{10}\left(\frac{d_1}{d_0}\right) - 10log_{10}\left(\frac{m_{r,1}}{m_{r,0}}\right) + 750\left[\frac{10log_{10}(|R_0|^2)}{2\,cot(\varphi)}\left(\frac{1}{h_1} - \frac{1}{h_0}\right)\right]$$

95. In this equation, E is the hammer energy employed in Joules, d is the pile diameter, m_r is the ram mass in kg, h is the water depth in m, $|R_0|$ is the reflection coefficient and φ is the propagation angle (approximately 17° for a Mach wave generated by impact piling). The equation allows measured pile noise data from one site (denoted by subscript 0) to be scaled to another site (denoted by subscript 1).

96. To account for the pile penetration and use of submerged piling rigs, a correction is applied through the piling sequence based on Lippert *et al.* (2017) by considering the quotient of wetted pile length L_w and water depth h_w using the following equation:

$$\Delta SEL = 8.3log_{10}(L_w/h_w)$$

97. This methodology therefore takes into account the following factors:

- pile diameter;
- pile length;
- pile penetration;
- water depth;
- rated maximum hammer energy of the proposed hammer;
- hammer energy being used;
- ram mass for the hammer; and
- acoustical parameters of the soil and water.

98. The paper includes a database of pile noise data measured on offshore wind farm projects for various types of piles and piling methodologies. Of those presented in the paper, the only measurement using a submersible hammer (i.e. similar to the technique likely to be used for the Proposed Development) is that for Global Tech I (GTI). For the GTI measurement, the pile head was submerged during the whole piling process (tripod foundation). The closest measurement distance was 583 m and a measurement value of an early piling stage with the pile head close to the sea surface is used in the database (i.e. the point at which sound levels will be highest).

99. A comparison has therefore been undertaken based on this submersible pile measurement for the purposes of scaling to the parameters used for the Proposed Development. The GTI piling parameters are set out in Table 8.2.

Table 8.2: Details of Parameters Used as Input to Scaling Model Based on GTI Offshore Wind Farm Piling

Parameter	Value
Measurement range	583 m
Strike energy	710 kJ
Pile diameter	2.48 m
Water depth	40 m
Ram weight	66 t
Hammer type	MHU 1200S
Foundation type	tripod
Pile length	46.5 m
Penetration depth	15 m
Wall thickness of pile	55 mm
SEL at measurement range	173 dB re 1 µPa^{2}s

100. The results of the scaling calculation in accordance with von Pein *et al.* (2022a) are shown in Table 8.3. Table 8.3 includes the scenario parameters used in the scaling for the Proposed Development as well as the resulting SEL at the same measurement range as the input parameters (i.e. for GTI) and the equivalent monopole source level and conversion factors.

Table 8.3: Parameters Used and Resulting SEL and Equivalent Conversion Factors for the Proposed Development, Based on Scaling from GTI Offshore Wind Farm

Parameter	Start of Piling	Maximum Realistic Hammer Energy	Maximum Hammer Energy
Rated max energy of hammer, kJ	4,000	4,000	4,000
Actual hammer energy, kJ	600	3,000	4,000
Pile diameter, m	5.5	5.5	5.5
Ram weight, kg	200	200	200
Water depth, m	70	70	70
Pile length, m	70	70	70

Parameter	Start of Piling	Maximum Realistic Hammer Energy	Maximum Hammer Energy
Penetration, m	5	68	68
SEL at measurement range, dB re 1 µPa^{2}s	174	168	169
Equivalent monopole source SEL, dB re 1 µPa^{2}s re 1 m	215	209	211
Equivalent energy conversion factor	4.3	0.2	0.2

101. From the results, it can be seen that scaling up the GTI offshore wind farm submersible piling sound levels for the proposed parameters at the Proposed Development results in a conversion factor of 4.3% at the start of piling and 0.2% at the end of piling. The scaling exercise, which takes into account site specific parameters for the Proposed Development, therefore results in a similar conversion factor to those recommended and used by Seiche Ltd in the noise modelling (volume 3, appendix 10.1 of the Offshore EIA Report) at the start of piling (i.e. a 4% conversion factor and source SEL of 215 dB re 1 µPa^{2}s). However, the scaled results show that the 0.5% conversion factor used in the Proposed Development noise modelling was likely to be a significant overestimate, resulting in source levels several decibels higher than found using the von Pein *et al.* (2022a) scaling laws.

102. In addition to the above calculation using the input parameters from the most similar operations in the measurement database provided (i.e. submersible hammer), Seiche Ltd has also carried out a sensitivity check utilising the database as a whole and carrying out averaging of the results, in accordance with the recommendations of von Pein *et al.* (2022a). The resulting source level and equivalent conversion factor are presented in Table 8.4 (using the same input parameters as presented in the previous table).

Table 8.4: Resulting SEL and Equivalent Conversion Factors for the Proposed Development, Based on Averaging and Scaling of Data from all Measurements Presented in von Pein *et al.* (2022a)

Parameter	Start of Piling	Maximum Realistic Hammer Energy	Maximum Hammer Energy
Equivalent monopole source SEL, dB re 1 µPa^{2}s re 1 m	215	209	211
Equivalent energy conversion factor	4.7	0.3	0.3

103. Results presented in Table 8.4 show that averaging and scaling of data from all measurements generate similar source sound levels and conversion factors to those found using the GTI pile (Table 8.3) and to those assumed in the Subsea Noise Technical Report (volume 3, appendix 10.1 of the Offshore EIA Report) (i.e. 4% reducing to 0.5% conversion factor). This updated evidence base therefore provides further supporting evidence that the use of a 4% reducing to 0.5% conversion factor in the Proposed Development underwater noise modelling (volume 3, appendix 10.1 of the Offshore EIA Report) was robust and appropriate.

104. It should be noted, however, that to adopt a precautionary assessment and to mitigate for uncertainties in the true value of the conversion factor at the time of writing, the marine mammal assessment presented in volume 2, chapter 10 of the Offshore EIA Report, took forward the predicted ranges from either the 4% reducing to 0.5% conversion factor or 1% constant conversion factor, whichever led to the greatest ranges using the relevant noise thresholds for injury and disturbance.

105. It is therefore concluded that:

- The 4% hammer energy conversion factor used in the Proposed Development underwater noise modelling (volume 3, appendix 10.1 of the Offshore EIA Report) at the start of piling is robust and realistic, based on a comparison to the results obtained using the methodology in von Pein *et al.* (2022a).
- The 0.5% conversion factor used in the Proposed Development underwater noise modelling at the end of piling is higher than found using the scaling method and could therefore be over-precautionary and result in higher sound levels and PTS/TTS ranges than will be encountered in reality.

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