HORIZON NUCLEAR POWER

WYLFA NEWYDD

ENERGY WORKING FOR BRITAIN

Wylfa Newydd Project

Horizon's Response to Natural Resources Wales' Deadline 5 submission

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1.1 Introduction

1.1.1 This document contains Horizon Nuclear Power Wylfa Limited's ("Horizon's") responses to items raised in Natural Resources Wales' (NRW's) written submission at Deadline 5 (12 February 2019) relating to the First and Second Biodiversity Hearings (ISHs). NRW's submission provides responses to actions set in the Biodiversity Issue Specific hearings and responses to the further written questions from the Examining Authority.

1.1.2 This document sets out Horizons responses to NRW's written response to the ISH items (section 1.3). Responses to specific Further Written Questions (FWQs) are provide separately and where relevant are cross-referenced below.

1.2 Summary of FWQ responses addressed

1.2.1 There is significant cross over with the comments made within of NRW's written response and NRW's responses to Examining Authority's questions. The responses have not been duplicated and instead table 1-1 below provides a summary of the relevant responses. Cross references to the further written question are also made within the text in section 1.3.

Table 1-1 Summary of further written questions response that support items addressed in section 1.3

Further Written Question Number	Summary
Q2.5.3	Relates specifically to section 2.1 of the response around potential impacts to terns
Q2.5.5	
Q2.5.6	
Q2.5.8	
Q2.5.9	
Q2.5.14	Relates specifically to section 2.3 of the response around potential impacts to marine mammals.
Q2.8.1	
Q2.8.10	

1.3 Horizon response to NRW's Written Response to Biodiversity ISH items

2.1 Morwenoliaid Ynys Mon / Anglesey Terns SPA – Mitigation

1.3.1 Further to NRW's review of the Technical Note on tern noise mitigation [REP3-048], NRW still has significant concerns regarding the effectiveness and

deliverability of the mitigation proposed, and they provide further detail in that regard in paragraphs 2.1.3 and 2.1.4 of their response.

1.3.2 In response to the main points raised by NRW in paragraph 2.1.3, Horizon has provided further clarification on the Technical Note concerned with noise mitigation for terns [REP3-048] in its detailed responses to Further Written Questions 2.5.7, 2.5.12 and 2.5.13 provided at Deadline 5 (12 February 2019). These are not repeated here. However, regarding NRW's point a), the red thresholds are already established through the proposed noise limits (set out in section 11.4 of the Main Power Station Site Sub-Code of Construction Practice (CoCP) and section 11.5 of the Marine Works sub-CoCP) submitted at Deadline 5 (12 February 2019) and it is proposed that the amber thresholds are set at 2dB below the red thresholds, but this will be agreed with NRW prior to the commencement of construction activities (see Horizon's response to FWQ2.5.7 submitted at Deadline 5 (12 February 2019). This response also explains why it is appropriate to use hourly averages.

1.3.3 Regarding NRW's points b) and c), Horizon's response to FWQ2.5.12 submitted at Deadline 5 (12 January 2019) explains how the action that should be taken to reduce noise levels will be determined (i.e. how the criteria will work). Significantly, the options available to the Site Manager typically will be numerous and he or she will determine which machinery or activities need to be altered or stopped (in order to reduce noise levels at the colony to below response thresholds) based on their expert knowledge of the site and the activities taking place and taking account of Health & Safety and environmental risk appropriately. There will always be more than one approach that will be able to be taken to reduce noise levels. Further, the addition of the reactive monitoring proposed (i.e. observers at the tern colony) will ensure that a disturbing activity would not be allowed to continue without mitigation being implemented (i.e. if the terns are disturbed mitigation will be provided).

1.3.4 Regarding NRW's point d), Horizon's response to NRW's response to FWQ2.5.5 (submitted alongside this submission) addresses the issue of avoiding adverse wind conditions (i.e. from the noise modelling and monitoring, Horizon will be able to predict with confidence the noise that will reach the colony under different wind and weather conditions, and the actions that will need to be taken to avoid the thresholds being breached).

1.3.5 Regarding NRW's point e), Horizon's response to FWQ2.5.12 submitted at Deadline 5 (12 January 2019) explains how the Project activities responsible for any 'fly-ups' that do occur (if any occur) will be able to be identified (based on matching acoustic signatures with site activities). Site activities will then be reviewed to identify what alterations can be made (e.g. change in work intensity, schedules or methods, or additional noise abatement), improvement plans developed, and alternatives approaches adopted.

1.3.6 In the context of NRW's conclusion set out in paragraph 2.1.4, it is worth restating that the observation of terns and reactive reduction in noise levels if fly ups are observed is being proposed on a precautionary basis only. It is Horizon's view that there is not reasonable scientific doubt regarding whether an adverse effect on the Anglesey Terns SPA will arise; the scientific literature and results of monitoring the Cemlyn colony indicate that an adverse effect will not arise, and the mitigation proposed will ensure this.

2.3 Marine Mammals (as features of Welsh SACs and European Protected Species)

1.3.7 Horizon's Deadline 4 (17 January 2018) responses to actions set in the Biodiversity ISH held on 10 January 2019 was provided in REP4-009, not REP4-005 as stated in 2.3.1 of NRW's Deadline 5 (12 February 2019) written response. With regard to marine mammals, the Deadline 5 response containing Appendix 1-3 which includes the *Marine Works Noise Modelling base on US National Marine Fisheries Services (NMFS)* as Appendix 2-1 was accepted as a late submission as it was absent from the initial version submitted.

1.3.8 Subsequent to this, however, errors have been identified in the modelling with regards to the SPL_{peak} sound levels and therefore the ranges to effect were over-calculated. Therefore, the updated NMFS modelling and accompanying report (previously Appendix 1.3 to REP4-009) have been updated and provided as Appendix 1-1 to this document.

1.3.9 There is significant cross over between the comments made within section 2.3 of NRW's written response to the Biodiversity ISH and NRW's responses to the Examining Authority's questions (Annex B) with regard to marine mammals in particular. Horizon's responses to NRW's responses to FWQs (submitted at Deadline 6 (19 February 2019)), therefore, also refer to the information presented here.

European Protected Species: Injury and mitigation – Choice of metrics

1.3.10 The construction activity that has been assessed to have the potential to create the largest impact range is rock breaking or peckering. The updated underwater noise modelling (Appendix 1-1) indicates that the PTS (Permanent Threshold Shift) could occur up to a distance of 380m for harbour porpoise, 10m for bottlenose dolphin, 790m for minke whale and 250m for grey seal, based on the NMFS (2018) impulsive criteria for the weighted cumulative Sound Exposure Level (SEL_{cum}).

1.3.11 The risk of a PTS based on the NMFS (2018) impulsive criteria [RD1] for the unweighted peak Sound Pressure Level (SPL_{peak}) to underwater noise during rock breaking in harbour porpoise, bottlenose dolphin, minke whale and grey seal has been modelled to have the potential to occur up to a range of 4m (metres), 1m, 1m and 1m respectively.

1.3.12 Therefore, the largest range at which PTS may occur is up to 790m (based on the NMFS (2018) impulsive criteria for the weighted SEL_{cum}); and this is Horizon's choice of metric as it represents worst case. That is, the range that would require mitigation to ensure no marine mammals are at risk of PTS onset. The commitment to mitigate underwater noise for marine mammals is secured in the Marine Works sub-CoCP (an updated version of which was submitted at Deadline 5 (12 February 2019)). The detail of the mitigation will be developed in consultation with NRW through the Marine Licence, for which they are the discharging authority.

1.3.13 Given the above Horizon is not of the opinion that the use of Acoustic Deterrent Devices (ADDs) or other further mitigation measures is warranted.

Modelling accuracy

1.3.14 As outlined in Appendix 1-1, the updated underwater modelling based on the NMFS (2018) criteria presented in Appendix 2.1 of Appendix 1.3 of REP4-009 (not REP4-005 as referred to by NRW) has been reviewed by Subacoustech and an error was detected. It was found that the peak values had been multiplied by 24-hours, which is not applicable for SPL_{peak} values. Therefore, the modelling has been re-run the for a single strike SPL_{peak} and updated. Resulting in a reduction of 6 dB for the SPL_{peak} criteria ranges within 10m.

1.3.15 This error was confined to the updated underwater noise modelling that was undertaken to examine the effects of the new NMFS criteria (2018). As a result, the conclusions made within chapter D13 (APP-132) of the ES and the shadow HRA (APP-051/052) are unaffected.

1.3.16 The revised modelling outputs are provided in Annex 1 to Appendix 1-1 herein.

HRA: Disturbance of harbour porpoise within North Anglesey Marine Site of Community Importance (SCI)

1.3.17 In the revised noise modelling based on the NMFS (2018) criteria (see Appendix 1-1) the predicted Temporary Threshold Shift (TTS) range for harbour porpoise as a result of rock breaking is 3.3km, which has a potential disturbance area of 34km^2; approximately 1% of the SCI area (the SCI is 3249 km^2). Therefore, as NRW has concluded, if the weighted SEL_{cum} TTS metric is used as a proxy for disturbance, there would not be significant disturbance of harbour porpoise in the North Anglesey Marine SCI.

1.3.18 Regarding the assessment of concurrent noise sources, the modelling of cumulative noise presented in Horizon's Deadline 4 (17 January 2019) response to the Biodiversity ISH [REP4-009] was undertaken based on a combined noise signal from all operations, i.e. the noise signatures from each activity were combined to create a single source level and frequency spectra. The modelling was, therefore, undertaken based on the combined noise source at a single location.

1.3.19 The noise signal from rock breaking has been incorporated into the combined source level used in the updated modelling (see Appendix 1-1). The results presented in table 16 of Annex 1 provide the range to effect based on the criteria for non-impulsive sounds. The range to effect criteria for impulsive sound used are those presented in tables 12 and 13 of Annex 1.

Percussive piling

1.3.20 The Request for Non-Material Change (RFNMC) - Working Hours [REP4-012] refers to marine piling. Horizon can confirm that there will be *no* piling operations within the wet marine environment (i.e. underwater). The piling operations referred to in table 2-1 and table 2-2 of REP4-012, refer to operations to be undertaken in the dry, for which airborne noise modelling has been completed and assessments for pinnipeds provided in chapter D13 [APP-132] of the Environmental Statement. The changes represented in the Working Hours RFNMC relate to a change in the working hours for operations of specific plant and do not introduce new construction activities.

1.3.21 Based on the fact that the RFNMC for working hours will not affect marine operations it is considered that there will be no effect on the assessment conclusions drawn in the ES and the Shadow HRA.

2.4 Benthic habitats

1.3.22 Horizon's commitment to deliver ecological enhancement mitigation, marine restoration and an adaptive monitoring and management programme is secured in the DCO application within the Marine Works sub-CoCP submitted at Deadline 5 (12 February 2019).

2.5 Water Framework Directive

1.3.23 Paragraph 2.5.2 of NRW's Deadline 5 (12 February 2019) submission advise that the scope of the Article 4(7) derogation is agreed as soon as possible. Horizon committed to submit an updated Water Framework Directive (WFD) Compliance Assessment and 'Information to support a derogation under Article 4(7) of the WFD' at Deadline 6 (19 February 2019). These materials were prepared in response to issues previously raised by NRW through the Statement of Common Ground process and in its relevant and written representations [REP1-029, REP2-325]. Horizon will continue to continue to work with NRW with reference to the Article 4(7) derogation and will follow up on the points raised in this submission with the objective of finalising the scope in mind.

1.3.24 In respect of Paragraphs 2.5.4 to 2.5.6, Horizon retains its position that, when referencing the normative definition for the ecological status in coastal waters (Table 1.2.4 of Annex V of the Water Framework Directive), it can be concluded that the benthic invertebrate fauna will remain at high status with the construction and operation of the Wylfa Newydd Project.

1.3.25 Horizon respects the position of NRW, both as an advisor in the DCO examination and as the competent authority for the marine licence. Therefore, and without prejudice, Horizon will provide materials to be considered under Article 4(7) of the WFD in respect of benthic invertebrate fauna. Horizon will discuss the scope of these materials with NRW and will provide NRW an opportunity to give feedback on the revised WFD documents submitted at Deadline 6 (19 February 2019). These documents have been provided to NRW ahead of the formal Deadline 6 submission in order to maximise the opportunity for NRW to review and provide comment.

3.1 Bae Cemlyn / Cemlyn Bay SAC – Coastal Processes

1.3.26 Horizon has agreed through the examination of the Wylfa Newydd DCO Project to undertake a monitoring programme of Esgair Gemlyn and adopt an adaptive management approach to mitigation. This approach is secured in the DCO application with the commitment set out in the Marine Works sub Code of Construction Practice (CoCP) submitted at Deadline 5 (12 February 2019).

1.3.27 Horizon have been engaging with NRW in the development of the strategy and these conversations will continue. The strategy provides a mechanism by which monitoring will be implemented and mitigation will be available to ensure that impacts are no greater than the residual effects predicted in the DCO application and removes the uncertainty of conclusions.

4 Annex A1 – NRW specialist comments on marine enhancements [REP4-023]

1.3.28 Additional information relating to the effects of the cooling water discharge on coastal processes has been provided as an appendix to Horizon's Deadline 5 Responses to actions set in Issue Specific Hearing on 10 January 2019 (appendix 1.3- effects of cooling water discharge on tidal vectors). This included a cumulative benthic assessment (section 1.4 of appendix 1.3) which concluded no cumulative impact to benthic habitats of conservation importance. Therefore, the area requiring mitigation remains unchanged from that stated in the DCO application (20.0 hectares).

1.3.29 Following a consultation meeting held with NRW on the 4 February 2019, Horizon has carried out further work to explore several options recommended by NRW. This information will be submitted into Examination at Deadline 6 (19 February 2019) through the Statement of Common Ground process.

1.3.30 Horizon's commitment to deliver ecological enhancement mitigation, marine restoration and an adaptive monitoring and management programme is secured in the DCO application within the Marine Works sub-CoCP submitted at Deadline 5 (12 February 2019).

1.3.31 The aim of the mitigation is to provide sufficient information to demonstrate that Horizon has appropriately considered the impacts of the Project footprint within the marine environment and has made satisfactory commitment to mitigation to reduce the significance of effect to subtidal and intertidal habitats of conservation importance from a moderate adverse significant effect to a minor adverse non-significant residual effect. Within the constraint of the WNDA Order limits, it is not physically possible to fully offset the area of habitat loss under the footprint of the Marine Works. Therefore, to reduce net loss as far as practicable, the enhanced ecological enhancement mitigation proposal has been focused on improving quality as well as maximising the spatial extent of enhancements over the greatest practical (i.e. logistically and financially) extent.

1.3.32 It is important to recognise that the approach taken to assessing marine habitat loss under the footprint of the Marine Works in the DCO application was extremely precautionary. The areal extent of impacts included 6.7ha of subtidal habitats of conservation importance which falls within and adjacent to the dredge area. Effects in this area will, in reality, be temporary in nature with recovery highly likely to occur. The area adjacent to the dredging footprint to the north (and characterised by muddy sands) may not be impacted at all. Additional hydrodynamic modelling work which has been carried out specifically to inform the detailed design of the Marine Works has shown that hydrodynamic conditions within the harbour will remain dynamic much like present conditions. Therefore, whilst Horizon agrees with NRW that the exact same communities are unlikely to recolonise the impacted area, similar communities would be expected. Critically, these would restore ecosystem function and processes which are characteristic of broad biotope complexes. Considering the area gained from the proposed mitigation and restoration plan, as well as the potential recovery of a further 6.7ha, the net loss of intertidal and subtidal habitats of conservation importance would be significantly reduced from 20.0ha to 6.1ha. This is sufficient to reduce the significance of the residual impact from moderate to minor adverse.

5 Annex A2 – NRW Specialist Comments on Coastal Processes [REP2-007]

North westerly reflected wave

1.3.33 As stated in 1.3.26 and 1.3.27 above, Horizon has committed to undertake a monitoring programme of Esgair Gemlyn and adopt an adaptive management approach to mitigation. This approach is secured in the DCO application with the commitment set out in the Marine Works sub Code of Construction Practice (CoCP) submitted at Deadline 5 (12 February 2019). This monitoring work will provide more information regarding the behaviour of the ridge.

Cooling water discharge

1.3.34 A technical note setting out Horizon's position on the effect of the cooling water discharge on the tidal vectors and velocity was submitted into examination at Deadline 5 (12 February 2019) as appendix 1.3 of Horizon's Deadline 5 Responses to actions set in Issue Specific Hearing on 10 January 2019.

Monitoring and mitigation

1.3.35 As stated previously, Horizon has committed to undertake a monitoring programme of Esgair Gemlyn and adopt an adaptive management approach to mitigation. This approach is secured in the DCO application with the commitment set out in the Marine Works sub Code of Construction Practice (CoCP) submitted at Deadline 5 (12 February 2019).

Appendix 1-1 Updated NMFS modelling

1-1.1 Introduction

1-1.1.1 In paragraph 7.11.11 of the National Resources Wales (NRW) Written Representation (WR) [REP2-325], NRW note that, since the Shadow Habitats Regulations Assessment (HRA) was written, the accepted underwater noise criteria for marine mammal injury and disturbance have changed. The Southall *et al*. 2007 [RD2] noise criteria, used to inform the Shadow HRA, were the accepted industry standard until April 2018, when updated criteria were published by the National Marine Fisheries Service (NMFS) (2018) [RD1]. These latest criteria have now been adopted by the appropriate nature conservation bodies as the preferred criteria to use in noise assessments.

1-1.1.2 Consequently, NRW propose that, although it does not consider that the conclusions regarding impacts from noise will change based on these new criteria, it may be beneficial to demonstrate this, since, especially for harbour porpoise, the distance from the sound source where it is predicted that hearing injury (Permanent Threshold Shift (PTS)) can occur can be much greater using the new NMFS criteria compared to the Southall *et al*. 2007 criteria [RD2].

1-1.1.3 In response, a Technical Note on the Shadow HRA's marine mammal PTS noise modelling was prepared for Deadline 3 [REP3-035, Appendix D] which describes the implications of using the NMFS criteria (2018) for the conclusions of the Shadow HRA [APP-050] based on a comparison with recent noise modelling undertaken for similar activities for a different site. This demonstrates that the conclusions of the Shadow HRA would not change based on the use of the new criteria.

1-1.1.4 Further to this, the underwater noise modelling undertaken for the Shadow HRA was updated using the NMFS (2018) criteria [RD1] and this was submitted into the Examination at Deadline 4 [REP4-009, Appendix 1.3 and Appendix 2.1 therein].

1-1.1.5 Subsequently, in section 2.3 of NRW's response to the Biodiversity ISHs produced for Deadline 5 (12 February 2019), questions were raised over the noise modelling that had been conducted based on the NMFS (2018) criteria [RD1]. The modelling has been reviewed by Subacoustech and errors have been identified in the modelling with regards to the SPL_{peak} sound levels and therefore the ranges to effect were over-calculated. It was found that the peak values had been multiplied by 24-hours, which is not applicable for SPL_{peak} values. Therefore, the modelling has been re-run for a single strike SPL_{peak} and updated; resulting in a reduction of 6dB for the SPL_{peak} criteria ranges within 10m.

1-1.1.6 The updated modelling results are presented in Annex 1 to this document.

1-1.2 Outcome of updated underwater noise modelling

Drilling

1-1.2.1 The updated noise modelling based on the NMFS (2018) criteria [RD1] for drilling (Table 1-2) indicates that there is a slight increase in the some of the maximum predicted impact ranges for auditory injury (Permeant Threshold Shift; PTS) in high frequency cetaceans (harbour porpoise), compared to the impacted ranges

modelled using the Southall *et al*. (2007) [RD2] (Table 1-3) used in the Shadow HRA [APP-050]. With the maximum predicted PTS range for two percussive drilling rigs increasing from 3metres to 10metres for harbour porpoise.

Table 1-2 Maximum predicted effect ranges for PTS in marine mammals[1] based on the weighted SEL NMFS (2018) non-impulsive criteria [RD1] for rotary drilling (570kW), percussive drilling and concurrent drilling noise for continuous 24 hours exposure

NMFS (2018)	Rotary drilling [570 kW]	Percussive drilling	2 rotary drilling rigs [570 kW]	2 percussive drilling rigs
Range to PTS in High Freq. Cetaceans (harbour porpoise) 173 dB re 1 µPa^{2}s Weighted SEL_{cum}	<1m	9m	<1m	10m
Range to PTS in Mid Freq. Cetaceans (dolphin species) 198 dB re 1 µPa^{2}s Weighted SEL_{cum}	<1m	<1m	<1m	1m
Range to PTS in Phocid Pinnipeds (seals) 201 dB re 1 µPa^{2}s Weighted SEL_{cum}	<1m	9m	<1m	10m

[1] Please note minke whale are not assessed in the Shadow HRA as they are not an Annex II species.

Table 1-3 Maximum predicted effect ranges for PTS in marine mammals based on the M-weighted SEL Southall *et al*. (2007) [RD2] criteria for rotary drilling (570kW), percussive drilling and concurrent drilling noise for continuous 24 hours exposure

Southall *et al* (2007)	Rotary drilling [570 kW]	Percussive drilling	2 rotary drilling rigs [570 kW]	2 percussive drilling rigs
Range to PTS in High Freq. Cetaceans (harbour porpoise) 215 dB re 1 μPa^{2}s	<1m	2m	<1m	3m
Range to PTS is Mid Freq. Cetaceans (dolphin species) 215 dB re 1 μPa^{2}s	<1m	3m	<1m	4m
Range to PTS in Phocid Pinnipeds (seals) 203 dB re 1 μPa^{2}s	1m	41m	3m	71m

1-1.1.1 The estimated number of harbour porpoise (based on a density estimate of 1.26/km^2) that could be in the area that could be affected by underwater noise from two percussive drilling rigs, based on the maximum area of effect (0.000314km^2 based on 10m radius) is 0.0004 (0.0000004% of the reference population of 104,695 individuals). In the Shadow HRA [APP-050], it was estimated that 0.00004 harbour porpoise (<0.00001% of the reference population) could be at risk during drilling activities.

1-1.1.2 Therefore, as predicted by NRW, based on the updated noise modelling [RD1] there is no significant increase in the potential risk of PTS in harbour porpoise from the proposed drilling activities.

1-1.1.3 It should be noted that all the potential impact areas are based on the area of a circle (in relation to the maximum impact range), and as the site is located adjacent to the coastline, this will significantly over-estimate the numbers of marine mammals that are expected to be exposed to each impact.

1-1.1.4 For two percussive drilling rigs, the range at which Temporary Threshold Shift (TTS) and a behavioural response could occur in harbour porpoise is up to 280m based on the NMFS (2018) criteria [RD1]. Which is less than the predicted range of 530m for minor behavioural effect in harbour porpoise based on the Lucke *et al*. (2009) criteria [RD3] (145 dB re 1 μPa^{2}s) used in the Shadow HRA [APP-050], but greater than the previously modelled TTS range of 36m (based on 165 dB re 1 μPa^{2}s SEL criteria). However, the effect in relation to the population remains negligible, with 0.0003% of the harbour porpoise reference population anticipated to be exposed to the temporary effect (based on the density estimate at WNDA).

Cutter-suction dredging

1-1.1.5 The updated noise modelling based on the NMFS (2018) criteria [RD1] for cutter-suction dredging (Table 1-4) indicates that there is a slight increase in some of the maximum predicted impact ranges for PTS in harbour porpoise and seals compared to the impacted ranges modelled using the Southall *et al*. (2007) criteria [RD2] (Table 1-5) used in the Shadow HRA [APP-050]. With the maximum predicted PTS range for cutter-suction dredging increasing from less than 1m to 10m for harbour porpoise and from 5m to 9m for seals.

1-1.1.6 The estimated number of harbour porpoise that could be affected by underwater noise from cutter-suction dredging (area based on 10m radius) is 0.0004 (0.0000004% of the reference population) in the Wylfa Newydd Development Area and up to 0.0008 (0.0000008% of reference population) at the disposal site. In the Shadow HRA [APP-050], it was estimated that 0.00004 harbour porpoise (<0.00001% of the reference population) in the Wylfa Newydd Development Area and up to 0.000008 harbour porpoise (<0.00001% of the reference population) at the disposal site could be at risk of PTS during cutter-suction dredging.

1-1.1.7 Therefore, based on the updated noise modelling [RD1], there is no significant increase in the potential risk of PTS in harbour porpoise from the proposed dredging activities

1-1.1.8 Similarly, for cutter-suction dredging, the range at which TTS onset may occur in harbour porpoise has increased from 4m to 260m in the updated modelling. However, as for percussive drilling described above, the effect in relation to the population remains negligible, with 0.0005% of the reference population anticipated to be exposed to the effect (based on the worst-case density for the Holyhead North site).

Table 1-4 Maximum predicted effect ranges for PTS in marine mammals based on the weighted SEL NMFS (2018) non-impulsive criteria [RD1] for cutter-suction dredging

NMFS (2018)	Cutter-suction dredging
Range to PTS in High Freq. Cetaceans (harbour porpoise) 173 dB re 1 μPa^2s Weighted SEL_{cum}	10m
Range to PTS in Mid Freq. Cetaceans (dolphin species) 198 dB re 1 μPa^2s Weighted SEL_{cum}	1m
Range to PTS in Phocid Pinnipeds (seals) 201 dB re 1 μPa^2s Weighted SEL_{cum}	9m

Table 1-5 Maximum predicted effect ranges for PTS in marine mammals based on the M-weighted SEL Southall *et al*. (2007) criteria [RD2] for cutter-suction dredging

NMFS (2018)	Cutter-suction dredging
Range to PTS in High Freq. Cetaceans 215 dB re 1 μPa^2s	<1m
Range to PTS in Mid Freq. Cetaceans 215 dB re 1 μPa^2s	<1m
Range to PTS in Phocid Pinnipeds 203 dB re 1 μPa^2s	5m

Rock breaking and cutting

1-1.1.1 The updated noise modelling based on the NMFS (2018) criteria [RD1] for rock breaking (Table 1-6) indicates that there is an increase in the maximum predicted impact ranges for PTS in harbour porpoise, based on the weighted SEL_{cum} criteria compared to the impacted ranges modelled using the Southall *et al*. (2007) criteria [RD2] (Table 1-8) used in the Shadow HRA [APP-050]. With the maximum predicted PTS range increasing from 25m to 380m for harbour porpoise.

1-1.1.2 The estimated number of harbour porpoise that could be affected by underwater noise during rock breaking (area based on 380m radius) is 0.57 (0.0005% of the reference population) in the Wylfa Newydd Development Area. In the Shadow HRA [APP-050], it was estimated that 0.0014 harbour porpoise (0.00035% of the reference population) in the Wylfa Newydd Development Area could be at risk of PTS during rock breaking. However, the effect in terms of population remains negligible.

1-1.1.3 Therefore, based on the updated noise modelling (NMFS, 2018), there is no significant increase in the potential risk of PTS in harbour porpoise from the proposed rock breaking activities

1-1.1.4 For rock cutting there was a slight increase in the predicted PTS impact range for harbour porpoise, from less than 1m to 7m. However, again, there is no significant increase in the potential risk of PTS in harbour porpoise from the proposed rock cutting activities

1-1.1.5 For rock breaking, modelling was also undertaken using the SPL_{peak} criterion for PTS and TTS. The results of this modelling show a significantly smaller predicted impact range compared to the SEL_{cum} criteria (Table 1-6).

1-1.1.6 However, the range at which TTS may occur in harbour porpoise for rock breaking has increased from 25m to a worst-case of 3.3km for harbour porpoise. Nevertheless, the effect on the population would remain negligible, with 0.04% of the reference population expected to be temporarily impacted.

1-1.1.7 The range at which TTS may occur in harbour porpoise for rock-cutting has increased from less than 1m to 130m; this also remains a negligible impact at the population level, with 0.00006% of the reference population anticipated to be temporarily impacted.

Table 1-6 Maximum predicted effect ranges for PTS in marine mammals based on the unweighted SPL and weighted SEL NMFS (2018) impulsive criteria [RD1] for rock breaking

NMFS (2018)	Rock breaking
Range to PTS in High Freq. Cetaceans (harbour porpoise) 202 dB re 1 µPa Unweighted SPL_{peak}	4m
Range to PTS is Mid Freq. Cetaceans (dolphin species) 230 dB re 1 µPa Unweighted SPL_{peak}	<1m
Range to PTS in Phocid Pinnipeds (seals) 218 dB re 1 µPa Unweighted SPL_{peak}	<1m
Range to PTS in High Freq. Cetaceans (harbour porpoise) 155 dB re 1 μPa^2s Weighted SEL_{cum}	380m
Range to PTS in Mid Freq. Cetaceans (dolphin species) 185 dB re 1 μPa^2s Weighted SEL_{cum}	10m
Range to PTS in Phocid Pinnipeds (seals) 185 dB re 1 μPa^2s Weighted SEL_{cum}	250m

Table 1-7 Maximum predicted effect ranges for PTS in marine mammals based on the weighted SEL NMFS (2018) non-impulsive criteria [RD1] for rock cutting

NMFS (2018)	Rock cutting
Range to PTS in High Freq. Cetaceans (harbour porpoise) 173 dB re 1 μPa^2s Weighted SEL_{cum}	7m
Range to PTS in Mid Freq. Cetaceans (dolphin species) 198 dB re 1 μPa^2s Weighted SEL_{cum}	<1m
Range to PTS in Phocid Pinnipeds (seals) 201 dB re 1 μPa^2s Weighted SEL_{cum}	4m

Table 1-8 Maximum predicted effect ranges for PTS in marine mammals based on the M-weighted SEL Southall *et al*. (2007) criteria [RD2] for rock breaking and rock cutting

NMFS (2018)	Rock breaking	Rock cutting
Range to PTS in High Freq. Cetaceans 198 dB re 1 μPa^2s	25m	<1m
Range to PTS in Mid Freq. Cetaceans 198 dB re 1 μPa^2s	36m	<1m
Range to PTS in Phocid Pinnipeds 186 dB re 1 μPa^2s	450m	4m

1-1.1 Conclusion

1-1.1.1 The potential risk of PTS and onset of TTS remains of negligible significance for marine mammal populations due to the Wylfa Newydd Project, with no significant changes to the assessment in the Shadow HRA [APP-050].

1-1.1.2 In addition, the Marine Mammal Mitigation Plan (MMMP) being developed through the Marine Licence will ensure that no marine mammals are within the PTS range of rock-breaking (maximum predicted PTS range of 380m based on SEL_{cum} criteria) prior to the commencement of works and, therefore, the potential effect of PTS onset will be negated.

1-1.1.3 Consequently, any potential effect from underwater noise during construction is highly unlikely to have an adverse effect on the integrity of the European Sites designated for marine mammals in the study area in relation to their conservation objectives.

1-1.2 References

Table 1-9 Schedule of references

ID	Reference
RD1	National Marine Fisheries Service (NMFS) (2018). 2018 Revisions to: Technical guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing (Version 2.0): Underwater Thresholds for Onset of Permanent and Temporary Threshold Shifts. U.S. Dept. of Commer., NOAA. NOAA Technical Memorandu, NMFS-OPR-59.
RD2	Southall, B.L., Bowles, A.E., Ellison, W.T., Finneran, J.J., Gentry, L., Greene, C.R., Kastak, D., Ketten, D., Miller, J.H., Nachtigall, P.E., Richardson, W.J., Thomas, J.A. and Tyack, P.L. (2007). Marine mammal noise exposure criteria: Initial scientific recommendations. *Aquatic Mammals*, Vol. 33, No. 4, pp.411-521.
RD3	Lucke, K., Lepper, P.A. and Blanchet, M. (2009). Temporary shift in masked hearing thresholds in a harbour porpoise (*Phocoena phocoena*) after exposure to seismic airgun stimuli. *Journal of the Acoustical Society of America*. 125(6), pp.4060 – 4070.

1-1.1 ANNEX 1: NMFS (2018) Modelling Results

Project title	Horizon's Response to Natural Resources Wales Deadline 5 submission
Project number	P251
Author(s)	Edwards, Sam
Company	Subacoustech Environmental Ltd.
Report number	Subject of the Report
Date of issue	14 February 2018

Introduction

Subacoustech Environmental previously undertook an underwater noise modelling study using RAMSGeo, in order to assess the possible noise impacts to marine fauna resulting from the various activities planned during construction at the Wylfa Newydd Generating Station (Subacoustech Report Reference: E522R0704). Since the issue of the report, additional RAMSGeo noise modelling has been undertaken to assess noise from the construction activities using the NMFS (2018)[2] criteria for injury and TTS to marine mammals. All parameters used for the additional modelling are identical to those used in the original modelling.

This report presents the additional modelling results for the construction noise sources considered in the original reporting using the NMFS (2018) criteria. The noise sources considered are:

- Two different rotary drilling rigs (242 kW and 570 kW);
- Percussive drilling;
- Cutter-suction dredging;
- Rock breaking (peckering);
- Rock cutting; and
- Vessel noise (using the SPEAR model).

The three drilling scenarios include the possibility of two identical rigs operating simultaneously. Also considered is a worst-case scenario where rotary drilling (570 kW), percussive drilling, cutter-suction dredging and rock breaking (peckering) are all operational at the same time.

NMFS criteria

The NMFS guidelines, first issued in 2016 and revised in 2018, are based on the best available research on the effects of noise on marine mammals.

The NMFS (2018) guidance groups marine mammals into functional hearing groups and applies filters to the noise level to approximate the hearing response of the receptor. The hearing groups given in the NMFS (2018) guidance are summarised in Table 1.

The auditory weighting functions for each hearing group relevant to this study are provided in Figure 1.

Hearing group	Example species	Generalised hearing range
Low Frequency (LF) Cetaceans	Baleen Whales	7 Hz to 35 kHz
Mid Frequency (MF) Cetaceans	Dolphins, Toothed Whales, Beaked Whales, Bottlenose Whales (including Bottlenose Dolphin)	150 Hz to 160 kHz
High Frequency (HF) Cetaceans	True Porpoises (including Harbour Porpoise)	275 Hz to 160 kHz
Phocid Pinnipeds (PW) (underwater)	True Seals (including Harbour Seal)	50 Hz to 86 kHz

Table 1 Marine mammal hearing groups (from NMFS, 2018)

[2] National Marine Fisheries Service (NMFS) (2018). 2018 Revisions to: Technical guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing (Version 2.0): Underwater Thresholds for Onset of Permanent and Temporary Threshold Shifts. U.S. Dept. of Commer., NOAA. NOAA Technical Memorandu, NMFS-OPR-59.

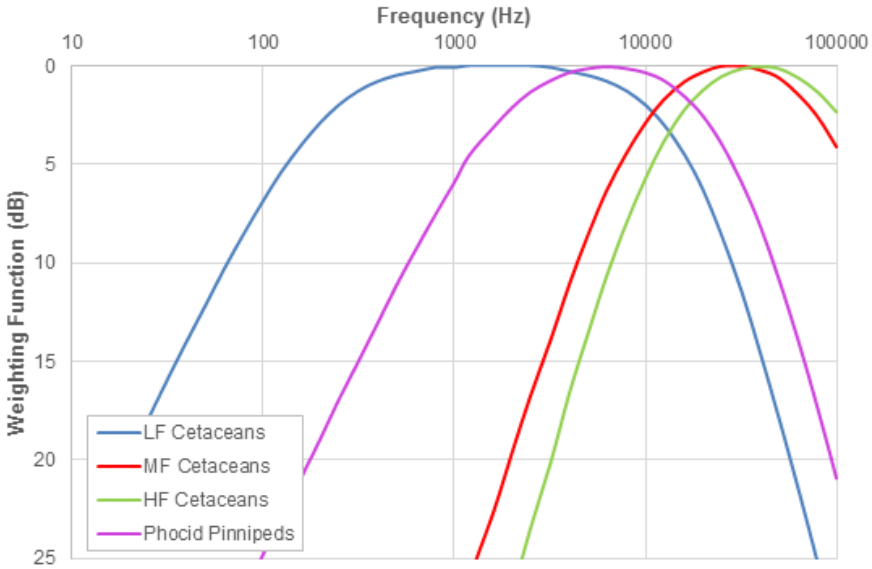

Figure 1 Auditory weighting functions for low frequency (LF) cetaceans, mid frequency (MF) cetaceans, high frequency (HF) cetaceans, phocid pinnipeds (PW) (underwater) (from NMFS, 2018)

For non-impulsive (i.e. continuous) noise, NMFS (2018) presents cumulative weighted sound exposure criteria (SEL_{cum}) for both permanent threshold shift (PTS), where unrecoverable hearing damage may occur, and temporary threshold shift (TTS), where a short-term, recoverable effect on hearing sensitivity may occur in individual receptors. Table 2 and Table 3 summarise the NMFS (2018) criteria for onset of risk of PTS and TTS for each of the key marine mammal hearing groups for impulsive and non-impulsive noise.

Impulsive noise	**PTS criteria**		**TTS criteria**	
Hearing group	**Unweighted SPL_{peak} (dB re 1 µPa)**	**Weighted SEL_{cum} (dB re 1 µPa²s)**	**Unweighted SPL_{peak} (dB re 1 µPa)**	**Weighted SEL_{cum} (dB re 1 µPa²s)**
LF Cetaceans	219	183	213	168
MF Cetaceans	230	185	224	170
HF Cetaceans	202	155	196	140
PW Pinnipeds	218	185	212	170

Table 2 NMFS (2018) noise exposure criteria for impulsive noise

Non-Impulsive noise	**PTS criteria**	**TTS criteria**
Hearing group	**Weighted SEL_{cum} (dB re 1 µPa²s)**	**Weighted SEL_{cum} (dB re 1 µPa²s)**
LF Cetaceans	199	179
MF Cetaceans	198	178
HF Cetaceans	173	153
PW Pinnipeds	201	181

Table 3 NMFS (2018) noise exposure criteria for non-impulsive noise

For the SEL_{cum} modelling a worst-case static animal models have been assumed, as per the modelling previously carried out at the Wylfa site. This assumes that the animal remains at a fixed distance from the noise source throughout, which in this case is a 24-hour period.

Weighted source levels

Table 4 presents the predicted NMFS (2018) weighted source levels used for modelling, in terms of single strike SELs (SEL_{ss}). These can be cross-referenced with the unweighted source levels given in the original modelling report.

Noise source	Predicted NMFS (2018) weighted source level (dB re 1 µPa²s @ 1 m) (SEL_{ss})			
	LF Cetacean	**MF Cetacean**	**HF Cetacean**	**Phocid Pinniped**
Rotary drilling (242 kW)	153.3	116.9	110.1	139.6
Rotary drilling (570 kW)	157.0	120.6	113.8	143.3
Percussive drilling	181.4	146.5	139.9	167.5
Cutter-suction dredging	171.7	150.2	144.7	163.4
Rock breaking (peckering)	183.2	154.8	148.7	173.6
Rock cutting	167.6	146.1	140.6	159.3
Large vessel movements	162.8	133.9	129.7	164.9
Medium vessel movements	155.0	126.1	121.9	157.1
All concurrent noise sources	185.9	156.5	150.6	174.7

Table 4 Summary of the predicted NMFS (2018) weighted source levels used for RAMSGeo modelling

Modelling outputs

The following sections present the noise modelling for construction noise relating to the Wylfa Newydd Generating Station using the NMFS (2018) criteria for marine mammals. As per the original report impact ranges have been presented along three transects. Details of these and all the parameters used for modelling can be found in the original modelling report.

Drilling

Table 5 to Table 10 present the impact ranges using the non-impulsive NMFS (2018) criteria for the various proposed drilling operations, assuming a stationary animal remaining in the vicinity over a 24-hour period. These include rotary drilling (Table 5 and Table 6), percussive drilling (Table 7), and scenarios where two drilling rigs are operating simultaneously (Table 8 to Table 10).

NMFS (2018) (Rotary drilling [242 kW])	**North East (038°)**	**North West (332°)**	**South West (156°)**
Range to PTS in Low Freq. Cetaceans 199 dB re 1 µPa²s Weighted SEL_{cum}	2 m	2 m	1 m
Range to PTS is Mid Freq. Cetaceans 198 dB re 1 µPa²s Weighted SEL_{cum}	< 1 m	< 1 m	< 1 m
Range to PTS in High Freq. Cetaceans 173 dB re 1 µPa²s Weighted SEL_{cum}	< 1 m	< 1 m	< 1 m
Range to PTS in Phocid Pinnipeds 201 dB re 1 µPa²s Weighted SEL_{cum}	< 1 m	< 1 m	< 1 m
Range to TTS in Low Freq. Cetaceans 179 dB re 1 µPa²s Weighted SEL_{cum}	20 m	20 m	28 m
Range to TTS is Mid Freq. Cetaceans 178 dB re 1 µPa²s Weighted SEL_{cum}	< 1 m	< 1 m	< 1 m
Range to TTS in High Freq. Cetaceans 153 dB re 1 µPa²s Weighted SEL_{cum}	4 m	4 m	2 m
Range to TTS in Phocid Pinnipeds 181 dB re 1 µPa²s Weighted SEL_{cum}	5 m	5 m	3 m

Table 5 Summary of the predicted weighted SEL_{cum} impact ranges from NMFS (2018) for non-impulsive sounds, based on noise from rotary drilling (242 kW) operations

NMFS (2018) (Rotary drilling [570 kW])	**North East (038°)**	**North West (332°)**	**South West (156°)**
Range to PTS in Low Freq. Cetaceans 199 dB re 1 µPa²s Weighted SEL_{cum}	4 m	4 m	3 m
Range to PTS is Mid Freq. Cetaceans 198 dB re 1 µPa²s Weighted SEL_{cum}	< 1 m	< 1 m	< 1 m
Range to PTS in High Freq. Cetaceans 173 dB re 1 µPa²s Weighted SEL_{cum}	< 1 m	< 1 m	< 1 m
Range to PTS in Phocid Pinnipeds 201 dB re 1 µPa²s Weighted SEL_{cum}	< 1 m	< 1 m	< 1 m
Range to TTS in Low Freq. Cetaceans 179 dB re 1 µPa²s Weighted SEL_{cum}	40 m	50 m	60 m
Range to TTS is Mid Freq. Cetaceans 178 dB re 1 µPa²s Weighted SEL_{cum}	< 1 m	< 1 m	< 1 m
Range to TTS in High Freq. Cetaceans 153 dB re 1 µPa²s Weighted SEL_{cum}	6 m	6 m	3 m
Range to TTS in Phocid Pinnipeds 181 dB re 1 µPa²s Weighted SEL_{cum}	7 m	7 m	5 m

Table 6 Summary of the predicted weighted SEL_{cum} impact ranges from NMFS (2018) for non-impulsive sounds, based on noise from rotary drilling (570 kW) operations

NMFS (2018) (Percussive drilling)	**North East (038°)**	**North West (332°)**	**South West (156°)**
Range to PTS in Low Freq. Cetaceans 199 dB re 1 µPa²s Weighted SEL_{cum}	100 m	110 m	120 m
Range to PTS is Mid Freq. Cetaceans 198 dB re 1 µPa²s Weighted SEL_{cum}	< 1 m	< 1 m	< 1 m
Range to PTS in High Freq. Cetaceans 173 dB re 1 µPa²s Weighted SEL_{cum}	9 m	9 m	8 m
Range to PTS in Phocid Pinnipeds 201 dB re 1 µPa²s Weighted SEL_{cum}	9 m	9 m	8 m
Range to TTS in Low Freq. Cetaceans 179 dB re 1 µPa²s Weighted SEL_{cum}	960 m	1.5 km	440 m
Range to TTS is Mid Freq. Cetaceans 178 dB re 1 µPa²s Weighted SEL_{cum}	10 m	10 m	10 m
Range to TTS in High Freq. Cetaceans 153 dB re 1 µPa²s Weighted SEL_{cum}	220 m	230 m	250 m
Range to TTS in Phocid Pinnipeds 181 dB re 1 µPa²s Weighted SEL_{cum}	190 m	230 m	240 m

Table 7 Summary of the predicted weighted SEL_{cum} impact ranges from NMFS (2018) for non-impulsive sounds, based on noise from percussive drilling operations

NMFS (2018) (2 rotary drilling rigs [242 kW])	**North East (038°)**	**North West (332°)**	**South West (156°)**
Range to PTS in Low Freq. Cetaceans 199 dB re 1 µPa²s Weighted SEL_{cum}	4 m	4 m	2 m
Range to PTS is Mid Freq. Cetaceans 198 dB re 1 µPa²s Weighted SEL_{cum}	< 1 m	< 1 m	< 1 m
Range to PTS in High Freq. Cetaceans 173 dB re 1 µPa²s Weighted SEL_{cum}	< 1 m	< 1 m	< 1 m
Range to PTS in Phocid Pinnipeds 201 dB re 1 µPa²s Weighted SEL_{cum}	< 1 m	< 1 m	< 1 m
Range to TTS in Low Freq. Cetaceans 179 dB re 1 µPa²s Weighted SEL_{cum}	40 m	40 m	51 m

Range to TTS is Mid Freq. Cetaceans 178 dB re 1 µPa²s Weighted SEL_{cum}	< 1 m	< 1 m	< 1 m
Range to TTS in High Freq. Cetaceans 153 dB re 1 µPa²s Weighted SEL_{cum}	5 m	5 m	3 m
Range to TTS in Phocid Pinnipeds 181 dB re 1 µPa²s Weighted SEL_{cum}	6 m	6 m	4 m

Table 8 Summary of the predicted weighted SEL_{cum} impact ranges from NMFS (2018) for non-impulsive sounds, based on noise from two rotary drilling rigs (242 kW) operating concurrently

NMFS (2018) (2 rotary drilling rigs [570 kW])	**North East (038°)**	**North West (332°)**	**South West (156°)**
Range to PTS in Low Freq. Cetaceans 199 dB re 1 µPa²s Weighted SEL_{cum}	6 m	6 m	4 m
Range to PTS is Mid Freq. Cetaceans 198 dB re 1 µPa²s Weighted SEL_{cum}	< 1 m	< 1 m	< 1 m
Range to PTS in High Freq. Cetaceans 173 dB re 1 µPa²s Weighted SEL_{cum}	< 1 m	< 1 m	< 1 m
Range to PTS in Phocid Pinnipeds 201 dB re 1 µPa²s Weighted SEL_{cum}	< 1 m	< 1 m	< 1 m
Range to TTS in Low Freq. Cetaceans 179 dB re 1 µPa²s Weighted SEL_{cum}	90 m	80 m	90 m
Range to TTS is Mid Freq. Cetaceans 178 dB re 1 µPa²s Weighted SEL_{cum}	< 1 m	< 1 m	< 1 m
Range to TTS in High Freq. Cetaceans 153 dB re 1 µPa²s Weighted SEL_{cum}	7 m	7 m	6 m
Range to TTS in Phocid Pinnipeds 181 dB re 1 µPa²s Weighted SEL_{cum}	8 m	8 m	7 m

Table 9 Summary of the predicted weighted SEL_{cum} impact ranges from NMFS (2018) for non-impulsive sounds, based on noise from two rotary drilling rigs (570 kW) operating concurrently

NMFS (2018) (2 percussive drilling rigs)	**North East (038°)**	**North West (332°)**	**South West (156°)**
Range to PTS in Low Freq. Cetaceans 199 dB re 1 µPa²s Weighted SEL_{cum}	190 m	180 m	210 m
Range to PTS is Mid Freq. Cetaceans 198 dB re 1 µPa²s Weighted SEL_{cum}	1 m	1 m	1 m
Range to PTS in High Freq. Cetaceans 173 dB re 1 µPa²s Weighted SEL_{cum}	10 m	10 m	10 m
Range to PTS in Phocid Pinnipeds 201 dB re 1 µPa²s Weighted SEL_{cum}	10 m	10 m	10 m
Range to TTS in Low Freq. Cetaceans 179 dB re 1 µPa²s Weighted SEL_{cum}	1.2 km	2.1 km	440 m
Range to TTS is Mid Freq. Cetaceans 178 dB re 1 µPa²s Weighted SEL_{cum}	10 m	10 m	20 m
Range to TTS in High Freq. Cetaceans 153 dB re 1 µPa²s Weighted SEL_{cum}	320 m	280 m	280 m
Range to TTS in Phocid Pinnipeds 181 dB re 1 µPa²s Weighted SEL_{cum}	320 m	280 m	280 m

Table 10 Summary of the predicted weighted SEL_{cum} impact ranges from NMFS (2018) for non-impulsive sounds, based on noise from two percussive drilling rigs operating concurrently

Cutter-suction dredging

Table 11 presents the impact ranges along the three calculated transects using the non-impulsive NMFS (2018) criteria for cutter-suction dredging noise, assuming a stationary animal over a 24-hour period.

NMFS (2018) (Cutter-suction dredging)	**North East (038°)**	**North West (332°)**	**South West (156°)**
Range to PTS in Low Freq. Cetaceans 199 dB re 1 µPa^{2}s Weighted SEL_{cum}	10 m	10 m	10 m
Range to PTS is Mid Freq. Cetaceans 198 dB re 1 µPa^{2}s Weighted SEL_{cum}	1 m	1 m	1 m
Range to PTS in High Freq. Cetaceans 173 dB re 1 µPa^{2}s Weighted SEL_{cum}	9 m	9 m	10 m
Range to PTS in Phocid Pinnipeds 201 dB re 1 µPa^{2}s Weighted SEL_{cum}	9 m	9 m	3 m
Range to TTS in Low Freq. Cetaceans 179 dB re 1 µPa^{2}s Weighted SEL_{cum}	270 m	270 m	280 m
Range to TTS is Mid Freq. Cetaceans 178 dB re 1 µPa^{2}s Weighted SEL_{cum}	5 m	5 m	10 m
Range to TTS in High Freq. Cetaceans 153 dB re 1 µPa^{2}s Weighted SEL_{cum}	240 m	250 m	260 m
Range to TTS in Phocid Pinnipeds 181 dB re 1 µPa^{2}s Weighted SEL_{cum}	40 m	40 m	70 m

Table 11 Summary of the predicted weighted SEL_{cum} impact ranges from NMFS (2018) for non-impulsive sounds, based on noise from cutter-suction dredging operations

Rock breaker / cutter

Table 12 to Table 14 present the impact ranges using the NMFS (2018) criteria for rock breaker (peckering) and rock cutting operations. Table 12 and Table 13 present the impulse criteria for SEL_{cum} and SPL_{peak} respectively. Table 14 presents the results for rock cutting operations. As with the other noise sources, all the SEL_{cum} criteria assume a stationary animal over a 24-hour period.

NMFS (2018) (impulse SEL_{cum}) (Rock breaking)	**North East (038°)**	**North West (332°)**	**South West (156°)**
Range to PTS in Low Freq. Cetaceans 183 dB re 1 µPa^{2}s Weighted SEL_{cum}	730 m	790 m	430 m
Range to PTS is Mid Freq. Cetaceans 185 dB re 1 µPa^{2}s Weighted SEL_{cum}	9 m	9 m	10 m
Range to PTS in High Freq. Cetaceans 155 dB re 1 µPa^{2}s Weighted SEL_{cum}	330 m	380 m	340 m
Range to PTS in Phocid Pinnipeds 185 dB re 1 µPa^{2}s Weighted SEL_{cum}	190 m	250 m	250 m
Range to TTS in Low Freq. Cetaceans 168 dB re 1 µPa^{2}s Weighted SEL_{cum}	4.3 km	9.9 km	440 m
Range to TTS is Mid Freq. Cetaceans 170 dB re 1 µPa^{2}s Weighted SEL_{cum}	110 m	100 m	120 m
Range to TTS in High Freq. Cetaceans 140 dB re 1 µPa^{2}s Weighted SEL_{cum}	1.2 km	3.3 km	440 m
Range to TTS in Phocid Pinnipeds 170 dB re 1 µPa^{2}s Weighted SEL_{cum}	830 m	1.1 km	440 m

Table 12 Summary of the predicted weighted SEL_{cum} impact ranges from NMFS (2018) for impulsive sounds, based on noise from rock breaking operations

NMFS (2018) (impulse SPL_{peak}) (Rock breaking)	**North East (038°)**	**North West (332°)**	**South West (156°)**
Range to PTS in Low Freq. Cetaceans 219 dB re 1 µPa Unweighted SPL_{peak}	< 1 m	< 1 m	< 1 m
Range to PTS is Mid Freq. Cetaceans	< 1 m	< 1 m	< 1 m

NMFS (2018) (impulse SPL_{peak}) (Rock breaking)	**North East (038°)**	**North West (332°)**	**South West (156°)**
230 dB re 1 µPa Unweighted SPL_{peak}			
Range to PTS in High Freq. Cetaceans 202 dB re 1 µPa Unweighted SPL_{peak}	4 m	4 m	2 m
Range to PTS in Phocid Pinnipeds 218 dB re 1 µPa Unweighted SPL_{peak}	< 1 m	< 1 m	< 1 m
Range to TTS in Low Freq. Cetaceans 213 dB re 1 µPa Unweighted SPL_{peak}	< 1 m	< 1 m	< 1 m
Range to TTS is Mid Freq. Cetaceans 224 dB re 1 µPa Unweighted SPL_{peak}	< 1 m	< 1 m	< 1 m
Range to TTS in High Freq. Cetaceans 196 dB re 1 µPa Unweighted SPL_{peak}	7 m	7 m	5 m
Range to TTS in Phocid Pinnipeds 212 dB re 1 µPa Unweighted SPL_{peak}	< 1 m	< 1 m	< 1 m

Table 13 Summary of the predicted unweighted SPL_{peak} impact ranges from NMFS (2018) for impulsive sounds, based on noise from rock breaking operations

NMFS (2018) (Rock cutting)	**North East (038°)**	**North West (332°)**	**South West (156°)**
Range to PTS in Low Freq. Cetaceans 199 dB re 1 µPa²s Weighted SEL_{cum}	8 m	8 m	6 m
Range to PTS is Mid Freq. Cetaceans 198 dB re 1 µPa²s Weighted SEL_{cum}	< 1 m	< 1 m	< 1 m
Range to PTS in High Freq. Cetaceans 173 dB re 1 µPa²s Weighted SEL_{cum}	7 m	7 m	5 m
Range to PTS in Phocid Pinnipeds 201 dB re 1 µPa²s Weighted SEL_{cum}	4 m	4 m	1 m
Range to TTS in Low Freq. Cetaceans 179 dB re 1 µPa²s Weighted SEL_{cum}	140 m	150 m	160 m
Range to TTS is Mid Freq. Cetaceans 178 dB re 1 µPa²s Weighted SEL_{cum}	8 m	8 m	6 m
Range to TTS in High Freq. Cetaceans 153 dB re 1 µPa²s Weighted SEL_{cum}	120 m	120 m	130 m
Range to TTS in Phocid Pinnipeds 181 dB re 1 µPa²s Weighted SEL_{cum}	20 m	20 m	40 m

Table 14 Summary of the predicted weighted SEL_{cum} impact ranges from NMFS (2018) for non-impulsive sounds, based on noise from rock cutting operations

Vessel noise

Noise from vessel movements have been calculated using a simple modelling approach rather than RAMSGeo; this is the same approach as used in the original report. The results for large and medium sized vessels are given in Table 15.

NMFS (2018) (Vessel movements)	**Large vessels**	**Medium vessels**
Range to PTS in Low Freq. Cetaceans 199 dB re 1 µPa²s Weighted SEL_{cum}	10 m	3 m
Range to PTS is Mid Freq. Cetaceans 198 dB re 1 µPa²s Weighted SEL_{cum}	< 1 m	< 1 m
Range to PTS in High Freq. Cetaceans 173 dB re 1 µPa²s Weighted SEL_{cum}	4	< 1 m
Range to PTS in Phocid Pinnipeds 201 dB re 1 µPa²s Weighted SEL_{cum}	< 1 m	< 1 m

NMFS (2018) (Vessel movements)	**Large vessels**	**Medium vessels**
Range to TTS in Low Freq. Cetaceans 179 dB re 1 µPa²s Weighted SEL_{cum}	480 m	130 m
Range to TTS is Mid Freq. Cetaceans 178 dB re 1 µPa²s Weighted SEL_{cum}	3 m	< 1 m
Range to TTS in High Freq. Cetaceans 153 dB re 1 µPa²s Weighted SEL_{cum}	140 m	30 m
Range to TTS in Phocid Pinnipeds 181 dB re 1 µPa²s Weighted SEL_{cum}	40 m	9 m

Table 15 Summary of the predicted weighted SEL_{cum} impact ranges from NMFS (2018) for non-impulsive sounds, based on noise from vessel movements

Concurrent noise sources

Table 16 presents the impact ranges using the NMFS (2018) criteria assuming that the rotary drilling (570 kW), percussive drilling, cutter-suction dredging, and rock breaking operations from the previous sections happen concurrently. It should be noted that this uses the non-impulsive criteria. Rock breaking (peckering) is the only impulsive source, as such the ranges in Table 12 and Table 13 can be used to apply in reference to these stricter thresholds.

NMFS (2018) (Concurrent noise sources)	**North East (038°)**	**North West (332°)**	**South West (156°)**
Range to PTS in Low Freq. Cetaceans 199 dB re 1 µPa²s Weighted SEL_{cum}	140 m	160 m	180 m
Range to PTS is Mid Freq. Cetaceans 198 dB re 1 µPa²s Weighted SEL_{cum}	2 m	3 m	2 m
Range to PTS in High Freq. Cetaceans 173 dB re 1 µPa²s Weighted SEL_{cum}	30 m	30 m	30 m
Range to PTS in Phocid Pinnipeds 201 dB re 1 µPa²s Weighted SEL_{cum}	20 m	20 m	20 m
Range to TTS in Low Freq. Cetaceans 179 dB re 1 µPa²s Weighted SEL_{cum}	920 m	1.8 km	360 m
Range to TTS is Mid Freq. Cetaceans 178 dB re 1 µPa²s Weighted SEL_{cum}	40 m	40 m	40 m
Range to TTS in High Freq. Cetaceans 153 dB re 1 µPa²s Weighted SEL_{cum}	610 m	660 m	330 m
Range to TTS in Phocid Pinnipeds 181 dB re 1 µPa²s Weighted SEL_{cum}	460 m	340 m	270 m

Table 16 Summary of the predicted weighted SEL_{cum} impact ranges from NMFS (2018) for non-impulsive sounds, based on the combined noise from noise from rotary drilling, percussive drilling, cutter-suction dredging, and rock breaking operations occurring simultaneously