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Morgan Underwater Sound Abatement Investigation: Fish

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MORGAN OFFSHORE WIND PROJECT: GENERATION ASSETS

Underwater Sound Abatement Modelling: Fish Receptors

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Image of an offshore wind farm

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Glossary

Term	Meaning
Applicant	Morgan Offshore Wind Limited.
Development Consent Order (DCO)	An order made under the Planning Act 2008 granting development consent for one or more Nationally Significant Infrastructure Project (NSIP).
Morgan Offshore Wind Project	The Morgan Offshore Wind Project is comprised of the generation assets and associated activities.
The Planning Inspectorate	The agency responsible for operating the planning process for Nationally Significant Infrastructure Projects.

Acronyms

Acronym	Description
DBBC	Double Big Bubble Curtain
MNRU	Menck Noise Reduction Unit
SEL_{cum}	Cumulative Sound Exposure Level
SEL_{ss}	Single Strike Sound Exposure Level
SPL_{pk}	Peak Sound Pressure Level
TTS	Temporary Threshold Shift
UWSMS	Underwater Sound Management Strategy

Units

Unit	Description
%	Percentage
dB	Decibel
kJ	Kilojoule
m	Metre
μPa	Micropascal

1 INTRODUCTION

1.1.1.1 This document has been prepared in response to the Marine Management Organisation's (MMO) outstanding concerns relating to piling during sensitive periods for fish (i.e. herring and cod) and the use of Noise Abatement Systems (NAS) as mitigation to avoid significant effects on these species (Paragraph 3.6.11 and 3.6.13 in REP5-056)). Specifically, the MMO considers it appropriate for seasonal piling restrictions to be on the face of the DCO in case they are needed to mitigate the potential underwater sound impacts on spawning herring and cod populations within the vicinity of the Morgan Offshore Wind Project: Generation Assets. The Applicant position is that inclusion of seasonal piling restrictions on the face of the DCO is not necessary as the Underwater Sound Management Strategy (UWSMS; REP5-025) provides the appropriate post consent compliance control document/mechanism through which necessary mitigation (if required to avoid significant effects) will be confirmed. The Applicant considers that this is now further enhanced by its commitment to the adherence to the Defra Reducing Marine Noise policy[1], which has specifically been brought forward to ensure significant effects on marine mammal and commercially important fish receptors are avoided. The MMO have stated that they are unable to agree to the Applicant's position without further evidence of a significant reduction in impact on these fish spawning habitats through the use of NAS.

1.1.1.2 The aim of this report is to provide to the MMO evidence of the effectiveness of NAS as a mitigation measure and this corroborates the evidence presented in the Cefas guidance 'Evidence on the efficacy of underwater noise abatement'[2] published in 2024 to support the Defra policy and SNCB Joint Position statements. Indicative scenarios for both unmitigated piling and piling mitigated through the use of NAS for the construction of the Morgan Offshore Wind Project: Generation Assets are presented in relation to agreed fish mortality, potential auditory injury (Temporary Threshold Shift (TTS)) thresholds and behavioural disturbance contours.

1.1.1.3 **Note:** The presented scenarios are indicative only (in a similar vein to the extant underwater noise modelling for piling as presented in the Environmental Statement, e.g. Volume 2, Chapter 3: Fish and Shellfish Ecology; APP-021). The finalised piling programme, including mitigation strategy (which will include NAS), will be presented for consideration and agreement with all relevant stakeholders post-consent within the final UWSMS, to be signed off by the MMO.

[1] https://www.gov.uk/government/publications/reducing-marine-noise/reducing-marine-noise.

[2] Evidence on the efficacy of underwater noise abatement.

2 SCENARIOS MODELLED

2.1.1.1 Site specific underwater noise modelling was undertaken at the westernmost location within the Morgan Offshore Wind Project: Generation Assets (see Figure 3.1). This location was selected due to proximity to both the mapped herring (Coull *et al*., 1998) and cod spawning grounds (Ellis *et al*., 2012), with the proximity of herring spawning grounds considered a key risk for the Morgan Offshore Wind Project. The following overarching scenarios were modelled on a 5.5 m diameter pile[3]:

- Case 0: which represents piling at the west location with no additional mitigation;
- Case 1: which represents piling at the west location with the use of hammer supplier sound reduction unit (i.e. Menck Noise Reduction Unit (MNRU)) but no far field sound mitigation systems added; and
- Case 2: which represents piling at the west location with the use of hammer supplier sound reduction unit (e.g. MNRU) plus far field sound mitigation systems in the form of a double big bubble curtain (DBBC) added.

2.1.1.2 For these scenarios, two hammer energies were used for each case; a maximum hammer energy of 4,400 kJ and a reduced hammer energy of 3,000 kJ (expected to be the maximum hammer energy used at the majority of locations).

2.1.1.3 Cases modelled are detailed in Table 2.1, with these scenarios used model impact ranges or mortality, injury and behavioural disturbance, to demonstrate the effectiveness of NAS as mitigation for impacts on fish spawning habitats. These scenarios were modelled using similar conservative assumptions used within the maximum design scenario for the Morgan Offshore Wind Project: Generation Assets, including location of piling relative to sensitive habitats, maximum hammer energy used. This is unlikely to be in the case during construction due to the refinement of the project maximum design scenario as the project is further developed (e.g. reduction in hammer energies used, maximum number of piling events etc.) along with mitigation measures applicable to fish spawning habitats which will be developed as part of the UWSMS (e.g. spatial and temporal considerations such as avoiding piling in the west of the array area during the herring spawning season). As such, the scenarios presented here are expected to be conservative with respect to effects on fish spawning habitats. Thereby giving the MMO comfort that there is no conservative requirement to have seasonal restrictions on the face of the DCO.

2.1.1.4 As set out in section 1 above, the presented scenarios are indicative only to demonstrate that NAS (based on current technologies) are effective. The precise NAS to be employed on the project will be set out in the final UWSMS, alongside project design refinements, which will be discussed and agreed with stakeholders post consent.

[3] While these pile diameters are greater than the scenario considered in Table 3.18 of Volume 2, Chapter 3: Fish and Shellfish Ecology (APP-021), for underwater noise effects, this scenario is within the maximum design scenario assessed (i.e. the noise levels associated with this scenario are lower than the maximum design scenario, but are comparable for the purposes of this exercise).

Table 2.1: Summary of modelling scenarios for fish injury and mortality, and behavioural disturbance.

Case	Scenario description	Hammer energy	Pile diameters
0a	Unmitigated case with the maximum driving energy.	Menck 4,400 kJ	5.5 m
1a	Use of hammer supplier noise reduction unit (MNRU) but no far field sound mitigation systems added, at maximum hammer energy.	Menck 4,400 kJ	5.5 m
2a	Use of hammer supplier MNRU and far field sound mitigation systems (DBBC) added, at maximum hammer energy.	Menck 4,400 kJ	5.5 m
0b	Unmitigated case with reduced driving energy.	Menck 3,000 kJ	5.5 m
1b	Use of MNRU but no far field sound mitigation systems added, for reduced hammer energy.	Menck 3,000 kJ	5.5 m
2b	Use of hammer supplier MNRU and far field sound mitigation systems (DBBC) added, at reduced hammer energy.	Menck 3,000 kJ	5.5 m

Mortality, Injury, and Behavioural Thresholds

2.1.1.5 Sound source and propagation modelling was carried out to determine distances at which predicted sound levels will decrease to below recognised threshold criteria for mortality, recoverable injury and TTS on any fish receptors which might experience such sound emissions. The auditory injury threshold criteria proposed by Popper *et al*. (2014) are outlined in Table 2.2. Both herring and cod are fish in which hearing involves a swim bladder or other gas volume.

Table 2.2: Criteria for onset of injury to fish due to impulsive piling (Popper *et al.*, 2014).

[a] Relative risk (high, moderate, low) is given for animals at three distances from the source defined in relative terms as near field (i.e. 10s of metres), intermediate (i.e. 100s of metres), and far field (i.e. 1000s of metres); Popper *et al*. (2014).

Type of animal	Parameter	Mortality and potential mortal injury	Recoverable injury	TTS
Fish with no swim bladder or other gas chamber (particle motion detection)	SEL, dB re 1 μPa²s	>219	>216	186
	Peak, dB re 1 μPa	>213	>213	-
Fish with swim bladder in which hearing does not involve the swim bladder or other gas volume (particle motion detection)	SEL, dB re 1 μPa²s	210	203	186
	Peak, dB re 1 μPa	>207	>207	-

Type of animal	Parameter	Mortality and potential mortal injury	Recoverable injury	TTS
Fish in which hearing involves a swim bladder or other gas volume (primarily pressure detection)	SEL, dB re 1 $\mu Pa^2 s$	207	203	186
	Peak, dB re 1 μPa	>207	>207	-
Eggs and larvae	SEL, dB re 1 $\mu Pa^2 s$	>210	(*Near*) Moderate[a] (*Intermediate*) Low (*Far*) Low	-
	Peak, dB re 1 μPa	>207		-

2.1.1.6 Sound source and propagation modelling was also carried out with regard to behavioural impact thresholds using an approach consistent with that taken in Volume 2, Chapter 3: Fish and Shellfish Ecology (APP-021).

2.1.1.7 For herring, in line with the precautionary approach applied for the Environmental Statement, and as recommended by stakeholders during Expert Working Group meetings, a precautionary threshold of 135 dB re 1$\mu Pa^2 s$ SEL_{ss} has been used to investigate the potential risk of noise impacts on spawning behaviour (Hawkins *et al*., 2014) and to demonstrate the effectiveness of NAS as mitigation for this species. As set out in paragraph 3.9.3.50 of Volume 2, Chapter 3: Fish and Shellfish Ecology (APP-021), the Applicant position is that this threshold is considered to be precautionary and overestimates the actual risk of behavioural effects on herring spawning, however this has been used in this paper to demonstrate effectiveness of NAS on this species.

2.1.1.8 Specific behavioural effects contours have not been presented for cod in this paper, although the results presented in section 3 below for injury and TTS (alongside herring spawning maps) demonstrate the effectiveness of NAS for this species also (i.e. reductions in the range of effect).

3 RESULTS

3.1.1 Mortality, Recoverable Injury, and TTS

3.1.1.1 Table 3.1 presents indicative mortality, recoverable injury and TTS ranges for static receptors for the groups of fish identified by Popper *et al*. (2014) potentially impacted from piling of a 5.5 m pile at the maximum hammer energy of 4,400 kJ for three scenarios (cases 0a, 1a and 2a; see Table 2.1). Table 3.2 presents the same information, although for the reduced hammer energy of 3,000 kJ for three scenarios (cases 0b, 1b and 2b; see Table 2.1).

Mortality

3.1.1.2 When comparing mortality ranges for static fish receptors between cases 0a, 1a and 2a (maximum hammer energy of 4,400 kJ) impact ranges were reduced from 343 m (fish with no swim bladder) to 2,130 m (fish which use their swim bladders in hearing) for an unmitigated piling scenario (case 0a), to 116 m to 585 m with the implementation of the MNRU (case 1a) and reduced to ranges of 116 m to a maximum of 150 m with the inclusion of the MNRU and DBBC mitigation (case 2a; Table 3.1).

3.1.1.3 Similar reductions in impact ranges were demonstrated for the reduced hammer energy of 3,000 kJ (Table 3.2), with maximum injury ranges reducing from up to 1,680 m for the unmitigated piling scenario (case 0b) to <150 m with implementation of both the MNRU and DBBC (case 2b).

Recoverable injury

3.1.1.4 Similarly to mortality, when comparing recoverable injury ranges for static fish receptors between cases 0a, 1a and 2a (maximum hammer energy of 4,400 kJ; refer to Table 2.1), impact ranges were reduced from 541 m to 3,780 m for the unmitigated piling scenario (case 0a) to a maximum of 150 m for all fish groups for piling with both the MNRU and DBBC mitigation (case 2a). Mitigation of the MNRU only (case 1a) also resulted in significant reductions in injury ranges for all species (i.e. ranges of approximately one third of the unmitigated scenario; Table 3.1).

3.1.1.5 Similar reductions in impact ranges were demonstrated for the reduced hammer energy of 3,000 kJ (Table 3.2), with maximum injury ranges reducing from up to 2,980 m for the unmitigated piling scenario (case 0b) to <150 m with implementation of both the MNRU and DBBC (case 2b) and significant reductions also predicted with the implementation of the MNRU also (i.e. recoverable injury ranges of a maximum of 800 m).

TTS

3.1.1.6 When comparing TTS ranges for static fish receptors between cases 0a, 1a and 2a (maximum hammer energy of 4,400 kJ; refer to Table 2.1), these ranged from 23,800 m for unmitigated piling (case 0a) for all fish receptor groups, reducing to 980 m for piling with both the MNRU and DBBC implemented (case 2a). With mitigation by the MNRU alone (case 1a), the TTS range were reduced to 7,900 m from the piling location (Table 3.1).

3.1.1.7 For the reduced hammer energy of 3,000 kJ, TTS ranges for static fish receptors ranged from 20,800 m for all fish receptor groups for unmitigated piling (case 0b) with implementation of both the MNRU and DBBC reducing this range to 795 m (case 2b) and 6,600 m for the MNRU alone.

Table 3.1: Modelled mortality, recoverable injury and TTS ranges (SEL_{cum}) for static fish receptors for the maximum hammer energy of 4,400 kJ for a 5.5 m pile.

N/A = not applicable.

For Case 2a, please note that 150 means less than the bubble curtain radius.

Case	Scenario	Injury Level	Range (m)			
			No swim bladder (Group 1)	Swim bladder not used in hearing (Group 2)	Swim bladder used in hearing (Groups 3 and 4)	Eggs and Larvae
0a	5.5m diameter Menck 4,400 kJ, unmitigated	Mortality	343	1,360	2,130	1,360
		Recoverable Injury	541	3,780	3,780	N/A
		TTS	23,800	23,800	23,800	N/A
1a	5.5m diameter Menck 4,400 kJ, MNRU	Mortality	116	393	585	393
		Recoverable Injury	174	1,000	1,000	N/A
		TTS	7,900	7,900	7,900	N/A
2a	5.5m diameter Menck 4,400 kJ, MNRU and DBBC	Mortality	116	150	150	150
		Recoverable Injury	150	150	150	N/A
		TTS	980	980	980	N/A

Table 3.2: Modelled mortality, recoverable injury and TTS ranges (SEL_{cum}) for static fish receptors for a reduced hammer energy of 3,000 kJ, for a 5.5 m pile.

N/A = not applicable.

For Case 2b, please note that 150 means less than the bubble curtain radius.

Case	Scenario	Injury Level	Range (m)			
			No swim bladder (Group 1)	Swim bladder not used in hearing (Group 2)	Swim bladder used in hearing (Groups 3 and 4)	Eggs and Larvae
0b	5.5m diameter Menck 3,000 kJ, unmitigated	Mortality	261	1,065	1,680	1,065
		Recoverable Injury	423	2,980	2,980	N/A
		TTS	20,800	20,800	20,800	N/A
1b	5.5m diameter Menck 3,000 kJ, MNRU	Mortality	92	311	471	311
		Recoverable Injury	138	800	800	N/A
		TTS	6,600	6,600	6,600	N/A
2b	5.5m diameter Menck 3,000 kJ, MNRU and DBBC	Mortality	92	150	150	150
		Recoverable Injury	138	150	150	N/A
		TTS	795	795	795	N/A

3.2 Behavioural Disturbance

3.2.1.1 Figure 3.1 presents underwater sound contours using the SEL_{ss} metric for a 5.5 m pin pile with the maximum hammer energy of 4,400 kJ for cases 0a, 1a and 2a (refer to Table 2.1) alongside mapped herring spawning grounds derived from Coull *et al.* (1998). The 135 dB re 1µPa^{2}s SEL_{ss} behavioural disturbance threshold contour (defined in section 2) is highlighted in red (noting that this contour is expected to be a conservative threshold for behavioural effects; see paragraph 2.1.1.7).

3.2.1.2 When comparing modelled contours using the SEL_{ss} metric against mapped herring spawning grounds and between cases 0a, 1a and 2a (maximum Menck hammer energy of 4,400 kJ; refer to Table 2.1), the noise contours show a significant decrease with increased mitigation measures applied (Figure 3.1).

3.2.1.3 When considering unmitigated piling at the worst case location within the array area for herring, the 135 dB re 1µPa^{2}s SEL_{ss} contour is modelled to overlap with approximately 27% of the mapped high intensity herring spawning ground and approximately 57% of mapped low intensity mapped herring spawning ground at Douglas Bank (as derived from Coull *et al*., 1998). When the MNRU is applied the degree of overlap with mapped high intensity herring spawning grounds are largely unchanged (see Figure 3.1) while the proportion of mapped low intensity herring spawning ground within this noise contour was considerably reduced to 42%. When both the MNRU and DBBC mitigation measures were applied, modelling showed no overlap between the 135 dB re 1µPa^{2}s SEL_{ss} contour and the mapped high intensity herring spawning grounds, and <1% overlap between the contour and the low intensity herring spawning grounds. Therefore, for any other location in the array there will be no overlap with these grounds.

3.2.1.4 Figure 3.2 presents underwater sound contours using the SEL_{ss} metric for a 5.5 m pin pile with the reduced hammer energy of 3,000 kJ for cases 0b, 1b and 2b (refer to Table 2.1) alongside mapped herring spawning grounds derived from Coull *et al.* (1998).

3.2.1.5 In line with the 4,400 kJ hammer energy scenario, this scenario also showed considerable reductions in the proportion of herring spawning habitats within the relevant noise contours. For unmitigated piling the 135 dB re 1µPa^{2}s SEL_{ss} contour is modelled to overlap with 27% of the mapped high intensity herring spawning ground and 55% of mapped low intensity mapped herring spawning ground at Douglas Bank (from Coull *et al*., 1998). As demonstrated in Figure 3.2, with the MNRU mitigation measures applied, there is no reduction in the overlap with the high intensity spawning habitats, despite the significant reduction in total area of disturbance, due to the modelled piling location in the western extent of the array area (i.e. piling at locations further east in the array area would result in significant reductions in the high intensity spawning habitats affected with the MNRU). The MNRU results do clearly demonstrate an overall reduction in the area affected with reduced overlap of approximately 30% of low intensity herring spawning habitat. The combined MNRU and DBBC results in no overlap with the high intensity spawning habitat and <1% overlap with the low intensity spawning habitat. Therefore, for any other location in the array there will be no overlap with these grounds.

3.2.1.6 While contours have not been presented for cod spawning, the same level of significant reductions in noise levels (and consequent reduced effects on spawning habitats) would be expected for cod spawning habitats. For example, the TTS ranges presented in Table 3.1 and Table 3.2, demonstrate that impact ranges are reduced by over 65% (MNRU only) and over 90% (MNRU and DBBC) from an unmitigated scenario.

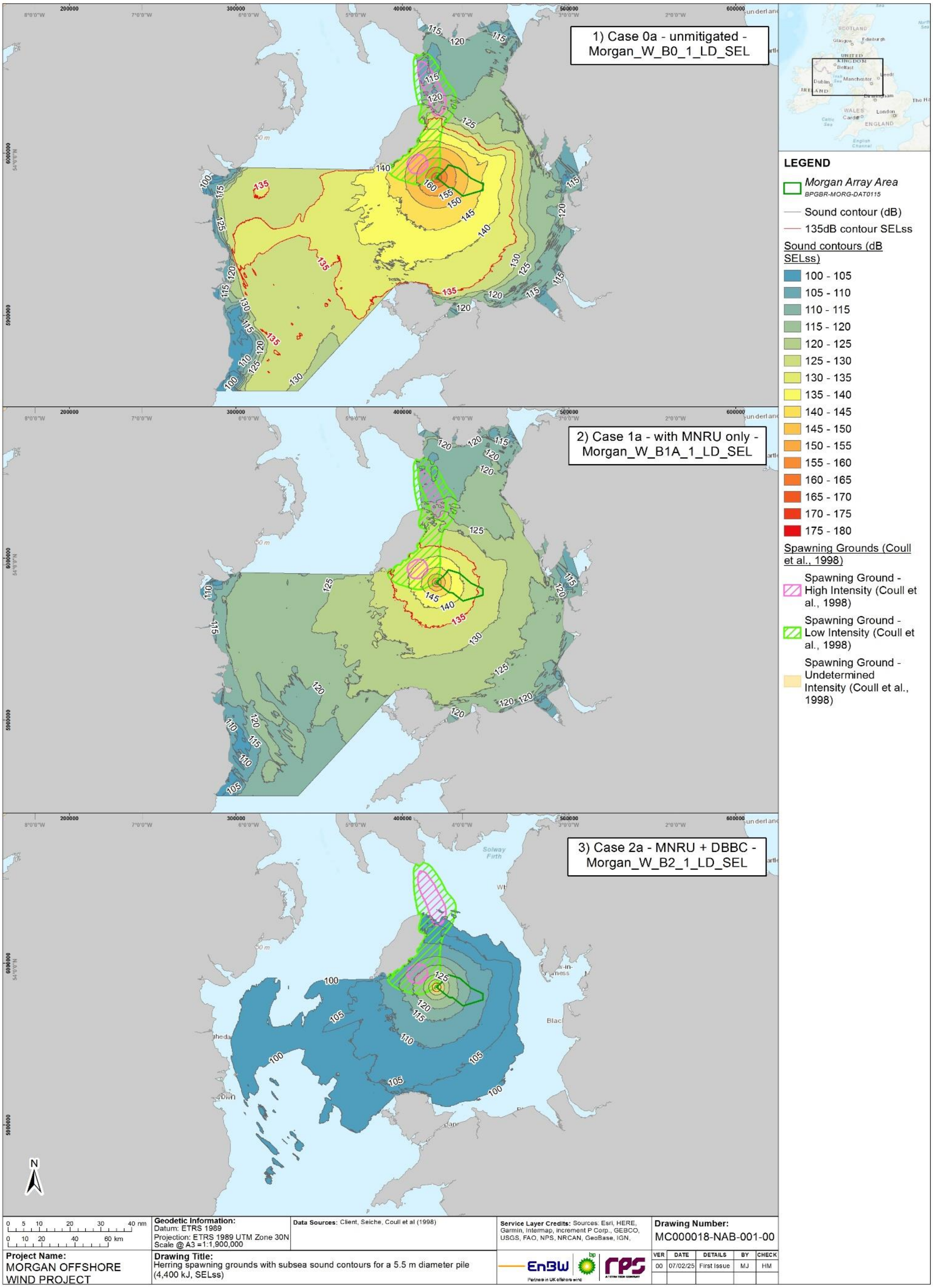

Figure 3.1: Herring spawning grounds with subsea sound contours for a 5.5 m diameter pile (Menck, 4,400 kJ, SEL$_{ss}$).

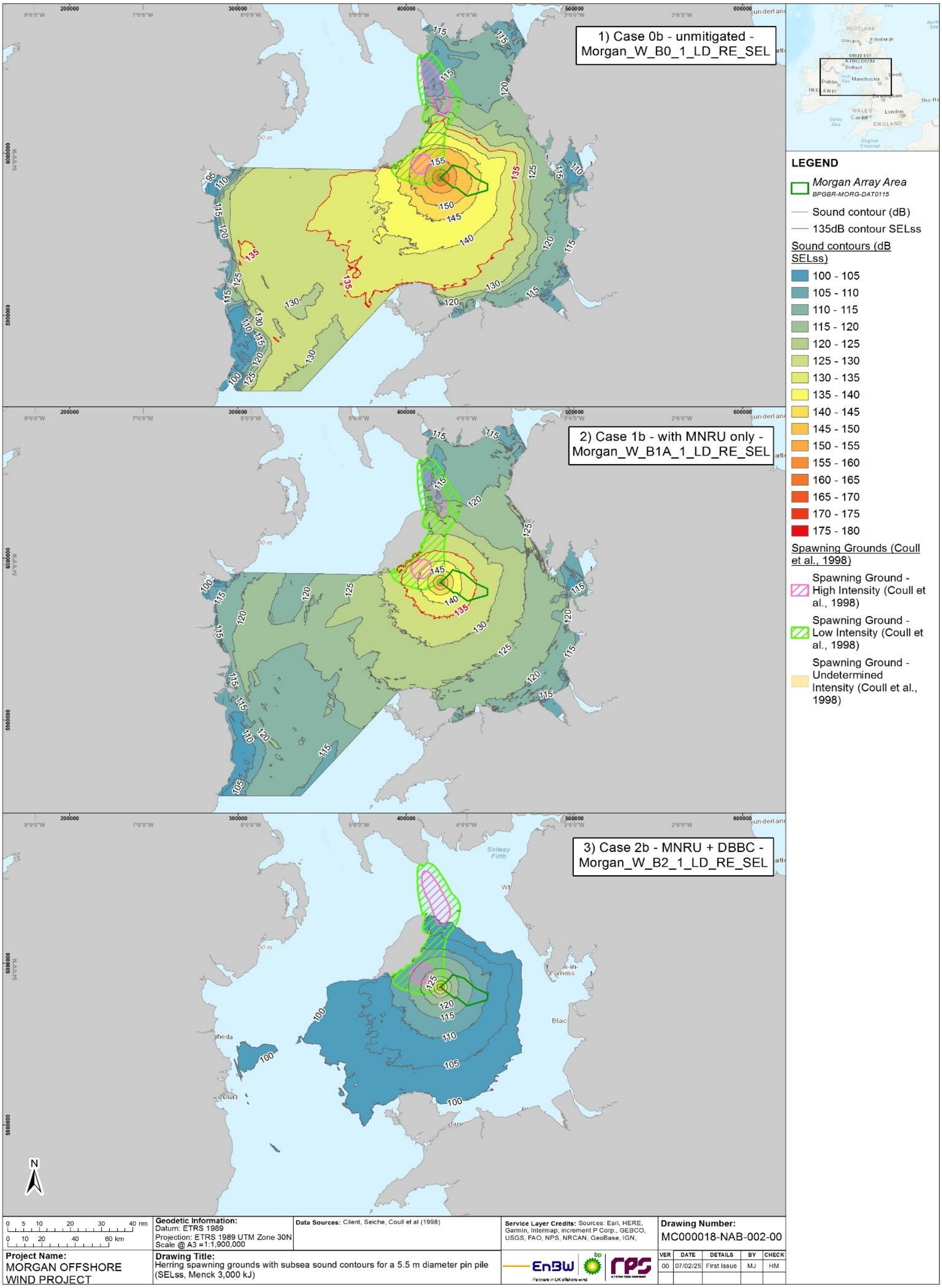

Figure 3.2 Herring spawning grounds with subsea sound contours for a 5.5 m diameter pin pile (SELss, Menck 3,000 kJ)

4 CONCLUSION

4.1.1.1 For mortality, recoverable injury, TTS, and behavioural disturbance, the evidence presented in section 3 for the relevant scenarios clearly demonstrates that existing NAS technology will be effective at reducing the impacts on herring and cod spawning grounds and populations such that effects will not be significant. As stated in section 2, the modelling assumptions and the behavioural impact threshold for herring are considered to be conservative (e.g. based on the modelled piling location at the closest point to herring spawning grounds and the precautionary metric used to consider behavioural responses). While this means that the indicative scenarios likely represent an overestimate of the potential impact on herring spawning grounds, this also demonstrates that NAS is effective even in this conservative scenario. This note demonstrates that both of the indicative NAS technologies modelled are highly effective at reducing noise levels to avoid significant effects on fish spawning populations (noting that while DBBC was not modelled on its own, the modelling clearly demonstrated the effectiveness of DBBC at reducing noise levels and therefore if this was deployed alone it would also be an effective measures to mitigate effects on fish species). When combined with the other measures set out in the UWSMS, there can be a high degree of certainty that significant effects on fish spawning habitats will be achievable, e.g. use of a MNRU in the eastern half of the array area during the herring spawning period would be expected to result in no overlap with high intensity herring spawning grounds.

4.1.1.2 The information provided within this note demonstrates significant reductions in noise levels associated with indicative NAS scenarios on fish populations and therefore this justifies the removal of the seasonal piling restrictions from the DCO.

4.1.1.3 The Applicant is committed to reducing effects during herring and cod spawning seasons via the UWSMS which secures the commitment to the use of NAS. As set out in section 1 above, the presented scenarios are therefore indicative only to demonstrate that NAS (based on current technologies) are effective. The precise NAS to be employed on the project will be set out in the final UWSMS, alongside project design refinements, which will be discussed and agreed with stakeholders post consent. In addition to providing the required evidence to remove the need for a seasonal piling restriction on the face of the DCO, this note also provides an outline of how the relevant evidence of effectiveness of mitigation measures will be provided to stakeholders (e.g. in the form of modelling, tables comparing impact ranges and noise contours relative to fish spawning habitats) which will be developed in consultation with stakeholders. The UWSMS requires approval from MMO before construction can commence. Therefore, with the commitment to complying with the Defra policy, the precautionary and the robust evidence based analysis of the effectiveness of NAS, there is no requirement for a seasonal restriction on the face of the DCO.

5 REFERENCES

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