innogy

Sofia Offshore Wind Farm

Appendix C: Environmental Appraisal of Increased Hammer Energy Addendum: Assessment of fish receptors

June 2018

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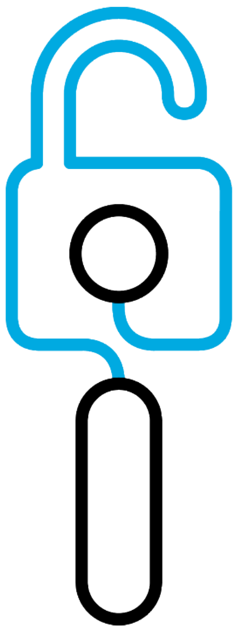

Contents

1 Introduction

This document represents Appendix C to the Environmental Appraisal of Increased Hammer Energy (Innogy, 2018. EcoDoc Ref; 002636963-03), and has been produced in response to comments received from the Marine Management Organisation (MMO). More specifically, this Appendix considers the potential impacts of increasing the maximum hammer energy to 5,500 kJ for monopole foundation installation on fish and shellfish receptors, and it is these impacts that will be further examined in this report.

2 Sofia Offshore Wind Farm

Sofia offshore wind farm (Sofia) (formally Teesside B) forms one of four consented projects within the Dogger Bank Zone. The Dogger Bank Zone comprises an area of 8,660km^2, located in the North Sea between 125km and 290km off the coast of Yorkshire. In August 2017 Innogy, previously one of four partners in the Forewind consortium, which obtained consent for the project, secured 100% ownership of the project.

The Development Consent Order (DCO) (SI 2015 No. 1592) (the "Order") for Sofia was granted on the 4th August 2015 and came into effect on 26th August 2015.

Sofia has consent for up to 200 wind turbines and the installed capacity of each turbine will be between 6MW and 10MW (to a total installed capacity of 1.2GW). The export cable will reach landfall along the Teesside coastline between Redcar and Marske-by-the-Sea. Offshore construction of the project may commence at the earliest from 2020 and therefore, this assumption has applied within the in-combination assessment. It is noted that this date is subject to change based on programme optimisation and the award of a Contract for Difference (CfD).

Piling (also referred to as percussive piling or impact piling) is permitted under the existing DCO for the installation of the foundations for the wind turbine generators (WTGs), however, as a result of engineering refinement and project optimisation, Innogy is seeking to make non-material variations to the consented parameters with regard to an increase in hammer energy in order to ensure successful monopole foundation installation. This document has therefore been prepared as an addendum to the Environmental Appraisal of Increased Hammer Energy (Innogy, 2018) in support of an application for non-material amendments to the Order pursuant to section 153 and schedule 6 of the Planning Act 2008 and for variations of the Deemed Marine Licences (dML) pursuant to section 72(3) of the Marine and Coastal Access Act 2009. The requirement for a non-material amendment to the DCO for Sofia is considered to be required since the maximum hammer energy permitted during construction is specified in the DCO requirements and dML conditions. This document examines the specific impacts of bringing forward the increase in hammer energy for monopole installation on fish and shellfish receptors.

3 Worst Case Scenario

3.1 Assumptions Made Within the ES

The worst case scenario for the potential effects from underwater noise during the construction phase on fish and shellfish receptors as detailed in Chapter 13 (Fish and Shellfish Ecology) of the ES (as detailed in Table 5.2 of the ES chapter) may be summarised as follows:

- 200 x 6 pin pile foundations (3.5m pin piles; jacket foundations for WTGs; 1,200 piles) at maximum 2,300 kJ hammer energy;
- 5 x 4 pin pile foundations (3.5m diameter pin piles, jacket foundation for met masts; 20 piles) at maximum 1,900 kJ hammer energy;
- 4 x 24 pin pile foundations (2.75m diameter pin piles, jacket foundation for Offshore Collector Platform; 96 piles) at maximum 1,900 kJ hammer energy;

- 1 x 24 pin pile foundations (2.75m diameter pin piles, jacket foundation for Offshore Converter Platform; 24 piles);
- 2 x 24 pin pile foundations (2.75m diameter pin piles, jacket foundation for Accommodation platform; 48 piles) at maximum 1,900 kJ hammer energy;
- Maximum of 2 simultaneous piling operations; and
- Maximum duration of piling (including soft starts) based on the above, was concluded to be approximately 202 days for the installation of pin pile foundations.

It is key to note that whilst monopole foundations had a maximum hammer energy of 3,000 kJ (and therefore, greater noise propagation range to the 2,300 kJ maximum hammer energy from the pin pile foundations), the pin pile foundation construction scenario was deemed to represent the "worst case" scenario for the effects on fish and shellfish receptors from percussive piling. The justification for this being that the increased duration of noise exposure was more important (in defining worst case) than maximum range of exposure to noise.

This point was agreed to by the MMO and its advisors as evidenced by the Statement of Common Ground (SoCG) between Forewind (the Applicant) and the MMO during the examination of the Project: 5-D-1 "The worst case scenario as defined in Table 5.1. (ref 6.13) is appropriate for the EIA"[1].

3.2 Assumptions Made Within the Increased Hammer Energy Report

The Non-Material Change (NMC) application and supporting documentation makes clear that the increase in hammer energy will only apply to monopole foundations. For pin pile foundations, 2,300 kJ will remain the maximum hammer energy. Within the NMC application the Environmental Appraisal of Increased Hammer Energy Report (Innogy, 2018) Sofia Offshore Wind Ltd (SOWL) therefore, did not seek to revisit the ES assumptions with regard to worst case scenario for underwater noise effects on fish, especially given the agreements reached on this assumption with the key stakeholders during the examination phase. Therefore, whilst the Increased Hammer Energy report made reference to fish and shellfish being a sensitive receptor, no new assessment was undertaken, and the assessment and conclusions presented within the original ES were considered to remain valid for these receptors.

3.3 Consultation on the Increased Hammer Energy Report

Following a review of the Increased Hammer Energy Report the MMO raised a number of comments (within the letter from Laura Opel dated 20 April 2018, Doc Ref DCO/2013/00011), one of which has direct relevance to the fish and shellfish worst case assumptions:

"*It is stated in section 6.1 that "the intention of this environmental appraisal is to evaluate the potential impact associated with an increase in maximum hammer energy for monopole foundations only. As the environmental statement (ES) has identified the worst case for fish and shellfish as being temporal and therefore derived from pin pile foundations, fish and shellfish are not assessed any further as the proposed increase in hammer energy is only relevant for monopole foundation installation". It is the MMOs opinion, that an assessment of impacts from the increase in hammer energy for fish and shellfish should be included in the report*"

SOWL has paid due regard to this comment, and whilst it stands by the original conclusion drawn within the Increased Hammer Energy Report (that the worst case assumptions made in the ES remain valid), further context is provided within this Addendum note to address the MMO's query. It is important to note that in doing so, SOWL does not consider it appropriate to present an entirely new assessment on fish and shellfish resource, as to do so would undermine the existing assessment and agreements. Rather, the aim of this note is to establish whether there would be any significant increase in noise propagation ranges from the monopole scenario at 5,500 kJ maximum hammer energy that would result in a change in the worst case assumptions made within the ES or not.

[1] https://infrastructure.planninginspectorate.gov.uk/wp-content/ipc/uploads/projects/EN010051/EN010051-001322-Forewind%20-%20SocG%20with%20MMO.pdf

The following sections therefore, consider the noise modelling outputs from the ES with regard to fish and shellfish resource, and then updated outputs from the 5,500 kJ modelling to enable a comparison to be made, noting that modelling techniques and threshold criteria are not directly like for like (as detailed below).

4 ES Assessment

4.1 Original Noise Modelling

In order to assess the impacts of underwater noise on fish and shellfish receptors during the construction phase, the National Physics Laboratory (NPL) used the Energy Flux model (Weston 1976). Twenty-seven locations were modelled across the Sofia site, and for each location pile driving noise was modelled for a hammer operating at up to 2,300 kJ for pin pile installation and a hammer of up to 3,000 kJ for monopoles.

Due to the limited data on the hearing capabilities of specific species of fish, generic criteria were used to model the ranges at which injury and behavioural effects were likely to occur, and species were divided into pelagic and demersal fish. The model utilised the criteria outlined by Popper et al. (2006) and Carlson et al. (2007) for injury in species of fish; and McCauley et al. (2000) and Pearson et al. (1992) for behavioural response in fish. The corresponding ranges modelled for each impact criterion are detailed in Table 4.1.

Impact Criterion		Potential Range of Impact		
		1,900 kJ Hammer Energy	2,300 kJ Hammer Energy	3,000 kJ Hammer Energy
Instantaneous injury/PTS (peak pressure level 206dB re 1µPa)	Pelagic Species	<200 m	<200 m	<250 m
	Demersal Species	<200 m	<200 m	<250 m
Startle response (peak pressure level 200dB dB re 1µPa)	Pelagic Species	~400 m	<500 m	<600 m
	Demersal Species	<400 m	<500 m	<600 m
Possible avoidance of area[2](peak pressure level 168 - 173dB re 1µPa)	Pelagic Species	8.5 – 18.5 km	~9.5 – 19.5 km	~10.0 – 21.0 km
	Demersal Species	11.0 – 26.5 km	7.5 – 15.5 km	8.0 – 17.5 km

Table 4.1 Summary of impact range for hearing sensitive pelagic (mid-water) and demersal (near or on the seabed) fish using the criteria Popper et al. (2006) and Carlson et al. (2007) for injury in species of fish; and McCauley et al. (2000) and Pearson et al. (1992) for behavioural response in fish (Forewind 2014b)

4.2 Impacts on Fish and Shellfish

Based on the ranges produced by the NPL model, the worst case piling assumptions (based around timing, duration, and number of events), and the baseline information informing the sensitivity of receptors, the ES concluded that the impacts of underwater noise on all fish and shellfish receptors were not significant in terms of the Environmental Impact Assessment (EIA) as summarised in Table 4.2. The worst case scenario as outlined in the ES was considered within the SoCG between Forewind and MMO and agreed as being appropriate for the EIA[3].

Potential Effect	Receptor	Magnitude	Sensitivity	Impact
Lethal / Injury	Adult and juvenile fish	Negligible	Low	Negligible
	Larvae	Negligible	Medium	Minor adverse
Behavioural	Adult and juvenile fish	Low	Low	Minor adverse

	Herring	Low	Medium	Minor adverse
	Sandeel	Low	Medium	Minor adverse
	Diadromous species	Low	Low	Minor adverse
	Other fish species	Low	Low	Minor adverse
Prey Species/feeding	Fish in general	Low	Low	Minor adverse
General	Shellfish	Low	Low	Minor adverse

Table 4.2: Construction noise impact assessment on fish and shellfish receptors taken from the ES (Forewind, 2014a)

5 Sofia Assessment

As previously noted in this report, the worst case scenario as detailed in the ES considered that temporal disturbance from construction noise had a greater effect on fish and shellfish than the maximum range disturbance. Furthermore, the worst case scenario as outlined by the ES was agreed to by both Forewind and the MMO in the SoCG.

An increase in maximum hammer energy to 5,500 kJ for the installation of monopoles will have no impact on the worst case scenario as stated in the ES, since it refers to the installation of multi-leg pin piles due to the longer installation period associated with this foundation type. Notwithstanding this, the effect of a 5,500 kJ hammer energy on fish and shellfish receptors has been modelled by Subacoustech as set out in the following sections of this report.

5.1 Updated model for a maximum hammer energy of 5,500 kJ

It has not been possible to secure use of the model used by NPL, therefore, Subacoustech have used the INSPIRE model to predict the noise levels and associated impacts at an increased hammer energy of 5,500 kJ (with the validation process between the two models presented in the Increased Hammer Energy Report (Innogy, 2018).

It is important to note that since the original (NPL) modelling work for the ES, new threshold criteria have been adopted (Popper et al, 2014). Therefore, effects of noise on fish have been assessed using criteria from Popper et al. (2014), which gives specific criteria for mortality and potential mortal injury, recoverable injury and Temporary Threshold Shift (TTS), masking and behaviour from various stimuli, including impact piling. Species of fish are grouped by whether they have a swim bladder and whether that swim bladder is involved in hearing. The criteria are given as unweighted SPL_{peak}, and SEL_{cum} values and are summarised in Table 5.1.

Type of animal	Mortality & potential mortal injury	Recoverable injury	TTS
Fish: no swim bladder	> 219 dB SEL_{cum} > 213 dB SPL_{peak}	> 216 dB SEL_{cum} > 213 dB SPL_{peak}	>> 186 dB SEL_{cum}
Fish: swim bladder not involved in hearing	210 dB SEL_{cum} > 207 dB SPL_{peak}	203 dB SEL_{cum} > 207 dB SPL_{peak}	> 186 dB SEL_{cum}
Fish: swim bladder involved in hearing	207 dB SEL_{cum} > 207 dB SPL_{peak}	203 dB SEL_{cum} > 207 dB SPL_{peak}	186 dB SEL_{cum}

Table 5.1 Assessment criteria for species of fish from Popper et al. (2014) for impact piling noise

Where insufficient data is available (which is the case for masking and behavioural effects from impact piling), qualitative criteria (from Popper et al., 2014) have been given, summarising the effect of the noise as having either a high, moderate or low effect on an individual in either the near-field (tens of metres), intermediate-field (hundreds of metres), or far-field (thousands of metres). This also includes information for masking and behavioural effect. These qualitative effects are reproduced in Table 5.2

[2] Some particularly insensitive species of fish might only exhibit avoidance behaviour at lesser ranges
[3] https://infrastructure.planninginspectorate.gov.uk/wp-content/ipc/uploads/projects/EN010051/EN010051-001322-Forewind%20-%20SocG%20with%20MMO.pdf

Type of animal	Masking	Behaviour
Fish: no swim bladder	(N) Moderate (I) Low (F) Low	(N) High (I) Moderate (F) Low
Fish: swim bladder not involved in hearing	(N) Moderate (I) Low (F) Low	(N) High (I) Moderate (F) Low
Fish: swim bladder involved in hearing	(N) High (I) High (F) Moderate	(N) High (I) High (F) Moderate

Table 5.2 Summary of the qualitative effects on fish from impact piling noise from Popper et al. (2014) (N=Near-field, I=Intermediate-field, F=Far-field)

The outputs from the updated 5,500 kJ modelling are presented in Table 5.3 (for SEL_{peak}) and Table 5.4 (for SEL_{cum}).

Fish - SEL_{peak} impact criterion		**2300 kJ hammer energy**	**3000 kJ hammer energy**	**5500 kJ hammer energy**
Injury (fish: no swim bladder) unwtd SEL_{peak} (> 213 re 1 µPa)	Maximum	100 m	120 m	160 m
	Minimum	90 m	110 m	150 m
	Mean	95 m	120 m	160 m
Injury (fish: no swim bladder) unwtd SEL_{peak}(> 207 re 1 µPa)	Maximum	220 m	250 m	360 m
	Minimum	210 m	240 m	350 m
	Mean	220 m	250 m	360 m

Table 5.3 Predicted unweighted SEL_{peak} impact ranges for fish using criteria from Popper et al. (2014)

Fish - SEL_{cum} impact criterion (Sequence 3)		**2300kJ hammer energy**	**3000kJ hammer energy**	**5500kJ hammer energy**
Mortality (Fish: no swim bladder) unwtd SEL_{cum} (> 219 re 1 µPa²s)	Maximum	< 50 m	< 50 m	< 50 m
	Minimum	< 50 m	< 50 m	< 50 m
	Mean	< 50 m	< 50 m	< 50 m
Recoverable injury (fish: no swim bladder) unwtd SEL_{cum} (> 216 re 1 µPa²s)	Maximum	< 50 m	< 50 m	< 50 m
	Minimum	< 50 m	< 50 m	< 50 m
	Mean	< 50 m	< 50 m	< 50 m
Mortality (Fish: swim bladder not involved in hearing) unwtd SEL_{cum} (210 re 1 µPa²s)	Maximum	< 50 m	< 50 m	< 50 m
	Minimum	< 50 m	< 50 m	< 50 m
	Mean	< 50 m	< 50 m	< 50 m
Mortality (Fish: swim bladder involved in hearing) unwtd SEL_{cum} (207 re 1 µPa²s)	Maximum	< 50 m	< 50 m	< 50 m
	Minimum	< 50 m	< 50 m	< 50 m
	Mean	< 50 m	< 50 m	< 50 m
Recoverable injury (fish: with swim bladder) unwtd SEL_{cum} (203 re 1 µPa²s)	Maximum	< 50 m	< 50 m	110 m
	Minimum	< 50 m	< 50 m	90 m
	Mean	< 50 m	< 50 m	98 m
TTS (all fish) unwtd SEL_{cum} (186	Maximum	14.6 km	16.7 km	21.8 km

Fish - SEL_{cum} impact criterion (Sequence 3)		2300kJ hammer energy	3000kJ hammer energy	5500kJ hammer energy
re 1 µPa²s)	Minimum	11.5 km	12.9 km	16.1 km
	Mean	13.0 km	14.7 km	18.9 km

Table 5.4 Predicted unweighted SEL_{cum} impact ranges for fish using criteria from Popper et al. (2014) assuming a fleeing speed of 1.5 ms^{-1} for potential ramp up sequence 3

Lethal / Injurious effects

The results (Tables 5.3 and 5.4) show that for lethal and or injurious effects even at an increased hammer energy of 5,500 kJ the impact ranges using the Popper *et al.* (2014) criteria are calculated to be no greater than 360 m (SEL_{peak}) or 110 m (SEL_{cum}). Lethal and injurious ranges in the ES were predicted to be up to or less than 250 m (see Table 4.1). Whilst a direct like for like comparison is not feasible (for reasons stated above), for all of the SEL_{cum} 5,500 kJ scenarios modelled the range remains well within that predicted within the ES. For SEL_{peak} outputs, the range is within that predicted within the ES for the > 213 re 1 µPa scenario (up to 110 m), but is greater for the > 207 re 1 µPa (up to 360 m).

The fish and shellfish chapter of the orginal ES concluded (at paragraph 6.9.2) that "*juvenile and adult fish are expected to avoid the localised areas where the highest noise levels will be reached during piling activity*" and therefore, a negligible impact was predicted. The maximum PTS range for SEL_{peak} when considering a maximum hammer energy of 5,500 kJ remain within a few hundred metres from the piling location, and therefore, the conclusion drawn in the ES remains valid, particularly when considering the fact that there will be a soft start and ramp up to the piling before maximum hammer energy is reached (if at all).

Behavioural effects

As Popper et al. (2014) concluded that there is insufficient data available to apply quantitative thresholds for behavioural effects of noise on fish, a direct comparison of the NPL and INSPIRE model output is not possible, given that different metrics were calculated. Therefore, in order allow for an examination of the impact of an increased hammer energy, the TTS impact criterion has been selected as the closest possible comparison to the possible avoidance response modelled by NPL. It has previously been demonstrated to and recognised by the MMO and Cefas (in relation to other offshore wind farm developments) that the modelled noise propagation contours for both the 186dB SEL_{cum} metric threshold and the 168dB SPL_{peak} metric threshold as identified by McCauley *et al*. (2000) and defined as representing the outer limit for moderate disturbance, are comparable in terms of spatial extent. Although the metrics themselves are not analogous, the areas of potential effect generated by the modelling can be used to inform the assessment of both criteria in general terms. This comparative approach has been developed in relation to other offshore wind farm developments where it has not been possible to carry out exactly like-for-like modelling.

Using the INSPIRE model, the maximum range of TTS (all fish) unwtd SEL_{cum} of 186 re 1 µPa²s was found to be 21.8 km for a hammer energy of 5,500 kJ, which is within the range of propagation distances predicted within the ES modelling for both demersal and pelagic species in response to a peak level of 173 dB re 1µPa (Table 4.1, above).

As previously stated, the ES considered that the temporal disturbance from construction noise has a greater effect on fish and shellfish than the maximum range disturbance. The worst case scenario outlines a piling duration of 202 days for pin pile installation, which is significantly greater (185%) than the 71 days required for monopole installation and therefore, this component of the impact magnitude will be greatly reduced.

Accordingly, it is the conclusion of this assessment that there is no evidence to suggest that the magnitude of effect on fish receptors (as presented in the original ES and agreed to by the MMO) would increase as a result of the proposed increased maximum hammer energy to 5,500 kJ. As a result the impact assessment as presented in the original ES and summarized in Table 4.2 above, remains a valid worst case assessment.

6 Conclusion

This technical note has considered the implications of an increased hammer energy for foundation installation on fish and shellfish receptors, through a comparison with the evidence presented in the original ES. In undertaking this assessment updated threshold criteria (from Popper et al, 2014) and modelling techniques (SELcum) have been applied.

The assessment of cumulative sound exposure presented within this report has identified that:

For lethal / injurious effects, whilst for some outputs the maximum range may increase as a result of the 5,500 kJ hammer energy the effects remain very much within the localised area and therefore, the rationale for the conclusion reached within the ES remains valid.

For behavioural effects the updated ranges predicted for a 5,500 kJ hammer energy scenario are within those ranges predicted within the ES (see Table 4.1 above) that underpinned the subsequent impact assessment. Furthermore, it has been identified that under the 5,500 kJ hammer energy scenario (to which this report relates), the duration of effect will be reduced by 185% from that considered within the ES.

As a result of these findings, the significance of these impacts will be no greater than that concluded within the original ES, when a 5,500 kJ maximum hammer energy is applied for monopole foundations.

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