Sheringham Shoal and Dudgeon Offshore Wind Farm Extension Projects

Potential Impacts of Vibration Disturbance to Spawning Freshwater Fish Technical Note

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Glossary of Acronyms

dB	Decibel
DCO	Development Consent Order
DEL	Dudgeon Extension Limited
DEP	Dudgeon Offshore Wind Farm Extension Project
EPS	European Protected Species
ES	Environmental Statement
EU	European Union
HDD	Horizontal Directional Drilling
km	Kilometre
mm	Millimetre
NSIP	Nationally Significant Infrastructure Project
Pa	Pascal
SEL	Scira Extension Limited
SEP	Sheringham Offshore Wind Farm Extension Project
UK	United Kingdom
UN	United Nations
v_{rms}	Root-mean-square velocity

Glossary of Terms

Dudgeon Offshore Wind Farm Extension Project (DEP)	The Dudgeon Offshore Wind Farm Extension onshore and offshore sites including all onshore and offshore infrastructure.
European site	Sites designated for nature conservation under the Habitats Directive and Birds Directive. This includes candidate Special Areas of Conservation, Sites of Community Importance, Special Areas of Conservation, potential Special Protection Areas, Special Protection Areas, Ramsar sites, proposed Ramsar sites and sites compensating for damage to a European site and is defined in regulation 8 of the Conservation of Habitats and Species Regulations 2017, although some of the sites listed here are afforded equivalent policy protection under the National Planning Policy Framework (2021) (paragraph 176) and joint Defra/Welsh Government/Natural England/NRW Guidance (February 2021).
Horizontal directional drilling (HDD) zones	The areas within the onshore cable route which would house HDD entry or exit points.
Onshore cable corridor	The area between the landfall and the onshore substation sites, within which the onshore cable circuits will be installed along with other temporary works for construction.
Order Limits	The area subject to the application for development consent, including all permanent and temporary works for SEP and DEP.
Sheringham Shoal Offshore Wind Farm Extension Project (SEP)	The Sheringham Shoal Offshore Wind Farm Extension onshore and offshore sites including all onshore and offshore infrastructure.
Study area	Area where potential impacts from the project could occur, as defined for each individual Environmental Impact Assessment (EIA) topic.
Swim bladder	Gas-filled organ that contributes to the ability of fish to control their buoyancy
The Applicant	Equinor New Energy Limited. As the owners of SEP and DEP, Scira Extension Limited and Dudgeon Extension Limited are the named undertakers that have the benefit of the DCO. References in this document to obligations on, or commitments by, 'the Applicant' are given on behalf of SEL and DEL as the undertakers of SEP and DEP.

1 Introduction

1.1 Background

1. This technical note has been prepared by Royal HaskoningDHV to provide further information in relation to the Environment Agency's **Responses to the Examining Authority's First Written Questions** [REP1-111]. Specifically, Written Question Q1.13.4.3 queries whether trenchless crossing techniques, e.g. Horizontal Directional Drilling (HDD) under watercourses would give rise to any likely effects upon fish or aquatic animal species from vibration causing displacement or fatality.
2. The Environment Agency, in their response, indicate that potential disturbance to fish and aquatic fauna can be minimised by avoiding HDD activity under the riverbed and trenching activity during spawning seasons, which is when disturbance through vibration is likely to have the greatest impact. Recommendations are made to complete works between 16th June to 30th September, outside of the coarse fish and salmonid spawning seasons.
3. The following technical note provides information that demonstrates that the planned HDD works will not result in significant impacts to spawning fish and therefore that additional mitigation is not required.

1.2 HDD parameters

4. The Applicant confirms that HDD depth under main rivers would be at least 2m below the channel bed. This has been presented and committed to within Environmental Statement (ES) **Chapter 18 Water Resources and Flood Risk** [APP104] and ES **Chapter 20 Onshore Ecology and Ornithology (Revision B)** [document reference 6.1.20] as embedded mitigation. This is the minimum depth of HDD.
5. The actual depth of the HDD at main rivers would likely be deeper. The preliminary drill profiles for the rivers Wensum, Yare, Tud and Tiffey have been produced, and it is likely that these will be at a depth of at least 10m below the riverbed. The final drill profiles will be determined and confirmed during detailed design.

2 Potential for disturbance to fish from HDD

6. The most recent and relevant guidelines for the purposes of the assessment of the impacts of HDD noise on spawning riverine fish, are the Acoustical Society of America (ASA) Sound Exposure Guidelines for Fishes and Sea Turtles (Popper *et al.*, 2014). These guidelines provide directions and recommendations for setting criteria (including injury and behavioural criteria) for fish.
7. The Popper *et al*. (2014) guidelines broadly group fish into the following categories based on their anatomy and the available information on hearing of other fish species with comparable anatomies:
   - Group 1: Fishes lacking swim bladders (a gas-filled organ that contributes to the ability of fish to control their buoyancy) that are sensitive only to sound particle motion and show sensitivity to a narrow band of frequencies.

- Group 2: Fishes with a swim bladder where the organ does not appear to play a role in hearing. These fish are sensitive only to particle motion and show sensitivity to a narrow band of frequencies (includes Atlantic salmon).
- Group 3: Fishes with swim bladders that are close, but not intimately connected to the ear. These fishes are sensitive to both particle motion and sound pressure and show a more extended frequency range than groups 1 and 2, extending to about 500Hz.
- Group 4: Fishes that have special structures mechanically linking the swim bladder to the ear. These fishes are sensitive primarily to sound pressure, although they also detect particle motion. These species have a wider frequency range, extending to several kHz and generally show higher sensitivity to sound pressure than fishes in Groups 1, 2 and 3.

8. Given that salmonids fall with hearing Group 2 they are considered 'hearing generalists' with low sensitivity to underwater noise. For example, Nedwell *et al*. (2006), concluded for salmon and brown trout, no obvious signs of trauma could be attributed to sound exposure from vibro and impact piling associated with these fish species which were caged between 30m – 400m from the source of noise. The specific piles used were 508mm and 914mm. The unweighted Source Level of the impact piling of the 508mm diameter pile was 193dB re: 1µPa @1m, with a linear Transmission Loss rate of 0.13dB per metre, and for the 914mm diameter pile the Source Level was 201dB re: 1µPa @1m and the Transmission Loss 0.13dB per metre.

9. Laboratory work on brown trout has shown that repeated sine sweeps (up to 2kHz), and intermittent 140Hz tones do not affect swimming behaviour (Jesus *et al*., 2019). Further, high intensity (114dB above the hearing threshold) low frequency sound at 150Hz has no effect on downstream smolt migration (Knudsen *et al*., 2005).

10. Other spawning riverine fish may fall into group 1 (e.g. lamprey, a qualifying feature of the River Wensum SAC. See **Report to Inform the Appropriate Assessment (RIAA) (onshore) Technical Note** [document reference 14.29]) to group 4 (e.g. shads). Other coarse fish species that may be present include but are not limited to barbel, roach and chub; these would fall between the four categories.

11. Popper *et al*. (2014) define the impact thresholds from continuous noise sources (such as HDD) for fish, and these are detailed in **Table 1** . Where insufficient data are available to inform threshold criteria for noise-induced effects, Popper *et al*. (2014) also gives qualitative criteria that summarise 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). It should be noted, these qualitative effects are based on the source level of a ship at sea which can range from 150dB to over 190dB (re 1µPa at 1m). These qualitative effects are also included.

Table 1 Criteria for mortality and potential mortal injury, recoverable injury and Tempory Threshold Shifts (TTS) in species of fish from continuous noise sources (Popper et al., 2014) (Near = tens of metres; Intermediate = hundreds of meters; Far = thousands of metres

Type of animal	Mortality and potential mortal injury	Recoverable injury	TTS
Group 1 Fish: no swim bladder (particle motion detection)	(Near) Low (Intermediate) Low (Far) Low	(Near) Low (Intermediate) Low (Far) Low	(Near) Moderate (Intermediate) Low (Far) Low
Group 2 Fish: where swim bladder is not involved in hearing (particle motion detection)	(Near) Low (Intermediate) Low (Far) Low	(Near) Low (Intermediate) Low (Far) Low	(Near) Moderate (Intermediate) Low (Far) Low
Groups 3 and 4 Fish: where swim bladder is involved in hearing (primarily pressure detection)	(Near) Low (Intermediate) Low (Far) Low	170 dB re 1µPa (rms) for 48 hours	158 dB re 1µPa (rms) for 12 hours

12. Nedwell *et al*. (2012) details the findings of underwater noise monitoring conducted during HDD operations in a shallow riverine environment, while drilling was taking place 39m directly below the riverbed. The environment was quiet, with no other potential noise sources, and the resulting underwater noise levels are reported as a maximum unweighted Sound Pressure Level of 129.5dB re 1µPa on the riverbed. The reported sound pressure levels can be considered comparable to those from the proposed SEP and DEP HDD, in so far as the type of works, the quiet riverine environment the works are undertaken in and the range of the baseline noise levels expected in the area. Assuming a transmission loss of 0.13 dB per metre (Nedwell *et al*., 2006), maximum underwater noise levels for SEP and DEP (with drilling 10m directly below the riverbed) are likely to be in the region of 133.27dB re 1µPa on the riverbed.

13. The maximum value of 133.27dB re 1µPa on the riverbed falls well below the threshold (158dB re 1 µPa (rms) for 12 hours) for temporary threshold shifts in hearing for the most sensitive group 4 fish species. In addition, HDD noise under the riverbed will likely occur for substantially less than 12 hours.

14. Taken together, the maximum noise levels at the riverbed, resulting from HDD works 10m directly below the riverbed fall well below the established noise thresholds for effects on all fish. In the case of salmonids, which display lower noise sensitivity, the likelihood of impact is further reduced. In the case of brook lamprey, a qualifying feature of the River Wensum SAC (which spawn March - June), this species displays the lowest noise sensitivity (group 1), and hence the likelihood of impact is further reduced.

15. Further assessment, or temporal mitigation, is not warranted based on appraisal of the relevant literature and guidance, the nature of the HDD operation and site specific circumstances.

3 Open cut crossing at Ordinary Watercourses

16. Where trenched crossings would be carried out on Ordinary Watercourses (this would involve installing temporary dams (composed of sandbags, straw bales and ditching clay, or another suitable technique) upstream and downstream of the crossing point. The cable trench would then be excavated in the dry area of riverbed between the two dams with the river flow maintained using a temporary pump or flume using fish-friendly filters.

17. The **Outline Code of Construction Practice (Revision B)** [REP1-023, Section 6.1.3] provides details of the mitigation measures to be adopted at such crossings to minimise impacts to fish.

4 Conclusion

18. This technical note provides clarification on the likely depth of HDD under watercourses (circa.10m under the riverbed). This depth is notably more than the depth indicated as embedded mitigation in the ES. Final drill depths will be confirmed during detailed design.

19. Maximum underwater noise levels for SEP and DEP (with drilling 10m directly below the riverbed) are likely to be in the region of 133.27dB re 1µPa on the riverbed, which falls well below the established noise thresholds for effects on all fish. The likelihood of impact to salmonids is further reduced as they are less sensitive to noise.

20. Mitigation measures to be adopted at Ordinary Watercourse crossings, which would be undertaken via open cut, to minimise impacts to fish are presented in the **Outline Code of Construction Practice (Revision B)** [REP1-023, Section 6.1.3].

21. Based on the information outlined in this technical note, further assessment or temporal mitigation for works to be completed between 16th June to 30th September outside of the coarse fish and salmonid spawning seasons, is therefore not considered necessary.

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