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Review of criticisms raised in *"An Independent Evaluation of the Potential impact of the Aberdeen Offshore Wind Farm upon Salmon and Sea Trout," (Loughine Limited, 2017)* in relation to underwater noise

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Table of contents

Executive summary

This advice note considers criticisms raised in a report (hereafter the *Loughine report*) commissioned by a stakeholder affected by the European Offshore Wind Deployment Centre (EOWDC), also known as the Aberdeen Offshore Wind Farm. The scope is limited to criticisms raised in regard to the assessment of underwater noise and its potential effects on salmon (*Salmo salar*) and sea trout (*Salmo trutta*) in the environmental impact assessment (EIA) carried out for EOWDC in 2011.

The review concluded that an EIA conducted according to current best practice would not identify a higher level of risk than the original EIA completed in 2011. This is primarily due to the subsequent decision to use suction buckets for the wind turbine foundations, rather than impact pile driving, as was assessed in the EIA. Some shortcomings in the EIA methodology were correctly identified in the Loughine report, particularly with regard to the use of appropriate noise exposure criteria and the lack of information on the sound propagation modelling methodology. However, it is our view that these deficiencies would not affect the outcome of the assessment.

Various criticisms were made on the lack of assessment of the particle motion component of sound. However, there are presently no assessment methodologies, standardised instruments, or noise exposure criteria with which to conduct such an assessment. Furthermore, such an assessment, were it possible, would be unlikely to increase the level of risk predicted in the EIA, due to the comparably low levels of noise expected from the installation of suction bucket foundations. Further criticisms related to the assessment of the operational noise and infrasound were considered to have a negligible effect on the assessment.

About the authors

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1. Introduction

This advice note reviews a report (hereafter the *Loughine report*) commissioned by a stakeholder affected by the European Offshore Wind Deployment Centre (EOWDC), also known as the Aberdeen Offshore Wind Farm.

> Hawkins, A.D. (2017) *An Independent Evaluation of the Potential impact of the Aberdeen Offshore Wind Farm upon Salmon and Sea Trout*. Loughine Limited, Aberdeen, UK

This document specifically considers the criticisms raised in the Loughine report in relation to the assessment of underwater noise and its potential effects on salmon (*Salmo salar*) and sea trout (*Salmo trutta*) in the environmental impact assessment (EIA) carried out for EOWDC in 2011. These criticisms are detailed on pp56-60 of the Loughine report.

2. Assessment of criticisms raised in Loughine report

Several criticisms are repeated in the report – we have collated these in the subsections below and provided responses with reference to the scientific literature and current best practice in EIA for underwater noise.

2.1 Use of suction bucket foundations

> **"the EIA [Environmental Impact Assessment] did not evaluate the noise associated with the installation of suction bucket foundations, despite these being the foundations subsequently decided upon" p57**

Impact pile driving was assessed in the EIA as a worst case construction method, but suction bucket foundations are now planned. As is common practice in EIA, an approach known as the Rochdale Envelope was applied (http://www.gov.scot/Publications/2013/08/6471/5), which identifies the 'worst case' from within the realistic and likely options that might be developed. For example, if several foundation types remain possible, then the assessment of the project will be based on the option considered to have the greatest effect. If the assessment shows that no significant effect is anticipated, it can be assumed that other (lesser) options would also have no significant effect.

Impact pile driving generates high-amplitude impulsive sound as the pile driving hammer strikes the pile:

> *Impact pile driving is a method used to install piles for marine and inland water construction projects using high-energy impact hammers. The installation of hollow steel piles in this manner can produce extremely high sound levels in the surrounding waters (as well as in the air).* (Dahl *et al.*, 2015)

In contrast, suction bucket foundations are expected to generate low levels of continuous sound:

> *The suction bucket principle is a low-noise foundation installation technology, as the only noise source is the suction pump used to evacuate water and loose sediment from the interior of the suction bucket/can. The installation process can be described as follows: First, the suction bucket is placed onto the seabed. Due to the deadweight of the substructure, the bucket penetrates the soil to a certain depth. Subsequently, negative pressure is applied to the interior of the bucket by means of several suction pumps. With ongoing evacuation, the hydrostatic pressure difference and the deadweight of the substructure cause the bucket to penetrate the soil. After installation is complete, the foundation acts like a hybrid of a gravity-based structure and a monopile.* (Verfuß, 2014)

It is therefore reasonable and appropriate that impact piling was assessed as a worst case. It also follows that if the potential effects of noise from impact pile driving were not expected to be above minor (as was the case, provided adequate mitigation measures are carried out), it can be inferred that the potential impact of alternative construction techniques would not exceed the same level of risk.

As an illustration of the potential magnitude of noise from installing suction bucket foundations, a conservative proxy would be the noise levels generated by suction dredging. This proxy is likely to overestimate noise levels since the suction head of a dredger is directly exposed to the water column, whereas for the suction bucket, the suction occurs within the foundation, which would be expected to attenuate noise transmission. Broadband source levels of up to 188 dB re 1 µPa have been reported for suction dredging (Robinson *et al.*, 2011), which is comparable to levels reported for a large and noisy container ship (McKenna *et al.*, 2012).

2.2 Consideration of particle motion

> **"What the assessment does not point out is that Hawkins and Johnstone (1978) revealed that salmon are sensitive to particle motion, rather than sound pressure, and that any estimates of effects must be based on consideration of particle motion levels" pp59-60**

As the EIA acknowledges (Appendix 9.2, p27), fish are indeed sensitive to the particle motion component of sound. However, despite the pioneering work of Hawkins and Johnstone (1978), particle motion is not currently assessed directly in EIAs (Hawkins and Popper, 2016). This is because: (i) standardised instrumentation and methods for measurement and modelling of particle motion are in their infancy or have yet to be developed (Nedelec *et al.*, 2016); and (ii) as a consequence, there is a lack of scientific evidence to support noise exposure criteria for fish based on particle motion (Popper *et al.*, 2014).

At present, the best available science on noise exposure criteria for fish are the Popper criteria (Popper *et al.*, 2014; published after the EIA was completed), which do not contain thresholds based on particle motion. The criteria do, however, contain noise exposure thresholds based on sound pressure, even for species (such as salmon) which are not thought to be directly sensitive to sound pressure. This is consistent with the approach taken in the EIA, which used thresholds based on sound pressure, though note comments below on the metrics used.

2.3 Consideration of infrasound

> **"The assessment does not consider possible effects from infrasound." p60**

This criticism is accurate. However, the sound levels generated by installation of suction buckets is not expected to be high (see above), and there is no evidence to suggest that levels of infrasound would be disproportionately higher than sound at other frequencies. Furthermore, in shallow water, low-frequency sound propagation is limited by a cut-off frequency, below which sound is strongly attenuated (Jensen *et al.*, 2011; Farcas *et al.*, 2016). This cut-off frequency increases as depth decreases. At the depth of the EOWDC site (~30 m), this cut-off frequency is ~12.5 Hz, meaning sound below this frequency will be strongly attenuated.

2.4 Assessment of operational noise

> **"The EIA did not recognise that the magnitude and nature of the noise generated by operational wind turbines will depend on the structure of the wind farm and its foundations. Earlier studies involved wind turbines attached to the seabed by piles. It would seem that there have been no noise measurements made on turbines with suction bucket foundations" p59**

The operational noise of wind turbines is generated by the gearbox, and is modulated by the rotor speed (Lindell, 2003; Pangerc *et al.*, 2016). The structure of the wind turbine will affect how much of this sound is transmitted into the water column, and so suction bucket foundations could potentially transmit higher (or lower) noise levels than the monopile foundations that have thus far been studied. However, the noise levels reported for these operational monopile turbines are very low: Tougaard et al. (2009) measured levels of 109–127 dB re 1 µPa at distances of 14-20 m from the pile, while Pangerc et al. (2016) noted that the noise is tonal, with a maximum of 126 dB re 1 $\mu Pa^2\ Hz^{-1}$ at 162 Hz measured at 50 m from the turbine, with most sound energy in the frequency range from 100 to 170 Hz. There is therefore little reason to expect that operational noise from turbines with suction bucket foundations will reach levels that would warrant mitigatory action in an EIA.

Although not cited in the Loughine report, there is one field study of particle motion levels around an operational (monopile) wind turbine foundation in the peer-reviewed literature, which concluded:

> *The results show that the wind turbines generate particle motion that fish sense. Close to the foundation, the maximum particle motion is comparable with levels observed in studies concerned with behavioral reactions. However, already at a distance of 10 m the amplitudes decreased to levels comparable with hearing thresholds, suggesting that the physical area where the environment is affected by anthropogenically generated particle motion is restricted to the immediate neighbourhood of the wind turbine. The results indicate that a single wind turbine has a limited impact on fish, corroborating a study made by Andersson*

and Öhman (2010). Still, pressure variations might have an influence at larger distances, especially on fish with enhanced hearing sensitivity. (Sigray and Andersson, 2011)

The best available scientific evidence suggests that levels of operational noise will be audible to fish only within 10 m of the foundation, and that the effect of particle motion will be less extensive than sound pressure. However, post-consent monitoring of particle motion levels would confirm whether this is also the case for these suction bucket foundations.

2.5 Use of the dBht metric

"the assessment does not take account of problems with the application of the dBht (species) metric" p60

There are recognised problems with the dB_{ht} metric, and Cefas does not support its application in EIA, which is reflected in our scientific advice to regulators. However, at the time of the EOWDC EIA, this approach was widely accepted by UK regulators, partly because it was the only method available to assess many of the potential effects on marine fauna. The question is whether more recent and robust noise exposure criteria (i.e. Popper *et al.*, 2014) would now result in a higher level of risk being identified in an EIA. Our view is that the marked reduction in noise levels expected through the use of suction bucket foundations would now lead to an assessment of minor (as in the EIA assessment for impact piling) or negligible potential impact from construction noise, whichever criteria are applied.

2.6 Adequacy of sound propagation modelling

"There may also be problems with the model that was used to predict sound levels at different distances" p56

With reference to the EIA, there appears to be insufficient evidence on the model specifications to evaluate the quality of sound propagation modelling. The description of the proprietary model ('INSPIRE') applied in the assessment is vague, and the scientific basis for the model is not described. This uncertainty would be a concern if impact piling were still planned, since uncertainties in the model will have the greatest effect on predictions far from the source, and long-range effects were predicted. However, given that noise levels are now expected to be low due to the suction bucket installation method, the predicted effects are likely to be localised, and would therefore be less dependent on the quality of the sound propagation model.

2.7 Noise from cable laying

Noise from cable laying is normally scoped out of EIAs, and was not raised in the Loughine report. For completeness, we note that the source level of cable trenching has been reported as 178 dB re 1 µPa (Nedwell *et al.*, 2003), and that the main source of noise is expected to be the presence of the cable laying vessels (Meißner *et al.*, 2006).

3. Conclusions

The use of suction bucket foundations is expected to substantially reduce the acoustic impact of the construction operation compared to impact pile driving. It is therefore appropriate that impact pile driving was considered as a worst case with regard to construction noise in the EIA. Although the effects of the particle motion component of sound were not explicitly assessed in the EIA (only sound pressure was considered), this remains the norm at present since measurement standards, instrumentation, and noise exposure criteria for particle motion are lacking. The best available noise exposure criteria for fish (Popper criteria; published after the EIA was completed) also provide thresholds based on sound pressure rather than particle motion. The Loughine report identifies deficiencies in the noise exposure criteria and the sound propagation modelling used in the EIA, which we consider to be valid criticisms. However, it is our view that addressing these shortcomings would not increase the predicted level of risk, due to the comparably low levels of construction noise now expected due to the use of suction bucket foundations. The risk of impact from operational noise and infrasound were expected to be negligible, based on published field studies of operational wind turbine noise and consideration of shallow water acoustic propagation, respectively.

In summary, with reference to the scientific literature and through consideration of current best practice for EIA of underwater noise, it is our view that an EIA conducted according to current best practice would not identify a higher level of risk than the original EIA completed in 2011. This is primarily due to the use of suction buckets for the wind turbine foundations, rather than impact pile driving, as was assessed in the EIA.

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