OX2 – Triton Offshore Wind Farm

Note on mitigation effect of HSD-DBBC NAS.

1 Introduction

This note is intended as an attachment to the report "OX2 Triton OWF – Technical report for underwater sound propagation" (Mikaelsen & Olsen, 2021a), providing additional information on the assumed mitigation effect used in underwater sound propagation modelling for the Triton monopile installation activities, where a Hydro Sound Damper & Double Big Bubble Curtain (HSD-DBBC) Noise Abatement System (NAS) was included.

The note is not intended to be read as an independent document, and the reader is referred to the main report, (Mikaelsen & Olsen, 2021a) for further details.

2 Updated mitigation effect of HSD-DBBC NAS

In the report "OX2 Triton OWF – Technical report for underwater sound propagation" (Mikaelsen & Olsen, 2021a), underwater sound propagation modelling was carried out for a 14 m monopile, installed using impact pile driving with environmental conditions representing a worst case scenario, and a summer scenario.

Calculations of underwater noise emission were carried out using two different NAS; a BBC and HSD-DBBC respectively. The mitigation effect used for the BBC NAS was directly derived from (Bellmann, et al., August 2020), where the mitigation effect of NAS implementations for the construction German offshore wind farms have been documented, see Figure 1, representing the frequency band specific mitigation effect of the BBC (teal), DBBC (dark blue) and HSD-DBBC (red).

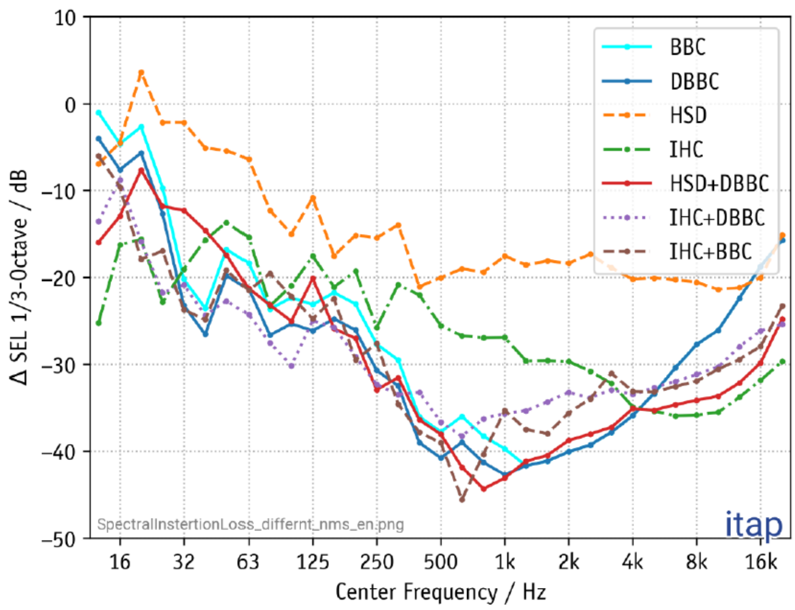

Figure 1: Mitigation effect of most common Noise Abatement Systems (NAS) by frequency. Source: (Bellmann, et al., August 2020)

The mitigation effect is provided as the noise emission relative to unmitigated scenario, so the more negative the value, the better the mitigation effect. In numeric form, the mitigation effect in the different frequency bands is provided in Table 1.

Table 1: Mitigation effect of different Noise Abatement Systems (NAS) (Bellmann, et al., August 2020). Values are indicated by frequency band specific mitigation effects. The more negative the value, the better the mitigation effect. Values in grey background indicate frequencies where the combination system HSD-DBBC is listed to have a lower (worse) mitigation effect than the DBBC system alone.

Mitigation effect of NAS [dB]																	
Frequency [Hz]	12.5	16	20	25	31.5	40	50	63	80	100	125	160	200	250	315	400	500
BBC	-1	-5	-3	-10	-20	-23	-16	-18	-23	-22	-23	-22	-23	-28	-29	-37	-38
DBBC	-4	-8	-6	-13	-23	-26	-20	-21	-27	-26	-27	-25	-26	-31	-32	-39	-41
HSD-DBBC	-10	-13	-8	-12	-13	-14	-17	-22	-23	-25	-20	-26	-27	-33	-32	-36	-38
Frequency [Hz]	630	800	1k	1.2k	1.6k	2k	2.5k	3.2k	4k	5k	6.3k	8k	10k	12.5k	16k	20k	25k
BBC	-36	-38	-40	-42	-41	-40	-39	-38	-36	-33	-30	-28	-27	-23	-19	-16	-13
DBBC	-39	-41	-43	-42	-41	-40	-39	-38	-36	-33	-30	-28	-27	-23	-19	-16	-13
HSD-DBBC	-42	-44	-43	-41	-41	-39	-38	-37	-35	-35	-34	-34	-33	-32	-30	-25	-20

It should be noted from Table 1, that the HSD-DBBC mitigation effect is less than that of the DBBC system at individual frequencies in the low and mid frequency region. This would imply, that the mitigation effect is worse for a NAS consisting of an HSD and a DBBC system, compared to a DBBC system alone. While the measurements would indeed indicate such an effect, it must be noted, that the representation method in (Bellmann, et al., August 2020) does not represent the effect of a single fixed system, but rather the average of a number of different systems, across different pile installations, across different project areas and current conditions. It is not clear from the report, when and where each NAS effect was measured, and it is therefore not possible to determine what would contribute to the achieved effects.

Given the continuous development of NAS technology, it is however considered unlikely and counter-intuitive, that adding an extra NAS component, such as HSD, to a DBBC system would result in a reduced mitigation effect.

It should also be noted that single-system implementations such as BBC, DBBC, HSD and IHC have been used alone significantly more times, than combinations of multiple NAS. Single system mitigation effect is therefore assessed to be statistically more reliable than that of combined systems. Due to German regulation, where a fixed upper noise limit per pile strike applies, the increase in pile sizes – due to increased turbine sizes – has resulted in a constant increase in noise mitigation requirements, to the point where single NAS implementations are no longer sufficient to comply with the regulatory requirements.

Furthermore, the effect of the HSD system alone, is primary in the high frequency region, as dictated by the NAS design, where foam-balls are suspended in a gridded net around the pile in the full water depth. It therefore contradicts logic that the low- and mid-frequency mitigation effect would be reduced by adding the HSD system. It is assessed, that the lowered mitigation effect of the HSD-DBBC NAS is a result of high statistical uncertainty due to the low number of implementations measured.

The sound propagation model therefore included a modified mitigation effect for the calculations with the HSD-DBBC system, where the mitigation effect in each frequency band corresponds to the best mitigation effect observed between the DBBC and HSD-DBBC systems as reported by (Bellmann, et al., August 2020). This would lead to a revised mitigation effect as listed in Table 2.

Table 2: Mitigation effect of revised HSD-DBBC system, where the mitigation effect is corrected on a band by band basis to be at least as effective as the DBBC system alone. The more negative the value, the better the mitigation effect.

Mitigation effect of NAS [dB]																	
Frequency [Hz]	12.5	16	20	25	31.5	40	50	63	80	100	125	160	200	250	315	400	500
HSD-DBBC (revised)	-10	-13	-8	-13	-23	-26	-20	-22	-27	-26	-27	-26	-27	-33	-32	-39	-41
Frequency [Hz]	630	800	1k	1.2k	1.6k	2k	2.5k	3.2k	4k	5k	6.3k	8k	10k	12.5k	16k	20k	25k
HSD-DBBC (revised)	-42	-44	-43	-42	-41	-40	-39	-38	-36	-35	-34	-34	-33	-32	-30	-25	-20

This note does not present additional results, rather provides supplementary documentation of the methodology used for the underwater sound propagation prognosis presented in the main report, (Mikaelsen & Olsen, 2021a), implementing the revised HSD-DBBC NAS mitigation effect.

3 Bibliography

Bellmann, M. A. et al., August 2020. *Underwater noise during percussive pile driving: Influencing factors on pile-driving noise and technical possibilities to comply with noise mitigation values*, Oldenburg, Germany: ITAP.

Mikaelsen, M. & Olsen, K., 2021a. *OX2 Triton OWF - Technical report for underwater sound propagation*, Aarhus, Denmark: NIRAS.