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Underwater noise emission from the NOAH's drilling operation at the narec site, Blyth, UK

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ABSTRACT

In November 2011, the National Renewable Energy Center (narec) launched their offshore wind demonstrator project 'round 3'. Narec commissioned SeaRoc to undertake the deployment and drilling operation of the Narec Offshore Anemometry Hub (NOAH). On this occasion, the Bio-Acoustic Research Consortium combining university and industry researchers conducted a study on noise and marine mammal occurrence before, during and after installation of the Noah platform. This paper describes the noise emission from the installation of the NOAH's jacket.

The team preliminary undertook underwater ambient noise measurements at different seasons, and locations at the site. The results of these measurements are discussed in this paper.

The pin pile drilling itself occurred at 3 nautical miles offshore Blyth and at a 40 m depth. The Newcastle research vessel Princess Royal was positioned at 500m and 3 nautical miles from the NOAH's drilling. The engine and all electronic equipment on board, such as sonar and depth sensors were switched off during the pin pile drilling noise monitoring. At each position, a self-recorder hydrophone was deployed from a semi-submersible drifting buoy to reduce the effect of the swell (sea state 3), which could have affected the quality of the recordings. The deployment from a drifting buoy also has the advantage of reducing mechanical noise from the boat as the buoy drifts freely away from the vessel. Each recording lasted between 5 and 10 minutes and the buoy was then retrieved for another deployment at the next position. Sample measurements were taken at approximately 10 m depth and at a sampling rate of 312 kHz and 24 bits resolution.

Matlab was used as a post-processing tool to analyse the data. Each file was processed on a 2 min average using a FFT of 216 points. The in-house code displays Sound Pressure Level (dB re1µParms) and Pressure Spectral Density (dB re1µPa_{rms}^2/Hz) with a 1Hz resolution.

The results demonstrate that the noise coming from the pin pile drilling was relatively low in comparison to the background noise. At 500 m from the drilling, the noise appears to be only 10 to 20 dB higher than the background noise over the frequency band 10 Hz to 50 kHz. Higher energy was concentrated between 100 Hz and 600 Hz reaching up to 100 dB re1µParms.

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INTRODUCTION

In 2010, the UK government launched it's 3rd round of offshore wind farm deployments around the British Isles. At this occasion, narec began setting up a demonstration facility for pre commercial testing in real conditions named the Offshore Wind Demonstrator Project. This test site (situated close to Blyth, Northumberland) will allow industries to measure and optimise the design of their turbines of up 7MW. The first stage of the project was deployment of an anemometry hub (NOAH) to validate environmental and wind resource measurements. This was installed in2012, three nautical miles offshore from their onshore facility in Blyth.

Figure 1: MPI Adventurer installing the anemometry hub off Blyth. Courtesy of Steve McDonald

In 2011, a group of engineers and biologists from academia and industry formed the Bio-Acoustic Research Consortium (BARC) to undertake underwater acoustic monitoring of marine mammals, ambient and anthropogenic noise prior to, during and after the installation of the anemometry hub NOAH and the subsequent build out of the turbines. This consortium aims to reduce uncertainties around underwater noise monitoring and impacts at marine renewable energy sites. The group also focuses on the comparison of different instrumentation and methodologies to measure underwater ambient and anthropogenic noise. This will enable the regulators to agree on common standards and provide guidance regarding underwater acoustic monitoring at marine renewable energy sites.

METHODOLOGY

Underwater acoustic monitoring was executed on two different occasions. Underwater ambient noise monitoring was undertaken on the 3rd October and 3rd November 2012. Additionally, operational drilling noise was also monitored on the 3rd November 2012. During both days the weather was sunny, and the wind speeds below 10 m/s. Sea state was estimated to be between 2 and 3.

Underwater background noise measurements were carried out between 500 m and 5 nautical miles (nm) east and north from the NOAH's location. Drilling noise monitoring was executed at 500 m east and 3 nm north from the platform.

Acoustic monitoring was carried out on board Newcastle University's research vessel Princess Royal. The methodology used by Swansea University was as follows: the research vessel was positioned at a chosen location and the engine was turned off as well as all electric appliances on board. From the deck, a HTI 99HF 40dB gain plugged on the EASDA data logger was deployed from a drifting buoy and released at sea. The use of a drifting buoy allowed the hydrophone to drift freely away from the vessel, reducing flow noise and boat noise. The system included a subsurface buoy and a bungee rope to reduce swell effect. The hydrophone was positioned at 10 m below the sea surface. Each recording lasted 15 minutes. The drifting buoy was then retrieved, checked and prepared checked for subsequent deployment.

The sound processing used a 312 kHz sampling rate and a 16 bit resolution. The post processing used in house Matlab code, based on a 2^{16} FFT points Hanning window. The Pressure Spectral Density (dB re 1μPa rms/Hz) was computed over 2 minute averaging time at1 Hz resolution. Thus, each plot represents 2 minutes averaging of sound post-processing.

OBSERVATIONS

Ambient Noise

Figure 2 below displays the background noise results 5 nm east of NOAH's hub. Ambient noise ranges between 30 and 100 dB re 1μPa rms with higher amplitudes being concentrated at low frequencies. The peaks occurring at 600Hz have not been identified so far. Noise variations below 100 Hz is surely due to surface noise and turbulence [1].

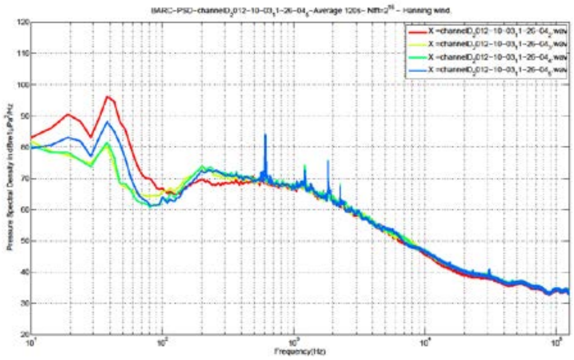

Figure 2: Background Noise at 5 nm east from the anemometry hub location – 03/10/2012

Figure 3 refers to the "background noise 3 nm north from Noah. No drilling operation occurred during this period. However, deck activities occurred on the MPI Adventurer. This study only focused on the operational drilling noise, therefore, it has been decided that deck work is included as background noise.

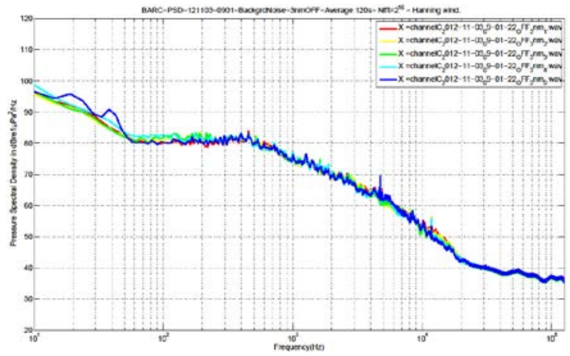

Figure 3: Background noise at 500 m north from the boreholes – 03/11/2012

In comparison with the results of the 3rd October (Figure 2), ambient noise amplitudes are on average 10 dB higher. Above 100 Hz, the noise source is attributed to anthropogenic noise, i.e traffic noise and maintenance relative to the NOAH's installation activities recorded 500 m from the NOAH's location.

Operational drilling noise

The NOAH sits on a tripod subsea structure and foundation. Drilling the NOAH's foundation required a socket to be drilled through each of the three pile sleeves and into the bedrock. The tripod was then secured to its foundation with grout. The foundation sits at 37 m [2]. The drill used during operation is shown on Figure 4. This type of operation is unconventional and was selected because of the nature of the grout made of clay and the particularly shallow water depth.

Figure 4: The MPI Adventurer installing the anemometry hub off Blyth. Courtesy of Steve McDonald

The first drilling noise monitoring occurred 500 m east from the boreholes. The second occurred 3 nm away from north from NOAH. The results are displayed on Figures 5 & 6.

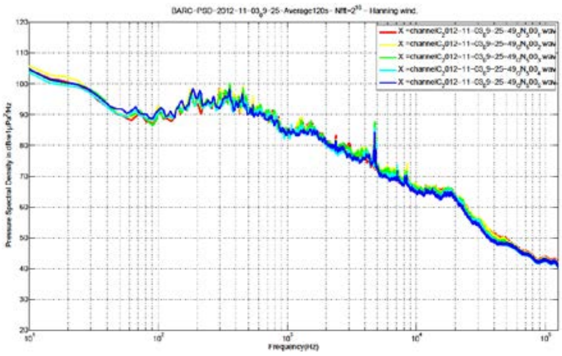

Figure 5: Operational drilling noise recorded 500 m east from the boreholes – 03/11/12.

Drilling operation noise evolves between 40 to 105 dB re1µPa$_{rms}^2$/Hz. By comparing the result of Figure 5 of the results on Figure 3, we can identify the noise signature of the drilling. Drilling noise is 10 dB to 30 dB higher than the background noise of the area (Figure 3), and is especially more intensive between 100 Hz and 2 kHz.

Compared to other types of drilling (e.g edited by Cowrie [3]), noise emission during the installation of NOAH is particularly low at 500 m from the boreholes, reaching a maximum of 100 dB re1µPa$_{rms}^2$/Hz at 500 m.

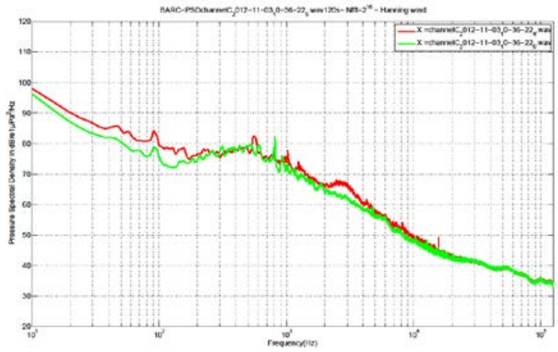

Figure 6: Drilling operation noise recorded at 3 nm north from the boreholes – 03/11/2012

Underwater noise monitoring of the drilling operation was also monitored at 3 nm north of the boreholes. The results are highly comparable to the background noise recorded at the same date, ranging between 40 and 100 dB re1µPa$_{rms}$. This is evidence that operational drilling noise did not propagate further than a few nautical miles from the boreholes and has potentially limited impact on the marine environment.

CONCLUSIONS

Underwater noise monitoring of background and drilling noise was completed at the Blyth offshore wind demonstration site. Underwater drilling noise was recorded at 500 m and 5km from the operational location. The results show that the noise signature of the drilling operations was particularly low in comparison with the levels expected. At 500 m the drilling noise levels was below 100dB re1µPa$_{rms}$

The technique used to fix NOAH constitutes of a jacket drilling operation. This technology allows the use of smaller boreholes that mitigate noise levels and noise propagation. In addition, the seabed constitution along over the test site is mainly made of mud and cobble. The substrates provide a better absorption of sound waves [1,4] in comparison with hard rock.

Finally, we would like to emphasise the complexity of undertaking environmental monitoring around a live, commercial drilling rig, as it is a high risk and highly sensitive operation. The success of such operations at sea is highly dependable on trust and communication between the hub deployment team and the monitoring team.

ACKNOWLEDGEMENTS

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