SUB-SEA NOISE MONITORING IN THE GERMAN NORTH SEA

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1 INTRODUCTION

An underwater acoustic monitoring station was installed at the German research platform FINO1 in July 2009. FINO1 is 45 km off the coast and about 15 km north of a traffic separation scheme. Furthermore the acoustic monitoring station is situated next to the German wind farm Alpha Ventus, which was also set up in 2009. Additional offshore wind farms are planned to be founded in the next years in several of distances to the underwater monitoring station.
The FINO1 research platform is equipped with meteorological and oceanographical sensors for measuring parameters like e.g. wind speed and direction, air temperature, radiation as well as wave and current information. FINO1 was set up in 2003 in order to realize investigations of the marine environment and the atmospheric boundary layer for offshore wind energy projects. Thus influences of such metocean parameters on underwater noise can easily be identified.
Underwater noise has become a crucial topic in the approval process of German offshore wind farms. Therefore the underwater acoustic monitoring system was set up to measure in a high range up to the intense noise of pile driving. During pile driving, hydro sound potentially might cause temporary (TTS) or even permanent threshold shifts (PTS) to marine animals. Potential banishment out of their common habitat or physical damage might harm sensitive marine mammals.
We will present data of two years sub-sea monitoring. Examples of pile driving from nearby as well as from great distances will be shown. Other environmental acoustic sources like ship or wave noise have also been considered within the study in order to distinguish them from sources caused by offshore wind activities. The extensive data base of hydro sound in the German Bight can be used to study ambient noise under a large variety of parameters.

2 MATERIALS AND METHODS

In order to record sub-sea noise in a wide dynamic range the underwater acoustic monitoring station is equipped with two different hydrophones. One of them is a sensitive one with a built-in amplifier and the other one is a low gain hydrophone, where a separate amplifier is installed close to the sensor. These two hydrophones are mounted in a protective construction. This construction takes care to keep the sensors out of turbulences due to tidal stream. Flexible parts like cables and ropes were tightly attached to the construction. One single cable connects the hydrophones and the recording system, which is placed inside the FINO 1 measurement container and is part of the DEWI data acquisition system. The hydrophone signals are continuously stored on hard discs, uncompressed and with a sample rate of 48 kHz and 24 Bit resolution.
Hence the recording system is sensitive for background noise as well as for peaks of impulsive sound pressure up to more than 200 dB $_{re\ 1\mu Pa}$.

3 RESULTS

3.1 Pile Driving Noise

The pile driving noise of two wind farms was detected within the two years of underwater acoustic measurements: Alpha Ventus and BARD Offshore 1. These events are different regarding their distance to FINO1. Alpha Ventus is located close to FINO1, whereas BARD Offshore 1 is situated in a distance of about 60 km to FINO1.
Figure 1 left shows the distribution of the sound pressure level in the time period July 7 to August 26, 2009. The data was averaged to 30 seconds and the average values are presented as hours of occurrence. During this time 4 wind turbines of the Alpha Ventus wind farm ware installed. The background noise can be found around 120 dB. Smaller peaks at the decreasing edge of the background noise can be related to offshore working activities and ship noise. A further concentration is obvious at sound pressure levels between 150 and 180 dB. The maximum of this broad peak can be found at 159 dB, which can be related as pile driving noise. The total time of pile driving which can be identified in the range between 148 and 178 dB is 21.6 h. A second example is presented in Figure 1 right. Here the sound pressure level distribution measured between May 1 and May 31, 2010 is shown. Within this time the pile driving at BARD Offshore 1 occurred. The maximum occurrence of background noise (in this context: "not pile driving noise") is at about 120 dB. Furthermore, a rise in the distribution above 128 dB can be observed, which includes distant pile driving noise. The total number of pile driving hours is about 21.7 hours. All data were measured by the sensible hydrophone.

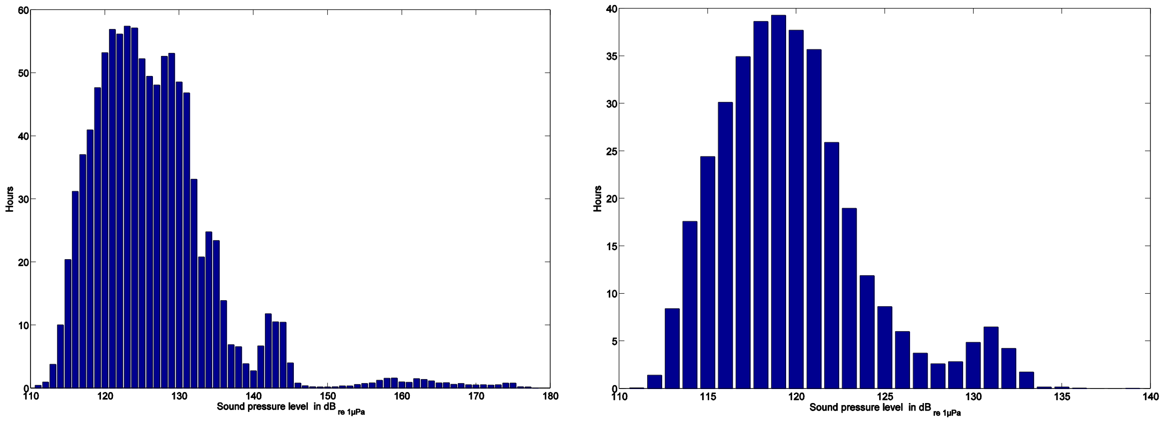

Figure 1 Distribution of Leq (30-second averages) for the time period July 7, 2009 to August 26, 2009 (left) and for May 1 to 31, 2010 (right)

Due to the explosiveness of this topic in Germany an algorithm for the automatic detection is under construction.

3.2 Ship Noise

The small distance of the acoustic monitoring station to the traffic separation system and the activities of the research and working vessels at FINO1 and Alpha Ventus implicate a high amount of detected ship noise at the underwater acoustic monitoring station. Statistical analysis as well as spectral characteristics of measured sounds of ships will be discussed.

3.3 Weather induced Noise

Increasing wind speed and wave heights show an increasing noise level. Figure 2 presents a time series of equivalent continuous sound pressure level, significant wave height and wind speed in 33 m above the sea surface for three days in October 2009. Influences of breaking waves, sea spray and bubble activities due to strong wind and wave action are obvious. These effects and their spectral characteristics will be shown in the presentation in more detail.

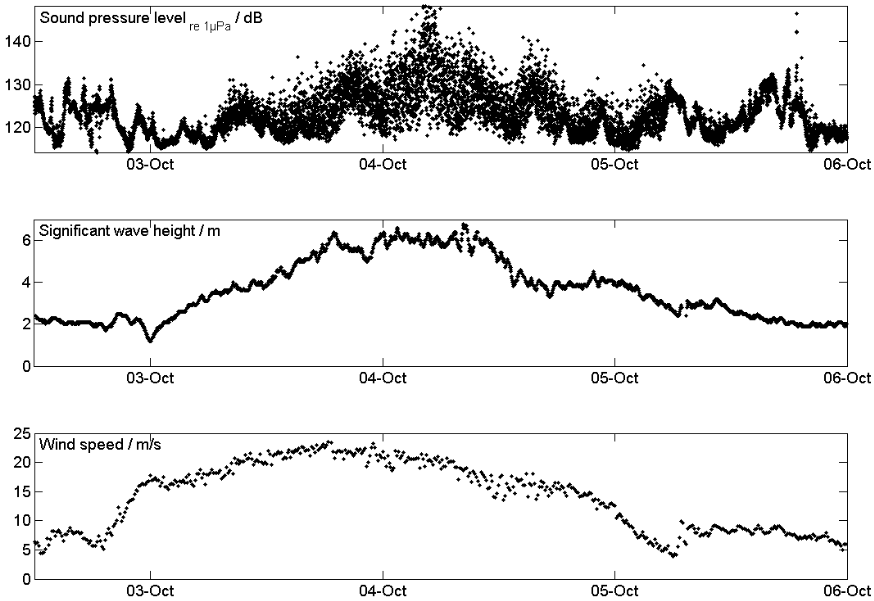

Figure 2 Example of a storm event: Sound pressure level, significant wave height and wind speed from October 2 to 6, 2009

4 CONCLUSIONS AND OUTLOOK

The FINO1 underwater acoustic monitoring station has been working continuously since July 2009 and demonstrates the feasibility of long term hydro sound measurements under hard offshore conditions. The dynamic range of sensors and the recording system allows collecting all kinds of ambient noises like e.g. ship noise, weather induced noise, noise caused by pile driving etc.

The data can be scanned for pile driving sound. A simple “threshold method” used as first attempt can detect noise from wind farm installation works more than 50 km away. Because of the characteristic acoustic finger print of pile driving noise, the automatically monitored area will enlarge by a factor of 2 to 3 applying more sophisticated scanning methods in the future.

The concept for the next DEWI long term underwater sound recording station will be similar, because the high availability of a simple but reliable recording system has been proved. It is planned in the North of the German Bight in order to detect future installation works of wind farms in this region. Furthermore an autarkic buoy for deployment in variable locations is under construction. Amongst other purposes the data is used as input for the research project “Hyprowind”, which aims to develop a prognosis tool for noise emission from offshore wind farm deployment.

Acknowledgements

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