Underwater Noise Monitoring

Pile driving conductor G18-2

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ONE-Dyas

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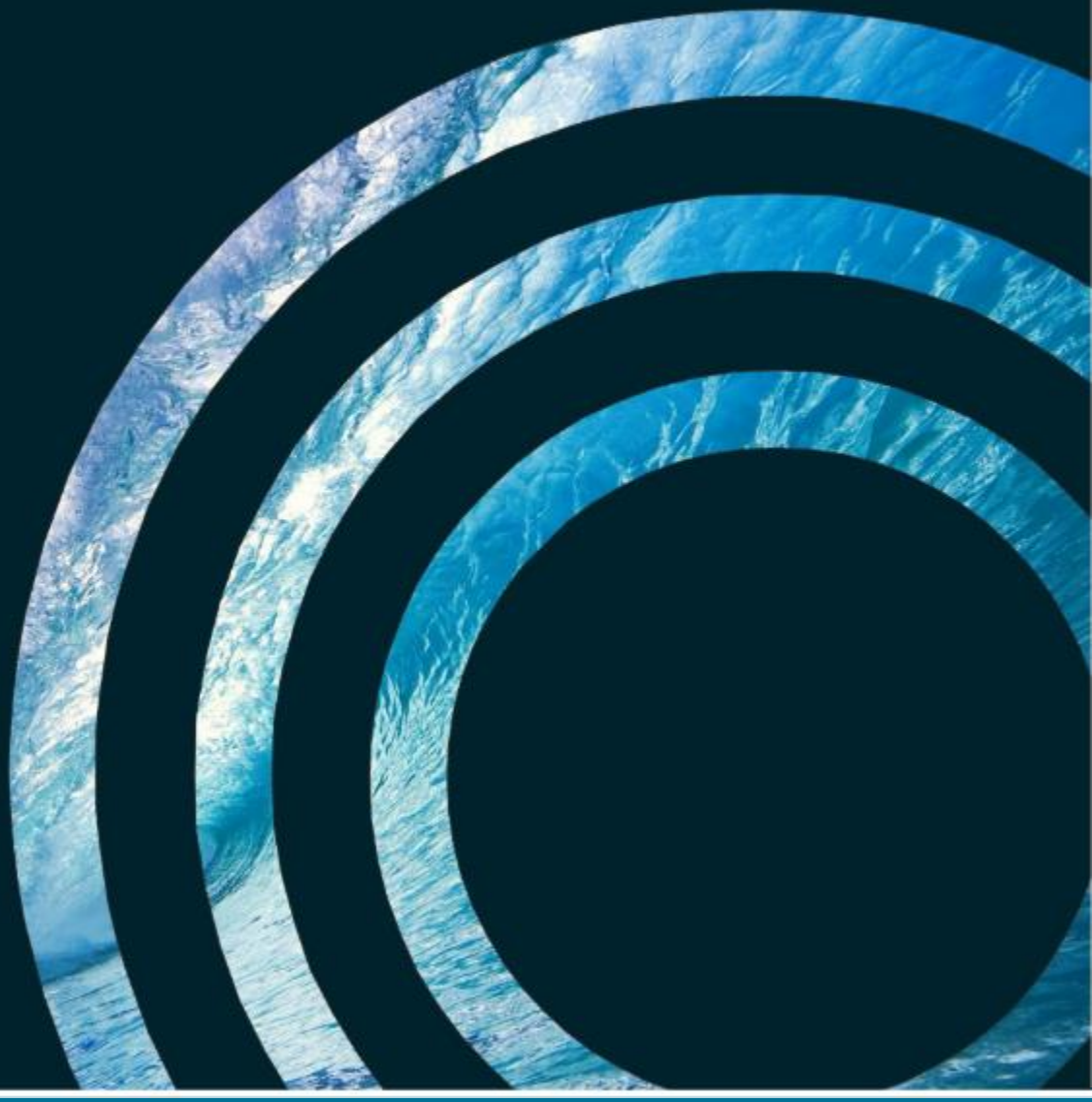

WATER PROOF Marine Consultancy & Services BV.

Title
Underwater Noise Monitoring – Pile driving conductor G18-2

Pile ID:
G18-2

Measurement period:
03-03-2020

Client
ONE-Dyas

Project leader
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TABLE OF CONTENTS

RESULT SUMMARY

Table 0.1 Statistics of the sound exposure levels (SEL) measured at a distance of 750 m from the piling location at during pile driving conductor G18-2.

Pile	Distance (m)	SEL (dB re 1µPa² s)					SPL_{ztp} (dB re 1µPa)
		SEL90	SEL50	SEL5	SEL1	SEL Max	SPL_{ztp} max
G18-2	750	152.5	155.3	157.6	158.5	160.9	191.1
	750	152.4	155.0	157.1	157.9	159.9	190.4

Table 0.1 shows the main results of the acoustic measurements during piling the conductor G18-2. Two different recorders were deployed at the same location at 750 m distance from the pile driving location. The 5% exceedance value for the Sound Exposure Level (SEL5) was 157.1 and 157.6 dB re 1µPa^2 s, maximum SEL measured was 160.9 dB re 1µPa^2 s. The maximum SPL zero-to-peak was 191.1 dB re 1µPa.

1 INTRODUCTION

ONE-Dyas BV plans exploratory drilling activities in the North-East of the Dutch North Sea. These activities include the installation of a conductor by means of pile driving. Pile driving activities at sea result in high noise levels underwater and can cause injuries or disturbance to marine life. ONE-Dyas therefor requested WaterProof BV to measure and report underwater noise levels during pile driving activities. Measurements were conducted at 750 m to gain insight in the propagation loss up to this distance and to compare the results with the German and Dutch noise thresholds. The German thresholds are currently lower, with a noise threshold of 160 dB for the five percent exceedance value of the Sound Exposure Level (SEL) and a maximum of 190 dB for the zero-to-peak Sound Pressure Level (SPL_{ztp}), both defined at 750 m from the source.

This report presents the results of underwater noise measurements during the installation of the conductor G18-2, measured at 750 m from the respective geometric centre of the pile. Pile-driving took place at 03-03-2020.

Figure 1.1 Impression of offshore site with (left) the ENSCO 121 rig from which the conductor was installed and (right) view from the vessel Energy Duchess that was used to deploy the instruments.

2 MEASUREMENT PROCEDURE

2.1 DATE AND PLACE

The measurements were conducted from 02-03-2020 21:30 CET until 03-03-2020 21:00 CET in the North-East of the Dutch North Sea (Figure 2.1).

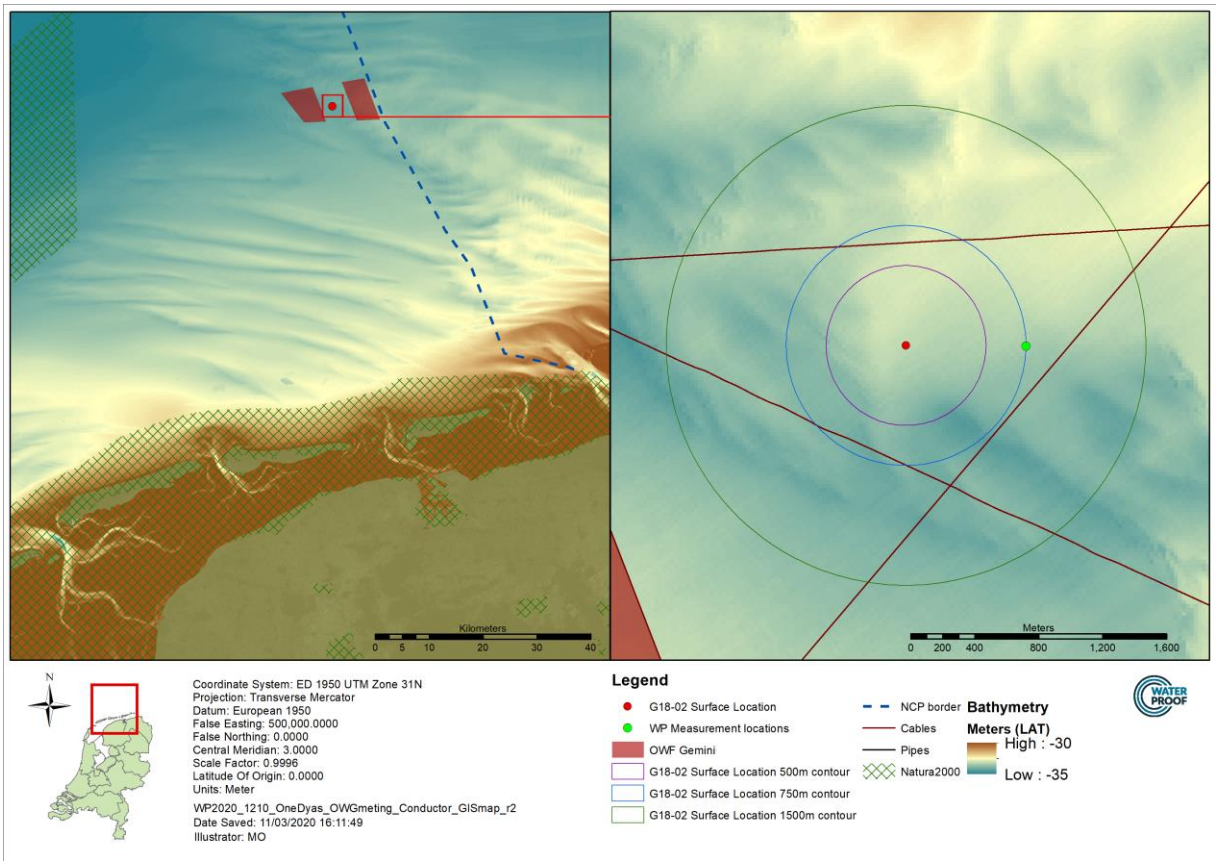

Figure 2.1 Location of the field site (left) with the measurement location in more detail (right).

2.2 MEASUREMENT EQUIPMENT

Measurements were collected with two different recorders (Table 2.1), both at the same location for contingency. The two recorders were manufactured by Turbulent Research (TR) and RTsys and were deployed at a height of 3.5 and 2.5 m above the bed, respectively. Recording was set at a sampling frequency of (TR) 48 kHz and (RTsys) 78 kHz to capture dynamics up to at least the deci-decade frequency band with a center-frequency of 20 kHz. Instruments were recently (19-11-2019) calibrated over the frequency range 10 Hz – 20 kHz in an anechoic basin at TNO.

Table 2.1 Overview of the equipment used for this report.

Recorder ID	Recorder type & serial number	Hydrophone	Hydrophone sensitivity	Calibrated
AR01	TR Porpoise SN90	Internal	-200 re 1 V/ µPa	19-11-2019 (TNO)
AR02	RTsys EA-SDA14 SN1612016	HTI-96min SN785160	-204 re 1 V/ µPa	19-11-2019 (TNO)

2.3 MEASUREMENT PROCEDURE

The instruments were deployed and retrieved from supply vessel Energy Duchess. Coordinates showing the location of the instruments at the time of deployment are given in Table 2.2 and the position is represented graphically in Figure 2.1.

Table 2.2: Coordinates (ED50 UTM 31N) of the noise measurement location for the recorders.

Distance from piling (m)	Measurement location (Anchor 1)		Surface buoy (Anchor 2)	
	X	Y	X	Y
750	694766.6	5991098.1	694758.21	5990997.5

The measurement set-up consisted of two autonomous acoustic recorders that were elevated from the anchor using a subsurface float (Figure 2.2). This anchor was subsequently connected to a second anchor by 100 m line. The second anchor is connected to a surface buoy for deployment and retrieval of the system.

All instruments were checked prior to and after deployment with a basic functionality test using a G.R.A.S. pistonphone (s.n. number 227959) at 250 Hz. The raw noise data that was collected was listened to and visually inspected to assess the data quality.

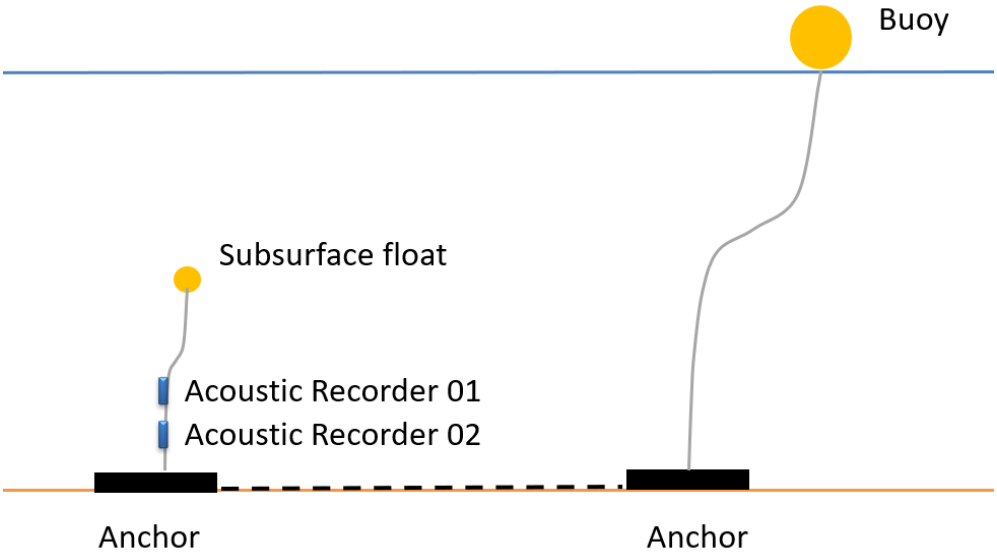

Figure 2.2 Measurement set-up with two anchors separated approx. 100 m. Two acoustic recorders (AR01 & AR02) were deployed along the same line for contingency.

2.4 DATA PROCESSING AND ANALYSIS

The raw voltages were converted to a sound pressure waveform using the frequency-dependent sensitivity of the measurement device, as measured in the calibration basin by TNO (Section 2.2). Data was subsequently filtered with a high-pass filter of 5Hz, to filter out low-frequency sound or disturbances by tidal flow and waves. Peaks in the sound pressure timeseries that represent the piling blows were identified using a peak detection algorithm. The start and end of these peaks were identified in one-second windows where the cumulative energy was 5 and 95% respectively. This is a robust method to define the start and end of a peak and separate peaks in the sound pressure timeseries that are related to piling blows.

Several properties were calculated for the identified peaks in the timeseries. The single-strike Sound Exposure Level (SEL_{ss}) in dB re 1 µPa^{2}s was calculated for each peak individually as:

$$SEL_{ss} = 10log_{10}\left(\frac{E}{E_{ref}}\right),$$

in which E is the sound exposure in µPa^{2}s and E_{ref} is 1 µPa^{2}s. The single-strike SEL is normally used to quantify the possible impact of impulsive noise on marine mammals and legal noise thresholds are thus often based on this parameter. All sound exposure levels calculated here are unweighted. The zero-to-peak sound pressure level (SPL_{ztp}) is also calculated for each piling blow and is the maximum magnitude in sound pressure in the peak window.

Besides these properties of the individual peaks in the time series, the equivalent sound energy (L_{eq}) in dB re 1 µPa s was calculated over the decidecade bands between 10 Hz and 20 kHz in blocks of 10 seconds. This property gives more insight in the frequency content of the noise levels and indicates whether the sound exposure levels of the piling blows are sufficiently elevated above the background noise (at least 10 dB).

3 PILING PROCEDURE & ENVIRONMENTAL CONDITIONS

The conductor with a diameter of 30 inch (76.2 cm) was installed by means of pile driving from the Ensco 121 rig (Table 3.2). The conductor reached a penetration depth of 53.62 m after a gross duration of 8 hours and 39 minutes (Table 3.1). The piling energy was ramped up from 10 kJ up to 90 kJ over the approximately first 4 hours and kept at 90 kJ for the rest of the piling period (Figure 4.1).

Prior to piling, three ADD's (specifications listed in Table 3.3) were deployed to deter marine mammals from the monitoring location. All three ADD's were also active during piling.

Table 3.1 Piling time

Piling start (CET)	Piling end (CET)	Gross duration
03/03/2020 02:07	03/03/2020 10:46	8h39m

Table 3.2 Details on the piling procedure

Piling procedure		
Well name	G18-2	
Pile diameter	30 inch (76.2 cm)	
Used noise mitigation	none	
Maximum piling energy	90 kJ	
Foundation coordinates (ED50 UTM31N)	694020 E	5991102 N
Rig name	Ensco 121/E121	

Table 3.3 ADD specifications

Dolphin Anti-Depredation Pinger (40kHz)
Frequency – 40kHz
Battery Life – 175 hours
Dimensions – 185mm x 52mm x 42mm
Weight (with battery) – 229 grams
Space the pinger every 75-100m
Sound level 175dB +/- 3dB @ 1m

The weather conditions during the measurements were high energetic during deployment of the instruments, but decreased during the piling procedure, with wind speeds decreasing from 30 to 5 knots and the sea state decreasing from 5 to 3 (Table 3.4).

Table 3.4 Environmental conditions during pile driving operations.

Environmental conditions	
Water depth	33 m
Wind speed	30 to 5 knts
Sea state	5 to 3
Rain	Partially

4 RESULTS

The Sound Exposure Level (in dB re 1µPa^{2}s) and the zero-to-peak Sound Pressure Level (in dB re 1µPa) of the individual blows at one of the recorders are shown in Figure 4.1. The SEL increases from approximately 147-156 at the start of the piling procedure up to 154 to 160 dB re 1µPa^2 s when piling energy was increased to 90 kJ. The equivalent sound energy in periods in between piling was always more than 10 dB lower than the sound exposure levels, around 140 dB at the start of the piling period, decreasing to 130 dB re 1µPa^{2}s between 6:00 and 7:00 AM. The results from the second recorder are not shown, but are within 1 dB difference (see also Table 4.1 and Table 4.2).

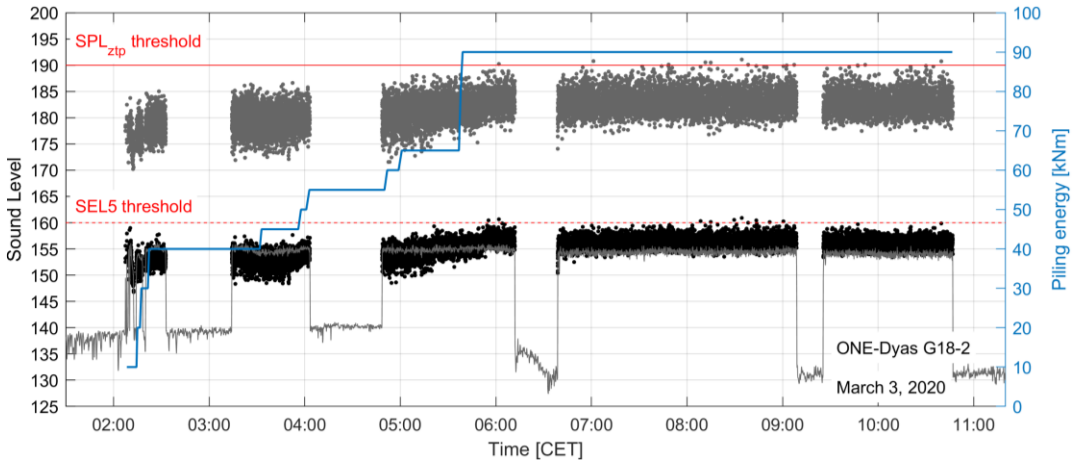

Figure 4.1: Broadband Sound Exposure Levels (black dots, SEL) and the zero-to-peak Sound Pressure Levels (grey dots, SPL_{ztp}) of the individual blows at 750 m for the entire piling duration. The red horizontal lines indicate noise thresholds in Germany, with (dashed line) the 5% exceedance SEL threshold level and (solid line) the max. SPL_{ztp} threshold. The grey line represents the equivalent sound energy calculated over blocks of 10 seconds of data. The blue line represents the estimated piling energy.

To explore the range in SEL_{ss} values, the 90, 50, 5 and 1 percent exceedance values and the maximum value were calculated (Table 4.1). The 5 percent exceedance value (SEL5) is used in Germany to define the noise threshold that should not be exceeded at 750 m from the source. The SEL5 threshold is 160 dB re 1µPa^{2}s and would thus not be exceeded with the current piling operation. The SPL_{ztp} threshold is 190 dB re 1µPa in Germany, and would have been exceeded if piling occurred in Germany, maximum measured SPL_{ztp} was 191.1 dB re 1µPa. Only 10 and 1 blow(s) (AR01 and AR02, respectively) exceeded this threshold, out of approximately 16.000 blows in total. In the Netherlands, the maximum SEL value is used as a threshold and is between 163 and 170 dB re 1µPa^{2}s depending on the season and the amount of piles installed.

Table 4.1 The statistics for single-strike sound exposure level, SEL_{ss}, and zero-to-peak Sound Pressure Level, SPL_{pp}, at 750 m for both recorders. The Nth percentile gives the level that is exceeded n% of the time.

Recorder	Distance (m)	SEL_{ss} (dB re 1µPa^2 s)					SPL_{ztp} (dB re 1µPa)
		90	50	5	1	Max	Max
AR01	750	152.5	155.3	157.6	158.5	160.9	191.1
AR02	750	152.4	155.0	157.1	157.9	159.9	190.4

Table 4.2 The Nth percentile exceedance levels for the equivalent sound energy calculate over blocks of 10 seconds.

Recorder	Distance (m)	L_{Eq} (dB re 1µPa² s)		
		90	50	5
AR01	750	135.5	154.1	155.3
AR02	750	135.3	154.1	155.3

The background noise level, which is exceeded 90% of the time during the measurements, is 135.3 (135.5) dB re 1µPa²s (Table 4.2). This background level is mainly related to the nearby presence of the supply vessel Energy Duchess, which was on standby close to the rig throughout the piling procedure.

The sounds produced by the ADD's did not contribute to the background noise levels. The pings emitted by the ADD's have a frequency of 40 kHz, much higher than the frequencies of pile-driving noise and outside the frequency range that was recorded for this project.

The equivalent sound pressure levels over the deci-decade bands between 10 Hz and 20 kHz show that the sound energy of the pile driving noise was mainly between 125 and 3000 Hz (Figure 4.2).

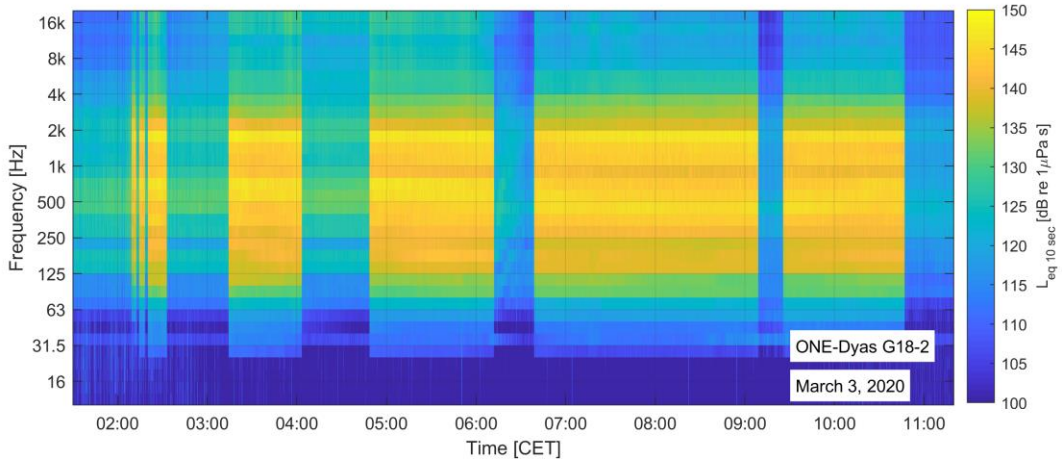

Figure 4.2 Equivalent sound pressure levels (L_{eq}) calculated over 10 seconds of data and for each deci-decade frequency band between 10 Hz and 20 kHz. In this figure, values from acoustic recorder 1 are shown.

5 CONCLUSION NOISE MONITORING

Noise monitoring measurements were conducted during the installation of conductor G18-2 in the Dutch North Sea, at a distance of 750 m from the centre of the conductor. The 5% exceedance value of the Sound Exposure Level (SEL5) was up to 157.6 dB re 1µPa^2 s, while the maximum SEL was 160.9 dB re 1µPa^2 s. These values are well below the noise threshold at 750 m imposed by Germany (SEL5 = 160 dB) and the Netherlands (SEL_{max} =163 - 170 dB, depending on season and the amount of piles installed). The maximum zero-to-peak Sound Pressure Level (SPL_{ztp}) was 191.1 dB re 1µPa, and is higher than the German threshold of 190 dB. The amount of blows higher than this threshold was very limited, 10 out of approximately 16.000 blows exceeded this threshold.