Nord Stream 2 Natural Gas Pipeline construction and operation in the Finnish EEZ Environmental and Technical Monitoring Quarterly Report Q2 2018

Date	24.9.2018
Project	PO 17-5149
Client	Nord Stream 2 AG
Document ID	W-PE-EMO-PFI-RQU-892-RQU218EN-06

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Summary

The report presents results and preliminary findings of the environmental and technical monitoring for construction activities of Nord Stream 2 Gas Pipeline in the Finnish EEZ for the second quarter 2018. Monitoring is based on the report Natural Gas Pipeline Route through the Baltic Sea – Environmental Monitoring Programme, Finland by Nord Stream 2 (W-PE-EMS-PFI-REP-805-032300EN-11). The programme has been approved on 12.4.2018 within the water permit decision (Nro 53/2018/2, Dnro ESAVI/9101/2017).

Sitowise Oy prepared this report based on data and reports provided by Nord Stream 2 AG and monitoring contractors. All findings are preliminary and final conclusions will be reported in annual report for 2018 to be published in May 2019.

The construction activities during the second quarter were munitions clearance, the first campaign of rock placement and pre-installation surveys for mattress installation.

The munitions clearance was successfully completed in the second quarter. The charge of munitions was either comparable to the charge presented in the permit application or smaller.

The area where the permanent threshold shift (PTS) level (risk of permanent hearing damage) of marine mammals was reached was significantly smaller than was assessed to in the permit application in all 3 vessel based munitions clearances. The PTS level was not reached within any of the adjacent Natura 2000 areas.

NSP2 has decided to conduct sampling of sediment contaminants and explosive residuals for 2 munition clearances. The sediment toxicity analysis at munition clearance locations showed no residuals of explosives exceeding the laboratory detection limits.

The first water quality analysis will be carried out during Q3.

A wreck inspection survey for the monitoring object S-R05-7978 and an anti-submarine net verification survey for monitoring object S-R09-09806 were performed in early May 2018.

Content

Annexes

Annex 1 Luode Consulting Oy 2018. Interim report of underwater noise monitoring during munition clearance in the Finnish EEZ. W-GE-EMO-PFI-REP-812-UWNIREEN-05

Annex 2 Nord Stream 2 construction activities during Q2/2018

1 Introduction

The report presents results and preliminary findings of the environmental and technical monitoring for the construction activities of Nord Stream 2 Gas Pipeline in the Finnish EEZ for the second quarter (Q2) of 2018.

Nord Stream 2 AG has started construction activities for a new two-pipeline offshore natural gas system from Russia to Germany through the Baltic Sea (Figure 1). The length of the corridor is approximately 1,200 km. Parallel pipelines pass through the territorial waters and/or Exclusive Economic Zones (EEZ) of Russia, Finland, Sweden, Denmark and Germany. In the Finnish EEZ the route follows the existing Nord Stream pipeline route. The length of the route in the Finnish sector is approximately 374 km. Pipelay of Line A started on the 5th of September 2018 and Pipelay of Line B is scheduled to start in 2019. Both lines are planned to be ready by the end of 2019, after which the pipelines are planned to be taken into operation.

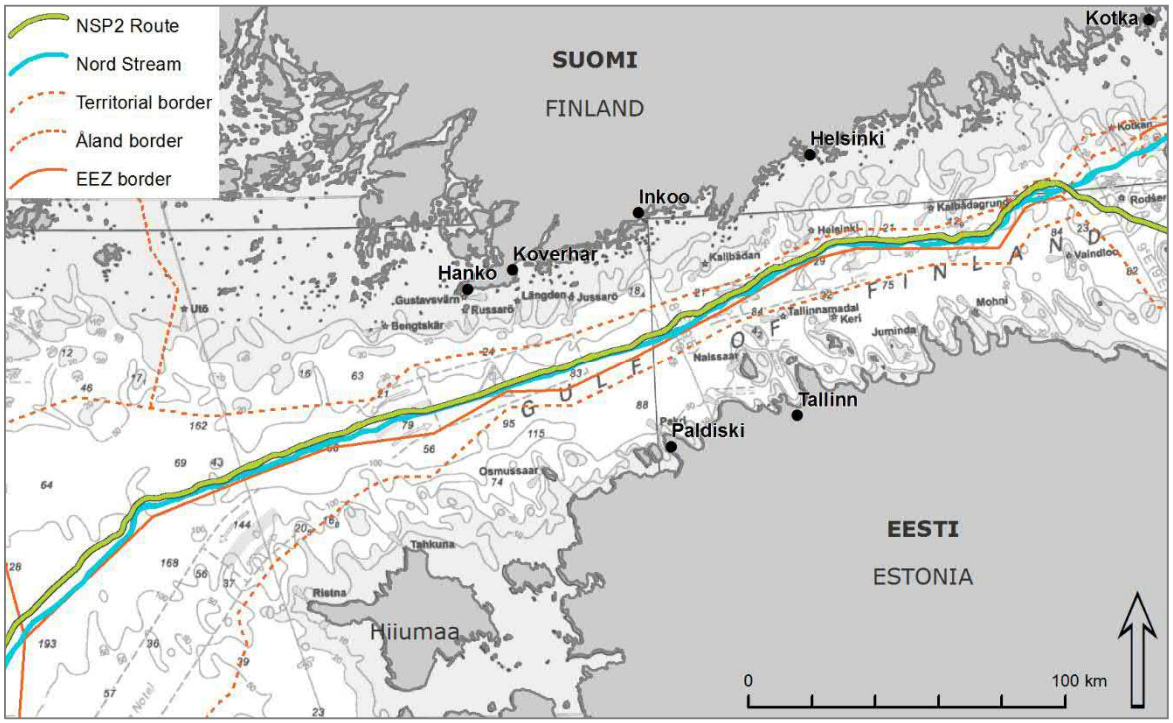


Figure 1. Nord Stream 2 route passes through the Finnish EEZ.

Nord Stream 2 AG is responsible for environmental monitoring and reporting during construction and operation of the pipelines. The content of monitoring is presented in the report Natural Gas Pipeline Route through the Baltic Sea – Environmental Monitoring Programme, Finland (W-PE-EMS-PFI-REP-805-032300EN-11, Ramboll 1.2.2018). The programme has been approved within the water permit decision 12.4.2018 (N:o 53/2018/2, Dnro ESAVI/9101/2017).

Monitoring is most intensive during the construction phase (Table 1).

Table 1. General schedule for monitoring activities 2018–2023 in the Finnish EEZ (based on Ramboll 2018, modified).

Monitoring target	Construction		Operation			
	2018	2019	2020	2021	2022	2023
Underwater noise	X					
Water quality and currents	X	X				
Commercial fishery					X	
Cultural heritage	X		X			

The supervising authorities for monitoring of underwater noise, turbidity and water quality are the regional ELY-Centres (The Centres for Economic Development, Transport and the Environment). For fishery monitoring, the supervising authority is Southwest Finland ELY-Centre. For cultural heritage, the supervising authority is National Board of Antiquities.

Quarterly reports will be provided three months after the end of the quarter during the construction period, and annual reports by the end of May the following year during construction and during operation.

Quarterly reporting aims at presenting the main results from technical and environmental monitoring to authorities. For this reason, they are concise and focused on results. Annual reports will include further data analysis, comparisons to the impact assessments presented in the EIA Report and the permit application and more thorough discussion on the observed impacts.

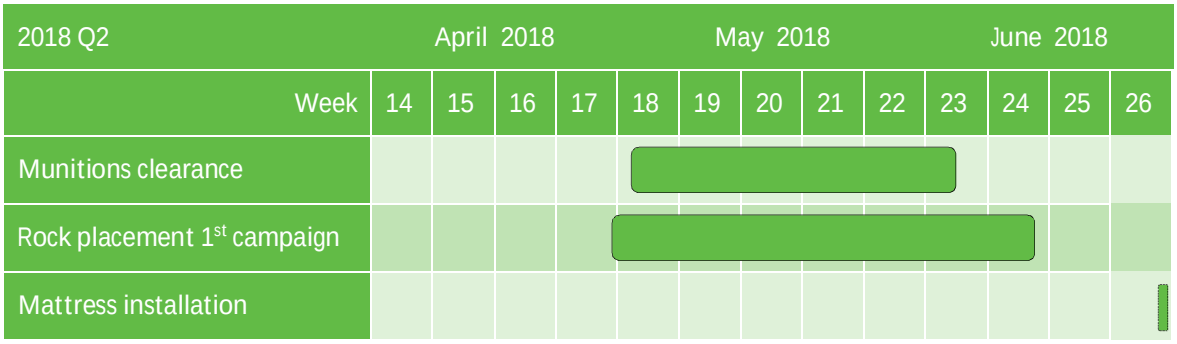
2 Construction activities during the second quarter

2.1 Schedule

The construction activities during the second quarter were munitions clearance, the first campaign of rock placement and pre-survey for mattress installation (Table 2). Munitions clearance started in the beginning of May and was completed in early June (3.5–6.6.2018). First rock placement campaign started in Finland 29.4 and ended 15.6.2018. The mattress installation at pipeline and cable crossings started 30.6.2018 with pre-installation surveys. The actual installation of mattresses started on the 1.7.2018 and will be reported in the Q3 report.

The second rock placement campaign is planned to start in August 2018. The pipelay (Line A) started on 5.9.2018. Line B is planned to be laid in 2019. Both lines are planned to be ready by the end of 2019, after which the pipelines are planned to be taken into operation.

Table 2. Construction activities during Q2 2018.



2.2 Activities during the period

Munition clearance

The scope of work included clearance and/or disposal of unexploded ordnance (UXO) at the locations identified by Nord Stream 2 and for any further "chance finds" located during the work and which could endanger the safe construction and operation of the pipelines. The results of the clearance works are presented in the contractor reports (MMT Sweden AB 2018 - W-SU-UXO-PFI-REP-808-EODSUREN-01, and N-Sea/BODAC - W-SU-UXO-PFI-REP-831-GEOFRREN-01). The removal of the unexploded ordnance was scheduled to ensure that areas are cleared prior to commencing rock placement and pipelay.

The work was divided between two companies MMT/Ramora and N-Sea/Bodac. Out of 87 planned clearance targets 15 were found not to be munitions. Additionally, 2 chance finds were cleared making the total number of detonated unexploded ordnance 74 (Table 3).

Bubble curtains were used to reduce or attenuate the acoustic noise from the detonation to mitigate noise levels based on the following criteria:

- if the total net explosive quantity (NEQ)* of target was >22 kg,

- within a sensitive marine environment (i.e. east of GKP 174)
- or requested by a cable owner with a cable within 500 m security corridor

During munition clearance the contractors were responsible for the implementation of mitigation measures in line with Great Britain's Joint Nature Conservation Committee (JNCC) guidelines.

To minimise the risk of injury to marine mammals from the explosives, a mitigation zone was established, where deployment of Acoustic Deterrent Devices (ADD), Passive Acoustic Monitoring (PAM) and Marine Mammal Observer (MMO) observations were conducted. ADD's were deployed around the UXO in a cardinal point configuration.

MMO was observing for minimum of one hour at 1 to 2 km radius from the detonation site. According to the guidelines, explosion would take place only if no marine mammals was observed during the last 20 minutes of the minimum of one-hour watch. No visual or other record of marine mammals in the mitigation zone were made.

Detonation was taking place only if no bird flocks or fish schools were detected/seen at the detonation site.

The charge of the munitions was either comparable to the charge presented in the permit application or smaller (Table 3). The duration of the munition clearance campaign was shorter than planned because objects were reassessed as not munitions and therefore did not require clearance. In addition, the weather conditions were favourable allowing uninterrupted operation, including clearance of more than one munition object a day on several occasions.

Table 3. Munition clearance campaign 3.5.-6.6.2018 including the work of MMT/Ramora and N-Sea/Bodac.

	Planned	Actual	Difference between planned and actual
Munitions clearances	87 No.	74 No.	15 objects were found not to be munitions*, 2 chance finds added
Bubble curtain use	80 No.	58 No.	26 munitions had total NEQ** smaller than 22 kg and of these, 16 were cleared without bubble curtain. In addition15 were not munitions and therefore did not require clearance.
Donor charge	15 kg	2,5 – 10 kg	The donor charges were 10, 5 or 2,5 kg, out of which 5 kg was most commonly used.
Charge	2 – 795 kg	0,5 – 300 kg	The total NEQ of all munitions was either smaller or equal to the estimated values. Small increases in munition sizes (max of 4 kg) were compensated by the use of smaller donor charge.

* 1 object was not found, 1 was left in situ, 13 were recovered to the deck
** the total net explosive quantity NEQ (munition charge plus donor charge)

During the munitions clearance campaign two chance finds were added to the scope. These were identified through additional inspections of previously identified targets. One was identified as Russian depth charge of 25 kg charge, and the other as a Russian fish mine of a 10 kg charge. Both were previously interpreted as boulders in July 2016 survey. Rerouting of the pipelines was not feasible because of uneven sea bottom.

The sediment displacement through the detonations exceeded 5 m^3 at 10 targets, the biggest displacement being 30,8 m^3 (R-R09-7495). The Environmental impact assessment on Munition by Munition basis (updated April 2018, W-PE-EIA-PFI-REP-999-MBYM00EN-08) indirectly indicated bigger effect for this object. The sediment release was assessed to be 190,3 tonnes equal to 127 m^3 (10% clay, 90% hard sediment). The largest sediment displacement mass was estimated to be 368,6 t with the munition item R-R12-10082. The actual displacement volume was significantly less, 12 m^3.

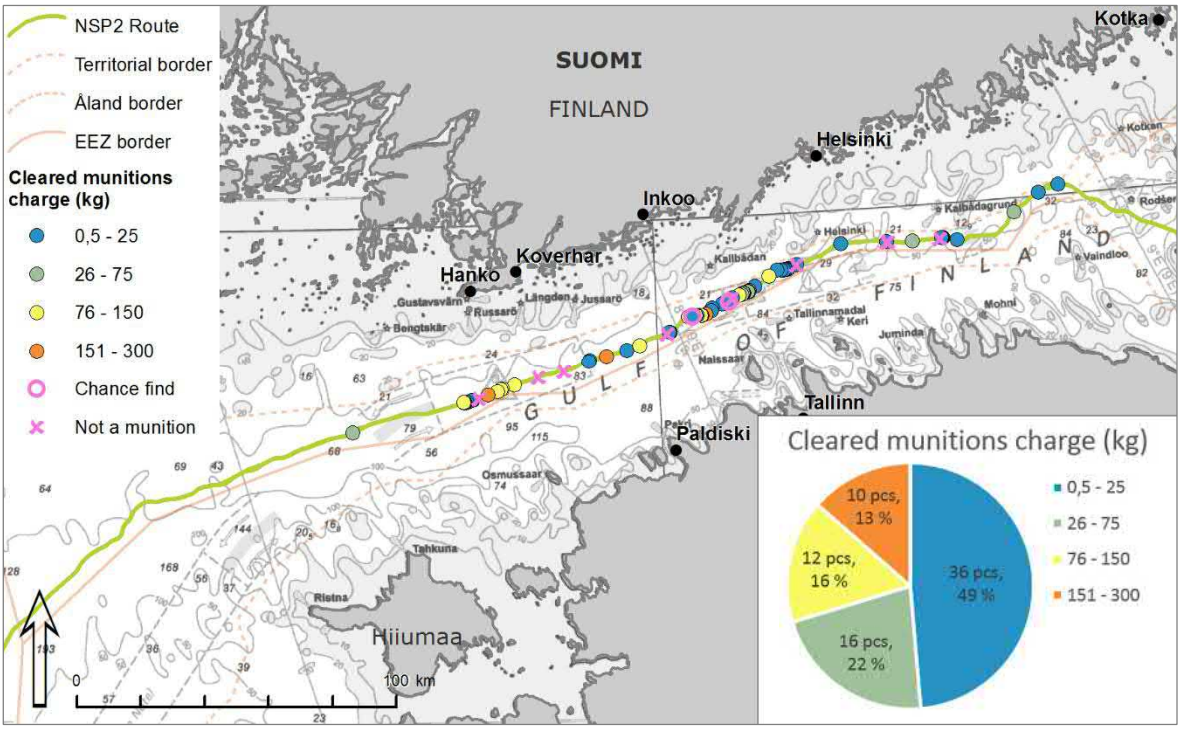


Figure 2. Total number of cleared munitions was 74. During the clearance 15 expected munition objects were found not to be munitions. Also 2 chance finds were discovered.

Rock placement

The first rock placement campaign took place from 29.4 to 15.6 between Inkoo and Russian border (GKP 122–237) (Figure 3). Rock placement was done for both Line A and Line B. NSP2 has accepted and approved certificates of all 44 installed berms.

The total mass of rock placement in the first campaign was 313 842 tonnes, which is equivalent to 200 847 m^3.

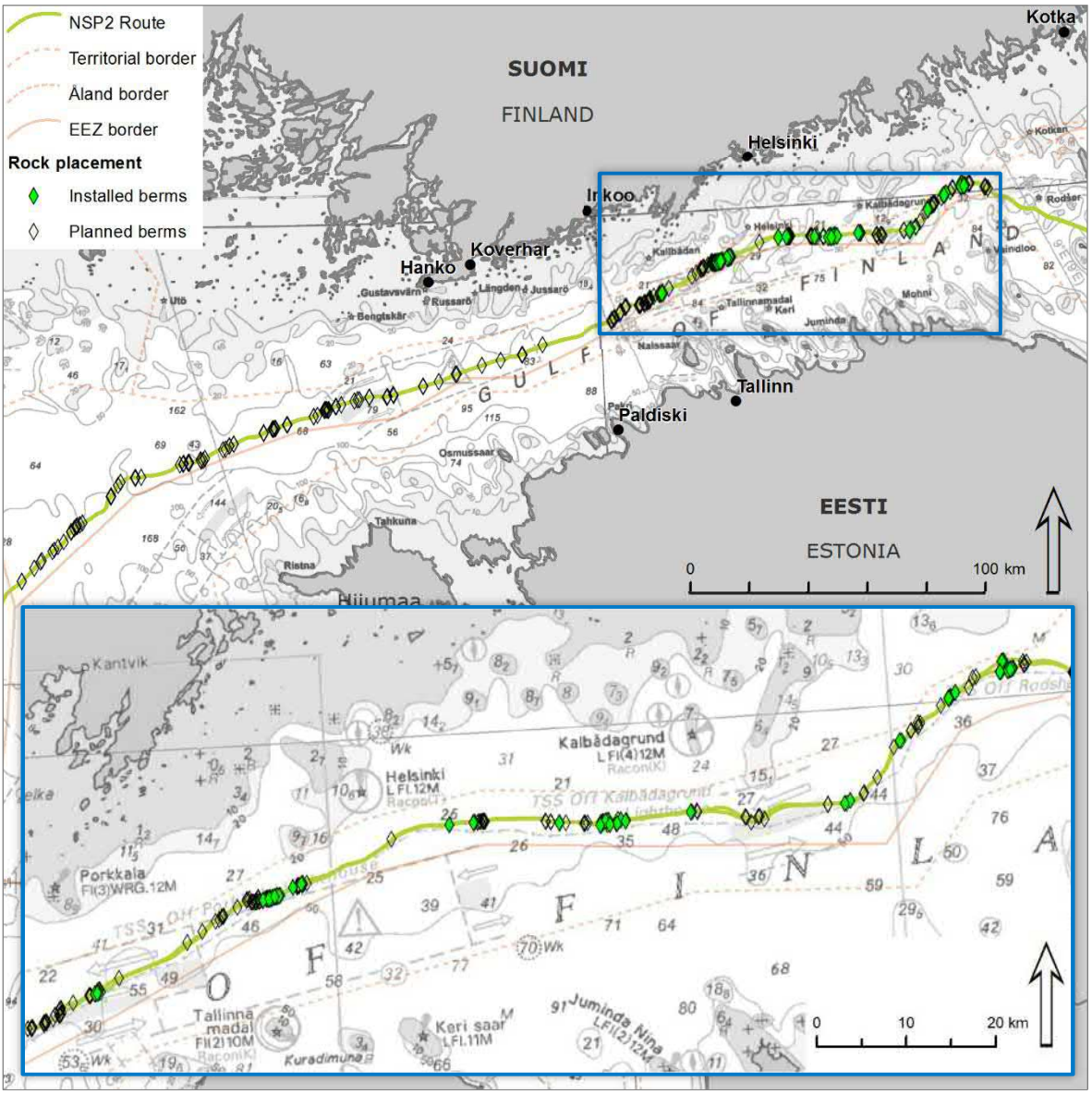


Figure 3. The first rock placement campaign. The lower map shows the area marked with the blue frame in more detail.

Mattress installation

Mattresses installation started in Finland on the 30.6 with the pre-installation surveys. The actual installation of mattresses started on the 1.7 and will be reported in Q3 report 2018.

3 Underwater noise

3.1 Monitoring activities

Underwater noise measurements were carried out according to the Environmental Monitoring Programme Finland, by Luode Consulting Oy. The monitoring consisted of 8 fixed long-term monitoring stations covering practically the whole Gulf of Finland, and vessel based on-site monitoring of 3 selected munitions clearance operations (Table 4).

Table 4. Munitions monitored with vessel based campaigns.

ID	Classification	Nationality	Predicted in permit application [TNT kg]	Clearance contractor re-evaluation [TNT kg]
R-R05-7058	Grenade	Russian	40	7
R-R06-20716	Depth Charge	Unknown	180	40
R-R09ALT1-20117	EMC-1	German	300	300

The long-term stations were installed between 17–24.4.2018 and serviced between 15.-26.5.2018 when the data was downloaded for further analysis. The available data covers approximately the first month of the munitions clearance operation. The final report of underwater noise monitoring will be finished during Q3.

Two main indicators were calculated based on the records:

- Peak Sound Pressure Level (SPL) is the maximum sound pressure level that is measured during the noise event. It is in units of dB.
- Permanent Threshold Shift (PTS) describes the sound pressure level that causes an increased risk of onset of permanent damage for hearing. For marine mammals this level is 179 dB. PTS is often presented as the area where the 179 dB level is exceeded. It can also be presented as the maximum distance from the sound source where the 179 dB level is still reached.

Calculation of PTS requires measurements also in the vicinity of the sound source. These measurements were available for the 3 vessel based monitored munitions clearance sites. In addition, the clearance operators carried out their own on-site measurements around other clearance sites. These measurements will be available for further assessment during Q3.

3.2 Results

In the data collected at the long-term monitoring stations, 24 munitions clearance events were detected and analysed. Because the same clearance event was measured on several stations, altogether 84 separate peak SPLs were detected. When compared to the modelled values in the permit application, 83 out of 84 measured peak SPLs were at or

below the modelled range (Figure 4). Only one measured peak (R-R09ALT1-20117 at 500 meters) was 5 dB higher than the modelled value. This took place well within the estimated influence area of the ADD's. The probability for the occurrence of marine mammals increases with increasing distance from the munition. However, all the measured SPLs were clearly below the modelled values within the 5–120 km range.

There is increasing variation in the measured peak SPLs with increasing distance which was not found in the model results. Bottom topography was estimated to be the main reason for this. Islands and shallow areas effectively break the SPLs. Thus the Finnish shallow archipelago was sheltered more effectively than the deeper Estonian coastline which typically has no islands.

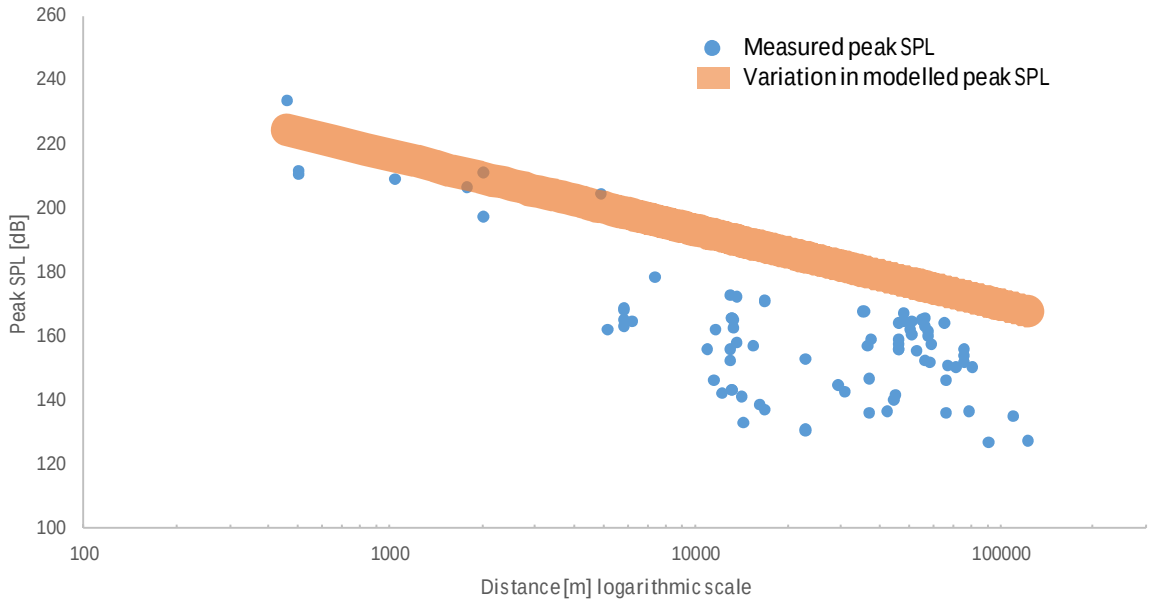


Figure 4. Peak sound pressure levels (SPL) from munitions clearance measured both by long term measurement stations and by vessel based stations. The SPL levels used in the permit application are based on modelling. They are presented as an area which covers the variation in the model results.

The area where the risk of onset of PTS level for marine mammals was reached was significantly smaller than it was assessed to be in the permit application in all 3 vessel based monitored munition clearances (Figure 5). The PTS level was not reached within any of the adjacent Natura 2000 areas.

In the case of the two smaller vessel based monitored munitions, the munition appeared to be of a smaller charge size than predicted (Table 4). The size of the largest munition (300 TNT kg) was not changed in the clearance contractor re-evaluation. However, even in the case of the largest munition, there was a significant decrease in the PTS area compared to the permit application. It is possible that the use of a bubble curtain around the cleared

munition was more effective than predicted in the modelling. In addition, munitions were old and may have had a low order detonation rather the assessed high order detonation.

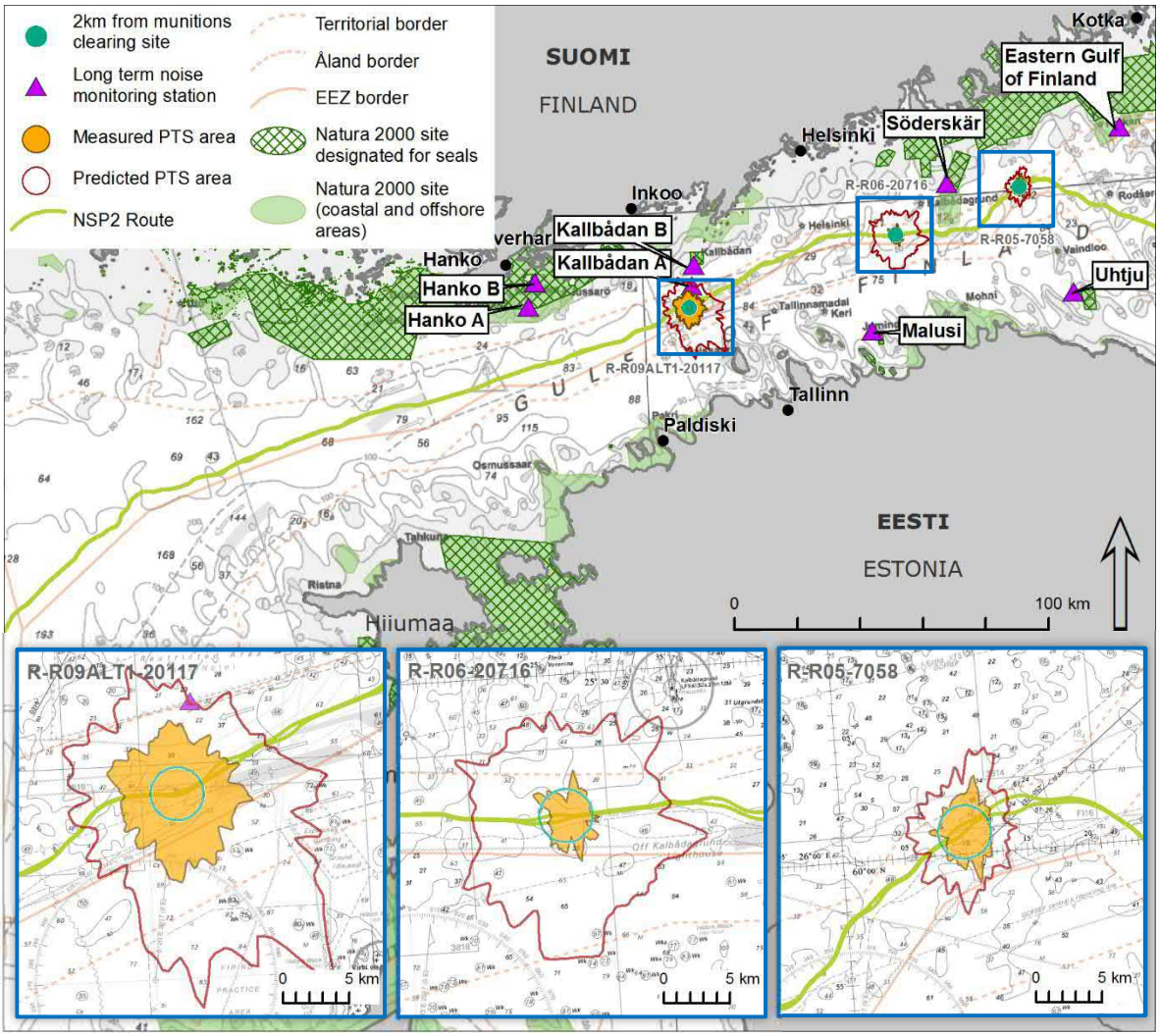


Figure 5. The map shows both the areas where the PTS levels for marine mammals was assessed to be reached in the permit application (predicted PTS area), and the actual measured areas (measured PTS area). The data for measurements was collected at 3 vessel based monitored munition clearance sites on 6– 8.5.2018.

4 Water quality and currents

4.1 Monitoring activities

Water quality and current velocity was monitored according to the approved Environmental Monitoring Programme Finland, at 6 sites by Luode Consulting (Table 5 and Figure 6). The sites were equipped with profiling current meters measuring flow speeds and directions in separate depth layers covering the whole depth range from the bottom to the surface. Water quality monitoring includes turbidity, dissolved oxygen, salinity and temperature measurements at three depth layers near bottom.

During Q2, two of the sites were located at munition clearance sites, one on a pre-lay rock placement site and one in the Sandkallan protected area relatively close to the munition clearance and rock placement sites. In addition, two control stations were set up in the Western and Eastern Gulf of Finland. The same control locations were used during the Nord Stream pipeline construction. First data analysis will be available during Q3. One additional monitoring site will be installed during Q3 to observe rock placement activities.

Table 5. Water quality and current velocity monitoring sites.

	Installed	Recovered
Munitions clearance 1 (R-R09ALT1-20467)	9.5.2018	
Munitions clearance 2 (R-R12-10513)	23.5.2018	21.6.2018
Sandkallan protected area	18.4.2018	
Rock placement 1 (FI-A1001)	18.4.2018	
Control 1	17.4.2014	
Control 2	18.4.2014	

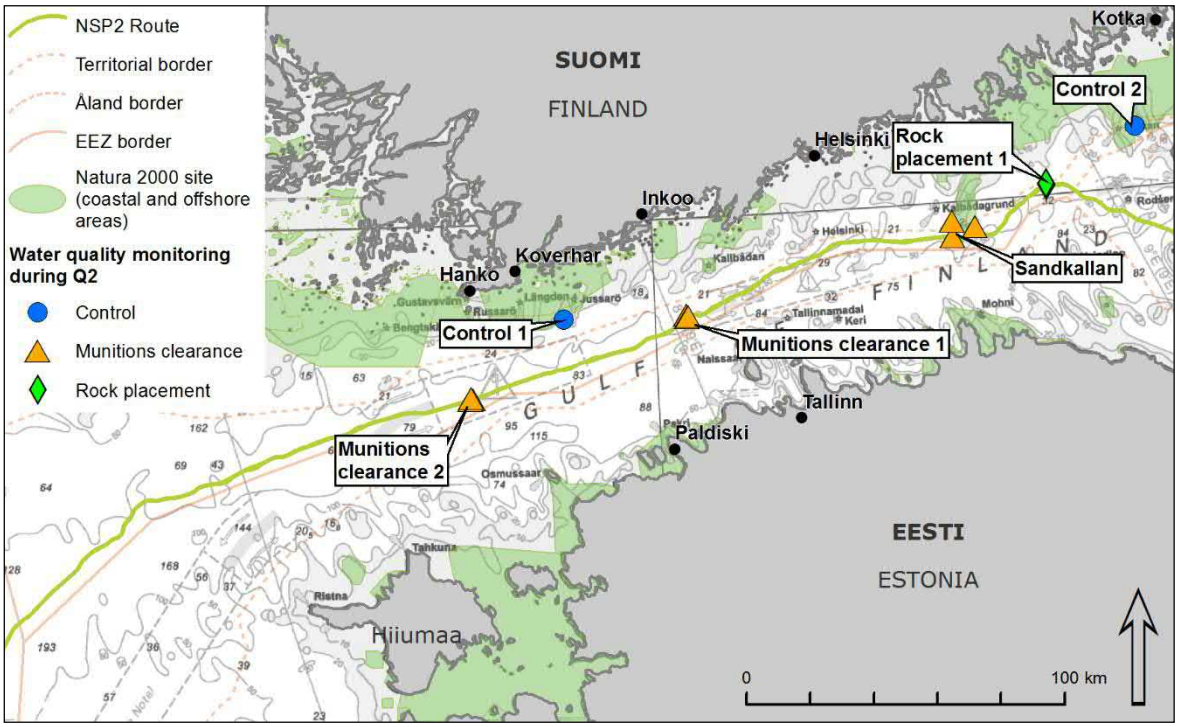


Figure 6. Water quality and current monitoring sites during Q2.

4.2 Results

First water quality and current data analysis will be available during Q3.

5 Sediment toxicity analysis

In order to study potential toxic material release to seabed due to munitions clearance, 17 sediment samples were collected to provide reference data of potential explosive residual and heavy metal spreading in clearance site surroundings of targets R-R08-5261 and R-R09-7495. Target R-R08-5261 was an old Russian depth charge BM-1 with NEQ 30 kg, and target R-R09-7495 a German EMC-1 mine with NEQ 310 kg. No residues of explosives exceeding the laboratory detection limits were found. Heavy metal concentrations were typical to those seen in earlier studies in the Gulf of Finland (W-PE-EMS-PFI-REP-812-SEDTOXSEN-01).

The study methodology and results will be presented in more detail in the Q3 report and in the 2018 annual report.

6 Cultural heritage

To verify any changes in the two monitored marine archaeological objects, surveys were performed before the start of construction.

Wreck S-R05-7978

The wreck inspection using Remotely Operated Vehicle (ROV) survey for the monitoring object S-R05-7978 was performed from the MV Stril Explorer on 6.5.2018. The cannon barge wreck site is regarded as an important archaeological site.

Figure 7. Wreck midship, cannons, cannon balls and debris. Picture from 2016 inspection W-SU-DET-POF-REP-808-CHO001EN-01.

The object is located approximately 59 meters from the nearest planned pipeline.

Distance to the nearest planned rock placement area is more than 500 meters, and to the nearest munition clearance 6,9 km.

Anti-submarine net S-R09-09806

The inspection of existence and condition of the historical anti-submarine net S-R09-09806 was performed by the MV Geosund on 2.5.2018.

A Multibeam Echo Sounder (MBES) sweep was performed from north to south, across the installation corridor for both cable routes, A and B. The Remotely Operated Vehicle (ROV) then proceeded to visually trace the line of floats and cables of the anti-submarine warfare net. Various, predefined targets defined by NSP2 were then each inspected, and their condition recorded for future reference.

Figure 8. Buoy attached to submarine net/wires (SD-Alt1-3372-J) from 2016 inspection, W-SU-DET-POF-REP-808-WRK014EN-03.

The seabed in this area is dominated by exposed rock outcrops. The eastern margin of this outcrop forms a steep scarp face (33 % gradient). The anti-submarine net seems to have been laid along this rock outcrop.

Only the associated floats / buoys and the cable were seen during the survey. No munitions or other debris items were visible.

7 Notifications to ELY-Centres during the second quarter

NSP2 delivered the following notifications to Uusimaa, Southeast and Southwest ELY-Centres during the monitoring period:

- 18/04: Nord Stream 2 notification on commencement of works in Finland – WP condition 44
- 23/04: Change in the monitoring programme (2 munitions for UW noise monitoring) – Water Permit (WP) provision 41
- 11/05: Change in the use of bubble curtains – WP provision 18
- 14/05: Preliminary results of UW noise (as per monitoring programme)
- 15/05: Summary table and map of munitions (interim version) –WP provision 18
- 24/05: Interim technical UW noise report (as per monitoring programme)
- 25/05: Munition chance finds –WP provision 24
- 31/05: Non-conformity notification regarding use of bubble curtains
- 29/06: Summary table and map of munitions (final version) –WP provision 18

The content of the notifications will be presented in the 2018 annual report.

8 Conclusions

The preliminary construction works have been proceeding as planned and environmental and technical monitoring has been carried out according to the monitoring programme.

The preliminary results indicate that environmental impacts of underwater noise have been as assessed or smaller.

The results in this report are preliminary. The final results will be presented in the annual report.

9 List of sources

Literature

Great Britain's Joint Nature Conservation Committee 2017. JNCC guidelines for minimising the risk of injury to marine mammals from geophysical surveys

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Maps and GIS data

Background admiralty charts, 2018. Charts are not to be used for navigation.
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INTERIM REPORT OF UNDERWATER NOISE MONITORING DURING MUNITION CLEARANCE IN THE FINNISH EEZ

Toni Meriläinen, Antti Lindfors & Olli Huttunen

Rev.	Date	Description	Prepared	Checked	Approved
05	2018-09-14	Amended version	TM	KR	AL
			Luode Consulting Oy		

		Document Title **INTERIM REPORT OF UNDERWATER NOISE MONITORING DURING MUNITION CLEARANCE IN THE FINNISH EEZ**	
Company Representative	: Enrica de Luca		
Reference	: PO17-5222	Document-No. **W-GE-EMO-PFI-REP-812-UWNIREEN-05**	Rev. **05**
PO. No.	: PO17-5222		
Contractor Representative	: Antti Lindfors		
Document Owner	: Luode Consulting Oy		

LIST OF ABBREVIATIONS:

EEZ	Exclusive Economic Zone
SPL	Sound Pressure Level
SEL	Sound Exposure Level
L5	L5 Statistical Sound pressure level for peak values (exceeded 5% of time)
CTD	Oceanography instrument for conductivity, temperature, depth etc.
PTS	Permanent Threshold Shift

Introduction

This report includes the results of the long-term and vessel based underwater noise measurements of the Nord Stream 2 project in Finland in line with the approved "Monitoring Programme Finland "(W-PE-EMS-PFI-REP-805-032300EN-11). The report includes comparison of the measured peak values with the modelled permit application values. Comparison covers munitions cleared until the 14th of May. Report includes also the time-series from all eight long-term stations: Hanko A, Hanko B, Kallbådan A, Kallbådan B, Söderskär, Eastern Gulf of Finland, Malusi and Uhjtu (figure 1). Depending on the service visit date long-term time-series include approximately the first one month measurement period starting from 17th of April and ending between 14th - 26th of May 2018. Exact dates depend on the measuring station and these are introduced in table 1. Monitoring started two weeks prior the munitions clearance operations and will continue until the clearance operations are completed. The first clearance operations took place on 3rd of May 2018. Complete time-series including post clearance period from all stations will be analyzed after the systems will be recovered in July 2018.

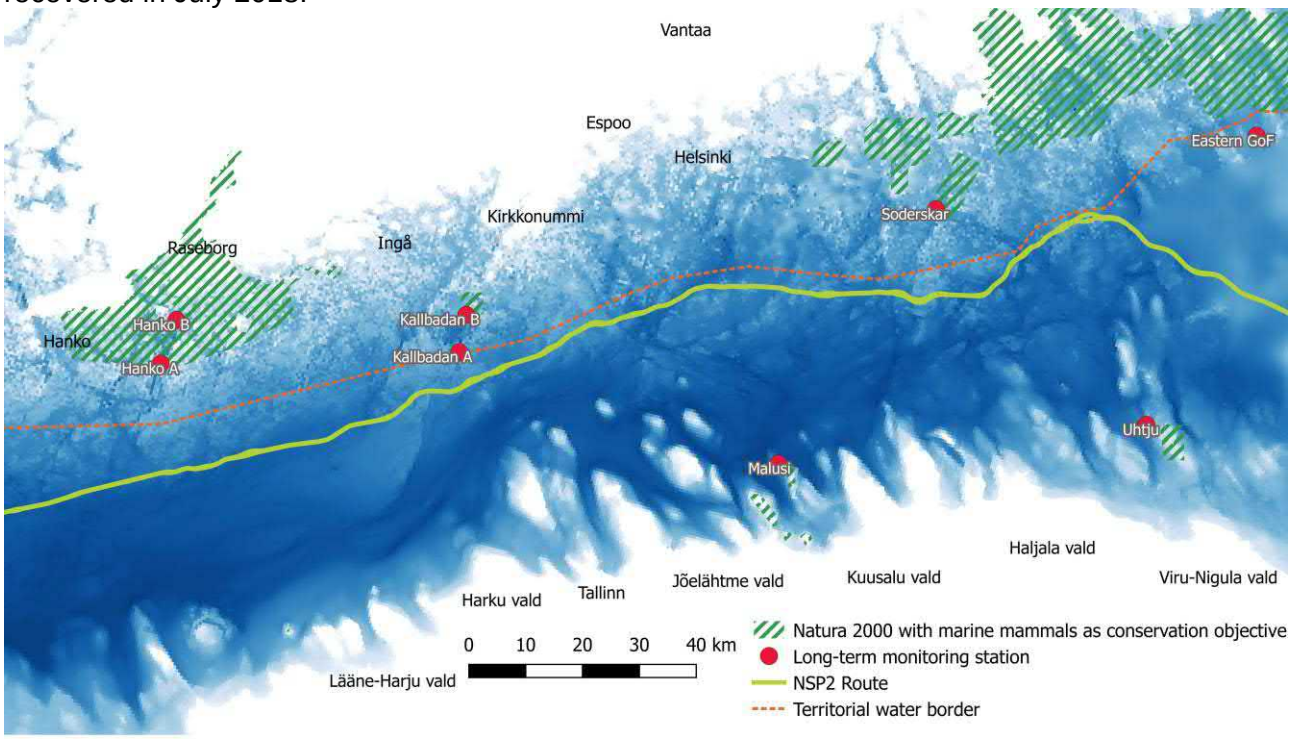


Figure 1 long-term monitoring station locations

Table 1 The first measurement period

Station	Deployment	Service visit	Estimated recovery
Hanko A	2018-04-17	2018-05-22	2018-07
Hanko B	2018-04-17	2018-05-22	2018-07
Kallbådan A	2018-04-17	2018-05-15	2018-07
Kallbådan B	2018-04-17	2018-05-15	2018-07
Söderskär	2018-04-18	2018-05-15	2018-07
Eastern GoF	2018-04-18	2018-05-15	2018-07
Malusi	2018-04-23	2018-05-26	2018-07
Uhtju	2018-04-23	2018-05-26	2018-07

In addition to long-term monitoring, three short-term vessel based monitoring campaigns were conducted. During these mobile noise measurements campaigns three different types and sizes munitions (table 2) were cleared. Results from the long-term stations are merged with the mobile monitoring results and the extent of PTS areas are modelled and compared to levels in updated

summary tables of Environmental Impact Assessment of Munition Clearance on Munition by Munition basis Finnish EEZ (W-PE-EIA-PFI-REP-999-MBYM02EN-01). PTS and other metrics are introduced in the next chapter. Measured peak levels from munitions clearance are compared to the modelled peak values from the permit application.

*Table 2 Mobile campaign munition clearance targets. *: These values were presented in the permit application*

ID	Classification	Nationality	Predicted values, TNT (kg)*
R-R05-7058	Grenade	Russian	40
R-R06-20716	Depth Charge	Unknown	180
R-R09ALT1-20117	EMC-1	German	300

Metrics

Underwater noise metrics are dependent on the characteristics of the noise source. For impulsive sounds appropriate metrics are Sound Exposure Level, Peak Sound Pressure level and Peak-to-Peak Sound Pressure Level. For continuous sound sources the Sound Pressure Level is commonly used.

Peak level is the maximum sound pressure level that is measured during the noise event. It is the maximum value reached by the sound pressure.

Sound Exposure Level, or SEL, is a useful metric to assess cumulative noise exposure as it allows for the comparison of sounds with varying durations. SEL gives an indication of the total acoustic energy of the noise event.

Permanent threshold shift (PTS) in hearing is recommended as a criterion injury. PTS thresholds for single impulsive noise for marine mammals is 179 dB unweighted SEL (single event). Sound exposure and mean square levels are related by:

$$SPL_{rms} + 10\,log_{10}\,(T) = SEL$$

where SEL is the sound exposure level (dB re 1 µPa2.s), SPL_{rms} is the mean square level (dB re 1 µPa2), and T is the signal duration in seconds.

The 5-percent exceeded level, L5, is used in long-term monitoring time series. It is the sound pressure level exceeded for 5 percent of the time. Each statistical Ln level indicates the percentage (etc. 5%, 50%, and 95%) of measurements for which the SPL has a higher value than the Ln level. L5 quantifies peaks of noise. L5 has been calculated for 20 second intervals for the whole measurement period.

Measurement set-up

A typical measurement installation is shown in figure 2. A set of monitoring devices were installed in a line. Moored hydrophone string is hanging from sub-surface buoys, which keep system suspended. More detailed information about used instruments can be found in Appendix 2. Before and after the measurements the hydrophones were tested and calibrated with a GRASS pistonphone. Pistonphone and Hydrophone calibration sheets are in Appendix 3. All measurement lines were identical having one monitoring device located 10 meters below the surface and second 35 meters below the surface. Water depth in all eight monitoring sites is more than 50 meters. CTD

(Conductivity Temperature Depth) and sound velocity profiles were collected during the installation and service visits in order to record background information concerning prevailing stratification.

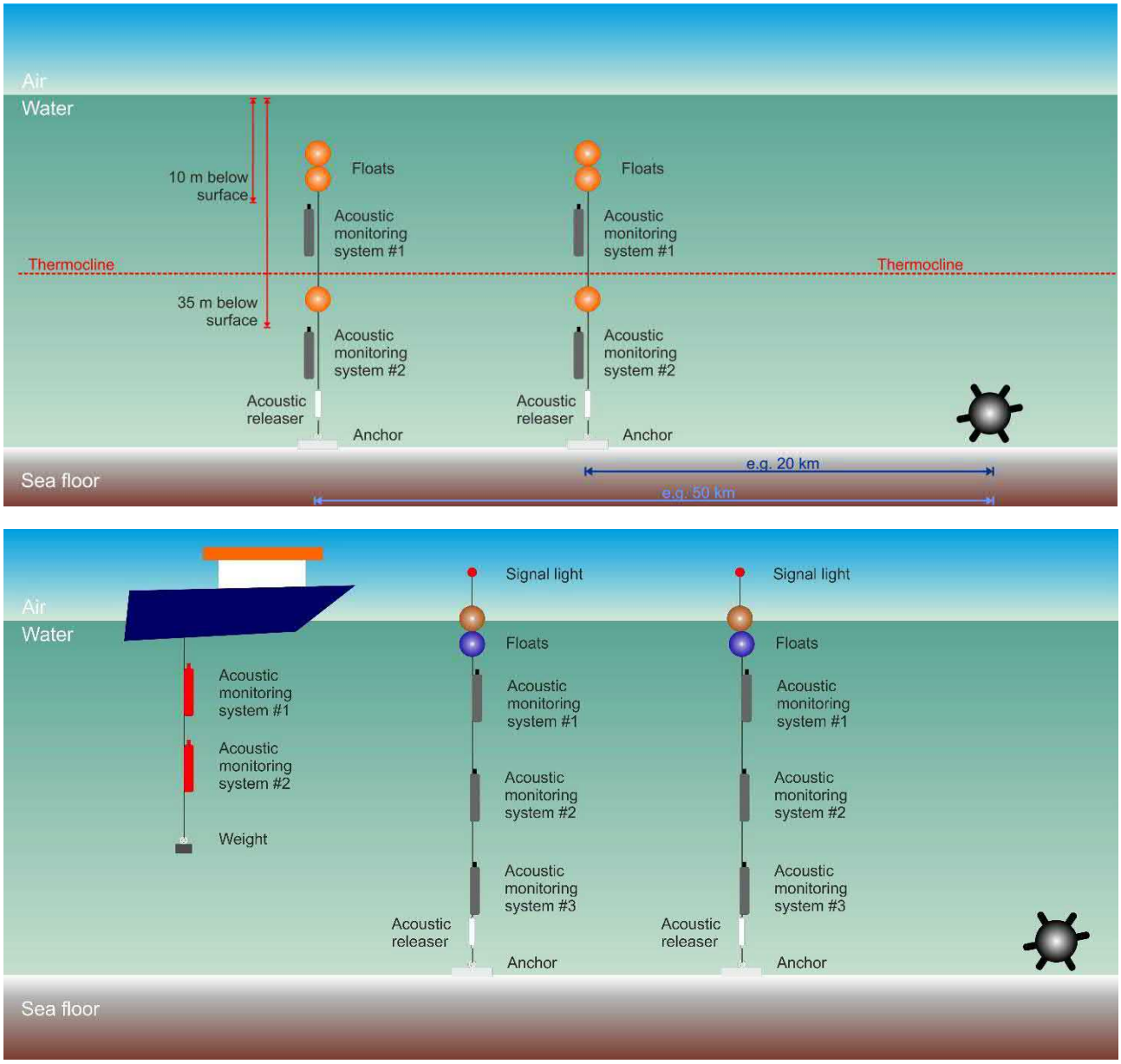


Figure 2 Upper: Schematic illustration of long-term installation, not in scale and lower: Schematic illustration of vessel based monitoring arrays.

Comparison of the measured peak values with the modelled permit application values

From the beginning of installation until the service visit of long-term noise monitoring stations 57 munitions were cleared. In four cases, two attempts were required to clear the munition. In this report 26 clearance operations were analyzed while other clearance operations from 15th to 26th of May were executed after the service visit to Eastern GOF, Söderskär and Kallbådan. Data especially from Kallbådan, which is the closest station, will be available after the systems are recovered in July. Analyses of the remaining munitions will be presented in the final report. Locations of the 26 analyzed munitions are shown in figure 3 and more details about the munitions and measurement distances are in the appendix 1.

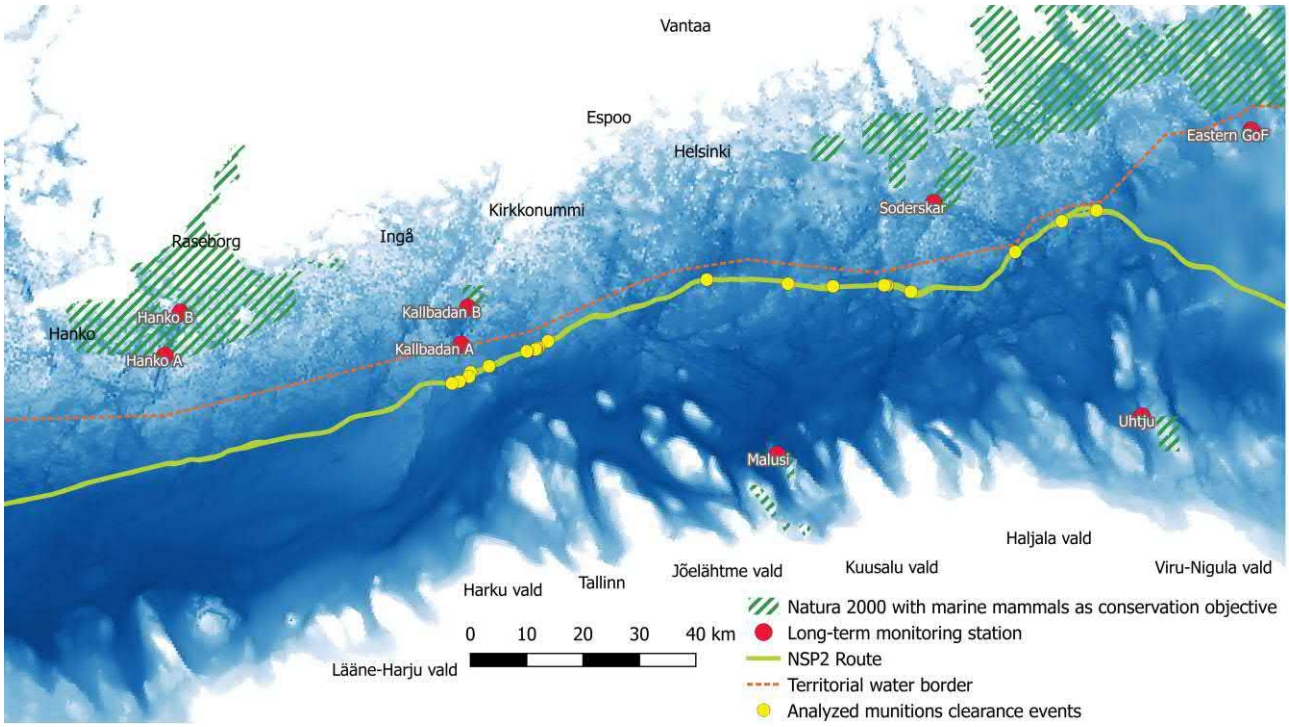


Figure 3 Location of the munitions (yellow)

In all except one cases, measured peak pressure levels were lower than assessed in the permit application. At 1000 m from the detonations, measured peak levels (figure 4) of 26 clearance actions were on average 20 dB lower than modelled values. Noise reduction with distance was also higher. Only one measured peak level (R-R09ALT1-20117 at 500 meters) which was recorded with vessel-based monitoring was higher (5 dB) than modelled value.

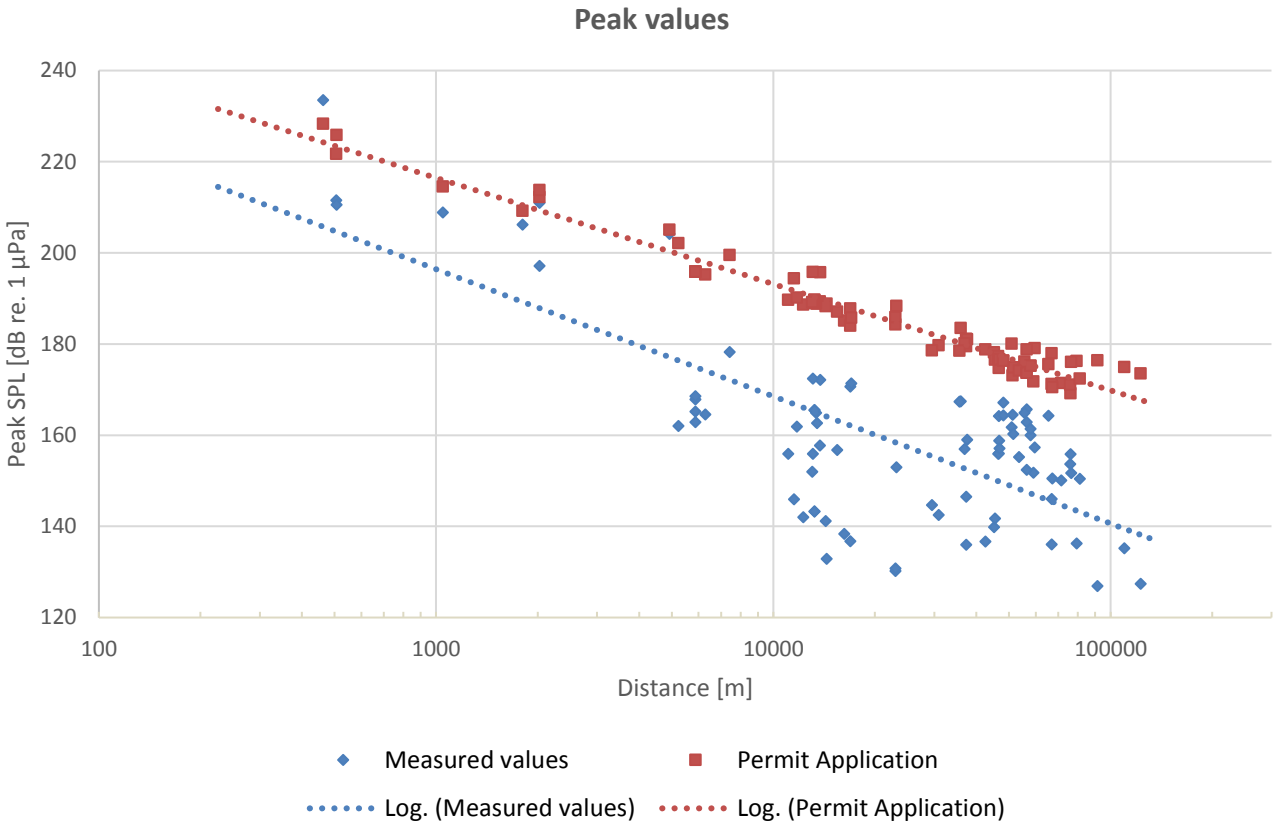


Figure 4 Measured peak pressure data from munitions clearance from 3rd of May to 14th of May.

Permanent threshold shift (PTS) distances of marine mammals

Permanent threshold shift (PTS) distances of marine mammals are introduced in Table 3 and the measured SEL results are compared against the modelled values with bubble curtain.

Table 3 Distances to the PTS assessment level limit thresholds.

PTS (179 dB re 1µPa²s)	R-R05-7058 TNT 40 kg	R-R06-20716 TNT 180 kg	R-R09ALT1-20117 TNT 300kg
Measured values	**2300 meters**	**1900 meters**	**4900 meters**
Modelled values	**4000 meters**	**8400 meters**	**10600 meters**

In these three cases enough data was available from different distances to model the PTS exposure areas which are introduced in figure 5. In all three cases the PTS-zone was smaller than it was assessed in the permit application. The difference between measured and modelled values is not due to munitions being smaller than originally assessed for R-R09ALT1-20117, because its re-evaluation confirmed the original size of 300 kg. The difference is in this case due to propagation loss being in general larger than modelled. For R-R06-20716 the difference was also due to the re-evaluation - the munition was probably smaller than assessed in the permit application.

More PTS exposure areas will be attempted to analyze and modelled to the final report after the recovery of long term monitoring stations and when the short range measurement data has been received from the munition clearance vessels.

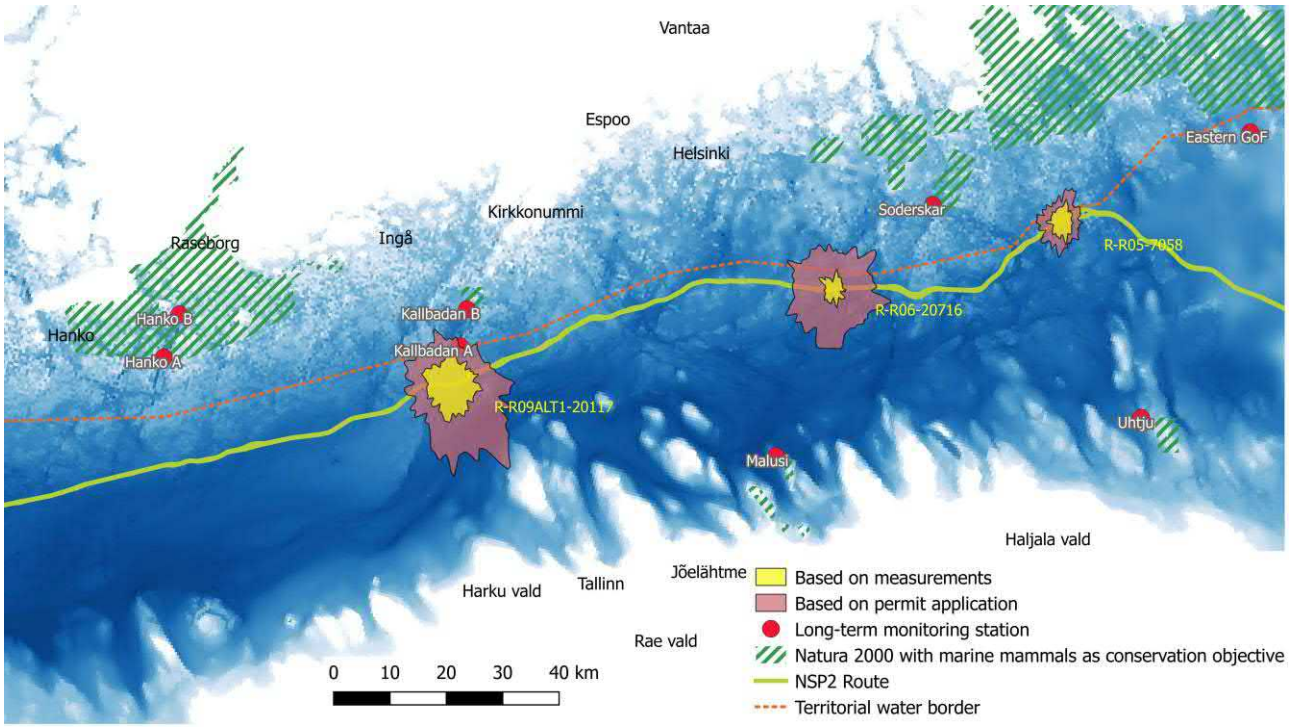


Figure 5 Distances to the PTS assessment level limit thresholds

Pressure waveform of explosion signal

While main part of explosion´s energy is transmitted through water, part of the energy is propagating in the ground. Low-frequency ground wave propagates faster and it can be seen before the main pulse is recorded on hydrophones. For example during the munition clearance R-R08-20321 ground wave arrived to Kallbådan A (11800 meters) 6.3 seconds prior to main pulse (figure 6).

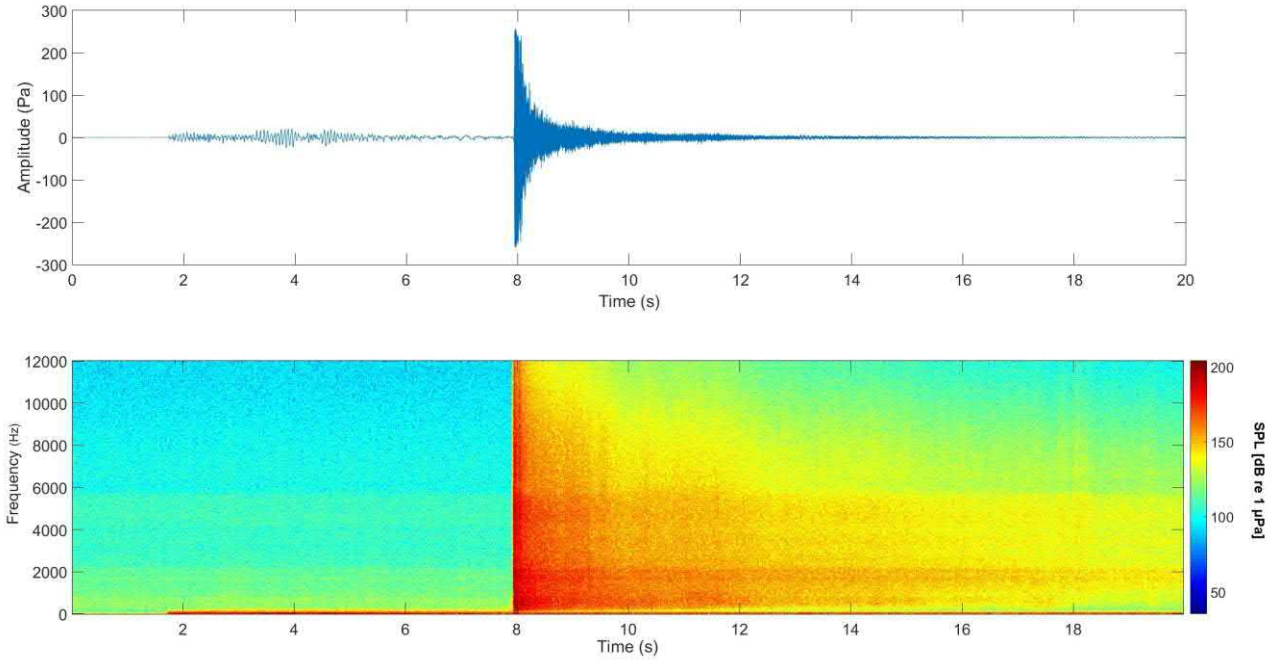


Figure 6 Munition clearance R-R08-20321 (24° 28.9076' 59° 47.1197'), German EMC 330 kg charge, measured from Kallbådan A, distance 11778 meters.

In figure 7 the same munition clearance was measured from a distance of 48000 meters. As seen on the figure main pulse reflected 5-6 times from surrounding islands and coastline after it was first recorded.

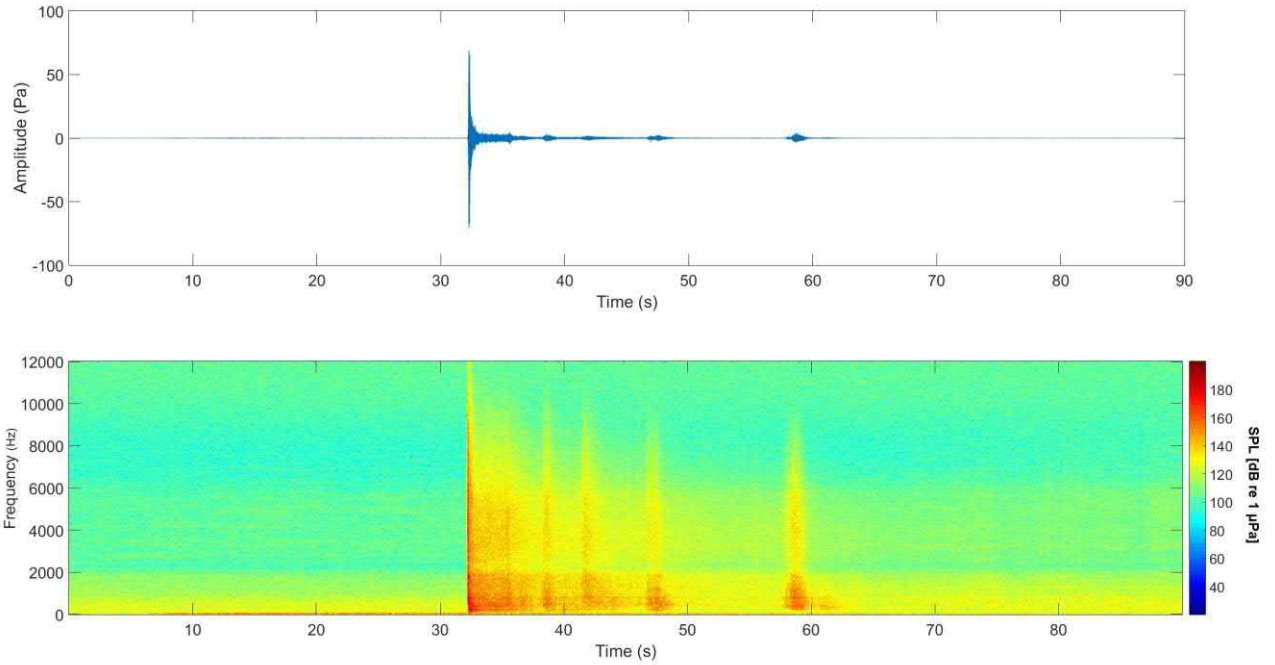


Figure 7 Munition clearance R-R08-20321 (24° 28.9076' 59° 47.1197'), German EMC 330 kg charge, measured from Malusi, distance 47984 meters.

Propagation loss variation with frequency

In addition to wide-band results it is interesting to consider how the sound propagation varies with frequency. In figure 8 1/3 octave sound exposure level of munition event R-R09ALT1-20117 (German EMC-1, 300 kg charge) is measured from distances of 462 m, 2025 m, 4918 m and 13756 m. Propagation loss is more intensive at frequencies below 160 Hz. Low-frequency cut-off is defined by the seafloor and the depth varies in this case from 20 meters to 50 meters. Variation of sound transmission loss with frequency is dependent on water depth, sound speed profile, seabed and sea-surface loss. The frequency response will be different in the far field compared with measurements from the nearby area.

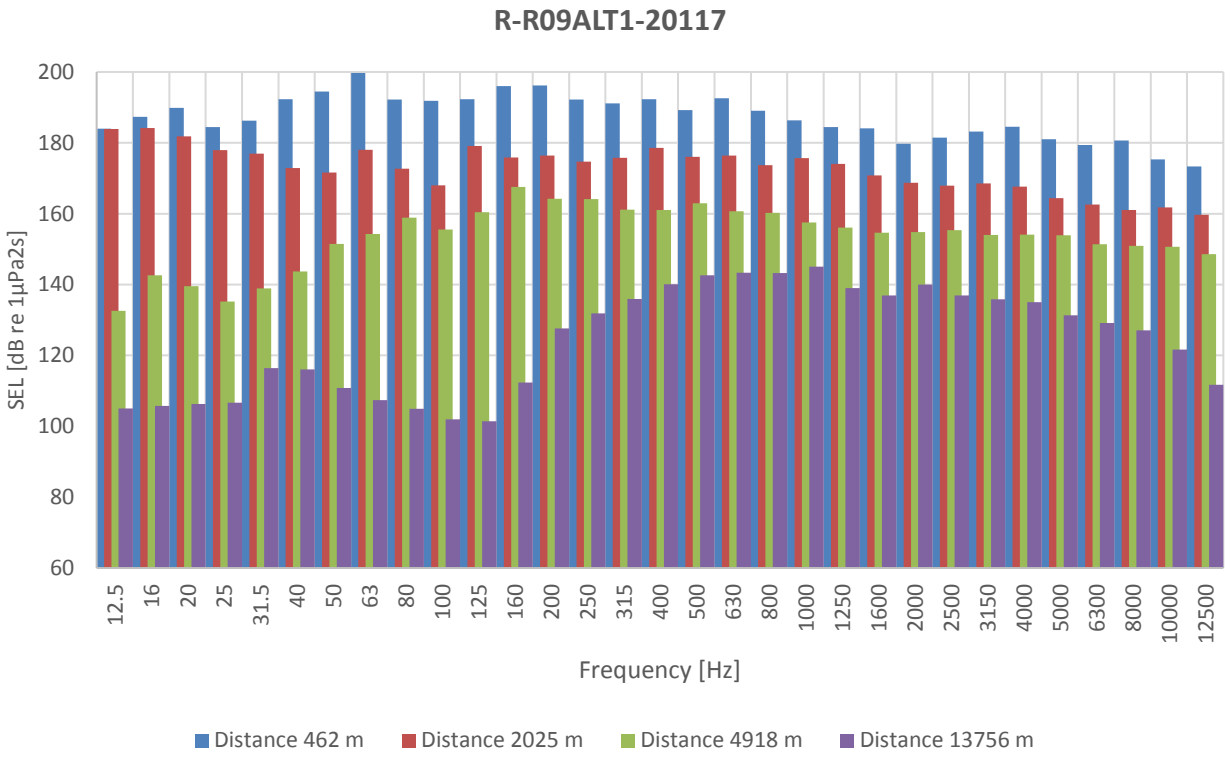


Figure 8 Munition clearance R-R09ALT1-20117 sound exposure level measured from four different distances.

Measurement depth and thermocline

CTD and sound velocity profiles were measured from the long term monitoring locations during the installation and recovery. CTD and sound velocity profiles are introduced in appendix 4. CTD and sound velocity profiles are used to give background information about the stratification and presence of the seasonal thermocline. Strong vertical gradients can impact the noise penetration and attenuation.

Thermocline was emerging during the first half of May and after the second recovery it is possible to detect the effect of the stratification on the sound attenuation and noise penetration.

One of the biggest difference was measured during the munition clearance R-R09ALT1-20560 (figure 9). Form of the frequency response is similar but the amplitude difference is almost 10 dB at several 1/3 octave frequency bands meaning that less energy was seen on uppermost layer. Hydrophones were 10 m and 35 meters below the surface.

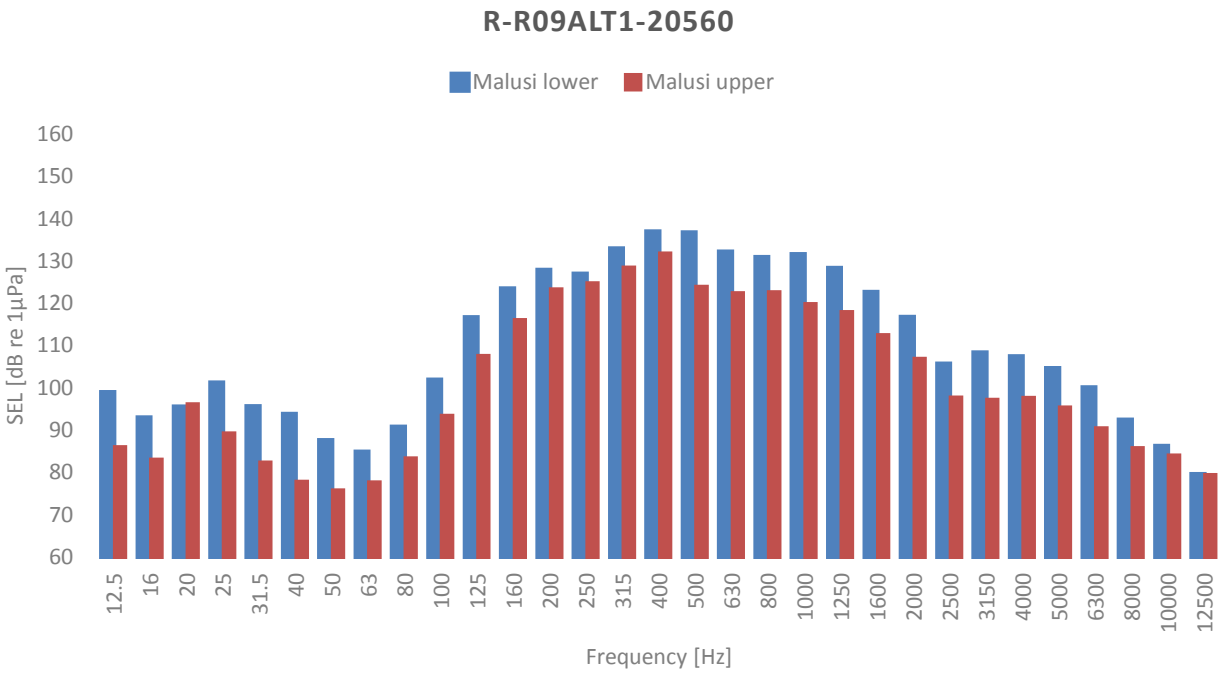


Figure 9 Munition clearance R-R09ALT1-20560 (24° 18.0863' 59° 44.5098'), shell with 17 kg TNT charge measured sound exposure level in Malusi, 10 m and 35 meters below the surface.

Time-series analysis of the long-term monitoring stations

For the long-term monitoring stations analyses, munition clearance occurring during the first three weeks of the clearance campaign were used. Munition clearance operations started on 3rd of May to first service visits were done on 14th of May, Hanko A and B on 22nd of May and Malusi and Uhjtu which were serviced on 26th of May. Time-series analysis of the long-term monitoring stations are presented in figures 10 – 15. Reported value is L5 (20 seconds) which indicates the percentage (5%) of measurement windows for which the SPL has a higher value than the L5 level. L5 quantifies peaks of noise and it has been calculated for 20 second intervals for the whole measurement period. It's not directly comparable with the peak SPL value which is the maximum value reached by the sound pressure.

At Eastern Gulf of Finland (figure 10) the noise levels did not change much during the munition clearance. Shipping density was moderate and the monitoring station was aside from the shipping lane. Distance between the monitoring and munitions clearance was from 30 to 150 km and on the west side of the monitoring area between the station and munition clearance depth was only 15 meters.

At Söderskär (figure 11) L5 (20 seconds data windows) values peaks from the munition clearance operations were standing out as 10 analyzed munitions clearance events were closer than 30 km from the monitoring station. Shallow area (under 10 meters) southwest from the station attenuated the noise levels of munition clearance operations which were cleared west side of Helsinki after 10th of May.

In general the highest noise levels were recorded at Kallbådan A (figure 12). Highest peak levels were measured during the munitions clearance R-R09ALT1-20117 (8th of May), R-R09-7495 and R-R09ALT1-20111 (13th of May). Sensitivity of the hydrophones at Kallbådan A was too high and peak levels exceeded the maximum measurement threshold. Due to the fact that distance to

construction activities was the shortest at Kallbådan A stations, the highest noise impacts were recorded, but when compared with munitions clearance times, an intensive shipping in the area was found to be the main reason for elevated readings. At Kallbådan B peak levels were 10-20 dB lower as the surrounding area has strong depth gradient and several shallow areas. Distance between Kallbådan A and Kallbådan B is 6663 meters.

At Hanko A & B munitions clearance between 3 of May and 14 of May had no effect to the time-series analysis. The shortest distance between the analyzed munition clearance and Hanko A/B monitoring station was over 50 km and on the east side of the measuring stations depth was under 10 meters. No significant difference was recorded between Hanko A & B stations. Peak levels are mostly caused by shipping in the area. High noise levels halfway through the measurement period are caused by stormy weather. Distance between Hanko A and Hanko B is 8143 meters.

As expected single peaks from the munition clearance operations stand out at Malusi as it's more silent in nature. A few peak before the operations are caused by shipping. Propagation loss is lower because of the constant depth all the way to the monitoring stations Malusi and Uhtju.Peaks at Uhtju (figure 15) are caused by shipping but also munition clearance operations which were cleared on the east side of Helsinki.

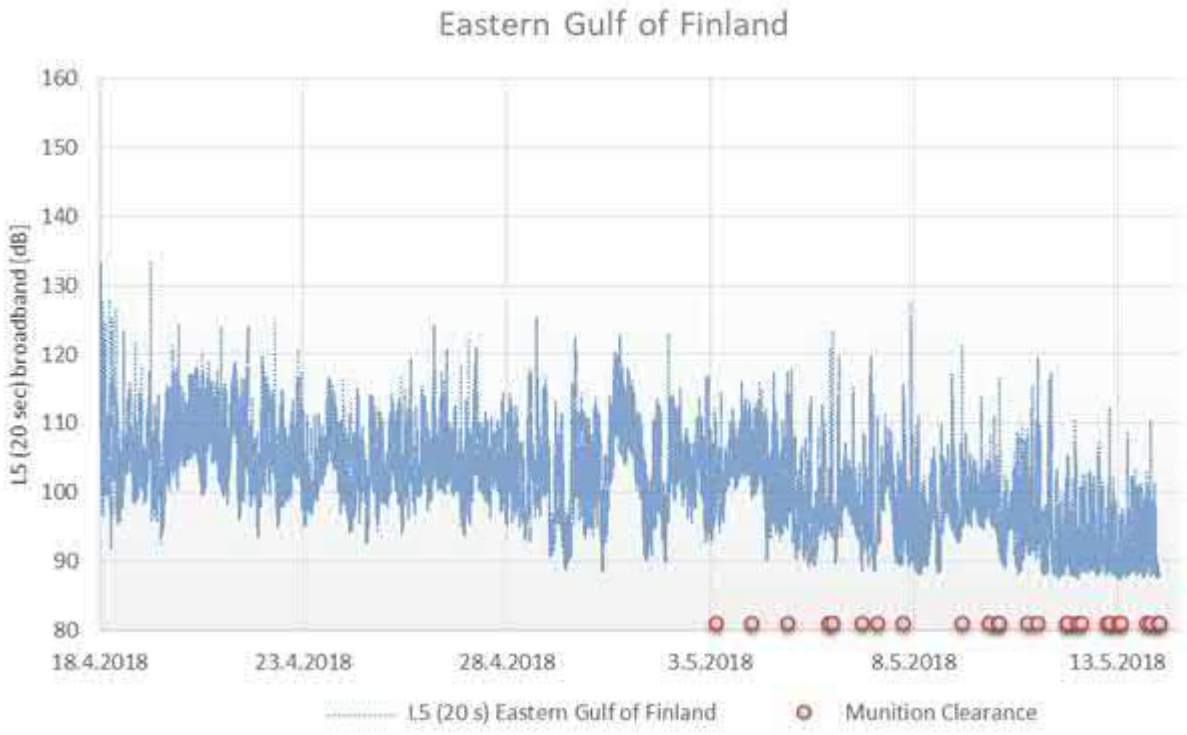


Figure 10 Time-series L5 (20 seconds) vs munition clearance events – Eastern Gulf of Finland

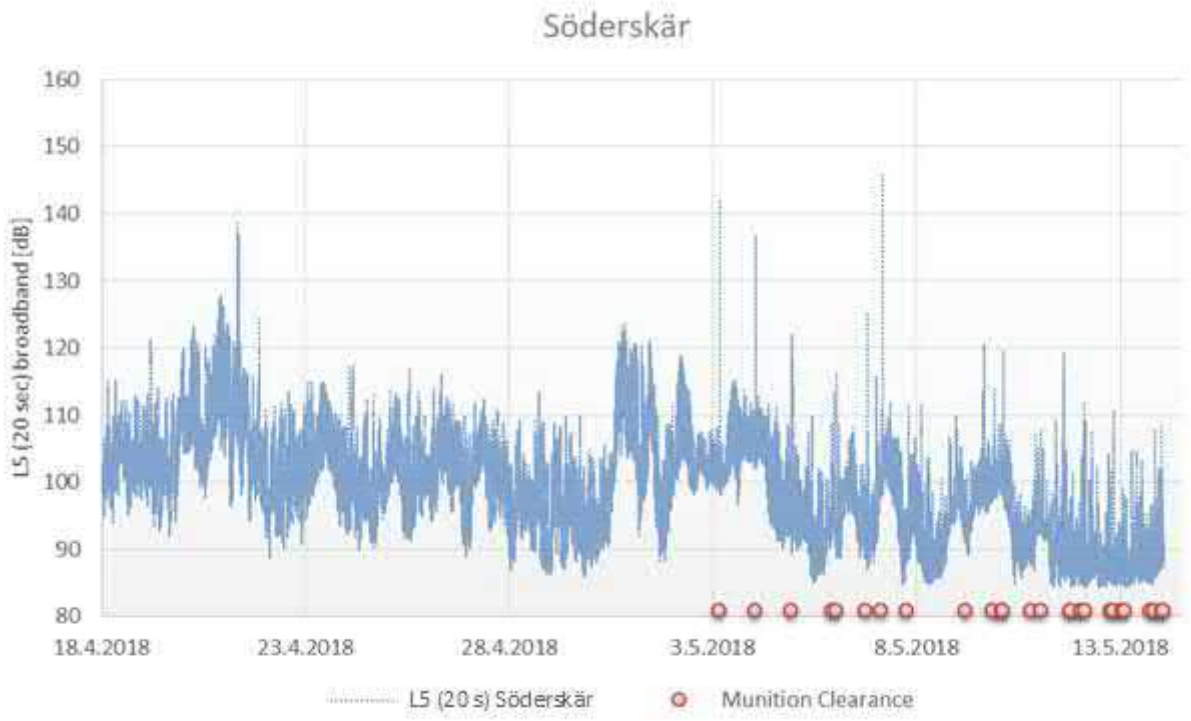


Figure 11 Time-series L5 (20 seconds) vs munition clearance events – Söderskär

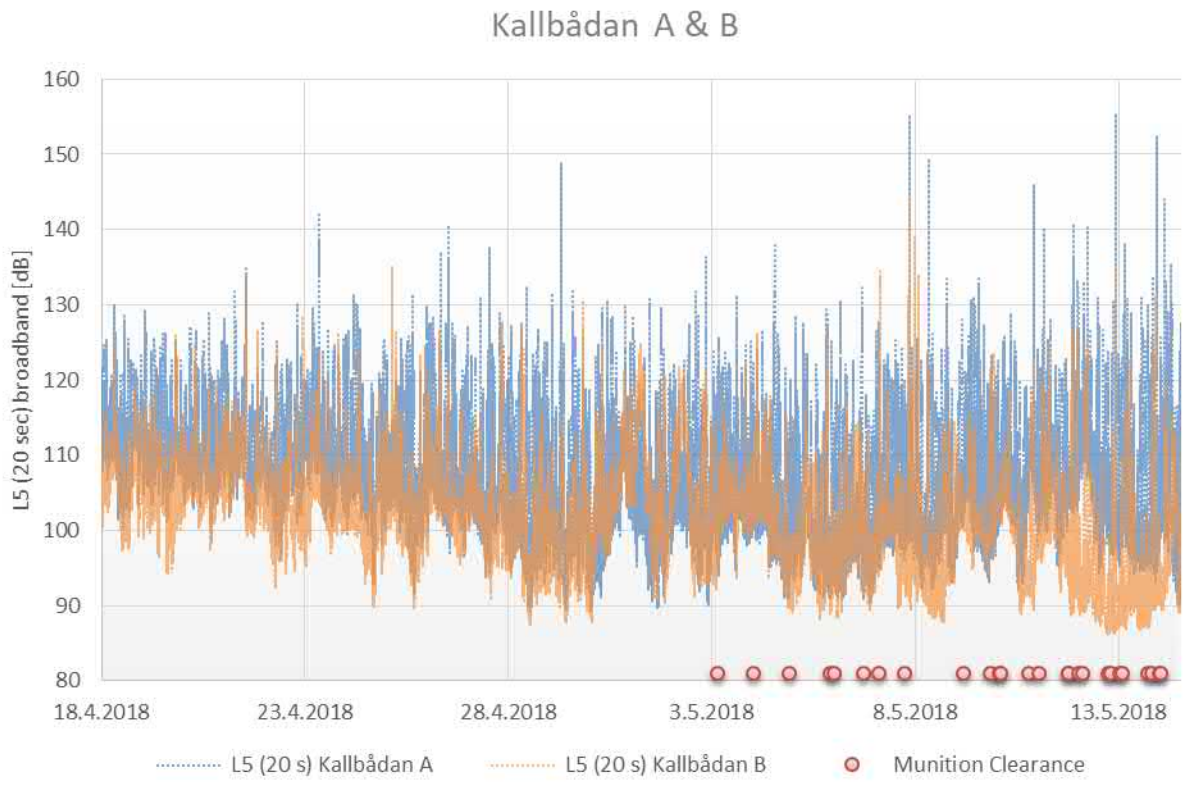


Figure 12 Time-series L5 (20 seconds) vs munition clearance events – Kallbådan A & B

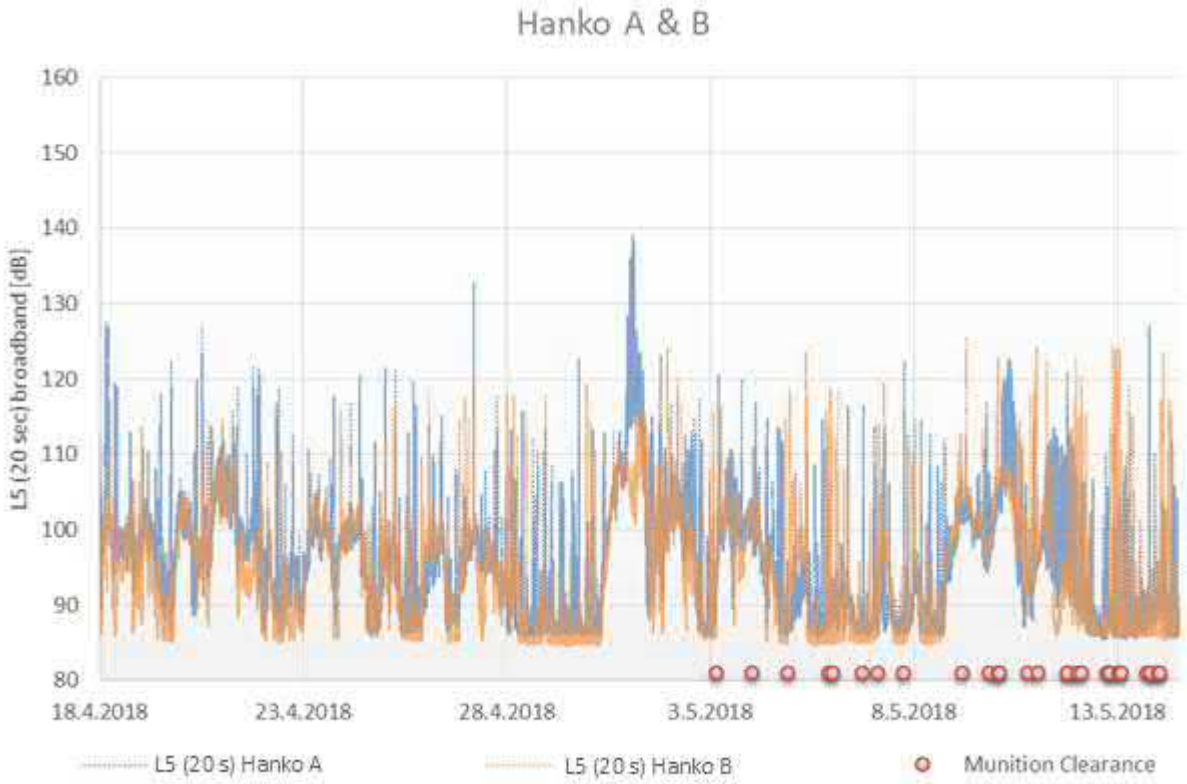


Figure 13 Time-series L5 (20 seconds) vs munition clearance events – Hanko A & B

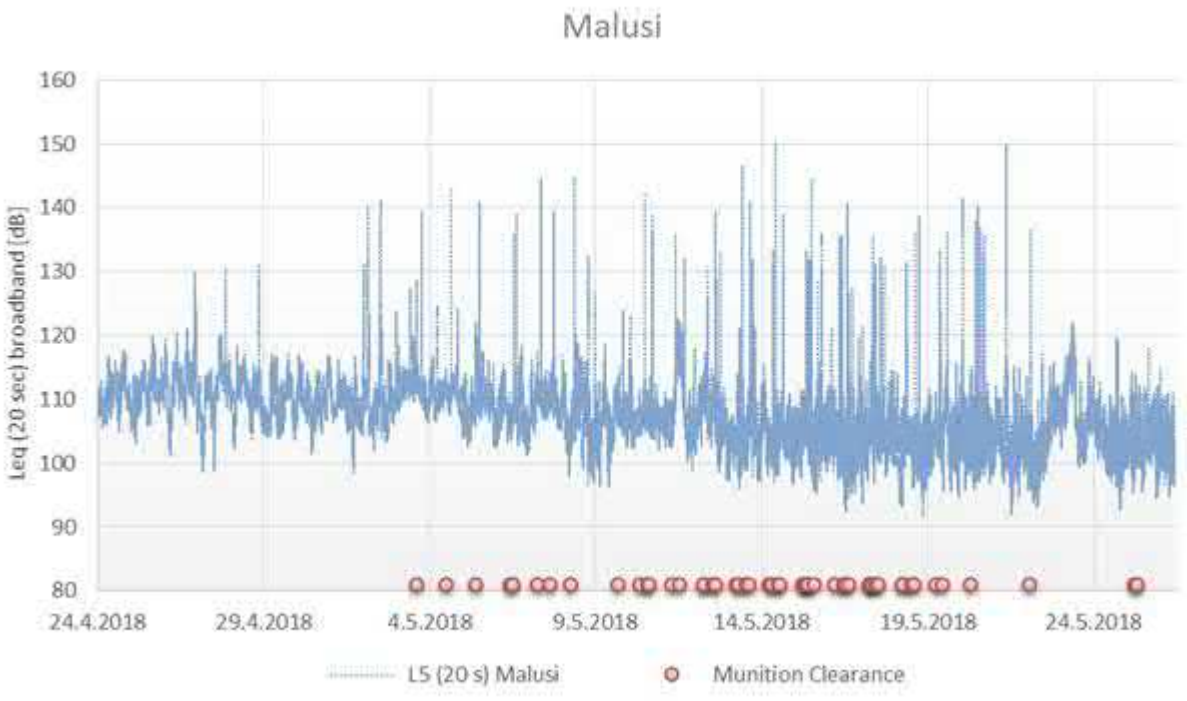


Figure 14 Time-series L5 (20 seconds) vs munition clearance events – Malusi

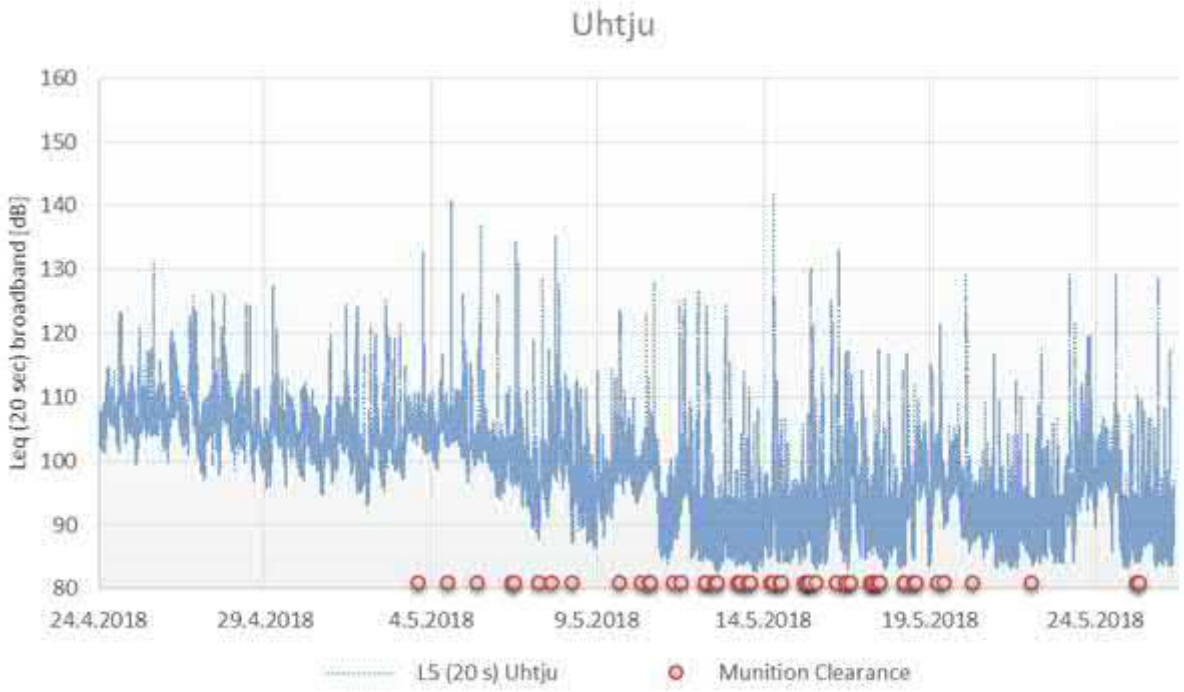


Figure 15 Time-series L5 (20 seconds) vs munition clearance events – Uhtju

Conclusions

These results are based on interim data analyzes.

- 83 out of 84 measured peak levels from 26 munition clearance operations were lower than modelled values.
- Based on information collect from three vessel based monitoring cases the observed propagation loss was higher and thus noise readings smaller compared to the modelled results. Therefore the PTS-zone was smaller than it was assessed in the permit application.
- As expected single peaks from the munition clearance operations stand out at Malusi and Söderskär stations as they are more silent in nature.
- Due to the fact that distance to construction activities was the shortest at Kallbådan A stations, the highest noise impacts were recorded, but when compared with munitions clearance times, an intensive shipping in the area was found to be the main reason for elevated readings.
- Generally low background levels were recorded due to relatively calm weather period during the munitions clearance operations
- Propagation loss was more intensive at frequencies below 160 Hz

Appendix 1. Analyzed munition clearances

List of the 57 munitions cleared during the reference period. In four cases, 2 attempts were required to clear the munition.

Munition	Detonation date/time	Charge [kg] Permit	Charge [kg] Clearance plan	Distace from Hanko A [m]	Distace from Hanko B [m]	Distace from Kallbådan A [m]	Distace from Kallbådan B [m]	Distace from Söderskär [m]	Distace from Eastern GoF [m]	Distace from Malusi [m]	Distace from Uhtju [m]
R-R05-20018	9.5.2018 16:18	18	18	167308	163551	115240	112862	28969	30895	71393	37454
R-R05-20261	6.5.2018 11:41	75	40	160920	157210	108813	106477	22984	37259	65390	37514
R-R05-7058	6.5.2018 9:55	40	7	160918	157209	108808	106475	22991	37271	65371	37483
R-R05-20805	10.5.2018 13:47	50	50	151997	148502	99688	97607	16902	47101	55527	36869
R-R06-0386	5.5.2018 9:18	10	10	132872	129672	80382	78666	16221	66806	37465	46602
R-R06-20411	3.5.2018 15:01	150	40	128746	125465	76314	74472	16741	70212	35879	50895
R-R06-26165	4.5.2018 12:04	5	5	128422	125139	75991	74146	16897	70510	35709	51189
R-R06-26167	7.5.2018 14:33	20	24	128210	124927	75781	73935	17014	70709	35587	51373
R-R06-20716	7.5.2018 5:28	180	40	119181	115870	66794	64882	23149	79198	31513	59513
R-R07-8004	10.5.2018 8:10	5,5	3	111274	107893	58981	56925	29528	86597	30428	67123
R-R07-31008	10.5.2018 14:03	50	5	97087	93559	45085	42661	42456	100171	33501	80978
R-R09ALT1-20060	12.5.2018 6:08	17	17	57541	55564	6282	11054	83996	141560	53462	116222
R-R09ALT1-20208	11.5.2018 6:59	137	25	54311	52544	5220	11501	87451	145016	56312	119416
R-R09ALT1-20560	11.5.2018 12:43	17	17	54068	52420	5870	12254	87986	145519	56399	119658
R-R09ALT1-20560	14.5.2018 11:59	17	17	54068	52420	5870	12254	87986	145519	56399	119658
R-R09ALT1-20531	12.5.2018 12:29	40	17	52423	50946	6582	13215	89901	147420	57863	121325
R-R09ALT1-20531	12.5.2018 14:34	40	17	52423	50946	6582	13215	89901	147420	57863	121325
R-R09-7495	13.5.2018 6:56	300	300	52279	50820	6679	13321	90074	147591	57992	121472
R-R09ALT1-20117	8.5.2018 5:50	300	115	51168	49777	7096	13756	91228	148752	59049	122598
R-R09ALT1-20111	13.5.2018 12:40	300	150	50912	49531	7175	13827	91476	149003	59299	122856
R-R09ALT1-20111	14.5.2018 6:58	300	150	50912	49531	7175	13827	91476	149003	59299	122856
R-R09ALT1-20468	20.5.2018 9:27	50	1	49581	48236	7619	14171	92723	150273	60607	124190
R-R09ALT1-20472	20.5.2018 10:54	50	1	49561	48216	7624	14172	92740	150290	60627	124210
R-R09ALT1-20478	20.5.2018 12:20	50	1	49541	48196	7627	14174	92756	150307	60647	124230
R-R09ALT1-20486	20.5.2018 13:46	50	1	49500	48155	7635	14176	92790	150342	60689	124270
R-R09-7563	19.5.2018 5:33	115	115	49181	47840	7753	14255	93080	150638	61006	124590
R-R09-7578	19.5.2018 10:36	300	300	48517	47182	8009	14413	93670	151242	61668	125252
R-R09ALT1-20133	20.5.2018 7:08	10	10	48170	46849	8219	14570	94007	151584	62007	125601
R-R08-1585	13.5.2018 5:20	25	25	68037	65418	15450	15421	72636	130247	45350	106246
R-R08-20342	12.5.2018 5:54	40	40	66273	63796	13721	14378	74656	132237	46421	107826
R-R08-20613	13.5.2018 14:05	30	30	65982	63538	13449	14266	75016	132588	46574	108080
R-R08-7249	14.5.2018 5:10	30	30	65913	63456	13372	14148	75045	132623	46684	108163
R-R08-7183	14.5.2018 12:39	30	34	65766	63328	13236	14101	75231	132804	46757	108290
R-R08-7245	16.5.2018 4:59	30	30	64535	62149	12047	13294	76513	134088	47736	109468
R-R08-20713	16.5.2018 11:54	30	30	64378	62002	11899	13210	76684	134258	47853	109616
R-R08-20423	15.5.2018 7:01	30	30	64267	61877	11775	13048	76748	134330	48003	109741
R-R08-20321	15.5.2018 8:56	330	300	64264	61881	11778	13079	76769	134349	47984	109737
R-R08-20422	15.5.2018 5:12	30	30	64227	61839	11737	13023	76789	134372	48035	109779
R-R08-7234	17.5.2018 5:11	30	30	63873	61515	11413	12881	77197	134774	48275	110105
R-R08-7227	17.5.2018 12:00	150	150	62945	60627	10536	12348	78159	135738	49035	110999
R-R08-4659	18.5.2018 5:57	25		60784	58558	8546	11282	80386	137973	50855	113095
R-R08-7030	15.5.2018 8:40	40	20	82183	79014	29868	28012	57782	115449	37173	93546
R-R08-7003	17.5.2018 13:08	3	3	79222	76139	26841	25176	60843	118503	38618	96163
R-R08-7409	15.5.2018 13:44	50	50	78966	75885	26585	24924	61093	118756	38794	96407
R-R08-20545	17.5.2018 5:40	17	17	78670	75590	26293	24631	61377	119043	39012	96694
R-R08-20530	17.5.2018 7:19	17	17	78660	75580	26282	24620	61388	119054	39020	96704
R-R08-31017	17.5.2018 10:26	6	7	78544	75465	26168	24506	61499	119166	39105	96816
R-R08-7131	22.5.2018 1:12	40	17	78372	75282	26008	24318	61639	119315	39307	97013
R-R08-26413	18.5.2018 5:38	17	17	77902	74834	25520	23884	62143	119813	39510	97412
R-R08-7063	16.5.2018 11:00	30	17	77048	73978	24677	23031	62959	120642	40175	98251
R-R08-7063	16.5.2018 14:27	30	17	77048	73978	24677	23031	62959	120642	40175	98251
R-R08-20157	18.5.2018 11:46	17	17	75923	72832	23591	21878	63992	121697	41188	99407
R-R08-20196	18.5.2018 14:12	100	100	73000	70063	20539	19275	67149	124823	42588	101899
R-R10-0188	19.5.2018 5:59	50	25	29877	31992	30459	35252	117260	174825	82202	146987
R-R10-10732	19.5.2018 14:18	240	230	24892	28384	36836	41278	123905	181512	88788	153650
R-R10-8109	20.5.2018 10:17	17	6	21566	26339	41948	46163	129163	186801	94035	158943
R-R11-10639	21.5.2018 5:45	100	115	23581	31706	66455	70149	153890	211593	118282	183375
R-R11-5233	21.5.2018 6:09	115	115	26604	34613	70914	74556	158364	216073	122664	187777
R-R11-10656	21.5.2018 12:00	115	115	27580	35551	72142	75780	159591	217299	123832	188953
R-R11-10174	22.5.2018 5:55	250	240	29896	37752	75126	78738	162582	220292	126751	191885
R-R12-10010	22.5.2018 12:06	100	100	36389	43887	83083	86608	170563	228289	134653	199808

Appendix 2. Instruments

Long-term monitoring stations were equipped with SoundTrap and DSG-ST hydrophones. SoundTrap is an autonomous acoustic recording unit with frequency range of 20 Hz to 60 kHz and several different sample rate options from 24 to 28 kHz. During the monitoring campaigns the sample rate was set to 24 kHz. Maximum level before clipping is 190 – 210 dB re 1 µPa depending on the model and gain settings.

Figure 16 SoundTrap hydrophone

Loggerhead DSG Ocean Logger is a long-term autonomous acoustic recording unit. The frequency range of the selected hydrophone model, HTI-96-MIN, is 2 Hz to 30 kHz. Sample rate was set to 24 kHz.

Figure 17 DSG-ST hydrophone

Appendix 3. Calibration data

Calibration chart

G.R.A.S. 42AA Pistonphone, Class 1

Serial No.	**306134**
Sound pressure level	114.00 dB re. 20 µPa with 1" coupler
	114.00 dB re. 20 µPa with 1/2" coupler
Nominal frequency	250 Hz
Calibration date	21. Feb, 2018
Operator	KAH

Environmental calibration conditions

Temperature	23 °C
Relative humidity	26 %
Barometric pressure	1022 hPa

Calibration

G.R.A.S. 42AA Pistonphone complies with IEC 942(1988) Class 1 L and ANSI S1.40 -1984.The uncertainty of the calibration value is less than 0.09 dB (99% confidence level).
The stated level is traceable to the Physikalisch-Technische Bundesanstalt, Germany and valid at the following conditions :

Reference conditions

Ambient Temperature	20 °C
Ambient Static Pressure	1013 hPa
Relative Humidity	50 %
Effective Load Volume	15540 mm^3 incl. effective load volume of a G.R.A.S. 40AG or G.R.A.S. 40EN microphone

If the pistonphone is used at an ambient static pressure different from the reference ambient static pressure (1013 hPa), the sound pressure level should be corrected with the value read on the enclosed correction barometer.

Description

G.R.A.S. 42AA Pistonphone is calibrated for use with ½" and 1" measurement microphones such as Laboratory Standard Microphones Type LS2aP (according to IEC Standard 1094-2) and Working Standard Microphones Type WS2P/F/D (according to IEC Standard 1094-4).

The calibrator may be used at ambient sound pressure levels up to 115 dB (re. 20 µPa). For higher ambient sound pressure levels and for comparison calibrations against a laboratory standard microphone a special coupler Type RA0024 is available.

For use as Type 0 calibrator a precision barometer with accuracy of ±1 hPa or better should be used.

Approved by

Peter Wolff-Andersen
Signature

21. Feb, 2018
Date

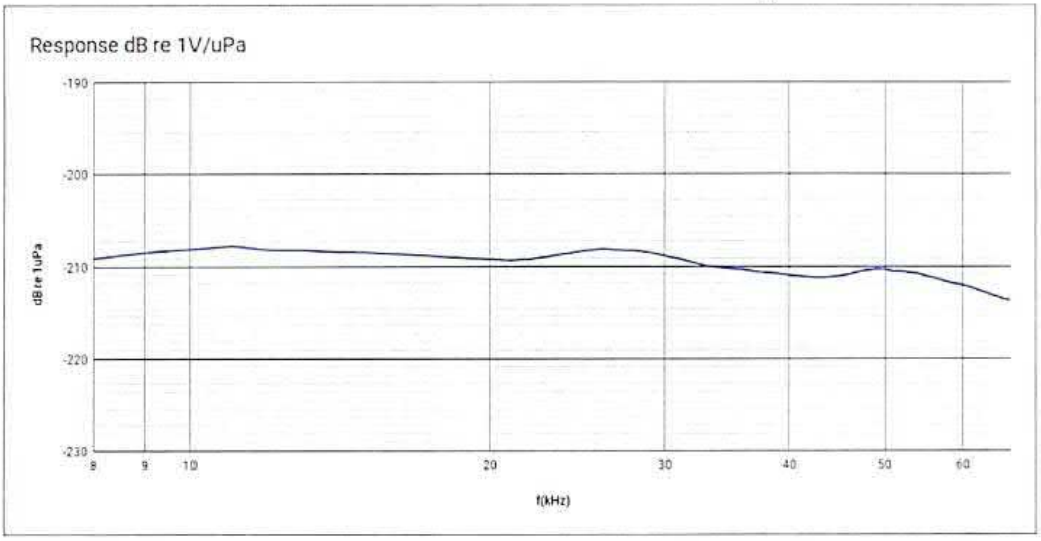
Skovlytoften 33 · 2840 Holte · Denmark
E-mail: gras@gras.dk · www.gras.dk

G.R.A.S.
SOUND & VIBRATION

HYDROPHONE SENSITIVITY

Under Test	ST300STD	**Amplitude**	20 Vp-p	**Temperature**	24 deg C
S/N	335585333	**Pulse Width**	250 us	**Depth**	0.75
Reference	TC4013 #1913116	**Rep Rate**	100 ms	**Distance**	0.7 m
Date	13/2/18	**Averages**	2	**Tested By**	JA
Comment	PHO @250Hz -207.5 FS	**Note**	Add 34 dB for high gain full scale response		

OceanInstruments NZ
Acoustic Monitoring Systems



Hydrophone	Sensitivity
1279	-179,8
1280	-180,4
1281	-180,5
1571	-201,2
1573	-200,8
1575	-200,9
1664	-200,8
1666	-201,2
1667	-200,7
SM2M HiSPL	-239,9
SM2M Ultrasonic	-164,1
Benthowave	-172,7
SN-B002524	-184,6
SN-B002525	-185,1
SN-B002526	-184,8
335573045	182.4
335585333	174.5
335822915	176.1
335827011	182.9
336072751	183.0
336101423	181.6
1208021018	176.2
1208221722	176.7
1208246306	176.2
1208258609	176.0
1208500255	176.0
1208545311	176.1
1208750105	176.3
1208774690	176.3
1208778777	176.8

wildlife ACOUSTICS
BIOACOUSTICS MONITORING SYSTEMS

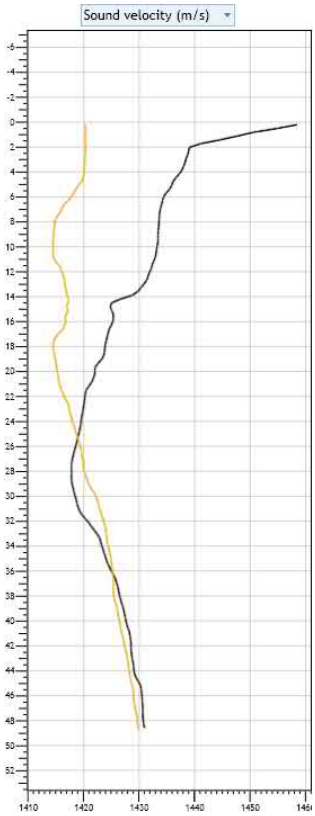
Wildlife Acoustics, Inc.
970 Sudbury Road
Concord, MA 01742-4939
USA

Voice: +1 (978) 369-5225
Fax: +1 (781) 207-5523
Email: sales2012@wildlifeacoustics.com
Web: http://www.wildlifeacoustics.com

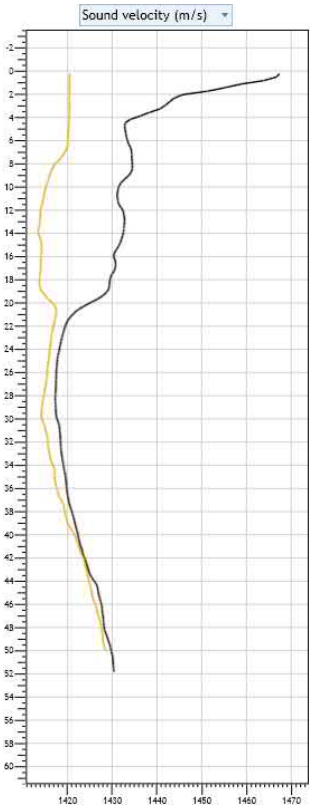
Item/Description		Quantity Ordered
SM2M Marine recorder Sched B # 8519814050		1
Ultrasonic option for Marine recorder Sched B # 8519814050 Sensitivity dB re: 1V/upa	-164.1	1
HiSPL hydrophone option for Marine recorder Sched B # 8519814050 Sensitivity dB re: 1V/upa	-239.9	1

Appendix 4. CTD profiles

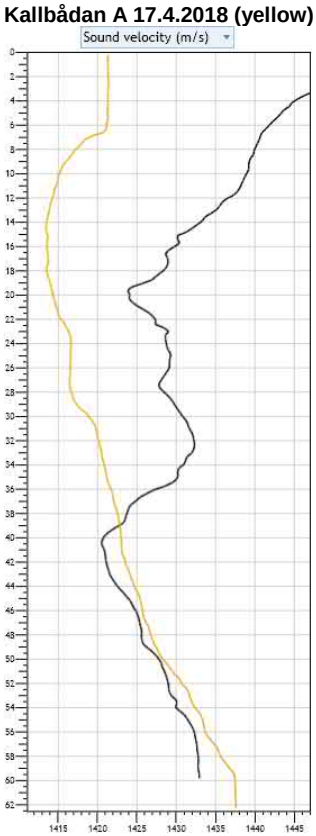
Eastern Gulf of Finland 18.4.2018 (yellow) and 15.5.2018 (black)



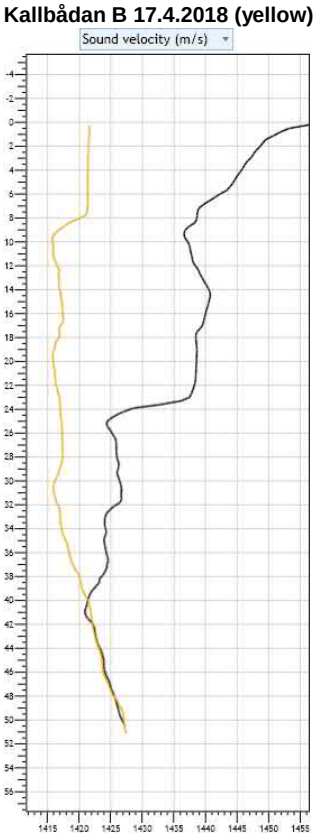
Söderskär 18.4.2018 (yellow) and 14.5.2018 (black)



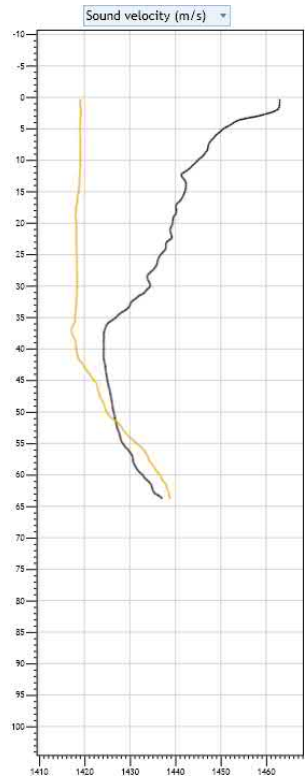
Kallbådan A 17.4.2018 (yellow) and 15.5.2018 (black)



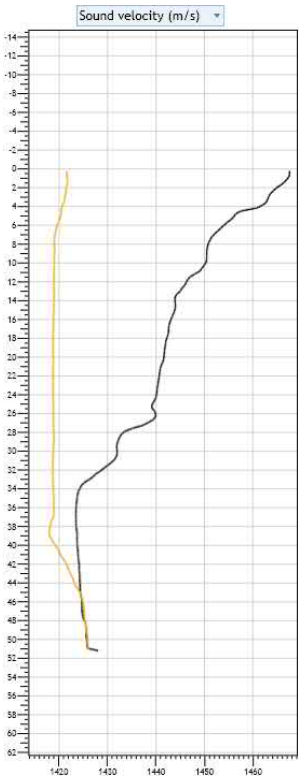
Kallbådan B 17.4.2018 (yellow) and 15.5.2018 (black)



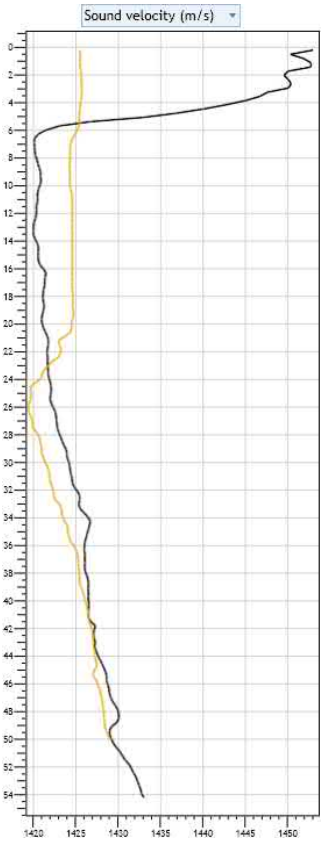
Hanko A 17.4.2018 (yellow) and 23.5.2018 (black)



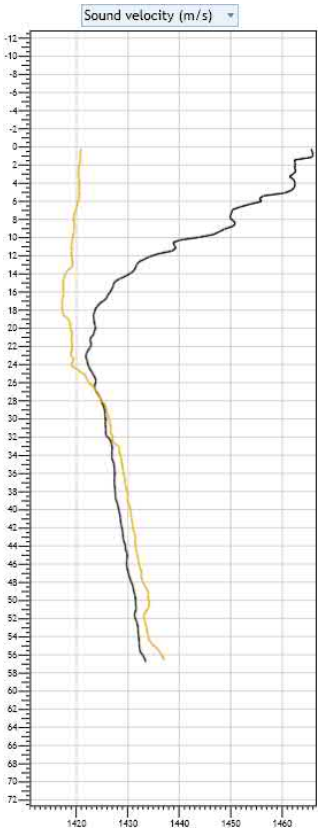
Hanko B 17.4.2018 (yellow) and 23.5.2018 (black)

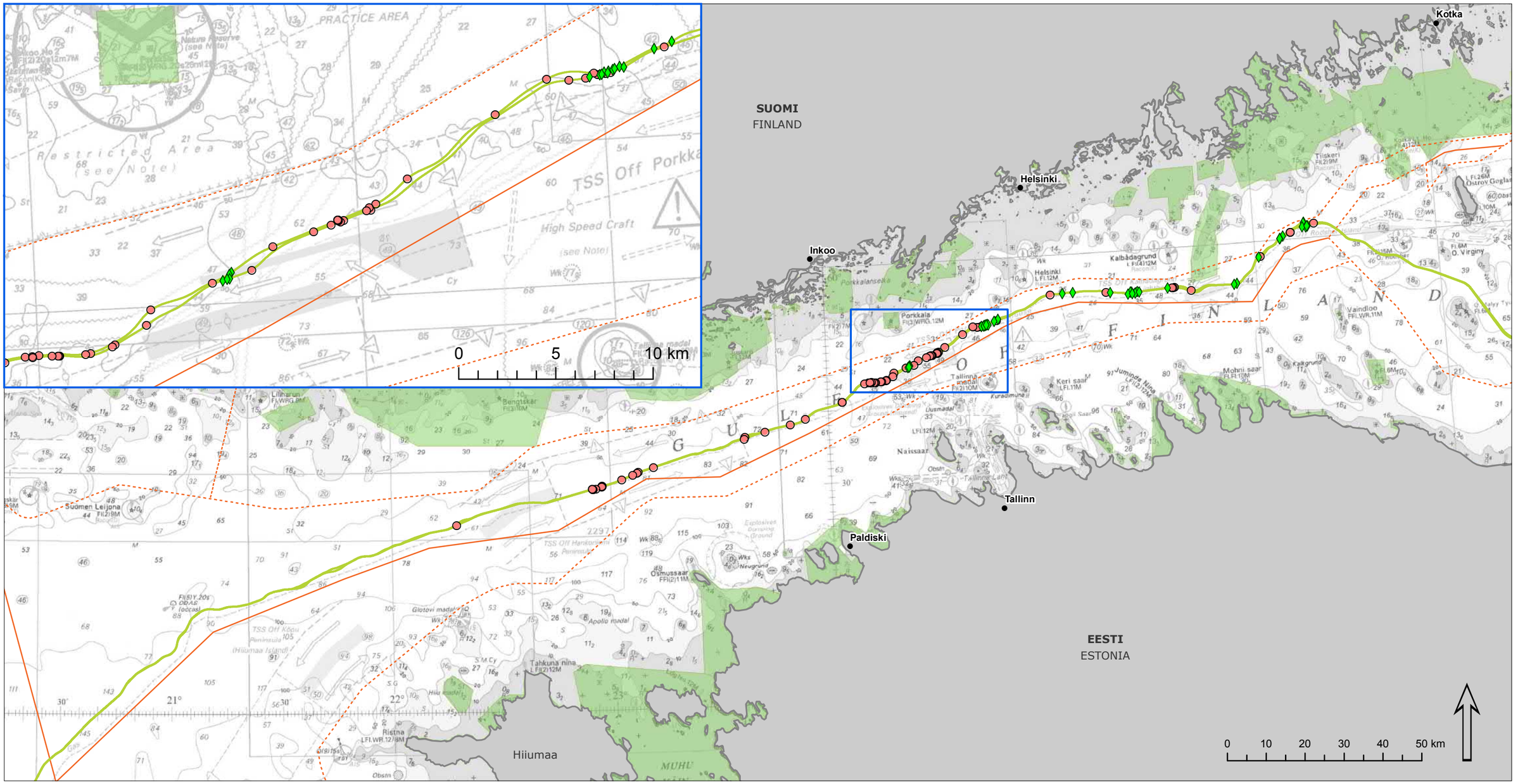


Malusi 23.4.2018 (yellow) and 26.5.2018 (black)



Uhtju 23.4.2018 (yellow) and 26.5.2018 (black)





Nord Stream 2 Construction activities during Q2/2018

- Cleared munitions (74 munition objects)
- Installed berms
- NSP2 Route
- Natura 2000 site (coastal and offshore areas)
- Territorial border
- Åland border
- EEZ border

References:
- Limits of Exclusive Economic Zones and Territorial Waters: IBRU May 2010
- Background sea charts are "Not to be used for navigation"
- Background sea chart; © Crown Copyright and/or database rights. Unauthorized copying prohibited. See further copyright descrpition in the report.

Appendix 2

Version: Q2 report EN ver6
Code: W-PE-EMO-PFI-RQU-892-RQU218EN-06
Date: 24.9.2018
Prepared: Sonja Oksman
Controlled: Sanna Vaalgamaa

Construction activities during Q2/2018

SITOWISE